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Genetic Analysis of Some Fibre Quality Characters in *Gossypium hirsutum* L.

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ABSTRACT

Mean squares for both general (GCA) and specific combining ability (SCA) effects were significant for the expression of fibre length and fibre fineness, but GCA effects for fibre strength were non-significant. The larger proportion of variance due to SCA for fibre fineness and fibre strength revealed the nature of gene action to be non-additive, while magnitude of genetic variance due to GCA was greater for fibre length showing the genetic control under gene effect. The variety NIAB-98 proved to be the best general combiner for fibre length and fibre strength, and CIM-435 proved to be the best general combiner for fibre fineness. The cross NIAB-98 x CIM-435 with higher numerical value was revealed to be the best varietal combination for fibre fineness, and for fibre length cross Arizona-6218 x Carolina-173 was shown to be better than other combinations. Similarly, for fibre strength cross CIM-435 x Carolina-173 appeared to be the promising one among the varietal combinations.

Key Words: Genetic analysis; Quality; Specific combining ability; General combining ability *Gossypium hirsutum* L.

INTRODUCTION

Development of cotton cultivars having improved fibre characteristics is the major objective of cotton breeder. The increasing demand for better staple length, fibre fineness and fibre strength necessitates the research workers to exploit the genetic resources, through selection and breeding, for greater benefits. Before making selection of plants combining desirable characteristics, information on the genetic mechanism controlling the characters must be available. The variation in fibre characters had been reported under both additive and non-additive genetic effects. The studies of (Akbar *et al*., 1993; Liu *et al*., 1998; Deshmukh *et al*., 1999) showed action of genes to be non-additive for fibre fineness, whilst (Debaby *et al*., 1997; Pavasia *et al*., 1999) did not find these genetic effects in their studies.

In another report genetic variance due to GCA for fibre length was greater than that due to SCA, suggesting action of the genes to be additive (Rauf *et al*., 1994; Tariq *et al*., 1995; Valarmathi & Jehangir, 1998). In contrast the work of Hassan *et al*. (1999) which revealed the presence of non-additive genes for fibre length, Hendawy *et al*. (1999) and Khan *et al*. (1991) reported the presence of both additive and non-additive gene effects for fibre length and fibre fineness. Thus, it is imperative to investigate the genetic basis of variation in these characters in the plant material at hand, and therefore present studies were conducted.

MATERIALS AND METHODS

The present genetic investigations were carried out in the experimental area of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during the year 2001-2003. The experimental material used in the studies was developed by crossing four parents namely NIAB-98, CIM-435, Arizona-6218 and Carolina-173 in all possible combinations. The seeds of these four parents were sown in 30 x 30 cm earthen pots in the greenhouse. For rapid growth and development of plants ambient temperature of the greenhouse during November, 2001 was maintained between 60 to 90°F by lighting mercury vapour lamps and circulating steam in pipes. All the necessary precautionary measures were taken to avoid pollen contamination of the genetic material at the time of emasculation and pollination. Maximum numbers of pollinations were made to produce sufficient number of F_1 seeds.

The seeds of 12 F_1 hybrids and four parents were planted in the field during June, 2002 to raise F_1 generation in three replications following randomized complete block design layout. The seeds were dibbled to ensure uniform plant population. The seeds were sown in single row plot having ten plants spaced 30 cm within the row and 75 cm between the rows. The data were taken on the middle eight plants leaving one plant on either end of each row to avoid border effects. Normal agronomic practices and plant protection measures were adopted to obtain healthy plants. The data on fibre length, fibre fineness and fibre strength were recorded using Spinlab high volume instrument (HVI-900) in the Department of Fibre Technology, University of Agriculture, Faisalabad. HVI-900 is a computerized high volume instrument, which provides a comprehensive profile of fibre quality characteristics. It measures the most important fibre characteristics such as fibre length (mm), fibre strength (g/tax), fibre fineness (μg/inch) and other fibre quality characteristics according to the international trading standards.

The mean values of the 16 entries in each replication were analyzed according to analysis of variance technique (Steel & Torrie, 1980) to determine the genotypic differences for all the characters. Combining ability analysis of the data was made following "Method I" and "Model II" of Griffing technique (Griffing, 1956).

RESULTS

Fibre length. The mean squares due 12 F_1 hybrids and four parents differed significantly ($P \leq 0.01$, Table I) from each other. The results of genetic analysis of the data revealed significant effects of general, specific combining abilities and reciprocal effects ($P \geq 0.05$) on fibre length. The magnitude of variance of GCA for fibre length (0.024) is greater than that of the variance of the SCA (0.017), (Table III). The comparison of indices of GCA revealed that NIAB-98 (0.266) and Carolina-173 (0.218) had positive and high indices than those of CIM-435 and Arizona-6218, and thus had better GCA for the character.

The potential of the parents in hybrid combinations (Table IV) showed that four combinations namely NIAB-98 x CIM-435 (0.258), CIM-435 x Arizona-6218 (0.107), CIM-435 x Carolina-173 (0.465) and Arizona-6218 x Carolina-173 (0.619) had positive and higher indices for the character, although statistically the indices did not differ each other.

In reciprocal combinations, only two combinations attained positive values, and these were Arizona-6218 x CIM-435 (0.102) and Carolina-173 x CIM-435 (0.112) and thus also displayed good SCA for fibre length.

Fibre fineness. Data on micronaire values of 12 F_1 hybrids and four parents were subjected to simple analysis of variance, and the results are given in Table I. Highly significant mean squares due to families showed that the genotypes differed from each other for fibre fineness. Differences between the replications were non-significant ($P \geq 0.05$). The results of combining ability analysis revealed that effects of GCA were significant ($P \leq 0.05$), whilst effects of SCA showed highly significant ($P \leq 0.01$) and reciprocal combination appeared to be non-significant ($P \geq 0.05$, Table II).

The genetic variance resulting from SCA effects (0.024) was higher than that due to GCA, showing the presence of non-additive gene loci (Table II). The results of comparison of the parents for fibre fineness given in Table IV showed that CIM-435 (0.056) and Arizona-6218 (0.031) with positive and higher indices expressed better GCA for fibre fineness, than NIAB-98 and Carolina173.

SCA of the four parents given in Table IV, revealed that NIAB-98 x CIM-435 (0.183), NIAB-98 x Carolina-173 (0.116), CIM-435 x Arizona-6218 (0.091) and Arizona-6218 x Carolina-173 (0.049) had attained positive values showing their higher SCA for the character. Although the indices of NIAB-98 x CIM-435 (0.183) is higher than those of three combinations, statistically these two were similar.

Comparison of the parents in reciprocal combinations (Table IV) showed that all six F_1 hybrids attained positive values which were CIM-435 x NIAB-98 (0.062), Arizona-6218 x NIAB-98 (0.077), Carolina-173 x NIAB-98 (0.090), Arizona-6218 x CIM-435 (0.067), Carolina-173 x CIM-435 (0.013) and Carolina-173 x Arizona-6218 (0.100) but did not differ significantly from one another.

Fibre strength. Simple analysis of variance of fibre strength of 16 families showed significant ($P \leq 0.05$) genotypic differences for fibre strength (Table I). Significant genotypic differences for the character suggested that the data was suitable for genetic analysis following Griffing's approach (1956). The results of the combining ability analysis are present in Table II.

The result of the analysis revealed that the effects of GCA were non-significant ($P \geq 0.01$), whilst the effects of SCA were highly significant ($P \leq 0.01$), effects of reciprocal combination were non-significant ($P \geq 0.01$). Variance of dominance (V_D) is greater (0.54) than that of variance of

Table I. Mean squares obtained from analysis of variance of fibre quality characters in *Gossypium hirsutum* L.

Source of variation	Fibre length	Fibre fineness	Fibre strength
Replications	0.041 N.S.	0.013 N.S.	1.246 N.S.
Genotypes	1.99**	0.093**	2.174*
Error	0.531	0.0331	0.966

Table II. Mean squares obtained from combining ability analysis of fibre quality characters in *Gossypium hirsutum* L.

Source of variation	Fibre length	Fibre fineness	Fibre strength
GCA	0.709*	0.035*	0.506 N.S.
SCA	0.546*	0.049**	1.205**
Reciprocals	0.759**	0.011 N.S.	0.353*
Error	0.177	0.011	0.322

Table III. Estimation of components of variation of fibre quality characters in *Gossypium hirsutum* L.

Source of variation	Fibre length	Fibre fineness	Fibre strength
GCA	0.024	-0.001	-0.071
SCA	0.017	0.024	0.543
Reciprocals	0.291	-0.0001	0.016
Error	0.177	0.011	0.322

N.S., *,** shows non-significant, significant and highly significant differences, respectively

Table IV. Estimation of GCA, SCA and reciprocal effects for fibre quality characters in *Gossypium hirsutum* L.

Parents	Fibre length	Fibre fineness	Fibre strength
NIAB-98	0.266	0.007	0.284
CIM-435	-0.119	0.056	0.066
Arizona-6218	-0.365	0.031	-0.323
Carolina-173	0.218	-0.095	-0.028
$Cd_1(gi – gj)$	0.412	0.103	0.556
Cross combinations			
NIAB-98 x CIM-435	0.258	0.183	-0.706
	0.480	0.062	-0.373
NIAB-98 x Arizona-6218	-0.090	-2.236	-0.825
	-0.883	0.077	-0.872
NIAB-98 x Carolina-173	0.283	0.116	0.231
	-1.110	0.090	0.163
CIM-435 x Arizona-6218	0.107	0.091	0.009
	0.102	0.067	-0.095
CIM-435 x Carolina-173	0.465	-0.136	0.799
	0.112	0.013	0.323
Arizona-6218 x Carolina-173	0.619	0.049	-0.184
	-0.100	0.100	0.145
$Cd_1(Sij – Sik)$	0.714	0.178	0.963
$Cd_1(rij – rkl)$	0.824	0.206	1.112

The values given in parenthesis are scores of sca in reciprocal combinations of varieties additive effect (V_A) (-0.16) (Table IV). The relative magnitude of these estimates showed that two parents NIAB-98 and CIM-435 had positive values (0.284) and (0.066) respectively. Although NIAB-98 attained higher value than CIM-435 but statistically the differences were non-significant.

Combining abilities of the parents for combining for fibre strength were tested (Table IV). The data showed that three combinations, NIAB-98 x Carolina-173 (0.231), CIM-435 x Arizona-6218 (0.009) and CIM-435 x Carolina-173 (0.799) had positive values and differed from each other. In reciprocal crosses, the combinations of Carolina-173 x NIAB-98 (0.163), Carolina-173 x CIM-435 (0.323) and Carolina-173 x Arizona-6218 (0.145) were shown to be good varietal combinations.

DISCUSSION

Development of cotton varieties possessing improved fibre characteristics had been the major objective of cotton breeders. Thus availability of genetically based variation for fibre characteristics like fibre length, fibre fineness and fibre strength in breeding population is essential.

Although the present sample of genetic material used here to generate information on genetic mechanism controlling the three fibre traits was small, the genotypic differences were revealed to be significant for all the characters (Table I). The combining ability analysis (Griffing, 1956) showed that effects of GCA and SCA were significant for controlling variation in all the characters except for fibre strength where effects of GCA were non-significant (Table II). Higher proportion of genetic variation due to SCA suggested that genes with non-additive effects were predominant in the inheritance of fibre fineness and fibre strength and thus the characters may have low heritability as suggested by Falconer and Mackey (1996). This information suggests that segregating populations originating from the parental crosses developed here may not be amenable to direct selection, and therefore, the breeders will have to be careful and imaginative while looking for plants having improved fibre characters from the segregating progenies. Similar genetic behaviour of variation in these characters had been reported in previous studies (Liu *et al*., 1998; Deshmukh *et al*., 1999 and Akbar *et al*., 1993). However the genetic mechanism controlling these characters studied by Pavasia *et al*. (1999) and Debaby *et al*. (1997) did not appear to agree with the present report, all these workers found the presence of additive genetic effects. The differences in the opinion may be due to different genetic makeup of the material tested under different environmental conditions.

The large magnitude of the genotypic variance resulted by GCA effects suggested that genes acted additively in the inheritance of fibre length, as suggested by Sprague and Tatum (1942), suggesting that F_2 population may hold a good promise for bringing genetic improvement in the characters, through selection and breeding. Similar genetic behaviour of genes had been reported by Valarmathi and Jehangir (1998), Tariq *et al*. (1995) and Rauf *et al*. (1994). However in some other plant materials fibre length had been reported to be effected by non-additive loci (Azhar & Rana, 1993; Hassan *et al*., 1999).

The comparison of the parents revealed that the variety NIAB-98 had the best GCA for fibre length and fibre strength (Table IV), while the variety CIM-435 displayed best GCA for fibre fineness. The high GCA of these two parental lines may be used to exploit variation in the breeding population, and plants having improved fibre characters may be selected. For example, the cross NIAB-98 x CIM-435 with higher numerical value i.e. 0.183 was revealed to be the best varietal combination for fibre fineness, and for fibre length cross Arizona-6218 x Carolina-173 was shown to be better than other combinations. Similarly, for fibre strength cross CIM-435 x Carolina-173 appeared to be the promising one among the varietal combinations. These results showed that the performance of the hybrids might have resulted due to the best GCA of NIAB-98, CIM-435, Carolina-173 and Arizona-6218 for all the characters. The reciprocal cross, Carolina-173 x CIM-435 for fibre length and fibre strength and Carolina-173 x NIAB-98 for fibre fineness displayed their superiority.

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