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HETEROSIS AND INBREEDING DEPRESSION ESTIMATES FOR YIELD AND FIBRE COMPONENTS IN UPLAND COTTON (*GOSSYPIUM HIRSUTUM* L.)

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ABSTARCT

Fifty nine varieties / genotypes of *Gossypium hirsutum* L. collected from various cotton research institutes in Pakistan were grown in the field. Five cotton cultivars were selected out of this germplasm contrasting for three fibre quality traits viz. staple length, fibre strength and fibre fineness. Three crosses were made using these five genotypes each between two varieties contrasting for one fibre quality trait, cross CIM-707 x 4-F for staple length designated as cross-I, cross NIAB-III x RH-1 for fibre strength designated as cross-II and MS-40 x 4-F for fibre fineness designated as cross-III. Four genotypes P_1, P_2, F_1 and F_2 of each cross were developed and evaluated in the field in triplicated RCB design. Measurements were made relating to seed cotton yield and fibre quality components. Results revealed significant differences observed for all the traits under study. The magnitude and direction of heterosis for different traits varied in three crosses. Significant and positive heterosis for number of bolls per plant, lint percentage, seed index and lint index in cross I (CIM-707 x 4-F) and II (NIAB-III x RH-1) without influence of inbreeding depression could persist in later generations. Significant and positive heterosis for seed cotton yield followed by significant and positive inbreeding depression could be best exploited as first generation hybrids. Heterosis for fibre quality traits was relatively smaller in magnitude than those of yield and yield components. Significant positive heterosis followed by significant positive inbreeding depression for staple length in cross-I (CIM-707 x 4-F) and III (MS-40 x 4-F), for fibre fineness in cross-II (NIAB-III x RH-1) for fibre strength in cross-III (MS-40 x 4-F), indicating that hybrid vigour for these traits will not persist in later generations.

Key-words: Heterosis, Inbreeding, cotton yield, fibre strength, fibre fineness, staple length.

INTRODUCTION

Pakistan has an agriculture based economy and largely upon the successful growing of cotton (*Gossypium hirsutum* L.). Remarkable progress has been made in cotton breeding after independence of Pakistan. But still Pakistan lags behind the other progressive cotton producing countries of the world as far as yield per unit is concerned. The increase in yield can be possible if the existing genetic resources and information are properly utilized. Heterosis breeding is a technological option available for the improvement of productivity and it has been exploited successfully in different areas of the world in many crops. There were many workers like Wang and Pan (1991) and Wu *et al.* (2004) who reported positive significant heterosis for seed cotton yield. Similarly inbreeding depression for seed cotton yield has been reported by Katageri *et al.* (1992). Yadav and Yadava (1992)and Lucket (1989) reported positive heterosis for boll weight in cotton. Kalsy and Vithal (1980) reported positive heterosis for staple length while Atlanov (1981), Singh *et al.* (1983) and Khan and Tariq (1984) reported positive heterosis for fibre strength. Positive and low magnitude of heterosis in lint percentage was also reported by Thompson (1971).

The estimates of heterosis in F_1 and inbreeding depression in F_2 when considered together can provide some information about the type of gene action involved in the expression of various polygenic characters and thus may help in isolating high yielding strains or genotypes from the promising crosses. The present study was undertaken to estimate the degree of heterosis and inbreeding depression for fibre and yield in upland cotton.

MATERIALS AND METHOS

The research work reported here was carried out in the Department of Plant Breeding and Genetics and Centre of Agricultural Biochemistry & Biotechnolohy (CABB), University of agriculture, Faisalabd, Pakistan during 2004-2007. The seed of 59 varieties / genotypes were obtained from the Department of Plant Breeding & Genetics, University of Agriculture, Faisalabad, Cotton Research Institute, AARI, Faisalabad and Central Cotton Research Institute, Multan. The varieties/genotypes were grown during normal crop season of 2004 in the experimental area of the department of Plant Breeding & Genetics, University of Agriculture, Faisalabad. Five varieties/genotypes (Table 1) with contrasting lint traits like staple length, lint fineness and lint strength were selected.

In the coming crop season, selected parent lines were planted during October 2004 in pots placed in the green house. Crossing between two parents having contrasting characters was made at the time of flowering during January and February 2005. Three crosses including CIM-707× 4-F for staple length, RH-1 × NIAB-111 for fibre strength and MS-40 × 4-F for fibre fineness were made to produce F_1 followed by F_2 generation. Four populations viz, parents (P_1, P_2), hybrids (F_1, F_2) for each of the crosses were grown in replicated field trail during the year 2006 as separate experiment. The field experiment was laid out in a triplicated randomized complete block design. Row to row distance of 75 cm, and plant to plant distance of 30 cm was maintained by thinning out plants at early four–leaf stage in every experimental plot. Row length was kept at 4 meter. A single row for parental and F_1 generations, and 15 rows for each of the F_2 generations were planted in each replication. Normal agronomic practices were followed for the experiment. Observations were recorded on individual plant basis for number of bolls, seed cotton yield, boll weight, number of seeds per boll, seed index, lint index, lint percentage, lint index, fibre length, fibre strength, fibre fineness.

Table 1. List of Selected Varieties/Genotypes contrasting for important traits.

Sr. #	Genotype	Trait
1	CIM-707	Long staple, High seed index
2	4-F	Short staple, low seed index, low lint fineness
3	RH-1	High lint strength, High lint fineness
4	NIAB-111	Low lint strength
5	MS-40	High lint fineness, long staple length

The individual plant data regarding all traits measured at plant maturity were analysed using standard analysis of variance technique as described by Steel *et al.* (1997). Heterosis was estimated over the mid parent i.e. mean value or average of the two parents, it is known as mid parent heterosis by using the formula of Miller and Marani (1963) as under.

$$\text{Heterosis } F_1 = \left[\frac{(F_1 - MP)}{MP}\right] \times 100$$

Where, F_1 is the mean value of the F_1 and MP is the mean value of two parents involved in cross.

Inbreeding depression is estimated when both F_1 and F_2 generations of the same cross are available. Inbreeding depression was measured by following Miller and Marani (1963).

$$\text{Inbreeding depression} = \left[\frac{(F_1 - F_2)}{F_1}\right] \times 100$$

Where, F_2 is the mean values of F_2 progeny respectively of the same cross for a given character.

RESULTS AND DISCUSSION

The development of an effective plant breeding programme and the efficiency of selection largely depends upon the magnitude of genetic variability existed in plant material under study because it is pre-requisite for further investigation. Therefore, analysis of variance (not presented here) was applied in order to test the significance of differences. Mean square values showed significant differences ($P \leq 0.01$) for all traits under study (not presented here). Estimates of heterosis and inbreeding depression in three crosses for different traits as presented in Table 2. The number of bolls is the most important trait which contributes directly to seed cotton yield. Therefore, high yielding plants must be prolific and set a larger number of bolls. The magnitude of heterosis for number of bolls varied from cross to cross (Table 2). Positive and highly significant heterosis (30.30%) along with non significant inbreeding depression (10.01%) was noted in cross-I. Cross-II exhibited positive and highly significant heterosis (18%) along with highest positive and significant inbreeding depression (16.02%), whereas, maximum positive and highly significant heterosis (32.45%) along with non significant inbreeding depression (12.02%) was observed in cross-III. Positive and highly significant heterosis along with non significant inbreeding depression in cross-I and cross-III indicated that heterosis in these crosses would persist in succeeding generations. It could be exploited as F_2 hybrids. Highly significant and positive heterosis followed by significant inbreeding depression in cross-II indicated the presence of non additive gene action suggested the utilization of heterosis in the form of first generation hybrids.

Heterosis and inbreeding depression for number of bolls per plant have also been reported by Wang and Pan (1991) and Wu *et al.* (2004) and thus the present results are corroborated.

Highly significant and positive heterosis for seed cotton yield was exhibited in cross-I, cross-II and cross-III. Minimum but Positive and highly significant heterosis (40.01%) along with significant inbreeding depression (12.02%) was noted in cross-I, positive and highly significant heterosis (41.02%) with highest positive and significant inbreeding depression (24%) was observed in cross-II, whereas, maximum positive and highly significant heterosis (47.62%) along with highly significant inbreeding depression (19.05%) was noted in cross-III. Highly significant and positive heterosis followed by significant inbreeding depression in three crosses indicated the presence of non additive gene action suggested the utilization of heterosis in the form of first generation hybrids. Wang and Pan (1991), and Wu *et al.* (2004) reported heterosis for seed cotton yield as it has been observed in present study. Similarly, Katageri *et al.* (1992) reported inbreeding depression for seed cotton yield.

Positive and highly significant heterosis was noted for boll weight in three crosses. There was positive and highly significant heterosis (7.02%) without inbreeding depression in cross-I, positive and highly significant heterosis (18.03%) along with highly significant and positive inbreeding depression (10.02%) in cross-II, whereas, positive and highly significant heterosis (13.03%) along with highly significant inbreeding depression (8.06%) in cross-III. Positive and high heterosis accompanied by significant positive inbreeding depression in cross-II and cross-III indicated not to persist in later generations and suggested utilization of heterosis in these two crosses in the form of first generation hybrids. Results of present study are in agreement with that of Lucket (1989), Wang and Pan (1991), Yadav and Yadava (1992), Katageri *et al. (*1992) and Wu *et al.* (2004) reported positive heterosis for boll weight in cotton.

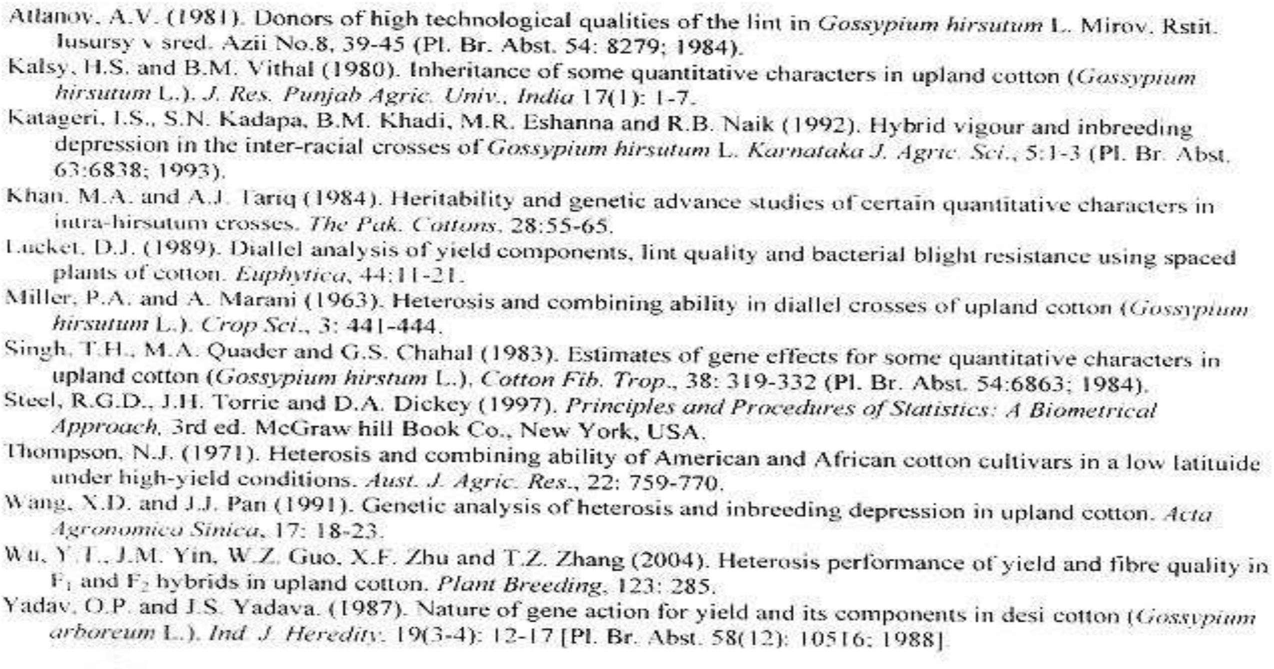
Table 2. Estimates of heterosis and inbreeding depression for cotton plant traits.

Cross Type / Plant Traits	Cross-I (CIM-707 × 4-F)		Cross-II (NIAB-111 × RH-1)		Cross-III (MS-40 × 4-F)	
	Heterosis (%)	Inbreeding Depression (%)	Heterosis (%)	Inbreeding Depression (%)	Heterosis (%)	Inbreeding Depression (%)
Number of Bolls	30.30**	10.01$_{NS}$	18.01**	16.02*	32.45**	12.02 $_{NS}$
Seed cotton yield (g)	41.01**	12.02*	41.02**	24.05**	47.62**	19.05**
Boll weight	7.02**	2.03 $_{NS}$	18.03**	10.02**	13.03**	8.06**
Number of seeds	2.33$_{NS}$	2.04 $_{NS}$	7.04*	1.03$_{NS}$	5.04**	7.01**
Seed index (g)	7.03**	-1.53 $_{NS}$	2.03$_{NS}$	-2.07 $_{NS}$	17.01**	10.04**
Lint Yield (g)	27.52**	-22.81**	9.93**	-40.05**	91.06**	18.02**
Lint percentage	3.61*	2.54 $_{NS}$	1.82 $_{NS}$	-0.92 $_{NS}$	7.02**	2.52 $_{NS}$
Lint index (g)	13.02 **	2.32 $_{NS}$	5.05 $_{NS}$	-1.41 $_{NS}$	32.01**	14.03**
Staple length (mm)	7.01**	5.01**	4.01*	0.20 $_{NS}$	5.03**	5.05**
Fibre fineness (µg/inch	0.91 $_{NS}$	0.71 $_{NS}$	7.52**	8.63**	2.60$_{NS}$	0.51 $_{NS}$
Fibre Strength (µg/tex)	6.02**	2.53 $_{NS}$	4.53**	2.65 $_{NS}$	6.65**	3.62**
Fibre uniformity	- 4.08 **	0.21 $_{NS}$	0.81 $_{NS}$	-20.04**	6.51**	-11.40

*, ** = Significant at P≤ 0.05 and P≤ 0.01 probability levels, respectively.

No heterosis and no inbreeding depression for number of seeds per boll were observed in cross-I. Positive and highly significant heterosis (7.04%) without inbreeding depression was noted in cross-II, whereas, positive and highly significant heterosis (5.04%) along with highly significant inbreeding depression (7.01%) was observed in cross-III. Positive and highly significant heterosis (7.03%) along with no inbreeding depression was observed for seed index in cross-I, while no heterosis and inbreeding depression were noted in cross-II. There were highly significant heterotic effects (27.52 and 9.93%) for lint yield along with negative and highly significant inbreeding depressions (-22.81 and -40.05%) in cross-I and II, respectively, whereas cross-III showed positive and highly significant heterosis (91.06%) along with highly significant positive inbreeding depression (18.02%). Significant heterosis along with negative inbreeding depression in cross-I and II indicated the predominance of additive gene action in the inheritance of lint yield in these two crosses. Positive and significant heterosis (3.61 and 7.02%) was noted for lint percentage in cross-I and cross-III, respectively whereas no heterosis was observed in cross-II. No inbreeding depression was noted in three crosses. The presence of heterosis with no inbreeding depression points out the existence of additive gene action in the expression of lint percentage, suggested thereby that improvement in the trait could be achieved through simple selection. Positive and low magnitude of heterosis in lint percentage was also reported by Thompson (1971), Singh *et al.* (1983). Positive and highly significant heterosis (13.02%) along with no inbreeding depression was observed for lint index in cross-I indicating the involvement of additive type of gene action in the inheritance of this trait, while cross-III showed positive and highly significant heterosis (32.01%) along with highly significant inbreeding depression (14.03%) reflecting the presence of non-additive gene effects for lint index thus suggested the utilization of cross-III as first generation hybrid. Present findings for staple length were supported by Kalsy and Vithal (1980), and Wang and Pan (1991) as they reported positive heterosis for staple length in cotton. Strength of yarn is determined by fibre strength. Cotton varieties producing weak fibres are difficult to handle in manufacturing process. Fibre strength is, therefore, a property of textile importance. Cross-III showed highly significant and positive magnitude of heterosis (6.65%) along with positive and highly significant inbreeding depression (3.62%) showing thereby the involvement of non additive genetic effects in the inheritance of this trait. So it is suggested that the utilization of this heterosis in first generation hybrids. Positive heterosis for fibre strength was also reported by earlier workers including Thompson (1971), Atlanov (1981), Singh *et al.* (1983), Khan and Tariq (1984) and Wu *et al.* (2004). Cross-II showed significant and positive heterosis (7.52%) along with positive and highly significant value of inbreeding depression (8.63%) for fibre fineness. It indicated that heterotic effect in cross-II was very sensitive to inbreeding depression and involved non-additive effects for this trait expression. Therefore, heterosis would not persist in later generation. Wang and Pan (1991) reported positive heterosis for fibre fineness. In case of fibre uniformity ratio, negative and highly significant heterosis (-4.0 %) along with no inbreeding depression was observed in cross-I while, negative and highly significant inbreeding depression (-19.8%) along with no heterotic effect was noted in cross-II. Similarly, cross-III showed positive and highly significant heterosis (6.51%) along with highly significant negative value of inbreeding depression (-11.4%). Therefore, simple selection would be required for the improvement of the trait. Wang and Pan (1991) reported positive heterosis for fibre uniformity ratio.

REFERENCES



Atlanov, A.V. (1981). Donors of high technological qualities of the lint in *Gossypium hirsutum* L. Mirov. Rstit. Iusursy v sred. Azii No.8, 39-45 (Pl. Br. Abst. 54: 8279; 1984).

Kalsy, H.S. and B.M. Vithal (1980). Inheritance of some quantitative characters in upland cotton (*Gossypium hirsutum* L.). *J. Res. Punjab Agric. Univ., India* 17(1): 1-7.

Katageri, I.S., S.N. Kadapa, B.M. Khadi, M.R. Eshanna and R.B. Naik (1992). Hybrid vigour and inbreeding depression in the inter-racial crosses of *Gossypium hirsutum* L. *Karnataka J. Agric. Sci.*, 5:1-3 (Pl. Br. Abst. 63:6838; 1993).

Khan, M.A. and A.J. Tariq (1984). Heritability and genetic advance studies of certain quantitative characters in intra-hirsutum crosses. *The Pak. Cottons*, 28:55-65.

Lucket, D.J. (1989). Diallel analysis of yield components, lint quality and bacterial blight resistance using spaced plants of cotton. *Euphytica*, 44:11-21.

Miller, P.A. and A. Marani (1963). Heterosis and combining ability in diallel crosses of upland cotton (*Gossypium hirsutum* L.). *Crop Sci.*, 3: 441-444.

Singh, T.H., M.A. Quader and G.S. Chahal (1983). Estimates of gene effects for some quantitative characters in upland cotton (*Gossypium hirstum* L.). *Cotton Fib. Trop.*, 38: 319-332 (Pl. Br. Abst. 54:6863; 1984).

Steel, R.G.D., J.H. Torrie and D.A. Dickey (1997). *Principles and Procedures of Statistics: A Biometrical Approach*, 3rd ed. McGraw hill Book Co., New York, USA.

Thompson, N.J. (1971). Heterosis and combining ability of American and African cotton cultivars in a low latituide under high-yield conditions. *Aust. J. Agric. Res.*, 22: 759-770.

Wang, X.D. and J.J. Pan (1991). Genetic analysis of heterosis and inbreeding depression in upland cotton. *Acta Agronomica Sinica*, 17: 18-23.

Wu, Y.T., J.M. Yin, W.Z. Guo, X.F. Zhu and T.Z. Zhang (2004). Heterosis performance of yield and fibre quality in F_1 and F_2 hybrids in upland cotton. *Plant Breeding*, 123: 285.

Yadav, O.P. and J.S. Yadava. (1987). Nature of gene action for yield and its components in desi cotton (*Gossypium arboreum* L.). *Ind. J. Heredity*. 19(3-4): 12-17 [Pl. Br. Abst. 58(12): 10516; 1988]

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