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

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ABSTRACT

The aim of this investigation is to determine combining ability estimates for yield and yield components traits and some fiber properties in cotton. The genetic materials used in the present study included five cotton varieties and their 30 three-way crosses. All these varieties belong to the species *Gossypium barbadense* L. In 2006 growing season, these genotypes were evaluated in a field trial experiment at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate. The following traits were estimated: seed cotton yield/plant, lint yield/plant, boll weight, number of bolls/plant, lint percentage, fiber fineness, fiber strength, upper half mean and uniformity ratio %.

The results showed that the performances of most the three-way crosses were as good as or better than their both grand parents or/and their third parent. The mean squares of genotypes were significant or highly significant for all studied traits. From the analyses of triallel crosses, the results revealed that the variety Giza 86 was the best combiner for yield and yield components traits as a parent and /or a grand parent as well as TNB1 as parent and/or grand parent and Giza 85 was a good combiner as parent and/or grand parent for most fiber properties .Therefore, these parental varieties could be utilized in a breeding program to improve these traits through the selection in segregating generations.

The results also investigated that the hybrids [P_1 x P_3] x P_4, [P_1 x P_4] x P_5, [P_1 x P_5] x P_4, [P_2 x P_3] x P_5, [P_2 x P_5] x P_4 appeared to be the best promising for breeding toward all studied yield traits potentiality. Meanwhile,[P_1 x P_2]x P_5 ,[(P_3) x [P_4]x P_5 would be the best for all studied yield traits and upper half mean (UHM) property. In addition, the combinations [P_1 x P_5] x P_3, [P_2 x P_4] x P_3 appeared to be the best promising for fiber strength (F.S.) property . Most of these combinations at least involved one of the best general combiners for yield.The results also showed that the fiber properties and yield components were mainly controlled by additive variance and /or additive x dominance epistatic variances. The results also cleared that the calculated values of heritability in broad sense ranged from 96.00% to 99.73% for fiber strength (F.S.) and seed cotton yield/plant (S.C.Y./P.), respectively. In the same time, narrow sense heritability ranged from 0.79% to 21.33% for lint percentage (L.%) and seed cotton yield/plant (S.C.Y./P.),respectively.

Keyword : Cotton , Triallel analysis , Gene action and Combining ability

INTRODUCTION

Triallel cross analysis provides additional informations about the components of epistatic variance, viz., additive x additive, additive x dominance and dominance x dominance, besides additive and dominance components of genetic variance. This technique also gives informations on the order in which parents should be crossed for obtaining superior recombinants (Singh and Narayanan, 2000).Triallel cross system assists and enables plant breeders to obtain estimates for general combining ability (GCA) and specific combining ability (SCA). These estimates could be translated into additive and non-additive genetic variances (dominance and epistatic genetic variances).

Two types of general combining ability effects are worked out through triallel crosses. viz., general line effect of first kind (h_i) and general line effect of second kind (g_l). The first refers to the general combining ability effect of a line used as one of the grand parents. Whereas, the latter one refers to the general combining ability effect of a line used as parent, which was crossed to the single cross hybrid. Triallel crosses included three kinds of specific combining ability effects ; two-line specific effect of first kind (d_{ij}) refers to the specific combining ability effect of a line used as one of the grand parents (parents involved in single cross) ; two-line specific effect of second kind (S_{ik}), which refers to the specific combining ability of a line when crossed as a parent to the single cross; the third kind is three-line specific effect (t_{ijk}), which refers to specific combining ability effect of lines in three-way cross. These three kinds of specific combining ability effects were determined for all studied traits. Many investigators studied general and specific combining abilities among them; Iftikhar *et al.* (2001), Zeina *et al.* (2001), Allam (2003), Yehia (2005) and Hemaida *et al.* (2006). Abd El-Maksoud *et al.* (2003 a) revealed that the magnitude of additive genetic variance was positive and larger than that of dominance genetic variance with respect to all studied yield component traits. In addition, the results revealed that the three types of epistatic variance (σ^2AA, σ^2AD and σ^2DD) were contributed in the genetic expression of most studied traits except for boll weight, lint percentage and lint index.

The present investigation was carried out to estimate combining ability and gene action for some yield components and fiber properties using triallel system of five cotton varieties.

MATERIALS AND METHODS

The genetic material:

The genetic material used in the present investigation included five cotton varieties belonged to (*Gossypium barbadense* L.).Three of them were long staple Egyptian cotton varieties: Giza 86 (P_1) very late in maturity, high in yield characters, long staple (33.2 mm.), coarse fiber (4.3 Micronair value) and strong lint (11.0 Pressley index),Giza 85 (P_4) exhibited fiber strength (10.4) and Micronaire value (3.8) and Giza 89 (P_5) is early in maturing, moderate in yield characters with high number of bolls per plant, long staple (32.0 mm.) and coarse lint (Pressley index 4.1). The other two varieties were: TNB1 Sea Island (P_2) an extra long staple variety, it characterized by Micronair value (3.1), Pressley index (10.3), lint length (33.7 mm.) and boll weight (2.7g.) and Suvin (P_3) Indian long staple germplasm. It is characterized by earliness and high yield.These five varieties were involved in a series of hybridization according to triallel crosses (three way crosses) mating design.

Experimental design:

In the growing season of 2004, the five parents were planted and mated in a diallel fashion excluding reciprocals to obtain 10 single crosses. The parental varieties were also selfed to obtain enough seeds for further investigations.

In 2005 growing season, mating of single crosses with parents was done in such a way that no parent should appear more than once in the same three way cross to obtain 30 three-way crosses; number of three-way crosses = n (n-1)(n-2)/2 where, n: is equal the number of parental varieties.

In 2006 growing season, the five parental varieties and the genetic materials obtained from hybridization (30 three way crosses) were evaluated in a field trial experiment at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate. The experimental design was a randomized complete blocks design with three replications. Each plot was one row 4.0 m. long and 0.6 m. wide. Hills were 0.4 m. apart to insure 10 hills per row. Hills were thinned to keep a constant stand of one plant per hill at seedling stage. Ordinary cultural practices were followed as the recommendations.

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

Biometrical analysis:

Statistical procedures used in this study were done according to the analysis of variance for a randomized complete blocks design as outlined by Cochran and Cox (1957). The significance was determined using the least significant difference value (L.S.D), which was calculated as suggested by Steel and Torrie (1980).

The theoretical aspect of triallel analysis has been illustrated by Rawlign and Cockerham (1962), Hinkelmann (1965) and Ponnuswamy (1972) and outlined by Singh and Chaudhary (1985). Considering Y_{ijkl} as the measurement recorded on a triallel cross $G_{(ij)k}$, the statistical model takes the following form: $Y_{ijkl} = m + b_l + h_i + h_j + d_{ij} + g_k + s_{ik} + s_{jk} + t_{ijk} + e_{ijkl}$

Where:

Y_{ijkl}:	Phenotypic value in the l^{th} replication on ij^{th} cross (grand parents) mated to k^{th} parent.
m:	general mean
b_l:	effects of l^{th} replication
h_i:	general line effect of i^{th} parent as grand parent (first kind general line effect)
h_j:	general line effect of j^{th} parent as grand parent (first kind general line effect)
d_{ij}:	two-line (i x j) specific effect of first kind (grand parents)
g_k:	general line effect of K as parent (second kind effect)
s_{ik}, s_{jk}:	two - line specific effect where i and j are half parents and K is the parent (specific effects of second kind)
t_{ijk}:	three-line specific effect
e_{ijkl}:	error effect

Estimation of the various effects:

(i) h_i : General line effect of first kind (grand parent). This is in fact the general combining ability effect of a line used as one of the grand parents.

h_i = [P-1 /(rP(P-2)(P-3))] [$Y_{i...}$ + [(P-4)/(P-1)]$Y_{..i.}$ – [(P-4)/(P-1)] $Y_{....}$]

(ii) gi : General line effect of the second kind. This refers to the general combining ability of a line used as parent which crossed to the single hybrid.

g_i = [(P-4)/rP(P-3)][$Y_{..i.}$ + [1/(P-2)] $Y_{i...}$ - [1/(P-2)] $Y_{....}$]

(iii) dij : Two-line specific effect of first kind (grand parents).

$$d_{ij} = \frac{P-3}{r(P-1)(P-4)}\left[Y_{ij} + \frac{1}{P-3}(Y_{i.j.} + Y_{j.i.}) - \frac{2}{P(P-3)}Y_{....} - \left(\frac{r(P^2-4+P+2)}{P-3}\right)(h_i + h_j) - \frac{r}{P-3}(g_i + g_j)\right]$$

(iv) Sik = two-line specific effect where i is half parent and K is parent. (Specific effect of second kind)

$$S_{ik} = \frac{D}{D_2}\left[Y_{i.k.} + \frac{1}{D}Y_{k.i.} + \left(\frac{V-3}{D}\right)Y_{ik..} - \left(\frac{2(P-3)}{PD}\right)Y_{....} - r(P-2)h_i - \left(\frac{P-2}{D}\right)rhi - \frac{rg_i}{D} - \frac{D_1}{D}rg_j\right]$$

Where: $D = P^2 - 5P + 5$ $D_1 = P^3 - 7P^2 + 14P - 7$

And $D_2 = r(P-1)(P-3)(P-4)$.

(v) Tijk : Three-line specific effect.

$$t_{ijk} = \overline{y}_{ijk} - \overline{y} - h_i - h_j - g_k - d_{ij} - S_{ik} - S_{jk}$$

Ponnuswamy *et al.* (1974) investigated that the variances and co-variances components of general effects i.e., σ^2h, σ^2g, σgh are the function of additive and additive x additive type of epistasis, whereas, σ^2d and σds are the functions of additive x additive type of epistasis only. σ^2s and σ_{ss} involve dominance components while σ^2t and σtt account for epistatic components other than additive x additive.

Estimates of genetic variances:

The genetic variance components could be calculated from the previous variances using the following manner if the breeding coefficient assumed to be equal to one (F = 1).

$$\sigma^2 A = \frac{1}{227\ F}\left[448\ \sigma^2 h + 40\ \sigma^2 g + 604\ \sigma gh - 292\ \sigma^2 d - 584\ \sigma ds\right]$$

σ^2D =

$$\frac{1}{127F^2}\left[416\sigma^2 h - 352\sigma^2 g + 496\sigma gh - 336\sigma^2 d - 672\sigma ds - \frac{1816}{3}\sigma^2 s + \frac{4540}{3}\sigma ss - 254\sigma^2 t - \frac{3556}{3}\sigma tt\right]$$

$$\sigma^2 AA = \frac{1}{227\ F^2}\left[-832\ \sigma^2 h + 704\ \sigma^2 g - 992\ \sigma gh + 672\ \sigma^2 d + 13446\ ds\right]$$

$$\sigma^2 AD = 32/3F^3\ [\sigma^2 S - \sigma^2 S + 4\sigma tt\ ]$$

$$\sigma^2 DD = \frac{1}{3F^4}\left[-16\sigma^2 s + 16\ \sigma ss + 24\ \sigma^2 t - 32\ \sigma tt\right]$$

Table1: Form of the analysis of variances of the triallel crosses and the expectation of mean squares

S.O.V.	d.F	M.S	E.M.S
Replications	r-1		.
Due to crosses	C-1		$\sigma^2 e + [2r / P (P-1) (P-2)-2] \sum\sum\sum C^2_{ijK}$
Due to *h* eliminating *g*	P-1	M (h/g)	$\sigma^2 e + [rp (P-2) (P-3)/(P-1)^2] \sum h^2_i$
Due to *g* eliminating *h*	P-1	M (g/h)	$\sigma^2 e + [rp (P-3)/(P-1)] \sum g^2_i$
Due to *s* eliminating *d*	P^2-3P + 1	M (s/d)	$\sigma^2 e + [r/(P^2-3P + 1)] \sum\sum S_{ij} [(P^2-5 P + 5) S_{ij} - S_{ji}]$
Due to *d* eliminating *s*	P(P-3)/2	M (d/s)	$\sigma^2 e + [2 (P-1)(P-4)/P(P-3)^2] \sum\sum d^2_{ij}$
Due to *t*	P(P^2-6 P + 7)/2	M (t)	$\sigma^2 e + [2r/P (P^2 - 6 P + 7)] \sum\sum\sum t^2_{ijk}$
Error	(r-1) (C-1)	ME	$\sigma^2 e$

Where: C, P and r are number crosses, parents and replications, respectively.

RESULTS AND DISCUSSION

The mean performances of the five parental varieties and their 30 three-way crosses were estimated for all studied traits and the results are presented in Table 2.

Table 2 :The mean performance of the parents and thier triallel crosses for yield and yield component traits and some fiber properties

Genotypes	B.W.	S.C.Y./P.	L.Y./P.	L.%	N.B./P.	F.F.	F.S	U.H.M	U.R.
G.86 (1)	3.2	120.0	40.0	33.3	37.2	4.3	9.9	34.2	85.1
TNB1 (2)	2.6	100.0	32.5	32.5	38.1	3.4	9.7	33.4	83.5
Suvin (3)	2.9	99.3	31.3	31.5	34.2	4.4	9.0	30.3	84.1
G.85 (4)	2.9	101.5	34.3	33.8	35.6	4.4	8.3	32.6	84.4
G.89 (5)	2.8	110.0	35.9	32.6	39.9	4.7	8.6	32.9	84.7
12 × 3	3.5	117.9	39.8	33.8	33.4	4.1	8.7	32.5	84.9
12 × 4	2.9	100.0	36.0	36.0	34.4	4.3	8.9	33.2	84.9
12 × 5	3.5	127.7	45.7	35.7	36.1	4.3	8.9	31.0	85.3
13 × 2	3.1	157.6	53.4	33.9	51.0	4.5	10.2	33.4	85.8
13 × 4	3.2	139.1	51.4	36.9	42.9	4.4	10.3	33.6	85.7
13 × 5	3.1	140.7	53.3	37.9	44.9	4.4	10.0	32.7	85.3
14 × 2	3.0	99.7	37.8	37.9	33.0	4.2	9.5	33.2	85.7
14 × 3	3.1	142.4	51.7	36.2	45.9	4.1	9.8	34.8	85.0
14 × 5	2.4	71.9	27.2	37.9	30.6	3.6	10.4	34.4	86.1
15 × 2	3.0	173.7	63.8	36.7	57.3	4.2	10.1	34.3	85.2
15 × 3	3.5	136.1	46.2	34.1	38.7	3.5	10.1	34.3	84.9
15 × 4	2.8	98.6	38.4	38.9	34.7	4.2	10.2	36.6	87.6
23 × 1	3.3	119.8	47.5	39.7	36.1	4.7	9.8	34.8	84.8
23 × 4	2.6	96.8	36.2	37.4	37.1	3.4	9.4	32.6	83.2
23 × 5	2.8	109.5	41.9	38.3	39.2	4.3	9.9	33.2	85.4
24 × 1	3.3	147.0	55.2	37.5	45.2	4.4	8.8	35.4	85.8
24 × 3	2.8	145.9	52.2	35.7	51.8	3.7	9.4	34.4	86.2
24 × 5	3.3	76.0	28.6	37.8	23.0	4.2	9.6	33.5	84.8
25 × 1	3.2	133.2	47.0	35.2	41.4	4.5	10.1	32.4	84.0
25 × 3	3.3	92.3	35.6	38.7	27.9	4.2	9.6	35.5	87.2
25 × 4	3.0	128.9	47.2	36.6	43.1	4.0	11.0	35.3	86.1
34 × 1	3.2	75.2	27.0	35.9	23.9	4.5	11.1	32.3	84.0
34 × 2	2.5	137.5	49.2	35.8	55.2	4.1	10.1	32.0	84.5
34 × 5	2.7	107.8	39.4	36.5	40.6	4.0	10.0	32.7	83.7
35 × 1	3.5	152.1	57.1	37.5	43.5	4.6	9.9	33.6	85.5
35 × 2	2.8	106.1	36.6	34.5	38.1	3.9	9.3	33.5	85.2
35 × 4	2.6	61.8	23.0	37.3	23.3	4.1	9.9	32.6	84.2
45 × 1	2.8	67.3	25.4	37.8	24.0	4.4	11.6	34.0	85.8
45 × 2	2.6	116.1	43.8	37.8	44.0	3.6	10.1	34.1	85.2
45 × 3	3.0	111.5	41.9	37.5	37.2	3.9	9.2	33.5	85.7
LSD 5%	0.3	14.8	6.5	3.5	6.1	0.5	1.4	1.8	1.9
LSD 1%	0.4	19.6	8.6	4.7	8.1	0.6	1.9	2.4	2.5

12 × 3 means (P_1 × P_2) × P_3 and so on..

The results showed that Giza 86 (P_1) was the highest yielding parent for seed cotton yield/plant (S.C.Y. /P.), lint yield/plant (L.Y. /P.) and boll weight (B.W.), also it was the best for fiber strength (F.S.), upper half mean (UHM) and uniformity ratio % (U.R. %).The parental varieties TNB1 (P_2), Giza 85 (P_4) and Giza 89 (P_5) exhibited the best mean performances for fiber fineness (F.F.), lint percentage (L.%) and number of bolls/plant (N.B. /P.), respectively. With respect to the triallel crosses, the means showed that no specific cross was superior or inferior for all studied traits. The results also revealed that the highest mean performances were found for the cross [(P_1) x (P_5)] x (P_2) for cotton yield/plant (S.C.Y. /P.), lint yield/plant (L.Y./P.) and number of bolls/plant (N.B. /P.) with the means of 173.7 g., 63.8 g. and 57.3, respectively. In the same time, the results showed that the cross [(P_2) x (P_3)] x (P_1) gave the highest mean for lint percentage (L. %) with mean of 39.7 %.Concerning fiber properties, the results showed that the cross [(P_4) x (P_5)] x (P_1) gave the highest mean for fiber strength (F.S.) with the mean of 11.6. Meanwhile, the results showed that the cross [(P_1) x (P_5)] x (P_4) gave the highest mean for upper half mean (UHM) and uniformity ratio % (U.R. %).

The analysis of variances of the five parents and their 30 three-way crosses were made for all studied yield and yield component traits [seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.), boll weight (B.W.) , lint percentage (L.%) and number of bolls/plant (N.B./P.)] and some fiber properties [fiber fineness (F.F.), fiber strength (F.S.) , upper half mean (UHM) and uniformity ratio % (U.R.%)] and the mean squares are presented in Table 3. The mean squares of genotypes were significant or highly significant for all studied traits, while the parents vs. crosses mean squares showed highly significant for all studied traits except number of bolls/plant (N.B. /P.) and fiber fineness (F.F.). Furthermore, the results indicated that the magnitudes of the crosses mean squares of all studied traits were significant or highly significant, the partition of crosses mean squares to its components showed that the mean square due to *h* eliminating *g* and *g* eliminating *h* were highly significant for seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.), boll weight (B.W.), number of bolls/plant (N.B./P.) and fiber fineness (F.F.).

The estimates due to *h* eliminating *g* were larger in magnitudes than the other crosses mean squares components for seed cotton yield/plant (S.C.Y./P.), boll weight (B.W.) and fiber strength (F.S.). This finding suggested that both additive and additive × additive genetic variances played a major role in the inheritance of these traits. Subsequently the selection through the advanced segregating generations of the highest yielding three-way crosses would be efficient to produce high yield lines.

In addition, the results indicated that the tests of significance showed that the mean squares due to *s* eliminating *d*, *d* eliminating *s* and *l* or t_{ijk} were significant for most studied traits. In the same time, the mean squares due to t_{ijk} were larger in magnitudes than those crosses mean squares components for lint yield/plant (L.Y. /P.), lint percentage (L. %) and number of bolls/plant (N.B. /P.), upper half mean (UHM) and uniformity ratio % (U.R. %) referred to the contribution of dominance, dominance × dominance and additive ×dominance genetic variances in the genetic expression of these traits.

Table 3: The results of the analysis of variances and the mean squares of the five parents and their 30 triallel crosses for yield and yield component traits and some fiber properties

S O V	d f	B.W.	S.C.Y./P.	L.Y./P.	L.%	N.B./P.	F.F.	F. S	U.H.M	U.R.
Rep.	2	0.002	165.26	5.85	12.49	20.71	0.62**	8.31**	1.23	0.65
Genotypes	34	0.290**	2188.02**	294.49**	12.08**	213.69**	0.38**	1.49*	4.79**	2.67*
Parients	4	0.153**	234.42*	34.53	2.24	13.87	0.73**	1.39	6.53**	1.14
Par. Vr. C	1	0.270**	1327.11**	824.08**	207.47**	32.40	0.16	7.48**	12.69**	10.53**
Crosses	29	0.298**	2487.17**	312.09**	6.701**	249.15**	0.334**	1.294*	4.283**	2.609*
Due to *h* eliminating *g*	4	0.691**	3518.51**	374.20**	4.525	129.47**	0.389**	2.588*	4.391*	3.792
Due to *g* eliminating *h*	4	0.332**	2121.13**	216.32**	4.678	216.46**	0.527**	0.668	1.019	0.031
Due to *s* eliminating *d*	11	0.296**	2192.74**	256.01**	5.401*	258.77**	0.433**	0.762	2.398	1.812
Due to *d* eliminating *s*	5	0.228**	2160.61**	245.86**	4.810	153.57**	0.173	1.482	4.145*	1.555
Due to *t*	5	0.029	2929.22**	528.61**	14.808**	445.46**	0.079	1.742	11.091**	6.531**
Triallel Error	58	0.016	77.95	15.31	2.615	11.114	0.086	0.776	1.356	1.600
Over all Error	68	0.029	81.59	15.86	4.690	13.860	0.080	0.720	1.170	1.370

*** & ** significant at 0.05 and .01 levels of probability, respectively.**

General combining ability effects for each parental variety:

The estimates of general combining ability effects for first kind (h_i) for parental varieties were obtained for yield and yield component traits and some fiber properties and the results are shown in Table 4. Positive estimates would indicate that a given variety is much better than the average of the group involved with it in the triallel crosses for all studied traits except fiber fineness. Comparison of the general combining ability effect (h_i) of individual parent exhibited that no parent was the best combiner as a grand parent for all yield and its component traits and/or fiber properties.

Table 4: General line effect (h_i) of first kind (grand parent) for yield and yield component traits and some fiber properties

Parents	B.W.	S.C.Y./P.	L.Y./P.	L.%	N.B./P.	F.F.	F. S	U.H.M	U.R.
G.86	0.188**	14.345**	4.607**	-0.529	1.869**	0.170**	-0.012	0.083	0.351
TNB1	0.099**	6.027**	2.056**	-0.122	1.326*	0.020	-0.559**	-0.081	-0.044
Suvin	-0.035	4.255*	1.334	-0.269	1.999**	0.066	0.040	-0.694**	-0.621*
G.85	-0.275**	-17.885**	-5.911**	0.547	-2.223**	-0.166**	0.216	0.196	-0.081
G.89	0.023	-6.742**	-2.086**	0.373	-2.971**	-0.090	0.316*	0.497*	0.396
S.E.	0.024	1.665	0.738	0.305	0.629	0.055	0.166	0.220	0.238

***, ** Significant at 0.05 and 0.01 levels of probability, respectively.**

The variety Giza 86 (P_1) was the best combiner as a grand parent for boll weight (B.W.), seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.) and number of bolls/plant (N.B./P.). Whereas, the variety TNB1 (P_2) had the positive and highly significant values of general combining ability as a grand parent for the same previous traits. The variety Suvin (P_3) was a good combiner as a grand parent for seed cotton yield/plant (S.C.Y./P.) and number of bolls/plant (N.B./P.). Furthermore , the results revealed that the variety Giza 85 (P_4) was the best combiner as a grand parent among this group of varieties for fiber fineness (F.F.) which had a negative (desirable) and significant value. Moreover, the variety Giza 89 (P_5) was good combiner as a grand parent for upper half mean (UHM).

Table 5: General combining ability effect (g_i) of parental varieties for yield and yield component traits and some fiber properties

Parents	B.W.	S.C.Y./P	L.Y./P.	L.%	N.B./P.	F.F.	F. S	U.H.M	U.R.
G.86	0.149**	3.305	1.425	0.115	-1.064**	0.229**	0.167	0.067	-0.042
TNB1	-0.056*	9.234**	2.912**	-0.372	4.163**	-0.018	-0.125	-0.141	-0.016
Suvin	0.055*	5.063*	1.291	-0.462	1.157**	-0.097	-0.185	0.092	0.036
G.85	-0.124**	-10.543**	-3.457**	0.343	-2.113**	-0.086	0.095	0.218	-0.004
G.89	-0.024	-7.060**	-2.171*	0.376	-2.143**	-0.028	0.048	-0.236	0.027
S.E.	0.029	2.039	0.904	0.373	0.112	0.068	0.203	0.269	0.292

***, ** Significant at 0.05 and 0.01 levels of probability, respectively.**

The estimates of general combining ability effect of the second kind (g_i) of the parental varieties were obtained for all studied yield and yield component traits and some fiber properties and the results are presented in Table 5. The results revealed that the best combiner as the third parent in the three way crosses was TNB1 (P_2), which exhibited positive and highly significant (g_i) values for seed cotton yield/plant (SCY/P), lint yield/plant (L.Y./P.) and number of bolls/plant (N.B./P.).In the same time, the variety Giza 86 (P_1) was the best combiner as a parent for (B.W.).

The variety Suvin (P_3) was a good combiner for seed cotton yield/plant (S.C.Y./P.) and number of bolls/plant (N.B./P.) .On the other hand, Giza 85(P_4) was a good combiner as a parent for fiber fineness (F.F.), fiber strength (F.S.) and upper half mean (UHM) which had a desierable (insignificant) values. This findings suggested that these parental varieties could be utilized in a breeding program for improving of that traits through the selection in segregating generations.

Two-line specific effects of first kind (d_{ij})

It refers to the specific combining ability effect of a line used as one of the grand parents (parents involved in single cross) for three way crosses. The specific combining ability effects of first kind (d_{ij}) [where i and j are grand parents] for all combinations, with respect to the studied yield components traits and some fiber properties were obtained and the results are presented in Table 6.

Table 6: Specific combining ability effects (d_{ij}) of each cross for yield and yield components traits and some fiber properties

Crosses	B.W.	S.C.Y./P.	L.Y./P.	L.%	N.B./P.	F.F.	F. S	U.H.M	U.R.
d_{12}	0.030	-7.262**	-3.767**	-1.132*	-3.021**	0.187*	-0.673*	-1.652**	-0.844*
d_{13}	0.307**	20.886**	7.357**	-0.163	3.203**	0.161	0.469	0.526	0.394
d_{14}	-0.179**	-27.199**	-8.481**	1.254**	-7.427**	0.046	0.100	0.949**	0.622
d_{15}	-0.046	16.054**	5.961**	0.127	6.446**	-0.222*	0.229	0.227	-0.204
d_{23}	-0.337**	-18.225**	-5.419**	1.369**	-1.855	-0.248**	0.241	1.032**	0.551
d_{24}	0.190**	26.243**	9.443**	-0.188	6.381**	-0.109	-0.312	0.589	0.232
d_{25}	0.075*	6.170*	1.927	-0.328	1.618	0.157	0.650*	-0.075	0.049
d_{34}	0.007	10.852**	2.496*	-1.422**	4.325**	-0.015	0.139	-1.267**	-0.976**
d_{35}	0.064	-9.715**	-3.466**	-0.131	-4.806**	0.030	-0.987**	-0.222	0.057
d_{45}	-0.111	-17.803**	-6.050**	0.613	-4.865**	0.015	0.144	-0.107	0.118
S.E.	0.036	2.549	1.130	0.467	0.962	0.085	0.254	0.336	0.365

1, 2, 3, 4 and 5: Giza 86, TNB1, Suvin , Giza 85, and Giza 89, respectively.
***, ** Significant at 0.05 and 0.01 levels of probability, respectively.**

The results cleared that no hybrids exhibited desirable and significant values for all studied traits. However, 3, 5, 4, 2, 4, 2,1 and 2 out of 10 combinations showed desirable and significant or highly significant specific combining ability effects (d_{ij}) values for boll weight (B.W.), seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.), number of bolls/plant (N.B./P.), lint percentage (L. %), fiber fineness (F.F.), fiber strength (F.S.) and upper half mean (UHM), respectively. Similar results were obtained by Abd El-Maksoud et al.(2003) and Yehia (2005).

Two-line specific effects of second kind (S_{ik}):

It refers to the specific combining ability effect of a line when crossed as a parent to the single cross. The specific combining ability effects of second kind (S_{ik}) [where i is a grand parent and k as a parent] for all possible combinations, with respect to the studied yield components traits and some fiber properties were obtained and the results are presented in Table 7.

Table 7: Two-line specific effect of second kind (S_{ik}) for yield and yield components traits and some fiber properties

Combinations	B.W.	S.C.Y./P.	L.Y./P.	L.%	N.B./P.	F.F.	F. S	U.H.M	U.R.
$S_{1.2.}$	0.025	12.207**	3.700**	-0.472	3.560**	0.216**	-0.280	-0.763**	-0.324
$S_{2.1.}$	0.174**	18.044**	7.100**	0.172	3.070**	0.395**	-0.499*	0.022	-0.691*
$S_{1.3.}$	0.196**	14.317**	2.691**	-2.128**	2.706**	-0.273**	0.063	0.036	-0.995**
$S_{3.1.}$	0.538**	7.457**	4.324**	1.157**	-4.120**	0.420**	0.523*	0.749**	0.330
$S_{1.4.}$	-0.178**	-26.745**	-7.706**	1.680**	-6.425**	0.128	-0.062	1.403**	1.148**
$S_{4.1.}$	0.154**	-23.232**	-8.362**	0.080	-10.656**	0.368**	0.538*	0.596*	0.578
$S_{1.5.}$	-0.209**	-3.497	-0.288	0.791*	1.357	-0.329**	0.090	-0.751**	0.218
$S_{5.1.}$	0.081**	18.802**	6.023**	-0.678	4.920**	0.276**	0.503*	-0.941**	-0.486
$S_{2.3.}$	-0.200**	-17.096**	-6.228**	0.277	-3.003**	-0.186**	0.037	0.862**	1.220**
$S_{3.2.}$	-0.327**	1.861	-1.727	-1.601**	5.504**	-0.097	0.016	0.357	0.721*
$S_{2.4.}$	-0.207**	2.310	0.605	-0.347	2.982**	-0.424**	0.229	0.237	-0.626*
$S_{4.2.}$	0.076*	22.351**	8.747**	0.407	7.712**	-0.097	-0.386	-0.605*	-0.028
$S_{2.5.}$	0.297**	-13.646**	-4.753**	0.316	-7.733**	0.235**	0.373	-0.963**	0.115
$S_{5.2.}$	-0.132**	22.449**	7.844**	-0.704	9.765**	-0.139*	-0.147	0.112	-0.472
$S_{3.4.}$	-0.170**	-17.639**	-6.535**	-0.043	-4.270**	-0.298**	-0.020	-1.219**	-1.228**
$S_{4.3.}$	0.045	43.229**	14.791**	-1.156**	14.188**	-0.008	-0.413	-0.439	-0.248
$S_{3.5.}$	-0.102**	2.625	2.485**	1.007*	1.584*	0.084	-0.312	0.010	0.138
$S_{5.3.}$	0.312**	-8.173**	-3.021**	0.062	-6.515**	-0.153*	-0.867**	0.124	0.250
$S_{4.5.}$	-0.135**	-30.488**	-11.286**	0.283	-8.867**	-0.167*	0.153	0.203	-0.297
$S_{5.4.}$	-0.234**	-25.136**	-8.403**	0.896*	-5.760**	0.048	0.458*	0.970**	0.677*
S E	0.030	2.094	0.928	0.384	0.791	0.070	0.209	0.276	0.300

1,2,3,4 and 5: Giza 86, TNB1, Suvin , Giza 85, and Giza 89, respectively.
***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

The results revealed that no combination exhibited desirable significant values for all yield and yield component traits and /or fiber properties. However, it could be concluded that the combination with line 4 (Giza 85) used as one of the grand parent (in single hybrid) and line 3 (Suvin) as parent (S_{43}) gave high performance as compared to any other combinations for seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.) and number of bolls/plant (N.B./P.). Meanwhile, the combination with line 3 (Suvin) used as one of the grand parent and line 1 (Giza 86) as parent (S_{31}) gave positive (desirable) and significant or highly significant estimates for seed cotton yield/plant, lint yield/plant, boll weight , Fiber strength (F.S.) and upper half mean(UHM). Moreover, the combination with line 2 (TNB1) used as one of the grand parent and line 3(Suvin) as parent (S_{23}) appeared to be the best specific combination for fiber fineness (F.F.), upper half mean (UHM) and uniformity ratio % (U.R.%) .

Three-line specific effect (t_{ijk}):

It refers to specific combining ability effect of a line in three-way cross.The specific combining ability effects (t_{ijk}) for all possible combinations, with respect to all studied traits were obtained and the results are presented in Table 8. The results illustrated that no three-way cross exhibited desirable significant values for all yield and yield components traits and/or fiber properties. However, 13, 12, 11, 5, 6, 2 ,3 and 1 out of 30 three-way crosses showed desirable and significant specific combining ability effects (t_{ijk}) values for boll weight (B.W.), seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.), number of bolls/plant (N.B./P.), lint percentage (L. %), fiber fineness (F.F.), fiber strength (F.S.) upper half mean (UHM) and uniformity ratio % (U.R.%), respectively. These three-way crosses involved [(poor x poor) x poor] or [(good x good) x good] general combiner varieties, indicating to the presence of important epistatic gene action. In general, the combinations [Giza 86 (P_1) x Suvin (P_3)] x Giza 85 (P_4), [Giza 86 (P_1) x Giza 85 (P_4)] x Giza 89 (P_5), [Giza 86 (P_1) x Giza 89 (P_5)] x Giza 85 (P_4) , [TNB1 (P_2) x Suvin (P_3)] x Giza 89 (P_5), [TNB1 (P_2) x Giza 89 (P_5)] x Giza 85 (P_4) appeared to be the best promising for breeding toward all studied yield traits potentiality. Meanwhile, [Giza 86 (P_1) x TNB1 (P_2)] x Giza 89 (P_5) ,[Suvin (P_3) x Giza 85 (P_4)] x Giza 89 (P_5) would be the best for all studied yield traits and upper half mean (UHM) property. In addition, the combinations [Giza 86 (P_1) x Giza 89 (P_5)] x Suvin (P_3), [TNB1 (P_2) x Giza 85 (P_4)] x Suvin (P_3) appeared to be the best promising for fiber strength (F.S.) property . Most of these combinations had 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 three-way crosses over their single crosses for these traits.

Genetic parameters :

The genetic parameters were estimated and the results are presented in Table 9. The results indicated that the magnitudes of additive genetic variances (σ^2A) were positive and larger than those of dominance genetic variances (σ^2D), with respect to lint percentage (L. %), fiber strength (F.S.) upper half mean (UHM) and uniformity ratio % (U.R.%). These results indicated the predominance of additive genetic variances (σ^2A) in the inheritance of these traits.

Concerning epistatic variances, additive by additive genetic variances (σ^2AA), it showed positive values for all studied traits except for the four traits [(L.%), (F.S.) ,(UHM) and (U.R.%)] .While, additive by dominance genetic variances (σ^2AD) showed positive and considerable magnitudes for all studied traits. It could be concluded that fiber properties and yield components traits were mainly controlled by additive variance and /or additive x dominance epistatic variances. Therefore, the breeder would design breeding programs which make use of these advantages to select superior lines from the advanced segregating generations of the high yielding three way crosses.

The estimated heritability values in broad sense ($h^2_{b.s.}$%) were larger than their corresponding heritability values in narrow sense ($h^2_{n.s.}$%) for all studied traits. The results also cleard that the calculated values of heritability in broad sense ranged from 96.00% to 99.73% for fiber strength (F.S.) and seed cotton yield/plant (S.C.Y./P.), respectively. While, narrow sense ($h^2_{n.s.}$%) ranged from 0.79% to 21.33% for lint percentage (L.%) and seed cotton yield/plant (S.C.Y./P.),respectively. These results were in common agreement with the results obtained by many authors among them Kosba *et al.*(1999), Abd El-Maksoud *et al.*(2000), Awad (2001), Abd El-Maksoud *et al.*(2003), Hemaida *et al.* (2006).

Table 8: Three-line specific effect (t_{ijk}) for yield and yield components traits and some fiber properties

Combinations	B.W.	S.C.Y./P.	L.Y./P.	L.%	N.B./P.	F.F.	F. S	U.H.M	U.R.
t_{123}	-0.149**	-13.819**	-3.501**	1.097**	-3.131**	0.148*	0.185	-0.474	-0.025
t_{124}	0.098**	5.509*	1.035	-0.634	0.956	0.174*	0.038	-0.609*	-0.316
t_{125}	0.155**	22.417**	7.346**	-0.753	5.661**	-0.085	-0.176	1.000**	0.275
t_{132}	-0.019	-21.553**	-7.407**	0.548	-8.071**	-0.127	0.250	0.400	0.010
t_{134}	0.247**	38.165**	13.115**	-0.852*	9.906**	0.129	-0.054	-0.351	0.425
t_{135}	0.000	-7.197**	-2.652**	-0.087	-1.731*	0.146*	-0.216	0.129	-0.442
t_{142}	0.242**	-29.653**	-10.430**	0.237	-13.497**	-0.081	0.145	-0.202	-0.109
t_{143}	-0.098**	-5.796**	0.064	1.922**	-0.605	0.298**	0.188	0.199	0.031
t_{145}	-0.116**	27.307**	8.080**	-1.644**	10.627**	-0.056	-0.038	0.323	0.025
t_{152}	0.025	-10.140**	-1.795	1.500**	-4.174**	0.153*	0.277	0.652*	0.234
t_{153}	-0.217**	-15.140**	-5.864**	-0.162	-2.842**	0.002	0.681**	-0.360	-0.201
t_{154}	0.333**	21.057**	6.819**	-0.786*	3.409**	0.071	-0.716**	-0.482	-0.049
t_{231}	-0.275**	-17.435**	-5.977**	0.511	-1.566	-0.361**	-0.007	0.023	0.084
t_{234}	0.381**	14.288**	4.963**	-0.289	0.211	0.190**	-0.519*	-0.527	-0.062
t_{235}	-0.107**	19.231**	5.742**	-1.160**	7.340**	0.041	0.177	0.449	0.000
t_{241}	-0.244**	18.154**	6.755**	0.140	9.584**	-0.468**	-0.595**	0.379	0.613*
t_{243}	-0.103**	-16.058**	-5.939**	0.033	-4.813**	0.116	0.773**	-0.452	-0.199
t_{245}	0.145**	-3.568	-1.429	-0.206	-2.465**	0.235**	-0.212	0.159	-0.437
t_{251}	-0.385**	-28.716**	-12.047**	-1.104**	-4.355**	-0.616**	-0.371	-0.721*	-0.415
t_{253}	-0.059*	-9.325**	-0.976	2.092**	-2.555**	0.369**	0.315	0.447	0.010
t_{254}	0.354**	40.487**	13.856**	-0.984*	9.183**	0.195**	-0.031	-0.150	0.418
t_{341}	-0.390**	-25.846**	-10.958**	-1.058**	-3.239**	-0.565**	-0.366	-0.979**	-0.423
t_{342}	0.097**	-9.493**	-1.263	1.728**	-5.018**	0.297**	0.391	0.472	0.216
t_{345}	0.215**	29.174**	9.784**	-0.805*	7.181**	0.062	-0.127	0.855**	0.242
t_{351}	-0.324**	18.412**	6.881**	0.161	10.722**	-0.460**	-0.555**	0.462	0.582
t_{352}	0.239**	-31.618**	-10.862**	0.441	-14.319**	0.019	0.295	-0.041	-0.150
t_{354}	0.120**	10.960**	2.991**	-0.698	2.488**	0.300**	0.106	-0.583*	-0.361
t_{451}	-0.220**	-5.472*	-2.290*	-0.071	2.025**	-0.362**	-0.176	0.011	0.082
t_{452}	0.113**	-11.814**	-4.277**	0.148	-6.440**	-0.035	0.190	0.466	-0.001
t_{453}	-0.059*	-2.516	0.236	0.731	-0.372	0.270**	0.147	-0.496	-0.055
S E	0.030	2.081	0.922	0.381	0.786	0.069	0.208	0.275	0.298

1,2,3,4 and 5: Giza 86, TNB1, Suvin , Giza 85, and Giza 89, respectively.

***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

Table 9 : The estimates of genetic parameters from the three – way crosses analysis for yield and yield components traits and some fiber properties

Genetic Parameters	B.W.	S.C.Y./P.	L.Y./P.	L.%	N.B./P.	F.F.	F.S	U.H.M	U.R.
σ^2A	-0.09	-887.32	-74.07	0.27	-37.67	-0.01	0.13	0.23	0.25
σ^2D	-0.32	-2832.96	-369.71	-8.37	-401.19	-0.42	-1.42	-6.94	-4.84
σ^2AA	0.22	2042.06	170.47	-0.50	86.69	0.03	-0.22	-0.39	-0.47
σ^2AD	0.93	7505.35	970.58	33.20	881.78	0.96	6.08	27.43	19.79
σ^2DD	-0.28	-2081.53	-245.51	-2.08	-271.16	-0.39	-0.38	-1.71	-1.24
$h^2_{n.s.}$%	18.81	21.33	14.87	0.79	8.92	3.34	2.00	0.82	1.23
$h^2_{b.s.}$%	99.54	99.73	99.55	97.46	99.62	97.17	96.00	98.39	97.41

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تحليل الهجن الثلاثية لمكونات المحصول وصفات التيلة في القطن

عبدالناصر محمد رضوان عبدالبارى - ياسر عبدالرؤوف محمد سليمان - هشام مسعد السيد عباس حمود و محمد عبدالفتاح ابواليزيد شتا

معهد بحوث القطن – مركزالبحوث الزراعية – الجيزة – مصر

اشتملت الدراسة على خمسة أصناف من القطن الباربادنس هى : جيزه ٨٦ ، TNB1 ، Suvin ، جيزه ٨٥ و جيزه ٨٩. اجرى التهجين بينها طبقا لنظام التزاوج الدائرى النصف كامل لتنتج ١٠ هجن جيل أول خلال موسم النمو ٢٠٠٤ . فى موسم النمو ٢٠٠٥ تم تزاوج هجن الجيل الأول مع الأباء لإنتاج ٣٠ هجين ثلاثي (بشرط ظهور أي أب في الهجين الثلاثي مرة واحدة). وفى موسم النمو ٢٠٠٦ تم تقييم هذه التراكيب الوراثية المختلفة (الأباء الخمسة ، ٣٠ هجين ثلاثى) بمحطة البحوث الزراعية بسخا فى تجربة قطاعات كاملة العشوائية ذات ثلاث مكررات حيث تم قياس الصفات الآتية: محصول القطن الزهر للنبات ، محصول القطن الشعر للنبات ، وزن اللوزة ، عدد اللوز المتفتح للنبات ، معامل الحليج ، متانة التيلة ،نعومة التيلة، طول التيلة ،معامل الأنتظام .

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

- اختبار المعنوية لمتوسط المربعات الخاصة بالتراكيب الوراثية أشار إلى أن هناك اختلافا معنويا أوعالى المعنوية بين هذه التراكيب الوراثية لكل الصفات المدروسة.
- من خلال تحليل الهجن الثلاثية كان أفضل الأصناف قدرة عامة علي التآلف الصنف جيزه ٨٦ عند استخدامه كأب والصنف TNB1 عند استخدامه كأب و/ أو نصف أب لصفات المحصول أما الصنف جيزه ٨٥ فقد كان افضل الأصناف قدرة عامة على الإئتلاف عند استخدامه كأب و/ أو نصف أب لمعظم صفات التيلة.
- أظهرت الهجن التالية أفضل إمكانية لإستخدامها في برامج التربية لتحسين صفات المحصول ومكوناته وفى مقدمتها محصول القطن الزهر ومحصول القطن الشعر وعدد اللوز المتفتح الكلي للنبات ثم باقى المكونات الأخرى للمحصول وهذه الهجن هى :[(جيزه ٨٦ × Suvin) × جيزه ٨٥]، [(جيزه ٨٦ × جيزه ٨٥) × جيزه ٨٩]، [(جيزه ٨٦ × جيزه ٨٩) × جيزه ٨٥]،[(Suvin ×TNB1) × جيزه ٨٩]. وأخيرا الهجين [(TNB1× جيزه ٨٩) × جيزه ٨٥].
- أظهر الهجينان [(جيزه ٨٦ × TNB1) × جيز٨٩]، [(Suvin × جيزه ٨٥) × جيزه ٨٩] افضل امكانية لإستخدامها فى تحسين صفات المحصول وطول التيلة معا.
- اوضح الهجينان[(جيزه ٨٦ × جيزه ٨٩) × Suvin]،[(TNB1 × جيزه ٨٥) × Suvin] افضل امكانية لإستخدامها فى تحسين صفة متانة التيلة .
- أظهر تحليل الهجن الثلاثية أن قيم معامل التوريث فى معناه الواسع تراوحت من ٩٦,٠٠% الى ٩٩,٧٣% لصفتى متانة التيلة و محصول القطن الزهر للنبات على الترتيب وفى المعنى الضيق تراوحت القيم من ٠,٧٩% الى ٢١,٣٣% لصفتى معدل الحليج و محصول القطن الزهر للنبات على التوالى .
- بينت النتائج أن قيم التباين المضيف و التباين المضيف × السيادى تلعب دوراً هاماً فى توارث جميع الصفات المدروسة ولذلك يجب على مربى القطن أن يستخدم هذه النتائج من اجل استنباط سلالات عالية الإنتاجية من خلال تصميم برنامج انتخابى فى الأجيال الانعزالية المتقدمة من الهجن الثلاثية المتفوقة.