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COMBINING ABILITY AND HETEROSIS FOR YIELD CONTRIBUTING TRAITS IN UPLAND COTTON (*GOSSYPIUM HIRSUTUM* L.)

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Abstract

A 4x4 complete diallel crosses between Sadori, CRIS-134, Sohni and CIM-448 was designed in F_1 generation to estimate the general and specific combining abilities of genotypes and to determine the degree and direction of heterosis and selection of promising recombinants for future breeding programme. The experiment was conducted in RCBD in three replication at experimental farm of Nuclear Institute of Agriculture, Tando Jam during 2005-06 for the traits plant height, sympodia/plant, bolls/plant and seed cotton yield/plant. The results of GCA showed that the variety Sadori proved to be best general combiner for plant height, number of bolls/ plant and seed cotton yield while the crosses Sadori x CIM-448 and Sadori x CRIS-134 exhibited higher SCA effects for boll number/plant. All the crosses showed positive magnitude of heterosis over mid and better parental means for plant height. The crosses Sadori x CIM-448 followed by CIM-448 x Sohni exhibited positively higher heterosis and heterobeltiosis for number of bolls /plant and seed cotton yield/plant.

Introduction

The increase in yield per unit area of the crop is a prime concern of breeding programme. Cotton breeders all over the world, have been utilizing the available genetic resource to modify the varieties to meet the ever changing requirement of their society. The purpose of this experiment was to obtain information regarding combining ability of four cotton (*G. hirsutum* L.) genotypes and manifestation of heterosis and their cross combination.

Combining ability describes the breeding value of parental lines to produce hybrids. Sprague & Tatum (1942) used the term general combining ability (GCA) to designate the average performance of a line in hybrid combinations and used the terms specific combining ability (SCA) to define those cases in which certain combinations do relatively better or worse than expected on the basis of the average performance of the lines involved. The importance of combining ability studies lies in the assessment of parental lines and their hybrids showing significant additive and non additive effect with respect to certain traits. In a systematic breeding program, it is essential to identify superior parents for hybridization and crosses to expand the genetic variability for selection of superior genotypes (Inamullah *et al*., 2006b).

Heterosis works like a basic tool for the improvement of crops in the form of F_1 generation. The feasibility of economic heterosis in inter and intra - crosses of *Gossypium* is emphasized where manpower is cheaper. Khan & Khan (1979), Salam (1991), Altaf *et al*., (1996) and Keerio *e. al*., (1996) conducted such studies for yield contributing traits and reported promising heterosis for yield parameters. Through heterosis, seed cotton contributing traits can be improved significantly (Naquibullah *et al*., 2000).

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The purposes of this research were to estimate the amount of heterosis, the GCA and SCA effects for yield contributing parameters among four different cotton genotypes and to determine appropriate parents and crosses for the investigated traits.

Material and Method

The research work was conducted at the experimental farm of Nuclear Institute of Agriculture, Tando Jam to estimate the combining ability (GCA and SCA), heterosis and heterobeltiosis of four commercial genotype viz, Sadori, CRIS-134, Sohni and CIM-448. These varieties were crossed in way to develop a complete diallel set of crosses and were attempted during 2005-06. The seed of parents along with F_1 hybrids (six direct and six reciprocals) were sown in randomize complete block design with three replication, the plant to plant distance 30 cm and line to line 75 cm was maintained during 2006-07. Ten plants/entries were randomly selected to record the data on plant height, number of sympodial branches per plant, number of bolls per plant and seed cotton yield.

The data were analysed as suggested by Steel & Torrie (1980).The data were also analysed for combining ability using method I model I of Griffing (1956). Heterosis was calculated in term of percent increase (+) or decrease (-) of hybrid against its mid-parent values. While heterobeltiosis was estimated in term of percent increase (+) or decrease (-) of hybrid over its better parent.

Mid-parent heterosis (MPH) = (F1- MP)/MP

Heterobeltiosis (HB) = (F1- BP)/BP, where MP (P1 + P2/2) = mid-parent and BP= better parent.

Result and Discussion

The present research work was carried out to determine the combining ability variance affect of parents and their F_1 hybrids for planning efficient breeding programme.

The analysis of variance (ANOVA) of parents and their hybrids (direct and reciprocals) for the traits under study is presented in Table 1. It reveals that traits were significant at ($p \leq 0.01$) level of probability which indicate considerable distance among genotypes.

The mean performance of parents and their hybrids (direct and reciprocal) for various traits under study is presented in Table 2 which indicates that maximum seed cotton yield (128.23g) and number of bolls per plant (40.75) were produced by cross Sadori x CRIS-134 and the tallest plant (115.16cm) produced by parents Sadori Xcim-448 while as for as trait sympodial branches per plant (20.99) was exhibited by cross Sohni x CRIS-134.

Combining ability (Variance and effects): The estimated general combining ability (GCA), Specific combining ability (SCA) and reciprocal effects are presented in Table 3, 4 and 5 respectively. The mean square of GCA presented in Table 1 revealed significant difference for all the traits. Mean square of SCA and reciprocals were also significant which indicates additive and non additive type of gene action involved in the manifestation of character under study. The finding of the parental study are in accordance with those of Sayal *et al*., (1997), Zia-ul-Islam *et al*., (2001) and Deshpade & Baig (2003).

Table 1. Mean squares for plant height, number of sympodia per plant, number of bolls per plant and seedcotton yield per plant.

S.O.V.	D.F.	Plant height (cm)	Sympodia per plant (No)	Bolls per plant (No)	S.C.Y. per plant (g)
Genotypes	15	316.97**	7.099**	35.53**	474.766**
Replications	2	0.564	1.25	1.94	1.279
Error	30	0.636	0.316	0.549	0.911
		Combining ability			
GCA	3	188.89**	0.82**	24.55**	373.01**
SCA	6	181.79**	1.48**	14.11**	149.35**
Reciprocals	6	8.41**	4.15**	3.12**	12.29**
Error	30	0.636	0.316	0.549	0.911

**Significant at 1% and 5% level of probability levels, respectively.

Table 2. Means for plant height, sympodia/plant, bolls/plant and seed cotton yield/plant of cotton parents and their F1 hybrids evaluated during 2005-06, at NIA,Tando Jam.

Genotype	plant height/plant (cm)	Sympodia/plant (No)	Bolls/ plant (No)	Seed cotton yield/plant (g)
Sadori	105.0 h	18.61 de	36.93 bc	114.15 de
CRIS-134	89.0 j	17.00 fg	28.51 i	96.27 h
Sohni	80.34 k	18.31 e	31.73 h	88.45 i
CIM-448	93.64 i	19.61 cd	29.61 i	82.45 j
Sadori x CRIS-134	114.00 abc	19.92 bc	40.75 a	128.23 a
Sadori x Sohni	113.46 bc	17.35 f	35.31 def	113.69 e
Sadori x CIM-448	115.16 a	18.71 de	39.69 a	125.71 b
CRIS-134 x Sohni	110.78 ef	17.13 g	30.93 h	95.35 h
CRIS-134 x CIM-448	114.13 abc	16.16 g	34.15 g	106.31 f
Sohni x CIM-448	113.67 bc	18.69 de	36.60 cd	105.68 f
CRIS-134 x Sadori	111.96 de	20.68 ab	37.98 b	115.61 d
Sohni x Sadori	114.56 ab	19.91 bc	34.35 efg	105.91 f
CIM-448 x Sadori	112.86 cd	20.73 abc	35.45 def	118.98 ef
Sohni x CRIS-134	108.51 g	20.99 a	33.63 g	99.69 g
CIM-448 x CRIS-134	110.31 f	20.66 ab	32.18 h	105.16 f
CIM-448 x Sohni	107.68 g	20.70 ab	35.65 cde	105.18 f

Table 3. Estimates of GCA effects for yield and its components in F_1 hybrid Generation of *Gossypium hirsutum* L.

Varieties	Plant height	Sympodial branches	Number of bolls	Seed cotton yield (gm)
Sadori	5.51	0.16	2.58	9.87
CRIS-134	-1.08	-0.38	-1.26	-1.81
Sohni	-4.82	-0.13	-0.85	-5.87
CIM-448	0.39	0.29	-0.48	-2.18

The significant GCA effects for all the traits measured in this study suggest an additive gene action for yield components. Among the parent only Sadori proved to be potential by manifesting significant positive GCA effects for the traits plant height, number of bolls and seed cotton yield, remaining parents manifested either nonsignificant positive or negative GCA effects for traits under discussion (Table 3).

Table 4. Estimates of SCA effects for yield and its components in F_1 hybrid generation of *Gossypium hirsutum* L.

Combination	Plant height	Sympodial branches	Number of bolls	Seed cotton yield (gm)
Sadori x CRIS-134	2.56	1.37	3.45	3.67
Sadori x Sohni	7.33	-0.53	-1.49	-0.38
Sadori x CIM-448	2.11	0.13	0.87	8.47
CRIS-134 x Sohni	4.55	0.52	-0.2	-0.9
CRIS-134 x CIM-448	6.92	-0.58	0.31	3.56
Sohni x CIM-448	4.11	0.49	3.15	7.32

Table 5. Estimates of reciprocals effects for yield and its components in F_1 hybrid generation of *Gossypium hirsutum* L.

Combination	Plant height	Sympodial branches	Number of bolls	Seed cotton yield (gm)
CRIS-134 x Sadori	1.02	0.38	1.38	2.31
Sohni x Sadori	-0.3	-1.28	0.48	3.89
CIM-448 x Sadori	1.15	1.99	2.12	3.36
Sohni x CRIS-134	-3.86	-1.93	-1.35	2.17
CIM-448 x CRIS-134	1.91	-2.22	1.97	0.57
CIM-448 x Sohni	2.27	1.00	0.47	0.22

The SCA effects of yield components for crosses among four cotton genotypes are given in Table 4 which reveals that the hybrid Sohni x CRIS-134 proved to be the best for sympodial braches, number of bolls and cross of Sadori x CIM-448 displayed highest SCA effects (8.4) for seed cotton yield. The best specific combiner for plant height was Sadori x Sohni. It is obvious from these results in three combinations involving Sadori, as one of the best general combiner with highest parental mean value in seed cotton yield, bolls per plant and plant height showing possibility of importance through careful selection.

Reciprocal effects is presented in Table 5 which indicated that cross Sohni x Sadori (3.89) and CIM-448 x Sadori (2.12) showed maximum reciprocal effect for the trait seed cotton yield and number of bolls/ plant respectively. These observations support the finding of Azhar *et al* ., (1994), Amin *et al.,* (1997), Ahmed *et al.,* (2000) and Khan *et al.,* (2000).

Heterosis and heterobeltiosis: The heterotic performance of 12 F_1 hybrid (direct and reciprocals) for traits plant height, sympodial branches, number of bolls/plant and seed cotton yield are presented in Table 6. All the combinations showed the different degree of heterosis for each character.

The hybrid Sohni x CRIS-134 manifested highly significant mid-parent heterosis (+27.55) and the hybrid CRIS-134 x CIM-448 (+21.07) and Sohni x CRIS-134 (+20.06) showed vigor over better parent for plant height. These findings are supported by previous researchers like Khan *et al.,* (1999) and Sayal *et al.,* (1999) who also reported fair degree of heterosis and heterobeltiosis for plant height.

Table 6. Estimate of Heterosis and Heterobeltiosis for yield and its components in F_1 hybrid generation of *Gossypium hirsutum* L.

Cross combination	Plant height/ plant (cm)		Sympodia/plant (No)		Bolls/plant (No)		Seed cotton yield/plant (g)	
	Percent increase (+) or decrease (-) over							
	MPH	HB	MPH	HB	MPH	HB	MPH	HB
	Direct crosses							
Sadori x CRIS-134	+17.04	+8.57	+13.31	+7.03	+24.54	+10.34	+14.05	+5.32
Sadori x Sohni	+22.43	+8.05	-6.01	-6.77	+2.85	-4.38	+12.22	+0.00
Sadori x CIM-448	+15.08	+9.67	-2.09	-4.58	+19.29	+7.47	+27.88	+10.12
CRIS-134 x Sohni	+18.32	+12.63	-2.94	-6.44	+2.68	-2.52	+3.55	+0.00
CRIS-134 x CIM-448	+24.43	+21.07	-11.69	-17.59	+17.51	+15.33	+18.96	+10.42
Sohni x CIM-448	+19.17	+10.48	-1.42	-4.69	+19.33	+15.34	+23.67	+19.47
Reciprocal crosses	Reciprocal crosses							
CRIS-134 x Sadori	+14.49	+6.62	+16.17	+11.12	+16.07	+2.84	+9.88	+1.27
Sohni x Sadori	+23.62	+9.10	+7.85	+6.98	+0.05	-6.98	+4.55	-7.21
CIM-448 x Sadori	+13.63	+7.52	+8.47	+5.71	+6.55	-4.00	+21.02	+4.23
Sohni x CRIS-134	+27.55	20.06	+18.92	+14.63	+11.65	+5.98	+7.93	+3.55
CIM-448 x CRIS-134	+20.26	+17.85	+13.00	+5.45	+10.73	+8.67	+17.68	+12.83
CIM-448 x Sohni	+23.78	+14.99	+9.17	+5.55	+16.23	+12.35	+22.87	+18.71

The highest heterotic performance was recorded in cross Sohni x CRIS-134 which surpassed its mid parent by (+18.92) and same cross showed vigour over better parent for the trait number of sympodia per plant (Table 6). The previous workers like Keerio *et al.*, (1996), Soomro & Kalhoro (2000) and Khan *et al.*, (2000) have reported heterotic and heterobeltiotic values and suggested number of sympodia per plant as suitable criteria for selection of high yielding hybrids.

The hybrid Sadori x CRIS-134 remained superior among all crosses incase of mid parent heterosis (+24.54). Therefore, bolls per plant being the most important and direct yield contributing trait can be exploited from this cross combination (Mukhtar & Khan, 2000; Chang *et al.*, (2001a, b & c) Solangi *et al*., (2001 & 2002). The hybrids Sohni XCIM-448, exhibited highly heterobeltiosis (+15.34).

Regarding seed cotton yield, cross Sadori x CIM-448 showed an appreciable degree of heterosis (+ 27.88) when compared with mid-parent value while heterobeltosis was observed for the cross Sohni x CIM-448 which suggested that both cross combination can be used in future hybridization programme for the exploitation of heterosis followed by selection to boost the seed cotton yield. The result of this research coincide with the result of Soomro & Kalhoro (2000), Mukhtar & Khan (2000) and Chang *et al*., (2001c).

Conclusion

It was concluded that variety Sadori being good general combiners for sympodial branches/ plant and number of bolls/ plant and seed cotton yield will make good breeding material to be exploited in breeding programmes for the improvement of these characters. while the crosses Sadori x CIM-448 and Sadori x CRIS-134 exhibited higher SCA effects for boll number/plant. However, the crosses Sadori x CIM-448 followed by CIM-448 x Sohni exhibited positively higher heterosis and heterobeltiosis for number of bolls /plant and seed cotton yield/plant and could be exploited in producing hybrid cotton.

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