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Genetic Basis of Varietal Differences for Seed Cotton Yield and its Components in *Hirsutum* spp

INAM-UL-HAQ AND FAQIR MUHAMMAD AZHAR
Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad–38040, Pakistan

ABSTRACT

A four parent diallel cross experiment was conducted in order to study the genetic mechanism controlling seed cotton yield and its components in *Gossypium hirsutum* L. Analysis of F_1 data following Griffing's approach showed that effects of specific combining ability were highly significant for the expression of number of bolls, seed cotton yield and lint percentage, whilst effects of general combining ability were significant for plant height. Mean squares due to both general and specific combining ability effects were significant for boll weight. The larger proportion of variance resulting from specific combining ability revealed genetic effects to be predominantly non-additive for number of bolls, seed cotton yield and lint percentage. Magnitude of additive variance is greater than that of non additive variance for plant height. Variety Carolina 173 proved to be the best general combiner for plant height and seed cotton yield, whilst NIAB 98 displayed its superiority for number of bolls and seed cotton yield. Cross combination NIAB 98 x Carolina 173 were revealed to be the best for number of bolls and seed cotton yield, whilst Arizona 6218 x Carolina 173 for boll weight. For lint percentage cross NIAB 98 x Arizona 6218 proved to be the best varietal combination.

Key Words: Genetic analysis; Seed cotton yield; Genetic variance; Additive gene

INTRODUCTION

The development of cotton varieties possessing greater yield potential becomes easier if genetically based variation in seed cotton yield and its components is available to a research worker. Selection of plants showing harmonious combination of desirable traits is facilitated if variation is controlled by additive gene effects. Previous studies showed that variation in seed cotton yield and its components was controlled by the genes acting additively and non-additively. Greater magnitude of variance due to general combining ability revealed that plant height was controlled by the genes showing additive properties (Saeed *et al*., 1996; Austin *et al*., 1998). In contrast, the work of Punitha *et al*. (1999) and Shakeel *et al*. (2001) showed that plant height was conditioned by the genes showing non-additive effects. Similarly opinions on the inheritance of seed cotton yield and its components differed. The studies of Punitha *et al*. (1991) and Shakeel *et al*. (2001) revealed that number of bolls, boll weight, seed cotton yield and lint percentage were influenced by the genes acting non-additively, and in contrast the studies of Kumaresan *et al*. (1999) and Khan and Idris (1995) indicated that both additive and non-additive gene effects were important for controlling number of bolls and seed cotton yield, while lint percentage was effected additively (Tariq *et al*., 1995; Debaby *et al*., 1997).

The present study envisages the analysis of plant material comprising a small sample of cotton genotypes / lines of *Gossypium hirsutum* L. taken from the available germplasm in order to find the genetic mechanism controlling seed cotton yield and its components.

MATERIALS AND METHODS

The plant material used in the present study was developed by crossing four different varieties, viz. NIAB 98, CIM 435, Arizona 6218, and Carolina 173, all belonging to *hirsutum* species. The four parents were grown in a greenhouse under controlled conditions during the month of November, 2001. The temperature required for germination, proper growth and development of plants ranged 60°-90°F, and was maintained using electric heaters. The day light during winter was supplemented by lighting mercury vapour lamps. When the parental lines started to flower, these were crossed in all possible combinations. Some of the buds of the parents were also selfed. Maximum numbers of crosses were made to develop sufficient F_1 seed. All the necessary precautions were taken at the time of emasculation and pollination to avoid alien pollen contamination.

The F_1 seed of twelve hybrids (including reciprocals) and the parents were planted in the field during June, 2002. Each entry was sown in three replications following randomized complete block design. The seeds were dibbled to ensure uniform plant population. The seeds were sown in single row plot having seven plants spaced 30 cm within and 75 cm between the rows. The data were taken on the middle five plants, leaving one plant on either end of the row to avoid the border effects. The data on plant height, number of bolls, boll weight, and seed cotton yield and lint percentage were recorded.

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

RESULTS

Plant height. Analysis of variance of plant height data showed highly significant differences ($P \leq 0.01$) among 12 F_1 hybrids and the four parents (Table I). However mean squares of replications were reduced to be non-significant for plant height ($P \geq 0.05$). The results of genetic analysis showed that effects of general combining ability on plant height were highly significant ($P \leq 0.01$, Table II). The magnitude of variance due to general combining ability (14.82) was greater than that due to specific combining ability (6.88) indicating the additive effects (Table III). The comparison of parents regarding their general (gca) and specific combining ability (sca) showed that Carolina 173 with 5.60 value appeared to be the best general combiner than other varieties (Table IV). The ranking of parental combinations showed that out of six direct F_1 hybrids, three combinations, NIAB 98 x Arizona 6218, CIM 435 x Arizona 6218 and CIM 435 x Carolina 173 with 0.745, 2.432 and 4.232 respectively attained positive values, and expressed the best specific combining ability for plant height, however these were similar statistically ($P \geq 0.05$).

Number of bolls. Simple analysis of variance showed that 12 F_1 hybrids and four parents were significantly different ($P \leq 0.01$) from each other for number of bolls (Table I). Statistical differences in replications were non-significant (P

Table I. Mean squares obtained from analysis of variance of seed cotton yield and its components in *Gossypium hirsutum* L.

Source of variation	Degree offreedom	Plantheight	Number of bolls	Bollweight	Seed cotton yield	Lint percentage
Replications	2	69.334 N.S.	32.491 N.S.	0.128 N.S.	450.175 N.S.	13.818**
Genotypes	15	123.714**	108.657**	0.108*	775.039**	7.502**
Error	30	32.581	39.748	0.050	279.891	2.637

Table II. Mean squares obtained from combining ability analysis of seed cotton yield and its components in *Gossypium hirsutum* L.

Source of variation	Degree offreedom	Plantheight	Number of bolls	Bollweight	Seed cotton yield	Lint percentage
GCA	3	139.394**	37.909 N.S.	0.032*	230.497 N.S.	0.373 N.S.
SCA	6	22.056 N.S.	51.069**	0.044*	359.181**	2.565*
Reciprocals	6	11.139 N.S.	20.524 N.S.	0.014 N.S.	171.434 N.S.	3.499**
Error	30	10.860	13.249	0.017	93.297	0.879

Table III. Estimation of components of variation in seed cotton yield and its components in *Gossypium hirsutum* L.

Source of variation	Degree offreedom	Plantheight	Number of bolls	Bollweight	Seed cottonyield	Lint percentage
GCA	3	14.825	-1.281	0.0025	-13.529	-0.257
SCA	6	6.889	23.273	0.017	163.621	1.037
Reciprocals	6	0.139	3.637	0.0013	39.068	1.310
Error	30	10.860	13.249	0.017	93.297	0.879

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

Table IV. Estimation of gca, sca and reciprocal effects for seed cotton yield and its components in *Gossypium hirsutum* L.

Parents	Plant height	Number of bolls	Boll weight	Seed cotton yield	Lint percentage
NIAB 98	-1.141	2.129	-0.089	4.019	0.144
CIM 435	-4.45	-1.765	0.121	-2.879	0.028
Arizona 6218	-0.016	-1.985	0.00001	-6.108	0.141
Carolina 173	5.601	1.621	-0.032	4.968	-0.313
$Cd_1(gi – gj)$	3.229	3.567	0.1270	9.465	0.9188
Cross combinations					
NIAB 98 x CIM 435	-3.176 (3.867)	-2.831 (-2.483)	0.157 (-0.063)	-5.866 (-7.113)	0.970 (-1.583)
NIAB 98 x Arizona 6218	0.745 (-1.617)	-2.460 1.933)	-0.086 (-0.107)	-7.578 (1.980)	1.650 (2.333)
NIAB 98 x Carolina 173	-2.755 (-1.333)	8.867 (1.133)	-0.137 (0.057)	22.036 (2.203)	-0.706 (0.300)
CIM 435 x Arizona 6218	2.432 (2.200)	1.133 (-4.767)	-0.039 (-0.013)	3.341 (-15.040)	-0.680 (-0.382)
CIM 435 x Carolina 173	4.232 (3.017)	2.019 (4.142)	0.084 (-0.093)	7.413 (13.978)	0.615 (-0.368)
Arizona 6218 x Carolina 173	-1.914 (-0.367)	-2.460 (3.242)	0.196 (-0.122)	-2.986 (5.773)	-0.419 (-1.475)
$Cd_1(Sij – Sik)$	5.593	6.178	0.220	16.395	1.5915
$Cd_1(rij – rkl)$	6.495	7.134	0.254	18.931	1.8377

The values given in parenthesis are scores of sca in reciprocal combinations of varieties.

$\geq$ 0.05). The mean squares due to general combining ability were non-significant for number of bolls ($P \geq 0.05$), whilst mean squares resulting from specific combining ability appeared to be highly significant ($P \leq 0.01$, Table II). Reciprocal effects for number of bolls were shown to be non-significant ($P \geq 0.05$). The comparison of gca values obtained by each parent revealed that NIAB 98 and Carolina 173 with positive values 2.129 and 1.621, respectively had better general combining ability than other two parents for number of bolls. The potential of NIAB 98 and other three varieties was also evaluated in their combinations (Table IV). The comparison showed that out of six direct crosses, three combinations i.e. NIAB 98 x Carolina 173 (8.867), CIM 435 x Arizona 6218 (1.133) and CIM 435 x Carolina 173 (2.019) attained positive sca values, and the former differed statistically from the other two crosses.

Boll weight. Genotypic differences for boll weight were significant ($P \leq 0.05$, Table I), whilst differences between replications appeared to be non-significant ($P \geq 0.05$). Analysis of variance of 16 families following combining ability technique showed that effects of both gca and sca were significant on the character ($P \leq 0.05$, Table II), however reciprocal effects were reduced to be non-significant ($P \geq 0.05$). Genetic variance due to specific combining ability (0.017) was greater than that due to general combining ability effects (-0.0025, Table III). The comparison of the gca estimates showed that parent CIM 435 with 0.121 index had displayed better general combining ability than the other parents for the character (Table IV). Cross combinations NIAB 98 x CIM 435 (0.157), CIM 435 x Carolina 173 (0.084) and Arizona 6218 x Carolina 173 (0.196) exhibited best specific combining ability for the character but statistically these estimates appeared to be similar.

Seed cotton yield. Ordinary analysis of variance of F_1 data showed highly significant differences ($P \leq 0.01$) among the 16 families for seed cotton yield (Table I). Differences in replications were reduced to be non-significant ($P \geq 0.05$). The results of combining ability analysis showed non significant ($P \geq 0.05$) mean squares due to general combining ability, whilst these were highly significant due to specific combining ability ($P \leq 0.01$). Effects of reciprocals appeared to be non-significant ($P \geq 0.05$). The magnitude of genetic variance due to specific combining ability was exceedingly greater (163.62) than that resulting from general combining ability (Table III). The four parents were evaluated for their general and specific combining ability for seed cotton yield (Table IV). The indices revealed that NIAB 98 and Carolina 173 with higher indices of 4.019 and 4.968, respectively, expressed the best potential as good general combiners. The potential of NIAB 98 and other parents in specific combinations showed that NIAB 98 x Carolina 173 (22.036), CIM 435 x Arizona 6218 (3.341), CIM 435 x Carolina 173 (7.413) attained positive values for seed cotton yield. Combination NIAB 98 x Carolina 173 with highest value (22.036) differed significantly from others which did not differ among themselves.

Lint percentage. Preliminary analysis of variance revealed highly significant ($P \leq 0.01$) genotypic differences for lint percentage, (Table I), and replications also differed significantly from each other ($P \leq 0.01$). Significant genotypic differences allowed further analysis following combining ability technique. Analysis of variance of data following combining ability technique showed that effects of gca were non-significant ($P \geq 0.05$), whilst genetic effects due to specific combining ability and reciprocals were significant ($P \leq 0.05$) and highly significant ($P \leq 0.01$), respectively (Table II). The variances resulting from sca and reciprocals were almost similar in magnitude i.e. 1.037 and 1.310, respectively (Table III). The evaluation of parents for general combining ability for lint percentage was made (Table IV). The parental comparison revealed that NIAB 98 (0.144), CIM 435 (0.028) and Arizona 6218 (0.141) had positive indices, and expressed the good general combining ability for lint percentage. The indices of specific combining ability revealed that three hybrids NIAB 98 x CIM 435 (0.970), NIAB 98 x Arizona 6218 (1.650) and CIM 435 x Carolina 173 (0.615) exhibited good specific combining ability for lint percentage. In reciprocal combinations the crosses Arizona 6218 x NIAB 98 (2.333), Carolina 173 x NIAB 98 (0.300) attained positive values and proved to be the best combinations for lint percentage.

DISCUSSION

Although the parent sample used to generate the genetic information was small, the genotypic differences were statistically significant for plant height, number of bolls, boll weight, seed cotton yield and lint percentage (Table I), and thus suggested the presence of workable variation. Significant effects of gca (Table II) and greater variance due to gca for plant height (Table III) suggested the presence of additive genetic effects (Griffing, 1956). The preponderance effects of additive genes controlling plant height may have high estimates of heritability as suggested by Falconer and Mackey (1996), and from these results it seems that desirable plants may be identified from F_2 population. Similar genetic behaviour of variation in plant height had been reported in previous studies (Amin *et al.* 1997; Austin *et al.* 1998; Kumaresan *et al.* 1999). However, in other studies (Punitha *et al.* 1999; Shakeel *et al.* 2001) plant height had been reported to be controlled by non-additive genetic effects. The controversy in the opinion may be due to different genetic makeup of the plant material studied and different environmental conditions of experimentations.

Although variation in boll weight was affected by significant effects of general and specific combining ability (Table II), the greater magnitude of variance due to sca suggested the presence of non additive genes. Likewise, greater magnitude of genetic variance of number of bolls, seed cotton yield and lint percentage, was due to significant effects of sca. Sprague and Tatum (1942) and Griffing (1956) had suggested that the greater contribution of sca towards the expression of variation in these characters was due to the presence of the genes acting non-additively, and thus the characters may have low heritability (Falconer & Mackey, 1996). This information suggests that segregating population originating from the crosses reported here may not be amenable to direct selection, and therefore the breeders will have to be careful while looking for desirable plants from the segregating progenies. The previous studies of Austin *et al*. (1998), Punitha *et al*. (1999) and Shakeel *et al*. (2001) are in great accord with the present studies.

The comparison of performance of general combining ability of the parents revealed that the variety Carolina 173 with its highest positive values i.e. 5.601 and 4.968 for plant height and seed cotton yield respectively proved, under the limits of the present investigations, to be the best general combiners for these characters (Table IV). The variety NIAB 98 with 2.129 and 4.019 exhibited its best general combining ability for number of bolls and seed cotton yield. The better gca of these two parental lines may be used advantageously to exploit potential variation in breeding population. For example, the cross NIAB 98 x Carolina 173 was revealed to be the best varietal combination, with higher indices, for seed cotton yield and number of bolls. For plant height, combination of CIM 435 with Carolina 173 proved to be better than other combinations. Similarly Carolina 173 nicked well with Arizona-6218 to express its potential for boll weight. The cross NIAB 98 x Arizona 6218 attained higher value (1.650) for lint percentage. From these results it may be concluded that increased performance of the hybrids might have resulted due to the best gca of Carolina 173 and NIAB 98 for all the characters. Similar observations about the potential of lines to nick with each other had been reported in previous studies (Azhar & Akbar, 1992; Deshpande *et al*., 1995; Shakeel *et al*., 2001).

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