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Combining Ability of Plant Characters Related to Earliness in *Gossypium hirsutum* L.

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ABSTRACT

Mean squares of both general (GCA) and specific combining ability (SCA) effects were significant for the expression of days to flowering, days to squaring, earliness index and seed cotton yield, while GCA effect was non-significant for position of first sympodial branch. Reciprocal effects were significant for earliness index and seed cotton yield. The variance due to SCA was greater for position of first sympodial branch and earliness index. The proportion of variance due to GCA and SCA for days to squaring, days to flowering and seed cotton yield occurred to a similar extent. The genotype CIM-435 proved to be the best general combiner for days to squaring, days to flowering and position of first sympodial branch and MNH-3570 was best general combiner for earliness index and seed cotton yield. MNH-3570 x BAR 12/1 was the best combination for days to squaring, MNH-3570 x MS-95 for days to flowering, position of first sympodial branch and earliness index and BAR 12/1 x MS-95 for seed cotton yield.

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

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is the main source of foreign exchange earnings amongst the agricultural commodities of Pakistan. Although a great deal of research work has already been done for increasing cotton production in Pakistan, the average yield is still low, which necessitates the breeder to accelerate their efforts at great pace than ever before. In addition to cotton, wheat is the main cereal crop of Pakistan and cotton–wheat–cotton rotation system is being practiced in the cotton belt of Pakistan. The planting of wheat in November is delayed due to non-availability of land, which is still under cotton crop. According to an estimate, sowing of wheat after November 10 caused 42 kg ha^{-1} day^{-1} loss in grain yield (Khan, 2003). On the other hand, late maturation of cotton crop results in the development of poor grading fiber characteristics like staple length and fineness, and declined fiber strength (Salam *et al*., 1993). Thus in order to produce quality fiber, there is need to breed early maturing cotton varieties through selection and breeding. Thus for pursuing breeding efforts effectively, it is necessary to have knowledge of the inheritance of plant characters related to early maturity in cotton.

There are certain morphological plant features that provide an estimate of earliness in cotton. For instance node of first fruiting branch, number of vegetative branches and percentage of bolls on vegetative branches were reported by previous workers (Ray & Richmond, 1966). In another study Richmond and Radwan (1962) reported that combined weight of first and second picking, expressed as percentage of total seed cotton yield harvested, was one of the most practical methods. The variation in traits related to earliness is under genetic control. The studies of Gomma and Shaheen (1995), Gomaa *et al*. (1999) and Iqbal *et al*. (2003) showed that additive gene effects controlled days to flowering and position of first sympodial branch, whereas earliness index and seed cotton yield were affected by the genes with non-additive effects. This knowledge is not sufficient to develop a well conceived breeding program aimed at breeding early maturing material of cotton. Therefore, present studies were conducted to obtain more information on the genetic basis of plant characters related to earliness in cotton.

MATERIALS AND METHODS

Plant material for the present study was developed by crossing Bamboosa-49, CIM-435, MNH-3570, BAR 12/1 and MS-95 of cotton (*Gossypium hirsutum* L.). Five parents were grown in earthen pots in glasshouse during November 2003. Temperature and light were optimum during germination and growth. At flowering the parents were crossed in all possible combinations. To avoid alien pollen contamination of the genetic material, all necessary precautions were observed at the time of emasculation and pollination. Many pollination attempts were made to produce sufficient quantity of hybrid seed. The seed of 20 F_1 hybrids and their parents were field planted during May 2004 in randomized complete block design with three replications. Seeds of each of the 25 entries in each replication were planted in a single row with 10 plants, spaced 30 cm within the row and 75 cm between the rows. Data on days to squaring, days to flowering and position of

1st sympodial branch were collected at vegetative stage, while seed cotton yield of 25 families were recorded of mature plants. Later earliness index was calculated. The data were collected from five guarded plants on the individual plant basis.

The data on the characters measured were subjected to analysis of variance (Steel & Torrie, 1980) to find the significant differences among the genotypes. The characters showing significant differences were further analyzed for genetic interpretation following combining ability technique (Griffing, 1956).

RESULTS

Mean squares obtained from analysis of variance revealed significant differences among the genotypes for days to squaring and flowering, position of first sympodial branch, earliness index and seed cotton yield (Table I). Computations were also made for combining ability analysis (Table II) and proportion of variances due to the effects of GCA, SCA and reciprocals (Table III). The GCA of the parents and the SCA of the hybrids were also ranked in order to identify the best combiners for each of the characters and specific combinants for use in hybrid seed production program. Description of each of the characters is given here (Table IV).

Days to squaring. Results of combining ability analysis showed that the effect of reciprocal on days to squaring was non-significant ($p \geq 0.05$), whilst effects of GCA and SCA appeared to be significant ($p \leq 0.05$) and highly significant ($p \leq 0.01$), respectively (Table II). The relative contribution of each these variance components to total variation (Table III) revealed that effects of general combining ability was greater than that due to specific combining ability. The parent CIM-435 with minimum negative value (-1.41) appeared to be best general combiner followed by BAR 12/1 with -0.36 value. In specific combinations, the cross MNH-3570 x BAR 12/1 had numerical value (-1.275) and thus exhibited best SCA for the days to squaring. Similarly combination of BAR 12/1 x MS-95 and Bamboosa-49 x BAR 12/1 with numerical values 1.34 and 0.88, respectively also displayed best specific combining ability for the character (Table IV).

Days to flowering. Analysis of variance of combining ability showed non-significant ($p \geq 0.05$) effects of reciprocal, however effects of general combining ability and specific combining ability were significant ($p \leq 0.05$) and highly significant ($p \leq 0.01$), respectively. The proportion of SCA towards genetic variation in days to flowering was greater (48.92%) than due to GCA (40.24%). Regarding general combining ability of plants, it was noted that CIM-435 and MS-95 with numerical value i.e., -0.49 and -0.51, respectively appeared to be the best general combiners for days to flowering and in contrast MNH-3570 with high numerical value 1.52 seemed to be poor general combiner. In specific combinations the cross MNH-3570 x MS-95 with numerical value (-0.16) was screened out to be best specific combination for the character. Similarly other two combinations CIM-435 x MNH-3570 and Bamboosa-49 x CIM-435 with values -0.17 and -0.14, respectively also exhibited best SCA for the character.

Position of 1st sympodial branch. Analysis of diallel cross data following combining ability technique showed that effect of both GCA and reciprocals controlling position of 1st sympodial branch were non-significant ($p \geq 0.05$), whilst effects due to SCA appeared to be significant, $p \leq 0.05$ (Table II). Genetic variation in position of 1st sympodial branch was predominantly influenced by specific combining ability, with percentage of 75.56% (Table III). Assessment of parents for combining ability showed that the parent CIM-435 with minimum negative value -0.26 was revealed to be the best general combiner followed by BAR 12/1 with -0.172 value. Comparison of specific combinations revealed that the cross MNH-3570 x MS-95 and Bamboosa-49 x MS-95 with numerical value (-0.54) and -0.53, respectively expressed best SCA for the characters.

Earliness index. Combining ability analysis of the data showed that effect of GCA, SCA and reciprocals were significant ($p \leq 0.01$) on the expression of earliness index (Table II). Partitioning of total genetic variation revealed that magnitude of reciprocal effects were greater than those of SCA and GCA (Table III). Genotype MNH-3570 with numerical value 3.943 was the best general combiner for earliness index followed by Bamboosa-49 and MS-95. The cross MNH-3570 x MS-95 with maximum mean value 5.505 was the best specific combination for the character. Except MNH-3570 x Bamboosa-49 (0.472) all other reciprocals had the negative numerical values (Table IV).

Seed cotton yield. The effects of GCA, SCA and reciprocals (Table II) were significant ($p \leq 0.01$) on the final productivity of plant. The relative proportion of each these components of variation revealed that GCA of the parents contributed more in the control of seed cotton yield (Table III). MNH-3570 and CIM-435 with respect to general combining ability excelled all other parental lines for seed cotton yield (Table IV). Other varieties with negative numerical values expressed poor general combining ability for seed cotton yield. Comparison of cross combination of varieties showed that cross BAR 12/1 x MS-95 was the best combination with maximum value 17.247, followed by MNH-3570 x BAR 12/1 and Bamboosa-49 x BAR 12/1 with numerical value of 9.226 and 7.201, respectively.

DISCUSSION

Analysis of the data following Griffing's (1956) technique revealed that effects of GCA and SCA and reciprocal effects were significant for earliness index and seed cotton yield. Effects of GCA and SCA were significant for days to squaring and days to flowering. Only specific combining ability was significant for position of first sympodial branch. The large magnitude of variance due to

Table I. Mean squares obtained from analysis of variance of earliness related characters in *G. hirsutum*

SOV	DF	Days to squaring	Days to flowering	Position of first sympodial branch	Earliness index	Seed cotton yield
Replication	2	1.712*	0.512 NS	0.372 NS	1.367 NS	1.308NS
Genotypes	24	11.301**	5.596**	0.974**	274.577**	911.680**
Error	48	0.431	0.537	0.195	4.226	4.993

** highly significant * significant NS non-significant

Table II. Mean squares obtained from combining ability analysis of earliness related characters in *Gossypium hirsutum* L.

SOV	DF	Days to squaring	Days to flowering	Position of first sympodial branch	Earliness index	Seed cotton yield
GCA	4	14.12031*	7.331*	0.528089 ns	168.634*	1335.395**
SCA	10	3.358471**	1.401**	0.485149*	43.891**	187.2465*
Reciprocal	10	0.03422ns	0.143 ns	0.083278 ns	108.316**	7.939811**
Error	48	0.143807	0.179	0.065059	1.408	1.664413

** highly significant * significant NS non-significant

Table III. Estimate of components of variation of earliness related characters in *G. hirsutum*

Source of variation	Days to squaring	Days to flowering	Position of first sympodial branch	Earliness index	Seed cotton yield
GCA	1.44	0.59	0.006	12.67	115.7
	(50.52)	(40.24)	(1.90)	(13.65)	(50.09)
SCA	1.32	0.73	0.25	25.29	110.46
	(46.35)	(48.92)	(75.65)	(27.24)	(47.83)
Reciprocal	-0.05	-0.02	0.009	53.45	3.14
	(-1.92)	(-1.21)	(2.76)	(57.58)	(1.36)
Error	0.14	0.18	0.065	1.41	1.66
	(5.06)	(12.04)	(19.68)	(1.52)	(0.72)

Table IV. Estimate of GCA, SCA and reciprocal effects of earliness related characters in *G. hirsutum*

Genotypes	Days to squaring	Days to flowering	Node no. of first sympodial branch	Earliness index	Seed cotton yield
			(a) GCA Effects		
Bamboosa-49	-0.258	-0.264	-0.32	2.312	-5.687
CIM-435	-1.412	-0.490	-0.265	-5.613	8.381
MNH-3570	0.581	1.516	0.228	3.944	12.312
BAR 12/1	1.454	-0.510	0.241	-3.045	-5.580
MS-95	-0.365	-0.250	-0.172	2.402	-9.425
			(b) SCA effects		
Bamboosa-49 x CIM-435	-0.668	-0.136	-0.401	-7.367	-3.497
BAMBOOSA-49 x MNH-3570	1.338	-0.109	0.572	1.278	-13.391
Bamboosa-49 x BAR 12/1	-0.868	0.017	0.025	2.751	7.201
Bamboosa-49 x MS-95	0.885	0.124	-0.528	-0.47	7.041
CIM-435 x MNH-3570	0.525	-0.116	-0.361	-1.277	-3.036
CIM-435 x BAR 12/1	3.018	0.677	0.625	3.643	1.903
CIM-435 x MS-95	0.438	0.817	0.438	-0.504	-4.098
MNH-3570 x Bar 12/1	-1.274	1.371	0.015	0.863	9.226
MNH-3570 x MS-95	-0.354	-0.156	-0.538	5.505	5.35
BAR 12/1 x MS-95	-0.961	0.071	-0.218	1.931	17.247
			(c) Reciprocal effects		
CIM-435 x Bamboosa-49	-0.067	-0.133	0.00	-1.112	1.388
MNH-3570 x Bamboosa-49	0	0.1	0.067	0.472	0.758
MNH-3570 x CIm-435	-0.367	-0.2	0.367	-15.253	-4.762
BAR 12/1 x Bamboosa-49	0.067	0.133	-0.367	-0.622	-2.485
BAR 12/1 x CIM-435	0.133	-0.1	0.03	-13.172	2.257
BAR 12/1 x MNH-3570	-0.033	0.067	0.25	-6.462	-0.95
MS-95 x Bamboosa-49	-0.067	-0.1	-0.167	-3.668	-0.876
MS-95 x CIM-435	-0.067	-0.033	-0.367	-6.345	-0.538
MS-95 x MNH-3570	0.00	-0.4	0.183	-3.325	-0.3445
MS-95 x BAR 12/1	0.00	-0.667	-0.117	-5.202	1.083
Cd_1(Sij-Sik)	0.11	0.14	0.05	1.13	1.33
Cd_1(Sij-Skl)	0.14	0.18	0.06	1.40	1.66

SCA indicated the presence of non-additive genes acting for position of first sympodial branch and earliness index (Sprague & Tatum, 1942). The occurrence of similar extent of variance resulting from GCA and SCA for days to squaring and days to flowering suggested the importance of both additive and non-additive gene effects (Griffing, 1956). A higher proportion of due to GCA signified the importance of the genes acting cumulatively for seed cotton yield. The variety MNH-3570 exhibited the best GCA for earliness index and seed cotton yield, whilst CIM-435 proved best general combiner for days to squaring and position of 1st sympodial branch. MS-95 was revealed to be good combiner for days to flowering.

The parents having good general combining ability for a particular character are expected to yield good hybrids (Khan *et al*., 1991; Haq & Azhar, 2005). In this study this notion was found to be valid. Varieties CIM-435, BAR 12/1 and Bamboosa-49 were the best combiners for days to squaring and thus they produced good hybrids, CIM-435 x BAR 12/1, CIM-435 x Bamboosa-49 and CIM-435 x MS-95 (Table IV). Other parents like MS-95 and CIM-435 displayed best GCA for days to flowering and they nicked well to yield best cross combinations including CIM-435 x MNH-3570 and MNH-3570 x MS-95 (Table IV). The combinations MNH-3570 x MS-95 and Bamboosa-49 x BAR 12/1 were found to be the promising ones among the varietal combinations originating from hybrids of best general combiners i.e., MNH-3570, Bamboosa-49 and BAR 12/1 for earliness index. However, sometimes this suggestion does not hold true, and parents having low or poor general combining ability may have the potential to give promising hybrids as reported previously (Azhar & Akbar, 1992; Azhar & Rana, 1993c; Patel *et al*., 1997). Varieties BAR 12/1 and MS-95 showed poor general combining ability for seed cotton yield but they produced best cross combination, BAR 12/1 x MS-95 (Table IV). For position of first sympodial branch, crosses Bamboosa-49 x MS-95 and MNH-3570 x MS-95 were the promising ones, and these crosses had originated from hybrids of parents having low general combining ability (Table IV). Thus it is concluded that best general combiner may not always produce good hybrids.

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