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Relative Performance of F_1 and F_2 Intrahirsutum Hybrids for some Quantitative Traits in Upland Cotton

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Because of difficulties in producing more quantity and cheaper F_1 hybrid seed, recently a possible alternative of using F_2 hybrid seed is receiving more importance. Fourteen F_1 and F_2 hybrids and their parents were compared for number of bolls, seed cotton yield, lint %, fibre length and fibre uniformity ratio. F_1 hybrids were superior to F_2 hybrids and their parents for all the traits. However, some of F_2 hybrids were also better than their high parents. The percent increase of some F_2 hybrids against their high parent was 66.7% in number of bolls per plant, 45.6% in seed cotton yield, 8.1 in lint %, 4.4% in fibre length and 4.8% in uniformity ratio. As expected, F_2 hybrids have generally expressed about 50% of inbreeding depression; nevertheless, deviations to this expectation were also noted in particular characters and cross combinations. These deviations were probably attributable to abnormal segregation at meiosis due to higher ploidy level of cotton plant and deterioration of dominant factors on selfing. Significant performance of some F_2 hybrids however suggested that parental choice and breeding objectives are very important when F_2 hybrids are considered for hybrid crop development.

Key words: F_1 and F_2 intrahirsutum hybrids, Quantitative traits, Upland cotton.

Introduction

Crosses between inbred lines show vigour and productiveness in F_1 generation Shull (1908) but with increasing homozygosity by selfing, vigour and productiveness reduce by half in successive generations due to inbreeding depression Falconer (1989). Vigour and inbreeding depression are complementary to each other and these two phenomenons are usua-lly observed in same studies. It is also established fact that some crosses show more vigour in F_1 and others less. Similarly, some hybrids give less inbreeding depression in F_2 as compared to others. It is therefore, important for cotton bre-eders to determine the performance of their lines in F_1 and F_2 hybrids.

The difficulty in producing F_1 hybrid seed and its cost makes F_1 hybrid cotton impractical, therefore search for F_2 hybrids that still express an economic level of heterosis seems to be a potential alternative in hybrid cotton development.

It is predicted that hybrid vigour in F_1 is due to dominant allelic factors and these deteriorate in F_2 and subsequent generations. Some researchers (Gunaseelan and Krishnaswami 1988; Vyahakar *et al* 1984 and Bhatade 1984) reported that high heterosis was generally associated with high inbreeding depression.

The classic study on the effects of self-fertilization in maize was reported by Jones (1918 and 1939). Jones (1939) conducted 30 generations of self-fertilization for plant height and yield. The effect of self-fertilization on both the traits was quite different in that, after 5 generations, plant height reduced by 30 % with little change thereafter, but yield continued to decrease and was reduced to 75% by generation 20. He discussed possible reasons for the differences in inbreeding depression for various traits. According to him, the level of homozygosity reduces 50% on an average with each generation of self-fertilization. Therefore, homozygosity is more rapidly approach for simpler traits than for more complicated traits. Consequently, complex traits are expected to show lower inbreeding depression than simpler traits in subsequent generations of self-fertilization.

In allopolyploids like cotton, it may not hold true that complex traits show less depression than the simpler traits. Aycock and Wilsie (1968) observed that in alfalfa, an autotetraploid, the yield decreased twice as much as predicted. This response, according to them was attributed to a decrease in favourable interactions among multiple alleles due to inbreeding and abnormal segregation at meiosis because of higher ploidy level in alfalfa. 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. Considering the importance of F_2 hybrids in cotton, present studies were conducted to determine the relative performance of F_1 and F_2 hybrids and the amount of inbreeding depression for simpler and more complicated traits in cotton (*Gossypium hirsutum* L.).

Materials and Methods

Twelve parents of which five varieties from Punjab viz., Alseemi-515, NIAB-78, BH-36, NH-26 and CIM-240 and six advanced strains developed at Cotton Research Institute, Sakrand viz., CRIS-121, CRIS-122, CRIS-127, CRIS-5A, CRIS-52 and CRIS-54 along with one exotic line PD-4548 were crossed in fourteen combinations during 1993. The F_1 seed was sown in 1994 to develop F_2 hybrids and fresh crosses were also attempted to develop F_1 seed to be grown in 1995, during 1995, the F_{1S} and their F_{2S} along with parents were grown simultaneously in Randomized Complete Block Design with four replications.

Two rows of F_{1S} and three rows of F_{2S} and parents were planted in each replication. Twenty-five plants from each replication of parents, F_{1S} and F_{2S} were randomly tagged and treated as index plants for taking the observations. The analysis of variance was carried-out as adapted by Gomez and Gomez (1984). Only useful heterosis (F_1 and F_2 compared with high parents) was determined as under:

High parent heterosis for F_1 = F_1-HP÷HP x 100
High parent heterosis for F_2 = F_2-HP÷HP x 100

Where F_1 and F_1 were the mean performance of first and second filial generations and HP was the high parent performance.

The inbreeding depression of F_1 hybrids was determined as percentage decrease or increase of F_2 against their respective F_1 hybrid as under:

Inbreeding depression = F_2-F_1÷F_1 x 100.

The characters under present study were number of bolls per plant, seedcotton yield per plant (gm), lint % (calculated as ratio of seed and lint), fibre length (mm) and uniformity ratio determined at 2.5 and 50% span length.

Results and Discussion

The average performance of F_1 hybrids and their parents are given in Table 2 and the mean squares from analysis of variance are presented in Table 1. The mean square suggested significant differences among F_{1S}, F_{2S} and the parents for all the five traits under study.

In respect of mean performance, all the 14 F_{1S} set more bolls, produced more seed cotton, ginned higher lint %, and produced longer and uniform fiber over their respective parents. Majority of F_{2S} but not all, were also superior to their parents (Table 2) suggesting that F_2 hybrids could be a potential alternative to F_1 hybrid in cotton. Baloch *et al*. (1991 & 1993) also observed that some of the F_2 hybrids from intra and interspecific crosses expressed 4.48 to 27.09 % increase in bolls, 2.78 to 23.90 % increase in seedcotton yield, 0.28 to 0.48 % increase in fibre length and no increase in lint % when compared with their higher parents. However, in present study the percent increase in F_2 hybrids against their high parents was more than reported by Baloch *et al*. (1991 & 1993) in their earlier studies.

The better performance of F_2 hybrids in our studies may be attributable to the parents used in the crosses, which suggested that parental choice in very important for hybrid crop development.

The hybrid Alseemi-515 x NIAB-78 expressed maximum increase of 150 & 66.7% and 159 & 45.6% over high parents in F_1 and F_2 hybrids for number of bolls and seedcotton yield respectively. Two hybrids, BH-36 x CRIS-122 and CIM-240 x NIAB-78 manifested maximum of 11.7% heterosis in F_1 and 8.1% in F_2 hybrids respectively for lint %. The highest heterosis of 13.0 & 4.4% for fibre length and 11.9 & 4.8% for uniformity ratio in F_1 and F_2 hybrids respectively were expressed by the hybrids Alseemi-515 x NIAB-78 and CRIS-127 x CRIS-122. These results further suggested that parental choice vary from character to character. Therefore priority to improve any character also depends on breeding objectives.

It is also important for breeder to determine the extent of inbreeding depression of particular traits. Aycock and Wilsie (1968) noted that yields decreased twice as much as predicted in alfalfa, an autotetraploid. Jones (1939) noted the differences

Table 1
Mean squares from analyses of variance for five quantitative traits in upland cotton

Source of variation	Degrees of freedom	Mean squares				
		Bolls/plant	Seedcotton yield (gm)	Lint %	Fibre length (mm)	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

** Significant at 1 % probability level.

in inbreeding depression for various traits. He observed more inbreeding depression in simpler traits as compared to more complicated traits and explained that by selfing, homozygosity in simpler traits is more rapidly achieved than complex traits. It was also noted that in the present study that hybrids showing higher level of heterosis in F_1 were generally associated to more inbreeding depression (Table 3) in F_2 hybrids. These results are in accordance to those of Gunaseelan and Krishnaswami (1988) and Wang and Pan (1991). The maximum percent -47.0 of inbreeding depression was observed in number of bolls and -43.0% in seedcotton yield. Though these traits are highly complicated (controlled by many genes and

Table 2

Mean performance of parents, F_1 and F_2 hybrids for five quantitative traits in upland cotton

Parents/hybrids	Bolls/plant	Seedcotton yield/plant (gm)	Lint %	Fibre length (mm)	Uniformity ratio
Alseemi-515	24	72.5	32.4	27.0	42.1
NIAB-78	30	80.3	33.0	25.5	45.0
BH-36	21	75.1	33.3	26.7	43.2
CRIS-121	30	90.2	33.4	25.6	43.0
CRIS-122	24	72.0	32.3	25.6	44.0
CRIS-127	28	84.0	33.2	25.3	43.0
NH-26	28	90.7	33.2	26.0	43.2
CRIS-5A	21	52.5	33.1	25.5	42.5
CRIS-52	23	65.1	32.0	25.0	43.1
CRIS-54	24	68.3	31.1	25.5	42.0
PD-4548	22	62.1	31.0	26.1	42.2
CIM-240	27	92.1	33.3	26.1	44.3
1. F_1=Alseemi x NIAB-78	75	267.0	33.6	30.5	44.9
F_2= do	50	116.0	33.0	28.2	43.0
2. F_1= BH-36 x CRIS-121	46	156.0	33.9	28.3	44.2
F_2= do	33	113.2	33.4	27.6	43.0
3. F_1= BH-36 x CRIS-122	36	99.8	37.2	26.7	46.3
F_2= do	27	74.0	35.1	25.8	44.3
4. F_1= CRIS-127 x CRIS-122	35	116.2	36.1	26.7	48.9
F_2= do	25	82.5	34.6	25.8	46.1
5. F_1=CRIS-127 x CRIS-5A	63	136.3	36.1	27.2	47.0
F_2= do	40	99.5	34.6	26.5	44.0
6. F_1= NH-26 x CRIS-121	68	187.4	35.7	27.0	46.3
F_2= do	36	102.6	34.5	26.6	44.4
7. F_1= CRIS-52 x CRIS-122	33	96.4	34.1	27.9	43.1
F_2= do	23	71.2	33.2	26.3	42.0
8. F_1=CRIS-52 x CRIS-121	30	94.3	34.5	26.9	44.1
F_2= do	20	62.5	33.1	25.5	43.2
9. F_1=CRIS-54 x CRIS-121	36	100.2	33.4	26.5	44.5
F_2= do	28	79.0	32.1	26.0	44.1
10. F_1CRIS-121 x CRIS-5A	35	97.6	34.2	25.9	45.4
F_2= do	25	70.5	33.1	25.0	42.8
11. F_1= PD-4548 x CRIS-121	45	130.4	32.9	26.8	44.8
F_2= do	32	93.4	31.7	26.0	43.5
12. F_1= NIAB-78 x CRIS-52	42	132.9	34.6	25.9	46.7
F_2= do	30	195.2	32.9	25.0	45.0
13. F_1=CIM-240 x NIAB-78	52	173.9	37.1	26.8	45.5
F_2= do	35	116.0	36.0	25.8	44.1
14. F_1= CIM-240 x CRIS-121	58	169.8	35.2	27.8	46.1
F_2= do	40	116.0	34.1	27.0	45.2
L.S.D. (5%)	4.39	9.6	0.096	1.054	1.105

Table 3
Relative performance of F_1 and F_2 hybrids and inbreeding depression for five quantitative traits in upland cotton

Crosses	F_1 hybrids					F_2 hybrids				
	Bolls/ plant	Seedcotton yield/plant (gm)	Lint %	Fibre length (mm)	Uniformity ratio	Bolls/ plant	Seedcotton yield/plant (gm)	Lint %	Fibre length (mm)	Uniformity ratio
Alseemi-515xNIAM-78	75	267.0	33.6	30.5	44.9	50	116.0	33.0	28.2	43.0
BH-36 x CRIS-121	46	156.0	33.9	28.2	44.2	33	113.2	33.4	28.3	43.0
BH-36 x CRIS-122	36	99.8	37.2	26.7	46.3	27	74.0	35.1	25.8	44.3
CRIS-127 x CRIS-122	35	116.2	36.1	26.7	48.9	25	82.5	34.6	25.8	46.1
CRIS-127 x CRIS-5A	63	136.3	36.1	27.2	47.0	40	99.5	34.6	26.5	44.0
NH-26 x CRIS-121	68	187.4	35.7	27.0	46.3	36	102.6	34.5	26.6	44.4
CRIS-52 x CRIS-122	33	96.4	34.1	27.9	43.1	23	71.2	33.2	26.3	42.0
CRIS-52 x CRIS-121	30	94.3	34.5	26.9	44.1	20	62.5	33.1	25.5	43.2
CRIS-54 x CRIS-121	36	100.2	33.4	26.5	44.5	28	79.0	32.1	26.0	43.1
CRIS-121 x CRIS-5A	35	97.6	34.2	25.9	45.4	25	70.5	33.1	25.0	42.8
PD-4548 x CRIS-121	45	130.4	32.9	26.8	44.8	32	93.4	31.7	26.0	43.5
NIAB-78 x CRIS-52	42	132.9	34.6	25.9	46.7	30	95.2	32.9	25.0	45.0
CIM-240 x NIAB-78	52	173.9	37.1	26.8	45.5	35	116.0	36.0	25.8	44.1
CIM-240 x CRIS-121	58	169.8	35.2	27.8	46.1	40	116.0	34.1	27.0	45.2
General Mean	46.7	140.3	34.9	27.2	45.6	31.7	92.3	33.7	26.2	43.8
Range of increase or decrease of F_1 over high parent (%)	0 to 150	4.5 to 159	-1.5 to 11.7	0.7 5 to 13.0	-2.0 to 11.9	-	-	-	-	-
Average of vigour in F_1	61.5	58.4	5.3	4.8	4.9	-	-	-	-	-
Range of increase or decrease of F_2 over high parent (%)	-	-	-	-	-	-33 to 66.7	-30 to 45.6	-5.1 to 8.1	-3.3 to 4.4	-4.5 to 4.8
Average of vigour in F_2	-	-	-	-	-	9.8	8.2	1.5	0.9	0.6
Range of inbreeding depression in F_2 hybrids (%)	-	-	-	-	-	-22.2 to -47.0	-21 to -45	-1.5 to -5.6	-1.4 to -5.7	-1.9 to -6.4
Av. inbreeding depression	-	-	-	-	-	-31.0	-30.6	-3.4	-3.3	-3.6

their interactions) which theoretically were supposed to show less inbreeding depression due to slow approach towards homozygosity. However, high level of inbreeding depression in these traits may be attributed to abnormal segregation at meiosis and was probably responsible for deviations in observed and expected inbreeding depression as reported by Aycock and Wilsie (1968). On the other hand small percent of inbreeding depression in lint percent (-1.5 to –5.6%); fibre length (–1.5 to –5.7%) and uniformity ratio (-1.5 to –6.4) suggested that due to selfing, dominant factors responsible for heterosis in F_1 hybrids, deteriorated in F_2 hybrids by inbreeding depression phenomenon. Baloch *et al* (1991 and 1993) also reported similar trend of inbreeding depression for the same traits.

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