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ESTIMATE OF HETEROSIS AND HETEROBELTIOSIS FOR THE IMPROVEMENT OF YIELD IN UPLAND COTTON (*GOSSYPIUM HIRSUTUM* L.)

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ABSTRACT

The enhancing seed cotton yield per acre of the crop is a prime concern of breeding programmes. To achieve high degree of heterotic response, it is essential to have knowledge about performance of desirable parents . Therefore, research was undertaken to assess the expression of heterotic effects in cross combination of upland cotton in F_1 crosses. The research work was carried out using six cross combinations sown under field condition during 2018 at Nuclear Institute of Agriculture, Tandojam experimental farm. The crosses were obtained by the combinations of four genotypes in half diallel method. The trial was conducted in a three replications with Randomized Complete Block Design (RCBD). Observations were made for plant height (cm), sympodial branches plant^{-1}, number of bolls plant^{-1}, weight boll (g) and yield of plant^{-1} (g). Results showed that crosses exhibited significant cross vigour while compared with mid and better parents. The crosses Sadori × CRIS-342 and Sadori × NIA-Noori displayed significant heterotic effects for characters under studied. For development of hybrid in cotton, cross combinations of these parents Sadori × CRIS-342 and Sadori × NIA-Noori will give highest heterosis for yield of plant^{-1}, bolls plant^{-1} and weight of bolls. Therefore, the above F_1 transgressive and heterotic hybrids can be exploited to create genetic variability followed by selection of high yielding in cotton genotypes to establish strains with superior and improved characteristics in segregating filial generations.

Keywords: cotton (*Gossypium hirsutum* L.), half diallel analysis, heterosis and heterobeltosis

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is effectively cultivated as yearly yield in tropical and sub-tropical district of Pakistan. Cotton is the most significant fiber money crop and furthermore developed as oilseed crop in the various countries included India, China, USA, Pakistan, Uzbekistan, Australia and Africa. (Riaz *et al*., 2013). included Cotton crop is principally used for fiber and part play a key role in national economy of Pakistan (Larik *et al*., 2004). Mexican cotton represents 95% of overall cotton fiber age (Tyagi *et al*., 2014). Heterosis is the phenomenon in which a hybrid has the better performance than its parents. Heterosis is extensively exploited by plant breeders to the benefit of agriculture, however, its molecular genetic mechanisms are not well understood. It is helpful in deciding the most fitting guardians for improving explicit qualities (Khan *et al*., 2010). The term heterotic design alludes to an assembly of associated or unrelated genotypes from the corresponding or different genetic makeup, which demonstrate unparalleled combined capability and heterotic affects while combined with genotypes from other genetically recognized germplasm (Melchinger and Gumber, 1998). Heterosis is the performance of F_1 hybrids in relation to mid and better parents. It is useful in determining the most appropriate parents for improving specific traits (Khan *et al*., 2010). Valuable heterosis is clarified as an expansion in the yield of F_1 hybrid over the standard business check (Khan *et al*., 1979; Salam, 1991; Altaf *et al*., 1996). Heterosis rearing for seed cotton yield alongside quality characteristics can be improved fundamentally. It is basic to have better information about the presentation of attractive guardians as far as half and half blend; the heterotic contemplates are useful in making such data. Cotton reproducers are constantly intrigued to grow

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new cotton assortments with high return and better fiber quality, and it has been an important objective of all cotton improvement. It has been accounted for that yield heterosis in cotton crop is hereditarily controlled because of added substance and predominance impacts (Tuteja and Agrawal, 2013). Heterotic studies can provide the basics for exploitation of valuable hybrid combinations and their commercial utilization in future breeding programmes. The hereditary improvement of new cotton assortments with high seed cotton yield and fiber quality parameters has been one of the important objective of all cotton reproducers. The accomplishment of transgressive isolation relies upon the distinguishing proof of genotypes with the capacity to transmit potential qualities for higher creation for genetic improvement (Khan *et al*., 2010). More noteworthy seed cotton yield has been a definitive objective of cotton rearing projects. The seed cotton yield is the last result of different yield parts including sympodial branches, boll number, boll weight, and so on. Seed cotton yield and its related characteristics are quantitative attributes and constrained by numerous qualities, thus indicating variable qualities in isolating age. Heterosis works like a fundamental apparatus for the improvement of harvests as F_1 generation.

MATERIALS AND METHODS

The seeds of six F_1 hybrids were developed by half diallel mating design with 04 parents. This breeding material was obtained from routine breeding programme of cotton group of Nuclear Institute of Agriculture (NIA), Tandojam. The experiments were conducted at research field of NIA, Tandojam, Pakistan during cropping season 2018. Six hybrids developed through half diallel mating design were studied along with their four parent lines. The research work carried out in three replications with randomized complete block design (RCBD). At the time of maturity, plant height (cm) from ground to tip was measured. The fruiting branches were counted on selected plants. The boll weight of plants was obtained by weight of seed cotton yield per plant divided by Number of bolls per plant. At the maturity seed cotton was picked separately and weighed with an electronic balance. The average seed cotton yield of each genotype in each replication was calculated for analysis. Heterosis was calculated in term of percent increase (+) or decrease (-) of hybrid against its mid-parent values.

Mid-parent heterosis (MPH) = (F_1- MP)/MP x 100. While heterobeltiosis was estimated in term of percent increase (+) or decrease (-) of hybrid over its better parent.

Heterobeltiosis (HB) = (F_1- BP)/BP x 100, where MP (P1 + P2/2) = mid-parent and BP= better parent.

RESULTS AND DISCUSSION

Yield and its characters are controlled by many genes and the phenotypic expression of these characters although influenced to a larger extent by environments. To understand the inheritance of such characters, this is correlated with the degree of success in the improvement during selection. Excluding environmental effect, the genetic variation is due to the additive gene effects, dominance and due to the allelic and non- allelic interaction of genes. In the present research their heterotic performance was analyzed. In the present study mean squares of genotypes parents and crosses were highly significant for all the traits under investigation, which exhibited considerable variation among the research material, which signified the present study. Previously, same pattern of findings were reported by various researchers (Baloch, 2015; Bilwal *et al*., 2018; Khokhar *et al*., 2018 and Prakashsinh *et al*., 2018. The factual examination of fluctuation and the mean execution of the considerable number of genotypes contemplated are given in the (Tables 1 and 2). Results demonstrated that genotypes contrasted exceptionally fundament-tally differed highly significantly ($P \leq 0.01$) for plant tallness, sympodial branches plant^{-1}, bolls plant^{-1}, boll weight and seed cotton yield plant^{-1} was huge at $P \leq 0.05$ level.

Table 1. Mean performance for various seed cotton yield and other components in upland cotton (*Gossypium hirsutum* L.)

S.O.V.	D.F.	Plant height (cm)	Sympodial branches plant^{-1}	Bolls plant^{-1}	Boll weight (g)	Seed cotton yield/ plant
Genotypes	9	79.14**	9.46*	22.66**	0.256*	669.26*
Replications	2	28.99	24.40	13.30	0.016	72.15
Error	18	2.93	3.17	3.63	0.064	87.27

****, *=** significant at 1% and 5% probability level respectively ‘
NS= non-significant

The mean execution of genotypes for different quantitative and qualitative characters was tried through least significant differences (LSD) and the outcomes are presented in (Table 2). In cotton, the moderate height plants are more desirable for high yield because medium plants have a more production capacity to set the maximum boll numbers plant^{-1}, which is the final result for desirable high yielding varieties. Our findings revelaved that, genotype NIA-Noori delivered higher plants stature (122.0cm) followed by Sindh-I (120.0cm) while Sadori plant had overshadow plant tallness (111.0cm) contrasted and different genotypes. Among hybrids Sindh-I × NIA-Noori and CRIS-342 × Sindh-I indicated tall plants (129.0), (127.0) though, cross Sadori × CRIS-342 showed predominate plant (118.0).

Table 2. Mean squares from analysis of variance for various seed cotton yield and other components in upland (*Gossypium hirsutum* L.)

Genotypes	Plant height (cm)	Sympodial branches/ plant	Bolls/ plant	Boll weight	Seed cotton yield/ plant
Sadori	111.0F	21.0AB	36.0BC	3.00CD	108.0B
CRIS-342	117.0E	18.0BC	34.0C	2.96CD	100.8B
Sindh-i	120.0CD	17.0C	30.0D	3.48 AB	103.6B
NIA-Noori	122.0BC	20.0ABC	34.0C	3.4ABC	115.9B
Sadori × CRIS-342	118.0DE	22.0A	40.0A	3.40ABC	135.6A
Sadori × Sindh-I	120.3CD	21.0AB	36.0BC	2.80D	100.9B
Sadori × NIA-Noori	124.0B	23.0AB	38.0AB	3.70A	140.6A
CRIS-342 × Sindh-I	127.0A	21.0AB	34.0C	3.0CD	101.8B
CRIS-342× NIA-Noori	122.0A	21.OAB	35.0BC	2.96CD	103.8B
Sindh-I × NIA-Noori	129.0A	20.0ABC	33.0CD	3.06BCD	101.0
LSD Value	2.9380	3.0579	3.2698	0.4341	16.025

The data presented in (Table 2) shows normal cotton yield. These findings indicated that, Sadori was the most extreme sympodial branches plant^{-1} (21.0), while Sindh-I produced the lowest sympodial branches plant^{-1} (17.0). Among crosses Sadori × NIA-Noor and Sadori × CRIS-342 indicated maximum sympodial branches (23.0), (22.0) though Sindh-I × NIA-Noori had least sympodial branches. Hybrid Sadori × CRIS-342 and Sadori × NIA-Noor gave maximum numbers of bolls per plant (40.0 and 38.0) and seed cotton yield (135.6g) and (140.6g) respectively among the cross combinations.

The heterosis and heterobeltiosis in yield is commonly characterized as increment in the yield over the mean of the two parents or over the better parents. Based on heterotic effects, the choice capability of any parent might be successfully utilized for upgrade of specific characteristics.The present research work was carried out to determine the heterosis and heterobeltiosis of 4 parents and their 6 F_1 hybrids for planning efficient breeding programme. Heterosis studies guide the breeder in identifying crosses for improvement of different traits. Heterosis is the resultant of heterozygosity and gene interaction. The heterosis values expressed as the percentage increase or decrease over mid parent (relative heterosis or mid parent heterosis) and over better parent (heterobeltiosis) are presented in (Tables 3 and 7).

Among the six hybrids, hybrid CRIS-342 × Sindh-I, Sindh-I × NIA-Noori and Sadori × NIA-Noori gave most elevated positive heterosis and heterobeltiosis for the trait plant tallness. This shown that, these crosses are best combiners for the taller plant while Sadori × CRIS-342 and CRIS-342 × NIA-Noori had most reduced worth proposing for the dwarf plants. The lines Sadori and CRIS-342 have demonstrated dwarfness, in the descendants. The huge heterosis over mid-parent and better parent demonstrated note worthy increment for plant stature and negative increment for plant tallness showed decline in plant tallness as contrast with their mid parent and better parent. Results of the present study indicated that the heterosis over mid parent esteem was more dominating than heterobeltiosis. The level of heterosis both over mid and better parent assorted fundamentally relies on the characteristics and method for the cross combinations. Comparable outcome was reported by various researchers (Mustungi and Ansari, 2011; Saravanan and Koodalingam, 2011; Khan and Qasim, 2012; Panni *et al*., 2012; Bilwal *et al*., 2018; Khokhar *et al*., 2018; Prakashsinh *et al*., 2018) who detailed predominance and over dominant gene action control this trait. Along these lines above cross combinations must be changed for the desire plants.

Table 3. Mean performance of parents, F_1 hybrids and percentage increase (+) or decrease (-) over mid parent (relative heterosis) and better parent (heterobeltiosis) for the character Plant height

Crosses	Seed parent plant	Pollen parent P_2	Mid parent	F_1 hybrids	% Increase (+) or decrease (-)	
					Mid parent	Better parent
Sadorix CRIS-342	111	117	114	118	3.51	0.85
Sadri= Sindh-I	111	120	116	120	4.18	0.27
Sadori x Nia-Noori	111	122	117	124	6.44	1.64
CRIS-342 x Sindh-I	117	120	119	127	7.17	5.83
CRIS-342×NIA-Noori	117	122	120	122	2.09	0.00
Sindh-I x NIA- Noori	120	122	121	129	6.61	5.74

The expansion or reduction over mid parent and better parent for the attribute number of sympodial branches plant^{-1} demonstrated that 6 crosses indicated positive mid parent heterosis and heterobeltiosis. Among the hybrid, CRIS-342 × Sindh-I, Sadori × NIA-Noori and Sadori × CRIS-342 showed most noteworthy positive heterosis and heterobeltosis effects showed over predominance heterosis for sympodia/ plant. These outcomes are in concurrence with those got by (Mustungi and Ansari, 2011, Saravanan and Koodalingam, 2011; Khan and Qasim, 2012; Nidagundi *et al*., 2012; Baloch *et al*., 2015; Chhavikant *et al*., 2017; Chinchane *et al*., 2018) who likewise watched heterosis for this character on mid just as better parent premise. Among the combinations, crosses Sadori × NIA-Noori and Sadori × CRIS-342 demonstrated most significant positive heterosis and heterobeltiosis effects, showing dominance and over dominance type gene action for characters bolls plant^{-1} and boll weight.

Table 4. Mean performance of parents, F_1 hybrids and percentage increase (+) or decrease (-) over mid parent (relative heterosis) and better parent (heterobeltiosis) for the character Sympodial branches

Crosses	Seed parent	Pollen parent	Mid parent	F_1 hybrids	% Increase (+) or decrease (-)	
					Mid parent	Better parent
Sadori x CRIS-342	21	18	19.5	22	12	4.76
Sadri = Sindh-I	21	17	19	21	10	0.00
Sadori x Nia-Noori	21	20	20	23	12	9.5
CRIS-342 x Sindh-I	18	17	17	21	20	16.6
CRIS-342×NIA-Noori	18	20	19	21	10	5.0
Sindh-I x NIA- Noori	17	20	18	20	8	0.00

Table 5. Mean performance of parents, F_1 hybrids and percentage increase (+) or decrease (-) over mid parent (relative heterosis) and better parent (heterobeltiosis) for the character Bolls/plant

Crosses	Seed parent	Pollen parent	Mid parent	F_1 hybrids	% Increase (+) or decrease (-)	
					Mid parent	Better parent
Sadori x CRIS-342	36	34	35	40	14.29	11.11
Sadri = Sindh-I	36	30	33	36	9.909	0.00
Sadori x Nia-Noori	36	34	35	38	8.57	5.56
CRIS-342 x Sindh-I	34	30	32	34	6.5	0.00
CRIS-342× NIA-Noori	34	34	34	35	2.94	2.94
Sindh-I x NIA- Noori	30	34	32	33	3.13	-2.94

Table 6. Mean performance of parents, F_1 hybrids and percentage increase (+) or decrease (-) over mid parent (relative heterosis) and better parent (heterobeltiosis) for the character boll weight

Crosses	Seed parent	Pollen parent	Mid parent	F_1 hybrids	% Increase (+) or decrease (-)	
					Mid parent	Better parent
Sadori x CRIS-342	3.00	2.96	2.98	3.4	14.09	13.33
Sadri = Sindh-I	3.00	3.48	3.24	2.8	-13.58	-19.54
Sadori x Nia-Noori	3.00	3.4	3.2	3.7	15.63	8.82
CRIS-342 x Sindh-I	2.96	3.48	3.23	3	-7.12	-13.79
CRIS-342×NIA-Noori	2.96	3.4	3.19	2.96	-7.21	-12.94
Sindh-I x NIA- Noori	3.48	3.4	3.44	3.06	-11.05	-12.07

Table 7. Mean performance of parents, F_1 hybrids and percentage increase (+) or decrease (-) over mid parent (relative heterosis) and better parent (heterobeltiosis) for the character seed cotton yield

Crosses	Seed parent	Pollen Parent	Mid parent	F_1 hybrids	% Increase (+) or decrease (-)	
					Mid parent	Better parent
Sadori x CRIS-342	108.0	100.8	104	135.6	29.89	25.56
Sadri = Sindh-I	108.0	103.6	106	101	-4.63	-6.57
Sadori x Nia-Noori	108.0	113.9	111	140.6	26.72	23.44
CRIS-342 x Sindh-I	100.8	103.6	102	101.8	-0.39	-1.74
CRIS-342×NIA-Noori	100.8	113.9	107	103.8	-3.31	-8.87
Sindh-I x NIA- Noori	103.6	113.9	109	101	-7.13	-11.33

The bolls per plant being the most significant and direct yield contributing attribute can be used from these cross combinations to increase yield. These outcomes are affirmation of the outcomes acquired by Nassar, 2013; Tuteja *et al*., 2013; Tigga *et al*., 2017; Khokhar *et al*. 2018; Prakashsinh *et al*., 2018; Bilwal *et al*., 2018 they likewise reported changing degrees of heterosis and heterobeltiosis for this character. Yield is polygenic character the information indicated that among the six crosses just two crosses Sadori × CRIS-342 and Sadori × NIA-Noori showed huge positive mid parent heterosis and heterobeltiosis for the attribute seed cotton yield/plant. In numerous cases F_1 crosses of cotton were found to out yield their parents or check. The higher yield of F_1 is basically because of amassing of positive effect of heterosis (corresponding epistatic). In this manner, these crosses should be planned for improvement of yield. Such kind of findings are already published by Khan and Qasim, 2012; El-Hashash, 2013; Ranganatha *et al*., 2013; Tuteja *et al*., 2013; Baloch *et al*., 2015; Narendra *et al*., 2017; Tigga *et al*., 2017 and Prakashsinh *et al*., 2018. They reported much comparative higher heterosis and heterobeltiosis in their hereditary material. Considering the character boll weight, the two crosses Sadori × CRIS-342 and Sadori × NIA-Noori, indicated positive mid parent heterosis and heterobeltiosis. While other four cross showed negative mid parent heterosis and heterobeltosis for the characteristic bolls weight. Our outcomes are upheld by the discoveries of different researchers, they stated importance of heterosis and heterobeltiosis in cotton crosses for improvement of this trait (Karademir and Gencer. 2010; Khan and Qasim, 2012; Nassar, 2013; Tuteja *et al*., 2013; Baloch *et al*., 2015; Tigga *et al*., 2017 and Prakashsinh *et al*., 2018).

CONCLUSION

The present research was carried out using six cross combinations sown under field condition during 2018 at Nuclear Institute of Agriculture, Tandojam experimental farm, to study the magnitude of heterosis of 9 genotypes (04 parents and 06 hybrids). Observations were made for height of plant (cm), sympodial branches (No.), bolls plant^{-1}, weight of boll (g) and yield of plant^{-1} (g). Greatly considerable difference for the traits under considered was showed by genotypes. Heterosis was more pronounced than heterobeltiosis. Cross combinations, Sadori × CRIS-342 and Sadori × NIA-Noori gave highest heterosis for yield of plant^{-1}, bolls plant^{-1} and weight of bolls. The crosses Sadori × CRIS-342 and Sadori × NIA-Noori displayed significant heterotic effects for characters under studied. For development of hybrid in cotton, cross combinations of these parents Sadori × CRIS-342 and Sadori × NIA-Noori will give highest heterosis for yield of plant^{-1}, bolls plant-I and weight of bolls.

AUTHOR'S CONTRIBUTION

S. Khuwaja: Developed the concept
H. Bux: Supervised the research experiment
S. Abro: Wrote the manuscript
M. Rizwan: Conducted the field experiment
G. M. Kaleri: Data analysis

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