Pak. J. Sci. Ind. Res. 2005 **48**(5) 358-361

Combining Ability Analysis of Seed Cotton Yield and its Components in Cotton *(Gossypium hirsutum)*

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(received November 10, 2003; revised August 10, 2005; accepted August 13, 2005)

Abstract. In order to examine the genetic mechanisms controlling seed cotton yield and its components, four lines of *Gossypium hirsutum* L., MNH-554, Delcerro, Coker-304 and Albacala-(71)1190 were crossed in all possible combinations. Combining ability analysis of the data revealed that general combining ability effects were highly significant at p = 0.01, in respect of the number of bolls, seed cotton yield and lint percentage. The general combining ability variances were greater than specific combining ability variances, which showed the predominance of additive gene effects. Among the four parents, MNH-554 appeared to be the best general combiner for all the characters studied. Due to the preponderance effects of additive genes, it seems that single plant selection in segregating generations would be effective for improving the seed cotton yield and its various components.

Keywords: combining ability, *Gossypium hirsutum*, seed cotton yield, additive variance

Introduction

For the development of genetically promising plant materials through hybridization, selection of the appropriate parent stock is the crucial step in plant improvement strategies. The selection of desirable plant characteristics in the breeding population can be effective, if information on the pattern of inheritance of plant yield and its components is also available. Several biometrical techniques are available, which can provide the working knowledge for determining the genetic basis of variation in different plant characters. These techniques include graphic analysis (Hayman, 1954), North Carolina designs (Comstock and Robinson, 1952), triple test cross technique (Kearsey and Jinks, 1968), generation mean analysis (Hayman, 1958), line x tester analysis (Kempthorne, 1957), besides several others. All these techniques describe the mode of gene action controlling the manifestation of characters. None of these techniques, however, deal with the potential of the parents involved in a crossing programme. The combining ability analysis (Griffing, 1956) is a biometrical method, which identifies the parents having the best combining ability and the effects of genes governing the inheritance of characters. This method was, therefore, followed in the present invistigations to collect information on seed cotton yield and its components.

In some previous genetic studies, the pattern of inheritance of seed cotton yield and its components normally appeared to vary, whereas both additive and non-additive gene effects have been reported in the literature. The work of Shakeel *et al.* (2001) and Khorgade *et al.* (2000) showed that the seed cotton yield was normally affected by the genes having dominance characteristics. On the contrary, Islam *et al.* (2001) and Hassan *et al.* (2000) have reported the genetic mechanism under additive gene effects. Similarly, the number of bolls, which is an important attribute of cotton plant yield, was reported to be controlled by non-additive gene effects (Ahmad *et al.,* 2000). Other studies, however, have shown it to be affected by genes with cumulative effects (Kumareson *et al.,* 2000; Ajmal *et al.,* 2000). Ginning percentage was also observed to be under the influence of genes acting additively and non-additively (Pavasia *et al.,* 1999). The present study was carried out to remove this confusion by undertaking investigations on these aspects on some of the genetic materials available in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan. The observations so made are likely to be useful for continued genetic improvement in the *Gossypium hirsutum* L. lines through the conventional breeding methods.

Materials and Methods

Study material. For the purpose of examining the genetic basis of yield and its components in *G. hirsutum*, the experimental materials used in the studies were developed by crossing four parents, namely, MNH-554, Coker-304, Delcerro, and Albacala-(71)1190 in 4x4 complete diallel fashion.

Experimental design and collection of data. The seeds of the parents were sown in 30x30 cm earthen pots using the greenhouse facility. At the time of flowering, the plants were

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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 flowers were pollinated to produce sufficient quantity of F-1 seeds of each cross. The seeds obtained from 12 F-1 crosses, and of the parents, were planted in the field to raise the F-1 generation plants. Each entry was sown in three replications, following the randomized complete block design layout. To ensure uniform plant population, the seeds were dibbled, which were then sown in a single row plot, having 10 plants spaced 30 cm within the row and 75 cm between the rows. The data were taken on the middle six plants, leaving out the two plants on either end of the row so as to avoid the border effects. The usual standard cultural and agronomic practices and plant protection measures were adopted to obtain healthy plants. At maturity, the number of bolls developed on the central eight plants, from each of the set in three replications, was counted. All of these bolls were picked to record yield of seed cotton, and the data on boll weight and lint percentage were recorded (Tables 1-3).

Statistical procedures. The 4x4 diallel data were subjected to ordinary analysis of variance technique in order to determine the genotypic differences. The data were further analyzed according to Griffing (1956).

Results and Discussion

The simple analysis of variance of seed cotton yield, the number of bolls produced per plant, and the ginning percentage indicated significant differences in these characters at $p = 0.01$ (Table 1). Further analysis of the data, following the combining ability technique (Griffing, 1956), revealed highly significant differences for mean squares due to the general and specific combining ability for seed cotton yield and the number of bolls. For reciprocal effects, these differences were non-significant for both the characters at $p = 0.05$. For lint percentage, the general combining ability effects were significant at $p = 0.01$ (Table 2). The comparison of genetic variances showed that the magnitude due to general combining ability was greater than that resulting from the specific combining ability for seed cotton yield, the number of bolls, and lint percentage (Table 2). It indicated that breeding for these characters was easy, as the inheritance of these characters was less complex (Liang and Walter, 1968).

The four parents were compared for their general combining ability effects (Table 3). The observations so made revealed that MNH-554, with the highest general combining ability index, was the best general combiner for all the characters. The crosses of variety MNH-554 with other lines expressed specific combinations for different characteristics as: MNH-554 x Coker-304 (2.032) and Albacala-(71)1190 x MNH-554 (0.733) for the number of bolls per plant, MNH-554 x Delcerro (3.256) and Albacala-(71)1190 x MNH-554 (2.770) for seed cotton yield, and MNH-554 x Albacala-(71)1190 (0.176) for lint percentage proved to be the best combinations. The parents having the high general combining ability effects are likely to have the potential to produce breeding materials for the development of some improved cotton lines. The previous studies, similar to the present, had also shown that some of the crosses which involved at least one good general combiner, as a parent, had shown superiority (Islam *et al.,* 1998; Azhar and Rana, 1993a). It has been also reported that parents known to be poor general combiners, sometimes yield hybrids that rank better than the others (Azhar and Khan, 2003; Azhar and Rana, 1993b). These types of crosses were also noted in the present studies, for example, the crosses Albacala-(71)1190 x Coker-304 (0.985) for the number of bolls, and Delcerro x Coker-304 (0.575) for the seed cotton yield.

Table 1. Mean squares from analysis of variance of three plant characters in 16 families of *Gossypium hirsutum* L

Source of variation	df	Number of bolls	Seed cotton yield (g)	Lint (%)
Replications	2	0.054 ns	7.595 ns	0.043 ns
Families	15	36.298**	211.739**	2.175**
Error	30	3.676	10.040	0.044

ns = non-significant; ** = differences highly significant; df = degree of freedom

Table 2. Mean squares from the combining ability analysis of three plant characters in 16 families of *Gossypium hirsutum* L

Source of variation	df	Number of bolls	Seed cotton yield (g)	Lint (%)
General combining ability	3	52.876** (6.220)	325.803** (39.541)	3.587** (0.446)
Specific combining ability	6	3.273* (1.260)	9.982* (4.083)	0.018 ns (0.002)
Reciprocal	6	0.536 ns (-0.344)	3.568 ns (0.111)	0.001 ns (-0.007)
Error	30	1.225	3.347	0.015

*, ** and ns show significant, highly significant and non-significant differences, respectively; values given in paranthesis are the variances; df = degree of freedom

In the present genetic examination, following the approach of genetic analysis of Griffing (1956), it was not possible to estimate the heritability of these characters. However, the

Table 3. Means of the number of bolls per plant, seed cotton yield, and lint percentage in four parents, and estimates of general combining ability (GCA), specific combining ability (SCA) and reciprocal effects

Parents/ cross-combinations	Number of bolls		Seed cotton yield (g)		Lint (%)	
Parents	**mean values**	**GCA**	**mean values**	**GCA**	**mean values**	**GCA**
MNH-554	27.467	3.719	76.730	9.458	35.420	0.887
Coker-304	19.867	- 0.627	58.667	- 1.771	33.900	0.071
Delcerro	18.400	- 2.190	52.757	- 3.995	32.370	- 0.697
Albacala-(71) 1190	20.533	0.901	54.453	- 3.691	33.090	- 0.261
cd_1 (g_i - g_l)	1.085		1.793		0.119	
Cross-combinations	**mean values**	**SCA**	**mean values**	**SCA**	**mean values**	**SCA**
MNH-554 × Coker-304	27.730	2.032	68.570	- 0.287	34.720	- 0.021
	(27.950)*	(- 0.110)	(71.377)	(- 0.403)	(34.70)	(0.010)
MNH-554 × Delcerro	25.000	0.521	70.490	3.256	33.920	- 0.028
	(24.533)	(0.233)	(72.093)	(- 0.802)	(33.950)	(- 0.015)
MNH-554 × Albacala-(71) 1190	26.400	0.133	72.900	1.790	34.600	0.176
	(24.933)	(0.733)	(67.360)	(2.770)	(34.500)	(0.025)
Coker-304 × Delcerro	19.330	- 0.634	57.520	0.138	33.180	0.043
	(19.200)	(0.065)	(56.370)	(0.575)	(33.200)	(- 0.010)
Coker-304 × Albacala-(71) 1190	22.370	0.197	57.690	0.514	33.550	- 0.008
	(20.400)	(0.985)	(57.560)	(0.065)	(33.600)	(- 0.025)
Delcerro × Albacala-(71) 1190	19.850	0.050	53.610	- 1.567	32.800	- 0.006
	(19.500)	(0.175)	(53.030)	(0.290)	(32.820)	(- 0.010)
cd_1 (s_{ij} - s_{ik})	1.879		3.105		0.206	
cd_1 (r_{ij} - r_{kl})	2.170		3.586		0.238	

* the values given in parenthesis are the means of reciprocal crosses and their SCA effects; $cd_1(g_i - g_l)$ = critical difference for general combining ability; cd_1 (s_{ij} - s_{ik}) = critical difference for specific combining ability; cd_1 = critical difference for reciproeal effects

preponderance effect of additive genes suggests that estimates of heritability may be high (Falconer and Mackey, 1996). Thus, from the present results it seems possible that segregating material would be of potential value, and single plant selection may be effective in improving seed cotton yield and its components.

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