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ESTIMATION OF HETEROSIS AND HETEROBELTIOSIS FOR YIELD AND FIBER TRAITS IN F_1 HYBRIDS OF UPLAND COTTON (*GOSSYPIUM HIRSUTUM* L.) GENOTYPES

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ABSTRACT

Heterosis and heterobeltiosis were estimated for eight yield and fiber traits in nine F_1 hybrids of upland cotton. Genotypes were highly significant ($P \leq 0.01$) for all the characters thus indicated existence of greater genetic variability among the genotypes for studied traits. On the basis of mean performance, the parental line Sadori showed best performance for some traits (sympodial branches plant^{-1}, bolls plant^{-1}, boll weight, seed cotton yield plant^{-1} and lint %). Among the F_1 hybrids, the hybrid BT-802 x Sadori performed well for various traits (plant height, bolls plant^{-1}, boll weight and seed index). Results regarding heterotic performance in F_1 hybrids, maximum heterosis and heterobeltiosis were achieved for sympodial branches plant^{-1}, bolls plant^{-1}, boll weight, lint% and seed cotton yield plant^{-1}. Positive heterosis over mid- and better parents for seed cotton yield plant^{-1} ranged from 32.86 to 57.26% and 12.33 to 42.69%, respectively. Overall, current study demonstrated that female lines, NIA-OKRA-01 and BT-802, exhibit greater heterosis and heterobeltiosis in crosses with Sadori and IR-3701 for seed cotton yield plant^{-1} and fiber traits. Therefore, above parental lines could efficiently be exploited for hybrids development in cotton crop.

Keywords: Heterobeltiosis, heterosis, upland cotton, yield and fiber traits.

INTRODUCTION

Greater seed cotton yield has been the ultimate goal of cotton breeding programs. The seed cotton yield is the final product of various yield components including sympodial branches, boll number, boll weight, etc. In order to meet the challenges of 21st century, the great efforts are needed for the genetic improvement of cotton crop in respect to yield and fiber quality traits in current era than before, because of a low production per unit area and low fiber quality in Pakistan when compared with other cotton growing nations of the world. Seed cotton yield and its associated traits are quantitative traits and controlled by many

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genes, hence showing variable values in segregating generation (Rauf *et al.,* 2005).

Heterosis is the increase in performance of a hybrid in regard to the parental average, and can be assumed with positive or negative values (Aguiar *et al.,* 2007). Since last couple of decades, the heterosis has gained more attention from cotton breeders (Karademir and Gencer, 2010). Previously, the heterosis had been exploited in achieving higher production in vegetatively propagated plants (Grivet *et al.,* 1996). However, in recent times, the induction of different approaches such as usage of gametocides, identification of male sterile lines and plants with imperfect-flower plants in many species, created possibilities to get more advantages from heterosis.

Cotton breeders are always interested to develop new cotton varieties with high yield and better fiber quality, and it has been a unique target of all cotton breeders. It has been reported that yield heterosis in cotton crop is genetically controlled due to additive and dominance effects (Marani, 1967). Heterosis has often been practiced in cotton, however to be of prospective value, a hybrid should be more advantageous than best existing commercial cultivar. This refers that the hybrid would have greater yield and superior fiber quality. Using heterosis to improve yield and fiber quality of cotton has long been a purpose of researchers. Therefore, the present study was aimed to estimate heterosis and heterobeltiosis in F_1 hybrids of upland cotton (*Gossypium hirsutum* L.).

MATERIALS AND METHODS

The current experiment was conducted at Nuclear Institute of Agriculture (NIA), Tandojam, during 2012. The experimental material comprised of three female lines (NIA-OKRA-01, BT-802 and BT-703) and three male testers (IR-2620, IR-3701 and Sadori) and their respective nine F_1 hybrids. The seeds of F_1 hybrids were obtained by line x tester mating design. The parental lines and F_1 hybrids were sown in randomized complete block design with three replications. The distance between row to row and plant to plant was 75 and 30 cm, respectively. In total, ten plants of each genotype per replication were tagged at random to record the data for plant height (cm), sympodial branches plant^{-1}, bolls plant^{-1}, boll weight (g), seed cotton yield plant^{-1} (g), lint %, staple length (mm) and seed index (100 seed weight, g). For determining the differences among the genotypes, the analysis of variance (ANOVA) was carried out as suggested by Gomez and Gomez (1984), while heterosis was calculated as proposed by Fehr (1987) which is given as under:

$$\text{Heterosis} = \frac{F_1 - \text{Mid Parent}}{\text{Mid Parent}} \; X\, 100$$

$$\text{Heterobeltiosis} = \frac{F_1 - \text{Better Parent}}{\text{Better Parent}} \; X\, 100$$

RESULTS AND DISCUSSION

Analysis of variance revealed that genotypes, parents, F_1 hybrids and parents vs F_1 hybrids were highly significant (P≤0.01) for all the studied characters, suggesting that sufficient genetic variability is existed in the present materials which can further be utilized to produce improved cotton varieties (Table 1). Similar to these results, Shah *et al.* (2015) also reported significant variations for the characters including bolls plant^{-1}, boll weight and seed cotton yield plant^{-1}. Based on the mean performance, the parental line Sadori showed better performance for various traits i.e. sympodial branches plant^{-1} (22.40), bolls plant^{-1} (35.33), boll weight (3.17 g), seed cotton yield plant^{-1} (111.21 g) and lint% (46.63) (Table 2). Among F_1 hybrids, NIA-OKRA-01 x Sadori demonstrated outstanding performance for sympodial branches plant^{-1} (23.73), boll weight (3.47 g), lint% (49.90) and seed cotton yield plant^{-1} (140.98 g) (Table 2). Mean performance reflects that these both (parent and F_1 hybrid) genotypes may prove potential plant genetic material for development of improved cotton varieties, thus can extensively be utilized in further breeding programs.

The results revealed that the occurrence of heterosis was general and its degree varied with the traits. Considering the positive heterotic effects of plant height in F_1 hybrids, it varied from 3.34 to 14.15% and 2.66 to 13.36% for heterosis and heterobeltiosis, respectively (Table 3). Highest heterosis (14.15%) and heterobeltiosis (13.36%) were calculated from cross NIA-OKRA-01 x Sadori. However, it is a well known fact that moderate heterosis is quite useful for plant height, thus medium tall plants may be considered for further selection. Three hybrids expressed moderate heterosis i.e. BT-802 x IR-2620, BT-703 x Sadori and BT-703 x IR-3701. These findings are in conformity with those of Abro *et al.* (2009) and Patil *et al*. (2011) who also obtained moderate heterosis for plant height.

About sympodial branches plant^{-1}, the positive heterosis and heterobeltiosis was ranged from 7.45 to 32.57% and 2.98 to 21.18%, respectively (Table 3). The maximum positive heterosis was manifested by NIA-OKRA-01 x IR-2620 (32.57%) and the maximum positive heterobeltiosis was shown by the cross BT-802 x IR-3701 (21.18%). The previous workers like Abro *et al.* (2014) have also observed positive heterotic and heterobeltiotic values and proposed sympodia plant^{-1} as appropriate selection criteria for high yielding hybrids.

All the nine hybrids expressed positive heterotic and heterobeltiotic effects for bolls plant^{-1} (Table 3), indicating that all parents used in the current study possess greater genetic distance for this trait which is a good indicator for future breeding programs since it helps to enhance seed cotton yield plant^{-1}. The cross NIA-OKRA-01 x IR-3701 exhibited maximum heterosis (40.74%) and heterobeltiois (24.59 %) for bolls plant^{-1}, offering that this F_1 hybrid has worth to be utilized in cotton hybrid breeding programs. Vineela *et al.* (2013) also observed high heterobeltiosis and commercial heterosis for bolls plant^{-1} which was correlated with higher seed cotton yield. For boll weight, the highest heterosis of 22.66% was produced by hybrid BT-703 x IR-3701 which also revealed the highest heterobeltiosis of 14.23% (Table 3), thus indicating the occurrence of dominant genes in these parents for boll weight. The obtained results are in conformity with Seoudy *et al.* (2014) who also reported fair amount of heterosis and heterobeltiosis for boll weight. Present results suggested that un-tapped resources of hybrid BT-703 x IR-3701 may be utilized for hybrid crop development to improve boll weight. Regarding the heterosis for seed cotton yield plant^{-1} (Table 4), the hybrid BT-802 x IR-3701 exhibited maximum amount of heterosis (57.26%) which was also associated with highest heterobeltiosis (42.69%). However F_1 hybrid NIA-OKRA-01 x IR-3701 was second in rank to show maximum heterosis (55.70%) and heterobeltiosis (37.30%) for seed cotton yield plant^{-1}. Consequently, these F_1 hybrids may be considered for commercial cultivation after thorough testing. Similarly, Alkuddsi *et al.* (2013) and Tyagi *et al.* (2014) also identified superior F_1 hybrids for seed cotton yield plant^{-1}.

For lint percentage, all the crosses showed positive heterosis, whereas only two crosses exhibited negative heterobeltiosis (Table 4). The top scoring hybrid with maximum heterosis (25.17%) over mid parent was NIA-OKRA-01 x IR-3701 while maximum heterobeltiosis (16.55%) was shown by BT-802 x Sadori. Significant positive heterosis for lint percentage was also noted by Tuteja and Agarwal (2013) and Solanki *et al.* (2014). Results regarding heterosis for staple length suggested that most of the crosses expressed positive heterosis and heterobeltiosis (Table 4). Nevertheless, the highest scoring hybrid was NIA-OKRA-01 x IR-3701 which gave high heterosis (18.05%) while BT-802 x IR-3701 expressed high heterobeltiosis (18.64%). Baloch *et al.* (2014) also reported similar findings about heterosis for staple length.

Table 1. Mean squares from line x tester analysis for different characters in upland cotton.

Source of Variation	Replications D.F. = 2	Genotypes D.F. = 14	Parents D.F. = 5	F_1 hybrids D.F. = 8	Parents x F_1 hybrids D.F. = 1	Error D.F. = 28
Plant height	24.05	168.51**	85.05**	130.27**	891.81**	7.96
Sympodial branches plant^{-1}	1.60	20.86**	24.25 **	6.32**	120.27**	0.66
Bolls plant $^{-1}$	19.34	92.43**	66.24**	5.89**	915.58**	2.56
Boll weight	0.007	0.16**	0.11**	0.05**	1.31**	0.01
Seed cotton yield plant^{-1}	177.95	1798.10**	1097.09**	131.88**	18632.88**	20.05
Lint %	2.76	97.09**	89.94**	57.88**	62.00**	7.10
Staple length	0.82	12.73**	19.59**	9.78**	8.07**	1.23
Seed index	0.03	0.97**	1.45 **	0.79**	3.06 **	0.08

**= significant at 1% probability level

Table 2. Mean performance of parents and F_1 hybrids for various traits in upland cotton.

Genotypes	Plant height (cm)	Sympodial branches ($plant^{-1}$)	Bolls ($plant^{-}$)^{1}	Boll weight (g)	Seed cotton yield ($plant^{-}$)^{1} (g)	Lint %	Staple length (mm)	Seed Index (100 seeds weight, g)
NIA-OKRA-01	120.27c	14.40d	25.20d	3.01ab	76.12f	42.15 a	22.14c	5.80c
BT-802	132.20a	19.20bc	28.13bc	2.91cd	81.05e	45.25 a	24.80b	5.89c
BT-703	132.21a	19.76bc	28.43bc	2.92bc	81.52d	42.73 a	25.33b	7.71a
IR-2620	124.27b	20.60ab	34.40ab	3.05ab	105.13b	41.49 a	30.00a	6.45b
IR-3701	118.07d	17.80c	32.53c	3.02ab	98.25c	31.13 b	24.73b	6.81b
Sadori	118.60d	22.40a	35.33a	3.17a	111.21a	46.63 a	25.65b	6.51b
LSD % 0.05	0.8576	0.9739	1.6402	0.0439	0.3019	2.4971	1.0431	0.2396
F_1Hybrids								
NIA-OKRA-01 x IR-2620	138.00a	14.40d	37.60c	3.21bc	120.23e	49.71bc	26.20bc	6.47b
BT-802 x IR-2620	138.40a	19.87c	39.93b	3.22b	137.94ab	47.83c	22.80e	6.45b
BT-703 x IR-2620	137.73a	23.20ab	40.33b	3.13c	126.99d	48.21c	25.47cd	5.43c
NIA-OKRA-01 x IR-3701	123.47b	20.13c	40.53b	3.29b	134.20bc	48.67c	27.67ab	6.43b
BT-802 x IR-3701	122.93b	23.27ab	40.07b	3.45a	137.94ab	43.59d	29.07a	7.10a
BT-703 x IR-3701	134.07a	22.40b	38.33c	3.45a	132.41c	39.11e	25.80cd	6.21b
NIA-OKRA-01 x Sadori	136.33a	23.73a	39.80b	3.47a	140.98a	49.90a	26.13bc	6.56b
BT-802 x Sadori	122.40b	23.20ab	41.73a	3.39a	138.25ab	49.80.ab	24.20de	7.05a
BT-703 x Sadori	133.87b	22.93ab	41.93a	3.23b	135.89bc	48.73c	25.60cd	6.96a
LSD% 0.05	2.7404	0.4791	0.4289	0.0400	2.2172	1.7133	0.8348	0.1709

For seed index, six crosses produced positive heterosis, whereas five F_1 hybrids revealed positive heterobeltiosis (Table 4). The cross BT-802 x Sadori produced maximum heterosis (13.76%) and heterobeltiosis (8.40%). The next high scoring hybrid was BT-802 x IR-3701 which expressed 11.81% and 4.31% heterosis and heterobeltiosis, respectively. Our findings are in accordance with those of Karademir and Gencer (2010) who also estimated heterosis and heterobeltiosis for seed index. The prevalence of additive gene effects for lint percentage, staple length and seed index proposed that considerable improvement for these traits could be made in segregating populations by approaching mass or pedigree method of breeding, which would enhance the frequency of desirable genes.

Table 3. Estimated heterosis and heterobeltiosis effects of F_1 hybrids for yield related traits in upland cotton.

F_1 hybrids	Plant height		Sympodial branches (plant^{-1})		Bolls (plant^{-})^{1}		Boll weight	
	H	HB	H	HB	H	HB	H	HB
NIA-OKRA-01 x IR-2620	12.86	11.05	32.57	12.62	27.89	11.46	5.95	5.25
BT-802 x IR-2620	7.93	4.69	-0.84	-4.21	29.09	18.38	8.05	5.69
BT-703 x IR-2620	9.92	9.02	11.83	11.65	31.38	19.57	10.98	2.84
NIA-OKRA-01 x IR-3701	3.34	2.66	26.89	16.15	40.74	24.59	9.07	8.83
BT-802 x IR-3701	-2.01	-7.01	27.37	21.18	32.09	23.16	16.18	14.13
BT-703 x IR-3701	9.43	6.12	18.31	9.09	27.35	17.83	22.66	14.23
NIA-OKRA-01 x Sadori	14.15	13.36	28.99	5.95	26.62	5.29	12.53	9.68
BT-802 x Sadori	-2.39	-7.41	11.54	3.57	26.59	10.41	11.40	6.95
BT-703 x Sadori	9.31	5.97	7.45	2.98	28.11	10.93	9.60	-0.21

Note. H= Heterosis; HB= Heterobeltiosis

Table 4. Estimated heterosis and heterobeltiosis effects of F_1 hybrids for yield and fiber traits in upland cotton.

F_1 hybrids	Seed cotton yield (plant^{-})^{1}		Lint %		Staple length		Seed index	
	H	HB	H	HB	H	HB	H	HB
NIA-OKRA-01x IR-2620	32.86	12.33	12.51	6.30	0.50	-12.67	5.72	0.41
BT-802 x IR-2620	38.67	20.43	10.28	5.70	-16.79	-24.00	4.59	0.10
BT-703 x IR-2620	41.03	17.82	14.50	12.84	-7.95	-15.11	-23.26	-29.56
NIA-OKRA-01x IR-3701	55.70	37.30	25.17	4.36	18.05	11.86	2.06	-5.48
BT-802 x IR-3701	57.26	42.69	14.16	-3.65	17.36	18.64	11.81	4.31
BT-703 x IR-3701	56.36	36.16	5.92	-8.46	3.06	1.86	-14.42	-19.45
NIA-OKRA-01 x Sadori	43.87	17.06	20.47	14.68	9.36	1.87	6.61	0.82
BT-802 x Sadori	43.58	19.83	20.67	16.55	-4.07	-5.67	13.76	8.40
BT-703 x Sadori	42.34	14.53	14.81	14.04	0.42	-0.21	-2.11	-9.77

Note. H= Heterosis; HB= Heterobeltiosis

CONCLUSION

Considering the mean performance among the parental lines, the variety Sadori and F_1 hybrids BT-802 x IR-3701 and NIA-OKRA-01 x Sadori displayed better performance for various characters. As far as heterosis is concerned, the F_1 hybrids NIA-OKRA-01 x IR-3701 and BT-802 x Sadori demonstrated superiority over their mid and better parents, respectively. Thus, above mentioned genotypes are valuable genetic stocks which can further be exploited for improvement in cotton crop.

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REFERENCES

Abro, S., M. M. Kandhro, S. Laghari, M. A. Arain and Z. A. Deho. 2009. Combining ability and heterosis for yield contributing traits in upland cotton (*Gossypium hirsutum* L.) Pak. J. Bot., 41 (4): 1769-1774.

Abro, S., S. Laghari, Z. A. Deho and M. A. Manjh. 2014. To estimates heterosis and heterobeltosis of yield and quality traits in upland cotton. J. Bio. Agri. Health, 4 (6): 19-22.

Aguiar, P. A. D., J. C. B. Penna, E. C. Freire and L. C. Melo. 2007. Diallel analysis of upland cotton cultivars. Crop Breed. App. Biotech., 7: 353-359.

Alkuddsi, Y., S. S. Patil , S. M. Manjula , B. C. Patil , H. L. Nadaf and B. S. Nandihali. 2013. Heterosis performance of seed cotton yield and physiological parameters in F1 inter specific hybrids in cotton. Cotton Geno. Genet., 4 (5): 60-72.

Baloch, M. J., J. A. Solangi, W. A. Jatoi, I. H. Rind and F. M. Halo. 2014. Heterosis and specific combining ability estimates for assessing potential crosses to develop F1 hybrids in upland cotton. Pak. J. Agric. Agril. Engg. Vet. Sci., 30 (1): 8-18.

Fehr, W. R. 1987. Principles of cultivar development. Theory and Technique. Vol.1. Macmillan Publishing Company, New York, U.S.A. pp.115.

Gomez, K. A. and A. A. Gomez. 1984. Statistics for Agricultural Research (Second Edition). John Willey and Sons, New York.

Grivet, L., A. Hont, D. Roques, P. Feldmann, C. Lanaud and J. C. Glaszmann. 1996. RFLP mapping in cultivated sugarcane (Saccharum spp.): genome organization in a highly polyploid and aneuploid interspecific hybrid. Genetics, 142 (3): 987-1000.

Karademir, E. and O. Gencer. 2010. Combining ability and heterosis for yield and fiber quality properties in cotton (*Gossypium hirsutum* L.) obtained by half diallel mating design. Not. Bot. Hort. Agrobot. Cluj., 38 (1): 222-227.

Marani, A. 1967. Heterosis and combining ability in intraspecific and interspecific crosses of cotton. Crop Sci., 7: 519-522.

Patil, S. A., M. R. Naik, A. B. Patil and G. R. Chaugule. 2011. Heterosis for seed cotton yield and its contributing characters in cotton (*Gossypium hirsutum* L.). Plant Archives, 11 (1): 461-465.

Rauf, S., T. M. Khan and S. Nazir. 2005. Combining ablility and heterosis in *Gossypium hirsutum* L. Inter. J. Agri. Bio., 1: 109-113.

Shah, K. A., N. U. Khan, L. Shah, A. Ali, A. Khan, X. Ying and Z. Abbas. 2015. Heterotic studies in 8 x 8 diallel crosses of upland cotton. Academic Res. J. Agric. Sci. Res., 3 (6): 128-136.

Seoudy, E., A. Alia, N. Y. Abdel-Ghaffar, H. Y. Awad, A. Hady and I. M. S. Darweesh. 2014. Evaluation of some crosses for economic traits in cotton (*Gossypium barbadense* L.). Egypt. J. Agric. Res., 92 (1): 183-187.

Solanki, H. V., D. R. Mehta, V. B. Rathod and M. G. Valu. 2014. Heterosis for seed cotton yield and its contributing characters in cotton (*Gossypium hirsutum* L.). Electronic J. Pl. Breed., 5 (1): 124-130.

Tuteja, O. P. and M. Agrawal. 2013. Heterosis for seed cotton yield and other traits in GMS based hybrids of American cotton (*Gossypium hirsutum* L.). Cotton Res. J., 5 (2): 131-141.

Tyagi, P., D. T. Bowman, F. M. Bourland, K. Edmisten, B. T. Campbell, D. E. Fraser, T. Wallace and B. Kuraparthy. 2014. Components of hybrid vigor in upland cotton (*Gossypium hirsutum* L.) and their relationship with environment. Euphy., 195 (1): 117-127.

Vineela, N., J. S. V. S. Murthy, P. V. Ramakumar and S. R. Kumari. 2013. Heterosis for morpho- physiological studies in cotton. J. Nat. Sci., 1 (2): 53-64.

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