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Evaluation of F_1 and F_2 Generations for Yield and Yield Components and Fiber Quality Parameters on Cotton (*Gossypium hirsutum* L.) Under Werer, Ethiopia Condition

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ABSTRACT

Due to the difficulty of producing F_1 hybrid seed, the use of heterosis in cotton (*Gossypium hirsutum* L.) has been limited. This study was conducted on fifteen F_1, fifteen F_2 and 6 parental genotypes obtained from partial diallel cross of 6 varieties with the objectives of comparing the parents, F_1 and F_2 generations and to identify the competitive potential of F_2 hybrids over the best yielding cultivars for yield component and fiber quality parameters.

It was evident to find the seedcotton and lint yield superiority of F_1 hybrid over parents and F_2 generations. F_1 hybrids showed an overall seedcotton yield advantage of F_1 over the parental means of 26.4 %, while F_2 hybrids were 9.3%. Best F_1 hybrids showed 19.5% yield advantage over the best check parent, while best F_2 hybrids were only 2.5%. Almost the same pattern was observed for lint yield with the level of heterosis at 28.6, 10.2, 30.4 and 0.8 % for F_1 and F_2 mid-parent and best parent, respectively. Significant differences were not observed for fiber quality parameters except fiber strength.

The result of this study demonstrated the potential of F_1 rather than F_2 hybrids and the need for further investigation on heterosis and inbreeding depression and development of economically feasible hybrid seed production technology.

Key words: cotton, F_2 hybrids, heterosis, yield component, fiber quality

INTRODUCTION

Researches on hybrid cotton have been conducted in many countries particularly India, China, U.S.A., Uzbekistan and Vietnam. Utilization of F_1 hybrids in cotton was the objective of many breeders all over the world. Numerous studies showed the existence of substantial heterosis on cotton (Davis, 1978; Basu, 1995; Raid, 1995). However, logistic and economic problem of F_1 seed production have limited their use in countries (Thomson and Luckett, 1988). The practical question involves the degree of heterosis attainable vs. the cost of obtaining large quantities of F_1 hybrid seeds. Similar problems in obtaining sufficient quantities of F_1 seed occurred in early history of developing hybrid corn. The potential of F_2 generation has been attempted to study for the same reason.

During the seventies and eighties, intensive

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researches in hybrid cotton have been carried out in all basic and applied aspects such as choices of parents and diversification of germplasm combining ability with extensive testing of thousands of combination at diploid and tetraploid levels and at intra- and inter-specific levels.

Research efforts on the use of genetic and cytoplasmic male sterility (Richmond and Kohel, 1961; Meyer, 1969, 1973) and fertility restoration factor (Weaver and Weaver, 1977) were the major areas of study for economic seed production. Even in the countries where manual pollination is generally predicted, the use of male sterility is preferred due to the great reduction of hybrid seed cost (Raid, 1995).

India was the first country in the world to exploit hybrid cotton commercially. The key success was utilization of the vast labor force for the production of hybrid seeds at a reasonable cost by hand emasculation and pollination. China, Uzbekistan and Vietnam also produce some amount of F_1 and F_2 hybrid cotton (Basu, 1995).

However recent research development in U.S.A. created renewed interest in the exploitation of F_2 cotton hybrids with demonstration of significant advantage. The F_2 cotton hybrids are expected to express only 50% of the heterosis (F_1-Midparent) expressed in the F_1 hybrids and even less when heterosis is defined (F_1 – Best parent). Although not obtaining as high yield as F_1 hybrids, F_2 generation types have competed well with the best pure line cultivars in some tests. Meredith (1990) found that the two best F_1 and F_2 hybrid combinations averaged 15 and 8%, respectively. Olvey (1986) reported an F_2 yield advantage of 10-24% over the better parent for selected hybrids. Not all results were encouraging. Miller and Mariani (1963) compared a set of F_1 and F_2 upland hybrids, and noted a 7% advantage of F_1 over the parents. However, in the same crosses there was highly significant inbreeding depression in the F_2. Tang *et al*. (1993a) reported acceptable level of F_2 heterosis for yield. Fiber traits of F_2 were similar to mid parental values, but about 50% of the F_2 hybrids were not different from their high parents for quality characters except microniar (Tang *et al.*, 1993b). Dever and Gannawy (1992) recorded lower fiber length in F_2 than in F_1 hybrids. Those encouraging research developments and the absence of hybrid cotton research results in Ethiopia initiated to make this first attempt to investigate in this area.

The objectives of the study were to compare the yield and its components and fiber quality parameters of F_1 and F_2 generations and to identify the competitive potential of F_2 hybrids over the best yielding cultivars.

MATERIALS AND METHODS

Fifteen F_1 hybrids from a six-parent diallel were produced during 2002 cropping season (April-August) using hand emasculation and pollination. The six varieties were Del Cerro, Arba, GL-7, Cucurova 1518, Niab-78 and Acala SJ2. They were obtained from U.S.A., Turkey, Pakistan and Ethiopia. These varieties assumed to be homozygous for their characteristics as evidenced by their status of developments were hybridized as half diallels. F_2 seed was produced by selfing the F_1 generation during 2002 late season (July – October). Selfed seeds from all F_1 plants of each cross were harvested and bulked to form F_2 seed for this experiment. Six parents, 15 F_1 and 15 F_2 generations making a total of 36 entries were planted during 2003 main cropping season using randomized complete block design with three replications. The planting was made by hand at the rate of two seeds per hole on four rows of 8.0 meter long with a spacing of 0.2 m between plants and 0.9 m between rows. The plots were hoed, weeded, irrigated and sprayed against insect pests. Furrow irrigation was used at two weeks interval making a total of eight irrigations. Crossing and all subsequent evaluation of generations were made at Werer Agricultural Research Center in Ethiopia

(WARC).

Data collected included seedcotton yield (SCY) = plot yield / plot area (later converted to kg/ha), boll weight (BW) = weight of bolls / number of bolls (sample), boll number per plant (B/P) = (SCY/BW)/ number of plants per plot, lint percentage (LP) = lint weight / total weight of seedcotton (sample), lint yield (LY) = (SCY) X (LP), seed index (SI) = seed weight / seed (100 seeds per sample), lint index (LI) = lint weight / seed (100 seeds per sample) and number of seeds per boll (SPB) = average number of seeds per boll (Worley *et al.*, 1976).

Boll samples were collected and saw ginned to estimate lint percentage, seed index, lint index and seeds per boll. Lint samples were tested for length, strength, fineness, short fiber index, and uniformity ratio. Staple lengths of 2.5 and 50%, short fiber index and uniformity ratio were measured using Digital Fibrograph 730. Fineness was measured by using Fineness Meter. Spinlab Stelometer 154 was used to test fiber bundle strength. All fiber quality tests except fiber bundle strength were made at Werer Agricultural Research Center (WARC). Fiber bundle strength was measured at Tak Fa Cotton and Corn Research Center in Thailand.

Heterosis was computed using the formulas: -

Percent mid-parent heterosis =

100(F_1 - mid-parent)/mid-parent

Percent best-parent heterosis =

100(F_1 - best-parent)/best-parent

The same formula was used to compute F_2 heterosis by replacing F_1 values.

RESULTS

Significant difference within generations at P≤0.01 probability level was observed in almost all parameters except F_1 generation for boll number per plant and parents for number of seeds per boll (data not shown). Highly significant differences were observed for contrasts of parents vs. F_1 and F_2 generations, parents vs. F_1, parents vs. F_2 and F_1 vs. F_2 for yield and yield components. F_1 hybrids showed significant differences over parents and F_2 hybrids for seed cotton yield, boll number per plant, boll weight, lint yield, lint index, seed index and seeds per boll. F_2 generations showed significant differences over parents for seedcotton yield, lint yield and lint percentage (Table 1). F_1 hybrids showed an overall yield advantage of the F_1 over the parental mean of 26.4%, while the F_2 generation was 9.3%. Best F_1 hybrid (Gl-7 X Cucurova 1518) showed yield advantage over the best check parent (Cucurova 1518) value of 19.5 %, while best F_2 hybrid (Del Cerro X Cucurova 1518) showed only 2.5%. For lint yield, best F_1 hybrid (Gl-7 X Cucurova 1518) showed 30.4% advantage over the best parent, while best F_2 hybrid (Gl-7 X Cucurova 1518) showed only 0.8%. F_1 heterosis over the parental mean was of 9.6% for boll number per plant, 13% for boll weight, 2.3% for lint percentage, 9.5% for lint index, 6.7% for seed index and 4.4% for number of seeds per boll. F_2 generations showed 1.9% lint percent advantage over parental mean. Best F_1 heterosis over the best check parent was 6.9% for boll number per plant, 20% for boll weight, 2.4 % for lint percent, 9.6% for lint index, 1.6 % for seed index and 7.9% for number of seeds per boll. Best F_2 generation showed negative heterosis over the best check parents for lint percentage (Table 2). The values of all F_1 hybrids were above the average of parent and F_2 generations for seed cotton yield. And the same pattern of range value was observed for lint yield where the values of all F_1 hybrids were above the average value of parents (Table 1).

No significant differences were observed for contrasts of parents vs. F_1 and F_2 generations, parents vs. F_1, parents vs. F_2 and F_1 vs. F_2 for all quality parameters, except fiber strength. There were slight improvements of F_1 and F_2 mean values except fiber strength. Highly significant differences were observed within generations for

Table 1 Means of yield and yield component for parents, F_1 and F_2 generations in cotton grown at Werer, April –August 2003, Ethiopia.

Generations	Seed cotton yield *	Bolls per plant	Boll weight gm	Lint yield*	Lint percent	Lint index %	Seed index	Seeds per boll
Parents								
Mean	25.8 c	20.8 b	4.6 b	9.8 c	37.6 b	6.3 b	10.5 b	29.8 b
Range	20.6-31.7	14.9-24.6	3.8-5.0	6.9-12.5	33.4-41.9	5.1-7.3	8.6-12.8	28.2-31.8
F_1								
Mean	32.6 a	22.8 a	5.2 a	12.6 a	38.5 a	6.9 a	11.2 a	31.1 a
Range	28.5-37.9	19.6-26.3	4.4-6.0	10.2-16.3	34.5-42.9	5.7-8.0	9.6-13.0	28.9-34.3
F_2								
Mean	28.2 b	21.7 b	4.7 b	10.8 b	38.3 a	6.4 b	10.4 b	29.9 b
Range	23.7-32.5	18.2-25.5	4.0-5.3	8.5-12.6	34.7-41.5	5.4-7.3	8.6-12.7	27.2-32.1

Values in a column, with different alphabets are significantly different at $p<0.01$.
* = ($x10^2$ kg /ha)

Table 2 F_1 and F_2 heterosis expressed as the percentages of mid-parent and best parent for yield and components.

Types of heterosis	Seed cotton yield *	Bolls per plant	Boll weight gm	Lint yield*	Lint percent %	Lint index	Seed index	Seeds per boll
Mid-parent								
F_1	26.4	9.6	13.0	28.6	2.3	9.5	6.7	4.4
F_2	9.3	3.4	2.1	10.2	1.9	1.6	-1.0	3.4
Best parent								
F_1	19.5	6.9	20.0	30.4	2.4	9.6	1.6	7.9
F_2	2.5	3.6	6.0	0.8	-1.0	-	-0.8	0.9

* = ($x10^2$ kg/ ha)

all quality parameters (data not shown). Wide ranges of result of 2.5% staple length and fiber strength were recorded for parents, while range values decreased through F_1 and F_2 generations for 2.5 % staple length. Parents showed the highest and significant difference for fiber strength. There were no significant differences between F_1 and F_2 generations. The best performing hybrid (Del Cerro X Niab-78) showed 26.1 and 26.4 g/tex for F_1 and F_2 generations, respectively (Table 3).

DISCUSSION

The existence of strong variability is very important for further selection and breeding activities. Significant shift of range values of F_1 over parents and F_2 generations indicated the importance of early generation selection.

Table 3 Averages of cotton fiber quality parameter for parents, F_1 and F_2 generations, grown at Werer, Ethiopia, April-August, 2003.

Generations	Staple length, mm		Fiber strength gm/tex	Fineness*	Short fiber index	Uniformity ratio (%)
	50%	2.5 %				
Parents						
Mean	14.9	30.8	23.9 a	3.8	4.7	48.3
Range	13.4-16.3	27.5-35.4	17.9-30.2	3.3-4.3	2.8-7.4	46.0-49.8
F_1						
Mean	15.5	31.8	22.5 b	4.1	4.0	48.8
Range	13.9-16.7	28.6-34.6	20.2-26.1	4.0-4.7	2.8-6.5	46.6-51.3
F_2						
Mean	15.1	31.4	22.3 b	3.8	4.3	48.0
Range	13.6-16.4	28.7-34.4	19.1-26.4	3.2-4.4	3.3-6.0	46.2-49.9

Values in a column, with different alphabets are significantly different at $p<0.01$.
* = Microniar –measurcment of fineness

Seedcotton and lint yield advantage of 26.4 and 28.6 % of F_1 over parental mean and 19.5 and 30.4 % over the best check parent showed the potential of F_1 hybrids. Similar results were observed by Sheetz and Quisenberry (1986) at 31.5 and 15.8 % and lower results by Thomson and Luckett (1988) at 15.1 and 20.3 % average and useful (best parent) heterosis for seedcotton yield, respectively. Mid parent heterosis for F_2 generations was of 9.3 % for seedcotton yield and 10.2 % for lint yield. Meredith (1990) and Tang *et al*. (1993b) found similar results. They were able to obtain 7.4 to 17.9 and 4.7 to 18.0 % F_2 heterosis over the parents, respectively. The strongest challenge was low value of F_2 heterosis over the best check parent, which was 2.5% and 0.8 % for seedcotton yield and lint yield, respectively. Similarly Miller and Mariani (1963) reported higher inbreeding effect and very low heterosis of F_2 generation at 3.5 % for seed cotton yield. Boll number per plant and boll weight contributed differently, for the improvement of seed cotton and lint yield in F_1 and F_2 generations. Combination of higher lint index and lower seed index contributed highly for the improvement of lint percentage and lint yield. All fiber quality results of all generations were between the acceptable ranges of value for *G. hirsutum* varieties. The absence of significant differences between generation mean of parents vs. F_1 and F_2 generations, parents vs. F_1, parents vs. F_2 and F_1 vs. F_2 for quality parameters confirmed that F_1 and F_2 generations had similar results as of their parents. Reports of Meredith (1990) and Tang *et al.* (1993a) also confirmed that F_1 and F_2 generations performed equally with parents or the improvements were too small to be of much practical value. The exception was with fiber strength where the parents showed the highest and significant differences over F_1 and F_2 generations.

Generally the average performance F_2 generation was better than mean of parents for all yield and yield components except seed index. But statistically significant differences were observed only for seedcotton yield, lint yield and lint percentage. The existence of strong variability of these characters demonstrated the possibility of further improvement in selection and breeding activities. Even though low level of best parent F_2

heterosis, second generation seed may be used as planting material if necessary, in order to save the cost of seed production.

CONCLUSION

Heterosis breeding offers considerable opportunity for increased production of cotton in the world. 19.5 % yield advantage of best F_1 over the best check parent demonstrated the potential of F_1 hybrids over high yielding varieties. Combination of the potential of F_1 hybrids with the available human resourse under Ethiopian condition, conventional hybrids produced by hand emasculation and pollination could be more important. Yield advantage 2.5% of best F_2 hybrids over best check parent shows the need for further investigation of heterosis and inbreeding depression and seed multiplication technologies, specially cytoplasmic and genetic male sterile system, chemical sterility and hybridizing agents for economically feasible hybrid seed production. To meet the future challenge regional and international cooperation would be very important.

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