Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

ANSInet
an open access publisher
http://ansinet.com

Asian Journal of Plant Sciences
Volume 1 Number 4: 432-435, 2002

Heterosis Studies for Yield and its Components in Various Crosses of Cotton (*Gossypium hirsutum* L.)

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Abstract: An 8-parent diallel cross experiment was conducted on *Gossypium hirsutum* L. to estimate the manifestation of heterosis and heterobeltiosis for yield and its components viz; No. bolls of /plant, seed cotton yield/plant, seeds/boll and staple length. Out of fifty six F_1 hybrids, 51 hybrids showed positive heterosis in case of bolls/plant, 47 in yield of seed cotton/plant, 47 in No. of seeds/boll and 48 in Staple length. Heterobeltiotic values were recorded 55 in bolls/plant, 31 for yield of seed cotton, 32 for No. of seeds/boll and 43 for staple length as positive values.

Key words: Hybrid vigour, heterobeltiosis, varieties, *Gossypium hirsutum*, crop yield, yield components

Inroduction

Agriculture is considered to be the back bone of the economy of Pakistan but it will not be an exaggeration to say that cotton is the back bone of our agriculture and ultimately of our economy. This is for the reasons that cotton provides fiber, food and fuel apart from employing millions of people right from its sowing and harvesting in fields to the processing in the ever expanding textile industry of the country. It is the biggest cash crop of Pakistan for it earns 55% of foreign exchange through its export as raw material and finished products.

Due to its importance, plant breeders have been working for improving its yield and quality. Consequently, they achieved a great success in this respect through the evolution of varieties having high yield and better qualities. Hybrid vigour or heterosis is the converse of inbreeding that deteriorates the vigour. The beneficial effect of crossing is a widely recognized phenomenon than inbreeding depression because it is observed in all F_1 hybrids. The exploitation of heterosis has increased the production of cotton in India (Krishnaswami and Kothandaraman (1977), Al-Raw and Kohel (1969), Krishnaswami and Kothandarman (1977) and Khan *et al*. (1984) reported heterosis for number of bolls and yield of seed cotton per plant. Aslam and Khan (1983) and Khan *et al.* (1985) reported a high degree of heterosis for the yield of seed cotton per plant. Malek *et al.* (1988) and Nadre *et al.* (1984) inferred that F1 hybrids showed heterosis for yield of seed cotton.

In this study magnitude of heterosis and heterobeltiosis was worked out as the percent increase (+) or decrease (-) over the respective mid and better parental values.

Materials and Methods

Eight cultivars of cotton, viz; CIM-443, MNH-93, CIM-448, NIAB-78, SLS-1, CIM-446, FH-634 and CIM-1100 were sown during May 1997 by dibbing on a well prepared seed bed and were crossed in a complete diallel fashion. The seed thus obtained was subsequently planted during May 1998 comprising 56 F_1 hybrids and 8 parents Randomised Complete Block Design (RCBD) at the Faculty of Agriculture, Gomal University, D. I. Khan. Each genotype was planted in a single row measuring 3.30 m long with 30 cm plant to plant distance, while row to row distance was kept 75 cms. All the inputs and recommended cultural practices like fertilizer, irrigation, weed management and insecticides application etc. were performed at the recommended level, while maintaining a constancy among all the treatments.

All the central ten plants, leaving border two plants in a row per treatment per replication were selected for taking other data and seed cotton samples, separately. After ginning with single roller electric gin, the samples were studied for different quality traits. All the traits were studied on a single sample basis for each genotype. After taking the mean of all plants, the replication wise data for the individual traits were Subsequently subjected to ANOVA as outlined by Steel and Torrie (1980) and the significant means were separated by Duncan's Multiple Range (DMR) test using MSTATC computer programme. The heterosis and heterobeltioisis were estimated as percent increase or decrease over mid and better parents, respectively for all the quality traits.

Heterosis (Het.%) = {F_1- Mid parent / Mid parent} x 100

Heterobeltiosis (Hbt.%) = {F_1- Better parent / Better parent } x 100

The positive heterosis values were also tested for significance to establish the difference of F1 hybrids means from their respective mid and better parents by applying t test with the following formula as quoted by Wynne *et al.* (1970).

$$t = F1\ ij - MP\ ij \ / \ / \ 3/8\ EMS$$

Results and Discussion

The differences among F_1 hybrids and their parents were highly significant for the characters no. of bolls plant $^{-1}$, seed cotton plant $^{-1}$, on. of seeds boll $^{-1}$ and staple length (Table1).

No. of bolls plant $^{-1}$: Bolls plant $^{-1}$, out of 56 F_1 hybrids, 51 crosses manifested positive heterosis over mid parent, while the degree of increase ranged (Table 3). from +0.52% (SLS-1X CIM-443) to +20.11% (CIM-1100XMNH-93). Eleven crosses were having negative values for better parent, the degree of increase regarding hetrobeltiosis ranged from + 0.12% (NIAB-78 X CIM-443) to + 15.96% (NIAB-78 X MNH-93).

Regarding the mean performance, in case of bolls/plant, maximum bolls/plant (64.85) were produced by hybrid CIM-1100 X MNH-93, while the lowest bolls were given by cross CIM-448 X CIM-1100 (28.68). Among parents CIM-443 was lowest in value with 25.34 bolls while CIM-1100 was the highest with 40.52 bolls/plant.

Table1: Mean squares and degree of freedom from the analysis of variance for the following traits in an 8x8 diallel cross

	Mean Squares		
Parameters	Genotype	Error	F.Ratio
No. of bolls plant^{-1}	277.95	13.77	20.19**
Seed cotton/plant^{-1}	1440.39	56.28	25.59**
Seeds boll^{-1}	17.00	04.80	03.54**
Staple length (mm)	5.79	00.58	10.05**

Significant at 1% level of probability

Table 2: Mean performance of eight parents and 56 F_1 Hybrids for bolls plant $^{-1}$, seed cotton yield plant $^{-1}$, seeds boll $^{-1}$ and staple length

F_1	Hybrids/	Parents	No. of bolls plant $^{-1}$	Seed cotton yield plant $^{-1}$	No. of Seeds boll^{-1}	Staple length (mm)
CIM – 443	X	MNH - 93	36.20p-v	70.72yz	22.68c-n	27.32n-u
CIM – 443	X	CIM - 448	37.85o-u	88.12rv	23.45c-n	27.08n-u
CIM – 443	X	NIAB - 78	46.12l-l	105.26kn	23.70c-m	25.14uv
CIM – 443	X	SLS - 1	35.58v-x	78.12uy	22.48f-q	26.24t-v
CIM – 443	X	CIM - 446	41.21l-o	72.99x-z	23.75c-n	28.20e-l
CIM – 443	X	FH - 634	45.25l-l	91.46s	20.14n-t	26.55p-u
CIM – 443	X	CIM-1100	47.62h-j	95.70n-q	20.08h-r	30.08a-d
MNH – 93	X	CIM - 448	36.18q-v	78.54v-y	24.56b-h	27.25k-q
MNH – 93	X	NIAB - 78	43.60k-n	87.33qs	22.44d-o	29.12c-h
MNH – 93	X	SLS - 1	48.20g-l	65.88z	25.36ab	25.34r-v
MNH – 93	X	CIM - 446	38.00o-s	77.80v-y	24.46b-h	28.10h-n
MNH – 93	X	FH - 634	40.52m-n	102.40n-q	18.55s-u	25.52n-t
MNH – 93	X	CIM-1100	49.33gh	108.67jk	21.82b-k	29.33b-f
MNH – 93	X	CIM - 443	60.12ab	120.30g-i	22.24l-s	28.16c-l
CIM – 448	X	NIAB - 78	35.68p-v	84.33s-w	22.88m-s	27.34l-q
CIM – 448	X	SLS - 1	40.22m-o	86.34r-u	20.26n-s	28.45e-l
CIM – 448	X	CIM – 446	52.34e-g	60.20z	20.18n-t	27.44d-j
CIM – 448	X	FH – 634	29.20yz	74.25t-x	22.20g-q	27.34j-p
CIM – 448	X	CIM–1100	28.68yz	75.56w-z	25.16b-h	26.55r-v
CIM – 448	X	CIM – 443	32.18w-y	100.45k-m	24.16b-k	29.20ab
CIM – 448	X	MNH - 93	48.28g-l	125.78c-e	23.72c-n	30.00ab
NIAB – 78	X	SLS – 1	38.54o-r	86.45r-t	21.50l-s	25.52v
NIAB – 78	X	CIM – 446	48.33hi	102.30l-m	23.88c-n	26.44o-u
NIAB – 78	X	FH – 634	56.48cd	80.69t-w	19.35p-u	27.88d-k
NIAB – 78	X	CIM–1100	50.62f-h	64.41z	22.86e-p	26.30p-u
NIAB – 78	X	CIM - 443	50.20f-h	81.22v-x	25.12b-h	24.15w
NIAB – 78	X	MNH - 93	38.68o-r	68.12z	24.16b-l	30.10ab
NIAB – 78	X	CIM - 448	60.61ab	126.43g-l	28.14a	8.56c-l
SLS - 1	X	CIM – 446	32.58w-y	71.60v-y	20.26n-s	27.14l-o
SLS - 1	X	FH – 634	34.58u-x	76.65u-y	22.58f-q	27.48m-t
SLS - 1	X	CIM–1100	32.98v-x	81.72t-w	22.62f-q	27.34q-v
SLS - 1	X	CIM - 443	47.54h-j	79.61u-x	22.54f-q	26.58m-s
SLS - 1	X	MNH - 93	36.30q-v	64.34z	19.14q-u	28.64d-j
SLS - 1	X	CIM - 448	40.82m-o	83.46u-y	20.88l-s	28.95a-e
SLS - 1	X	NIAB -78	60.30ab	18.36ij	20.52m-s	28.14f-l
CIM – 446	X	FH – 634	39.00n-q	76.59w-z	24.24b-l	26.90j-p
CIM – 446	X	CIM–1100	46.27h-k	105.36m-o	21.18k-s	25.30uv
CIM – 446	X	CIM – 443	30.52x-z	82.63u-y	24.48b-k	25.46s-u
CIM – 446	X	MNH – 93	46.54h-j	103.33l-n	25.32b-h	26.33l-o
CIM – 446	X	CIM – 448	38.12o-r	70.54z	21.80l-s	27.62j-p
CIM – 446	X	NIAB – 78	33.30v-x	90.58o-r	24.16b-l	28.62c-g
CIM – 446	X	SLS - 1	155.28c-e	102.96n-q	26.35a-d	30.42a
FH – 634	X	CIM–1100	52.40e-g	90.12o-r	23.44c-n	27.16j-p
FH – 634	X	CIM - 443	36.66p-v	98.30n-q	23.34c-n	30.05ab
FH – 634	X	MNH - 93	39.36n-q	96.80m-p	22.68e-p	28.16c-l
FH – 634	X	CIM - 448	38.30o-s	85.42r-t	24.28b-k	28.88e-l
FH – 634	X	NIAB - 78	43.62k-n	77.45v-z	17.22c-h	28.98a-e
FH – 634	X	SLS - 1	37.58o-t	68.64z	23.14d-n	27.48j-p
FH – 634	X	CIM - 446	57.14cd	124.56e-h	25.15b-h	27.54e-l
CIM-1100	X	CIM - 443	42.20l-o	115.62h-l	25.54b-g	28.08c-l
CIM-1100	X	MNH - 93	64.85a	122.33f-l	25.46b-g	29.28c-g
CIM-1100	X	CIM - 448	50.22f-k	110.20kl	24.62b-k	28.22e-l
CIM-1100	X	NIAB - 78	60.30ab	142.56a	26.24a-d	29.15a-c
CIM-1100	X	SLS - 1	55.68c-e	115.62jk	22.58h-q	27.63g-m
CIM-1100	X	CIM – 446	40.56m-o	94.10p-s	25.90b-h	28.10g-m
CIM-1100	X	FH – 634	52.06e-g	97.64m-p	26.14a-c	29.46a-f
CIM – 443			25.34z	98.15m-q	20.10k-s	27.88h-n
MNH - 93			35.22t-w	133.26bc	21.84s-u	26.24o-u
CIM – 448			24.32z	114.45k-l	22.85e-p	27.00m-r
NIAB – 78			37.54o-t	136.28cd	19.54p-u	26.13p-v
SLS - 1			30.24x-z	127.33d-g	17.18t-u	25.22p-u
CIM – 446			30.58x-z	129.48d-f	19.16q-u	24.66b-f
FH – 634			36.88o-v	120.68f-l	18.22s-u	27.36d-j
CIM-1100			40.52f-h	138.73g-l	20.78l-s	26.38n-u

Means sharing the same letter do not differ statistically from each other at 1% level of probability

Table 3: Estimates of heterosis and heterobeltiosis for no. of bolls plant^{-1}, seed cotton yield/ plant^{-1}, seeds boll^{-1} and staple length in a 8x8 diallel cross of cotton

		Bolls plant^{-1}		Seed cotton yield plant^{-1}		Seds boll^{-1}		Staple length	
Genotyps		Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
CIM – 443	X MNH - 93	4.06*	3.55**	0.55	-0.38	0.55	-0.38	4.34*	0.25
CIM – 443	X CIM - 448	8.52*	11.19**	10.67**	3.50**	10.67*	3.50**	4.80*	1.60**
CIM – 443	X NIAB - 78	6.00*	3.65**	17.60**	10.07**	17.60*	10.07**	1.68*	1.08
CIM – 443	X SLS - 1	7.58*	8.22**	9.93**	-0.75*	9.93*	-0.75	4.71*	3.25**
CIM – 443	X CIM- 446	10.22*	10.15**	-3.41	-8.25	-3.41	-8.25	8.41*	5.53**
CIM – 443	X F H – 634	15.82*	13.18**	15.57**	15.81**	15.57*	15.81**	0.84	-2.95
CIM – 443	X CIM-1100	5.02*	-2.51	7.74**	-8.46	7.74*	-8.46	6.95*	1.83**
MNH – 93	X CIM - 448	4.74*	1.55**	8.36**	0.26	8.36*	0.26	5.64*	4.75**
MNH – 93	X NIAB - 78	6.32*	4.48**	-0.67	-7.28	-0.67	-7.28	4.94*	1.45
MNH – 93	X SLS - 1	6.52*	7.66**	9.36**	-2.25	9.36*	-2.25	3.23*	0.60
MNH – 93	X CIM - 446	7.15*	6.71**	14.48**	8.71**	14.48*	8.71**	-8.25	-9.45
MNH – 93	X F H – 634	12.87*	10.74**	19.97**	21.14**	19.97*	21.14**	3.38*	3.08**
MNH – 93	X CIM-1100	13.58*	6.55**	27.08**	11.80**	27.08*	11.80**	1.11	0.08
MNH – 93	X CIM - 443	1.74*	1.23	-2.03	-2.96	-2.03	-2.96	4.64*	0.55
CIM – 448	X NIAB - 78	4.85*	-0.18	-12.87	-27.57	-12.87	-27.57	4.43*	0.31
CIM – 448	X SLS – 1	3.45*	1.41	8.53**	5.01**	8.53*	5.01**	2.71*	0.98
CIM – 448	X CIM – 446	-0.14	-2.88	0.82	3.14**	0.82	3.14**	1.69*	1.38
CIM – 448	X F H – 634	9.21*	3.89**	19.56**	12.64**	19.56*	12.64**	1.34	0.75
CIM – 448	X CIM–1100	11.98*	1.77**	30.59**	7.22**	30.59*	7.22**	4.05*	2.13**
CIM – 448	X CIM - 443	5.69*	3.02**	6.38**	-0.79*	6.38*	-0.79	4.08*	0.88
CIM – 448	X MNH - 93	9.05*	5.86**	5.21**	-2.88*	5.21*	-2.88	1.31	0.42
NIAB – 78	X SLS – 1	7.02*	4.03**	-12.27	-30.48	-12.27	-30.48	5.84*	4.98**
NIAB – 78	X CIM – 446	14.91*	12.62**	5.30**	-7.07*	5.30*	-7.07	0.76	-1.53
NIAB – 78	X F H – 634	-0.38	-0.10	-10.95	-18.72	-10.95	-18.72	7.09*	3.90**
NIAB – 78	X CIM–1100	15.28*	10.11**	17.52**	8.85**	17.52*	8.85**	4.25*	-0.27
NIAB – 78	X CIM - 443	2.48*	0.12	13.24**	5.71**	13.24*	5.71**	2.48*	1.88**
NIAB – 78	X MNH - 93	14.12*	15.96**	4.93**	-1.67*	4.93*	-1.67	1.86*	-1.63
NIAB – 78	X CIM - 448	9.02*	3.98**	-8.58	-23.28	-8.58	-23.28	5.58*	2.98**
SLS - 1	X CIM – 446	3.97*	4.66**	4.41**	-1.43*	4.41*	-1.43	-2.33	-3.75
SLS - 1	X F H – 634	8.08*	4.82**	7.23**	-3.20*	7.23*	-3.20	3.90*	1.58**
SLS - 1	X CIM–1100	19.30*	11.14**	30.00**	3.12**	30.00*	3.12**	5.36*	1.70**
SLS - 1	X CIM - 443	0.52	-0.11	5.29**	-5.39	5.29*	-5.39	6.46*	7.93**
SLS - 1	X MNH - 93	3.94*	2.80**	7.30**	-4.31	7.30*	-4.31	1.83*	-0.80
SLS - 1	X CIM - 448	5.02*	7.06**	11.31**	7.80**	11.31*	7.80**	4.09*	2.35**
SLS - 1	X NIAB - 78	10.02*	7.03**	-6.56	-24.77	-6.56	-24.77	5.79*	6.65**
CIM – 446	X F H -634	-1.24	-3.82	9.97**	13.38**	19.97*	15.38**	7.00*	6.10**
CIM – 446	X CIM-1100	10.85*	3.38**	32.66**	11.62**	32.66*	11.62**	4.69*	2.45**
CIM – 446	X CIM - 443	6.82*	6.75**	0.86	-3.98	0.86	-3.98	5.01*	2.13**
CIM – 446	X MNH - 93	0.22*	9.77**	17.42**	11.65**	17.42*	11.65**	-7.10	-8.30
CIM – 446	X CIM - 448	0.98	3.72**	5.12**	7.45**	5.12*	7.45**	-9.41	-9.73
CIM – 446	X NIAB - 78	5.57*	3.28**	13.80**	1.43	13.80*	1.43	6.89*	9.18**
CIM – 446	X SLS - 1	9.69*	10.38**	13.10**	18.94**	13.10*	18.94**	3.13*	1.70**
FH – 634	X CIM-1100	9.83*	4.94**	10.66**	-5.79	10.66*	-5.79	3.86*	5.20**
FH – 634	X CIM - 443	12.95*	10.31**	12.59**	12.84**	12.59*	12.84**	-3.01	-6.80
FH – 634	X MNH - 93	9.47*	7.34**	14.39**	15.57**	14.39*	15.57**	2.33*	2.63**
FH – 634	X CIM - 448	8.16*	2.85**	15.32**	8.40**	15.32*	8.40**	3.74*	3.15**
FH – 634	X NIAB - 78	3.18*	3.46**	-8.05	-0.28	-8.05	-0.28	8.61*	5.43**
FH – 634	X SLS - 1	13.47*	10.20**	11.68**	1.25*	11.68*	1.25	4.93*	2.60**
FH – 634	X CIM - 446	2.24*	-0.34	7.20**	2.60**	7.20*	2.60**	1.85*	0.95
CIM-1100	X CIM - 443	-1.42	-8.95	6.02**	-10.18	6.02*	-10.18	3.05*	-2.08
CIM-1100	X MNH - 93	20.11*	13.08**	18.12**	2.85**	18.12*	2.85**	-0.44	-1.48
CIM-1100	X CIM - 448	9.21*	-1.00	26.29**	2.92**	26.29*	2.92**	2.90*	0.98
CIM-1100	X NIAB - 78	11.62*	6.45**	24.89**	16.22**	24.89*	16.22**	-8.85	-13.38
CIM-1100	X SLS - 1	3.88*	-4.28	28.34**	1.46*	28.34*	1.46	3.94*	0.28
CIM-1100	X CIM - 446	-1.56	-9.03	29.90**	8.86**	29.90*	8.86**	-6.81	-9.05
CIM-1100	X F H - 634	6.94*	2.05**	13.63**	-2.82*	13.63*	-2.82	5.11*	3.78**

*Significant at $P < 0.05$ Het % = Heterosis (over mid parent); **Significant at $P < 0.01$ Hbt. % = Heterobeltiosis (over better parent)

The results are in compromise with the findings of Turner (1953), Krishnaswami and Kothandaraman (1977) and Khan and Ali (1980).

Seed cotton yield plant^{-1}: Performance of 47, F_1 hybrids as compared to mid parent was positive ranging from + 0.55 % (CIM-443XMNH-93) to +32.66% (CIM-446XCIM-1100) (Table 3). The 31 F_1 hybrids, dominated the better parent, the degree of dominance ranged from +0.26% (MNH-93X CIM-448) to +21.14% (MNH-93 X FH-634). For mean performance regarding this character, cross combination of CIM-1100 with NIAB-78 exhibited maximum seed cotton yield/plant (142.56g), while the lowest seed cotton yield of 60.20g is given by hybrid of CIM-448 X FH-634. Parent CIM-443 is lowest in value with 98.15g and CIM-1100 is highest in yield with 138.72g.

These results conform the findings of Karishnaswami and Kothandaraman (1977), Ali and Khan (1980) and Khan *et al.* (1984).

No. of seeds boll $^{-1}$: In case of Seeds boll $^{-1}$, range of heterosis and heterobeltiosis was noted from +0.55 (CIM-443 X MNH-93) to + 32.66% (CIM-446 X CIM-1100) and +0.26 (MNH-93X CIM-

448) to +21.14% (MNH-93X FH-634), respectively. Majority of the F_1 hybrids have surpassed their parents (Table 2). Maximum seeds boll^{-1} were produced by hybrid NIAB-78 X CIM-448 (28.14) and 18.55 seeds boll^{-1} were produced by cross of MNH-93XFH-634 among hybrids. Minimum No. of seeds/boll was given by parent SLS-1 (17.18) and maximum seeds by CIM-448 (22.85). Abo-El-Zahab and Methwaly (1979), Hussain *et al.* (1990), Khan *et al.* (1976) and Thompson (1971) have also reported varying degree of heterosis and heterobeltiosis for number of bolls per plant.

Staple length (mm): Excepting eight crosses, rest of the hybrids gave increased values of staple length and dominated mid parent values. The frequency of increase ranged from +0.76 (NIAB-78 X CIM-446) to +8.61% (FH-634 X NIAB-78) for mid parent and from +0.08 (MNH-93 X CIM-1100) to +9.18% (CIM-446XNIAB-78) for better parent.

The data pertaining to this parameter shows (Table 2) that maximum staple length was given by the cross of CIM-446 and SLS-1 (30.42 mm) and minimum by hybrid of CIM-446 X CIM-1100 (25.30mm) respectively. Lowest staple length was given by the parent SLS-1 (25.22 mm) and highest by parent FH-634 (27.36 mm). The findings regarding heterosis for staple length are in agreement with those of Khan *et al.* (1985) and Mirza and Chaudhry (1985).

The results of this studies indicated that the cross CIM-1100 X NIAB-78, which provided maximum seed cotton yield prove that maximum dominant alleles for this character were accumulated in this cross. As for as number of bolls per plant is concerned cross CIM-1100 X MNH-93 exhibited maximum bolls per plant. It shows that cultivar CIM-1100 is a best combiner and can be used successfully for heterotic exploitation. This is concluded that consideration should be given to above combinations instead of all to minimize expenses.

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