Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences
Volume 1 Number 5: 593-595, 2002

Study of Heterosis in Fibre Quality Traits of Upland Cotton

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Abstract: A 6 x 6 diallel cross experiment was carried out on *Gossypium hirsutum* L. to study the expression of heterosis over mid and better parent for fibre quality traits. Out of thirty hybrids, positive heterotic and heterobeltiotic values were recorded in 16 and 11 hybrids for lint %, 21 and 14 in fibre strength, 19 and 13 in staple length, 16 and 21 in fibre micronaire (negative heterosis), respectively. The significant heterosis and heterobeltiosis were performed by 1 and 2 hybrids in lint percentage, 10 and 5 in fibre strength, 5 and 3 for staple length and 10 and 5 in fibre micronaire (negative heterosis), respectively.

Key words: Heterosis, cotton, fibre quality traits

Introduction

Cotton (*Gossypium hirsutum* L.) plays a vital role in the economy of Pakistan. Pakistan stands fourth in world cotton production. In Pakistan 10% (2.983 m) of cultivated land is used for cotton crop. During 2000 – 2001, 10800 thousand bales were produced .

The climate and area of D.I.Khan is very suitable for cotton cultivation and there is a developing trend towards the raising of this crop. If cotton cultivation is started in this underdeveloped area, it will improve the living standard of the people of this area. Pakistan being one of the major cotton producer and exporter, there is a need to increase cotton yield and fibre quality consciousness among the growers, exporters and spinners to improve cotton standards and its gradation to compete in the international market to earn more foreign exchange.

Heterosis is a basic tool for the improvement of crops in the form of F1 hybrid seed production. It is necessary to have a detailed information about the desirable parental combination in any breeding programme, which can reflect a high degree of heterotic response. Therefore, the heterotic studies can provide the basis for the exploitation of valuable hybrid combinations in the future breeding programme.

Hybrid cotton is an optimistic approach for significant improvement in genetic potential for yield and fibre quality traits. All the cotton producing countries are conscious to increase yield through commercial cultivation of hybrid generations but up till now India and China are the leading countries having significant acreage under hybrid cotton (Krishnaswami and Kothandaraman, 1997; Chaudhry, 1991; Salam, 1991; Somro *et al.*, 1991).

The interspecific hybrids between *G. hirsutum* and *G. barbadensc* have longer and fine fibres than their *G. barbadense* (Davis, 1979). Significant heterosis for staple length was reported by Syiam *et al.* (1982) both in inter-specific and intra-specific crosses. A variable magnitude of positive and significant heterosis for staple length and lint % was reported by Ali and Khan (1983), Aslam and Khan (1983), Gupta and Singh (1987), Hussain *et al.* (1990), Rahman *et al.* (1993) and Khan *et al.* (1996).

Keeping in mind the economic importance of the use of heterosis for quality traits and its impact upon the future cotton production, a study was carried out to evaluate the manifestation of heterosis and heterobeltiosis for quality traits in F1 hybrids in a 6 parent diallel cross experiment at Faculty of Agriculture, Gomal University, D.I.Khan during 1997 – 98.

Materials and Methods

During the year 1997, Six cultivars of cotton namely CIM–443, CIM–435, CIM–1100, FH–634, Vihari–53 and MNH–93 were planted on 27 May by dibbling method on well prepared seed bed and were crossed in a complete diallel fashion. Thus 30 F1 hybrids were obtained.

During the year 1998, all these 30 F1 hybrids alongwith their six parental cultivars were planted in randomized complete block design at faculty of Agriculture. Each hybrid was planted in a single row spaced at 75cm, and plant to plant spaced at 30cm. All the recommended cultural practices like weeding, hoeing, Fertilizer application and irrigation were done properly at the required time. Ten plants (except two border plants) were selected from each row of F1 hybrid from each replication and their cotton samples were subjected to ginning. After ginning the lint samples were taken to Fibre Technology Laboratory of Pakistan Central Cotton Committee at Central Cotton Research Institute (CCRI), Multan for measuring fibre quality traits by computerized machine HVI USTER 900A. The fibre quality traits measured were staple length (mm), micronaire (μg inch^{-1}) fibre strength (g tex^{-1}). Lint percentage for each sample of each hybrid was calculated at the home station. The data were subjected to ANOVA as outlined by Steel and Torrie (1980). The heterosis and heterobeltiosis were estimated as percent increase (+) or decrease (–) over mid and better parents, respectively, for all the quality traits by adopting the following equation:

Heterosis (Het%) = (F1 – MP) / MP x 100 (Fehr, 1987)
Heterobeltiosis (Hbt%) = (F1 – BP) / BP x 100 (Fonseca, 1965)

The positive heterotic values were tested for significance to establish the differences of F1 hybrid means from their respective mid and better parents by applying "t" test with the method reported by Wynne *et al.* (1970).

Results and Discussion

Significant differences were noted among the hybrids regarding lint percentage, while the differences among the hybrids regarding fibre length, fibre micronaire and fibre strength were highly significant (Table 1). When the F1 hybrid means were compared with their parental means (Table 2), the crosses were found to be having higher values generally and in some cases they surpassed their better parents revealing positive heterosis and heterobeltiosis for fibre quality traits i.e. lint percentage, staple length (mm), fibre strength (g tex^{-1}) and micronaire (μg inch^{-1}) (Table 3).

Table 1: The analysis of variance for various quality traits in 6 X 6 diallel cross in cotton

Source of variation	D.f	Lint%	Fibre length	Micronaire	Fibre strength
Genotypes	35	6.539	1.881	0.301	6.692
Error	70	4.389	0.598	0.077	0.842
F.ratio	-	4.489*	3.145**	3.901**	7.943**

*,** = $P < 0.05$ and 0.01 respectively

Lint percentage: The maximum lint percent (Table 3) was recorded in the hybrid MNH-93 x CIM-1100 (36.09) and CIM 435 x VH-53 (36.02) (Table 3). Sixteen out of thirty hybrids surpassed their mid parents and eleven out of thirty hybrids showed increased heterosis over better parents (Table 2). The degree of increased heterosis ranged from 0.92% in case of CIM 435 x VH-53 to 9.16% in case of CIM443 x FH634 in mid parent, while in case of better parent it ranged from 0.58% (CIM435 x VH-53) to 8.77% (FH634 x CIM443).

Table 2: Heterosis and heterobeltiosis estimates of 30 F_1 hybrids for fibre quality traits of 1998 6 X 6 diallel cross

	Fibre strength		Fibre length		Fibre fineness		Lint %	
F_1 hybrids	Heterosis	Heterobeltiosis	MP%	BP%	MP%	BP%	MP%	BP%
CIM-443XVH-53	-3.068	-7.401	*3.69	*3.58	0.195	-1.92	2.317	-1.368
CIM-443XFH-634	-1.940	-10.05	-0.22	-1.17	4.971	-0.0	*9.160	*7.912
CIM-443XCIM435	3.686	-3.05	-1.500	-3.40	8.465	1.990	-3.363	-6.550
CIM-443XMNH-93	**11.528	**11.38	1.90	1.87	-9.264	-9.95	3.919	3.700
CIM-443XCIM1100	3.301	-2.558	1.18	0.219	2.348	-1.99	3.124	1.515
VH-53XFH-634	4.130	0.314	0.148	-0.915	-12.73	-18.2	-4.745	-9.187
VH-53XCIM-435	*6.175	**4.366	1.648	-0.430	3.387	-4.32	-5.015	-5.333
VH-53XMNH-93	**8.076	2.824	1.56	1.418	1.576	-0.96	-2.089	-5.808
VH-53XCIM-1100	1.596	0.801	2.97	1.879	5.612	-0.48	-0.484	-2.569
FH-634XCIM-435	3.507	1.381	2.68	1.614	5.357	3.84	-0.293	-4.638
FH-634XMNH-93	*7.289	-1.464	-1.146	-2.08	-8.421	-12.1	-4.056	-4.954
FH-634XCIM1100	3.150	0.125	0.952	0.952	-5.908	-6.52	4.776	1.981
CIM-435XMNH-93	1.259	-5.24	-3.695	-5.561	-2.777	-8.08	-0.203	-3.682
CIM-435XCIM1100	-2.116	-3.056	-2.610	-3.623	0.886	-1.08	-6.210	-7.871
MNH-93XCIM1100	-0.094	-5.651	3.088	2.087	3.144	-0.60	7.091	5.187
VH-53XCIM-443	**9.276	3.842	-2.242	-2.380	-9.001	-10.5	3.505	-0.223
FH-634XCIM-443	3.972	-4.608	0.048	-0.904	3.974	-1.09	7.516	*8.774
CIM-435XCIM443	-1.869	-8.296	-3.585	-5.45	5.932	-0.43	2.558	-0.815
MNH-93XCIM-443	4.511	4.406	-3.55	-3.55	1.405	0.49	5.215	4.993
CIM1100XCIM443	1.981	-3.782	0.721	-0.238	1.247	-3.08	3.464	1.836
FH-634XVH-53	**10.54	**6.514	*3.760	*3.509	-5.544	-11.5	-4.833	-9.271
CIM-435XVH-53	**6.942	**5.131	-1.838	-3.874	-1.247	-8.65	0.924	0.586
MNH-93XVH-53	*6.650	1.486	0.130	-0.011	-4.339	-6.73	-0.870	-4.635
CIM-1100XVH-53	*5.829	**5.005	*4.62	*3.509	-5.102	-10.5	1.711	-0.418
CIM-435XFH-634	-1.967	-3.979	-1.910	-2.953	10.491	8.79	5.349	0.759
MNH-93XFH-634	**9.707	0.732	0.036	-0.951	-6.315	-10.1	6.922	5.921
CIM-1100XFH634	-2.891	-5.759	0.714	0.714	-2.625	-3.26	2.695	-0.058
MNH-93XCIM-435	-1.306	-7.641	-5.433	-7.292	-0.213	-5.65	-2.621	-6.016
CIM1100XCIM435	-4.100	-5.021	*4.289	3.174	4.212	2.17	-3.262	-4.976
CIM1100XMNH-93	-0.094	-5.651	*3.801	2.813	-7.756*	-11.1	-6.261	-7.927

MP: Mid parent heterosis percent   BP: Better parent heterosis percent   *,**: $P < 0.05$ and 0.01 respectively

Table 3: Mean performance of 30 F_1 hybrids and their six parents for fibre quality traits of cotton in a 6 x 6 diallel cross fiber micronaire

F_1 hybirds	Fiber micronaire	Lint %	Fibre length	Fibre strength
CIM-443XVH-53	5.10	35.32	27.75	20.37
CIM-443XFH-634	5.02	35.87	26.98	21.47
CIM-443XCIM435	5.12	33.24	26.92	22.20
CIM-443XMNH-93	4.52	34.47	27.30	22.25
CIM-443XCIM1100	4.92	34.83	27.36	21.90
VH-53XFH-634	4.25	32.52	27.05	23.95
VH-53XCIM-435	4.97	33.90	27.75	23.95
VH-53XMNH-93	5.15	33.73	27.17	22.75
VH-53XCIM-1100	5.17	34.89	27.81	22.65
FH-634XCIM-435	4.72	33.92	28.32	24.20
FH-634XMNH-93	4.35	31.46	26.73	23.52
FH-634XCIM1100	4.30	34.99	27.56	22.90
CIM-435XMNH-93	4.55	34.26	26.35	21.70
CIM-435XCIM1100	4.55	32.7	26.86	22.20
MNH-93XCIM1100	4.92	36.09	27.87	21.20
VH-53XCIM-443	4.65	35.73	26.16	22.97
FH-634XCIM-443	4.97	35.33	27.05	22.77
CIM-435XCIM443	5.00	35.28	26.35	21.00
MNH-93XCIM-443	5.05	34.90	25.84	25.84
CIM1100XCIM443	4.87	34.94	27.23	21.62
FH-634XVH-53	4.60	32.49	28.25	25.42
CIM-435XVH-53	4.75	36.02	26.79	24.07
MNH-93XVH-53	4.85	34.15	26.79	22.45
CIM-1100XVH-53	4.65	35.66	28.25	23.60
CIM-435XFH-634	4.95	353.84	27.05	22.92
MNH-93XFH-634	4.45	35.06	27.05	24.05
CIM-1100XFH634	4.45	4.29	27.49	22.50
MNH-93XCIM-435	4.67	33.43	25.84	21.15
CIM1100XCIM435	4.70	33.80	28.76	21.75
CIM1100XMNH-93	4.40	31.59	28.06	21.20
CIM 443	5.02	33.24	26.79	19.92
VIHARI-53	5.20	35.81	26.73	22.12
FH 634	4.55	32.48	27.30	23.87
CIM 435	4.42	35.57	27.87	22.90
MNH-93	4.95	33.10	26.79	19.97
CIM1100	4.60	34.31	27.30	22.47

The minimum values of lint percentage were recorded in the hybrids FH634 x MNH-93 (31.46%) and CIM1100 x MNH-93 (31.9%) while in parents, FH634 was the lowest (32.48) and Vihari-53 was the highest (35.81) in lint percentage (Table 3). One hybrid (CIM 443 x FH634) showed significant heterosis ($P < 0.05$) (9.16%) in mid parent while two crosses showed significant heterobeltiosis ($P < 0.05$) (Table 2), (CIM443 x FH634 and FH634 x CIM443), which means that CIM 443 increased lint% both as a male parent and as a female parent in combinations with FH634. These findings are in close conformity with those of Aslam and Khan (1983), Khan (1986), Somro *et al*. (1991) and Rahman *et al*. (1993).

Fibre strength (g/tex): A maximum increase of 11.52 and 11.38% was noted in fibre strength by the hybrid CIM 443 x MNH-93 both in mid parent as well as in better parent heterosis followed by FH634 x VH53 (10.54 and 6.51), CIM 1100 x VH-53 (5.82 and 5.00) (Table 2). CIM 1100 x FH634 was noted to be the highest scorer in Fibre strength by producing (25.42 g/tex) fibre (Table 3). 21 F1 hybrids produced positive heterosis over mid parent (Table 2) and the increase ranged from 1.56. (VH-53 x CIM1100) to 11.52% (CIM443 x MNH-93), while 14 hybrids were superior over better parent and their heterobeltiosis range was from 0.12% (FH634 x CIM 1100) to 11.38% (CIM443 x MNH-93) (Table 2). Six hybrids out of thirty manifested highly significant heterosis while five hybrids exhibited highly significant heterobeltiosis. Four hybrids were significant in heterosis in case of mid parent heterosis. These results are in close analogy with the findings of Syciam *et al*. (1982) who reported partial dominance in interspecific and complete dominance in intraspecific crosses for fibre strength. Davis (1979) noted equality in fibre strength in inter-specific crosses.

Fiber length: The maximum fiber length (28.76 mm) was manifested by the hybrid CIM1100 x CIM435 (Table 3). CIM 1100 (27.30 mm) and its crosses with MNH-93 (28.06 mm) as a female parent and (27.87 mm) as a male parent. Also its combination with

Vihari-53 produced (28.25 mm) as a reciprocal cross and 27.81 mm as a direct cross. (CIM 435 (27.87mm) also contributed great in combination with FH634 (28.32 mm).

The range of positive heterosis and heterobeltiosis was from 0.048 (FH634 x CIM443) to 4.62% (CIM1100 x VH-53) in mid parent and from 0.71% (CIM1100 x FH634) to 3.58% (CIM 443 x VH-53) in better parent respectively (Table 2).

19 hybrids out of 30 surpassed their mid parent, while 13 hybrids proved increased vigor over better parent.

The maximum and significant heterosis of 3.69 to 4.62% was attained by five crosses in mid parent and 3.50 to 3.58% was manifested by three crosses in better parent (Table 2).

These findings are confirmed by the work of Ali and Khan (1983), Khan *et al.* (1984), Khan (1986), Hussain *et al.* (1990) and Rahman *et al.* (1993), who reported varying levels of heterosis for fiber length. Khan *et al.* (1996) obtained long fibre in cross combination of HG2 with M11.

Fibre micronaire: FH634 (4.55) and CIM 1100 (4.60) produced low micronaire values ranging from 4.30 to 4.45 in combination with other varieties as maternal and paternal parents (Table 3). The highest micronaire reading were recorded in hybrids VH-53 x CIM 1100 (5.17 μg inch^{-1}), CIM 443 x CIM435 (5.12 μg inch^{-1}), VH-53 x MNH-93 (5.15 μg inch^{-1}) and cultivar Vihari-53 (5.20 μg inch^{-1}) (Table 3).

Six crosses of FH 634 and CIM 443 with other cultivars exhibited negative heterosis ranging from 6.31 to 12.73% in mid parent and combinations of these cultivars showed negative heterosis ranging from 6.52 to 18.2% in better parent which seems encouraging (Table 2).

Four hybrids showed highly significant decrease over mid parent while seven hybrids showed highly significant negative heterosis over better parent (Table 2).

These results are supported by Davis (1978, 1979) and Syiam *et al.* (1982) as they observed fibre finess in intra-hirsutum and intra-barbadanse hybrids but a varying level of heterosis was reported in inter-specific crosses (*G. hirsutum* x *G. banbadense*).

It is concluded from the present study that in cotton there is a greater scope of exploiting hybrid vigor and the present cotton varieties can be upgraded to more promising varieties with long, strong and fine fibre.

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