Pakistan J. Sci. Ind. Res., Vol. 30, No. 11, November 1987

EVALUATION OF PARENT VARIETIES IN THE HYBRID COTTON PRODUCTION PROGRAMME IN PAKISTAN

Iftikhar Ahmad Khan, Manzoor Ahmad Khan and Shahid Nadeem

University of Agriculture, Faisalabad

(Received April 26, 1987; revised November 16, 1987)

An experiment was conducted to evaluate the genetic potential of some varieties of cotton (*Gossypium hirsutum* L.) for the production of productive hybrids. Highly significant, general combining ability effects were observed for all characters studied, whereas specific combining ability effects were highly significant for boll weight and lint percentage, significant for staple length and non-significant for number of bolls and yield of seed cotton. No reciprocal effects were noted. A considerable degree of heterosis and heterobeltiosis also was observed in various plant characters.

Key words: Heterosis, Combining ability, Hybrid cotton.

INTRODUCTION

One way of increasing the yield and quality of cotton (*Gossypium hirsutum* L.) in Pakistan could be the exploitation of heterosis on a commercial level as emphasized by Khan and Khan [10]. This avenue involves the prior selection of suitable parents for developing productive hybrids.

The selection efficiency for suitable parents can be enhanced by increasing our understanding of the relative magnitudes of genetic variances due to general combining ability, specific combining ability, and reciprocal effects along with the extent of heterosis for various plant characters. Knowledge of the type of gene action involved in the control of various characters helps the breeder in predicting the performance of the hybrids. Workers like Khan *et al.* [11], Mirza and Choudhry [18], and Shahani and Chang [17] have suggested the usefulness of such studies in cotton. The objectives of this research were to evaluate the combining ability and heterotic effects for various plant characters within several cotton hybrids.

MATERIALS AND METHODS

The experimental material consisted of five cotton varieties, Delcot 277, Tamcot SP37, NIAB(B-97), B557 and Express. The varieties were grown in the greenhouse during December, 1983 and were crossed in a complete diallel during February-March 1984. Seeds of the above set of crosses obtained at maturity of the crop were sown in the field in a randomized complete block design with 3 replications on June 13, 1984. Each genotype consisted of a single row of 10 plants. The distance among the plants, between and within the lines, was kept at 75 and 30 cm respectively. At maturity, plant data with respect to number of bolls, boll weight, yield of seedcotton, lint percentage and staple length were recorded. Griffing's [7] Method I, Model I was followed to study the combining ability general (GCA) and specific (SCA) and reciprocal effects, whereas heterosis was calculated as percent increase (+) or decrease (–) of the hybrids against their mid parent values. Heterobeltiosis was estimated as percent increase (+) or decrease (–) of the hybrids against their high yielding parents as suggested by Fonceca (1965).

RESULTS AND DISCUSSION

A highly significant variation was observed among the genotypes for all characters under study (Table 1).

The total genetic variability observed was partitioned into various components attributable to GCA, SCA and reciprocal effects.

The GCA effects were highly significant for all characters, the SCA effects were significant for staple length and highly significant for lint percent and boll weight whereas it was non-significant for boll number and yield of seedcotton. No reciprocal effects were observed in any character (Table 2). Higher magnitude of GCA effects as compared to SCA effects has been observed by Marani [12], Al-Rawi and Kohel [2], Omran *et al.* [15] and Din [5]. The larger variances due to GCA lead to the conclusion that the major portion of genetic variability in these traits was additive in nature as the GCA is the result of additive gene effects [15]. The significance of specific combining ability in boll weight, lint percentage, and staple length

Table 1. Mean squares for different plant characters.

Source of variation	D.F.	Number of bolls	Boll weight	Yield of seed-cotton	Lint percentage	Staple length
Replication	2	589.27	1375.65	0.13	8.59	1.58
Treatment	24	155.81**	501.37**	0.32**	7.018**	2.25**
Error	48	40.91	131.28	0.09	2.75	0.65
Total	74					

** = Signficant at 1 % level of probability.

Table 2. Mean square values of different plant characters due to various genetic parameters.

Source of variation	Number of bolls	Boll weight	Yield of seed-cotton	Lint percentage	Staple length
GCA	225.84**	0.42**	622.63**	4.13**	1.81**
SCA	25.84^{NS}	0.09**	7.83^{NS}	2.99**	0.52*
Reciprocal	18.35^{NS}	0.02^{NS}	67.27NS	0.99NS	0.39^{NS}
Error	13.64	0.03	43.76	0.92	0.22

* = Significant at 5 % level of probability
** = Significant at 1 % level of probability
NS = Non-significant

Table 3. General combining ability effects for different plant characters.

Parents	Yield of seed-cotton	Number of bolls	Boll weight	Lint percentage	Staple length
NIAB (B-97)	8.13	5.80	–0.24	0.514	–0.23
B557	5.04	2.98	–0.10	0.27	–0.22
Express	3.18	1.69	–0.08	–0.76	0.72
Tamcot SP37	–4.55	–4.26	0.21	0.50	0.21
Delcot 277	–10.80	–6.23	0.22	–0.54	–0.48
S.E.	2.95	1.65	0.08	0.43	0.21

indicated the importance of non-additive type of gene action [19].

General combining ability (GCA) effects. NIAB(B-97) scored the highest value (8.13) for general combining ability followed by B557 (5.04) relative to yield of seedcotton per plant. Delcot 277 was the poorest combiner for this character.

The same situation was observed for the number of bolls as in the case of yield of seedcotton i.e. NIAB(B-97) proved to be a better general combiner at 5.80 and was followed by B557 (2.98). Similarly the poorest general combiner was Delcot 277 (-6.23).

In the case of boll weight, Delcot 277 ranked the highest (0.22), followed by Tamcot SP37 while NIAB (B-97) proved to be the poorest combiner for boll weight, i.e. -0.24.

As far as the GCA effect for lint percentage is concerned, NIAB(B-97) topped the list at 0.51 and was followed by Tamcot, SP37 (0.50). Express and Delcot 277 yielded negative effects.

For staple length, data suggest that Express was the best general combiner as it secured the highest value (0.72) for GCA effect (Table 3). Tamcot SP37 (0.21) occupied the second position, whereas all other varieties gave negative value.

NIAB(B-97), the highest yielding parent, proved to be best general combiner for the yield of seedcotton, number of bolls, and lint percentage. Similarly, B557 also showed better performance as a general combiner for the same character whereas Express behaved moderately in its GCA

Table 4. Specific combining ability effects for different plant characters.

Crosses	Number of bolls	Boll weight	Yield of seed-cotton	Lint percentage	Staple length
Delcot-x Tamcot SP37 277	– 0.774	0.032	3.13	1.962	– 0.338
Delcot-x NIAB(B-97) 277	– 0.734	1.092	0.48	0.722	0.239
Delcot-x B-557 277	– 0.214	– 0.058	1.07	– 0.488	– 0.114
Delcot-x Express 277	2.526	– 0.308	3.83	– 0.648	0.080
Tamcot-x NIAB(B-97) SP37	3.246	0.042	8.43	– 0.518	0.081
Tamcot-x B-557 SP37	0.216	0.102	2.62	– 0.178	– 0.087
Tamcot x Express SP37	0.156	0.132	1.83	– 0.538	– 0.910
NIAB(B-97) x B-557	0.956	0.052	0.94	– 0.418	0.460
NIAB(B-97) x Express	0.996	0.032	0.45	0.422	0.257
B-557 x Express	0.666	2.092	7.29	0.112	0.739
SE. I.	3.504	0.164	6.276	0.908	0.442
SE. II.	2.816	0.134	5.124	5.741	0.361

effects. For staple length Express topped the list and was followed by Tamcot, SP37. Tamcot, SP37 proved a poor combiner for yield of seedcotton and number of bolls, whereas it behaved moderately for boll weight, lint percentage and staple length. Delcot 277 generally performed poor by securing negative values for all characters except boll weight. NIAB(B-97), B-557 and Express exhibited comparatively better performance in most of the characters.

Specific combining ability (SCA) effects. Estimates of SCA effects in ten cross combinations for the characters are presented in Table 4.

All crosses except Delcot 277 x B557 and Delcot 277 x Express showed positive SCA effects. B557 x Express ranked the highest with an SCA of 2.09.

Delcot 277 x Tamcot SP37 exhibited the highest (1.16) SCA effect for lint percentage followed by Delcot 277 x NIAB(B-97), NIAB(B-97) x Express, and B557 x Express. All crosses showed positive performance.

For staple length, the combination of B557 and Express gave the highest SCA (0.74) followed by NIAB (B-97) x B557. Tamcot SP37 x Express occupied the lowest position in that respect.

These data suggest that the cross of B-557 and Express performed best followed by Delcot 277 x NIAB(B-97) for boll weight. Although the SCA effects for yield of seedcotton were observed to be non-significant (Table 2), the cross B557 x Express (the best one in the list of boll weight) showed better numerical values of SCA effects for the yield of seedcotton. This cross also had the highest SCA for staple length. The crosses of Delcot 277 with Tamcot SP37 and NIAB (B-97) gave higher values for lint percentage.

Table 4 further indicates an erratic behaviour for all varieties, for instance, the genotypes showing good GCA for various characters did not show constantly good results in combinations with others. Similarly, the genotypes showing relatively poor GCA effects for various characters performed better in some specific combinations. This situation agrees with Chang and Baluch [4] and Din [5] who stated that general combining ability was not the criterion for predicting specific combining ability.

Reciprocal effects. The absence of reciprocal effects (Table 2) suggested that there is no complication in bulking the crosses and their reciprocals for the characters under study as had been recommended by Hussain [8] in wheat. The absence of reciprocal effects in some quantitative characters of cotton (*G. hirsutum* L.) was also observed by Soomro and Soomro [18].

Heterosis and Heterobeltiosis. A considerable degree of heterotic effects in various quantitative characters of cotton (*G. hirsutum* L.) has been reported by many workers [16,3,14,6,1,18].

Since no reciprocal differences were noted in the present studies, the heterotic and heterobeltiotic effects were computed from the average of the values of crosses and their reciprocals. The estimates of heterosis and heterobeltiosis for the characters are given in Table 5.

As regards the yield of seedcotton it was found that all the crosses showed heterosis ranging from 36.49 (Delcot 277 x NIAB(B-97) to 99.25 percent (Tamcot SP37 x Express), whereas, all but two i.e. Delcot 277 x NIAB (B-97) and Delcot 277 x B557 showed heterobeltiosis. The cross B557 x Express scored the maximum (67.77 %), whereas Tamcot SP37 x NIAB(B-97) the minimum value

Table 5. Heterotic and heterobeltiotic effects for different plant characters.

Crosses	Yield of seed-cotton cotton	Number of bolls	Boll weight	Lint percentage	Staple length
Delcot-x Tamcot-SP37 277	55.88 (20.45)*	46.70 (3.13)	0.00 (– 12.50)	13.90 (12.37)	– 2.58 (– 5.50)
Delcot-x NIAB(B-97) 277	36.49 (– 24.40)	16.52 (– 38.25)	– 13.95 (– 33.93)	5.19 (– 0.46)	2.43 (1.05)
Delcot-x B-557 277	55.82 (– 11.13)	21.98 (– 34.32)	– 4.65 (– 26.79)	2.64 (– 1.27)	1.06 (– 0.22)
Delcot-x Express 277	97-00 (15.93)	94.57 (8.19)	– 15.56 – (32.14)	– 0.67 (– 3.26)	1.13 (– 3.49)
Tamcot-x NIAB(B-97) SP37	67.25 (0.15)	55.42 (– 10.83)	11.11 (– 4.76)	3.04 (– 1.23)	1.21 (– 3.10)
Tamcot-x B-557 SP37	83.54 (15.43)	34.33 (– 20.12)	22.22 (4.76)	12.05 (9-21)	0.44 (– 3.70)
Tamcot-x Express SP37	99.25 (31.86)	64.19 (4.74)	18.42 (7.14)	1.65 (0.33)	– 0.18 (– 0.74)
NIAB(B-97) x B-557	40.85 (24.40)	25.91 (11.98)	13.33 (13.33)	0.62 – (1.07)	5.70 (5.62)
NIAB(B-97) x Express	45.72 (17.37)	38.44 (6.22)	6.25 (0.00)	0.63 (– 2.30)	2.47 (0.46)
B-557 x Express	86.74 (67.77)	53.68 (29.59)	25.00 (17.65)	0.96 (– 0.32)	6.07 (2.17)

* = The values of heterobeltiotic effects are given in the parentheses.

0.15 percent (Table 5). Table 5 further reveals that Express is a promising parent as it gave a good amount of heterosis and heterobeltiosis in combination with all other parents.

For number of bolls, all the crosses expressed a considerable degree of heterosis (Table 5). It ranged from 16.52 (Delcot 277 x NIAB(B-97) to 94.57 percent (Delcot 277 x Express). Heterobeltiosis was exhibited by six out of ten crosses which ranged from 3.13 (Delcot 277 x Tamcot SP37) to 29.59 percent (B557 x Express). Here, in this case Express again performed better as compared to others by giving good combinations for this character.

For boll weight, six out of ten crosses showed heterosis and four heterobeltiosis (Table 5). The cross B557 x Express topped the list by securing 25 percent heterosis as well as 17.65 percent heterobeltiosis.

Since the number of bolls and boll weight are the most important components of yield, the crosses performing good for these characters are expected to perform good for yield of seedcotton [9,12]. In the present studies, the crosses, B557 x Express, Tamcot SP37 x Express and NIAB(B-97) x B557 have shown better results for these characters. They, therefore, may be given due consideration

in any breeding programme for increasing cotton production through the exploitation of heterosis.

All the crosses but one manifested heterosis varying from 0.62 (NIAB(B-97) x B557) to 13.90 percent (Delcot 277 x Tamcot SP37), while only three out of ten crosses exhibited heterobeltiosis which ranged from 0.33 (Tamcot SP37 x Express) to 12.37 percent (Delcot 277 x Tamcot SP37) for lint percentage. The cross Delcot 277 x Tamcot SP37 proved to be the best as it gave the highest estimates for heterotic as well as heterobeltiotic effects. The cross of Tamcot SP37 and B557 occupied the second position in that respect.

Table 5 further indicates heterosis for staple length in all but two crosses. It ranged from 0.44 (Tamcot SP37 x B557) to 6.07 percent (B557 x Express). Heterobeltiosis was observed in four out of ten crosses. The maximum value was attained by the cross NIAB(B-97) x B557, which occupied second position in the list of heterotic effects.

From an overall study of heterotic and heterobeltiotic effects, it can be concluded that the cross B557 x Express, Tamcot SP37 x Express, and Delcot 277 x Express showed good results for the yield of seedcotton, number of bolls, boll weight, and staple length. Similarly, Delcot 277 x Tamcot SP37 proved promising for lint percentage.

This information can be advantageously used in cotton breeding programmes where the exploitation of heterosis for increasing crop production is the primary emphasis.

REFERENCES

1. M.D. Ahmad and M.H. Channa, Pakistan Cottons, **25**, 271 (1981).
2. K.M. Al-Rawi and R.J. Kohel, Crop Sci., **10**, 82 (1970).
3. G.S. Chahal and T.H. Singh, Crop Improvement, **2**, 25 (1975).
4. M.A.K. Chang and M.A. Baluch, Pakistan Cottons, **12**, 55-84 (1968).
5. F. Din, *Heterosis and Combining Ability in G. hirsutum* L., M.Sc. thesis, Univ. Agr., Faisalabad (1981).
6. F.A. Faiz, *Heterosis Studies for Various Plant Characteristics in Intraspecific Crosses of G. hirsutum* L., M.Sc. thesis, Univ. Agr., Faisalabad (1980).
7. B. Griffing, Aust. J. Biol. Sci., **9**, 463 (1956).
8. S. Hussain, *Estimation of Heterosis and Combining Ability in some Varieties of Triticum aestivum* L. in a Diallel Cross, M.Sc. thesis, Agr. Univ., Lyallpur (1972).
9. J.E. Jones and H.D. Loden, Agron. J., **43**, 514 (1951).
10. M.A. Khan and I.A. Khan, *Commercial Use of Hybrid Vigour for Increasing Cotton Production in Pakistan,* paper read at Nat. Sem. Cotton Prod., Lahore (1979).
11. I. A. Khan, M.A. Khan and M. Iqbal, Pakistan Cottons, **29**, 77 (1985).
12. A. Marani, Crop Sci., **4**, 265 (1963).
13. M.Y. Mirza and M.R. Chaudhry, Pakistan Cottons, **29**, 63 (1985).
14. Z.A. Nasir, M.A. Khan and I.A. Khan, Pakistan Cottons, **22**, 91 (1978).
15. A.O. Omran, E. El-Ganayani and H. Jalal, Cotton Growers, Rev., **51**, 192 (1974).
16. M. Rafique, *Heterosis Studies in Gossypium hirsutum* L. M.Sc. thesis, Agr. Univ., Lyallpur (1972).
17. N.M. Shahani and M.A. Chang, Pakistan Cottons, **29**, 47 (1985).
18. B.A. Soomro, M. Ahmad and A.R. Soomro, Pakistan Cottons, **26**, 53 (1982).
19. G.F. Sprague and L.A. Tatum, J. Am. Soc. Agron., **34**, 923 (1942).