

COMBINING ABILITY FOR YIELDS AND FIBER QUALITIES IN COTTON CROSSES (*GOSSYPIMUM HIRSUTUM* L.)

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Abstract

The experimental material consisted of the five parents (GSN 12, Şahin 2000, BA 308, Lider, Delcerro) and their 10 F_1 diallel combinations. An experiment was carried out in randomized complete block design with four replications to assess combining abilities for yield and fiber qualities at Cotton Research Station Nazilli during the year 2013. The experiment was conducted to obtain genetic information on seed cotton yield, ginning out turn, fiber length, fiber fineness and fiber strength. The parents Şahin 2000 and BA 308 are the best combiner for seed cotton yields and fiber fineness; Delcerro for fiber length and fiber strength; Lider for ginning outturn. The F_1 crosses of Şahin 2000 $\times$ Delcerro and BA 308 $\times$ Lider were the leading specific combiners for seed cotton yield per plant. The F_1 crosses of GSN-12 $\times$ Şahin 2000, GSN-12 $\times$ BA 308, GSN-12 $\times$ Delcerro and Lider $\times$ Delcerro was found to be good combiners for ginning outturn, GSN-12 $\times$ Lider, Şahin 2000 $\times$ Delcerro and BA 308 $\times$ Delcerro for fiber length, GSN-12 $\times$ BA 308, GSN-12 $\times$ Lider, Şahin 2000 $\times$ BA 308, Şahin 2000 $\times$ Lider and Şahin 2000 $\times$ Delcerro for fiber fineness, GSN-12 $\times$ Şahin 2000 and Lider $\times$ Delcerro for fiber strength.

Key words: combining ability, diallel, gene action, general combining ability, specific combining ability

1. INTRODUCTION

Upland cotton (*Gossypium hirsutum* L.) account for approximately 90% of the world cotton production. *Gossypium barbadense* L. with extra-long, strong and fine cotton is the second most cultivated species (Lacape et al., 2007; Yu et al., 2011). Interspecific crossing between *G. hirsutum* L. and *G. barbadense* L. is useful tool in increasing genetic diversity among elite germplasm for fiber traits such as fiber length and strength. Commercial potential of interspecific hybrids is greater than intraspecific hybrids and, less inbreeding depression in interspecific was determined (Baloch et al., 1993). Berger et al. (2011) revealed that although some interspecific crosses exhibited lower yield potential and lint percent than commercial cultivars, improvement in length and bundle strength were possibly the result of introgression from *G. barbadense* L. into *G. hirsutum* L.

Cotton breeders face the problem of selecting suitable parents and promising crosses to breed high yielding and high quality cotton varieties. The diallel technique is a useful tool to obtain precise information about the type of gene action involved in the expression of various plant characters.

The main purpose of the diallel technique is the estimate of the combining ability related with the basic population in reference. The general combining ability (GCA) is the average behavior of a genotypes in the hybrid combination: each genotypes is crossed with the rest of the genotypes in the group and the average behavior of the resultant F_1 individuals is considered as the base to determine the general combining ability of that particular genotypes. But, the specific combining ability (SCA) is used to designate those cases in which certain combinations behave relatively better or worse than the average behavior of the involved lines or varieties and constitute a deviation of the general combining ability of the two lines or varieties involved in the cross.

Combining ability plays a significant role in crop improvement because it helps the breeder to determine the nature and magnitude of gene action involved in the inheritance traits. Combining ability is useful in selection of desirable parents for exploitation of hybrids and transgressive expressions and also to assess the ability of parents to generate potential hybrids with a reasonable

level of stability (Ashokkumar and Ravikesavan, 2008). Identification of potential parents in cotton on the basis of progeny performance requires a large number of crosses, which is very laborious. Diallel analysis is a mating design whereby the selected parents are crossed in a certain order to predict the combining ability of the parents and elucidate the nature of gene action involved in the inheritance of the traits. The combining ability works as the basic tool for improved production of crops in the form of F₁ hybrids. The combining ability and heterosis work as the principal methods for screening of germplasm and determination of the ability of the genotypes to be included or not in a breeding program on the basis of their GCA and SCA effects. Therefore, both methods are very contributive in choosing potential parents with desired genetic variance, vigor, and, in some cases, through maternal effects (Khan et al., 2009). Some researchers (Gupta and Singh, 1986; Jagtap and Kolhe, 1987; Karademir et al., 2009; Singh et al., 2010) carried out trials to evaluate the general and specific combining ability of several cotton cultivars used in each trial and found good combiners with excellent materials for the genetic improvement in cotton.

Combining ability analysis gives an adequate opportunity to cotton breeders to understand the basis on which parental lines could be better in the breeding program. The improvement of a new variety with high yield and fiber quality parameters is the unique target of all cotton breeders. The first step in a successful breeding program is to select appropriate parents. Diallel analysis provides a systematic approach for the detection of appropriate parents and crosses superior in terms of the investigated traits (Basal and Turgut, 2003).

The objective of the present research was to determine the general and specific combining ability of five commercial cotton cultivars and their 10 hybrid combinations, respectively (excluding reciprocals) and to select those cultivars and F₁ crosses that were good combiners for seed cotton yields (SCY; g plant⁻¹), ginning out turn (GOT; %), fiber length (FL; mm), fiber fineness (FF; mic) and fiber strength (FS; g tex⁻¹).

2. MATERIAL AND METHODS

The research work comprised of diallel analysis in 5 × 5 F₁ diallel cross of *G. hirsutum* L. was conducted at Cotton Research Station Nazilli. Four diverse upland cotton genotypes (GSN-12, Şahin 2000, BA 308 and Lider) one diverse (Delcerro) which come from interspecific hybrid (*G. hirsutum* L. × *G. barbadense* L.) × (*G. arboretum* × *G. thurberi* × *G. hirsutum* L.).

The parents and their 10 F₁ hybrids were raised in a randomized complete block (RCB) design during crop season 2013. Each parent and hybrid was raised in one row with a row length of 12 meter, 0.7 meter between rows and 0.2 meter between plants. Recommended cultural practices were applied for all entries. Picking was made during the months of October. Data were collected on ten consecutive plants in row. Each genotype were assessed for seed cotton yields (SCY; g plant⁻¹), ginning out turn (GOT; %), fiber length (FL; mm), fiber fineness (FF; mic) and fiber strength (FS; g tex⁻¹).

After getting significant means variations in F₁s and parental populations, the genetic analysis was performed following Hayman's and Mather's diallel approach with concept of D and H genetic components of variation for additive and dominance variances, respectively (Hayman, 1954).

The genetic components of variation, their ratio along with standard error and correlation coefficient were estimated as follows:

— D: additive genetic variance; $F_1 = [D = V_{\text{D}} - E]$ (Volo = Variance of the parents)] where E is the expected environmental component of variation.

— H₁: dominance variance [$H_1 = V_{\text{D}} - 4W_{\text{D}} + 4V_{\text{L}} - (3n-2)E/n$, (Wolo = Mean covariance between the parents and the arrays)], where V_L is mean variance of arrays, and n is number of parental cultivars.

— H₂: H₁ [1-(u-v) ²], where u and v are the proportions of positive and negative genes, in the parents.

— F: Mean of Fr values over arrays = $2V_{\text{olo}} - 4W_{\text{olo}} - 2(n-2)E/n$, where Fr is the covariance of additive and dominance effects in a single array. F is positive where dominant genes are more frequent than recessive.

— $h^2: 4(ML_1 - MLo)2 - 4(n-1)E/n2$; Dominance effect (as algebraic sum over all loci in heterozygous phase in all crosses). When frequency of dominant and recessive alleles is equal, then $H_1 = H_2 = h^2$. Significance of h^2 confirms that dominance is unidirectional.

— E: Expected environmental component of variation

3. RESULTS AND DISCUSSION

Analysis of variance and combining ability of variance for the traits measured in the F_1 generation shown at table 1. Analysis of variance revealed that genotypes were significant for all studied characters. Mean squares obtained from analysis of variance indicated significant differences among the parents and their F_1 crosses for all studied characters and this validated the use of Hayman-Jinks model for genetic analysis.

The analysis of variance for combining abilities revealed that GCA variance of parents were significant for all traits except for seed cotton yields. On the other SCA variance of F_1 crosses were significant for all the traits measured in the study.

This indicated that both GCA and SCA variances were important for the inheritance of various traits under study.

Table 1. Analysis of variance and combining ability of variance for the traits measured in the F_1 generation.

Source	DF	SCY		GOT		FF		FS		FL	
Rep.	3	56,418		0,549		0,007		3,922		0,119	
Genotypes	14	248,921	*	32,978	**	0,510	**	78,671	**	10,888	**
Error	42	125,699		0,846		0,019		1,623		0,239	
σ^2 GCA	4	19,955		22,745	**	0,183	**	63,352	**	8,431	**
σ^2 SCA	10	79,140	*	2,444	**	0,105	**	2,194	**	0,438	**
Error	42	31,425		0,211		0,005		0,406		0,060	

*, ** = Significant at $P \leq 0.05$ and $P \leq 0.01$, NS = Non-Significant

The general combining abilities of parents and mean values are shown at table 2. General combining ability was not found significant for seed cotton yield per plant and it ranged from 78,40 to 83 g plant⁻¹ among the parental cultivars. GCA effects for ginning outturn was found significant for all parents except for GSN-12 and it is ranged 30,70% to 41,90%. The values showed that GCA effects for FL, FF and FS was found significant. Parents was ranged from 28,90 to 34,60 mm for FL, 4,86 to 4,32 mic for FF and 29,10 to 45,20 for FS.

High estimates of SCA variances (σ^2 SCA) were observed for SCY, GOT and FS . The presence of repulsion phase linkage and linkage disequilibrium might have resulted in an over estimation of non-additive component.

Table 2-a General combining ability and mean values of parents.

	SCY			GOT		
	GCA		Mean	GCA		Mean
GSN-12	-1,197	ns	81,00	0,006	ns	37,70
Şahin 2000	1,496	ns	80,00	0,634	**	39,00
BA 308	1,224	ns	83,00	1,163	**	41,90
Lider	0,831	ns	82,00	1,291	**	40,20
Delcerro	-2,354	ns	78,40	-3,094	**	30,70
SE (GCA)	1,895			0,155		
t %5	1,960			1,960		
t %1	2,500			2,500		
LSD 0,05	3,714			0,304		
LSD 0,01	4,738			0,388		

*, ** = Significant at $P \leq 0.05$ and $P \leq 0.01$, NS = Non-Significant

Table 2-b General combining ability and mean values of parents.

	FL			FF			FS		
	GCA		Mean	GCA		Mean	GCA		Mean
GSN-12	-0,776	**	30,30	0,103	**	4,86	-1,174	**	31,00
Şahin 2000	-0,377	**	30,00	-0,259	**	4,32	-2,753	**	29,10
BA 308	0,338	**	32,10	-0,057	*	4,70	-0,667	**	32,00
Lider	-0,940	**	28,90	0,088	**	4,75	-0,553	**	34,10
Delcerro	1,754	**	34,60	0,125	**	4,66	5,147	**	45,20
SE (GCA)	0,083			0,023			0,215		
t %5	1,960			1,960			1,960		
t %1	2,500			2,500			2,500		
LSD 0,05	0,163			0,045			0,421		
LSD 0,01	0,208			0,058			0,538		

*, ** = Significant at $P \leq 0.05$ and $P \leq 0.01$, NS = Non-Significant

The parents Şahin 2000 and BA 308 are the best combiner for seed cotton yields and fiber fineness; Delcerro for fiber length and fiber strength; Lider for ginning outturn.

The SCA effects and mean values of crosses are shown table 3. Specific combining ability effect is the index to determine the usefulness of particular crosses. The F_1 crosses of Şahin 2000 × Delcerro and BA 308 × Lider were the leading specific combiners for seed cotton yield per plant. The F_1 crosses of GSN-12 × Şahin 2000, GSN-12 × BA 308, GSN-12 × Delcerro and Lider × Delcerro was found to be

good combiners for ginning outturn, GSN-12 × Lider, Şahin 2000 × Delcerro and BA 308 × Delcerro for fiber length, GSN-12 × BA 308, GSN-12 × Lider, Şahin 2000 × BA 308, Şahin 2000 × Lider and Şahin 2000 × Delcerro for fiber fineness, GSN-12 × Şahin 2000 and Lider × Delcerro for fiber strength.

Table 3-a Specific combining ability and mean values of crosses.

	SCY			GOT		
	SCA		Mean	SCA		Mean
GSN-12 × Şahin 2000	4,355	ns	85,20	1,483	**	39,90
GSN-12 × BA 308	2,576	ns	83,20	1,055	**	40,00
GSN-12 × Lider	2,119	ns	82,30	-0,874	**	38,20
GSN-12 × Delcerro	-2,745	ns	74,30	1,412	**	36,10
Şahin 2000 × BA 308	-3,217	ns	80,10	-1,724	**	37,80
Şahin 2000 × Lider	6,876	ns	89,80	0,298	ns	40,00
Şahin 2000 × Delcerro	9,062	*	88,80	-0,017	ns	35,30
BA 308 × Lider	16,748	**	99,40	-1,281	**	38,90
BA 308 × Delcerro	-0,117	ns	79,30	-1,695	**	34,20
Lider × Delcerro	-11,324	**	67,70	2,076	**	38,10
SE (SCA)	3,868			0,317		
t %5	1,96			1,96		
t %1	2,5			2,5		
LSD 0,05	7,581			0,621		
LSD 0,01	9,670			0,793		

*, ** = Significant at $P \leq 0.05$ and $P \leq 0.01$, NS = Non-Significant

Table 3-b Specific combining ability and mean values of crosses.

	FL			FF			FS		
	SCA		Mean	SCA		Mean	SCA		Mean
GSN-12 × Şahin 2000	0,100	ns	30,20	0,253	**	4,62	1,249	**	32,10
GSN-12 × BA 308	-0,785	**	32,00	-0,564	**	4,00	-0,937	*	32,00
GSN-12 × Lider	0,633	**	30,10	-0,179	**	4,53	-3,251	**	29,80
GSN-12 × Delcerro	-1,206	**	31,00	0,219	**	4,98	-0,201	ns	38,60
Şahin 2000 × BA 308	-0,049	ns	31,10	-0,307	**	3,90	0,092	ns	31,50
Şahin 2000 × Lider	0,093	ns	32,00	-0,347	**	4,00	0,527	ns	32,00
Şahin 2000 × Delcerro	0,800	**	33,40	-0,244	**	4,14	-1,473	**	35,70
BA 308 × Lider	0,018	ns	30,60	0,231	**	4,78	0,042	ns	33,60
BA 308 × Delcerro	0,535	**	33,90	0,059	ns	4,65	-0,308	ns	39,00
Lider × Delcerro	0,233	ns	32,30	0,194	**	4,93	1,827	**	41,20
SE (SCA)	0,169			0,048			0,44		
t %5	1,96			1,96			1,96		
t %1	2,5			2,5			2,5		
LSD 0,05	0,33124			0,09408			0,8624		
LSD 0,01	0,4225			0,12			1,1		

*, ** = Significant at $P \leq 0.05$ and $P \leq 0.01$, NS = Non-Significant

Table 4. Genetic components of variance.

	SCY		GOT		FL		FF		FS	
D	7822,79	**	1742,08	ns	1171,55	**	26,07	**	1450,22	ns
F	15560,86	ns	3280,01	ns	2433,84	ns	51,94	**	3316,93	ns
H ₁	7906,85	ns	1555,94	ns	1268,67	ns	26,37	**	1911,94	ns
H ₂	141,72	ns	6,67	ns	2,71	ns	0,36	ns	5,81	ns
h ²	-7,76	ns	-0,13	ns	0,55	ns	0,10	ns	-0,10	ns
E	30,27	ns	0,21	ns	0,06	ns	0,01	ns	0,44	ns

*, ** = Significant at $P \leq 0.05$ and $P \leq 0.01$, NS = Non-Significant

Maximum SCY per plant (99,40 g plant⁻¹) was owned by F₁ crosses BA 308 × Lider. The lowest SCY was noted in Lider × Delcerro crosses (67,70 g plant⁻¹). GOT was varied from BA 308 × Delcerro 34,20% to GSN-12 × BA 308 and Şahin 2000 × Lider 40,00% in F₁ cross combinations. FL was varied from GSN-12 × Lider 30,10 to BA 308 × Delcerro 33,90 mm; FF was changed Şahin 2000 ×

BA 308 3,90 to GSN-12 × Delcerro 4,98 mic. and FS was ranged GSN-12 × Lider 29,80 to Lider × Delcerro 41,20 g tex⁻¹.

The significance of the components of variation i.e. D, F, H₁, H₂, h² and E calculated for seed cotton yield, fiber length and fiber strength (Table 4) suggested that the additive component (D) being significant, revealed the presence of genes showing additive properties. However, D component was significant for seed cotton yield, fiber length and fiber fineness, H₁ and F components were significant only for fiber fineness. Similar genetic control of fibre length and fibre strength had been reported by Nadeem and Azhar 2005.

The results revealed that D, F, E, H₁ and H₂ was positive for all characters. The positive values of F for traits is revealed that there were more dominant genes than recessive alleles in the parents.

Overall, the F1 crosses Şahin 2000 × Lider, Şahin 2000 × Delcerro, BA 308 × Lider and Lider × Delcerro manifested best genetic potential for majority of the traits.

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