



Quadriallel Analysis of Some Yield Components and Fiber Quality Traits in Egyptian Cotton Varieties

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Abstract

Six Egyptian cotton varieties and their 45 double crosses were used to evaluating for combining ability and gene action .Results shown that the mean squares of genotypes were highly significant for most studied traits. Further partition of crosses mean squares to its component showed that the mean squares due to 1-line general, 2-line specific effect, 2-line arrangement, 3-line arrangement and 4-line arrangement were either significant or highly significant for most studied traits suggesting the presence of the additive and non-additive variance in the inheritance of these traits. Two-line interaction effect i.e. (S^2_{12}), (S^2_{25}) and (S^2_{34}) showed positive or negative(desirable) the best combination effect for most of yield compounds and fiber quality studied traits. Regarding, the three –line interaction effect, the combinations (S^3_{124}), (S^3_{125}) and (S^3_{134}) were the best combinations for most studied traits. Moreover, the four- line interaction effect point that, best combinations and exhibited desirable effects for most studied traits were (S^4_{1346}), (S^4_{3456}), (S^4_{1235}) and (S^4_{1234}). The specific $t^2_{(ij)(..)}$ combining ability effects showed that, the better combination $t^2_{(14)(..)}$, for (B/P), (BWg.), (UHM) and (UI), Also, $t^2_{(45)(..)}$ for (SCY/P.g.) and (LY/P.g.) traits. In the same time, the two $t^2_{(36)(..)}$ and $t^2_{(26)(..)}$ were the best for FF trait and the best combination $t^2_{(25)(..)}$ for (FS) trait. Through the specific $t^2_{(i,j)}$ combining ability effect noticed that, $t^2_{(4)(6)}$, $t^2_{(1)(5)}$, $t^2_{(1)(6)}$, $t^2_{(2)(4)}$, $t^2_{(1)(3)}$, $t^2_{(2)(5)}$, $t^2_{(3)(4)}$ as well as $t^2_{(3)(5)}$, were the best effect combinations for most yield and fiber quality traits.

Keywords: Egyptian cotton, Quadriallel analysis, Mean performance, Gene action, and Combining ability.

Introduction

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 ability 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 The genetic components which were valid in these analyses are additive, dominance and epistatic variances. The epistatic variance include additive x additive (σ^2_{AA}), additive x dominance (σ^2_{AD}), dominance x dominance (σ^2_{DD}) and additive x additive x additive (σ^2_{AAA}) 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). A double cross is the first generation progeny of the crossing between unrelated F_1 hybrids viz., (a x b) (c x d) where a, b, c and d are the four parents, and a x b and c x d are the two unrelated F_1 hybrids

involving these parents. Taking ‘P’ as the number of parents, all possible double crosses would be $\frac{1}{2}P(P-1)(P-3)$. The theoretical aspect of quadriallel analysis has been dealt with by Rawling and Cockerham (1962). Abd El-Bary (2008) and Abd El Samad et al. (2017) revealed that, the magnitude of additive genetic variance was 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^2_{AA} , σ^2_{AD} and σ^2_{DD}) were contributed in the genetic expression of most studied traits except for boll weight and lint percentage. El-Hoseiny (2009) reported that, Parent Australian (P_1) and BBB (P_2), and (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. El-Feki *et al.*, (2012) reported that, [$(P_1 \times P_5) \times (P_2 \times P_4)$], [$(P_1 \times P_5) \times (P_3 \times P_6)$] and [$(P_2 \times P_4) \times (P_3 \times P_6)$] would be good combinations for most studied yield and all fiber quality traits. Soliman (2014) found that, the crosses [$(P_1 \times P_5) \times (P_2 \times P_4)$], [$(P_1 \times P_5) \times (P_3 \times P_6)$] and [$(P_2 \times P_4) \times (P_3 \times P_6)$]

$P_4 \times (P_3 \times P_6)$] would be good combinations for most studied yield and fiber traits. Recently, El-Fesheikawy *et al.*, (2018) reported that, (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, it could be concluded that fiber properties and yield components were mainly controlled by epistatic variances; (σ^2DD) and (σ^2AAA). Also, heritability in narrow sense (h^2_{ns} %) ranged from 36.4% for LY/P to 84.2% for BW. So, the present investigation was carried out to estimate combining ability and gene action for some yield components and fiber properties using quadriallel system of six Egyptian cotton genotypes.

Materials and Methods

The genetic material and mating design:

Six Egyptian parents long staple cotton varieties belonging to *Gossypium barbadense*, L.; Giza 94 (P₁), Giza 95 (P₂), Giza 75 (P₃), Giza 83 (P₄), Giza 80 (P₅) as well as, Giza 85(P₆) were used to produce 45 possible double crosses (quadriallel crosses). Pure seeds of these varieties were kindly by Cotton Research Institute, Agriculture Research Center at Giza, Egypt.

In 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 varieties.

Experimental design:

In 2020 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 included three ridges; each was four m long and 65 cm apart. Hills were thinned

to keep a constant stand of two plant per hill . The measurements, were recorded on 5 individual guarded plants from the middle in each plot for yield and yield component traits and fiber properties were taken from the whole plot. Ordinary cultural practices were followed as the recommendations.

Data were recorded on the following traits: boll weight in grams g (BW), seed cotton yield per plant in grams g (SCY/P), lint yield per plant in grams g (LY/P), lint percentage (L%) and fiber fineness (FF), fiber strength (FS), and upper half mean mm (UHM) as a measure of Span length in mm. The fiber properties were measured in the laboratories of Cotton Fiber Research Section, Cotton Research Institute according to A.S.T.M.D - 4605-98 and D-3818-98(1998).

Biometrical analysis:

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

The significance of means were determined using the least significant difference value (L.S.D) at 0.05 and 0.01 levels, according to Steel and Torrie (1980).

Analysis of double cross data is carried out according to the procedure outlined by Singh and Chaudhary (1985).

The theoretical aspect of quadriallel analysis has been illustrated by Rawling and Cockerham (1962) and outlined by Singh and Chaudhary (1985).

Estimates of heritability were determined according to Singh and Narayanan, 2000 In double crosses.

Results and Discussion

Analysis of variance of 45 double crosses were made for all the studied traits *viz.*, BW, SCY/P, LY/P, L%, FF, FS and UHM. Also, the mean squares are calculated (results are presented in Table1. Results indicated that the mean squares of crosses were highly significant for all the studied traits with except fiber FF and FS.

Table 1. The analysis of variance of the double crosses for yield and yield component and fiber quality traits.

SOV	df	BW(g)	SCY/P(g)	LY/P(g)	L %	FF	FS	UHM
Replications	2	0.029*	0.635	1.073	0.979*	0.213	0.182	1.203
Hybrid	44	0.038**	968.803**	152.826**	2.303**	0.100	0.386	1.656**
1-line general	5	0.084**	1372.085**	232.293**	8.259**	0.143	0.398	5.301**
2- line specific	9	0.021*	1256.003**	201.952**	2.596**	0.100	0.211	1.267
2-line arrangement	9	0.039**	771.679**	115.912**	1.270**	0.060	0.229	2.776**
3-line arrangement	16	0.021**	878.386**	136.832**	0.959**	0.102	0.465	0.396
4-line arrangement	5	0.074**	692.718**	102.556**	1.979**	0.120	0.721	0.726
Error	88	0.008	22.053	3.227	0.223	0.069	0.354	0.880

Furthermore, the partition of crosses mean squares to its components Table 1 showed that, the mean square due to 1-line general were highly significant for all studied traits except for FF and FS, 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.

Estimates due to 2-line specific and arrangement were significant and highly significant for all studied traits with except for all fiber quality traits for 2-line specific and FF, FS for 2-line arrangement 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 except for all fiber quality 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 highly significant for all yield components traits except for all fiber quality 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. These Results were agree with those reported by Abd El-Bary (2008), Yehia, *et al.*, (2009), Said (2011), El-Feki, *et*

al., (2012). Soliman (2014) and El-Fesheikawy, *et al.*, (2018).

Genetical parameters:

Genetic parameters estimates were taken and the results are shown in Table 2. 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. Respecting epistatic variances, additive by additive genetic variance (σ^2AA) showed negative and considerable magnitude for all studied traits except for UHM, trait. Moreover, additive by dominance genetic variance (σ^2AD) showed negative and considerable magnitude for all studied traits except for the same previous trait UHM. While, dominance by dominance genetic variance (σ^2DD) and additive by additive by additive genetic variance (σ^2AAA) showed positive and considerable magnitude for all studied traits except for UHM trait. It could be concluded that yield components as well as fiber quality traits were mainly controlled by σ^2DD and σ^2AAA epistatic variances. Through results in the Table 2, heritability in narrow-sense estimates (h^2_{ns}) was high for all studied traits except for UHM trait was moderate (37.166). Same results were obtained by Said (2011), El-Feki, *et al.*, (2012), El-Hashash (2013), Soliman (2014) and El-Fesheikawy, *et al.*, (2018).

Table 2. Estimation of genetic variances in addition to, heritability in broad and narrow sense for yield and yield components and fiber quality traits.

Genetic Parameter	BW(g)	SCY/P(g)	LCY/P(g)	L %	FF	FS	UHM
σ^2A	0.006	-1419.691	-229.663	-1.937	-0.107	-0.121	-1.099
σ^2D	0.789	4342.837	606.021	18.985	0.371	3.520	1.121
σ^2AA	-0.875	-1692.678	-158.348	-14.161	-0.121	-3.574	4.444
σ^2AD	-3.497	-25817.602	-3727.598	-87.843	-1.938	-16.758	8.092
σ^2DD	2.737	28458.224	4215.075	73.341	1.677	13.127	-12.793
σ^2AAA	6.994	51635.203	7455.197	175.685	3.876	33.516	-16.185
σ^2e	0.008	22.053	3.227	0.223	0.069	0.354	0.880
(h^2_{ns} %)	70.116	69.153	69.081	69.851	66.544	68.390	37.166

Mean performances:

The mean performance for 45 double crosses for yield and its components and fiber quality traits were determined and the results are presented in Table 3. The results showed that the crosses [(P₁ × P₂) × (P₄ × P₅)], [(P₁ × P₄) × (P₂ × P₅)], [(P₁ × P₅) × (P₂ ×

P₃)], [(P₁ × P₅) × (P₂ × P₄)] and [(P₁ × P₆) × (P₂ × P₅)] cleared the highest desirable mean performances for yield, its components and fiber quality traits, respectively. Results are in harmony with by Hassan (2009), Yehia, *et al.*, (2009) and Said (2011).

Table 3. Mean performances for yield and its component and fiber quality traits.

Crosses	BW(g)	SCY/P(g)	LCY/P(g)	L %	FF	FS	UHM
12×34	3.4	99.3	37.6	37.8	4.0	11.1	32.4
12×35	3.5	93.0	34.8	37.5	4.4	10.0	33.3
12×36	3.4	95.4	36.2	37.9	4.1	10.5	33.2
12×45	3.3	110.8	45.0	40.6	4.1	10.1	33.3
12×46	3.4	83.1	31.0	37.5	4.2	10.3	32.9

12×56	3.3	94.2	35.8	38.0	3.5	10.8	32.5
13×24	3.4	105.7	40.1	38.0	3.8	10.1	32.1
13×25	3.3	89.6	34.4	38.4	4.2	10.7	33.4
13×26	3.2	110.6	42.2	38.2	4.2	10.4	32.1
13×45	3.2	97.0	36.3	37.4	4.1	10.5	32.8
13×46	3.2	96.9	36.7	37.9	4.0	10.5	32.1
13×56	3.3	71.9	26.9	37.5	3.7	10.5	32.4
14×23	3.5	133.5	50.6	37.9	4.4	10.0	32.8
14×25	3.4	141.3	56.8	40.2	4.1	10.6	33.1
14×26	3.4	77.5	30.0	38.7	3.9	11.1	33.5
14×35	3.3	81.8	31.0	37.8	4.0	11.1	34.0
14×36	3.6	97.7	35.1	37.5	3.9	10.5	33.7
14×56	3.3	52.5	19.9	38.1	4.2	10.6	34.1
15×23	3.3	117.0	47.3	40.4	4.1	10.3	33.0
15×24	3.3	69.9	28.1	40.1	3.8	10.8	32.2
15×26	3.5	77.0	29.7	38.5	4.1	10.8	33.1
15×34	3.3	94.2	35.0	37.1	4.1	10.1	31.8
15×36	3.3	83.7	31.6	37.8	4.2	9.9	33.0
15×46	3.2	72.5	27.1	37.5	4.1	10.5	32.6
16×23	3.4	92.6	34.8	37.5	4.1	10.2	31.8
16×24	3.4	74.5	28.7	38.5	4.1	10.6	31.8
16×25	3.2	71.3	28.8	40.4	4.1	10.4	32.9
16×34	3.4	77.4	29.5	38.2	3.9	11.1	33.0
16×35	3.2	79.6	30.5	38.4	4.1	10.7	32.7
16×45	3.1	88.7	33.4	37.7	4.1	10.6	32.1
23×45	3.3	82.3	31.8	38.7	4.3	10.6	31.4
23×46	3.2	65.0	24.6	37.8	4.0	10.4	31.5
23×56	3.2	77.4	30.0	38.8	4.3	10.5	31.9
24×35	3.5	93.4	35.5	38.0	4.3	9.5	31.0
24×36	3.2	81.6	30.2	37.0	4.1	10.6	31.8
24×56	3.1	81.5	31.3	38.3	4.0	10.4	31.2
25×34	3.2	73.2	27.7	37.8	4.2	10.0	31.6
25×36	3.4	75.3	28.1	37.4	4.2	10.7	32.4
25×46	3.2	82.6	31.4	38.0	4.0	11.4	31.2
26×34	3.4	103.6	39.4	38.0	4.3	10.6	32.4
26×35	3.2	91.4	34.9	38.2	4.4	10.7	32.9
26×45	3.2	111.9	42.3	37.8	4.0	10.5	31.9
34×56	3.3	103.4	39.1	37.8	4.2	10.8	32.2
35×46	3.4	76.5	28.4	37.1	3.8	10.4	32.3
36×45	3.2	124.2	46.9	37.8	4.1	10.9	32.9
Mean	3.3	90.1	34.4	38.2	4.1	10.5	32.5
LSD 5%	0.15	7.63	2.92	0.77	N.S	N.S	1.52
1%	0.20	10.12	3.87	1.02	N.S	N.S	2.02

General combining ability effects for each parental variety:

Estimates of general combining ability effects (g_i) of parental varieties were obtained for studied traits and the results are shown in Table 4, the parent Giza 94 (P_1) was the best general combiner for BW, FF which had a negative (desirable) value and UHM traits. Also, the Giza 95 variety (P_2) had positive desirable general combining

ability effects for LY/P and L% and it was the best combiner for these traits. Also, Giza 75 variety (P_3) was the best combiner for SCY/P and had positive desirable values of general combining ability for (FS), Giza 85 variety (P_6) was the best combiner. Results are in harmony with those found by Abd El-Bary (2008), Yehia, *et al.*, (2009), Said (2011), El-Feki, *et al.*, (2012). Soliman (2014) and El-Fesheikawy, *et al.*, (2018).

Table 4. General parent effect (g_i) of the double crosses for yield and yield component traits and fiber quality traits.

Parents	BW(g)	SCY/P(g)	LCY/P(g)	L %	FF	FS	UHM
P1 (G.94)	0.0204	0.9258	0.4639	0.1306	-0.0281	-0.0189	0.2937
p2	0.0128	1.7758	0.9365	0.2288	0.0207	-0.0200	-0.1396

(G.95)							
p3 (G.75)	0.0138	2.0639	0.5387	-0.2463	0.0341	-0.0500	-0.0363
p4 (G.83)	-0.0007	1.0394	0.3147	-0.0779	-0.0137	0.0189	-0.0974
p5 (G.80)	-0.0270	-1.4376	-0.3716	0.1353	0.0096	-0.0022	0.0126
p6 (G.85)	-0.0193	-4.3673	-1.8822	-0.1705	-0.0226	0.0722	-0.0330

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}). Results are presented in Table 5-I. Results illuminated that No combinations exhibited desirable values for all studied traits. For BW, SCY/P and UHM traits; six combinations had positive two-line specific effects (S^2_{ij}). Seven combinations had S^2_{ij} for LY/P and FS traits. Also, five combinations had positive S^2_{ij} for L% trait. Desirable negative S^2_{ij} for FF trait were recorded of seven combinations. Finally, the combinations parents (S^2_{12}), was the best combinations for BW, SCY/P and LY/P and (S^2_{25}) for L% traits which have good specific combiners for yield and yield component traits. In the same time, these results indicating that, the parent (S^2_{34}) was the best combinations for FF trait, (S^2_{26}) for FS trait and (S^2_{14}) for UHM trait which possessed good specific combiners for fiber quality traits. Thus, the parent arrangement was more important for consist the double cross, as grand-parent in double crosses. These finding indicated the predominance of non-additive effects in the inheritance of yield and yield components.

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

particular arrangement:

Specific combining ability effects $t^2_{(ij)(..)}$. With respect to the studied yield components and fiber quality traits are presented in Table 5-II. The results highlighted that no hybrids exhibited desirable values for all studied traits. The better combination $t^2_{(14)(..)}$, for BW and UHM. Also, The best combination $t^2_{(45)(..)}$ for SCY/P and LY/P traits. For L% was the best combination $t^2_{(23)(..)}$. In the same time, the best combinations $t^2_{(36)(..)}$ and $t^2_{(26)(..)}$ were the best combinations for FF trait and the best combination $t^2_{(25)(..)}$ for FS trait.

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

The specific combining ability effects $t^2_{(i)(j)}$. Results are presented in Table 5-III. The results showed that no combinations exhibited desirable values for all studied traits. It could be noticed that $t^2_{(4)(6)}$, $t^2_{(1)(3)}$, $t^2_{(1)(5)}$, $t^2_{(1)(6)}$, $t^2_{(2)(4)}$ and $t^2_{(2)(5)}$, were recorded that the best combinations for most yield, its components and fiber quality traits. Our results are in harmony with those obtained by Abd El-Bary (2008), Yehia *et al.*,(2009), Said (2011), El-Feki *et al.*, (2012), Soliman (2014) and El-Fesheikawy *et al.*, (2018).

Table (5-I): 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(g)	SCY/P(g)	LCY/P(g)	L %	FF	FS	UHM
S^2_{12}	0.017	3.679	1.559	0.048	-0.012	0.001	0.096
S^2_{13}	-0.001	2.310	0.770	-0.011	-0.009	-0.008	-0.003
S^2_{14}	0.003	-0.140	-0.037	0.024	0.004	0.030	0.113
S^2_{15}	-0.005	-1.449	-0.434	0.057	-0.007	-0.015	0.101
S^2_{16}	0.007	-3.474	-1.394	0.036	-0.004	-0.027	-0.014
S^2_{23}	0.002	-0.579	-0.274	-0.013	0.044	-0.040	-0.046
S^2_{24}	0.002	-0.071	0.055	-0.015	-0.008	-0.031	-0.127
S^2_{25}	0.003	0.321	0.275	0.057	-0.004	0.014	-0.011
S^2_{26}	-0.012	-1.575	-0.679	-0.041	0.001	0.037	-0.051
S^2_{34}	0.011	0.528	0.079	-0.026	-0.018	0.004	-0.036
S^2_{35}	0.003	-1.540	-0.630	-0.033	0.026	-0.012	0.028
S^2_{36}	-0.001	1.345	0.594	-0.002	-0.009	0.006	0.021
S^2_{45}	-0.016	1.308	0.520	-0.031	0.007	-0.014	-0.081
S^2_{46}	-0.001	-0.585	-0.301	-0.013	0.002	0.030	0.034
S^2_{56}	-0.013	-0.078	-0.102	-0.036	-0.012	0.025	-0.024

(5-II): The 2-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(g)	SCY/P(g)	LCY/P(g)	L %	FF	FS	UHM
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t2 (12)(..).	0.00	-0.48	-0.59	-0.47	-0.03	-0.02	0.17
t2 (13)(..).	-0.07	-0.13	-0.03	-0.04	-0.08	0.00	-0.25
t2 (14)(..).	0.07	5.48	2.11	0.12	0.06	0.09	0.75
t2 (15)(..).	0.04	-2.39	-0.89	0.05	0.02	-0.10	-0.29
t2 (16)(..).	-0.03	-2.48	-0.60	0.34	0.03	0.04	-0.38
t2 (23)(..).	0.00	1.32	0.95	0.43	0.02	-0.06	-0.21
t2 (24)(..).	0.01	-8.41	-3.35	-0.04	-0.08	-0.17	-0.42
t2 (25)(..).	-0.03	-1.84	-0.67	-0.03	0.01	0.17	0.09
t2 (26)(..).	0.03	9.41	3.66	0.11	0.07	0.07	0.37
t2 (34)(..).	-0.02	-1.83	-0.61	0.02	0.04	0.17	-0.11
t2 (35)(..).	0.06	-3.21	-1.39	-0.16	0.02	-0.06	0.20
t2 (36)(..).	0.03	3.85	1.07	-0.26	0.00	-0.05	0.38
t2 (45)(..).	-0.05	11.49	4.46	0.11	0.02	-0.02	0.07
t2 (46)(..).	-0.01	-6.73	-2.62	-0.21	-0.03	-0.07	-0.29
t2 (56)(..).	-0.02	-4.05	-1.51	0.03	-0.07	0.01	-0.07

(5-III): The 2-line interaction effect of lines i and j due to particular arrangement $t^2(i)(j)$. for yield component and fiber quality traits.

$t^2(i)(j)$	BW(g)	SCY/P(g)	LCY/P(g)	L %	FF	FS	UHM
$t^2(1)(2)$	0.00	0.24	0.29	0.24	0.01	0.01	-0.09
$t^2(1)(3)$	0.03	0.06	0.01	0.02	0.04	0.00	0.13
$t^2(1)(4)$	-0.03	-2.74	-1.06	-0.06	-0.03	-0.04	-0.38
$t^2(1)(5)$	-0.02	1.20	0.45	-0.03	-0.01	0.05	0.15
$t^2(1)(6)$	0.02	1.24	0.30	-0.17	-0.02	-0.02	0.19
$t^2(2)(3)$	0.00	-0.66	-0.47	-0.22	-0.01	0.03	0.11
$t^2(2)(4)$	-0.01	4.20	1.67	0.02	0.04	0.08	0.21
$t^2(2)(5)$	0.02	0.92	0.33	0.01	-0.01	-0.09	-0.04
$t^2(2)(6)$	-0.01	-4.70	-1.83	-0.05	-0.04	-0.04	-0.18
$t^2(3)(4)$	0.01	0.92	0.30	-0.01	-0.02	-0.09	0.06
$t^2(3)(5)$	-0.03	1.60	0.69	0.08	-0.01	0.03	-0.10
$t^2(3)(6)$	-0.02	-1.93	-0.54	0.13	0.00	0.03	-0.19
$t^2(4)(5)$	0.03	-5.75	-2.23	-0.05	-0.01	0.01	-0.04
$t^2(4)(6)$	0.01	3.36	1.31	0.11	0.02	0.03	0.15
$t^2(5)(6)$	0.01	2.03	0.76	-0.01	0.04	0.00	0.04

Three-line specific effects:

Three-line interaction effect of lines (i, j and k) appearing together irrespective of arrangement (S^3_{ijk}). Results are presented in Table 6. The results illustrated that were combinations possessed desirable values for all studied traits. In the same time, the combinations (S^3_{124}), (S^3_{125}), (S^3_{134}), (S^3_{346})

and (S^3_{356}) showed the best positive and negative (desirable) effects for all and most yield components and fiber quality traits. Results were acceptance with those reported by Abd El-Bary (2008), Yehia *et al.*,(2009), Said (2011), El-Feki *et al.*, (2012), Soliman (2014) and El-Fesheikaw *et al.*,(2018).

Table 6. 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(g)	SCY/P(g)	LCY/P(g)	L %	FF	FS	UHM
S^3_{123}	0.00	3.82	1.41	-0.07	0.01	-0.02	0.01
S^3_{124}	0.01	2.22	1.00	0.13	-0.01	0.01	0.06
S^3_{125}	0.01	2.13	1.06	0.25	-0.02	0.01	0.13
S^3_{126}	0.01	-0.81	-0.35	-0.03	-0.01	0.00	-0.01
S^3_{134}	0.00	1.35	0.37	-0.09	-0.02	0.04	0.02
S^3_{135}	-0.01	-1.20	-0.50	-0.09	0.00	-0.01	0.04
S^3_{136}	0.00	0.64	0.26	0.04	-0.02	-0.03	-0.07
S^3_{145}	-0.02	-0.46	-0.09	0.05	0.01	0.00	0.06
S^3_{146}	0.01	-3.40	-1.36	-0.02	0.02	0.01	0.08
S^3_{156}	0.00	-3.37	-1.33	-0.04	-0.01	-0.03	-0.03
S^3_{234}	0.01	-1.75	-0.74	-0.07	0.00	-0.05	-0.12
S^3_{235}	0.01	-2.60	-1.00	0.01	0.04	-0.01	0.02
S^3_{236}	-0.01	-0.63	-0.22	-0.02	0.03	0.00	-0.01
S^3_{245}	-0.01	1.10	0.56	0.14	-0.01	-0.03	-0.15
S^3_{246}	-0.01	-1.71	-0.71	-0.09	0.00	0.01	-0.05

S ³ ₂₅₆	-0.01	0.01	-0.07	-0.02	-0.02	0.06	-0.03
S ³ ₃₄₅	0.00	-0.26	-0.19	-0.10	0.00	-0.01	-0.05
S ³ ₃₄₆	0.01	1.71	0.71	0.09	-0.02	0.03	0.08
S ³ ₃₅₆	0.00	0.97	0.43	0.04	0.00	0.01	0.04
S ³ ₄₅₆	-0.01	2.23	0.76	-0.11	0.01	0.01	-0.03

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

Specific combining ability effects $t^3_{(ij)(k)}$. Results are presented in Table 7. Results indicated that, no combinations exhibited desirable values for all studied traits. It could be noticed that $t^3_{(12)(6)}$, $t^3_{(13)(4)}$, $t^3_{(14)(5)}$ and $t^3_{(16)(4)}$ were the best

combinations for most studied traits. In the same time, there are some combinations observed that were the best for all fiber quality traits, $t^3_{(13)(2)}$, $t^3_{(15)(2)}$, $t^3_{(16)(3)}$ and $t^3_{(24)(1)}$. Same trend were observed by Abd El-Bary (2008), Yehia *et al.*, (2009), Said (2011), El-Feki *et al.*, (2012), Soliman (2014) and El-Fesheikawy *et al.*, (2018).

Table 7. Three - Line interaction effect of lines i, j and k due to particular arrangement $t^3_{(ij)(k)}$ for yield and its component and fiber quality traits.

$t^3_{(ij)(k)}$	BW(g)	SCY/P(g)	LCY/P(g)	L %	FF	FS	UHM
$t^3_{(12)(3)}$	0.003	-7.089	-2.528	0.214	0.017	0.159	-0.138
$t^3_{(12)(4)}$	0.001	-2.742	-0.820	0.316	0.065	-0.038	0.165
$t^3_{(12)(5)}$	0.005	1.700	0.500	-0.183	-0.009	-0.135	-0.229
$t^3_{(12)(6)}$	-0.005	8.615	3.437	0.124	-0.043	0.032	0.030
$t^3_{(13)(2)}$	-0.014	-1.597	-0.670	0.058	-0.019	0.001	0.101
$t^3_{(13)(4)}$	0.004	3.612	1.623	0.151	0.067	-0.052	0.192
$t^3_{(13)(5)}$	0.083	-6.282	-2.765	-0.260	-0.019	0.054	0.150
$t^3_{(13)(6)}$	-0.005	4.394	1.841	0.092	0.051	-0.001	-0.189
$t^3_{(14)(2)}$	-0.023	8.003	3.056	-0.257	0.004	-0.138	-0.416
$t^3_{(14)(3)}$	-0.001	-0.282	-0.401	-0.111	0.008	-0.038	-0.172
$t^3_{(14)(5)}$	-0.022	1.084	0.818	0.156	0.013	0.079	0.006
$t^3_{(14)(6)}$	-0.021	-14.282	-5.585	0.091	-0.081	0.012	-0.169
$t^3_{(15)(2)}$	0.005	-6.825	-2.572	0.041	-0.051	0.304	0.232
$t^3_{(15)(3)}$	-0.055	9.281	3.940	0.238	-0.002	-0.249	-0.072
$t^3_{(15)(4)}$	-0.003	-0.100	-0.480	-0.195	-0.056	0.073	-0.008
$t^3_{(15)(6)}$	0.014	0.036	0.007	-0.139	0.089	-0.024	0.139
$t^3_{(16)(2)}$	0.030	0.177	-0.108	-0.077	0.052	-0.176	0.169
$t^3_{(16)(3)}$	0.019	-1.973	-1.025	-0.361	-0.063	0.127	0.256
$t^3_{(16)(4)}$	0.031	1.969	0.733	-0.212	-0.047	0.059	0.028
$t^3_{(16)(5)}$	-0.046	2.303	0.999	0.315	0.025	-0.049	-0.072
$t^3_{(23)(1)}$	0.011	8.686	3.199	-0.272	0.003	-0.160	0.037
$t^3_{(23)(4)}$	0.007	-5.888	-2.511	-0.197	0.035	-0.001	-0.047
$t^3_{(23)(5)}$	-0.030	0.327	0.543	0.390	-0.037	0.244	0.142
$t^3_{(23)(6)}$	0.017	-4.444	-2.176	-0.355	-0.025	-0.026	0.080
$t^3_{(24)(1)}$	0.021	-5.261	-2.236	-0.059	-0.069	0.176	0.251
$t^3_{(24)(3)}$	0.001	8.613	3.508	0.043	0.005	-0.056	0.019
$t^3_{(24)(5)}$	-0.002	0.717	0.220	0.070	0.043	0.016	0.095
$t^3_{(24)(6)}$	-0.034	4.338	1.857	-0.012	0.103	0.033	0.053
$t^3_{(25)(1)}$	-0.010	5.125	2.072	0.142	0.060	-0.169	-0.004
$t^3_{(25)(3)}$	0.030	-7.813	-3.315	-0.298	-0.054	-0.058	0.058
$t^3_{(25)(4)}$	-0.023	8.329	3.199	-0.113	-0.021	0.057	-0.166
$t^3_{(25)(6)}$	0.036	-3.804	-1.289	0.296	0.002	-0.005	0.022
$t^3_{(26)(1)}$	-0.025	-8.792	-3.329	-0.046	-0.009	0.144	-0.198
$t^3_{(26)(3)}$	-0.036	6.949	2.808	0.258	0.044	-0.073	-0.045
$t^3_{(26)(4)}$	0.022	-3.903	-1.542	-0.027	-0.119	-0.103	-0.161
$t^3_{(26)(5)}$	0.011	-3.664	-1.596	-0.291	0.010	-0.038	0.036
$t^3_{(34)(1)}$	-0.003	-3.330	-1.222	-0.039	-0.075	0.090	-0.019
$t^3_{(34)(2)}$	-0.008	-2.725	-0.997	0.154	-0.040	0.057	0.028
$t^3_{(34)(5)}$	-0.026	4.481	1.442	-0.186	0.046	-0.262	-0.128
$t^3_{(34)(6)}$	0.056	3.407	1.384	0.046	0.031	-0.056	0.232

t ³ (35)(1.).	-0.028	-2.999	-1.175	0.022	0.020	0.195	-0.078
t ³ (35)(2.).	0.000	7.486	2.773	-0.093	0.091	-0.186	-0.200
t ³ (35)(4.).	0.020	0.154	0.299	0.144	-0.073	-0.006	0.011
t ³ (35)(6.).	-0.052	-1.432	-0.511	0.088	-0.058	0.056	0.065
t ³ (36)(1.).	-0.014	-2.421	-0.816	0.269	0.012	-0.126	-0.067
t ³ (36)(2.).	0.019	-2.505	-0.632	0.097	-0.019	0.099	-0.034
t ³ (36)(4.).	-0.040	1.205	0.286	-0.085	-0.010	0.144	-0.212
t ³ (36)(5.).	0.003	-0.131	0.088	-0.024	0.019	-0.066	-0.063
t ³ (45)(1.).	0.025	-0.984	-0.338	0.039	0.044	-0.152	0.003
t ³ (45)(2.).	0.026	-9.047	-3.418	0.043	-0.021	-0.073	0.070
t ³ (45)(3.).	0.006	-4.635	-1.740	0.042	0.027	0.269	0.117
t ³ (45)(6.).	-0.007	3.173	1.035	-0.231	-0.069	-0.023	-0.262
t ³ (46)(1.).	-0.010	12.314	4.852	0.121	0.128	-0.071	0.142
t ³ (46)(2.).	0.012	-0.435	-0.314	0.039	0.017	0.069	0.108
t ³ (46)(3.).	-0.016	-4.613	-1.670	0.039	-0.021	-0.089	-0.020
t ³ (46)(5.).	0.026	-0.536	-0.249	0.014	-0.092	0.157	0.063
t ³ (56)(1.).	0.032	-2.339	-1.007	-0.176	-0.114	0.073	-0.067
t ³ (56)(2.).	-0.047	7.467	2.884	-0.006	-0.012	0.043	-0.058
t ³ (56)(3.).	0.049	1.562	0.423	-0.063	0.039	0.009	-0.002
t ³ (56)(4.).	-0.019	-2.636	-0.786	0.217	0.161	-0.134	0.199

Four-line specific effects:

Four- line interaction effect of lines i, j, k and l appearing together irrespective of arrangement (S⁴_{ijkl}). Results are presented in Table 8. Results highlighted that be found hybrids exhibited desirable values for all studied traits. The best double

combinations and exhibited desirable effects for all and most study traits were (S⁴₁₃₄₆), (S⁴₃₄₅₆), (S⁴₁₂₃₅), (S⁴₁₂₃₄), (S⁴₁₂₄₅) and (S⁴₁₂₅₆). Results are in harmony with those found by Abd El-Bary (2008), Yehia *et al.*, (2009), Said (2011), El-Feki *et al.*,(2012), Soliman(2014)and El-Fesheikawy *et al.*,(2018).

Table 8. The 4-line interaction effect of lines i, j, k and l appearing together irrespective of arrangement S⁴_{ijkl} for yield components and fiber quality traits.

S ⁴ _{ijkl}	BW(g)	SCY/P(g)	LCY/P(g)	L %	FF	FS	UHM
S ₁₂₃₄	0.01	5.57	1.95	-0.17	-0.02	0.01	-0.05
S ₁₂₃₅	0.02	1.57	0.66	0.04	0.04	0.00	0.23
S ₁₂₃₆	-0.02	4.32	1.62	-0.09	0.02	-0.06	-0.16
S ₁₂₄₅	0.00	6.34	3.13	0.65	-0.04	0.00	0.13
S ₁₂₄₆	0.02	-5.25	-2.06	-0.08	0.03	0.02	0.11
S ₁₂₅₆	0.02	-1.52	-0.62	0.08	-0.07	0.04	0.02
S ₁₃₄₅	-0.03	-2.13	-1.09	-0.30	0.00	0.06	0.02
S ₁₃₄₆	0.02	0.63	0.26	0.22	-0.04	0.06	0.09
S ₁₃₅₆	-0.01	-3.03	-1.09	0.00	-0.03	-0.09	-0.15
S ₁₄₅₆	-0.02	-5.58	-2.30	-0.21	0.08	-0.05	0.04
S ₂₃₄₅	0.02	-6.98	-2.76	-0.04	0.04	-0.13	-0.30
S ₂₃₄₆	-0.01	-3.84	-1.40	-0.01	0.00	-0.02	0.00
S ₂₃₅₆	-0.01	-2.39	-0.89	0.05	0.05	0.09	0.14
S ₂₄₅₆	-0.04	3.94	1.31	-0.19	-0.03	0.04	-0.27
S ₃₄₅₆	0.02	8.34	3.28	0.06	-0.03	0.04	0.13

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

Specific combining ability effects t⁴_{(ij)(kl)}. results are shown in Table 9. The results highlighted that no hybrids exhibited desirable values for all studied traits. However, 24, 21, 18, 21,24,21, 21,21 and 30 out of 45 quadriallel crosses showed desirable specific combining ability effects t⁴_{(ij)(kl)} values for B/P, BW, SCY/P, LY/P, L%, FF, FS, UHM and UI traits, 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 t⁴_{(ij)(kl)}. However, three combinations viz., t⁴[(P₁ x P₆)(P₂ x P₄)], t⁴[(P₁ x P₆)(P₃ x P₅)] and t⁴[(P₂ x P₄)(P₃ x P₅)] contained two or three out of the four parents which had desirable g_i for yield and its components traits. on the other hand, the three combinations viz., t⁴[(P₁ x P₄)(P₂ x P₆)], t⁴[(P₁ x P₄)(P₃ x P₅)] and t⁴[(P₂ x P₆)(P₃ x P₅)] involved two

or three out of four parents with poor general combining ability effects (g_i) for fiber quality 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), Yehia *et al.*, (2009), Said (2011), El-Feki *et al.*,(2012), El-Hashash (2013), Soliman (2014) and El-Fesheikawy *et al.*, (2018).

Table 9. The 4-line interaction effect of lines i, j, k and l due to particular arrangement $t^4_{(i,j)(k,l)}$ for yield component and fiber quality traits.

No	$t^4_{(i,j)(k,l)}$	BW(g)	SCY/P(g)	LCY/P(g)	L %	FF	FS	UHM
1	$t^4(12)(34)$	-0.027	3.818	1.393	-0.076	-0.070	0.242	-0.227
2	$t^4(12)(35)$	0.047	-3.784	-1.905	-0.409	0.046	-0.261	-0.019
3	$t^4(12)(36)$	-0.020	-0.034	0.512	0.485	0.024	0.019	0.245
4	$t^4(12)(45)$	-0.020	-0.034	0.512	0.485	0.024	0.019	0.245
5	$t^4(12)(46)$	0.047	-3.784	-1.905	-0.409	0.046	-0.261	-0.019
6	$t^4(12)(56)$	-0.027	3.818	1.393	-0.076	-0.070	0.242	-0.227
7	$t^4(13)(24)$	0.019	-1.769	-0.592	0.025	-0.068	-0.108	0.109
8	$t^4(13)(25)$	-0.008	-0.137	-0.026	0.030	0.049	0.236	-0.060
9	$t^4(13)(26)$	-0.011	1.906	0.618	-0.055	0.019	-0.128	-0.049
10	$t^4(13)(45)$	-0.011	1.906	0.618	-0.055	0.019	-0.128	-0.049
11	$t^4(13)(46)$	-0.008	-0.137	-0.026	0.030	0.049	0.236	-0.060
12	$t^4(13)(56)$	0.019	-1.769	-0.592	0.025	-0.068	-0.108	0.109
13	$t^4(14)(23)$	0.008	-2.049	-0.801	0.052	0.138	-0.133	0.118
14	$t^4(14)(25)$	0.080	7.887	2.710	-0.322	-0.037	-0.156	-0.260
15	$t^4(14)(26)$	-0.088	-5.839	-1.908	0.270	-0.101	0.289	0.143
16	$t^4(14)(35)$	-0.088	-5.839	-1.908	0.270	-0.101	0.289	0.143
17	$t^4(14)(36)$	0.080	7.887	2.710	-0.322	-0.037	-0.156	-0.260
18	$t^4(14)(56)$	0.008	-2.049	-0.801	0.052	0.138	-0.133	0.118
19	$t^4(15)(23)$	-0.039	3.921	1.931	0.379	-0.095	0.025	0.079
20	$t^4(15)(24)$	-0.060	-7.853	-3.221	-0.163	0.013	0.136	0.015
21	$t^4(15)(26)$	0.099	3.932	1.290	-0.216	0.082	-0.161	-0.094
22	$t^4(15)(34)$	0.099	3.932	1.290	-0.216	0.082	-0.161	-0.094
23	$t^4(15)(36)$	-0.060	-7.853	-3.221	-0.163	0.013	0.136	0.015
24	$t^4(15)(46)$	-0.039	3.921	1.931	0.379	-0.095	0.025	0.079
25	$t^4(16)(23)$	0.031	-1.873	-1.130	-0.431	-0.043	0.108	-0.196
26	$t^4(16)(24)$	0.042	9.623	3.813	0.139	0.055	-0.028	-0.124
27	$t^4(16)(25)$	-0.072	-7.750	-2.683	0.292	-0.012	-0.081	0.320
28	$t^4(16)(34)$	-0.072	-7.750	-2.683	0.292	-0.012	-0.081	0.320
29	$t^4(16)(35)$	0.042	9.623	3.813	0.139	0.055	-0.028	-0.124
30	$t^4(16)(45)$	0.031	-1.873	-1.130	-0.431	-0.043	0.108	-0.196
31	$t^4(23)(45)$	0.031	-1.873	-1.130	-0.431	-0.043	0.108	-0.196
32	$t^4(23)(46)$	-0.039	3.921	1.931	0.379	-0.095	0.025	0.079
33	$t^4(23)(56)$	0.008	-2.049	-0.801	0.052	0.138	-0.133	0.118
34	$t^4(24)(35)$	0.042	9.623	3.813	0.139	0.055	-0.028	-0.124
35	$t^4(24)(36)$	-0.060	-7.853	-3.221	-0.163	0.013	0.136	0.015
36	$t^4(24)(56)$	0.019	-1.769	-0.592	0.025	-0.068	-0.108	0.109
37	$t^4(25)(34)$	-0.072	-7.750	-2.683	0.292	-0.012	-0.081	0.320
38	$t^4(25)(36)$	0.080	7.887	2.710	-0.322	-0.037	-0.156	-0.260
39	$t^4(25)(46)$	-0.008	-0.137	-0.026	0.030	0.049	0.236	-0.060
40	$t^4(26)(34)$	0.099	3.932	1.290	-0.216	0.082	-0.161	-0.094
41	$t^4(26)(35)$	-0.088	-5.839	-1.908	0.270	-0.101	0.289	0.143
42	$t^4(26)(45)$	-0.011	1.906	0.618	-0.055	0.019	-0.128	-0.049
43	$t^4(34)(56)$	-0.027	3.818	1.393	-0.076	-0.070	0.242	-0.227
44	$t^4(35)(46)$	0.047	-3.784	-1.905	-0.409	0.046	-0.261	-0.019
45	$t^4(36)(45)$	-0.020	-0.034	0.512	0.485	0.024	0.019	0.245

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تحليل الهجن الرباعية لبعض صفات مكونات المحصول وجودة الالياف فى أصناف القطن المصرى

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الهدف من البحث هو تقدير التباين الراجع للقدرة على التآلف والفعل الجينى بغرض تحسين بعض الصفات الإقتصادية الهامة فى القطن المصرى عن طريق استخدام نظام الهجن الزوجية (الرباعية) حيث اشتملت الدراسة على ستة أصناف من القطن الباربادنس هي : جيزه ٩٤ (P₁) ، جيزه ٩٥ (P₂) ، جيزه ٧٥ (P₃) ، جيزه ٨٣ (P₄) ، جيزه ٨٠ (P₅) بالإضافة الى جيزه ٨٥ (P₆). وتم العمل فى ثلاثة مواسم (٢٠٢٠:٢٠١٨) وطبقا لنظام التزاوج التبادلى النصف كامل أدخلت هذه الأباء فى سلسله من التهجينات لتنتج ١٥ هجين جيل اول خلال موسم النمو ٢٠١٨ وفى الموسم التالى (٢٠١٩) تم تزاوج هجن الجيل الاول لإنتاج ٤٥ هجين رباعى (زوجى) بشرط ظهور اى أب فى الهجين الرباعى مرة واحدة وفى موسم النمو ٢٠٢٠ تم تقييم عدد ٥١ تركيب وراثى مختلف (الأباء الستة ، ٤٥ هجين رباعى) بمحطة البحوث الزراعية بسدس - مركز البحوث الزراعية وتم قياس الصفات المحصولية الآتية : وزن اللوزة (جم) ، محصول النبات من القطن الزهر (جم) ، محصول النبات من الشعر (جم) ، معدل الحليج % وتم قياس صفات جودة التيلة من خلال معامل التكنولوجيا بمعهد بحوث القطن - مركز البحوث الزراعية - مصر وهى : نعومة التيلة، متانة التيلة و طول التيلة

هذا فقد أعطت الهجن التالية أفضل النتائج لإستخدامها فى برامج التربية لتحسين صفات المحصول ومكوناته وهذه الهجن هي : [جيزه ٩٤ x جيزه ٨٥ (مع (جيزه ٩٥ x جيزه ٨٣)] ، [(جيزه ٩٤ x جيزه ٨٥) مع (جيزه ٧٥ x جيزه ٨٠)] و [(جيزه ٩٥ x جيزه ٨٣) مع (جيزه ٧٥ x جيزه ٨٠)] . كما أظهرت الهجن التالية أفضل النتائج لتحسين صفات التيلة : [(جيزه ٩٤ x جيزه ٨٣) مع (جيزه ٩٥ x جيزه ٨٥)] ، [(جيزه ٩٤ x جيزه ٨٣) مع (جيزه ٧٥ x جيزه ٨٠)] .