INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2004/06–2–272–274
http://www.ijab.org

Combining Ability Analysis of Fibre Characteristics in *Gossypium hirsutum* L.

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ABSTRACT

In order to study the genetic basis of fibre characters of *Gossypium hirsutum* L. lint four varieties namely, MNH-554, Delcerro, Coker-304 and Albacala (71)1190 were crossed in all possible combinations. The genetic analysis of the F_1 data showed that effects of general combining ability were significant for fibre length, fibre fineness, fibre strength, fibre whiteness and fibre yellowness as affected by specific combining ability, and these effects were also significant. The greater magnitude of variance resulting from general combining ability suggested that all the fibre characters ere influenced by the genes acting additively except for yellowness which appeared to be influenced by non-additive loci. The varieties differed for their general combining ability for different characters. MNH-554 proved to be the best general combiner for fibre length and fibre whiteness, Coker-304 as better for fibre strength and fibre yellowness, than others and Albacala (71)1190 exhibited its potential for fibre fineness. The preponderance effects of additive genes suggested estimates of narrow sense heritability may be high, and thus it seems that F_2 population may be amenable to selection, single plant selection followed by pedigree method may be effective in improving fibre characters.

Key Words: *Gossypium hirsutum*; Combining ability; Fibre

INTRODUCTION

Amongst the species which produce spinable fibre, *Gossypium hirsutum* L. is the most important as it contributes 90% to the world cotton production. Being the major exporting commodity of Pakistan, the cotton breeders focused their attention to increase its production and improve fibre characteristics. As a result of concerted research endeavors, numerous varieties were bred using the local and exotic germplasm. Whilst high yielding varieties are important for farmers, owners of textile industry need long and strong fibre for cloth making. Further in the changing scenario of world market, fibre lint with improved fibre characteristics will fetch more foreign exchange shipping exportable surplus. Thus in view of the changing trade circumstances it is necessary to continue their efforts to breed varieties with better fibre characters. Selection of parents from germplasm for hybridization is difficult task for the breeders. The breeders are facilitated by the use of numerical approach of Griffing (1956), which in addition to rating the variation with respect to their general and specific combining abilities helps in portioning the genetic components of variation. The information obtained from the analysis facilitates the development of a well-conceived breeding programme.

The previous investigations revealed that for inheritance of fibre fineness and length additive genes effects were more important (Pavasia *et al.*, 1999; Amin & Hussain, 2000; Kurgade *et al.*, 2000) whilst in some cases non-additive were predominant (Rehman *et al.*, 1993; Ajmal *et al.*, 2000; Islam *et al.*, 2001). Fibre strength is another important parameter in the process of cloth making, which has been reported under the effect of genes having commutative effect (Hussain *et al.*, 1999; Ajmal *et al.*, 2000; Khan *et al.*, 2001). In order to collect such information on genetic material available in department, the present research work was conducted, and the information derived may provide guideline to cotton breeders for continued improvement fibre characters.

MATERIALS AND METHODS

In order to examine the genetic basis of fibre characteristics in *hirsutum* spp., the experimental materials used in the studies was developed by crossing four parents namely MNH-554, Coker-304, Delcerro and Albacala (71)1190 in all possible combinations. The seeds of the parents were sown in 30 × 30 cm earthen pots using the greenhouse facility in the department. At the time of flowering, plants were emasculated and pollinated. All the necessary precautionary measures were taken to avoid alien pollen contamination of the genetic material at the time of emasculation and pollination. Maximum number of pollinations was made to produce sufficient of F_1 seed of each cross.

The seed of the 12 F_1 crosses and the parents were planted in the field on 10 June, 2002 to raise F_1 generation. Each entry was sown in three replications following randomized complete block design layout. To ensure uniform plant population the seed was dibbled. The seed was sown in single row plot having 10 plants spaced 30 cm within the row and 75 cm between the rows. The seed cotton was taken from the middle eight plants leaving two plants on either end of the row to avoid the border effects. Seed cotton of all the family picked was ginned using single roller ginning machine available in the department. A lint sample was taken from all the plants, and fibre length**,** fibre fineness, fibre strength, fibre whiteness and fibre yellowness for each plant of a family were measured using Spinlab High Volume Instrument (HIV) in the department of Fibre Technology, University of Agriculture, Faisalabad. Means of parents and F_1 families for fibre characteristics were used for genetic analysis.

Statistical procedures. The data of all the characters measured were subjected to analysis of variance technique (Steel & Torrie, 1980) to see whether the genotypic differences were significant for the characters. Data were further analysed genetically followed combining ability technique (Griffing, 1956) "Method I 'Model II".

RESULTS

Simple analysis of variance of the F_1 data showed that genotypic differences for all the fibre characters were highly significant ($P \leq 0.01$, Table I). The genetic analysis of the data, following Griffing approach (1956) revealed that the presence of highly significant ($P \leq 0.01$) mean squares due to general combining ability for fibre length, fibre strength, and fibre whiteness except fibre fineness the effects of both general and specific combining abilities were significant ($P \leq 0.01$). Mean squares due to specific and reciprocal effects were significant ($P \leq 0.05$) for fibre yellowness (Table II).

The ranking of the four parents, and their crosses for each of the fibre character is given in the following paragraphs.

Fibre length. Amongst the four parents, three had positive values, general combining ability of MNH-554 was better than that of Delcerro and Albacala (71)1190. Comparison of specific combinations showed that Coker-304 × Delcerro, Coker-304 × Albacala (71)1190, Delcerro × Albacala (71)1190, Delcerro × Coker-304 and Albacala × Delcerro showed best specific combining ability for fibre length, however specific combining ability and reciprocal effects of the combinations differs non-significantly from each other.

Fibre fineness. Assessment of the parents for their general combining ability for fibre fineness was made in Table III. Comparisons of the estimates showed that only one parent, Albacala (71)1190 attained positive value, 0.157 suggesting its best general combining ability for fibre fineness. The potential of the parents to nick with each other was compared in their combinations, and relative estimates of specific combining ability are given in Table III showed that cross MNH-554 × Delcerro (0.009), Coker-304 × Delcerro (0.024), Delcerro × MNH-554 (0.025), Delcerro × Coker-304 (0.010), Albacala (71)1190 × Coker-304 (0.007) and Albacala (71)1190 × Delcerro (0.020) attained positive values, but statistically all of them are similar.

Fibre strength. The relative magnitude of the estimates of general combining ability given in Table III, showed that two parents, MNH-554 (0.569) and Coker-304 (0.583) for fibre strength, and expressed the best general combining ability for the character. Although, Coker-304 attained highest but statistically it is non-significantly difference from MNH-554, suggesting similar potential for fibre strength. The comparison of varietal combinations showed that only one combination, Coker-304 × Delcerro (0.109) attained positive value out of 12 combinations, proved to be the best combination for fibre strength.

Fibre whiteness. Although the effects of general combining ability for fibre whiteness were highly significant, further analysis showed that only one parent i.e. MNH-554 attained positive value of 0.746, and revealed to be a best general combiner (Table III). The performance of the parents was compared in their specific combinations, given in Table III. The comparison showed that MNH-554 × Delcerro (0.134), MNH-554 × Albacala (71)1190 (0.201), Coker-304 × Delcerro (0.156), Coker-304 × Albacala (71)1190 (0.144) and Albacala (71)1190 × MNH-554 (0.075), but statistically the differences among these crosses were non-significant.

Fibre yellowness. General combining ability of the four parents for fibre yellowness was determined and is given in Table III. The results of combining ability analysis showed that only one parent, Coker-304 with 0.124, attained positive value, so proved to be the best general combiner for the character. The comparison of the parents in their combinations showed that out of 12 hybrids eight combinations namely, MNH-554 × Coker-304, MNH-554 × Delcerro, Delcerro × Albacala (71)1190, Coker-304 × MNH-554, Delcerro × MNH-554, Albacala (71)1190 × MNH-554, Delcerro × Coker-304 and Albacala (71)1190 × Delcerro with 0.031, 0.034, 0.110, 0.155, .0355, 0.155, 0.040 and 0.043, respectively, attained positive values.

Table I. Mean squares from analysis of variance of five fibre characters in 16 families of *Gossypium hirsutum* L.

Source of variation	D.F.	Fibre length	Fibre fineness	Fibre strength	Fibre whiteness	Fibre yellowness
Replication	2	0.452N.S.	0.0003N.S.	0.125N.S.	0.426N.S.	0.211N.S.
Families	15	0.658**	0.0713**	2.811**	2.003**	0.192*
Error	30	0.167	0.0043	0.888	0.643	0.075

Table II. Mean squares and variances (italic) obtained from combining ability analysis of five fibre characters in 16 families of *Gossypium hirsutum* L.

Source of variation	D.F.	Fibre length	Fibre fineness	Fibre strength	Fibre whiteness	Fibre yellowness
General combining ability	3	1.023** 0.123	0.1030** 0.012	3.677** 0.399	2.204** 0.247	0.056N.S. -0.001
Specific combining ability	6	0.034N.S. -0.013	0.0074** 0.004	0.503N.S. 0.128	0.227N.S. 0.008	0.068* 0.026
Reciprocal	6	0.002N.S. -0.027	0.0005N.S -0.001.	0.001N.S. -0.148	0.343N.S. 0.064	0.064* 0.020
Error	30	0.056	0.0014	0.296	0.214	0.025

Table III. Estimates of general and specific combining abilities, and reciprocal effects for five fibre characters in 16 families of *Gossypium hirsutum* L.

Parents	Fibre length	Fibre fineness	Fibre strength	Fibre whiteness	Fibre yellowness
MNH-554	0.369	-0.024	0.569	0.746	-0.035
Coker-304	-0.487	-0.114	0.583	-0.196	0.124
Delcerro	0.098	-0.020	-0.416	-0.471	-0.029
Albacala (71) 1190	0.020	0.157	-0.736	-0.079	-0.060
cd1 (gi - gl)	0.231	0.037	0.533	0.454	0.155
Cross Combination					
MNH-554 × Coker-304	-0.129	-0.012	-0.256	-0.646	0.031
	-0.015	-0.010	-0.015	-0.010	0.155
MNH-554 × Delcerro	0.114	0.009	-0.385	0.134	0.043
	-0.015	0.025	-0.027	-0.015	0.355
MNH-554 × Albacala (71) 1190	-0.081	-0.079	-0.522	0.201	-0.048
	-0.020	-0.013	-0.020	0.075	0.155
Coker-304 × Delcerro	0.092	0.024	0.109	0.156	-0.197
	0.065	0.010	-0.015	-0.025	0.040
Coker-304 × Albacala (71) 1190	0.075	-0.046	-0.021	0.144	-0.231
	-0.020	0.007	-0.015	-0.025	-0.125
Delcerro × Albacala (71) 1190	0.035	-0.007	-0.127	-0.106	0.110
	0.015	0.020	-0.020	-0.050	0.043
cd1 (sij - sik)	0.400	0.064	0.925	0.786	0.268
cd1 (rij - rkl)	0.462	0.074	1.066	0.907	0.309

The values given in italic are specific combining ability of the reciprocal combinations

Performance of cross Delcerro × MNH-554 was significantly different from Delcerro × Coker-304 and Albacala (71)1190 × Delcerro for fibre yellowness.

DISCUSSION

Development of high yielding varieties with improved fibre characters has been the major objective of cotton breeders. For making selection of genotypes giving greater seed cotton yield with acceptable fibre characters, the availability of genetically based variation in the breeding population is essential. Although the parental material used here to develop plant material for genetic studies was small, yet statistical differences among the genotypes for all the characters were revealed to be highly significant (Table I). The combining ability analysis showed that greater magnitude of variances resulting from general combining ability for fibre length, fibre fineness, fibre strength and fibre whiteness appeared to be affected by genes having cumulative effects, however variance due to specific combining ability was greater for fibre yellowness. The previous studies (Babar & Khan, 1999; Pavasia *et al.*, 1999; Amin & Hussain, 2000; Ajmal *et al.*, 2000; Khurgade *et al.*, 2000) on fibre characteristics appeared to be in great accord with the present information. However, the genetic analysis of the data on fibre yellowness revealed its inheritance to be effected by non-additive loci. There is no work reported in the literature which may support the present information on the genetic basis of fibre yellowness.

It had been reported that the characters influenced by genes having additive properties were less complex in inheritance and characters influenced by genes having non-additive properties were more complex in inheritance (Liang & Walter, 1968). The presence of additive gene effects indicate that the estimates of heritability may be high (Falconer & Mackey, 1996), suggesting that further genetic advance may be possible by making single plant selection from F_2 generation.

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(Received 10 November 2003; Accepted 14 February 2004)