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BRIEF NOTE

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# Finding heterosis for fiber traits in intervarietal crosses of cotton, *Gossypium hirsutum* L.



**Abstract** Raising yield and fiber quality of cotton through heterosis (hybrid vigor) has been an objective of plant breeders and scientists. Heterosis over mid parent for fiber-related traits was calculated in three crosses of cotton (*Gossypium hirsutum* L.) involving five cotton varieties, viz., CIM 506, CIM 702, CIM 443, FH 1000 and CIM 1100 being commercially grown in Pakistan. Heterosis was observed for all four characters. The cross CIM 443 × CIM 1100 showed maximum positive heterosis (8.57%) for ginning outturn (GOT) (%) followed by fineness (7.81%) and staple length (1.01%). Therefore, the cross CIM 506 × CIM 1100 appeared to be promising for providing potential breeding materials for further commercial exploitation of heterosis in Pakistan, and heterosis breeding has a great potential for increasing stagnant cotton yields around the world.

**Keywords** breeding, fiber, *Gossypium hirsutum* L., heterosis, mid parent

## 1 Introduction

Cotton (*Gossypium hirsutum* L.) is the most important cash and fiber crop and plays an important role in the economy of Pakistan, not only by providing the raw material to the entire textile industry but also earning valuable foreign exchange for the development of the country (Memon et al., 2007). Pakistan ranked the 4th largest among the cotton-producing countries in the world (Cotton Market Monthly Economic Letter, Cotton Incorporated Strategic Planning, February, 2005).

Heterosis is the superior or inferior performance of hybrid individuals compared with their parents. On the other hand, hybrid vigor which is sometimes used interchangeably with heterosis is the superiority of hybrid over its parents. Regarding previous studies on heterosis in cotton, researchers reported different heterosis values for yield components and fiber quality parameters. The amount of exploitable heterosis for seed cotton yield ranged from 15.5% (Al-Rawi and Kohel, 1969) to 35% (Thomson and Luckett, 1988). The amount of heterosis for fiber properties was usually lower (5%–10%) than that for yield and its components (Luckett, 1989; Meredith and Brown, 1998).

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 of heterosis was laid in 1908 by Shull (Randhawa and Singh, 1994). Since then, interspecific, intraspecific as well as intervarietal heterosis in cotton has been reported by a number of researchers (Turner, 1953; Davis, 1978). Heterosis studies have driven wide release and wide utilization of many advanced cotton hybrids, particularly in China (Wu et al., 2004). The present study was, therefore, undertaken to estimate heterosis for fiber parameters using five different varieties with their three crosses.

## 2 Materials and methods

The present study was conducted during 2004–2005 in the Central Cotton Research Institute (CCRI), Multan, Pakistan. Three crosses along with their five parents were tested for their heterosis in fiber-related 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 a randomized complete block (RCBD) with three replications. Seed sowing was done on June 2, 2004. Plant-to-plant and row-to-row spacings were 0.3 m and 0.75 m, respectively. Dibbling was the method used for sowing. Two to three seeds were planted per hole and seedlings

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thinned to one per hill after full emergence. Standard methods for water and fertilizer application, weeds and pest control were conducted following local practices. Plant morphological characters and fruit-bearing were monitored at regular intervals. At maturity, five plants were selected at random, and data were recorded on fiber traits such as staple length (mm), ginning outturn (GOT) (%), fiber strength, and fineness (micronaire).

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

## 3 Results and discussion

The analysis of variance revealed significant differences among all cotton genotypes for all fiber traits measured in this study except ginning outturn (GOT) (%) (Table 1).

### 3.1 Staple length

The individual comparison of means of all genotypes (Table 2) indicated that, among parental varieties, CIM 702 showed the highest staple length (31.7 mm), while the parent CIM 443 had the shortest staple length with an average 27.8 mm. Among $F_1$ hybrids, CIM 506×CIM 702 had the highest staple length (29.6 mm), while cross CIM 443 × FH1000 had the lowest staple length (27.4 mm).

The heterotic effects (Table 3) indicated that cross CIM 506 × CIM 702 showed the highest negative heterosis (−3.05%), while the cross CIM 443 × CIM 1100 showed a positive heterosis (1.01%). The positive heterotic estimate is desirable for staple length as it translates to better fiber quality. Our results are in conformity with Khan (2002) who observed a significant degree of positive heterosis for certain fiber quality traits such as staple length and fiber strength but negative heterosis for fiber micronaire.

### 3.2 Ginning outturn

No significant differences among genotypes were observed for ginning outturn (GOT) (%) (Table 1). However, the average GOT (%) ranged from 40.1% (CIM 443×CIM 1100) to 36.0% (CIM 443) (Table 2). The cross CIM 443 × CIM 1100 showed both the highest positive heterosis at 8.57% and the highest GOT % of 40.1%, while the cross CIM 443 × FH 1000 showed the lowest negative estimate of heterosis (−3.00%) and the lowest GOT% of 36% (Tables 2 and 3). Earlier, You et al., (1998) also made similar findings by working on heterosis in $F_1$ hybrids between three cultivars and five breeding lines. They also observed heterosis for fiber properties.

### 3.3 Fiber strength

A mean value of fiber strength ranged from 31.2 (CIM 506 × CIM 702) to 25.7 (CIM 443 × FH 1000) (Table 2). The

**Table 1** Mean squares of different fiber traits in upland cotton (*G. hirsutum* L.)

| SOV | *df* | staple length/mm | GOT/% | fiber strength/(g·tex$^{-1}$) | fiber fineness (micronaire) |
|---|---|---|---|---|---|
| replication | 2 | 0.095 | 921.334 | 0.341 | 0.007 |
| genotype | 7 | 5.135* | 420.744$^{NS}$ | 9.874* | 0.227* |
| error | 14 | 95.502 | 3.802222 | 0.597884 | 80.87312 |

Note: * indicates significant at 0.05 probability level, and $^{NS}$ indicates non significant at 0.05 probability level.

**Table 2** Mean performance of different traits in cotton

| genotypes | staple length/mm | GOT/% | fiber strength/(g·tex$^{-1}$) | fiber fineness (micronaire) |
|---|---|---|---|---|
| CIM 506 | 29.4b | 36.9 $^{NS}$ | 30.2a | 4.4de |
| CIM 702 | 31.7a | 38.6 | 30.5a | 4.3e |
| CIM 443 | 27.8d | 36.0 | 27.8bc | 4.7de |
| FH 1000 | 27.9cd | 39.1 | 28.0b | 5.0a |
| CIM 1100 | 28.3bcd | 37.9 | 28.2bc | 4.3de |
| CIM 506 × CIM702 | 29.6bc | 37.1 | 31.2a | 4.5cd |
| CIM 443 × FH 1000 | 27.4cd | 36.6 | 25.7d | 4.8b |
| CIM 443 × CIM 1100 | 28.3bcd | 40.1 | 27.9c | 4.8bc |
| S.E. | 0.5511 | 11.73 | 0.3768 | 0.09309 |

Note: $^{NS}$ stands for non significant at 0.05% probability. Means sharing similar letters are statistically similar at 0.05% probability. Duncan Multiple Range Test (DMR) was used in the analysis.

cross CIM 506 × CIM 702 which had the highest fiber strength also showed the highest positive value of heterosis (2.58%). Also, the cross CIM 443 × FH 1000 with the lowest fiber strength showed the lowest negative value of heterosis (−8.00) (Table 3). A positive heterosis value for fiber strength is desirable as it correlates with an increase in fiber quality as reported by Arshad et al., (2001) who observed that the highest increase for lint percentage and for staple length over the mid-parent was 3.92 and 9.50%, respectively. For fiber strength, the increase over mid-parent was 9.95%. For fiber strength, their results indicated that 13 $F_1$ hybrids expressed positive heterosis ranging from 0.23% to 9.95%. Thus, Arshad et al., (2001) reported positive heterosis for all fiber-related parameters.

### 3.4 Fiber fineness

The average value of fiber fineness ranged from 5.0 (FH 1000) to 4.3 (CIM 702) (Table 2). The cross CIM 443 × CIM 1100 showed the highest positive value of heterosis (7.81%), and the cross CIM 443 × FH 1000 showed the lowest negative value of heterosis (−1.00%) (Table 3). Our results were in accordance with the findings of Khan (2002) observing a significant degree of negative heterosis for fiber micronaire.

**Table 3** Estimates of percent heterosis for fiber parameters

| crosses | staple length /mm | GOT/% | fiber strength /(g·tex$^{-1}$) | fiber fineness (micronaire) |
|---|---|---|---|---|
| CIM 506×CIM 702 | −3.05 | −1.72 | 2.58 | 3.85 |
| CIM 443×FH 1000 | −2.00 | −3.00 | −8.00 | −1.00 |
| CIM 443×CIM 1100 | 1.10 | 8.57 | −0.48 | 7.81 |

## 4 Conclusion

In conclusion, intervarietal crosses like these have excellent potential for increasing the stagnant cotton fiber production not only in Pakistan but also around the world. Heterotic breeding techniques may be highly beneficial for the development of high yielding and perhaps superior quality upland cotton (*G. hirsutum* L.) varieties.

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