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GENETIC BASIS OF SOME YIELD COMPONENTS IN *Gossypium hirsutum* L.

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A 5 × 5 diallel analysis was conducted to study the inheritance of seed cotton yield, number of bolls and boll weight in *Gossypium hirsutum* L. using combining ability technique. The analysis of the data revealed that variance due to specific combining ability was significant for all the three traits signifying the importance of non additive gene action. The comparison of the parents showed that NF-801-2-37 was the best general combiner for seed cotton yield, number of bolls and boll weight followed by Acala-63-75. Best hybrid combinations identified were Acala-63-75× NF-801-2-37 for seed cotton yield and DPL-61 × NF-801-2-37 for number of bolls and boll weight. Higher proportion of dominance variance in all three traits suggested delayed selection or use of heterosis breeding in crop improvement programs.

Keywords: Additive gene effects, diallel analysis, genetic variation, cotton

INTRODUCTION

American cotton (*Gossypium hirsutum* L.) being of paramount importance for the uplift of the economy of Pakistan, has been studied extensively to find ways and means for increasing its production on unit area basis. Consequently, numerous high yielding varieties have been developed which are contributing towards the increase in total yield of seed cotton of the country. These high yielding cotton varieties show harmonious combination of yield, number of bolls, average boll weight and fibre characteristics. For exploiting yield of seed cotton through selection and breeding, a working knowledge on the inheritance pattern of number of bolls and boll weight is essential (Abbas *et al.,* 2008; Abd EI Haleem *et al.,* 2010). In previous work on cotton, the researchers have investigated genetic controlling mechanisms of plant height, number of bolls, average boll weight, seed cotton yield and reported both additive and non additive gene effects (Mukhtar *et al.,* 2000; Subhan *et al.,* 2000; Murtaza *et al.,* 2002; Haq and Azhar, 2004; Ahmad *et al.*, 2005; Murtaza *et al.,* 2006; Ali and Khan, 2007; Batool *et al*., 2010). The present study is a step forward to study the genetic basis of variation in plant material at hand. The information reported herein may be useful for continued work on breeding cotton varieties in this area.

MATERIALS AND METHODS

The study was conducted in the research area of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during the year 2007-08. In this investigation, a small sample of cotton varieties, were crossed according to diallel system of crossing (Griffing, 1956). Data on mean seed cotton yield, number of bolls and boll weight were analyzed following method I, model II. The Plant material was consisted of five cotton varieties/lines namely Acala-63-75, DPL-61, NF-801-2-37, F-281, and CIM-499, all belonging to *hirsutum* species.

These five parental cultivars were grown in the glasshouse of the department during November 2007. Seeds of parents were sown in earthen pots having a mixture of sand, soil and farm yard manure in equal proportions. During germination and growth of the parents, temperature and humidity in the glasshouse were maintained at 20°C during night and 30°C during day using circulating water and electric heaters. After two weeks of planting, seedlings were thinned keeping one seedling per pot (Murtaza, 2005). At flowering parental lines were crossed in 5 × 5 diallel fashion. For emasculation and pollination procedures, sterilized tools (forceps, scissors and needle) were used. Hands were properly washed for each emasculation attempt in order to prevent foreign pollen contamination. In addition, each emasculated bud was covered with soda straw tube. The selfed seed of the parents were obtained by covering the buds with glassine bags. At maturity, crossed and selfed bolls were picked and ginned to obtain F_0 and selfed seeds.

***Assessment of the F_1 plant material*:** The seeds of 20 hybrids and their five parents were field-planted during May 2008 in randomized complete block design with three replications. Seeds of 25 entries in each replication were planted in single row plot having eight plants spaced at the distance of 75 cm between the rows and 30 cm within the rows. All standard agronomic practices i.e. hoeing, irrigation, fertilization were followed from sowing to harvest as and when required. At maturity, a count of total number of bolls on each plant was made. The bolls were handpicked in kraft paper bags and harvest of each plant was bulked and weighed using electronic balance. Data regarding boll weight were obtained by dividing the total harvest of seed cotton of a plant by 10 randomly picked from each plant. For analysis, mean values were computed. In each F_1 family, average yield of seed cotton, number of bolls and boll weight were obtained for statistical analysis.

***Statistical analysis*:** The data collected on seed cotton yield, number of bolls and boll weight were subjected to analysis of variance technique (Steel *et al.,* 1997) to see whether the genotypic differences are significant. The characters showing significant genotypic differences were further analyzed through combining ability technique developed by Griffing (1956) Method I, Model II to investigate genetic mechanisms controlling these three traits.

RESULTS

Simple analysis of variance revealed significant differences ($P \leq 0.01$) among the parents and their hybrids for seed cotton yield, number of bolls and boll weight (Table 1). Results of combining ability analysis and general and specific combining abilities variances are given in Table 1. The general combining ability effects of five parents are presented in Table 2, whilst Table 3 contained estimates for specific combining ability and reciprocal effects for hybrid evaluation. These estimates are explained in following sections.

Table 1. Mean squares of preliminary analysis of variance and combining ability analysis for seed cotton yield, number of bolls and boll weight of *Gossypium hirsutum* L.

Sources of variation	df	Seed cotton yield (g)	Number of bolls	Boll weight (g)
Replication	2	544.55**	308.41**	1.26 ns
Genotypes	24	2035.78**	226.43**	0.18 ns
GCA	4	-182083.93ns	-24143.89ns	-306.51ns
SCA	10	508**	74.39**	0.052 ns
Reciprocal	10	1012.06**	138.09**	0.16*
Error	48	2.52	0.712	0.042
σ2GCA		-18256.78	-2421.47	-30.660
σ2SCA		300.88	43.85	0.006
σ2Reciprocal		504.77	68.69	0.061
σ2A		-36513.57	-4842.96	-61.310
σ2D		300.88	43.85	0.006

*, **: Significant at P < 0.05, P < 0.01 probability level, respectively; ns: non-significant; df: degree of freedom
GCA = general combining ability; SCA = specific combining ability, σ^2A = additive variance, σ^2D = dominance variance

Table 2. Estimates of general combining abilities for seed cotton yield, number of bolls and boll weight of *Gossypium hirsutum* L.

Sources of variation	Seed cotton yield (g)	Number of bolls	Boll weight (g)
Acala-63-75	8.21	0.38	-0.036
DPL-61	-2.15	-0.49	0.034
NF-801-2-37	14.07	4.43	0.054
F-281	-18.49	-4.21	0.004
CIM-499	-1.64	-0.11	-0.056

Table 3. Estimates of specific combining abilities for seed cotton yield, number of bolls and boll weight of *Gossypium hirsutum* L.

Sources of variation	Seed cotton yield (g)	Number of bolls	Boll weight (g)
Acala-63-75 × DPL-61	-18.26 (-4.99)*	-1.25 (4.87)*	-0.22 (0.05)*
Acala-63-75× NF-801-2-37	28.52 (31.70)*	2.97 (-3.20)*	0.01 (0.10)*
Acala-63-75 × F-281	-15.77 (5.85)*	-1.49 (-0.70)*	-0.04 (0.10)*
Acala-63-75 × CIM-499	3.03(1.9)*	-1.43 (-7.97)*	0.06 (-0.25)*
DPL-61 × NF-801-2-37	7.28 (-19.20)*	8.48 (-12.93)*	0.24 (-0.50)*
DPL-61× F-281	-3.36 (-5.79)*	3.07 (-2.22)*	-0.01(0.10)*
DPL-61× CIM-499	2.14 (7.45)*	-2.61 (0.97)*	0.05 (0.00)*
NF-801-2-37 × F-281	-8.93 (3.66)*	-0.48 (-1.42)*	0.12 (-0.05)*
NF-801-2-37× CIM-499	-17.83 (8.00)*	7.06 (7.87)*	-0.39 (0.00)*
F-281×CIM-499	19.78 (-30.45)*	5.85 (-3.22)*	-0.07 (-0.25)*

*: shows the reciprocal effects in parenthesis

***Seed cotton yield*:** The results revealed that effects of specific combining ability and reciprocals on seed cotton yield were highly significant ($p \leq 0.01$) whereas general combining ability effects appeared to be non significant. The variance due to specific combining ability (300.88) is greater than that due to general combing ability (-18256.78). This suggested the stronger influence of non additive variation (σ^2D) in the inheritance of seed cotton yield than that of additive variation (σ^2A). General combining ability of five parents (Table 2) showed that NF-801-2-37 was the best general combiner (14.07) followed by Acala-3-75 (8.21) for seed cotton yield. The other three parents namely DPL-61, F-281 and CIM-499 with estimates (-2.15, -18.49 and -1.64, respectively) were revealed to be poor general combiners for this trait. Among F_1 hybrids, Acala-63-75 × NF-801-2-37, F-281 × CIM-499 and DPL-61 × NF-801-2-37 with 28.52, 19.78 and 7.28, respectively (Table 3) were identified as best specific combinations. Among the 10 varietal combinations, NF-801-2-37 × Acala-63-75 appeared to be best cross (31.70), whilst DPL-61 × Acala-63-75 and F-281 × DPL-61 with negative values -4.99 exhibited the poor performance (Table 3).

***Number of bolls per plant*:** The results of combining ability analysis for number of bolls are given in table 1. Mean squares for general combining ability were non-significant, whilst these were highly significant ($p \leq 0.01$) for specific combining ability (Table 1). The significant estimate for specific combining ability variance (43.85) revealed that number of bolls was largely controlled by dominance variance. The non significant estimates for general combining ability variance (-2421.47) and additive variance (-4842.96) suggested that in this plant material, number of bolls was not influenced by additive genes. The comparison of general combining ability effects in table 2, revealed NF-801-2-37 (4.43) as the best general combiner for number of bolls, whilst Acla-63-75 also exhibited good general combining ability (0.38). The three parents namely F-281, DPL-61 and CIM-499 revealed negative general combining ability effects (-4.21, -0.49 and -0.11, respectively). The best specific cross combination was DPL-61 × NF-801-2-37 (8.48). The hybrids resulted from crosses NF-801-2-37 × CIM-499 and F-281 × CIM-499 (7.06 and 585 respectively) performed better regarding number of bolls (Table 3). The superior reciprocal combinations identified for this trait were CIM-499 × NF-801-2-37 (7.87) and DPL-61 × Acala-63-75 (4.87) (Table 3) The combination F-281 × Acala-63-75 exhibited poor performance due to negative reciprocal effect (-0.70) followed by F-281 × NF-801-2-37 (-1.42).

***Average boll weight*:** Genetic analysis of boll weight revealed that the general and specific combining abilities were non-significant, whilst the reciprocal effects appeared to be significant (Table 1). The magnitude of specific combining ability variance (0.006) was greater than general combining ability variance (-30.66) indicating the role of dominant genes in expression of boll weight. This result was supported by estimates of additive and non additive variances (σ^2A = -61.31 and σ^2D = 0.006 respectively) measured for boll weight (Table 1). The comparison of general combining abilities (Table 2) identified NF-801-2-037 as the best general combiner and the second important general combiner was DPL-61 (0.034) for this trait. The best specific cross appeared to be DPL-61 × NF-801-2-37 (0.24). The hybrids resulted from specific combinations NF-801-2-37 × F-281, Acala-63-75 × CIM-499 and DPL-61× CIM-499 and Acala-63-75× NF-801-2-37 performed better for boll weight (Table 3). The reciprocal combinations, for example, NF-801-2-37 × Acala-63-75, F-281 × Acala-63-75 and F-281 × DPL-61 (0.1, 0.1 and 0.1 respectively) were found to be superior. The combination CIM-499 × Acala-63-75 had the strongest negative reciprocal effect (-0.25) for boll weight.

DISCUSSION

An effective genetic improvement in seed cotton yield, number of bolls and boll weight may be achieved by exploiting the genetic basis of variation in different morphological characters. Quantitative genetic analyses provide reliable information about the type of genetic effects involved in the inheritance of polygenic traits and they also assist in modifying selection methods to enhance cultivar development besides upgrading germplasm pools (Hallauer, 2007). From the present data, it was revealed that NF-801-2-37 proved to be the best general combiner due to highest seed cotton yield and production of maximum number of heavy bolls. Acala-63-75 was also identified as a good general combiner for seed cotton yield and boll number. Therefore, inclusion of both these varieties in crop breeding programs for yield enhancement could be rewarding. The parental variety CIM-499 appeared to be poor parent for all the three traits. The varieties DPL-61 and F-281 also exhibited poor general combining abilities for seed cotton yield and number of bolls.

The combining ability analysis (Griffing, 1956) revealed that effects of specific combining ability were highly significant for controlling variation in seed cotton yield and number of bolls, whilst only reciprocal effects were significant for boll weight (Table 1). Higher proportion of dominance variance due to specific combining ability suggested that these three traits were operated by non additive genes as reported by Shakeel *et al.* (2001), Haq and Azhar (2004) and Basal *et al.* (2009). In contrast, Basal and Turgut (2003) and Samreen *et al.* (2008) reported greater influence of additive genes in the phenotypic expression of seed cotton yield, number of bolls and boll weight.

In the present research work, some unique combinations were identified. The parental varieties which revealed negative general combining ability effects produced hybrid combinations exhibiting superior performance. For example, F-281, CIM-499 and DPL-61 did not perform well as general combiners but when put in combination with other varieties, these exhibited good response in specific crosses as suggested by Patel *et al.* (1997) that parents showing poor general combining ability effects may result in good hybrid combinations. For example, the specific cross CIM-499 × F-281 performed better for seed cotton yield and number of bolls. Similar findings were reported by Haq and Azhar (2004) and Imran *et al.* (2012) for seed cotton yield number of bolls, boll weight and boll size. The best combinations identified for higher number of bolls were DPL-61 × NF-801-2-37, NF-801-2-37× CIM-499 and F-281×CIM-499 (Table 3). The combination Acala-63-75 × NF-801-2-37 showed best performance for all three traits as it involved two best general combiners.

The five parents possessed substantial genetic diversity for seed cotton yield, boll number and boll weight. Selection must be delayed until later generations as all the three traits showed non additive type of gene action. It is further suggested that characters showing non additive inheritance may be improved by application of heterosis breeding.

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