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TRIALLEL ANALYSIS OF SOME QUANTITATIVELY INHERITED TRAITS IN *Gossypium barbadense* L.: I- YIELD AND YIELD COMPONENTS

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ABSTRACT

This investigation aimed to evaluate some three-way crosses of Egyptian cotton for combining ability and further partition of genotypic variance to its components for yield and yield components. The genetic materials used in the present study included six cotton varieties and their 60 three-way crosses. These genotypes were evaluated during two successive growing seasons at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate for the following traits: seed cotton yield/plant, lint yield/plant, boll weight, number of open bolls/plant, lint percentage, seed index and lint index.

The results revealed that partition of the three-way crosses mean squares to its components predicted the significant contribution of additive, dominance and epistatic variances in the genetic expression of yield and its components. Giza 86 and Giza 89 varieties were the best general combiners as a parent and/or grand parent in the three-way crosses for yield and yield components. Therefore, these parental varieties could be utilized in a breeding program for improving these traits to pass favorable genes for improving hybrid and subsequently producing improved genotypes through the selection in segregating generations. The best combinations as grand parents (parent's of single cross) were a result of crossing poor x poor and/or good x poor general combiners in most of studied traits. Thus, it is not necessary that parents having high general combining ability effect (g_k) would also contribute to high specific combining ability effects (d_{ij}).The combinations [(Giza 76 x Giza 87) x Giza 85, (Giza 76 x Giza 77) x Giza 89, (Giza 86 x Giza 89) x Giza 85, (Giza 86 x Giza 76) x Giza 87, (Giza 86 x Giza 77) x Giza 85, (Giza 86 x Giza 87) x Giza 89, (Giza 85 x Giza 77) x Giza 87, (Giza 86 x Giza 87) x Giza 77 and (Giza 89 x Giza 87) x Giza 85] appeared to be the best promising three – way crosses for breeding toward improving the yield traits potentiality. Most of these combinations involved at least one of the best general combiners for yield. In addition, the results showed that yield and its components were mainly controlled by additive variance as well as additive x dominance and dominance x dominance epistatic variances, while the other components play the minor role in the inheritance of these traits. Thus, the selection within the advanced generations of the previous three-way crosses may be effective for improving yield components.

Keywords: Triallel analysis, Gene action, Cotton, Combining ability

INTRODUCTION

Combining ability analysis and the genetic components of any breeding materials supply the breeders useful information regarding choice of parents for development superior hybrids and/or determine the most effective breeding methods. Two types of general combining ability effects and three kinds of specific combining ability effects according to the parent's order in the three-way cross are valid (Ponnuswamy *et al.*, 1974). In addition, triallel cross analysis provides additional information 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 information on the order in which parents should be crossed for obtaining superior recombinants (Singh and Narayanan, 2000).

General (GCA) and specific (SCA) combining ability effects have been studied in cotton by several investigators, among them, Carvalho *et al.*, (1995) , Hassan and Awaad (1997), Kosba *et al.*, (1999), Iftikhar *et al.*, (2001), Kumar and Raveendran (2001), El-Helw, (2002) and Christopher *et al.*, (2003). Rady *et al.* (1999) mentioned that both GCA and SCA are important in the genetic expression of studied yield traits. They added that additive and additive by additive types of gene action were of greater importance in the inheritance of most yield attributes. On the other hand, Sorour *et al.*, (2000) reported that the variances due to dominance effects were larger than those of additive effects for seed cotton yield/plant and number of bolls/plant. In addition, additive and dominance variances were played the same role in the inheritance of lint cotton yield/plant, boll weight and lint index. However, Zeina *et al.*, (2001) observed that dominance genetic variance was larger than those of additive genetic variance for seed cotton yield, lint yield, lint percentage and number of bolls/plant at most of soil salinity and their combined data. While, dominance and additive genetic variance played approximately the same role in the inheritance of these traits.

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

MATERIALS AND METHODS

Genetic materials:

The genetic material used in the present investigation included six Egyptian cotton varieties belong to *Gossypium barbadense* L.). Three of them are long staple, Giza-85 (P_1), Giza-86 (P_2) and Giza-89 (P_3), while the other are extra-long staple, Giza-76 (P_4), Giza-77 (P_5) and Giza-87 (P_6). The inbred seeds of all varieties were obtained from Cotton Breeding Section, Cotton Research Institute, Agricultural Research Center, Giza, Egypt. In the growing season of 1999, the six parents were planted and mated in a diallel fashion excluding reciprocals to obtain 15 single crosses. In 2000 growing season, the crossing of these 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 60 three-way crosses; number of three-way crosses = p (p-1)(p-2)/2 where, p: is equal to number of parental varieties. In addition, the parental varieties were also self-pollinated to obtain enough seed for further investigations.

Experimental procedure:

In the two growing seasons of 2001 and 2002, the genetic materials were evaluated in a field trial experiment at Sakha Agricultural Research

Station, Kafr El-Sheikh Governorate. The genetic material used in these experiments consisted of 66 genotypes (six parental varieties and 60 three way crosses). The experimental design used was a randomized complete blocks design with three replications in both years. Each plot was one row 4.0 m long and 0.6 m. wide. Hills were 0.4 m apart to insure 10 hills per row. Hills were thinned to keep a constant stand of one plant per hill at seedlings stage. Ordinary cultural practices were followed as usual for the cotton field in the two years.

Data were recorded on the following traits: Seed cotton yield per plant in grams (S.C.Y./P); lint yield per plant in grams (L.Y./P); boll weight in grams (B.W); number of open bolls per plant (N.B./P); lint percentage (L%); seed index (S.I) and lint index (L.I).

Biometrical analysis:

The combined analysis for combining ability over two years was carried out for all studied traits according to the procedure outlined by Singh (1973) with modification for triallel-crosses analysis (Singh and Chaudhary, 1985). Considering Y_{ijkl} as the measurement recorded on a triallel cross, the mathematical model takes the following form:

$$Y_{ijkl} = m + b_1 + h_i + h_j + d_{ij} + g_k + s_{ik} + s_{jk} + t_{ijk} + e_{ijkl}$$

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. Hence specific effects of second kind.

t_{ijk} : three-line specific effect.

e_{ijkl} : error effect.

Where the estimation of these effects were as follows:

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

$$g_k = \frac{P-4}{rP(P-3)} \left[Y_{..i.} + [1/(P-2)]\, Y_{i...} - [1/(P-2)]\, Y_{....}\right]$$

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

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

Where:

$D = P^2 - 5P + 5$

$D_1 = P^3 - 7P^2 + 14P - 7$

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

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

The variance components; $\sigma^2 e$, $\sigma^2 t$, $\sigma^2 tt$, $\sigma^2 d$, $\sigma^2 ds$, $\sigma^2 s$, $\sigma^2 ss$, $\sigma^2 gh$, $\sigma^2 h$ and $\sigma^2 g$ were estimated according to the formulae cited in Singh and Chaudhary (1985). Where, Ponnuswamy *et al.* (1974) demonstrated that the variances and co-variances components of general effects i.e., $\sigma^2 h$, $\sigma^2 g$, $\sigma^2 gh$ are the function of additive and additive x additive type of epistasis, whereas $\sigma^2 d$ and $\sigma^2 ds$ are the functions of additive x additive type of epistasis only. $\sigma^2 s$ and $\sigma^2 ss$ involve dominance components, while $\sigma^2 t$ and $\sigma^2 tt$ account for epistatic components other than additive x additive. Therefore, the genetic variance components could be calculated from the previous variances using the following manner and the breeding coefficient assumed to be one (F = 1).

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

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

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

$$\sigma^2 AD = \frac{32}{3F^3}\left[\sigma^2 s - \sigma ss + 4\,\sigma tt\right]$$

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

Subsequently, the estimate of dominance degree ratio was recorded for all studied traits.

RESULTS AND DISCUSSION

Analysis of variance of 60 three-way crosses were made for all studied yield and yield component traits and the mean square from the combined data over two years are presented in Table 1. The results indicated that the magnitudes of the crosses mean squares of all studied yield and yield component traits were 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 all studied yield traits except for seed index, indicating to the role of additive gene action in the inheritance of these traits. In addition, the mean squares due to s eliminating d, d eliminating s and t_{ijk} were significant for all studied yield traits, referred to the contribution of dominance and epistatic variances in the genetic expression of these traits. While, the first two source of variances were larger in magnitudes than other crosses mean squares components, suggesting that additive genetic variance played the 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.

Table 1: Combined analysis of variance and mean squares of triallel crosses for yield and yield component traits

S.O.V.	d.f	S.C.Y./P.	L.Y./P.	B.W.	N.B./P.	L. %	S.I.	L.I.
Years (Y)	1	ˊ52621.3**	2906.3**	5.71**	15402**	219.1**	9.19	22.64*
Rep/years.	4	314.6	59.7	0.04	31.04	9.7	4.28	2.01
Crosses	59	1469.2**	187.5**	0.18**	229.6**	12.2**	0.80**	0.92**
Due to *h* eliminating *g*	5	4206.1**	38937**	0.32**	535.7**	42.1**	0.63	1.69**
Due to *g* eliminating *h*	5	6920.5**	978.4**	0.22**	872.3**	91.6**	0.60	5.16**
Due to *s* eliminating *d*	19	503.7**	51.4**	0.18**	85.4**	3.4**	0.86**	C 48**
Due to *d* eliminating *s*	9	978.6**	104.8**	0.16*	255.9**	2.8	0.68	C.43*
Due to *t*	21	1042.1**	112.4**	0.13**	152.6**	4.0**	0.76*	0.51**
Crosses x Y	59	1510.0**	269.15**	0.21**	194.9**	4.63**	.87**	0.50**
Due to *h* eliminating *g* x Y	5	1649 8**	180.3**	0.18*	166.6**	3.7	0.77	0.37
Due to *g* eliminating *h* x Y	5	2150.3**	294.0**	0.26**	235.4**	17.5**	1.01*	1.19**
Due to *s* eliminating *d* x Y	19	733.5**	92.1**	0.26**	132.3**	3.8**	0.96**	0 46**
Due to *d* eliminating *s* x Y	9	1487.4**	204.1**	0.13*	170.8**	5.2**	1.09**	0.66**
Due to *t* x Y	21	1573.2**	172.9**	0.20**	200.7**	2.7	0.91**	0.39**
Error	236	45.6	10.48	0.07	20.33	1.71	0.41	0.19

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

The results showed that the crosses interacted significantly with years for the studied traits. Moreover, the mean squares due to h eliminating g by years, g eliminating h by years, s eliminating d by years, d eliminating s by years and tijk by years interaction were significant or highly significant for studied traits except mean square due to tijk by years interaction for lint percentage as well as mean squares due to h eliminating g by years interactions in the cases of lint percentage, seed index and lint index. The significant estimates indicated that these components were unstable with different environmental conditions.

Combining ability effects:

Due to the variable magnitudes and signs of general and specific combining ability effects were different from year to another with respect to most of studied yield and yield/component traits. Therefore, the general and specific combining ability effects from the combined data would be more precise to present information concerning the behavior of these varieties.

Two types of general combining ability effects are worked out through triallel crosses. viz., general line effect of first kind (hi) and general line effect of second kind (g_i). 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 crossed to the single cross.

The estimates of general combining ability effect (hi) of the parental varieties are presented in Table 2. Positive estimates would indicate that a given variety is much better than the average of the group involved with it in the triallel crosses. Comparison of the general combining ability effect (hi) of individual parent exhibited that no parent was the best combiner as a grand parent for all yield and its component traits in the two years. The results from the combined data over both years revealed that the variety Giza 89 (P_3) was the best combiner as a grand parent among this group of varieties for yield and yield component traits except seed index. Moreover, the variety Giza 86 (P_2) was good combiner as a grand parent for lint index (L.I.), boll weight (B.W) and lint percentage (L.%). Furthermore, the estimates of general combining ability effect of second kind (g_k) of the parental varieties (Table 3) showed again that Giza 89 (P_3) followed by Giza 86 (P_2) were the best combiners for seed cotton yield/plant (S.C.Y./P.), lint yield/plant (L.Y./P.), number of bolls/plant (N.B./P.), lint percentage (L %) and lint index (L.I.). Thus, it could be suggested that these parental varieties could be utilized in a breeding program for improving these traits to pass favorable genes for improving hybrid and subsequently producing improved genotypes through the selection in segregating generations.

Table 2: Predicted general combining ability effects (h_i) for yield and yield component traits of the first kind lines (grand parent)

Parents	S.C.Y./P.	L.Y./P.	B.W.	N.B./P.	L.%	S.I.	L.I.
Giza 85	0.23	0.45	-0.029	0.35	0.397**	-0.165**	0.008
Giza 86	-3.56**	-0.24	0.071**	-2.45**	0.677**	0.038	0.173**
Giza 89	9.71**	3.48**	0.090**	2.39**	0.483**	-0.010	0.093*
Giza 76	-6.50**	-2.23**	-0.051*	-1.71**	-0.171	0.017	-0.026
Giza 77	-6.80**	-2.17**	-0.046	-2.06**	-0.146	0.058	-0.006
Giza 87	6.92**	0.70*	-0.027	3.47**	-1.240**	0.063	-0.242**
S.E.	0.66	0.32	0.025	0.44	0.128	0.063	0.042

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

Table 3 : Predicted general combining ability effects (g_k) for yield and yield component traits of the second kind lines (Parents)

Parents	S.C.Y./P.	L.Y./P.	B.W.	N.B./P.	L.%	S.I.	L.I.
Giza 85	-7.371**	-2.114**	-0.099**	-2.052**	0.834**	-0.049	0.15**
Giza 86	2.500*	1.881**	-0.038	1.090	1.571**	0.064	0.39**
Giza 89	19.752**	7.521**	0.075*	6.147**	0.751**	0.061	0.18**
Giza 76	-12.615**	-4.627**	0.058	-5.608**	-0.636**	-0.141	-0.21**
Giza 77	-4.427**	-2.060**	0.005	-1.528**	-0.492*	0.140	-0.04
Giza 87	4.162**	-0.601	0.000	1.950**	-2.027**	-0.075	-0.48**
S.E.	0.839	0.402	0.032	0.560	0.158	0.080	0.05

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

Regarding the specific combining ability effects, triallel crosses included three kinds of specific combining ability effects according to the parent's order in the three-way cross. These kinds are: two-line specific effects of the first kind (d_{ij}), which 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 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.The estimates of specific combining ability effects (d_{ij}) for all studied crosses with respect to yield and yield component traits are shown in Table 4.

Table 4: Predicted two-line specific combining ability effects of first kind (d_{ij}) for yield and yield components

Crosses	S.C.Y./P.	L.Y./P.	B.W.	N.B./P.	L.%	S.I.	L.I.
d_{12}	5.29*	1.76*	-0.12	3.11**	-0.61	-0.01	-0.15
d_{13}	3.46	2.30**	-0.20*	4.78**	1.06**	0.13	0.29**
d_{14}	-1.94	-1.88*	-0.20*	1.61	-1.78**	-0.41*	-0.57**
d_{15}	-11.42**	-4.03**	0.16*	-6.51**	0.34	0.13	0.14
d_{16}	-3.61	-2.20**	0.11	-3.22**	-0.26	0.14	0.01
d_{23}	-7.57**	-3.74**	0.10	-4.72**	-0.82*	-0.32	-0.33**
d_{24}	-3.02	-1.18	0.09	-1.72	0.24	0.21	0.16
d_{25}	4.15	0.92	-0.07	2.99**	-0.23	0.11	0.00
d_{26}	-10.86**	-4.34**	-0.17*	-2.22**	-0.91**	-0.14	-0.25*
d_{34}	7.12**	2.61*	0.28**	-0.55	0.39	0.48*	0.31**
d_{35}	3.39	0.93	0.14	-1.18	-0.37	0.43*	0.12
d_{36}	23.52**	6.16**	-0.10	14.45**	-1.68**	0.10	-0.30**
d_{45}	3.02	1.20	-0.08	3.32**	-0.11	-0.07	-0.07
d_{46}	1.02	1.07	0.09	-0.89	1.09**	0.01	0.25
d_{56}	19.42**	9.96**	0.37**	2.99**	0.33	0.14	0.13
S.E.	2.08	0.75	0.08	1.07	0.33	0.20	0.11

1, 2, 3, 4, 5 and 6: are Giza 85, Giza 86, Giza 89, Giza 76, Giza 77 and Giza 87, respectively.
***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

The results cleared that no hybrid exhibited positive and significant values for all studied yield traits. However, 4, 5, 3, 6, 2, 2 and 3 out of 15 combinations showed positive and significant or highly significant specific combining ability effects (d_{ij}) values 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.), lint percentage (L. %), seed index (S.I.) and lint index (L.I.), respectively. It is worth to notice that these crosses in cases of seed cotton yield/plant (S.C.Y./P.) and lint yield/plant (L.Y./P.) were a result of crossing poor x poor general combiners Giza 77 x Giza 87 (d_{56}) and good (Giza 89) x poor (Giza 76) general combiners (d_{34}). The same trend was observed in other yield and its component traits. Thus, it is not necessary that parents having high general combination ability effect (g_k) would also contribute to high specific combining ability effects (d_{ij}). The specific combining ability effects of second kind (S_{ik}) [where i is a grand parent and k is a parent] for all possible combination, with respect to the studied yield and its components traits from the combined data over two years were obtained and the results are presented in Table 5.

Table 5: Predicted two-line specific combining ability effect of second kind (S_{ik}) for yield and yield components traits

Combinations	S.C.Y./P.	L.Y./P.	B.W.	N.B./P.	L%	S.I.	L.I.
S_{12}	5.701**	2.191**	0.204**	-1.043	0.140	0.293*	0.164
r	-0.846	1.198	-0.009	-0.263	0.582*	0.060	0.178*
S_{13}	-3.533**	-1.072	-0.121*	0.605	-0.189	-0.127	-0.117
r	4.239**	0.214	0.123*	-0.736	-0.778**	-0.429**	-0 339**
S_{14}	0.149	-0.045	-0.015	-0.464	-0.184	-0 152	-0.112
r	1.493	0.658	0.010	1.249	0.201	0.074	0.089
S_{15}	3.434**	1.204	-0.067	3.032**	0.634*	0 059	0.168*
r	-6.181**	-1.289*	-0.189**	-0.105	-0.031	0.002	0.001
S_{16}	-5.751**	-2.279**	-0.001	-2.130	-0.402	-0.072	-0.103
r	1.295	-0782	0.065	-0.145	0.026	0.293*	0.131
S_{23}	-2.060	0.670	-0.055	0.036	-0.151	-0.158	-0.114
r	-7.698**	-2.103**	-0.003	-2.818**	0.337	-0.027	0.087
S_{24}	0.946	-0.151	-0.088	1.532	0.187	-0.006	0.027
r	0.859	-0.55	-0.102*	0.974	-0.132	0.042	-0.010
S_{25}	-1.842	-0.797	0.056	-1.208	0.070	-0.0985	-0.029
r	3.879**	0.576	-0.011	2 035*	-0.412	0 045	-0 076
S_{26}	3.801**	0.420	0.096	3-0.097	-0.688**	0.190	-0.061
r	-2.740*	-0.609	-0.088	0.852	0.067	-0.352**	-0.165
S_{34}	8.676**	3.011**	-0.041	4.530**	0.148	0.420**	0.235**
r	-3.050*	-1.246*	0.018	-1.153	-0.067	0.095	0.034
S_{35}	1.729	0.806	-0.017	0.172	0.039	-0.062	-0.021
r	5.449**	1.739**	0.121*	0.591	0.216	0.214	0.168*
S_{36}	-6.946**	-1.929**	-0.063	-1.147	0.255	0.098	0.098
r	3.195*	1.249	0.036	-0.079	0.190	-0.024	0.304
S_{45}	-2.214	-1.370*	0.062	-1.623	-0.738**	-0.143	-0.230**
r	-9.129**	-2.801**	0.122*	-5.344**	0.128	-0.114	-0.041
S_{46}	2.913*	2.012**	0.011	0.552	0.736**	-0.068	0.117
r	-0.642	-0.014	0.022	-0.254	-0.279	-0.148	-0.108
S_{56}	5.983**	1.776**	-0.043	2.822**	0.098	-0.147	-0.051
R	-1.107	0.157	-0.034	-0.373	-0.004	0.231	0.112
S.E.	1.325	0.636	0.051	0.885	0.257	0.126	0.085

***,** Significant at 0.05 and 0.01 levels of probability, respectively**
1, 2, 3, 4, 5 and 6: are Giza 85, Giza 86, Giza 89, Giza 76, Giza 77 and Giza 87, respectively. r: is the reciprocal order.

The results revealed that no combination exhibited positive significant values for all yield and yield component traits. However, it could be notice that the combination with line 3 (Giza 89) used as one of the grand parent (in single hybrid) and line 4 (Giza 76) as parent (S_{34}) gave high performance as compared to any other combinations for seed cotton yield/plant (S.C.Y./P.), line yield/plant (L.Y./P.), number of bolls/plant (N.B./P.), seed index (S.I.) and lint index (L.I.). Meanwhile, the combination with line 1 (Giza 85) used as one of the grand parent and line 2 (Giza 86) as parent (S_{12}) gave positive (desirable) and significant or highly significant for seed cotton yield/plant, lint yield/plant, boll weight and seed index. Moreover, the combination with line 4 used as one of the grand parent and line 6 (Giza 87) as parent (S_{46}) appeared to be the best specific combination for seed cotton yield/plant, lint yield/plant and lint percentage.

Three-line specific effect (t_{ijk}) which, refers to specific combining ability effect of a line in three-way cross for all possible combinations for the studied traits were obtained and the results are presented in Table 6.

Table 6: Predicted three-line specific effect (t) for yield and yield component traits

Crosses	S.C.Y./P.	L.Y./P.	B.W.	N.B./P.	L. %	S.I.	L.I.
$P_1 \times P_2 \times P_3$	5.736**	1.981*	-0.013	3.123**	0.165	0.001	0.034
$P_1 \times P_2 \times P_4$	5.833**	2.729**	-0.021	2.955**	0.901*	0.234	0.294**
$P_1 \times P_2 \times P_5$	-3.719*	-1.438	0.056	-3.097**	-0.045	0.073	0.028
$P_1 \times P_2 \times P_6$	-7.850**	-3.271**	-0.021	-2.981**	-1.021**	-0.308	-0.356**
$P_1 \times P_3 \times P_2$	-2.933	-1.724*	-0.087	0.187	-0.330	-0.255	-0.197
$P_1 \times P_3 \times P_4$	0.377	-0.010	0.188**	-2.488	-0.407	-0.091	-0.125
$P_1 \times P_3 \times P_5$	4.551**	1.728*	0.045	0.790	0.256	-0.059	0.036
$P_1 \times P_3 \times P_6$	-1.995	0.007	-0.146*	1.510	0.481	-0.405**	0.286**
$P_1 \times P_4 \times P_2$	5.319**	1.144	-0.003	1.647	-0.433	0.183	-0.031
$P_1 \times P_4 \times P_3$	-3.074	-1.104	0.025	-2.194*	-0.023	-0.108	-0.062
$P_1 \times P_4 \times P_5$	-3.315*	-0.189	-0.116	1.084	0.408	0.242	0.214*
$P_1 \times P_4 \times P_6$	1.070	0.150	0.095	-0.537	0.048	-0.317*	-0.120
$P_1 \times P_5 \times P_2$	-4.959**	-1.417	0.018	-1.905	-0.273	-0.233	-0.149
$P_1 \times P_5 \times P_3$	-0.015	0.364	-0.005	-0.133	0.267	-0.056	0.029
$P_1 \times P_5 \times P_4$	-3.801*	-2.062**	-0.085	0.330	-0.486	0.069	-0.070
$P_1 \times P_5 \times P_6$	8.775**	3.115**	0.073	2.008	0.492	0.220	0.190
$P_1 \times P_6 \times P_3$	2.573	1.997*	0.072	0.071	1.037**	0.305*	0.378**
$P_1 \times P_6 \times P_3$	-2.648	-1.240	-0.007	-0.796	-0.409	0.163	-0.001
$P_1 \times P_6 \times P_4$	-2.409	-0.657	-0.081	-0.497	-0.008	-0.212	-0.099
$P_1 \times P_6 \times P_5$	2.483	-0.100	0.016	1.223	-0.619*	-0.257	-0.278*
$P_2 \times P_3 \times P_1$	12.425**	5.002**	0.134*	3.101**	-0.711*	-0.047	-0.182
$P_2 \times P_3 \times P_4$	-7.793**	-2.889**	-0.061	-2.614*	0.089	0.122	0.100
$P_2 \times P_3 \times P_5$	1.771	-0.132	-0.182*	3.464**	-0.029	-0.208	-0.116
$P_2 \times P_3 \times P_6$	-6.403**	-1.980*	0.089	-3.952**	0.650*	0.133	0.198
$P_3 \times P_4 \times P_1$	-3.561*	-2.704**	-0.071	-0.816	-0.269	0.042	-0.024
$P_2 \times P_4 \times P_3$	-1.560	-0.157	0.037	-1.467	0.087	-0.195	-0.072
$P_2 \times P_4 \times P_5$	-7.268**	-1.789*	0.075	-3.713**	-0.285	-0.179	-0.158
$P_2 \times P_4 \times P_6$	12.389**	4.651**	-0.041	5.996**	0.466	0.333*	0.253*
$P_2 \times P_5 \times P_1$	14.074**	4.375**	0.088	4.745**	0.522	0.346*	0.289**
$P_2 \times P_5 \times P_3$	-16.264**	-5.641**	-0.089	-5.322**	-0.102	0.150	0.052
$P_2 \times P_5 \times P_4$	0.325	0.865	0.030	-0.361	-0.324	-0.339*	-0.246*
$P_2 \times P_5 \times P_6$	1.864	0.601	-0.027	0.937	-0.096	-0.157	-0.035
$P_2 \times P_6 \times P_1$	-22.938**	-6.672**	-0.149*	-7.031**	0.457	-0.341*	-0.083
$P_2 \times P_6 \times P_3$	12.087**	3.817**	0.065	3.685**	-0.151	0.045	-0.015
$P_2 \times P_6 \times P_4$	1.635	-0.505	0.053	0.019	-0.666	-0.018	-0.148
$P_2 \times P_6 \times P_5$	9.216**	3.360**	0.031	3.346**	0.359	0.314*	0.246*
$P_3 \times P_4 \times P_1$	-10.210**	-2.872**	-0.022	-3.302**	0.083	0.117	0.065
$P_3 \times P_4 \times P_2$	-0.560	0.606	-0.105	1.866	0.647**	-0.002	0.200
$P_3 \times P_4 \times P_5$	7.960**	1.821*	0.102	1.471	-0.306	0.131	-0.004
$P_3 \times P_4 \times P_6$	2.789	0.445	0.025	-0.036	-0.625*	-0.246	-0.261*
$P_3 \times P_5 \times P_1$	-11.413**	-3.681**	-0.194**	-1.734	-0.322	-0.194	-0.173
$P_3 \times P_5 \times P_2$	0.744	0.585	0.212**	-3.221**	0.601	0.482**	0.349**
$P_3 \times P_5 \times P_4$	5.059**	1.567*	-0.050	2.478*	0.227	0.005	0.047
$P_3 \times P_5 \times P_6$	5.609**	1.529	0.032	2.478*	-0.507	-0.292	-0.223*
$P_3 \times P_6 \times P_1$	9.197**	1.551*	0.083	1.935	0.949**	0.124	0.290*
$P_3 \times P_6 \times P_2$	2.748	0.533	-0.020	1.167	-1.118**	-0.225	-0.352**
$P_3 \times P_6 \times P_4$	2.357	1.333	-0.077	2.624*	0.091	-0.035	-0.023
$P_3 \times P_6 \times P_5$	-14.302**	-3.417**	0.014	-5.726**	0.078	0.137	0.084
$P_4 \times P_5 \times P_1$	-1.316	-0.119	0.067	-1.994	0.695*	-0.264	0.025
$P_4 \times P_5 \times P_2$	2.389	0.806	-0.034	1.425	-0.411	-0.174	-0.171
$P_4 \times P_5 \times P_3$	15.176**	4.558**	0.045	5.992**	-0.395	0.209	0.019
$P_4 \times P_5 \times P_6$	-16.249**	-5.245**	-0.078	-5.423**	0.111	0.230	0.128
$P_4 \times P_6 \times P_1$	15.087**	5.695**	0.026	6.112**	-0.510	0.106	-0.066
$P_4 \times P_6 \times P_2$	-7.147**	-2.556*	0.143*	-4.939**	-0.003	-0.006	0.003
$P_4 \times P_6 \times P_3$	10.542**	-3.296**	-0.107	-2.331*	0.330	0.095	0.116
$P_4 \times P_6 \times P_5$	2.602	0.157	-0.061	1.158	0.182	0.194	-0.052
$P_5 \times P_6 \times P_1$	-1.346	-0.574	0.041	-1.017	-0.896**	0.112	-0.140
$P_5 \times P_6 \times P_2$	1.826	0.026	-0.195**	3.701**	0.083	-0.074	-0.029
$P_5 \times P_6 \times P_3$	1.102	0.719	0.049	-0.538	0.230	-0.302	-0.100
$P_5 \times P_6 \times P_4$	-1.583	-0.171	0.106	-2.146*	0.583	0.265	0.270
S.E.	1.631	0.782	0.062	1.089	0.316	0.155	0.104

P_1, P_2, P_3, P_4, P_5 and P_6: Giza 85, Giza 86, Giza 89, Giza 76, Giza 77 and Giza 87, respectively.
*, ** Significant at 0.05 and 0.01 levels of probability, respectively

The results revealed that no three-way cross exhibited positive significant values for all yield and yield component traits. However, 17, 15, 4, 14, 6, 6 and 9 out of 60 three-way crosses showed positive and significant specific combining ability effects (t_{ijk}) values 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.), lint percentage (L.%), seed index (S.I.) and lint index (L.I.), respectively. In general, the combinations [(Giza 76 x Giza 87) x Giza 85, (Giza 76 x Giza 77) x Giza 89, (Giza 86 x Giza 89) x Giza 85, (Giza 86 x Giza 76) x Giza 87, (Giza 86 x Giza 77) x Giza 85, (Giza 86 x Giza 87) x Giza 89, (Giza 85 x Giza 77) x Giza 87, (Giza 86 x Giza 87) x Giza 77 and (Giza 89 x Giza 87) x Giza 85] appeared to be the best promising three way crosses for breeding toward all studied yield traits potentiality. 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.

Genetic parameters:

The genetic parameters estimates were obtained and the results are presented in Table 7.

Table 7:The estimates of genetic parameters from the three-way crosses analysis for yield and yield component traits

G. Parameters	S.C.Y/P	L.Y./P.	B.W.	N.B./P.	L. %	S.I.	L.I.
σ^2A	393.39	44.52	2.98	38.42	6.92	3.03	3.16
σ^2D	-515.01	-63.28	2.96	-87.38	2.15	2.54	2.74
σ^2AA	-172.96	-6.541	-3.42	-1.07	-4.42	-3.52	-3.42
σ^2AD	1451.71	150.80	0.31	191.38	4.49	2.11	0.86
σ^2DD	1045.16	106.87	1.58	138.06	2.12	4.13	0.28
σ^2e	45.60	10.483	0.06	20.32	1.70	0.41	0.18
D.d	0.00	0.000	0.99	0.000	0.55	0.91	0.93

Note: Negative values were considered equal to zero during the calculation of dominance degree ratio.

The results revealed that the magnitudes of additive genetic variance (σ^2A) were positive and larger than those of dominance genetic variance (σ^2D), with respect to all the studied traits. These indicated the predominance of additive generic variance in the inheritance of these traits. These could be emphasized by the dominance degree ratio (D.d), which was less than one or equal to zero, revealing the importance of partial or no-dominance in the inheritance of these traits. Generally, these results were in agreement with those reported by Rahoumah *et al.* (1989), Gomaa (1997), Kosba *et al.* (1999), Abd El-Maksoud *et al.* (2000), Sorour *et al.* (2000), Awad (2001) and Christopher *et al.*, (2003). Concerning epistatic variances, additive by additive genetic variance (σ^2AA) showed negative estimates for all studied yield traits. While, additive by dominance genetic variance (σ^2AD) and dominance by dominance genetic variance (σ^2DD), showed positive and considerable magnitude for all studied traits. It could be concluded that yield components were mainly controlled by additive variance in addition to additive x dominance and dominance x dominance epistatic variances. These findings suggested that the selection within the advanced generations of superior three way-crosses may be effective for improving yield components.

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تحليل الهجن الثلاثية لبعض الصفات المورثة كميا فى القطن
١- صفات المحصول ومكوناته

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تهدف هذه الدراسة إلى تقييم بعض الهجن الثلاثية من القطن المصرى من حيث قدرتها على التآلف ، علاوة على تقسيم التباين الوراثى إلى مكوناته لصفات المحصول. وفى هذه الدراسة تم تقييم ستة أصناف من القطن المصرى والهجن الثلاثية الناتجة بينها (٦٠ هجين ثلاثى) وذلك فى موسمين زراعيين متتاليين بمحطة البحوث الزراعية بسخا – محافظة كفر الشيخ للصفات التالية :- محصول القطن الزهر ، محصول القطن الشعر ، وزن اللوزة ، عدد اللوز المتفتح للنبات ، معامل الحليج ، معامل البذرة ، ومعامل الشعر.

أشارت النتائج المتحصل عليها أنه بتقسيم متوسط مربعات الهجن الثلاثية إلى مكوناته ، إتضح أن كل من الفعل الجينى المضيف والسيادى والتفوقى يساهم معنويا فى التعبير الوراثى لهذه الصفات.

الصنف جيزة ٨٦ ، جيزة ٨٩ كانا أحسن الأباء قدرة عامة على التآلف عند إستخدام كل منهما كأحد الأباء للهجن الفردية أو كأب ثالث فى الهجن الثلاثية فى الصفات المدروسة. ولذلك يمكن إستخدام هذه الأصناف فى برامج التربية بغرض تحسين هذه الصفات من خلال إنتاج هجن ثلاثية بتجميع الجينات المرغوبة فيها ثم يتبعها الإنتخاب فى الأجيال الإنعزالية المتقدمة للحصول على تراكيب وراثية مميزة فى صفات المحصول.

إتضح أن أفضل الهجن الثلاثية لقدرتها الخاصة على التآلف كانت (جيزه ٧٦ ×جيزه ٨٧) ×جيزه ٨٥ ، (جيزه ٧٦ ×جيزه ٧٧) ×جيزه ٨٩ ، (جيزه ٨٦ ×جيزه ٨٩) ×جيزه ٨٥ ، (جيزه ٨٦ ×جيزه ٧٦) × جيزه ٨٧ ، (جيزه ٨٦ ×جيزه ٧٧) ×جيزه ٨٥ ، (جيزه ٨٦ ×جيزه ٨٧) ×جيزه ٨٩ ، (جيزة ٨٥ × جيزة ٧٧) ×جيزة ٨٧ ، (جيزة ٨٦ × جيزة ٨٧) ×جيزة ٧٧ و (جيزه ٨٩ ×جيزه ٨٧) ×جيزه ٨٥. ومعظم هذه الهجن أشتملت أحد الأصناف ذات القدرة العامة عالية التآلف. بالإضافة إلى ذلك أشارت النتائج إلى أن صفات المحصول ومكوناته محكومة رئيسيا" بالفعل الجينى المضيف والتفاعل التفوقى بين الفعل الجينى المضيف والسيادى والسيادى مع السيادى بينما المكونات الأخرى التى تشمل الفعل الجينى السيادى والمضيف x المضيف تلعب الدور الثانوى فى توريث مثل هذه الصفات. ولذلك فإن الإنتخاب فى الأجيال الإنعزالية المتقدمة للهجن الثلاثية السابق الأشارة إليها يكون هو الطريقة الفعالة لتحسين المحصول ومكوناته.