COMBINING ABILITY AND THE ORDER EFFECT IN DOUBLE CROSS HYBRIDS OF COTTON 1- EARLINESS TRAITS

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(Manuscript received 16 May 2011)

Abstract

The objectives of this study were to determine the components of genetic variance and its order on the effect of the hybrids of double cross. Six diverse strains belonging to (*Gossypium barbadense,* L.). were used to produce 45 possible double cross hybrids. These hybrids were raised cross in a randomized complete block design with three replications. The additive gene variances were negative for earliness traits while the values of epistasis of additive (A) x additive (A) types were considerable for earliness traits. The epistasis additive x additive x additive was significant for earliness traits except for position of first fruiting node where the epistasis additive x dominance was considerable. The parent Karshenky (p_3) was the best parent when used as one forming the double crosses hybrids for earliness traits. The parent {Australian (P_1), BBB (P_2)}, {Karshenky (P_3) and Suvin (P_5)} and {BBB (P_2) and Giza 70 (P_4)} had highest negative of 2-lines general effect. in all possible combinations without respect to arrangement (ijk) the best triple was ($P_3P_5P_6$) followed $P_1P_2P_4$, $P_1P_2P_5$ and $P_1P_2P_3$ and $P_2P_4P_5$. From previously results it could be suggested that P_1, P_5, P_6, as well as P_3 formed the best "quadrialle" or with the parent Giza 70 (P_4) in earliness index. The general effect of set of any four parents parent in various combination irrespective of order, it was obvious that parents (P_1, P_2, P_5 and P_6), (p_1, P_2, P_4 and P_5), (P_1, P_3, P_5 and P_6), (p_1, P_4, P_5 and P_6) exhibited the best effected to forming the double crosses for position of first node, for days to first flower, days to first boll and earliness index. The results confirm that the order in which the parents go into double cross hybrids is a deciding factor for its high or low performance.

INTRODUCTION

Enhancement for earliness in cotton has recorded a staying period cotton was shortened from 270 days to 210 days. This improvement cannot be attributed to management practices only but also due to genetic improvement of cultivars. El-Tabbakh and El-Nakhlawy (1995) investigated inter-specific crosses of *G. barbadense* x *G. hirsutum*. They observed that the general combining ability (GCA) variance was not significant for height of first fruiting node and earliness index. On the other hand SCA variance was significant for height of first fruiting node while, it was highly significant for earliness index, suggesting that non-additive genetic variance was predominant over additive genetic variance in the inheritance of these traits. Abou El-Yazied (2004) indicated that the comparison of parental varieties for their combining ability revealed that the variety TNBI followed by BBB were the bet combiners for earliness traits. While the most pronounced SCA effects were found in the crosses (P.H. P x 24022, P.H.P. x Suvin and 24022 x G.88) in the case of height of first fruiting node. El-Hoseiny (2004) found that both GCA and SCA variances were significant for position of first fruiting node and days to first flower. He also added that the ratio GCA/SCA reflected the magnitude of dominance for the position of the first fruiting node and days to first flower. Kaushik *etal* (2006) and Kaushik and Kapoor (2007) found that significant general combining ability (GCA) and specific combining ability (SCA) x environment interactions were observed for those traits and they reported that variance ratio revealed the preponderance of non-additive genetic variance. Prasad *et al.* (2005) indicated that the heritability for days to 50% flowering was moderate while Potdukh and Parmar (2006) indicated that this trait exhibited low value of heritability. This study was conducted to giving the information on order effect of parent to form double crosses and estimated the genetic component for double crosses.

MATERIALS AND METHODS

Fourty five double crosses were obtained by mating between 15 F_1's of six parents belonging to *Gossypium barbadense,* L. which are Australian (P_1), BBB (big black boll) (P_2), Karshenky (P_3) and Suvin (P_5), while the other two varieties were extra-long staple, Giza 70 (P_4), Giza 77 x Pima S_6 (P_6). The .45 double crosses were sown in randomized complete block design experiment with three replications at Sakha Agricultural Research Station. Each plot consisted of three rows. The rows were 4 meter long and 65 cm apart. Hills were spaced 20 cm within rows and seedlings were thinned to two plants / hill. Conventional cultural practices were followed through the growing season. The measurements, were recorded on ten individual guarded plants from the middle row of each plot.

I. The studied traits:

1. Position of First fruiting node.
2. Days to the first flower.
3. Days to first boll opening.
4. Earliness index.

The analysis of variance of the quadriallel crosses was made for all studied traits according to the procedures outlined by Singh and Chudhary (1985). As follows:

II. C_4. Combining Ability Effects:

1- Average effect of line i = $g_i = [\, Y_{i....} / (r\, p_1\, p_2\, p_3/2)] - \mu$
Where, $\mu = Y_{....} / (p_1\, p_2\, p_3/8)$ Check: $\sum g_i = 0$

2- The two line interaction effect of lines i and j appearing together irrespective of arrangement. $= S^2_{ij} = [Y_{ij...}/(3r\, p_2 p_3/2)] - \mu - g_i - g_j$ Check: $\sum S^2_{(ij)} = 0$

3- The three line interaction effect of lines i, j and k appearing together irrespective of arrangement. $= S^3_{ijk} = (Y_{ijk...} / 3r\, p_3) - \mu - g_i - g_j - g_k - S_{ij} - S_{ik} - S_{jk}$ Check: $\sum S^3_{ijk} = 0$

4- The 4-line interaction effect of lines i, j, k and l appearing together irrespective of arrangement. $= S^4_{(ijkl)} = S_{ijkl} = [(Y_{ijkl..} / (3r)] - \mu - g_i - g_j - g_k - g_l - S_{ij} - S_{ik} - S_{il} - S_{jk} - S_{jl} - S_{kl} - S_{ijk} - S_{ijl} - S_{jkl} - S_{jkl}$ Check: $\sum S_{ijkl} = 0$

5- The 2- line interaction effect of lines i and j due to particular arrangement.(ij) (--)
$t_{(ij)(--)} = t^2_{(ij)(..)} = [Y_{(ij)(..).} /(r\, p_2 p_3/2)] - \mu - g_i - g_j - S_{ij}$ Check: $\sum t_{(ij)(..)} = 0$

6- The 2- line interaction effect of lines i and j due to particular arrangement.(i -) (j)
$t_{(i-)(j-)} = t^2_{(i-)(j-)} = [Y_{(i.)(j.).} / r\, p_2 p_3] - \mu - g_i - g_j - S_{ij}$ Check: $\sum t^2_{i.j.} = 0$

7- The 3- line interaction effect of lines i, j and k due to particular arrangement.(i j) (k -) $t^3_{ij.k} = t_{(ij)(k-)} = [Y_{(ij)(k.).} / r\, p_3] - \mu - g_i - g_j - g_k - S_{ij} - S_{ik} - S_{jk} - S_{ijk} - t^2_{ij} - t^2_{i.k} - t^2_{j.k}$

8- The 4- line interaction effect of lines i, j, k and l due to particular arrangement.(i j) (k l) $t^4_{ij\,kl} = t_{(ij)(kl)} = [Y_{(ij)(kl).} / r] - \mu - g_i - g_j - g_k - g_l - S_{ij} - S_{ik} - S_{il} - S_{jk} - S_{jl} - S_{kl} - S_{ijk} - S_{ijl} - S_{ikl} - S_{jkl} - S_{ijkl} - t^2_{ij} - t^2_{kl} - t^2_{i.k} - t^2_{i.l} - t^2_{j.k} - t^2_{j.l} - t^3_{ij.k} - t^3_{ij.l} - t^3_{kl.i.} - t^3_{kl.j}$ Check: $\sum t^4_{ijkl} = 0$

9- Check:

a) $t^2_{ij} + 2t_{i.j.} = 0$

b) $t^3_{ij.k} + t^3_{ik.j} + t^3_{jk.i} = 0$

c) $t^4_{ij.kl} + t^4_{ik.jl} + t^4_{il.jk} = 0$

10- Narrow sense heritability was estimated following equations

$$h^2 ns = \frac{\frac{1}{4}A + \frac{1}{8}AA + \frac{1}{16}AAA}{\frac{1}{4}A + \frac{1}{8}AA + \frac{1}{16}AAA + \frac{1}{8}D + \frac{1}{16}AD + \frac{1}{32}DD + \frac{E}{3}}$$

Where, A = Adittive, D= Dominance and E= Error variance

RESULTS AND DISCUSSION

I. The validity of double hybrids to additive dominance model

The analysis of double crosses serves a two fold purposes. The classification of genetic system underlying double cross hybrids of primary significance. In addition, the analysis provides estimates of genetic variance and test of genetic hypothesis. Table (1) revealed that 1-general and 2-line specific and arrangement effects were significant indicating the importance of additive gene effects and all additive type of epistatic interaction. The data also showed that 2-line specific and 2, 3 and 4-line arrangement effects were significant except 2-line specific for day to first boll opening and 3 and 4 arrangement for days to frist flower indicating importance of the dominance and the interaction involving dominance component for these results seemed to be predominant of non additive gene effect in the present material (Rawling and Cockarham 1962).

Table 1. Analysis of variance of double cross hybrids for earliness characters

Source	d.f	Position of first fruiting node	Days to first flower	Days to first boll	Earliness index
Replications	2	0.356	1.092	4.003	0.346
Hybrid	44	1.084**	2.386**	8.857**	90.717**
1-line general	5	3.438**	5.462**	19.874**	51.439**
2- line specific	9	0.622**	1.599*	4.600	94.928**
2- line arrangement	9	1.264**	4.499**	6.865**	134.410**
3- line arrangement	16	0.731**	1.027	9.453*	82.581**
4- line arrangement	5	0.370*	1.271	7.176*	69.808**
Error	88	0.158	0.693	2.328	4.295
Total	134	0.465	1.255	4.496	32.613

*,** significantly different at the 0.05 and 0.01 levels of probability, respectively

2. Genetic components and heritabilities.

The results in Table (2) indicated that the additive gene variance (σ^2A) was could be consideration equivalent to zero due to negative variance of all earliness traits. With respect the dominance variance were significant for the days to first flower, days to first boll and earliness index.

Table 2. The estimates of genetic variance to its components and genetic ratio for earliness characters in double cross hybrids

Source	Position of first fruiting node	Days to first flower	Days to first boll	Earliness index
Additive (A)	-0.799±0.087	-2.122±0.176	-6.261±0.273	-193.204±1.670
Dominance (D)	-0.702±0.046	5.360±0.131	3.089±0.185	235.345±0.623
A X A	2.696±0.056	0.206±0.097	7.270±0.159	19.449±0.823
A X D	1.736±0.029	-10.877±0.051	-54.501±0.086	-1185.419±0.306
D X D	3.401±0.034	7.402±0.058	86.883±0.121	1367.079±0.458
A X A X A	-1.157±0.030	7.251±0.051	36.334±0.085	790.280±0.409
Heritability	55.75	29.72	45.06	41.33

Table (2) showed that the genetic variance of all earliness traits except postion of first fruiting node were due to dominance (D), additive (A) x additive (A) , A x A X A and dominance x dominance gene effects. While the positive genetic variance positive for first fruiting node were due to A x A and A x D gene action. These results was are in partial agreement with those obtained by Abd El-Hadi *et al*., (2005) using three way crosses indicated that the additive effect was larger than dominance and the additive x dominance epistatic genetic variance were larger than those of dominance x dominance and additive x additive for number and of days day to first flower.

Table (2) showed that the heritability's were of high values for position first fruiting node, days to first boll and earliness index while, intermediate value of were detected for days to first flower. These results were in common with other results obtained by Zeina (2002), Abd El-Bary (2003), Yehia (2005) and Aziza Sultan (2008)

3. General combining ability effects for double cross hybrids

The1-line general combining ability effects are given in Table (3). As indicated by the data line (P_3) Karshenky must be used as one parent, because it provides the highest and negative effect which is desirable direction for all earliness traits, except for, the earliness index which the positive direction is desirable. As four lines are needed to produce a double cross hybrid, all lines can be used with the same efficiency for position of first fruiting node except the two line Giza 70 and Giza 77 x Pima S_6 because the general effect is not only positive but also high. With regard the days to first flower it may be considered the two parents of Karshenky and Australian were classified as good combiner because it provides the highest negative effect and every of them could be used as one parent. As four lines needed to produce a double cross hybrid for days to first boll same lines can be used with the same efficiency except the two lines Giza 70 and Giza 77 x Pima S_6 since the general effect is positive and highest.

Table 3. Estimates of general combining ability effects of double cross hybrids for earliness characters

Source	Position of first fruiting node	Days to first flower	Days to first boll	Earliness index
Australian (p_1)	-0.039	-0.021	-0.187	0.473
BBB (p_2)	-0.101	-0.148	0.384	-0.084
Karshenky (p_3)	-0.157*	-0.148	-0.464*	0.531
Giza 70 (p_4)	0.156*	0.220	0.178	-0.681*
Suvin (p_5)	0.019	-0.060	-0.018	-0.383
Giza 77 x Pima S_6 (p_6)	0.123*	0.159	0.107	0.145

*,** significantly different at the 0.05 and 0.01 levels of probability, respectively

As for the days to first boll. The parent of variety Karshenky exhibited good combining ability and could be used as one parent, because it provides the negative highest effect for days to first boll opening. As four lines are needed to produce a double cross all lines can be used with the same efficiency except the lines BBB, Giza 70, and Giza 77 x Pima S_6 because the general effect is not only positive but also high with respect to days to first boll. While for the earliness index, data indicated that the two lines, Australian and Karshenky must be used as one parent, because it provides the highest positive effect.

4. The 2-line general and 2-line arrangement effects

The 2-line effects with and without respect to their particular arrangement are given in Table (4). With respect to the position of first fruiting node, as regards to the 2-line general effects the parent (P_1 and P_3) in various combinations performed the best, followed by (P_3 and P_5) and (P_2 and P_4) in this case the general effects was not only negative but also high.

Table 4. 2-line interaction effect of lines i and j due to particular arrangement (ij)(..) i.e. t ij , i.j. and specific effects correspond to s ij effect i.e. effect of i and j irrespective of arrangement for earliness characters

Source	Position of first fruiting node			Days to first flower			Days to first boll			Earliness index		
	ij	(ij)(--)	(i.)(j.)	ij	(ij)(--)	(i.)(j.)	ij	(ij)(--)	(i.)(j.)	ij	(ij)(--)	(i.)(j.)
P_1 x P_2	-0.030	-0.189	0.094	-0.119	-1.033	0.517	0.172	-0.341	0.170	-0.278	1.948	-0.974
P_1 x P_3	-0.063	-0.067	0.033	-0.063	0.139	-0.069	-0.239	-0.426	0.213	0.512	1.224	-0.612
P_1 x P_4	0.079	-0.156	0.078	0.143	0.748	-0.374	0.093	1.189	-0.594	-0.331	-5.009	2.504
P_1 x P_5	-0.009	-0.007	0.004	-0.036	-0.087	0.044	-0.181	-0.407	0.204	0.397	4.172	-2.086
P_1 x P_6	-0.017	0.419	-0.209	0.053	0.233	-0.117	-0.032	-0.015	0.007	0.172	-2.335	1.167
P_2 x P_3	-0.045	0.100	-0.050	0.001	0.324	-0.162	-0.021	0.119	-0.059	0.761	-0.637	0.319
P_2 x P_4	-0.051	-0.196	0.098	-0.087	0.178	-0.089	-0.081	0.226	-0.113	0.048	0.828	-0.414
P_2 x P_5	0.005	0.163	-0.081	0.002	0.202	-0.101	0.218	0.100	-0.050	-1.030	-3.140	1.570
P_2 x P_6	0.019	0.122	-0.061	0.055	0.330	-0.165	0.097	-0.104	0.052	0.414	1.002	-0.501
P_3 x P_4	0.049	0.237	-0.119	0.035	-0.433	0.217	-0.059	-0.837	0.419	-0.479	1.419	-0.710
P_3 x P_5	-0.061	0.163	-0.081	-0.052	0.283	-0.142	-0.078	0.900	-0.450	0.188	-1.814	0.907
P_3 x P_6	-0.036	-0.433	0.217	-0.069	-0.313	0.156	-0.069	0.244	-0.122	-0.451	-0.192	0.096
P_4 x P_5	0.003	-0.048	0.024	0.017	-0.320	0.160	0.069	-0.522	0.261	0.066	1.009	-0.505
P_4 x P_6	0.076	0.163	-0.081	0.111	-0.172	0.086	0.156	-0.056	0.028	0.016	1.752	-0.876
P_5 x P_6	0.081	-0.270	0.135	0.008	-0.078	0.039	-0.045	-0.070	0.035	-0.005	-0.227	0.114

Australian (p_1), BBB (p_2), Karshenky (p_3), Giza 70 (p_4), Suvin (p_5) and (Giza 77 x Pima S_6) (p_6)

The other 2-line effects which did well in combinations were (P_2 and P_3) and (P_3 and P_6). In most of other cases the 2-line general effects were negative. As regard to the 2-line with particular arrangement the specific combination (P_3 x P_6) (--) had the highest 2-line specific effect of (ij)(--) type, followed by (P_5 x P_6)(--) and (P_2 x P_4)(--).The cases of (P_1 x P_6)(--) and (P_2 x P_5)(--) were bad combinations because its 2-line specific effects are not only positive but also high. The 2-line of (i-)(j-) type were high and negative in the case (P_1 x -)(P_6 x -) followed by (P_3 x -)(P_4 x -) and (P_2 x -)(P_5 x -) and (P_3 x -)(P_5 x -), The2-line specific effects (P_3 x -)(P_6 x -) is poor combination because it is not only positive but also high. When the order of arrangement become (P_3 x P_6)(- -) had desirable 2-line specific effect. Also the specific combination (P_1 x P_4) was poor specific 2-line when used another combination (P_1 -)(P_4 -) gave good 2-line specific effect. Similar, the Australian parent and BBB which were good in specific combination of (P_1 x P_2) (--) and (P_2 x P_4) (--) respectively when used in another combination (P_1 x -) (P_2 x -) and (P_2 x -) (P_4 x-) showed the positive 2-line specific. These results suggested that the order in which the parents were involved in double cross was important. This means that importance consideration should be given to this parameters while attempting multiple crosses. The evidence of order effect in double crosses have been reported by Singh and Choudary (1977).

As regard to 2-line general interaction effects for days to first flower, the parents (P_1 and P_2) in various combinations were the best followed by (P_2 and P_4) and (P_3 and P_6). The other 2-line which did well in combination were (P_1 and P_3), (P_3 and P_5) and (P_3 and P_6). In most of cases, the 2-line general effects were positive (Table 4). As particular arrangement the specific combination (P_1 x P_2) (--) hade high 2-line specific effect (ij) (--) type, followed by (P_3 x P_4) (--) and (P_4 x P_5) (--) and (P_3 x P_6) (--). These effect were high and negative so these effects were good combination. The combinations (P_2 x P_3)(--) and (P_1 x P_4)(--) were poor combinations because its 2-specific effect was not only positive but also highest. The other cases exhibited positive effect were (P_1 x P_6) (--), (P_2 x P_6)(--) and (P_2 x P_5)(--). The 2-line specific effects of (i-)(j-) type was highest and negative in case of (P_1 x -)(P_4 x -) followed by (P_2 x -)(P_6 x -) and (P_3 x -)(P_5 x -) so these combinations were the best. It is obvious that the lines (P_1 P_2 P_3 P_6) which did well in 2-line general effects were also included in the best 2-line specific effect. While the parents P_2 and P_6 were bad in combination (ij)(--). For instance the specific combination (P_1 x P_2) (--) which had high and negative 2-line specific effect, gave the highest and positive effect, when used in mother combination i.e. (P_1 x -) (P_2 x -). Similarity, parent 3and 4 which were good in specific combination (P_3 x P_4) (--) showed the positive 2-line specific effect when used in combination (P_3 x -) (P_4 x -). It is obvious that, the order in which the parents were involved in double cross was important.

With respect to the days to first boll opening the 2-line general effects are given in Table (4). The data indicated that the parents 1 and 2 in various combinations did the best performance, followed by (P_1 and P_5). The other 2-line which did well in combinations were (P_2 and P_4) and (P_3 and P_5), as well as parents (P_3 and P_6) and (P_3 and P_5). The other cases of the 2-line general effect were positive for (P_2 and P_5), (P_1 and P_2) and (P_2 and P_6) exhibited poor combination (Table 16). As for the particular arrangement the specific combination (P_3 x P_4)(--), (P_4 x P_5)(--), (P_1 x P_3)(--) and (P_1 x P_5)(--) had high and negative 2-line specific effect of (ij)(--) type and followed by (P_1 x P_2)(--) which were the best combinations while the combination (P_3 x P_6)(--), (P_1 x P_4)(--) and (P_2 x P_4)(--) exhibited positive and high effect therefore these combination were poor. The 2-line specific effect of (i-)(j-) type was high and negative in the case of (P_1 x -)(P_4 x -) followed by (P_3 x -) (P_5 x -) and (P_2 x -)(P_4 x -). It is obvious that line P_1, P_3, P_4 and P_5 which did well in 2-line general effect, were also included in the best 2-line specific combinations. Another very important point to be noted here in the order effect of parents, for instance the specific combination (P_3 x P_4)(--) which had negative highest 2-line specific effect, gave the highest positive effect when used in another combination (P_3 x -)(P_4 x -). Similarly parent 4 and 5 which were good in specific combination of (P_4 x P_5) (--) showed positive 2-line specific effect when used in combination as (P_4 x -)(P_5 x -). It is obviously that, the order in which the parents were involved in double crosses was important.

With regard to for 2-line general effect for earliness index, the parents (P_2 and P_3) in various combinations were the best, followed by (P_1 and P_3), (P_2 and P_6) and (P_1 and P_5), because it had high and positive effects which was desirable direction for 2-line general effect. The other 2-line which did well in combinations were (P_3 and P_5) and (P_1 and P_6) because its had positive 2-line general effect. With regard to the particular arrangement the specific combination (P_1 x P_5)(--) had the highest and positive 2-line specific effect of (ij) (--) followed by (P_1 x P_2) (--), (P_4 x P_6) (--), (P_3 x P_4)(--) and (P_1 x P_3)(--). About half of cases had negative 2-line specific effects which was bad combination. The 2-line specific effect of (i-)(j-) type were high in the cases of (P_1 x -)(P_4 x -) and (P_2 x -)(P_5 x -) followed by (P_1 x -)(P_6 x -) and (P_3 x -)(P_5 x -). It is obvious that lines P_1, P_2, P_3 and 6 which did well in 2-line general effect were also included in the best line specific combinations. For instance the specific combination (P_1 x P_5)(--) which had the highest 2-line specific effect, gave highest negative effect when used in another combination i.e. (P_1 x -)(P_5 x -) similar parents (P_1 and P_2) which were good in specific combination (P_1 x P_2) (--) showed the negative 2-line specific effect when used in combination as (P_1 x -) (P_2 x -) as well as the parents P_1 and P_3 were good 2-line specific effect when used (P_1 x P_3)(--) but when its used as (P_1 x -)(P_3 x -) exhibited negative specific effect. These results, indicate that the order in which the parents were involved in double crosses was important. This was agreement with Singh and Choudary (1977)

5. The three-line interaction effect

The three line interaction effect of lines i, j and k with and without arrangement are presented in Table (5). For the first fruiting node considering the specific order effect of three out of four parents i.e. (ij) (k-) type in double crosses it was found that (P_1 x P_5) (P_4 x -), (P_1 x P_6)(P_5 x -), (P_2 x P_3)(P_4 x -), (P_3 x P_4)(P_5 x -) and (P_3 x P_5)(P_1 x-) combination were the best combination (Table 5). However, on the basis of the overall performance of any three parents in all possible combination regardless of their arrangement (ijk-), the best triple combination was $P_1P_3P_6$ followed by $P_1P_3P_5$, $P_2P_4P_6$ and $P_2P_5P_6$. The order of these parents in cross events can be differd by changing the arrangement of the parents of a particular cross.

Table 5. Three-line interaction effect of lines I, j and k due to the particular arrangement (ij)(k-) i.e. t ijk and specific effect irrespective s ijk i.e. 3-line effect irrespective of the arrangement for earliness characters of cotton

Crosses	Position of first fruiting node		Days to first flower		Days to first boll		Earliness index	
	(ij)(k-)	i,j and k	(ij)(k-)	i,j and k	(ij)(k-)	i,j and k	(ij)(k-)	i,j and k
(P_1xP_2) $(P_3.)$.	-0.069	-0.039	0.172	-0.075	-0.109	0.001	-0.462	0.689
(P_1xP_2) $(P_4.)$.	0.124	-0.007	0.233	-0.079	-0.085	0.059	1.152	-0.463
(P_1xP_2) $(P_5.)$.	0.089	0.007	0.150	-0.076	0.135	0.148	-1.324	-0.912
(P_1xP_2) $(P_6.)$.	0.044	-0.021	0.478	-0.007	0.400	0.136	-1.313	0.130
(P_1xP_3) $(P_2.)$.	-0.052		0.025		-0.381		0.702	
(P_1xP_3) $(P_4.)$.	0.167	0.079	0.067	0.099	1.009	-0.046	-3.360	-0.41
(P_1xP_3) $(P_5.)$.	0.004	-0.074	0.148	-0.074	0.531	-0.275	0.717	0.891
(P_1xP_3) $(P_6.)$.	-0.052	-0.092	-0.379	-0.076	-0.733	-0.158	0.717	-0.150
(P_1xP_4) $(P_2.)$.	0.052		-0.183		0.131		-2.405	
(P_1xP_4) $(P_3.)$.	-0.122		-0.081		-0.057		2.644	
(P_1xP_4) $(P_5.)$.	0.120	0.028	-0.004	0.079	-0.046	-0.010	0.894	0.329
(P_1xP_4) $(P_6.)$.	0.106	0.059	-0.481	0.189	-1.217	0.184	3.877	-0.122
(P_1xP_5) $(P_2.)$.	-0.117		-0.092		0.302		1.418	
(P_1xP_5) $(P_3.)$.	0.248		-0.124		-0.541		-2.303	
(P_1xP_5) $(P_4.)$.	-0.235		-0.195		-0.896		1.162	
(P_1xP_5) $(P_6.)$.	0.111		0.498		1.543		-4.448	
(P_1xP_6) $(P_2.)$.	0.022		-0.267		-0.222		1.259	
(P_1xP_6) $(P_3.)$.	-0.091		0.102		0.494		0.734	
(P_1xP_6) $(P_4.)$.	-0.133		0.269		0.567		-1.458	
(P_1xP_6) $(P_5.)$.	-0.217		-0.338		-0.824		1.799	
(P_2xP_3) $(P_1.)$.	0.120		-0.197		0.491		-0.240	
(P_2xP_3) $(P_4.)$.	-0.398	0.021	-0.019	-0.001	-0.172	-0.226	-0.649	0.486
(P_2xP_3) $(P_5.)$.	-0.056	-0.013	-0.244	-0.026	-0.530	-0.193	1.569	0.408
(P_2xP_3) $(P_6.)$.	0.233	-0.021	0.136	0.070	0.093	0.152	-0.043	-0.101
(P_2xP_4) $(P_1.)$.	-0.176		-0.050		-0.046		1.254	
(P_2xP_4) $(P_3.)$.	0.269		-0.099		-0.178		-0.332	
(P_2xP_4) $(P_5.)$.	0.209	-0.017	-0.096	0.033	-0.237	-0.001	-1.170	0.527
(P_2xP_4) $(P_6.)$.	-0.106	-0.067	0.068	-0.072	0.235	0.024	-0.579	-0.533
(P_2xP_5) $(P_1.)$.	0.028		-0.058		-0.437		-0.093	
(P_2xP_5) $(P_3.)$.	-0.061		0.339		0.431		0.894	

Australian (p_1), BBB (p_2), Karshenky (p_3), Giza 70 (p_4), Suvin (p_5) and (Giza 77 x Pima S_6)(p_6)

Cont. Table 5.

Crosses	Position of first fruiting node		Days to first flower		Days to first boll		Earliness index	
	(ij)(k-)	i,j and k	(ij)(k-)	i,j and k	(ij)(k-)	i,j and k	(ij)(k-)	i,j and k
(P_2xP_5) (P_4.).	-0.019	-0.015	0.034	0.003	0.685	-0.052	-0.096	0.685
(P_2xP_5) (P_6.).	-0.111	0.092	-0.517	0.082	-0.780	0.112	2.436	-0.513
(P_2xP_6) (P_1.).	-0.067		-0.211		-0.178		0.054	
(P_2xP_6) (P_3.).	-0.089		-0.250		-0.085		-0.418	
(P_2xP_6) (P_4.).	0.194		-0.160		-0.315		0.007	
(P_2xP_6) (P_5.).	-0.161		0.292		0.681		-0.644	
(P_3xP_4) (P_1.).	-0.044		0.014		-0.952		0.716	
(P_3xP_4) (P_2.).	0.130		0.118		0.350		0.981	
(P_3xP_4) (P_5.).	-0.231	-0.016	0.085	-0.003	0.181	0.034	-0.571	-0.048
(P_3xP_4) (P_6.).	-0.091	0.048	0.217	0.001	1.257	0.088	-2.545	-0.914
(P_3xP_5) (P_1.).	-0.252		-0.024		0.009		1.587	
(P_3xP_5) (P_2.).	0.117		-0.094		0.098		-2.463	
(P_3xP_5) (P_4.).	0.280		-0.034		-0.513		0.915	
(P_3xP_5) (P_6.).	-0.307	-0.012	-0.131	-0.096	-0.494	-0.067	1.775	-0.365
(P_3xP_6) (1.).	0.143		0.277		0.239		-1.451	
(P_3xP_6) (2.).	-0.144		0.114		-0.007		0.461	
(P_3xP_6) (P_4.).	0.070		-0.231		-0.743		3.803	
(P_3xP_6) (P_5.).	0.365		0.153		0.267		-2.621	
(P_4xP_5) (P_1.).	0.115		0.199		0.943		-2.056	
(P_4xP_5) (P_2.).	-0.191		0.062		-0.448		1.266	
(P_4xP_5) (P_3.).	-0.048		-0.051		0.331		-0.344	
(P_4xP_5) (P_6.).	0.172	0.061	0.110	0.031	-0.304	0.090	0.124	0.382
(P_4xP_6) (P_1.).	0.028		0.211		0.650		-2.419	
(P_4xP_6) (P_2.).	-0.089		0.093		0.080		0.572	
(P_4xP_6) (P_3.).	0.020		0.014		-0.515		-1.258	
(P_4xP_6) (P_5.).	-0.122		-0.145		-0.159		1.352	
(P_5xP_6) (P_1.).	0.106		-0.160		-0.719		2.648	
(P_5xP_6) (P_2.).	0.272		0.225		0.098		-1.792	
(P_5xP_6) (P_3.).	-0.057		-0.022		0.228		0.846	
(P_5xP_6) (P_4.).	-0.050		0.035		0.463		-1.476	

Australian (p_1), BBB (p_2), Karshenky (p_3), Giza 70 (p_4), Suvin (p_5) and (Giza 77 x Pima S_6) (p_6)

For example change in the arrangement of parents of the best combination parents (P_1 x P_5) (P_4 x -) into another combination say (P_1 x P_4)(P_5 x -) makes specific effect positive with value (0.120) another combination which involves the same three parents, but in some other order (P_4 x P_5)(P_1 -) had positive specific effect with value (0.115). This observation clearly shows the significance of order in which the parents are involved in multiple crosses. With regard to the days to first flower the specific order effect of three out of four parents i.e. (ij)(k-) type in double crosses revealed that (P_2 x P_5)(P_6 x -) (P_1 x P_4)(P_6 x -) (P_1 x P_3)(P_6 x -) and (P_1 x P_6)(P_5 x -) combination were the best combinations (Table 5). However on the basis of the overall performance of any three parents, in all possible combinations without respect to arrangement (ijk) the best triple were (P_3 P_5 P_6) followed by P_1 P_2 P_4, P_1 P_2 P_5 and P_1 P_2 P_3 and P_2 P_4 P_5. Another very important point to be noted here is the order effect of the parents, for instance the specific combination P_3 p_5 P_6 had the highest 3-line specific effect which give little negative effect of value (-0.22) when used in another combination (P_5 x P_6) (P_3 x -) and another combination $P_3P_6P_5$ also gave little negative effect. This observation clearly shows the significance of the order in which the parents are involved in multiple crosses.

For the first boll opening, considering the specific order effect of three out of four parents i.e. (ij)(k-) type in double crosses, the combination of (P_1 x P_4)(P_6 x -), (P_3 x P_4)(P_1 x -), (P_1 x P_5)(P_4 x -) , (P_1 x P_3)(P_6 x -), (P_2 x P_5)(P_6 x -) and (P_3 x P_6)(P_4.) were the best combinations. With regard to the specific effect regardless of the arrangement (ijk-), the best triples were $P_1P_3P_5$, $P_2P_3P_4$, $P_2P_3P_5$ and $P_2P_3P_6$. The changing in the arrangement of parents of the best combination of three parents (P_1 x P_4) (P_6 x -) into another combination as (P_1 x P_6) (P_4 x -) make specific effect positive (0.567), other combination in which the same three parents were involved, but in another order (P_4 x P_6) (P_1 x -) had specific combination positive effect. It is obvious that the order in which the parents were involved in double cross was important. This means that more consideration should be given to this parameters while attempting multiple crosses.

With respect to the earliness index, the positive effect is desirable for the specific order of three out of four parents i.e. (ij)(k-) type in double crosses as it was found that (P_1 x P_4)(P_6 x -), (P_3 x P_6)(P_4 x -), (P_5 x P_6)(P_4 x -), (P_1 x P_4)(P_3 x -) and (P_2 x P_5)(P_6 x -) were the best combinations (Table 20). However, on the basis of the overall performance of any three parents in all possible combinations regardless of the arrangement (ijk) the best triple was P_1 P_3 P_5 followed P_1 P_2 P_3, P_2 P_4 P_5, P_2 P_3 P_4 and P_2 P_3 P_5. The changing in arrangement of the parents of the best combinations (P_1 x P_4)(P_6 -) into another combination i.e. (P_1 x P_6)(P_4 -) had negative specific effect. The second best combination (P_3 x P_6) (P_4 x -) when arrangement into another combination (P_3 x P_4) (P_6 x -) had the high negative specific effect. This means that the order in which the parents were involved in double crosses was important (Singh and Choudary (1977).

6. The four-line interaction:

The 4-line interaction with and without respect to particular arrangements of the parents in double crosses are given in (Table 6). A critical assessment of the data in this Table (6) clearly showed that the involvement of the parents in crosses in particular arrangements such as (P_1 x P_2)(P_3 x P_4), (P_1 x P_2)(P_5 x P_6), (P_1 x P_5)(P_3 x P_6), (P_1 x P_6)(P_2 x P_3), (P_1 x P_6)(P_4 x P_5), (P_2 x P_3)(P_4 x P_5)(P_2 x P_4)(P_3 x P_6) and (P_3 x P_4)(P_5 x P_6) provided the maximum interaction effect with regard to the position of first fruiting node. That means that the four parents of the obvious double cross with this specific arrangement were the best combination but not in other order.

For example the combination (P_1 x P_2)(P_3 x P_4) gave the negative specific effect. -0.193 when used other arrangement for the same parents as (P_1 x P_3)(P_2 x P_4) gave positive specific effect (0.074). These results confirm that the order in which the parents were involved into a double cross is deciding factor for its high or low performance. Considering the general effect of set of any four parents in various combinations irrespective of the order, it is obvious that parents P_1, P_3, P_5 and P_6 formed the best combination.

With regard to the days to first flower, the data in Table(6) clearly showed that the involvement of parents in crosses in particular arrangements such as (P_1 x P_2)(P_3 x P_4), (P_1 x P_2)(P_5 x P_6) and (P_3 x P_4)(P_5 x P_6) had highest specific effects with value -0.387 followed by the combination (P_1 x P_3)(P_4 x P_6) and (P_2 x P_5)(P_4 x P_6) with values -0.295. The other combinations as (P_1 x P_4) (P_2 x P_6), (P_1 x P_4) (P_3 x P_5), (P_1 x P_5) (P_3 x P_6), (P_2 x P_6) (P_4 x P_5), (P_2 x P_3) (P_4 x P_5) and (P_2 x P_3) (P_3 x P_6) were also best specific effects. When the arrangement were changed the performance also changed for example the four parents involved as arrangement (P_1 x P_2) (P_3 x P_4) is best combination when the arrangement became (P_1 x P_3) (P_2 x P_4) this combination had a poor specific effect. So the order in which the parents go into double hybrids is a deciding factor for its high or low performance.

Table 6. Four-line interaction effect of lines I, j, k and l due to the particular arrangement (ij) (kl) i.e. t ijkl and 4-lin effect irrespective of their arrangement for earliness characters of cotton.

Crosses	Position of first fruiting node		Days to first flower		Days to first boll		Earliness index	
(P_1xP_2) (P_3xP_4)	-0.193	0.101	-0.387	-0.074	0.283	-0.224	0.676	0.224
(P_1xP_2) (P_3xP_5)	-0.031	-0.050	0.224	-0.044	-0.067	0.182	0.126	0.582
(P_1xP_2) (P_3xP_6)	0.224	-0.166	0.163	-0.107	-0.217	0.047	-0.802	1.261
(P_1xP_2) (P_4xP_5)	0.224	-0.075	0.163	-0.217	-0.217	0.151	-0.802	-2.030
(P_1xP_2) (P_4xP_6)	-0.031	-0.046	0.224	0.053	-0.067	0.249	0.126	0.418
(P_1xP_2) (P_5xP_6)	-0.193	0.147	-0.387	0.033	0.283	0.111	0.676	-1.288
(P_1xP_3) (P_2xP_4)	0.074		0.199		-1.050		1.508	
(P_1xP_3) (P_2xP_5)	0.019		-0.295		0.317		-1.147	
(P_1xP_3) (P_2xP_6)	-0.093		0.096		0.733		-0.361	
(P_1xP_3) (P_4xP_5)	-0.093	0.036	0.096	0.155	0.733	-0.200	-0.361	1.182
(P_1xP_3) (P_4xP_6)	0.019	0.099	-0.295	0.214	0.317	0.287	-1.147	-2.621
(P_1xP_3) (P_5xP_6)	0.074	-0.208	0.199	-0.334	-1.050	-0.807	1.508	0.910
(P_1xP_4) (P_2xP_3)	0.119		0.188		0.767		-2.184	
(P_1xP_4) (P_2xP_5)	-0.054		0.096		-0.500		3.326	
(P_1xP_4) (P_2xP_6)	-0.065		-0.284		-0.267		-1.142	
(P_1xP_4) (P_3xP_5)	-0.065		-0.284		-0.267		-1.142	
(P_1xP_4) (P_3xP_6)	-0.054		0.096		-0.500		3.326	
(P_1xP_4) (P_5xP_6)	0.119	0.123	0.188	0.299	0.767	0.018	-2.184	1.836
(P_1xP_5) (P_2xP_3)	0.013		0.071		-0.250		1.021	
(P_1xP_5) (P_2xP_4)	-0.170		-0.259		0.717		-2.524	
(P_1xP_5) (P_2xP_6)	0.157		0.188		-0.467		1.503	
(P_1xP_5) (P_3xP_4)	0.157		0.188		-0.467		1.503	
(P_1xP_5) (P_3xP_6)	-0.170		-0.259		0.717		-2.524	
(P_1xP_5) (P_4xP_6)	0.013		0.071		-0.250		1.021	
(P_1xP_6) (P_2xP_3)	-0.131		-0.259		-0.517		1.163	
(P_1xP_6) (P_2xP_4)	0.096		0.060		0.333		1.016	
(P_1xP_6) (P_2xP_5)	0.035		0.199		0.183		-2.179	
(P_1xP_6) (P_3xP_4)	0.035		0.199		0.183		-2.179	
(P_1xP_6) (P_3xP_5)	0.096		0.060		0.333		1.016	
(P_1xP_6) (P_4xP_5)	-0.131		-0.259		-0.517		1.163	
(P_2xP_3) (P_4xP_5)	-0.131	-0.135	-0.259	0.021	-0.517	-0.016	1.163	-0.103
(P_2xP_3) (P_4xP_6)	0.013	-0.006	0.071	-0.026	-0.250	-0.340	1.021	1.103
(P_2xP_3) (P_5xP_6)	0.119	0.121	0.188	0.232	0.767	0.289	-2.184	-0.783
(P_2xP_4) (P_3xP_5)	0.096		0.060		0.333		1.016	
(P_2xP_4) (P_3xP_6)	-0.170		-0.259		0.717		-2.524	
(P_2xP_4) (P_5xP_6)	0.074	0.007	0.199	-0.019	-1.050	-0.064	1.508	0.533
(P_2xP_5) (P_3xP_4)	0.035		0.199		0.183		-2.179	
(P_2xP_5) (P_3xP_6)	-0.054		0.096		-0.500		3.326	
(P_2xP_5) (P_4xP_6)	0.019		-0.295		0.317		-1.147	
(P_2xP_6) (P_3xP_4)	0.157		0.188		-0.467		1.503	
(P_2xP_6) (P_3xP_5)	-0.065		-0.284		-0.267		-1.142	
(P_2xP_6) (P_4xP_5)	-0.093		0.096		0.733		-0.361	
(P_3xP_4) (P_5xP_6)	-0.193		-0.387		0.283		0.676	
(P_3xP_5) (P_4xP_6)	-0.031		0.224		-0.067		0.126	
(P_3xP_6) (P_4xP_5)	0.224		0.163		-0.217		-0.802	

Australian (p_1), BBB (p_2), Karshenky (p_3), Giza 70 (p_4), Suvin (p_5) and (Giza 77 x Pima S_6) (p_6)

Considering the general effect, of set of any four parents in various combinations, irrespective of the order, it is clear that parents P_1, P_3, P_5 and P_6 formed the best combination.

With respect to the days to first boll, we found that the specific effect of particular arrangement of four parents as (P_1x P_3) (P_2 x P_4), (P_1 x P_3) (P_5 x P_6) and (P_2 x P_4) (P_5 x P_6) were highest and negative specific effects followed by the combinations with particular arrangement as (Table 6) (P_2 x P_5), (P_1 x P_6) (P_2 x P_3), (P_1 x P_4) (P_3 x P_6) and (P_2 x P_3) (P_4 x P_5). The other combination with particular arrangement of four parents such (P_1 x P_4) (P_2 x P_5) and (P_1 x P_4) (P_3 x P_6) were best specific effects. We found in (Table 6) that best 4-line combination (P_1 x P_3) (P_2 x P_4) in this order when combined in other order such (P_1 x P_2) (P_3 x P_4) produced the positive effect which is undesirable. These results are a given confirm that the order in which the parents go into a double hybrids is deciding factor of high or low performance. Considering the general effect of set of any four parents in various combinations irrespective of order it is evident that parents P_1, P_3, P_5 and P_6 formed the best combination.

For earliness index, the data in Table (6) clearly showed that the involvement of parents in crosses in particular arrangements such as (P_1 x P_4)(P_2 x P_5), (P_1 x P_4)(P_3 x P_6) and (P_2 x P_5)(P_3 x P_6) provided the maximum interaction effect. The other combinations as particular arrangement (P_1 x P_3)(P_2 x P_4), (P_1 x P_3)(P_5 x P_6), (P_1 x P_5)$(P)_2$ x P_6), (P_2 x P_4)(P_5 x P6) and (P_2 x P_6)(P_3 x P_4) were the best, when the arrangement of highest interaction specific effect combination (p_1 x P_4)(P_2 x P_5) changed to other arrangement i.e. (P_1 x P_2)(P_4 x P_5) this combination had negative specific effect which is undesirable. These results again confirm that the order in which the parents go into double hybrids is deciding factor for its high or low performance. With regard to the general effect of set of any four parents in various combinations, irrespective of the order it is obvious that parents P_1, P_4, P_5 and P_6 formed the best combination. From aforementioned results, it could be suggested that P_1, P_5, P_6, as well as P_3 formed the best "quadriallel" or with the parent Giza 70 (P_4) in case earliness index.

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قدرة التالف ونظم ترتيب الاباء فى الهجن الزوجية للقطن

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يهدف البحث إلى دراسة القدرة العامة والخاصة على الائتلاف واستخدام الهجن الزوجية في تحسين صفات التبكير للقطن المصرى وقد استخدمت في ذلك ستة اصناف وهي استرالي ، BBB ، كراشنكي ، جيزة 70، سيوفين ، الهجين المبشر (جـ77 × بيما س6) وقد زرعت هذه الأصناف فى عام 2005م بمحطة بحوث سخا بمركز البحوث الزراعية وتم إجراء التهجين بينها بطريقة الهجن الدائرية في اتجاه واحد للحصول على 15 هجين فردى، وفي الموسم الثاني عام 2006م تم زراعة الجيل الأول للهجن الفردية والتهجين بينها بحيث لا يتكرر اى اب فى الجيل الاول مرتين في الهجين الزوجي فيكون عدد الهجن الزوجية الناتجة هو 45 هجين زوجي تبعا للمعادلة الاتية: عدد الهجن الزوجية = P (P-1) (P-2) (P-3)/8، وفي الموسم الثالث 2007م تم زراعة الهجن الزوجية فى تجربة قطاعات كاملة عشوائية من ثلاث مكررات احتوت القطعة على ثلاث خطوط طول الخط 4م وزرعت النباتات على مسافة 20 سم تمثل الزراعة العادية وتم خف التجربة على نباتين فى الجورة وأجريت عليها العمليات الزراعية العادية لمحطة بحوث سخا وأخذت بيانات التبكير على عشر نباتات محاطة من الجوانب.

وكانت الصفات المدروسة كالأتي :

أولا : صفات التبكير :1- موقع أول عقدة ثمرية 2- ميعاد ظهور أول زهرة
3 – ميعاد تفتح أول لوزة 4- معامل التبكير

ويمكن تلخيص النتائج المتحصل عليها فيما يلي :

1. كان الأب كراشنكى ذو قدرة تالف عامة كاب أوحد لتكوين الهجن الزوجية عالية القيمة وسالبة وهو الاتجاه المرغوب لجميع صفات التبكير ماعدا صفة معامل التبكير فان القيمة الموجبة هى المرغوبة.
2. كانت افضل قدرة تالف عامة ثنائية للابين استرالي مع ال BBB ، ال BBB مع جيزة 70 فى هجين فردى واحد مع صرف النظر عن الهجين الفردى الاخر، وعند تغير الترتيب لنفس الآباء يصبح الهجين الزوجى الثانى له قيمة قد تكون غير مرغوبة في صفات التبكير.

3. كانت أفضل قدرة تالف عامة ثلاثية الترتيب (استرالي × سيوفين) × (جيزة 70 × –) بصرف النظر عن الأب الرابع ومع تغير الترتيب يصبح الهجين الزوجي الناتج غير مرغوب لصفات التبكير.

4. كانت أفضل مجموعة رباعية بصرف النظر عن الترتيب (استرالي ، BBB، سيوفين ، الهجين المبشر (جـ77 × بيما س6)) فى صفة أول عقدة ثمرية والمجموعة (استرالي ، BBB، جيزة 70، سيوفين) لصفة تفتح اول زهره، والمجموعة (استرالي ، كراشنكى، سيوفين ، الهجين المبشر (جـ77 × بيما س6)) لصفة تفتح أول لوزة ، والمجموعة (استرالي ، جيزة70 ، سيوفين ، الهجين المبشر (جـ77 × بيما س6)) لمعامل التبكير.

5. تؤكد النتائج ان ترتيب الاباء فى تكوين الهجن الزوجية يحدد القيمة المظهرية للهجين اما ان تكون هذه القيمة مرتفعة او منخفضة.

6. باستعراض مكونات التباين الوراثى وجد ان التفاعل بين التباينات الاضافية لها قيمة فى توريث الصفات ويمكن استخلاص ان الهجين الزوجى (1 × 2) (3 × 6) ، (1 × 2) (5 × 6) مميزين فى صفات التبكير.

7. دلت النتائج على ان ترتيب الاباء الداخلة فى الهجن الفردية المستخدمة فى انتاج الهجن الزوجية له اعتبار فى تميز الهجن الزوجية حيث ان التغيير فى هذا الترتيب لنفس الاباء يفقد الهجين الزوجي تميزه.