Menoufia J. Plant Prod., Vol. 3 April (2018): ١٤٧ - 164

DOUBLE CROSSES ANALYSIS OF SOME ECONOMIC CHARACTERS IN EGYPTIAN COTTON

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Received: Jan. 3٠ , 2018 Accepted: Mar. 1 , 2018

ABSTRACT: ***The genetic materials used in the present study included six Egyptian cotton varieties Giza 85 (P_1), Ashmouni (P_2), Giza 75 (P_3), Giza 80 (P_4), Giza 86 (P_5) and Giza 90(P_6) and their corresponding 45 double crosses.These genotypes were evaluated in a field trial experiment at Sids Agricultural Research Station, Beni-suef Governorate through 2017 growing season for the following traits: boll weight (BW), bolls/plant (B/P),seed cotton yield/plant (SCY/P), lint yield/plant (LY/P), lint percentage (LP), fiber fineness (FF), fiber strength (FS), upper half mean (UHM) and uniformity ratio(UR).***

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 all studied characters.This result suggesting the presence of the additive and non-additive genetic variance in the inheritance of these traits . Concerning the two-line interaction effect, (S^2_{12}),(S^2_{13}),(S^2_{14}),(S^2_{24}) and (S^2_{45}) showed positive (desirable) effects for most yield components and fiber quality traits. Also, the three-line interaction effect cleared that the combinations (S^3_{124}),(S^3_{125}),(S^3_{126}),(S^3_{134}),(S^3_{136}) ,(S^3_{145}) and ,(S^3_{245}) were the best combinations for most studied characters. Furthermore, the four-line interaction effect revealed that the best double cross combination for SCY/P, LY/P, UHM and UR was (S^4_{1245}). Moreover, (S^4_{1236}), (S^4_{1246}), (S^4_{2345}), (S^4_{2346}) and (S^4_{3456}) were the best double combinations for B/P, LP, FF, FS and BW, respectively. The parent Giza 85 (P_1) was the best general combiner among this group of varieties for all yield and its components under study except BW and recorded desirable effects for all studied fiber quality traits.Also, Giza 86 variety (P_5) was the best combiner for BW ,while Ashmouni variety (P_2) was the best combiner for FF and Giza 90 variety (P_6) was the best for FS.

The specific combining ability effects $t^2_{(ij)}(..)$ showed that the combinations $t^2_{(13)}(..)$, $t^2_{(14)}(..)$, $t^2_{(26)}(..)$, $t^2_{(36)}(..)$, $t^2_{(45)}(..)$, $t^2_{(46)}(..)$ and $t^2_{(56)}(..)$ were the best combinations for SCY/P,LY/P and UHM , B/P,FS,FF,LP,BW,UR traits, respectively. Generally, from preivous results, it could be concluded that the combinations : [(P_1 x P_3) x (P_2 x P_4)], [(P_1 x P_3) x (P_5 x P_6)] and [(P_2 x P_4) x (P_5 x P_6)] appeared to be the best promising double crosses for breeding toward improvment most studied yield and fiber quality traits .

Dominance genetic variance magnitudes (σ^2D) were positive and larger than those of additive genetic variance (σ^2A) for all studied traits except for BW and FS.Regarding epistatic variances, additive by dominance genetic variance (σ^2AD) showed negative and considerable magnitude for all studied traits except for BW. Moreover, additive by additive genetic variance (σ^2AA) showed negative and considerable magnitude for all studied traits except for BW,LP and FS traits. 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 BW. It could be concluded that fiber properties and yield components were mainly controlled by

epistatic variances; dominance by dominance (σ^2DD) and additive by additive by additive (σ^2AAA). 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 involve in the selection breeding programs is the desirable way for improvement these traits. Heritability in narrow sense (h^2_{ns} %) ranged from 36.4% for LY/P to 84.2% for BW.

Key words: ***Cotton, Quadriallel analysis (Double crosses), Combining ability and Gene action.***

INTRODUCTION

The main goal of cotton breeding is to increase yield and fiber quality. Many of these characters were quantitatively inherited. Quantitative characters display continuous variation and in general are controlled by polygenes showing Mendelian inheritance, modified by environment, to study inheritance of such continuously varying characters different biometrical approaches are used. Basic requirement for the breeder before they initiate the sensible breeding programme is to partition the variation into components which measured the different types of gene. Quadriallel (Double crosses)analysis is one of the important biometrical tools that provide information on gene action on different quantitative characters, and also useful for estimating both general and specific combining abilities effects for evaluation of potential breeding lines and crosses under study .Also, double cross analysis provides information about nature of gene action for interested traits., quadriallel analysis had clearly elucidated its advantages over diallel analysis by giving additional information on magnitude of types of epistatic components and also on order of parents to be crosses in double-cross hybrids for obtaining superior transgressive segregations (Singh and Narayanan, 2000).However, the epistatic variances 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. Double crosses were known to perform quite well under a wide range of environmental conditions (Sujlprihatp *et al*., 2003). The theoretical aspect of quadriallel analysis has been dealt with by Rawling and Cockerham (1962). Potdukhe and Parmar (2006) indicated that yield and yield components exhibited low value of heritability. They added that, high estimates (101.28) were observed for seed index followed by seed cotton yield (30.04). This study was conducted to give the information on order effect of parent to form double crosses and estimated the genetic component for double crosses. 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 (2008) revealed that the magnitude of additive genetic variance was positive and larger than those 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) found that Parent Australian (P_1) and 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 x P_2)(--) and (P_2 x P_4) (--) when they go into another arrangement i.e. (P_1 x -)(P_2 x -) and (P_2 x -)(P_4 x-) showed the positive 2-line specific for most earliness traits as undesirable direction. Said (2011) found that moderate narrow sense heritability estimates from (30 -50%) for yield and yield components while high narrow sense of heritability for upper half mean (over 50%) was obtained. He added that additive by additive (σ^2AA), additive by dominance (σ^2AD) and additive by additive by additive genetic variances (σ^2AAA) were positive and considerable magnitude for most studied traits. El-Hashash (2013) reported that additive x additive and additive x dominance genetic variances were observed and highest than the other types of epistatic genetic variances for all yield components and fiber quality traits under study. Narrow-sense heritability was low for all these traits in double-crosses. Many investigators studied general and specific combining abilities among them; Hemaida *et al.* (2006), Ahuja and Dhayal (2007), Eman et al (2007), Basal et al. (2009), Karademir et al. (2009), Karademir and Gençer (2010) and Said (2011)who used the six parents ; Giza 80 (P_1), Giza 83 (P_2), Giza 90 (P_3), Giza 91 (P_4), Karashenky (P_5) and Australian (P_6) and stated that, the double crosses (S^4_{1246}),(S^4_{1356}),(S^4_{3456}), (S^4_{1345}), (S^4_{1346}),(S^4_{2345}) were the best combinations for most studied traits. In conclusion, from the results, it could be concluded that the combinations t^4[(P_1xP_6)(P_2xP_4)],t4[(P_1xP_6)(P_3xP_5)] and t^4 [(P_2xP_4)(P_3xP_5)] appeared to be the best promising double crosses for breeding towards most studied yield traits potentiality .Also, and El-Feki et al(2012) reported that, [(P_1 x P_5) x (P_2 x P_4)], [(P_1 x P_5) x (P_3 x P_6)] and [(P_2 x P_4) x (P_3 x P_6)] would be good combinations for most studied yield traits and all fiber properties when they used Australian (P_1),BBB (P_2), Karshenky (P_3), Giza 70 (P_4), Suvin (P_5) and (Giza 77 x Pima S6) (P_6) in this study.

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

MATERIALS AND METHODS

The genetic material and mating design:

Six Egyptian long staple cotton varieties belonging to *Gossypium barbadense,* L.; Giza 85 (P_1), Ashmouni (P_2), Giza 75 (P_3), Giza 80 (P_4), Giza 86 (P_5) and Giza 90(P_6) were used as parents to produce 45 possible double crosses (quadriallel crosses). throw a series of hybridization according to (double crosses) mating design as following:In growing season 2015 ,the six parents were planted and mated in a diallel fashion excluding reciprocals to obtain 15 single crosses. In 2016 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 varieties.

Experimental design:

In 2017 growing season, these 51 genotypes which included the six parental varieties 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 blocks design with three replications. Each plot was one row 4.0 m. long and 0.65 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 seedling stage. Ordinary cultural practices were followed as the recommendations.

Data were recorded on the following traits: boll weight in grams (BWg.); number of opened bolls per plant(B/P); seed cotton yield per plant in grams (SCY/P.g.); lint yield per plant in grams (LY/P.g.); lint percentage (LP) and fiber fineness (FF), fiber strength (FS); upper half mean (UHM) as a measure of Span length in mm and uniformity ratio(UR). The fiber properties were measured in the laboratories of Cotton Fiber Research Section, Cotton Research Institute according to (A.S.T.M. ;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 a Randomized Complete Blocks Design(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 Rawlign 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.

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- $t^2_{(ij)(..)} = [Y_{(ij)(..)}. /(r\, p_2 p_3/2)] - \mu - g_i - g_j - S_{ij}$
6- $t^2_{(i\,.)(j\,.)} = [Y_{(i\,.)(j\,.)}. / r\, p_2 p_3] - \mu - g_i - g_j - S_{ij}$
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- $t^4_{(ij)(k\,l)} = [Y_{(ij)(kl)}. / r] - \mu - g_i - g_j - g_k - g_l - S_{ij} - S_{ik} - S_{il} - S_{jk} - S_{jl} - S_{kl} - S_{ijk} - S_{ijl} - S_{ikl} - S_{jkl} - S_{ijkl} - t^2_{ij} - t^2_{kl} - t^2_{i.k} - t^2_{i.l} - t^2_{j.k} - t^2_{j.l} - t^3_{ij.k} - t^3_{ij.l} - t^3_{kl.i.} - t^3_{kl.j}$

Narrow sense heritability was estimated by the following equations according to Rawlign and Cockerham (1962):

$$h^2 n = \frac{\frac{1}{2}VA + \frac{1}{4}VAA + \frac{1}{8}VAAA}{\frac{1}{2}VA + \frac{1}{4}VD + \frac{1}{4}VAA + \frac{1}{8}VAD + \frac{1}{16}VDD + \frac{1}{8}VAAA + \sigma^2 e/3}$$

Where, A = Additive, D= Dominance and E= Error variances

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	$(8\sum Y^2 .... m) /(r\ p\ p_1\ p_2\ p_3)$ - 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	$P\ P_1\ P_4\ P_5 / 12$	$(\sum Y^2_{(i\ j)\ (k\ l)} /r) - (\sum Y^2_{ijkl\ .} /3r) - T_2 - T_3$	T_4
Error	$(r-1)\ (3^6\ C_4 - 1)$	M - R - H	E
Total	$3r^6\ C_4 - 1$	$\sum Y^2\ (i\ j)\ (kl)\ m - C$	

RESULTS AND DISCUSSION

The mean squares of genotypes and crosses were highly significant for all studied traits. Furthermore, the partition of crosses mean squares to its components (Table 2) showed that the mean square due to 1-line general were 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 highly significant for all studied traits suggesting the presence of the non-additive variance in the inheritance of these traits. Also,3-line arrangement mean squares were highly significant for all studied traits indicating the contribution of additive by dominance interaction including all three factors or higher order interactions except all dominance types. Furthermore, the results indicated that tests of significant showed that the mean squares due to 4-line arrangement were significant and/or highly significant for all 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.Similar results were reported by Abd El-Bary (2008), Said (2011) and El-Feki *et al.*, (2012) .

General combining ability effects for each parental variety:

The estimates of general combining ability effects (g_i) of parental varieties were obtained for studied traits and the obtained results are shown in Table 3. 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). In multiple crossing programs prior information on the order effect of lines could be of great value (Singh and Chaudhary 1985).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. However, the parent Giza 85 (P_1) was the best general combiner for all studied yield component traits except for boll weight (BW) and recorded desirable values for all fiber quality traits under study. Moreover, the Ashmouni variety (P_2) had positive desirable general combining ability effects for seed cotton yield/plant (SCY/P), lint yield /plant (LY/P),bolls/plant(B/P) and it was the best combiner for fiber fineness (FF) which had a negative (desirable) value. Also, Giza 75 variety (P_3) was the best combiner for UR and had positive desirable values of general combining ability for BW and UHM, Giza 80 variety (P_4) was the best combiner for upper half mean (UHM) ,Giza 86 variety (P_5) was the best combiner for BW. In addition, the results revealed that Giza 90 variety (P_6) was the best for fiber strength (FS). From previuos results, 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.Results are in harmony with those found by Abd El-Bary (2008), Said (2011) and El-Feki *et al*. (2012) .

Table 2: Analysis of variance and mean squares of the double crosses for yield and its components as well as fiber quality properties.

SOV	DF	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
Rep. ss	2	0.00	1.41	11.16	1.69	0.00	0.00	0.00	0.00	0.00
Crosses ss	44	0.06**	66.29**	687.71**	108.1**	2.13**	0.40**	0.58**	5.52**	19.22**
1_line general ss	5	0.08**	241.08**	1937.61**	316.8**	1.29**	0.38**	1.02**	4.82**	13.42**
2_line specific ss	9	0.11**	10.07**	187.06**	33.44**	2.59**	0.07**	0.56**	4.97**	35.01**
2_line arrangement ss	9	0.07**	141.77**	1710.32**	252.5**	3.49**	0.38**	0.44**	8.06**	21.30**
3_line arrangement ss	16	0.03**	16.24**	155.44**	27.26**	1.54**	0.60**	0.62**	4.20**	9.90**
4_line arrangement ss	5	0.02*	16.96**	201.53**	32.51**	1.54**	0.40**	0.35**	6.83**	22.74**
Error ss	88	0.01	1.59	20.82	3.01	0.06	0.00	0.00	0.00	0.00

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

Table 3: General line effect (g_i) for yield and its components as well as fiber quality traits.

Parent	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
G.85(P_1)	-0.033	1.792	4.974	2.048	0.095	-0.011	0.029	0.048	0.099
Ashmouni(P_2)	-0.002	0.406	1.337	0.428	-0.106	-0.037	-0.030	-0.025	-0.013
G.75(P_3)	0.016	-0.145	-0.070	-0.052	-0.028	0.071	-0.110	0.108	0.441
G.80(P_4)	-0.007	-0.114	-0.595	-0.139	0.079	-0.012	-0.018	0.113	-0.145
G.86(P_5)	0.022	-1.157	-3.161	-1.260	-0.002	-0.035	0.053	0.037	-0.184
G.90(P_6)	0.004	-0.781	-2.485	-1.025	-0.037	0.024	0.076	-0.280	-0.198

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. The results cleared that no combinations involved desirable values for all studied traits. It could be noticed that (S^2_{12}), (S^2_{13}), (S^2_{14}), (S^2_{24}) and (S^2_{45}) showed positive (desirable) effects for most yield components. Moreover, the best combinations for fiber fineness were (S^2_{16}), (S^2_{25}) and (S^2_{56}). Also, the best two-line interaction effects for fiber strength were (S^2_{15}), (S^2_{25}) and (S^2_{46}), the best combinations for UHM were (S^2_{12}), (S^2_{36}) and (S^2_{45}) and the best combinations for UR were (S^2_{13}), (S^2_{14}) and (S^2_{36}). These Results were agree with those reported by Abd El-Bary (2008), Yehia *et al.* (2009) and Said (2011).

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. The results showed that no combinations possessed desirable values for all studied traits. However, the combinations (S^3_{123}), (S^3_{124}), (S^3_{125}), (S^3_{134}) , (S^3_{136}) and (S^3_{145}) showed great positive (desirable) effects for BW, B/P, SCY/P, LY/P and FF. In the same time, (S^3_{125}), (S^3_{145}), (S^3_{245}), and (S^3_{346}) were the best combinations for most fiber quality traits. Similar results were obtained by Yehia *et al.* (2009) and El-Feki *et al.* (2012).

Table 4: The 2-line interaction effect of lines i and j appearing together irrespective of arrangement S^2_{ij} for yield components and fiber quality traits.

S^2_{ij}	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
S^2_{12}	0.026	0.444	2.168	0.777	-0.081	-0.006	-0.041	0.090	0.106
S^2_{13}	-0.015	0.574	1.492	0.640	0.054	0.021	-0.024	-0.128	0.207
S^2_{14}	0.004	0.519	1.815	0.871	0.146	-0.010	-0.013	0.042	0.239
S^2_{15}	-0.023	0.070	-0.407	-0.193	-0.025	0.000	0.085	-0.008	-0.018
S^2_{16}	-0.026	0.185	-0.094	-0.048	0.000	-0.016	0.021	0.051	-0.435
S^2_{23}	-0.008	-0.071	-0.436	-0.258	-0.070	-0.008	-0.007	0.001	-0.217
S^2_{24}	-0.017	0.075	-0.203	-0.023	0.051	-0.001	0.004	0.001	0.007
S^2_{25}	0.000	-0.120	-0.362	-0.122	0.015	-0.018	0.037	-0.020	0.104
S^2_{26}	-0.003	0.078	0.170	0.053	-0.022	-0.004	-0.022	-0.097	-0.013
S^2_{34}	0.007	-0.118	-0.192	-0.208	-0.138	0.001	-0.011	0.024	-0.219
S^2_{35}	0.017	-0.479	-1.069	-0.305	0.109	0.006	-0.063	0.086	-0.053
S^2_{36}	0.015	-0.051	0.135	0.079	0.016	0.050	-0.004	0.125	0.723
S^2_{45}	0.004	-0.112	-0.321	-0.155	-0.026	-0.009	-0.042	0.191	0.042
S^2_{46}	-0.006	-0.479	-1.694	-0.624	0.044	0.008	0.044	-0.146	-0.214
S^2_{56}	0.023	-0514	-1.002	-0.485	-0.075	-0.014	0.036	-0.212	-0.259

Table 5: The 3-line interaction effect of lines i, j and k appearing together irrespective of arrangement S^3_{ijk} for yield components and fiber quality traits .

S^3_{ijk}	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
S^3_{123}	0.009	0.263	1.144	0.352	-0.083	0.000	-0.036	-0.081	-0.080
S^3_{124}	0.027	0.344	1.874	0.846	0.094	0.002	-0.044	0.088	0.372
S^3_{125}	0.008	0.046	0.349	0.058	-0.087	0.003	0.063	0.043	0.225
S^3_{126}	0.008	0.235	0.968	0.299	-0.087	-0.018	-0.067	0.129	-0.304
S^3_{134}	0.005	0.465	1.678	0.684	0.015	-0.003	-0.015	-0.150	0.095
S^3_{135}	-0.022	0.001	-0.565	-0.104	0.117	0.019	0.008	-0.113	0.017
S^3_{136}	-0.021	0.419	0.727	0.348	0.060	0.027	-0.005	0.089	0.381
S^3_{145}	-0.008	0.303	0.681	0.307	0.038	0.00	0.009	0.160	0.340
S^3_{146}	-0.015	-0.073	-0.604	-0.096	0.145	-0.019	0.024	-0.013	-0.329
S^3_{156}	-0.023	-0.211	-1.279	-0.647	-0.119	-0.023	0.091	-0.104	-0.617
S^3_{234}	-0.020	-0.162	-1.055	-0.568	-0.137	-0.015	0.038	-0.039	-.0523
S^3_{235}	-0.003	-0.372	-1.236	-0.390	0.100	-0.019	-0.005	0.027	-0.248
S^3_{236}	-0.002	0.130	0.275	0.091	-0.019	0.019	-0.012	0.094	0.416
S^3_{245}	-0.017	0.131	-0.079	0.024	0.050	-0.001	-0.003	0.131	0.267
S^3_{246}	-0.024	-0.162	-1.146	-0.349	0.095	0.011	0.017	-0.178	-0.101
S^3_{256}	0.013	-0.046	0.242	0.065	-0.034	-0.019	0.018	-0.240	-0.037
S^3_{345}	0.018	-0.237	-0.307	-0.184	-0.070	-0.010	-0.092	0.215	-0.267
S^3_{346}	0.012	-0.301	-0.701	-0.348	-0.082	0.031	0.046	0.023	0.258
S^3_{356}	0.041	-0. 350	-0.031	0.067	0.072	0.022	-0.037	0.043	0.392
S^3_{456}	0.016	-0.422	-0.936	-0.456	-0.070	-0.007	0.001	-0.124	-0.255

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. The results revealed that no hybrids exhibited desirable values for all studied traits. The best double combinations for SCY, LY/P, UHM and UR were (S^4_{1245}). Moreover, (S^4_{3456}), (S^4_{1236}), (S^4_{1246}), (S^4_{2345}), (S^4_{2346}) and (S^4_{1456}) were the best double combinations for BW, B/P, L %, FF and FS, respectively. These results were in harmony with those obtained by Abd El-Bary (2008) and Yehia *et al.* (2009).

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

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 and fiber quality traits are presented in Table 7. Results indicated that no hybrids exhibited desirable values for all studied traits. The combinations $t^2(_{13})(..)$, $t^2(_{46})(..)$, $t^2(_{14})(..)$, $t^2(_{45})(..)$, $t^2(_{36})(..)$ and $t^2(_{26})(..)$ were the best combinations for SCY/P, LY/P and UHM, BW,B/P, LP, FF, (UHM) and FS traits, respectively. Similar results were obtained by Said(2011) and El-Feki *et al.* (2012).

Table 6: The 4-line interaction effect of lines i, j, k and l appearing together irrespective of arrangement S^4_{ijkl} for yield components and fiber quality traits .

S^4_{ijkl}	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
S^4_{1234}	0.045	0.395	2.639	0.829	-0.186	-0.030	-0.020	-0.394	-0.395
S^4_{1235}	-0.014	-0.541	-2.001	-0.709	0.091	0.011	0.075	-0.270	-0.299
S^4_{1236}	-0.003	0.935	2.794	0.935	-0.154	0.019	-0.162	0.422	0.454
S^4_{1245}	0.025	0.773	2.961	1.314	0.112	0.054	0.021	0.546	1.926
S^4_{1246}	0.013	-0.136	0.023	0.395	0.358	-0.017	-0.133	0.113	-0.415
S^4_{1256}	0.013	-0.093	0.088	-0.433	-0.463	-0.055	0.095	-0.148	-0.952
S^4_{1345}	-0.010	0.610	1.657	0.756	0.078	0.002	-0.111	0.013	0.172
S^4_{1346}	-0.019	0.390	0.738	0.467	0.153	0.017	0.087	-0.071	0.508
S^4_{1356}	-0.042	-0.066	-1.351	-0.359	0.182	0.044	0.060	-0.084	0.179
S^4_{1456}	-0.039	-0.474	-2.574	-1.149	-0.074	-0.057	0.118	-0.080	-1.079
S^4_{2345}	-0.049	-0.455	-2.771	-1.166	-0.057	-0.062	-0.041	0.384	-1.207
S^4_{2346}	-0.057	-0.426	-3.033	-1.366	-0.168	0.046	0.175	-0.107	0.032
S^4_{2356}	0.053	-0.119	1.065	0.704	0.266	-0.008	-0.049	-0.033	0.763
S^4_{2456}	-0.027	0.075	-0.428	-0.077	0.096	0.004	0.009	-0.539	0.080
S^4_{3456}	0.113	-0.866	0.193	-0.144	-0.232	0.030	-0.123	0.247	0.233

Table 7: Two- line interaction effect of lines i and j due to particular arrangement $t^2(_{ij})(..)$. for yield component and fiber quality traits.

$t^2_{(ij)\,(..)}$	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
$t^2_{(12)(..)}$	0.019	2.301	8.036	3.918	0.602	-0.130	-0.004	-0.514	0.673
$t^2_{(13)(..)}$	0.090	2.818	12.215	4.472	-0.349	0.086	0.002	0.836	1.314
$t^2_{(14)(..)}$	-0.039	3.109	8.211	2.501	-0.712	-0.053	-0.020	0.010	-0.782
$t^2_{(15)(..)}$	0.035	-4.369	-12.968	-4.906	0.264	0.137	0.064	-0.426	-0.650
$t^2_{(16)(..)}$	-0.106	-3.859	-15.493	-5.986	0.196	-0.040	-0.042	0.094	-0.556
$t^2_{(23)(..)}$	-0.003	-2.150	-7.228	-2.944	-0.038	0.066	-0.219	0.438	0.287
$t^2_{(24)(..)}$	-0.007	-1.001	-3.204	-1.336	-0.018	-0.093	-0.112	0.831	0.318
$t^2_{(25)(..)}$	-0.004	0.052	-0.036	-0.508	-0.485	-0.055	0.015	-0.743	-1.796
$t^2_{(26)(..)}$	-0.006	0.798	2.432	0.870	-0.061	0.213	0.320	-0.012	0.517
$t^2_{(34)(..)}$	-0.023	-2.611	-9.202	-3.470	0.164	0.010	0.169	-1.070	-0.442
$t^2_{(35)(..)}$	-0.039	1.563	3.829	1.507	-0.041	0.067	0.064	0.292	-0.069
$t^2_{(36)(..)}$	-0.026	0.380	0.386	0.435	0.264	-0.229	-0.017	-0.496	-1.091
$t^2_{(45)(..)}$	-0.031	0.288	0.347	0.766	0.614	-0.035	0.040	0.347	1.146
$t^2_{(46)(..)}$	0.099	0.216	3.848	1.539	-0.047	0.171	-0.077	-0.117	-0.239
$t^2_{(56)(..)}$	0.038	2.466	8.828	3.141	-0.352	-0.114	-0.184	0.530	1.369

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 combinations exhibited desirable values for all studied traits. It could be noticed that $t^2(_{1.})(_{4.})$, $t^2(_{1}.)(_{5.})$ and $t^2(_{1.})(_{6.})$ were the best combinations for all yield and its components traits. Meanwhile, $t^2(_{2.})(_{3.})$, $t^2(_{2.})(_{5.})$, $t^2(_{2.})(_{6.})$, and $t^2(_{3.})(_{4.})$ were the best combinations for FS, UR, FF and UHM traits,respectively. Yehia *et al,* (2009) and El-Feki *et al.* (2012) reported similar results.

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. The results cleared that five combinations *viz.,* $t^3(_{14})(_{6.})$, $t^3(_{16})(_{3.})$, $t^3(_{23})(_{1.})$, $t^3(_{23})(_{6.})$ and $t^3(_{56})(_{3.})$, were the best combinations for BW,SCY/P, B/P,LY/P and LP traits, respectively. Meanwhile, t3(13)(6.), t3(15)(6.), t3(25)(4.) and t3(26)(1.),were the best combinations for FF, UHM , FS and UR traits,respectively.These results were in harmony with those obtained by Said (2011) and El-Feki *et al.* (2012).

Table 8: Two-line interaction effect of lines i and j due to particular arrangement t^2(i.)(j.). for yield component and fiber quality traits

t2(i.)(j.).	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
t2(1.)(2.).	-0.0096	-1.1505	-4.0180	-1.9591	-0.3010	0.0652	0.0019	0.2571	-0.3367
t2(1.)(3.).	-0.0452	-1.4090	-6.1074	-2.2369	0.1745	-0.0430	-0.0009	-0.4181	-0.6572
t2(1.)(4.).	0.0194	-1.5545	-4.1054	-1.2507	0.3562	0.0263	0.0102	-0.0048	0.3911
t2(1.)(5.).	-0.0176	2.1844	6.4841	2.4530	-0.1318	-0.0687	-0.0322	0.2130	0.3250
t2(1.)(6.).	0.0530	1.9296	7.7467	2.9928	-0.0979	0.0202	0.0211	-0.0471	0.2778
t2(2.)(3.).	0.0015	1.0748	3.6139	1.4719	0.0189	-0.0328	0.1094	-0.2190	-0.1437
t2(2.)(4.).	0.0033	0.5007	1.6019	0.6681	0.0091	0.0465	0.0561	-0.4154	-0.1589
t2(2.)(5.).	0.0019	-0.0260	0.0181	0.2539	0.2424	0.0276	-0.0074	0.3715	0.8978
t2(2.)(6.).	0.0030	-0.3989	-1.2159	-0.4348	0.0305	-0.1065	-0.1600	0.0058	-0.2585
t2(3.)(4.).	0.0115	1.3057	4.6009	1.7350	-0.0819	-0.0050	-0.0846	0.5352	0.2209
t2(3.)(5.).	0.0194	-0.7814	-1.9146	-0.7533	0.0205	-0.0337	-0.0322	-0.1461	0.0344
t2(3.)(6.).	0.0128	-0.1901	-0.1928	-0.2176	-0.1321	0.1144	0.0083	0.2480	0.5456
t2(4.)(5.).	0.0154	-0.1441	-0.1735	-0.3828	-0.3070	0.0176	-0.0202	-0.1733	-0.5728
t2(4.)(6.).	-0.0496	-0.1078	-1.9239	-0.7696	0.0235	-0.0854	0.0385	0.0583	0.1196
t2(5.)(6.).	-0.0191	-1.2329	-4.4141	-1.5707	0.1759	0.0572	0.0920	-0.2650	-0.6844

Table 9: Three- line interaction effect of lines i, j and k due to particular arrangement $t^3 (_{ij})(_{k-})$ for yield component and fiber quality traits

$t^3 (_{ij})(_{k-})$	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
$t^3 (_{12})(_{3.})$.	0.020	-1.268	-3.788	-1.163	0.313	0.011	0.006	0.816	0.101
$t^3 (_{12})(_{4.})$.	-0.003	0.488	1.514	0.203	-0.399	-0.101	-0.080	0.278	0.614
$t^3 (_{12})(_{5.})$.	0.003	-0.761	-2.317	-1.270	-0.297	0.140	-0.074	-0.135	-0.451
$t^3 (_{12})(_{6.})$.	-0.040	-0.759	-3.445	-1.688	-0.219	0.080	0.152	-0.445	-0.937
$t^3 (_{13})(_{2.})$.	0.022	-0.599	-1.080	-0.409	0.050	0.085	-0.023	-0.643	-0.414
$t^3 (_{13})(_{4.})$.	-0.002	-0.880	-2.919	-0.856	0.234	0.071	0.179	-0.061	-1.084
$t^3 (_{13})(_{5.})$.	-0.023	-0.560	-2.849	-1.259	-0.121	0.045	-0.204	0.395	0.243
$t^3 (_{13})(_{6.})$.	-0.087	-0.779	-5.366	-1.948	0.186	-0.287	0.046	-0.528	-0.060
$t^3 (_{14})(_{2.})$.	-0.029	0.372	0.354	0.395	0.279	-0.064	-0.110	0.188	0.526
$t^3 (_{14})(_{3.})$.	-0.006	-0.542	-1.904	-0.747	0.025	-0.112	0.115	-0.617	0.090
$t^3 (_{14})(_{5.})$.	0.009	-0.709	-1.692	-0.389	0.271	0.132	0.179	0.286	-0.277
$t^3 (_{14})(_{6.})$.	0.065	-2.230	-4.969	-1.760	0.139	0.097	-0.064	0.133	0.443
$t^3 (_{15})(_{2.})$.	0.001	-0.011	-0.065	-0.072	-0.095	-0.029	0.186	0.086	0.414
$t^3 (_{15})(_{3.})$.	-0.012	1.407	4.487	1.594	-0.174	-0.014	0.142	-0.320	-0.008
$t^3 (_{15})(_{4.})$.	-0.034	1.135	2.512	0.980	0.014	-0.184	-0.237	-0.227	-0.033
$t^3 (_{15})(_{6.})$.	0.009	1.838	6.033	2.403	-0.008	0.090	-0.155	0.887	0.277
$t^3 (_{16})(_{2.})$.	0.015	1.388	4.809	2.045	0.068	-0.057	-0.054	0.111	-0.189
$t^3 (_{16})(_{3.})$.	0.043	1.813	7.312	2.552	-0.338	0.158	-0.161	0.539	0.474
$t^3 (_{16})(_{4.})$.	0.019	0.812	2.998	0.924	-0.205	0.188	0.127	0.015	0.111
$t^3 (_{16})(_{5.})$.	0.029	-0.154	0.374	0.465	0.279	-0.248	0.131	-0.760	0.159
$t^3 (_{23})(_{1.})$.	-0.042	1.867	4.868	1.572	-0.362	-0.096	0.017	-0.174	0.313
$t^3 (_{23})(_{4.})$.	0.024	-1.037	-2.874	-1.458	-0.269	-0.050	-0.165	-0.456	-0.384
$t^3 (_{23})(_{5.})$.	-0.035	0.068	-0.592	0.031	0.207	0.075	0.228	-0.213	-0.876
$t^3 (_{23})(_{6.})$.	0.055	1.251	5.826	2.798	0.463	0.006	0.139	0.404	0.660
$t^3 (_{24})(_{1.})$.	0.032	-0.860	-1.869	-0.598	0.121	0.165	0.190	-0.466	-1.140
$t^3 (_{24})(_{3.})$.	0.010	1.305	4.532	1.882	0.039	0.119	0.164	-0.189	0.930
$t^3 (_{24})(_{5.})$.	0.001	-0.099	-0.426	-0.223	-0.049	-0.079	-0.217	-0.187	0.167
$t^3 (_{24})(_{6.})$.	-0.036	0.656	0.966	0.275	-0.092	-0.112	-0.024	0.011	-0.275
$t^3 (_{25})(_{1.})$.	-0.005	0.772	2.382	1.342	0.392	-0.111	-0.111	0.048	0.037
$t^3 (_{25})(_{3.})$.	0.029	-0.074	0.627	0.024	-0.178	-0.151	0.158	0.115	0.246
$t^3 (_{25})(_{4.})$.	-0.037	-0.001	-0.842	0.092	0.453	0.184	0.361	0.785	0.701
$t^3 (_{25})(_{6.})$.	0.017	-0.750	-2.131	-0.950	-0.182	0.133	-0.107	0.024	0.811
$t^3 (_{26})(_{1.})$.	0.025	-0.629	-1.364	-0.357	0.151	-0.024	-0.098	0.334	1.126
$t^3 (_{26})(_{3.})$.	-0.060	-1.037	-4.986	-2.215	-0.192	0.054	-0.121	-0.293	-0.134
$t^3 (_{26})(_{4.})$.	0.012	0.049	0.600	0.495	0.206	-0.080	-0.172	-0.192	-0.772
$t^3 (_{26})(_{5.})$.	0.029	0.819	3.317	1.208	-0.104	-0.163	0.071	0.163	0.262
$t^3 (_{34})(_{1.})$.	0.008	1.422	4.824	1.603	-0.259	0.041	-0.194	0.678	0.993
$t^3 (_{34})(_{2.})$.	-0.034	-0.268	-1.658	-0.424	0.230	-0.069	0.001	0.645	-0.546

Table 9: Cont.

t^3 (i j)(k.)	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
t^3 (34)(5.).	0.027	0.829	3.463	1.539	0.165	-0.255	0.180	-0.412	0.509
t^3 (34)(6.).	0.023	0.627	2.573	0.752	-0.300	0.274	-0.157	0.160	-0.514
t^3 (35)(1.).	0.035	-0.847	-1.638	-0.336	0.295	-0.031	0.062	-0.075	-0.235
t^3 (35)(2.).	0.006	0.006	-0.035	-0.055	-0.029	0.076	-0.070	0.328	0.630
t^3 (35)(4.).	0.002	0.188	0.685	0.269	-0.009	-0.006	-0.020	-0.261	0.305
t^3 (35)(6.).	-0.004	-0.910	-2.841	-1.385	-0.217	-0.106	-0.036	-0.284	-0.631
t^3 (36)(1.).	0.044	-1.034	-1.946	-0.604	0.152	0.129	0.116	-0.012	-0.414
t^3 (36)(2.).	0.005	-0.214	-0.841	-0.583	-0.270	-0.059	-0.018	-0.111	0.474
t^3 (36)(4.).	-0.036	0.424	0.508	0.310	0.126	-0.010	0.091	0.243	0.942
t^3 (36)(5.).	0.012	0.444	1.894	0.442	-0.271	0.169	-0.172	0.376	0.089
t^3 (45)(1.).	0.025	-0.426	-0.821	-0.591	-0.284	0.052	0.057	-0.059	0.309
t^3 (45)(2.).	0.037	0.100	1.268	0.131	-0.404	-0.106	-0.144	-0.598	-0.868
t^3 (45)(3.).	-0.028	-1.017	-4.147	-1.808	-0.157	0.261	-0.160	0.673	-0.814
t^3 (45)(6.).	-0.003	1.054	3.353	1.503	0.231	-0.173	0.206	-0.362	0.227
t^3 (46)(1.).	-0.084	1.418	1.971	0.836	0.066	-0.285	-0.063	-0.184	-0.554
t^3 (46)(2.).	0.023	-0.706	-1.566	-0.770	-0.114	0.192	0.196	0.181	1.047
t^3 (46)(3.).	0.013	-1.051	-3.081	-1.062	0.175	-0.263	0.066	-0.402	-0.427
t^3 (46)(5.).	-0.051	0.123	-1.171	-0.544	-0.080	0.185	-0.122	0.486	0.174
t^3 (56)(1.).	-0.038	-1.685	-6.408	-2.868	-0.271	0.159	0.024	-0.127	-0.436
t^3 (56)(2.).	-0.046	-0.069	-1.186	-0.258	0.286	0.030	0.036	-0.187	-1.073
t^3 (56)(3.).	-0.008	0.466	0.947	0.943	0.488	-0.063	0.208	-0.092	0.541
t^3 (56)(4.).	0.054	-1.177	-2.182	-0.959	-0.151	-0.012	-0.084	-0.124	-0.401

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 10. which revealed that no hybrids exhibited desirable values for all studied traits. However, 24,21, 21, 24, 15, 24, 24,18 and 18 out of 45 quadriallel crosses showed desirable specific combining ability effects $t^4_{(ij)(kl)}$ values for boll weight (BW), bolls/plant(B/P), seed cotton yield/plant(SCY/P), lint yield/plant(LY/P), lint percentage (LP), fiber fineness (FF), fiber strength (FS), upper half mean (UHM) and uniformity ratio(UR), 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 (g_i) would also contribute to high specific combining ability effects $t^4_{(ij)(kl)}$.However, some crosses *viz.*, [(P_1 x P_2) x (P_3 x P_4)], [(P_1 x P_2) x (P_5 x P_6)], [(P_1 x P_3) x (P_2 x P_6)], [(P_1 x P_5) x (P_2 x P_3)] and

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 and fiber quality traits .

$t^4_{(i\,j)(k\,l)}$	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
$t^4_{(12)(34)}$	0.014	-1.441	-4.487	-1.859	-0.038	-0.181	-0.054	-0.425	-0.200
$t^4_{(12)(35)}$	0.022	0.825	3.233	1.123	-0.164	0.133	-0.057	0.860	0.974
$t^4_{(12)(36)}$	-0.036	0.616	1.254	0.735	0.202	0.048	0.111	-0.436	-0.774
$t^4_{(12)(45)}$	-0.036	0.616	1.254	0.735	0.202	0.048	0.111	-0.436	-0.774
$t^4_{(12)(46)}$	0.022	0.825	3.233	1.123	-0.164	0.133	-0.057	0.860	0.974
$t^4_{(12)(56)}$	0.014	-1.441	-4.487	-1.859	-0.038	-0.181	-0.054	-0.425	-0.200
$t^4_{(13)(24)}$	0.012	0.938	3.623	1.844	0.326	-0.022	0.097	-0.172	0.554
$t^4_{(13)(25)}$	0.003	-0.075	-0.061	-0.215	-0.171	0.100	-0.165	0.182	-1.986
$t^4_{(13)(26)}$	-0.015	-0.863	-3.561	-1.629	-0.155	-0.078	0.069	-0.010	1.431
$t^4_{(13)(45)}$	-0.015	-0.863	-3.561	-1.629	-0.155	-0.078	0.069	-0.010	1.431
$t^4_{(13)(46)}$	0.003	-0.075	-0.061	-0.215	-0.171	0.100	-0.165	0.182	-1.986
$t^4_{(13)(56)}$	0.012	0.938	3.623	1.844	0.326	-0.022	0.097	-0.172	0.554
$t^4_{(14)(23)}$	-0.026	0.503	0.865	0.015	-0.288	0.203	-0.043	0.596	-0.354
$t^4_{(14)(25)}$	0.009	0.215	0.795	0.176	-0.134	-0.094	0.014	-0.029	1.071
$t^4_{(14)(26)}$	0.017	-0.718	-1.660	-0.191	0.421	-0.109	0.029	-0.567	-0.717
$t^4_{(14)(35)}$	0.017	-0.718	-1.660	-0.191	0.421	-0.109	0.029	-0.567	-0.717
$t^4_{(14)(36)}$	0.009	0.215	0.795	0.176	-0.134	-0.094	0.014	-0.029	1.071
$t^4_{(14)(56)}$	-0.026	0.503	0.865	0.015	-0.288	0.203	-0.043	0.596	-0.354
$t^4_{(15)(23)}$	-0.025	-0.749	-3.172	-0.909	0.335	-0.233	0.222	-1.043	1.012
$t^4_{(15)(24)}$	0.027	-0.831	-2.049	-0.911	-0.068	0.046	-0.125	0.465	-0.298
$t^4_{(15)(26)}$	-0.002	1.581	5.221	1.820	-0.267	0.187	-0.098	0.578	-0.714
$t^4_{(15)(34)}$	-0.002	1.581	5.221	1.820	-0.267	0.187	-0.098	0.578	-0.714
$t^4_{(15)(36)}$	0.027	-0.831	-2.049	-0.911	-0.068	0.046	-0.125	0.465	-0.298
$t^4_{(15)(46)}$	-0.025	-0.749	-3.172	-0.909	0.335	-0.233	0.222	-1.043	1.012
$t^4_{(16)(23)}$	0.051	0.247	2.307	0.894	-0.047	0.029	-0.179	0.446	-0.658
$t^4_{(16)(24)}$	-0.038	-0.107	-1.574	-0.932	-0.257	-0.023	0.028	-0.293	-0.256
$t^4_{(16)(25)}$	-0.012	-0.140	-0.734	0.039	0.305	-0.006	0.151	-0.153	0.914
$t^4_{(16)(34)}$	-0.012	-0.140	-0.734	0.039	0.305	-0.006	0.151	-0.153	0.914
$t^4_{(16)(35)}$	-0.038	-0.107	-1.574	-0.932	-0.257	-0.023	0.028	-0.293	-0.256
$t^4_{(16)(45)}$	0.051	0.247	2.307	0.894	-0.047	0.029	-0.179	0.446	-0.658
$t^4_{(23)(45)}$	0.051	0.247	2.307	0.894	-0.047	0.029	-0.179	0.446	-0.658
$t^4_{(23)(46)}$	-0.025	-0.749	-3.172	-0.909	0.335	-0.233	0.222	-1.043	1.012
$t^4_{(23)(56)}$	-0.026	0.503	0.865	0.015	-0.288	0.203	-0.043	0.596	-0.354
$t^4_{(24)(35)}$	-0.038	-0.107	-1.574	-0.932	-0.257	-0.023	0.028	-0.293	-0.256
$t^4_{(24)(36)}$	0.027	-0.831	-2.049	-0.911	-0.068	0.046	-0.125	0.465	-0.298
$t^4_{(24)(56)}$	0.012	0.938	3.623	1.844	0.326	-0.022	0.097	-0.172	0.554
$t^4_{(25)(34)}$	-0.012	-0.140	-0.734	0.039	0.305	-0.006	0.151	-0.153	0.914
$t^4_{(25)(36)}$	0.009	0.215	0.795	0.176	-0.134	-0.094	0.014	-0.029	1.071
$t^4_{(25)(46)}$	0.003	-0.075	-0.061	-0.215	-0.171	0.100	-0.165	0.182	-1.986
$t^4_{(26)(34)}$	-0.002	1.581	5.221	1.820	-0.267	0.187	-0.098	0.578	-0.714
$t^4_{(26)(35)}$	0.017	-0.718	-1.660	-0.191	0.421	-0.109	0.029	-0.567	-0.717
$t^4_{(26)(45)}$	-0.015	-0.863	-3.561	-1.629	-0.155	-0.078	0.069	-0.010	1.431
$t^4_{(34)(56)}$	0.014	-1.441	-4.487	-1.859	-0.038	-0.181	-0.054	-0.425	-0.200
$t^4_{(35)(46)}$	0.022	0.825	3.233	1.123	-0.164	0.133	-0.057	0.860	0.974
$t^4_{(36)(45)}$	-0.036	0.616	1.254	0.735	0.202	0.048	0.111	-0.436	-0.774

[(P_1 x P_5) x (P_2x P_4)] included two or three out of the four parents which had desirable g_i for yield and some of its components, but these combinations gave comparatively low specific combining ability effects $t^4_{(ij)(kl)}$ for the same traits. In contrast, the crosses [(P_1 x P_2) x (P_3 x P_5)], [(P_1 x P_3) x (P_2 x P_4)], [(P_1 x P_3) x (P_5 x P_6)], [(P_1 x P_5) x (P_3 x P_4)], [(P_2 x P_4) x (P_5 x P_6)] and [(P_2x P_6) x (P_3x P_4)] involved two or 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 the same traits. These finding are in general acceptance with those obtained by Abd El-Bary (2008), Said (2011) and El-Feki *et al.* (2012).

In conclusion, from the previous results it could be concluded that the combinations [(Giza 85 x Giza 86) x (Ashmouni x Giza 90)], [(Giza 85 x Giza 86) x (Giza 75 x Giza 80)] and [(Ashmouni x Giza 90) x (Giza 75 x Giza 80)] appeared to be the best promising double crosses for breeding toward most studied yield traits potentiality.In general, [(Giza 85 x Giza 75) x (Ashmouni x Giza 80)], [(Giza 85 x Giza 75) x (Giza 86 x Giza 90)] and [(Ashmouni x Giza 80) x (Giza 86 x Giza 90)] would be good combinations for all studied yield traits and most fiber properties. 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, semilar results were obtained by Yehia *et al.* (2009), Said (2011) and El-Feki *et al.* (2012).

Genetic parameters:

Estimation of genetic parameters and the results are presented in Table 11. Results revealed that the magnitudes of dominance genetic variance (σ2D) were positive and larger than those of additive genetic variance (σ2A), for all studied traits except for BW and FS property.

Concerning epistatic variances, additive by dominance genetic variance (σ^2AD) showed negative and considerable magnitude for all studied traits except for the same previous trait (BW). Moreover, additive by additive genetic variance (σ^2AA) showed negative and considerable magnitude for all studied traits except for LP, BW and FS traits. 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 except σ^2AAA for BW. It could be concluded that yield and its components as well as fiber quality properties 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), Hemaida *et al* (2006), Abd El-Bary (2008), El-Feki *et al* (2012) El-Fesheikawy *et al* (2012), El-Hashash (2013) and El-Fesheikawy *et al* (2015).As shown in Table 11, heritability in narrow-sense estimates (h^2_{ns}) was ranged from high(84.2%) for BW to moderate (36.4%) for LY/P. Same results were obtained by Said (2011), El-Feki *et al* (2012), El-Hashash (2013) and Al-Ashmoony *et al* (2016).

Table 11: Estimation of genetic variances for yield components and fiber quality traits.

Genetic Parameters	BW	B/P	SCY/P	LY/P	LP	FF	FS	UHM	UR
σ^2A	-0.26	47.02	209.26	23.67	-5.23	-0.02	-1.13	-6.52	-65.77
σ^2D	-0.01	163.31	2164.33	319.88	7.39	0.05	-0.07	43.32	162.84
σ^2AA	0.40	-136.00	-1585.89	-218.18	0.05	-0.83	1.55	-34.03	-65.76
σ^2AD	0.04	-326.77	-4362.65	-682.66	-31.11	-5.87	-3.58	-183.26	667.64
σ^2DD	0.16	316.45	3707.14	607.99	31.13	8.60	7.39	145.75	485.03
σ^2AAA	-0.03	217.84	2908.43	455.11	20.74	3.91	2.39	122.17	445.09
h^2_{ns}	84.15	45.14	37.31	36.42	40.45	42.47	59.73	43.37	43.93

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تحليل الهجن الزوجية لبعض الصفات الإقتصادية فى القطن المصرى

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الملخص العربى

يهدف البحث للتقدير القدرة على الإتلاف و التفاعل الجيني بغرض تحسين بعض الصفات المحصوليه و الغزليه في القطن المصري بإستخدام نظام الهجن الزوجيه. اشتملت الدراسة على ستة أصناف من القطن الباربادنس هى : جيزه ٨٥، الأشمونى ، جيزة ٧٥ ، جيزة ٨٠، جيزه ٨٦ و جيزه ٩٠. وطبقا لنظام التزاوج التبادلى النصف كامل أدخلت هذه الأباء فى سلسله من التهجينات لتنتج ١٥ هجين جيل اول خلال موسم النمو ٢٠١٥ وفى الموسم التالى (٢٠١٦) تم تزاوج هجن الجيل الاول لأنتاج ٤٥ هجين رباعى (زوجى) بشرط ظهور اى أب فى الهجين الرباعى مرة واحدة وفى موسم النمو ٢٠١٧ تم تقييم عدد ٥١ تركيب وراثي مختلف (الأباء الستة ،٤٥ هجين رباعى) بمحطة البحوث الزراعية بسدس وتم قياس الصفات الآتية : وزن اللوزة (جم) ، عدد اللوز المتفتح على النبات، محصول النبات من القطن الزهر(جم) ، محصول النبات من الشعر (جم) ، معدل الحليج %،،نعومة التيلة ،متانة التيلة، طول التيلةعند ٢.٥%، معامل الانتظام%.

هذا ويمكن تلخيص أهم النتائج المتحصل عليها من هذه الدراسة فى النقاط التالية:-

- اختبار المعنوية لمتوسط المربعات الخاصة بالهجن الزوجية أشار إلى أن هناك اختلافا 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 × المضيف ، التباين المضيف × السيادى، التباين السيادى × السيادى و التباين المضيف × المضيف × المضيف).
- من خلال تحليل الهجن الرباعية كان أفضل الاباء قدرة عامة على التآلف التراكيب الوراثية الابوية جيزه ٨٥ لمعظم صفات المحصول ،الأشمونى لنعومة التيلة ، جيزه ٧٥ لمعامل الإنتظام ، جيزه ٨٠ لطول التيلة ،جيزة ٨٦ لوزن اللوزة، اما الصنف جيزة ٩٠ فقد كان افضل الاباء قدرة عامة على التآلف لصفة متانة التيلة .
- بالنسبة لتقديرات القدرة الخاصة علي التآلف بأنواعها السبعة والتى تندرج تحت ثلاث مجاميع نوجزها فيما يلى:

المجموعة الاولي (قدرة خاصة بين صنفين):

١- في هذا النوع لا يهم ترتيب الاصناف سواءاً كانتا معا في نفس الهجين الفردى أو كل صنف في هجين فردى مستقل وكانت افضل الأتحادات عند تواجد جـ ٨٥ مع الاشمونى أو جـ ٧٥ أو جـ ٨٠ لمعظم صفات المحصول.

٢- في هذا النوع يشترط وجود الصنفين معا في نفس الهجين الفردى وكانت أفضل الاتحادات عند تواجد (جـ ٨٥ x اشمونى) أو (جـ ٨٥ x جـ ٧٥) او(جـ ٨٥ x جـ ٨٠) أو تواجد (جـ ٨٦ x جـ ٩٠) لمعظم صفات المحصول.

٣- في هذا النوع يشترط وجود إحدى السلالتين في هجين فردى والصنف الأخر في الهجين الفردي الثاني وكانت افضل الأتحادات عند تواجد جـ٨٥ في هجين فردى و جـ٩٠ في هجين فردى آخر لنفس الهجين الزوجى لصفات محصول الزهر والشعر ومتوسط وزن اللوزة، الاشمونى في هجين فردى و جـ٧٥ في هجين فردى آخر لنفس الهجين الزوجى لصفة متانة التيلة بجانب صفات المحصول كما كانت افضل الأتحادات عند تواجد ، جـ٧٥ في هجين فردى و جـ ٨٠ في هجين فردى آخر لنفس الهجين الزوجى لصفة طول التيلة بجانب صفات المحصول .

المجموعة الثانية (قدرة خاصة بين ثلاثة اصناف):

٤-في هذا النوع لا يهم ترتيب الاصناف (اي صنفين في هجين فردي والصنف الثالث في الهجين الفردى الآخر) وكانت أفضل الاتحادات عند تواجد جـ٨٥ مع الاشمونى مع جـ ٨٠ لمعظم صفات المحصول.

٥-في هذا النوع يشترط وجود الصنفين الأول والثاني في الهجين الفردى الأول والصنف الثالث في الهجين الفردي الثاني) وكانت افضل الاتحادات عند تواجد جـ٨٥ مع جـ٩٠ في الهجين الفردى الأول و جـ٧٥في الهجين الفردى الثانى لصفات المحصول وكذلك عند تواجد الاشمونى مع جـ٧٥ في الهجين الفردى الأول و جـ٩٠ في الهجين الفردى الثانى لصفات المحصول ومعظم صفات التيلة.

المجموعة الثالثة (قدرة خاصة بين أربع اصناف):

٦-في هذا النوع لا يهم ترتيب الاصناف (اي صنفين في هجين فردي والصنفين الأخريين في الهجين الفردى الأخر) وكانت أفضل الاتحادات عند تواجد جـ٨٥ و الاشمونى و جـ ٨٠ و جـ ٨٦ معا لمعظم صفات المحصول والتيلة.

٧-في هذا النوع يشترط وجود الصنفين الأول والثاني في الهجين الفردى الأول والصنفين الثالث والرابع في الهجين الفردي الثاني) وكانت أفضل الاتحادات عند تواجد جـ ٨٥ مع جـ٨٦ في الهجين الفردى الاول وكلا من (الاشمونى مع جـ ٩٠) أو (جـ ٨٠ مع جـ ٨٦) في الهجين الفردى الثانى أو تواجد (الاشمونى مع جـ ٩٠) في الهجين الفردى الأول و (جـ٧٥ مع جـ٨٠) في الهجين الفردى الثانى لصفات المحصول مع إمكانية تحسين طول التيلة فى نفس الوقت .

- أظهرت الهجن التالية أفضل إمكانية لإستخدامها في برامج التربية لتحسين صفات المحصول ومكوناته وفى مقدمتها محصول القطن الزهر ومحصول القطن الشعر ثم باقى المكونات الأخرى للمحصول وهذه الهجن هى : [(جيزه ٨٥ ×

جيزه ٨٦) (الاشمونى × جيزه ٩٠)] ، [(جيزه ٨٥ × جيزه ٨٦) (جيزه ٧٥ × جيزه ٨٠)] و[(الاشمونى × جيزه ٩٠)(جيزه ٧٥ × جيزه ٨٠)] . كما أظهرت الهجن : [(جيزه ٨٥ × جيزه ٧٥) (الاشمونى × جيزه ٨٠)] ، [(جيزه ٨٥ × جيزه ٧٥) (جيزة ٨٦ × جيزه ٩٠)] ،[(الاشمونى × جيزه ٨٠) (جيزة ٨٦ × جيزه ٩٠)] افضل امكانية لإستخدامها فى تحسين صفات المحصول و التيلة معا.

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