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Estimation of Heterosis, Heterobeltiosis and Economic Heterosis in Upland Cotton *(Gossypium hirsutum* L.)

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Abstract: A four-parent di-allel cross including CRIS-5A, CRIS-9, CRIS-52 and CRIS-54, cultivars of *Gossypium hirsutum* was analyzed for heterosis, heterobeltiosis and economic heterosis. The traits studied were the number of sympodia, bolls per plant, boll weight and seedcotton yield. Results revealed that seedcotton yield was dependent on number of bolls per plant (whenever the heterosis for number of bolls per plant went high heterosis for seedcotton yield was also increased). Four hybrids CRIS-52 x CRIS-54, CRIS-5A x CRIS-52, CRIS-52 x CRIS-9 and CRIS-54 x CRIS-52, exhibiting more than 70% of all types of heterosis were singled out.

Key words: Di-allel, heterosis, economic heterosis, mid parent value, better parent value

Introduction

Heterosis is the superiority of the hybrid over the mid or better parent value and is the result of allelic or non-allelic interactions of the genes under influence of particular environment. Meredith and Bridge (1972) coined the term "useful heterosis" which may be defined as superiority of the hybrid over a commercial variety. Heterosis has been observed in many crop species and has been the object of considerable study as a mean of increasing productivity of crop plants. It is now well-established fact that heterosis does occur with proper combination of parents.

Khan *et al.* (1980) evaluated heterosis in intra specific crosses of *G. hirsutum* cotton for yield and its components for 30 hybrids from a diallel cross involving the commercially grown *G. hirsutum* varieties 149F, AC-134, B-557 and three exotics, Northern Star 4-11, Rilcot stripper and Lambright GL. Heterosis over the mid parents value ranged from 57.14% to 97.97%, for yield per plant, -52.94%-107.89% while for boll number and boll weight was −38.88% to 19.33%.

Soomro *et al.* (1982) carried out heterosis studies in some intraspecific crosses of cotton. Data on seven traits were collected for six hybrids and their parents. Five hybrids exhibited hybrid vigor for yield, four for boll number per plant and boll weight and three for number of sympodia per plant. Kolte and Thombre (1984) carried out heterosis studies in gossypium species for 12 yield and fiber characters in 8 x 8 diallel set, excluding reciprocals, involving 4 varieties indicating that the intraspecific hybrid Andrews x Sujata and the interspecific hybrids Sujata x American Nectariless and N28 x American Nectariless were most promising for number of sympodia, bolls/plant and seedcotton yield/plant.

Sangwan and Yadava, (1986) studied heterosis in upland cotton and its commercial utilization in 30 hybrids of *G. hirsutum* derived from crossing. Heterosis was observed for all the 11 quantitative characters studied specially yield, boll weight and bolls/plant. The cross H777 x BR 70-118 had 100% heterosis for yield and also acceptable heterosis for other traits.

Significant heterosis and heterobeltiosis in cotton were observed by Khan and Ali (1980), Singh *et al.* (1980), Aslam and Khan (1983), Kolte and Thombre (1984), Khan *et al.* (1985), Ranganadhacharyulu and Rao (1986), Malik *et al.* (1988), Khan *et al.* (1993) and Soomro *et al.* (1996) for boll number, boll weight and seedcotton yield.

Keeping in view the importance of heterosis, the present study was under taken, including a 4-parent complete diallel set of crosses of *Gossypium hirsutum* L to single out the best performing hybrids for further exploitation by the breeders and research workers in the country.

Materials and Methods

An experiment was conducted in the Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam during 1995-96. Materials comprised of 12 intraspecific crosses (6 direct and 6 reciprocals) developed from a 4-parent complete diallel cross of CRIS-5A, CRIS-9, CRIS-52 and CRIS-54 (*Gossypium hirsutum* L.). The trial was conducted in a Randomized Complete Block Design (RCBD) with four replications. Ten plants were randomly selected from each replication and genotype for recording the data on number of sympodia, bolls/plant, boll weight and seedcotton yield. The data thus obtained for each character was subjected to statistical analysis (Snedecor and Cochran, 1967). The heterosis of all F1 hybrids was computed after Fehr (1987), which is as follows:

$$\text{Mid parent heterosis (percent)} = \frac{F1 - MP}{MP} \times 100$$

$$\text{Mid parent value} = \frac{P1 + P2}{2}$$

$$\text{Heterobeltiosis} = \frac{F1 - BP}{BP} \times 100$$

BP = Better Parent MP = Mid Parent

$$\text{Economic heterosis} = \frac{F1 - \text{Standard variety}}{\text{Standard variety}} \times 100$$

Results and Discussions

Number of sympodia per plant: The data regarding the number of sympodia per plant are presented in Table 1, which revealed that 7 hybrids out of 12 were positive heterosis over mid parent, while remaining 5 hybrids showed negative heterosis. 5 out of 12 hybrids excelled their better parents and 7 hybrids showed negative heterosis. In case of economic heterosis 5 hybrids showed positive and remaining gave negative economic heterosis. Hybrid CRIS-52 x CRIS-54

Table 1: Heterotic performance of F_1 hybrids for number of sympodia

Hybrids	Seed parent	Pollen parent	Mid parent	F1 Hybrid	Percentage (+) or (-) Mid parent	Better parent	Economic heterosis
CRIS-5A x CRIS-9	23.05	23.6	23.32	21.9	- 6.10	- 7.20	- 7.20
CRIS-5A x CRIS-52	23.05	26.05	24.55	26.5	+ 7.92	+ 1.72	+12.28
CRIS-5A x CRIS-54	23.05	22.4	22.72	27.3	+20.15	+18.43	+15.67
CRIS-9 x CRIS-52	23.6	26.05	24.82	21.2	-14.68	- 18.6	-10.16
CRIS-9 x CRIS-54	23.6	22.4	23.00	20.05	-12.82	- 15.0	-15.0
CRIS-52 x CRIS-54	26.5	22.4	24.22	29.7	+22.62	+ 14.0	+27.38
CRIS-9 x CRIS-5A	23.6	23.05	23.32	25.95	+11.27	+ 9.95	+ 9.95
CRIS-52 x CRIS-5A	26.05	23.05	24.55	27.05	+10.18	+ 3.83	+14.6
CRIS-54 x CRIS-5A	22.4	23.05	22.72	23.15	+ 1.87	+ 0.43	-1.90
CRIS-52 x CRIS-9	26.05	23.6	24.82	19.8	-20.22	-23.99	-16.10
CRIS-54 x CRIS-9	22.4	23.6	23.00	23.45	+ 1.95	- 0.63	-0.63
CRIS-54 x CRIS-52	22.4	26.05	24.22	23.6	- 2.57	- 9.4	0

Table 2: Heterotic performance of F_1 hybrids for number of bolls/plant

Hybrids	Seed parent	Pollen parent	Mid parent	F1 Hybrid	Percentage (+) or (-) Mid parent	Better parent	Economic heterosis
CRIS-5A x CRIS-9	29.4	25.5	27.45	30.62	+11.54	+ 4.14	+20.07
CRIS-5A x CRIS-52	29.4	24.85	27.12	44.15	+62.79	+50.17	+73.13
CRIS-5A x CRIS-54	29.4	27.11	28.25	30.4	+ 7.6	+ 3.4	+19.1
CRIS-9 x CRIS-52	25.5	24.85	25.17	37.91	+50.57	+48.62	+48.62
CRIS-9 x CRIS-54	25.5	27.11	26.30	25.34	- 3.65	- 6.45	- 0.62
CRIS-52 x CRIS-54	24.85	27.11	25.98	47.4	+82.41	+74.81	+85.88
CRIS-9 x CRIS-5A	25.5	29.4	27.45	31.86	+16.06	+ 8.36	+24.94
CRIS-52 x CRIS-5A	24.85	29.4	27.12	38.53	+42.07	+31.05	+51.09
CRIS-54 x CRIS-5A	27.11	29.4	28.25	30.42	+ 7.6	+ 3.46	+19.29
CRIS-52 x CRIS-9	24.85	25.5	25.17	41.99	+66.77	+64.66	+64.66
CRIS-54 x CRIS-9	27.11	25.5	26.30	41.82	+59.01	+54.23	+64.00
CRIS-54 x CRIS-52	27.11	24.85	25.98	39.04	+50.24	+43.98	+53.09

Table 3: Heterotic performance of F_1 hybrids for boll weight

Hybrids	Seed parent	Pollen parent	Mid parent	F1 Hybrid	Percentage (+) or (-) Mid parent	Better parent	Economic heterosis
CRIS-5A x CRIS-9	3.72	3.8	3.76	3.05	-18.93	-19.73	-19.73
CRIS-5A x CRIS-52	3.72	4.05	3.88	3.26	-15.11	-18.51	-13.15
CRIS-5A x CRIS-54	3.72	4.05	3.88	3.92	+ 0.96	- 3.0	+ 3.28
CRIS-9 x CRIS-52	3.08	4.05	3.92	4.37	+12.10	+ 8.64	+15.78
CRIS-9 x CRIS-54	3.08	4.05	3.92	4.17	+ 7.0	+ 3.70	+10.52
CRIS-52 x CRIS-54	4.05	4.05	4.05	3.7	- 8.6	- 8.6	- 2.63
CRIS-9 x CRIS-5A	3.8	3.72	3.76	2.9	-22.92	-23.68	-23.68
CRIS-52 x CRIS-5A	4.05	3.72	3.88	3.07	-20.90	-24.07	-19.07
CRIS-54 x CRIS-5A	4.05	3.72	3.88	3.95	+ 1.60	- 2.46	+ 3.94
CRIS-52 x CRIS-9	4.05	3.8	3.92	4.15	+ 5.73	+ 2.46	+ 9.21
CRIS-54 x CRIS-9	4.05	3.8	3.92	3.12	-20.38	-22.83	-17.76
CRIS-54 x CRIS-52	4.05	4.05	4.05	3.95	- 2.46	- 2.46	+ 3.94

Table 4: Heterotic performance of F_1 hybrids for seedcotton yield per plant

Hybrids	Seed parent	Pollen parent	Mid parent	F1Hybrid	Percentage (+) or (-) Mid parent	Better parent	Economic heterosis
CRIS-5A x CRIS-9	102.91	94.34	98.67	131.66	+33.49	+27.93	+39.47
CRIS-5A x CRIS-52	102.91	94.47	98.69	176.62	+78.95	+71.62	+87.09
CRIS-5A x CRIS-54	102.91	94.90	98.90	115.06	+16.87	+12.33	+22.45
CRIS-9 x CRIS-52	94.34	94.47	94.40	147.08	+56.55	+56.44	+56.56
CRIS-9 x CRIS-54	94.34	94.90	94.62	108.98	+15.16	+14.82	+15.44
CRIS-52 x CRIS-54	94.47	94.90	94.69	199.01	+110.26	+109.07	+110.91
CRIS-9 x CRIS-5A	94.34	102.91	98.62	138.08	+40.00	+34.18	+46.27
CRIS-52 x CRIS-5A	94.47	102.91	98.69	154.14	+56.18	+49.78	+63.28
CRIS-54 x CRIS-5A	94.90	102.91	98.90	115.60	+16.88	+12.33	+22.46
CRIS-52 x CRIS-9	94.47	94.34	94.40	163.77	+73.47	+73.35	+73.49
CRIS-54 x CRIS-9	94.90	94.34	94.62	179.83	+90.04	+89.4	+90.50
CRIS-54 x CRIS-52	94.90	94.47	94.69	163.78	+72.96	+72.5	+73.49

showed remarkable increase (22.67%, 14.0%, 27.38%) in comparison to its mid parent, better parent and standard variety, followed by hybrid CRIS-5A x CRIS-54 (20.15%, 18.43%, 15.67%). The results were in accord with those of Soomro *et al.* (1982), Kolte and Thombre (1984), Khan *et al.* (1993) and Soomro *et al.* (1996).

Number of bolls/plant: Number of bolls/plant is an important quantitative character in cotton, which plays a key role towards seedcotton yield performance. The data for number of bolls/plant are presented in Table 2, which showed the highest heterotic values displayed by all F1 hybrids over the mid parent, better parent and standard variety, except CRIS-9 x CRIS-54, giving negative values. However the F1 hybrids showed an increase in number of bolls/plant by 7.6%-82.41% over their mid parent, 3.4%-64.66% over better parent and 19.1-85.88% over standard variety. 7 hybrids showed high heterotic values over their relative parents for number of bolls/plant.

These findings suggested that all F1 hybrids were superior and could be exploited in developing varieties that ultimately would affect the seedcotton yield/plant. These findings are in agreement with those of Khan *et al.* (1980), Soomro *et al.* (1982), Kolte and Thombre (1984), Sangwan and Yadava (1986), Ranganadhacharyulu and Rao (1986), Malik *et al.* (1988), Khan *et al.* (1993) and Soomro *et al.* (1996).

Boll weight: The data presented in Table 3, revealed that 5 out of 12 hybrids surpassed their mid parents (values varied from 0.96% to 12.10%). CRIS-9 x CRIS-52 showed high positive heterosis over mid parent indicating the involvement of dominant genes. 3 out of 12 hybrids surpassing their better parent ranged from 2.46% (CRIS-52 x CRIS-9) to 8.64% (CRIS-9 x CRIS-52) which indicated the over dominant type of gene action. The positive economic heterosis was observed in 6 out of 12 hybrids ranging from 3.28% (CRIS-5A x CRIS-54) to 15.78% (CRIS-9 x CRIS-52). Results are in agreement with those of Khan *et al.* (1980), Soomro *et al.* (1982) and Sangwan and Yadava (1986).

Seedcotton yield/plant: The data for seedcotton yield/plant are presented in Table 4, all hybrids exhibited mid parent, better parent and economic heterosis. The greatest heterotic values were observed in CRIS-52 x CRIS-54, CRIS-5A x CRIS-52, CRIS-9 x CRIS-52, CRIS-5A x CRIS-9, CRIS-54 x CRIS-52 and CRIS-52 x CRIS-5A hybrids. It is revealed that all hybrids were superior in seedcotton yield and exhibited all types of heterosis indicating preponderance of the additive gene action.

It was observed that the hybrids possessing CRIS-52 and CRIS-54 parents when used in hybridization program either direct or reciprocal, exhibited all types of high heterosis. These two cultivars were also good general combiners and provide bright chance of promising segregates to evolve the varieties or hybrids with outstanding performance. These findings are in agreement with those of Chahal and Singh (1975) who estimated the heterosis in a di-allel cross analysis in *G. arboreum L*, in which ten quantitative characters were studied in the F2 of a diallel cross involving ten lines. Heterosis was relatively high for seedcotton yield and number of bolls per plant. Soomro *et al.* (1982), Kolte and Thombre (1984), Ranganadhacharyulu and Rao (1986), Malik *et al.* (1988), Khan *et al.* (1993) and Soomro *et al.* (1996) also observed the same kind of results.

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