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Heterosis in three intervarietal crosses for yield and yield contributing traits in cotton (*Gossypium hirsutum* L.)

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Abstract

Objective: Pakistan's economy depends on cotton production and the use of heterosis (hybrid vigor) in cotton genotypes to increase yield and improve fiber quality has long been an objective of research scientists. This study was designed to exploit heterosis in cotton as a breeding tool to improve cotton yields that have stagnated in recent years.
Methodology and Results: Heterosis over mid or better parent was calculated in three crosses of upland cotton (*Gossypium hirsutum* L.) involving varieties CIM 506, CIM 702, CIM 443, FH 1000 and CIM 1100 that are grown in Pakistan. Heterosis was observed for all the characters. The cross CIM 443 x CIM 1100 showed maximum positive heterosis (181%) for seed cotton yield followed by number of bolls per plant (93%) and number of sympodia (24%).
Conclusion and application of findings: We conclude that cotton plant exhibit fair amount of heterosis and crosses involving these parents would provide potential breeding material for further exploitation of heterosis in Pakistan.

Key words: Breeding, *Gossypium hirsutum* L., heterosis, mid parent, Pakistan.

Introduction

Cotton, the silver fiber, occupies a key position in the national economy and provides livelihood to millions of people associated with its production, ginning, transport, spinning, textiles and other allied industries. A considerable quantity of its production is exported in form of yarn, cloth and value added ready made garments to earn precious foreign exchange needed for the

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development of the country (Arshad *et al*., 2005).

Heterosis in cotton was reported as early as in 1894 by Mell (cited indirectly from Randhawa and Singh, 1994), and the foundation of the modern concept to heterosis was laid in 1908 by Shull (Randhawa and Singh, 1994). Since then, interspecific, intraspecific as well as inter varietal heterosis in cotton has been reported by a number of researchers (Turner, 1953; Davis, 1978). Many further reports have described heterosis for fiber quality, vegetative, reproductive growth, and photosynthetic production in cotton (Khan, 2002; Chen *et al.,* 2005). Heterosis studies have driven the release of many advanced cotton hybrids and large scale heterosis utilization, particularly in China (Wu *et al*., 2004).

Abdul-Razzaque (2000) found more yield in hybrid varieties compared to non hybrid in terms of bolls per plant and heavier bolls than the conventional cultivars. Xu-Xian *et a*l. (1995) studied combining ability, performance and heterosis of F1- hybrids and six varieties of upland cotton (*Gossypium hirsutum* L*.)* and found that heterosis existed in all yield traits and was greatest for seed cotton and lint yields. Rajput *et al.* (1997) studied heterosis over mid parent, better parent and control for six yield components in hybrid cotton grown during 1995-96. They observed a significant degree of heterosis for bolls per plant and plant height. The present study was, therefore, undertaken to estimate heterosis for yield and yield contributing traits using five varieties with their three crosses.

Materials and Methods

The present study was conducted in 2004-05 at the Central Cotton Research Institute (CCRI) Multan, Pakistan. Three crosses along with their five parents were tested for their heterosis in yield and yield contributing traits. The crosses were performed through standard procedures randomly in the previous year. The resulting seed of crosses was planted in the next year along with cotton varieties used in crosses for quick comparison. The experimental design was randomized complete block (RCBD) with three replications. Sowing was done on June 2nd, 2004. Plant -to-plant and row-to-row spacing were 1 ft (0.3m) and 2.5 ft (0.75m) respectively. Dibbling was the method used for sowing. Two to three seeds were planted per hole, later thinned to one seed per hill. Standard methods for water and fertilizer application, weeds and pest control were followed to raise a good crop. Plant morphological characters and fruit bearing were monitored at regular intervals. At maturity, five plants were selected at random and the following data were recorded for each individual plant, (1) plant height (measured using centimeter scale), (2) number of sympodia, (3) number of monopodia, (4) number of bolls, (5) boll weight, (6)number of seeds per boll and, (7) seed cotton yield (weighed using an electronic balance).

To estimate significant differences among parents and hybrids, the data were subjected to statistical analysis using M Stat-C software program. To estimate possible heterotic effects of the traits measured in this study, the percent increase or decrease of F_1 hybrids over mid or better parent value was calculated using the following formula:Heterosis = F1 - Mean / Mean x 100.

Results and Discussion

The analysis of variance revealed highly significant differences among all cotton genotypes for all traits measured in this study, except number of bolls per plant (Table 1).

Plant height: The individual comparison of means of all genotypes (Table 2) indicated that among parents, variety CIM 702 had the tallest plants (mean 149 cm), while the parent CIM 443 had the shortest plants averaging 86 cm. Among F1 hybrids CIM 506 x CIM 702 had the tallest plants (mean height 107.3 cm) while cross CIM 443 x CIM 1100 had the shortest plants averaging 91.3 cm tall. Computation of heterotic effects (Table 3) indicated that cross CIM 506 x CIM 702 had negative heterosis (-17.22%) while cross CIM 443 x FH 1000 showed positive heterosis (8.00 %). Similar results have been found by Rajput *et al.* (1997) who observed significant degree of heterosis for bolls per plant and plant height. In cotton breeding, medium plant height is a desirable trait.. The medium positive heterosis obtained in our crosses has potential value in that it could lead to development of medium height cotton plants that facilitate picking by hand.

Table 1: Mean squares of different traits in upland cotton (*Gossypium hirsutum* L.) evaluated in 2005 at CCRI, Multan, Pakistan

SOV	Df	Plant height (cm)	Number of Sympodia	Number of monopodia	Number of bolls /plant	Boll weight/10 bolls (gm)	Number of seeds / 5 bolls	Seed cotton yield/5 plants
Replication	2	18.481	4.087778	0.694815	25.338	4.40259	73.854	3050.7
Genotype	7	1137.8*	36.1104*	2.595979*	279.33 NS	125.687*	339.33*	7881.9*
Error	14	95.502	3.802222	0.597884	80.87312	12.1720	57.087	1598.5

* = Significant at 0.05 probability level. NS= Non significant at 0.05 probability level

Table 2: Mean performance of different traits in cotton

Crosses	Plant Height (cm)	Number of sympodia	Number of monopodia	Number of bolls /plant	Boll weight/10 bolls (gm)	Number of seeds/5 bolls	Seed yield/ 5 plants
CIM 506	110.3bc	20.0ab	4.4abc	43.0 NS	36.7bc	120.9bc	425.0b
CIM 702	149.0ab	23.1a	3.3bcd	35.0	51.2a	142.2a	455.0b
FH 1000	111.0ab	15.3c	2.7d	36.5	34.6bcd	125.9bc	466.7b
CIM 443	86.0d	16.3c	3.4bcd	29.5	33.7bcd	113.2cd	386.7b
CIM 1100	98.3bcd	11.3d	5.5a	26.3	37.3b	126.1bc	130.0c
CIM 506 x CIM702	107.3bc	18.1bc	4.5ab	43.3	35.2bcd	127.5b	396.7b
CIM 443 x FH 1000	99.3bcd	19.0bc	3.9bcd	41.8	31.8cd	107.4d	433.3b
CIM 443 x CIM 1100	91.3cd	17.2bc	3.0cd	53.8	30.2d	116.5bcd	726.7a
S.E	5.528	1.104	0.434	8.748	1.636	3.996	67.83

NS= Non significant at 0.05 level. Means followed by similar letters along the columns are not statistically different at 0.05 probabaility level.

Number of sympodia per plant: The average number of sympodia per plant ranged from 23.1 (CIM 702) to 11.3 (CIM 1100) (Table 2). The cross CIM 443 x CIM 1100 showed maximum positive value of heterosis (24.40 %) while the cross CIM 506 x CIM 702 showed negative estimate of heterosis (-16.10 %) (Table 3). The negative heterosis estimates are not desirable because less number of sympodia would translate to low yield (Malek and Shamsuddin, 1998).

Number of monopodia per plant: The mean number of monopodia per plant ranged from 5.5 (CIM 1100) to 2.7 (FH 1000) (Table 2) with cross CIM 443 x CIM 1100 showing maximum negative value for heterosis (-32.33 %) (Table 3). It has previously been noted that the node of first fruiting branch, monopodial and sympodial branches per plant, number of flower, number of bolls per plant and boll weight are positively and significantly correlated with plant yield (Iqbal *et al.,*2003).

Table 3: Estimates of percent heterosis for different parameters.

Crosses	Plant height (cm)	Number of sympodia	Number of monopodia	Number of bolls /plant	Boll weight/10 bolls (gm)	Number of seeds /5 bolls	Seed cotton yield/5 plants
CIM 506 x CIM702	-17.22	-16.10	15.52	10.94	-20.02	-3.12	-9.85
CIM 443 x FH 1000	8.00	20.00	28.00	27.00	-7.00	-10.00	2.00
CIM 443 x CIM 1100	-7.28	24.40	-32.33	93.06	-15.10	-2.59	181.29

Number of bolls per plant: The average number of bolls per plant ranged from 53.8 (CIM 443 x CIM 1100) to 26.3 (CIM 1100) (Table 2). Computation of heterotic effects for this parameter indicated that cross CIM 443 x CIM 1100 had positive heterosis (93.06 %), followed by the cross CIM 443 x FH 1000 with 27.00% heterosis. A positive value of heterosis is highly desirable for number of bolls per plant as it is correlated to increase in yield. These results indicate good potential of identifying hybrids that would yield more and heavier bolls per plant than the conventional cultivars, as reported by Abdul-Razzaque (2000).

Boll weight: The boll weight (gm) assessed per 10 bolls ranged from 51.2gm (CIM 702) to 30.2gm (CIM 443 x CIM 1100) (Table 2). All the crosses showed negative estimates for heterosis, ranging from -7.00 (CIM 443 x FH 1000) to -20.02 % (CIM 506 x CIM 702) (Table 3). Medium to low levels of heterosis for days to first flowering and boll weight seems to be a regular outcome of breeding efforts as similar results have been reported by Rajput *et al*., (1997).

Number of seeds (per 5 bolls): The individual comparison of means of all genotypes indicated that the number of seeds per 5 bolls ranged from 142.2 (CIM 702) to 107.4 (CIM 443 x FH 1000) (Table 2). All the crosses showed negative heterosis (Table 3) between -2.59 (CIM 443 x CIM1100) and -10.00 % (CIM 443 x FH 1000). Significant heterosis is usually expected for seeds per boll, seed cotton yield, seed index and plant height (Nadeem *et al*., 1998).

Seed cotton yield: Results (Table 2) indicated that seed cotton yield (based on a sample of 5 plants) ranged from a maximum of 726.7 (CIM 443 x CIM 1100) to minimum of 130.0 gm for variety CIM 1100). The highest yielding was an F_1 hybrids of cross CIM 443 x CIM 1100, which also showed maximum positive heterosis (181.29 %). The identification of a hybrid (CIM 443 x CIM 1100) with a 181% increase in seed cotton (compared to other varieties) is an important finding of this study. Such a high yielding hybrid may be suitable for direct releae or a good candidate for further improvement through breeding (Xu-Xian *et a*l., 1995).

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