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Assessment of Heterosis (F1) and Inbreeding Depression (F2) for Some Economic Characters in Upland Cotton

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Abstract: Twelve parents in fourteen cross combinations were studied for heterosis in F1 and inbreeding depression in F2 populations for seedcotton yield, number of bolls per plant, ginning out turn %, staple length and uniformity ratio. Seedcotton yield and number of bolls expressed fair amount of heterosis, however, hybrids showing higher magnitudes of heterosis were generally associated with higher amount of inbreeding depression suggesting dominant genes functioning for these traits. Small amount of heterosis, lower magnitude of inbreeding depression for lint percent, staple length and uniformity ratio indicated that additive genes were responsible for the expressions of these traits. Hybrid vigor recorded in F1 in respect of seedcotton yield per plant ranged from 4.5 to 159.0 percent, whereas in bolls per plant, ginning out turn, staple length and uniformity ratio the range was 0 to 150.0, -1.5 to 11.7, 0.7 to 13.0 and -2.0 to 11.1% respectively.

Key words: Inbreeding depression, heterosis, homozygosity, dominant genes, additive genes

Introduction

Crosses between inbred lines show vigor and productiveness in F1 generation (Shull, 1908), but with increasing homozygosity due to selfing, vigor and productiveness reduce by 50 percent in each generation because of inbreeding depression (Falconer, 1989). Heterosis and inbreeding depression are complementary to each other and the two phenomenons are usually observed in the same studies. Thus, the character, which shows high heterosis due to dominant allelic factors proportionally show high inbreeding depression because of fixation of allelic genes with increased homozygosity. Gunaseelan and Krishna swami (1988), Vyahalkar *et al.* (1984) and Bhatade (1984) also reported that high heterosis was generally associated with high inbreeding depression.

In polyploids like cotton, it may not hold true that complex traits show less depression than the simpler traits. Aycock and Wilsie (1968) found that in auto-tetraploid alfalfa, the yield decreased twice as much as predicted. This response according to them was attributed to a decrease in favorable interactions among multiple alleles due to inbreeding and abnormal segregation at meiosis because of higher ploidy. Gupta and Singh (1987) and Katageri *et al.* (1992) recorded 81.85, 12.2, 69.4 and 5.4% inbreeding depression for seedcotton yield, boll weight, number of bolls and staple length respectively. Present studies were therefore carried out to provide information on heterosis, type of gene action and relative inbreeding depression for simpler and more complex traits of upland cotton.

Materials and Methods

Five Punjab varieties viz., Alseemi-515, NIAB-78, BH-36, NH-26N and CIM-240, six advance strains CRIS-121, CRIS-122, CRIS-127, CRIS-5A, CRIS-52 and CRIS-54 developed by Central Cotton Research Institute, Sakrand and one exotic PD-4548 were crossed during 1993. The F1 seed from 14 cross combinations was grown in 1994 to raise F2 population and fresh crosses were also attempted to compare F1s and F2s simultaneously. In 1995, F1 and their F2 populations combined with parents were grown in a randomized complete block design with four replications. Two rows of F1s and three rows of F2s and parents were planted in each replication. Twen five plants from each replication, totaling 100 plants of ea parent, F1 and F2 were selected at random and treated index plants for recording the data. The standard analysis variance method developed by Gomez and Gomes (1984) v adopted. Hybrid vigor compared with respect to high pare was calculated for F1 and F2 hybrids as under:

$$\text{High parent heterosis for F1} = \frac{F1 - HP}{HP} \times$$

$$\text{High parent heterosis for F2} = \frac{F2 - HP}{HP} \times 1$$

Where F1 and F2 were the mean values of first and sec filial generations and HP being the high parent value for e economic trait.

The inbreeding depression in F2 population was determine percent decrease (-) of F2 against their respective F1 hyb as under: -

$$\text{Inbreeding depression} = \frac{F2 - F1}{F1} \times 1$$

The observations were recorded on number of bolls per pl seed cotton yield per plant (gm), lint percent, staple le (mm), and uniformity ratio.

Results and Discussion

The mean performance of F1 hybrids, F2 population and t parents has been depicted in Table-1. The mean squares f the analyses of variance are presented in Table 2 demonstrates significant differences among F1, F2 and parents for all the five traits under investigation. In the m performance, all the 14 F1s set more bolls, gave hi seedcotton yield, ginned better and gave longer and m uniform fibers than their respective parents, whereas maj

Table 1: Mean performance of parents, F1 and F2 hybrids for five economic traits

S. No.	Parents / hybrids	Bolls per plant	Seedcotton yield/plant (g)	GOT (%)	Staple length (mm)	Uniformityratio %
P1	PARENTS					
	Alseemi – 515	24	72.5	32.4	27.0	42.1
P2	NIAB-78	30	80.3	33.0	25.5	45.0
P3	BH-36	21	75.1	33.3	26.7	43.2
P4	CRIS-121	30	90.2	33.4	25.6	43.0
P5	CRIS-122	24	72.0	32.3	25.6	44.0
P6	CRIS-127	28	84.0	33.2	25.3	43.0
P7	NH-26 N	28	90.7	33.2	26.0	43.2
P8	CRIS-5A	21	52.5	33.1	25.5	42.5
P9	CRIS-52	23	65.1	32.0	25.0	43.1
P10	CRIS-54	24	68.3	31.1	25.5	42.0
P11	PD-4548	22	62.1	31.0	26.1	42.2
P12	CIM-240	27	92.1	33.3	26.0	44.3
	HYBRIDS					
H1	F1 = Alseemi – 515 x NIAB-78	75	267.0	33.6	30.5	44.9
	F2 – -do-	50	116.0	33.0	28.2	43.0
H2	F1 = BH-36 x CRIS-121	46	156.0	33.9	28.3	44.2
	F2 = -do-	33	113.0	33.4	27.6	43.0
H3	F1 = BH-36 x CRIS-122	36	99.8	37.2	26.7	46.3
	F2 – -do-	27	74.0	35.1	25.8	44.3
H4	F1 = CRIS-127 x CRIS-122	35	16.2	36.1	26.7	48.9
	F2 = -do-	25	82.5	34.6	25.8	46.1
H5	F1 = CRIS-127 x CRIS-5A	63	136.3	36.1	27.2	47.0
	F2 – -do-	40	99.5	34.6	26.5	44.0
H6	F1 = NH-26N x CRIS-121	68	187.4	35.7	27.0	46.3x
	F2 = -do-	36	102.6	34.5	26.6	44.4
H7	F1 = CRIS-52 x CRIS-122	33	96.4	34.1	27.9	43.1
	F2 = -do-	23	71.2	33.2	26.3	42.0
H8	F1 = CRIS-52 x CRIS-121	30	94.3	34.5	26.9	44.1
	F2 = -do-	20	62.5	33.1	25.5	43.2
H9	F1 = CRIS-54 x CRIS-121	36	100.2	33.4	26.5	44.5
	F2 = -do-	28	79.0	32.1	26.0	44.1
H10	F1 = CRIS-121 x CRIS-5A	35	97.6	34.2	25.9	45.4
	F2 = -do-	25	70.5	33.1	25.0	42.8
H11	F1 – PD-4548 x CRIS-121	45	130.4	32.9	26.8	44.8
	F2 = -do-	32	93.4	31.7	26.0	43.5
H12	F1 = NIAB-78 x CRIS-52	42	132.9	34.6	25.9	46.7
	F2 = -do-	30	195.2	32.9	25.0	45.0
H13	F1 = CIM-240 x NIAB-78	52	173.9	37.1	26.8	45.5
	F2 = -do-	35	116.0	36.0	25.8	44.1
H14	F1 = CIM-240 x CRIS-121	58	169.0	35.2	27.8	46.1
	F2 = -do-	40	116.0	34.1	27.0	45.2
	LSD (0.05)	4.39	9.66	0.096	1.054	1.105

Table 2: Mean squares from analyses of variance for five economic traits

Source of variation	Degrees of freedom	Mean squares				
		Bolls per plant	Seedcotton Yield	GOT	Staple length	Uniformity Ratio
Replication	3	7.59	75.82	1.898	0.896	0.796
Hybrids and parents	39	40.75**	230.32**	2.567**	3.251**	1.985**
Error	117	9.85	47.58	0.097	0.567	0.521

but not all the F2s were superior to their respective parents for these traits. The data of heterosis in the F1 and F2 and the percentage of inbreeding depression in F2 for all the traits are depicted in Table-3. For number of bolls per plant the average heterosis in F1 was 61.5 per cent, however the maximum heterosis of 150.0 per cent was shown by Alseemi-515 x NIAB-78 followed by NH-26N x CRIS-121. F2 population although manifested 9.8 % average heterosis, nevertheless, five out of 14 combinations suffered from considerable amount of inbreeding depression. Minimum and maximum depressions were noted in CRIS 54 x CRIS-121 and NH-26N x CRIS-121 combinations, respectively. On an average, the inbreeding depression in F2 was about halfway smaller to that of heterosis expressed in the F1. These results coincide with the theoretical assumptions that vigor and productiveness in F2 reduces by 50% in each selfing generation. It is also interesting to note that NH-26N x CRIS-121 that manifested second maximum heterosis for number of bolls also suffered from maximum inbreeding depression. Our results that high heterosis was generally associated with high inbreeding depression are in conformity with those of Gunaseelain and Krishna swami (1988) and Wang and Pan (1991).

The association of heterosis and inbreeding depression suggested that dominant and over-dominant genes are responsible for number of bolls. Katageri *et al.* (1992) also recorded 34.5 to 69.4 % inbreeding depression for this trait.

Table 3: Heterosis in F1 hybrids and inbreeding depression in F2 population

Character	Name of Hybrid	Mother parent	Pollen parent	F1	F2	Percent increase (+) or decrease (-) over high		Inbreeding depressionin F2hybrids
						F1	F2	
Bolls per plant								
1.	Alseemi-515 x NIAB-78	24	30	75	50	150.0	66.7	-33.3
2.	BH-36 x CRIS-121	21	30	46	33	53.3	10.0	-28.3
3.	BH-36 x CRIS-122	21	24	36	27	50.0	12.5	-25.0
4.	CRIS-127 x CRIS-122	28	24	35	25	25.0	-10.7	-28.6
5.	CRIS-127 x CRIS-5A	28	21	63	40	125.0	42.8	-36.5
6.	NH-26N x CRIS-121	28	30	68	36	126.6	20.0	-47.0
7.	CRIS-52 x CRIS-122	23	24	33	23	37.5	-4.1	-30.3
8.	CRIS-52 x CRIS-121	23	30	30	20	00.0	-33.3	-33.3
9.	CRIS-54 x CRIS-121	24	30	36	28	20.0	-6.7	-22.2
10.	CRIS-121 x CRIS-5A	30	21	35	25	16.6	-16.7	-28.6
11.	PD-4548 x CRIS-121	22	30	45	32	50.0	6.6	-28.9
12.	NIAB-78 x CRIS-52	30	23	42	30	40.0	0.0	-32.7
13.	CIM-240 x NIAB-78	27	30	52	35	73.3	16.7	-32.7
14.	CIM-240 x CRIS-121	27	30	58	40	93.3	33.3	-31.0
	Mean	**24.0**	**28.6**	**46.7**	**31.7**	**61.5**	**9.8**	**-31.0**
Seedcotton Yield per plant (gm)								
1.	Alseemi-515 x NIAB-78	72	80	207.2	116.5	159.0	45.6	-43.8
2.	BH-36 x CRIS-121	75	90	156.6	113.2	74.0	25.8	-27.8
3.	BH-36 x CRIS-122	75	72	99.8	74.0	33.0	-1.3	-25.8
4.	CRIS-127 x CRIS-122	84	72	116.2	82.5	38.3	-1.8	-29.0
5.	CRIS-127 x CRIS-5A	84	52.5	136.3	99.5	62.2	18.4	-27.0
6.	NH-26N x CRIS-121	90.7	90.2	187.4	102.6	106.6	33.1	-45.2
7.	CRIS-52 x CRIS-122	65.1	72.0	96.4	71.2	33.8	0.3	-26.1
8.	CRIS-52 x CRIS-121	65.1	90.2	94.3	62.5	4.5	-30.7	-33.7
9.	CRIS-54 x CRIS-121	68.3	90.2	100.2	79.0	11.1	-12.4	-21.1
10.	CRIS-121 x CRIS-5A	90.2	52.5	97.6	70.5	8.2	-21.8	-27.8
11.	PD-4548 x CRIS-121	62.1	90.2	130.4	93.4	44.6	3.5	-28.4
12.	NIAB-78 x CRIS-52	80.3	65.1	132.9	95.2	65.5	18.5	-28.4
13.	CIM-240 x NIAB-78	92.1	80.3	173.9	116.0	88.8	25.9	-33.3
14.	CIM-240 x CRIS-121	90.1	90.2	169.8	116.0	88.2	28.6	-31.7
	Mean	**78.1**	**73.4**	**140.3**	**92.3**	**58.4**	**8.2**	**-30.6**
Ginning outturn percent								
1.	Alseemi-515 x NIAB-78	32.4	33.0	33.6	33.0	1.8	0.0	-1.8
2.	BH-36 x CRIS-121	33.3	33.4	33.9	33.4	1.5	0.0	-1.5
3.	BH-36 x CRIS-122	33.3	32.3	37.2	35.1	11.7	5.4	-5.6
4.	CRIS-127 x CRIS-122	33.2	32.3	36.1	34.6	8.7	3.9	-4.1
5.	CRIS-127 x CRIS-5A	33.2	33.1	36.1	34.6	8.7	4.2	-4.1
6.	NH-26N x CRIS-121	33.2	33.4	35.7	34.5	6.9	3.3	-3.4
7.	CRIS-52 x CRIS-122	32.0	32.3	34.1	33.2	5.6	2.8	-2.6
8.	CRIS-52 x CRIS-121	32.0	33.4	34.5	33.1	3.3	-0.9	-4.0
9.	CRIS-54 x CRIS-121	31.1	32.4	33.4	32.1	3.1	-0.9	-3.9
10.	CRIS-121 x CRIS-5A	33.4	33.1	34.2	33.1	3.3	-0.9	-3.2
11.	PD-4548 x CRIS-121	31.0	33.4	32.9	31.7	-1.5	-5.1	-3.6
12.	NIAB-78 x CRIS-52	33.0	32.0	34.6	32.9	4.8	-0.3	-4.9
13.	CIM-240 x NIAB-78	33.3	33.0	37.1	36.0	11.4	8.1	-2.6
14.	CIM-240 x CRIS-121	33.3	33.4	35.2	34.1	5.4	2.1	-2.7
	Mean	**32.7**	**32.9**	**34.9**	**33.7**	**5.3**	**1.5**	**-3.4**
Staple length (mm)								
1.	Alseemi-515 x NIAB-78	27.0	25.5	30.5	28.2	13.0	4.4	-3.0
2.	BH-36 x CRIS-121	26.7	25.6	28.3	27.5	6.0	3.0	-2.8
3.	BH-36 x CRIS-122	26.7	25.6	26.9	25.8	0.7	-3.3	-4.1
4.	CRIS-127 x CRIS-122	25.3	25.6	26.7	25.8	4.3	0.8	-3.6
5.	CRIS-127 x CRIS-5A	25.3	25.5	27.2	26.5	6.7	3.9	-2.5
6.	NH-26N x CRIS-121	26.0	25.6	27.0	26.6	3.8	2.3	-1.4
7.	CRIS-52 x CRIS-122	25.0	25.6	27.9	26.3	9.0	-2.7	-5.7
8.	CRIS-52 x CRIS-121	25.0	25.6	26.9	25.5	5.1	-0.4	-5.2
9.	CRIS-54 x CRIS-121	25.5	25.6	26.5	26.0	3.5	-1.5	-1.9
10.	CRIS-121 x CRIS-5A	25.6	25.5	25.9	25.0	1.2	-2.3	-3.5
11.	PD-4548 x CRIS-121	26.1	25.6	26.8	26.0	2.7	-0.4	-3.0
12.	NIAB-78 x CRIS-52	25.5	25.0	25.9	25.0	1.6	-2.0	-3.5
13.	CIM-240 x NIAB-78	26.0	25.5	26.8	25.8	3.1	-0.8	-3.7
14.	CIM-240 x CRIS-121	26.0	25.5	27.8	27.0	6.9	3.8	-2.9
	Mean	**25.8**	**25.5**	**27.2**	**26.2**	**4.8**	**0.9**	**-3.3**
Uniformity Ratio (%)								
1.	Alseemi-515 x NIAB-78	42.1	43.0	44.9	43.0	4.4	0.0	-4.2
2.	BH-36 x CRIS 121	43.2	43.0	44.2	43.0	2.3	-0.5	-2.7
3.	BH-36 x CRIS-122	43.2	44.0	46.3	44.3	5.2	0.7	-4.3

4.	CRIS-127 x CRIS-122	43.0	44.0	48.9	46.1	11.1	4.8	-5.7
5.	CRIS-127 x CRIS-5A	43.0	42.5	47.0	44.0	9.3	2.3	-6.4
6.	NH-26N x CRIS-121	43.2	43.0	46.3	44.4	7.2	2.8	-2.5
7.	CRIS-52 x CRIS-122	43.1	44.0	43.1	42.0	-2.0	-4.5	-2.0
8.	CRIS-52 x CRIS-121	43.1	43.0	44.1	43.2	2.3	0.2	-2.0
9.	CRIS-54 x CRIS-121	42.0	43.0	44.5	43.1	3.5	0.2	-3.1
10.	CRIS-121 x CRIS-5A	43.0	42.5	45.4	42.8	5.6	-0.5	-5.7
11.	PD-4548 x CRIS-121	42.2	43.0	44.8	43.5	4.2	1.2	-2.9
12.	NIAB-78 x CRIS-52	43.0	43.1	46.7	45.0	8.3	4.4	-3.6
13.	CIM-240 x NIAB-78	44.3	43.0	45.5	44.1	2.7	-4.5	-3.1
14.	CIM-240 x CRIS-121	44.3	43.0	46.1	45.2	4.0	2.0	-1.9
	Mean	**43.0**	**43.1**	**45.6**	**43.8**	**4.9**	**0.6**	**-3.6**

Majority of the F1s has shown above 50 % heterosis suggesting that these hybrids can be useful for hybrid cotton development. High inbreeding depression for number of bolls in F2 could be explained by abnormal segregation at meiosis due to higher ploidy and dissociation of favorable dominant factors due to selfing.

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