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Assessment of Cotton (*Gossypium hirsutum*) Germplasm for Combining Abilities in Fiber Traits

FAQIR MUHAMMAD AZHAR AND MUHAMMAD NAEEM[1]
Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad-38040, Pakistan
[1]Corresponding author's e-mail: mnbzu@hotmail.com

ABSTRACT

An experiment was conducted to find combining abilities of some varieties for lint percentage, fiber fineness, fiber strength and fiber length in Cotton (*Gossypium hirsutum* L.) using line × tester mating design. Among the eight varieties LRA blight was found to be best general combiner for most of the characters and its combination with NIAB 111 was the best for most of the traits measured. Analysis showed that line × tester interaction was highly significant for most of the traits, whilst variation for fiber length was significant; however, their interaction was non-significant for fiber fineness. Estimates of variances due to GCA and SCA and their ratios revealed predominant role of dominance properties of genes for all the traits.

Key Words: *Gossypium hirsutum*; Combining ability; Additive and non-additive gene action

INTRODUCTION

Cotton is one of the most important cash crops of Pakistan and its role in the economy of the country can hardly be under-estimated. Pakistan ranks 4th in area and production of cotton in the world and about 65% of total foreign exchange earnings is obtained from the exportable surplus and through the export of finished products. The raw cotton alone contributes the highest share (58.9%) in the total export of the country. It accounts for 10.5% of value added in agriculture and about 2.4% of GDP (Anonymous, 2005).

Keeping in view the role of cotton crop in the economy of the country, the cotton breeders always focus their attention on bringing genetic improvement in cotton plant by exploiting the genetic resources. Therefore, before developing cotton improvement program, assessment of cotton germplasm for its genetic potential in hybridization is a crucial step. Combining ability studies help the research workers for the identification of parents for the development high yielding hybrids. Line × tester analysis technique developed by Kempthorne (1957) is useful for screening the varieties/lines of various crops with a reasonable degree of reliance. In the present study eight varieties of cotton were examined for general and specific combining abilities.

MATERIALS AND METHODS

Eight genetically diverse varieties namely MNH 93, NIAB 111, NIAB 999, FH 901, CM 448, CP15/21, LRA Blight and 289 F-1, all belonging to cotton (*Gossypium hirsutum* L.) were grown in 30 cm × 30 cm earthen pots during November 2004 in glasshouse. The temperature in glass house was maintained between 21ºC (night) and 37ºC (day) using steam as well as electric heaters. When the parents started to flower they were crossed according to line × tester fashion, keeping MNH 93, NIAB 999, NIAB 111, FH 901 and CIM 448 as seed parents and CP 15/21, LRA Blight and 289F-1 as testers (male parent). The seed parents were hand emasculated in the evening and pollinated the following morning to produce enough F1 hybrid seed. Some flowers of the parents were also selfed to produce selfed seeds. Extreme precautionary measures were taken to avoid pollen contamination of the genetic material during emasculation and pollinations.

The seeds of 15 hybrids and their eight parents were sown in field during May 2005, in a randomized complete block design with three replications. The seeds were sown in single row plot having seven plants spaced 30 cm within the row and 75 cm apart between the rows. Normal agronomic practices and plant protection measures were adopted during growth and development of plants. The data were taken on five consecutive middle plants, one plant at both the ends of each row was left as non-experimental. After picking the plant material, the lint samples of the 15 families were measured for lint percentage, fiber fineness, fiber strength and length. The data were statistically analyzed following the analysis of variance (Steel & Torrie, 1980) in order to see the genotypic differences for the characters. Estimates of combining abilities of the parents were made by analyzing the data using line × tester method (Kempthorne, 1957).

RESULTS

The mean squares from analysis of variance showed

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that genotypic differences for lint percentage, fiber strength and fiber length were highly significant ($P \leq 0.01$), whilst genotypic differences for fiber fineness were found to be significant ($P \leq 0.05$). When mean squares due to the eight parents were partitioned into components it was revealed that 5 females (lines) and 3 males (testers) did not differ significantly from each other for all the characters (Table I). However, when pooled data were analyzed they differed significantly for lint percentage, fiber length and strength. As evident from mean squares (Table I), 15 crosses differed significantly ($P \leq 0.01$) for lint percentage, fiber length and fiber strength, whilst the differences for fiber fineness appeared to be non-significant ($P \leq 0.05$).

Mean squares resulting from interaction of parents and crosses were significant only for fiber strength, whilst non-significant for other characters. Similarly interaction due to lines × testers was significant for lint percentage, fiber length, fiber strength and fiber fineness, suggesting that significant amount of variation was present in these characters, although interaction was non-significant for fiber fineness (Table I).

Estimates of general combining ability of the eight parents for lint percentage cultivar NIAB 999 indicated the highest value (10.42) and thus showed the best general combining ability followed by LRA Blight (7.23). Other varieties exhibited poor general combining ability for these characters. For fiber length comparison of parents showed that LRA Blight was best general combiner for fiber length and it was followed by MNH 93 with 0.269 value. The remaining parents exhibited poor general combining ability for fiber length (Table II).

For fiber strength three parents, NIAB 111 and MNH 93 among males and CP 15/21 among females were revealed to possess the best general combining ability, scoring 0.262, 0.244 and 0.904 numerical values, respectively. The other varieties displayed poor performance in this respect. For fiber fineness, parents with negative general combining ability were desirable, as emphasis was given on selection of plants with minimum micronaire value. The analysis of data revealed that NIAB 111, NIAB 999 and LRA Blight had negative estimates i.e., -0.076, -0.299 and -0.181, respectively revealing that these parents were of potential use for bringing improvement in these characters.

Estimates of specific combining ability of various parents for fiber characteristics revealed that the crosses NIAB 999 × CP 15/21, MNH 93 × 289 F-1, CIM 448 × 289 F-1 and NIAB 111 × LRA Blight with high numerical values were revealed to be the best specific combinations for the characters measured (Table III). However, cross FH 901 × CP 15/21 with negative value, -0.444 displayed best combining ability for fiber fineness. Other promising crosses for improving the character were MNH 93 × 289 F-1 (-0.238), NIAB 999 × LRA Blight (-0.191), which exhibited negative combining ability for the character. Specific combining abilities for fiber strength were varied greatly. For example, the cross FH 901 × 289 F-1 with negative numerical value i.e., -1.647 was the poorest, whereas the cross FH 901 × CP 15/21 with positive numerical value i.e., 2.289 was shown to be the most promising parent. For fiber length positive specific combining ability was noted in eight crosses. Specific combining ability was positive in 40% crosses. The crosses FH 901 × CP 15/21 (2.50) showed the highest value followed by NIAB 999 × 289 F-1 (0.88) and CIM 448 ×

Table I. Mean squares obtained from partitioned analysis of variance of various plant traits in *Gossypium hirsutum*

Source of variation	d.f.	Lint percentage	Fiber fineness	Fiber strength	Fiber length
Replications	2	3.8501^{NS}	0.3523^{NS}	1.6504^{NS}	3.7250^{NS}
Genotypes	22	375.43**	0.3177*	5.1257**	6.4188**
Parents	7	278.15**	0.4215*	6.8679**	10.737**
Crosses	14	450.88**	0.2875^{NS}	3.8732**	4.7062*
Parents vs crosses	1	0.0114^{NS}	0.0143^{NS}	10.465*	0.1634^{NS}
Lines	4	407.36^{NS}	0.3491^{NS}	0.2204^{NS}	1.0649^{NS}
Testers	2	702.43^{NS}	0.4390^{NS}	2.3978^{NS}	9.6041^{NS}
Line × testers	8	409.76**	0.2188^{NS}	6.068**	5.3024*
Error	44	1.2829	0.1688	1.4505	1.9006

*, ** reveal differences highly significant at 5% and 1% probability levels, whilst "NS" shows non-significant differences.

Table II. General combining abilities of parents for various plant traits in *Gossypium hirsutum*

Parents	Lint percentage	Fiber fineness	Fiber strength	Fiber length
		Lines		
NIAB 111	-1.131	-0.076	-0.003	0.262
NIAB 999	10.42	-0.299	-0.059	-0.307
MNH 93	-3.689	0.173	0.269	0.244
FH 901	-7.311	0.033	-0.120	0.241
CIM 448	1.885	0.168	-0.086	-0.439
SE	0.378	0.137	0.401	0.460
		Testers		
LRA Blight	7.226	-0.181	0.460	-0.286
CP 15/21	-6.381	0.022	-0.262	0.904
289 F-1	0.844	0.159	-0.198	-0.618
SE	0.0292	0.1061	0.3109	0.3559

Table III. Estimate of SCA of crosses for various plant traits in *Gossypium hirsutum*

crosses	Lint percentage	Seed cotton	Fiber fineness	Fiber strength	Fiber length
NIAB 111 × LRA Blight	8.152	3.194	-0.134	0.423	0.396
NIAB 111 × CP 15/21	-2.949	0.539	0.072	-1.491	-0.440
NIAB 111 × 289 F-1	-5.203	-3.734	0.062	1.068	0.045
NIAB 999 × LRA Blight	-5.985	-1.439	-0.191	0.462	-0.139
NIAB 999 × CP 15/21	19.27	11.33	0.289	-0.033	-0.742
NIAB 999 × 289 F-1	-13.29	-9.893	-0.098	-0.429	0.880
MNH 93 × LRA Blight	-0.336	0.286	0.022	-0.666	-0.070
MNH 93 × CP 15/21	-11.601	-10.78	0.216	-0.844	-0.176
MNH 93 × 289 F-1	11.938	10.49	0.238	1.509	0.246
FH 901 × LRA B light	3.399	3.800	0.242	-0.642	-0.567
FH 901 × CP 15/21	-1.409	-3.22	-0.444	2.289	2.500
FH 901 × 289 F-1	-1.99	-0.577	0.202	-1.647	-1.934
CIM 448 × LRA Blight	-5.231	-5.840	0.061	0.423	0.38
CIM 448 × CP 15/21	-3.319	2.132	-0.132	0.078	-1.143
CIM 448 × 289 F-1	8.550	3.709	0.071	-0.502	0.763
SE	0.6539	0.6622	0.2373	0.6954	0.796

Table IV. Estimates of variance due to GCA (δ^2_{GCA}), variance due to SCA (δ^2_{SCA}), additive variance (δ^2A), dominance variance (δ^2D), ratio of GCA to SCA (δ^2_{GCA} / δ^2_{SCA}) and degree of dominance ($[\delta^2_H / \delta^2_D]^{1/2}$) for various plant traits of *Gossypium hirsutum*

Sr no	Genetic components	Lint percentage	Fiber fineness	Fiber strength	Fiber length
1	Cov H.S (lines)	-0.267	0.0144	-0.649	-0.4708
2	Cov H.S (tester)	19.512	0.0147	-0.244	0.2867
3	Cov H.S (Aveg)	1.4548	0.0024	-0.078	-0.0210
4	Cov F.S	1151.6	0.4544	0.2820	7.2599
5	$\delta^2_{GCA}=[(1+F)/4]\delta^2A$	1.4548	0.0024	-0.078	-0.0210
	(a) with F = 0, δ^2A	5.8155	0.0097	-0.310	-0.0843
6	$\delta^2_{SCA}=[(1+F)/2]^2\delta^2D$	136.16	0.0167	1.5393	1.1339
	(b) with F = 0, δ^2D	544.64	0.0067	6.1572	4.5357
7	$\delta^2_{GCA} / \delta^2_{SCA}$	0.010	0.144	-0.051	-0.0185
8	$[\delta^2_H / \delta^2_D]^{1/2}$	9.68	0.83	0.00	0.00

289 F-1 (0.763) emerged as the best varietal combinations (Table III).

Estimates of variance due to general combining ability (δ2 GCA), specific combining ability (δ2 SCA), additive variance (δ2A), dominance variance (δ2D), ratios of δ2 GCA / δ2 SCA and degree of dominance ([δ2 H/δ2 D]1/2) for four fiber characteristics studied are given in Table IV. Genetic analysis revealed that dominance effects were important for lint percentage, fiber fineness, strength and length. Ratio of δ2 GCA/δ2 SCA and degree of dominance, more than one indicated the over dominance of genes.

DISCUSSION

The results obtained from the present genetic investigation revealed that LRA Blight, NIAB 111, CM 448, MNH 3, NIAB 999 and CP15/21 were the best general combiner and suggesting that these parental lines may show a good promise to a breeder for exploiting variability in the characters examined here (Table II). It had been suggested that parents having good general combining ability for a particular character are expected to yield good hybrids (Ayub *et al.,* 1991; Khan *et al.;* 1991; Irfanullah *et al.,* 1994) and this suggestion appeared to be true in the present studies. For lint percentage NIAB 999 and CIM 448 were best general combiners and their crosses i.e., NIAB 999 × CP 15/21 and CIM 448 × 289 F-1 also produced hybrids showing good specific combining ability (Table III). For fiber length CP 15/21 was the best general combiner and when crossed with FH 901 yielded the best combination. Variety MNH 93 being good general combiner for fiber strength appeared to have nicked well with LRA Blight. For fiber fineness NIAB 999 revealed its best general combining ability and thus produced best varietals combination with LRA Blight. These results are in agreement with the findings of earlier research workers Khan *et al.* (1991), Haq and Azhar (2005). However, the present results appeared to disagree with the findings of Baloch and Chang (1970) and Azhar and Rana (1993) who observed that the parents with high general combining ability did not necessarily produce hybrid with high specific combining ability. The difference in the opinion might have resulted due to different breeding material tested under particular environmental condition.

For fiber strength and fiber length the best cross combinations NIAB 111 × 289 F-1 and NIAB 999 × 289 F-1, respectively were developed by crossing one of the parents showing poor general combining ability (Table III). For fiber fineness FH 901 and CP 15/21 proved to be poor general combiners, yet they yielded good hybrids (Table III). For lint percentage, CIM 448 × 289 F-1 was promising one, which originated from parents having poor general combining ability. This observation appeared to agree with the findings of Azhar and Rana (1993).

In conclusion, identification of the best general combiner and presence of over dominance for lint percentage and fiber fineness was encouraging to cotton breeder interested in the hybrid cotton with good fiber characteristics. The parents with high general combining ability may be advantageously utilized in crossing program aiming to develop hybrid material of (*Gossypium hirsutum* L.) under local conditions. However it is suggested that further experimentation may be made to substantiate the information reported here.

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