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Responses of Upland Cotton to Selection for Fiber Length and Fineness in a Nonirrigated Semiarid Environment[1]

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ABSTRACT

Fiber length and fineness were used as the selection criteria in the development of four groups of lines from a composite-cross of upland cotton (*Gossypium hirsutum* L). These groups consisted of lines with long-coarse, long-fine, short-coarse, and short-fine fibers. These fiber groups were used to evaluate selection for fiber length and fineness on fiber strength and elongation, lint yield, earliness of crop maturity, stormproofness, lint percent, lint index, and seed index. All selections and evaluations were made in a semiarid environment without irrigation. Orthogonal comparisons, based on the fiber groups, were used to determine the response of these characters to selection for fiber length and fineness. Comparisons of linear regression coefficients from the parental and selected lines were used to estimate the changes in character relationships that occurred during selection.

Significant residual variation for most characters, existed among the selected lines within each group. This residual variation suggested that selection had not eliminated all genetic variance. The orthogonal comparisons showed that fiber length was associated with fiber fineness and elongation, lint yield, stormproofness, lint percent, and seed index and that fiber fineness was associated with fiber strength and elongation, earliness of crop maturity, stormproofness, lint percent, lint index, and seed index. Correlation coefficients from the parental and the selected lines suggested that the relationships between fiber length and both lint yield and lint percent did not change during the selection process, but that the associations between fiber length and earliness of crop maturity, stormproofness, lint index, and seed index did change. The relationships between fiber fineness and both fiber strength and lint index were the same in both the parental and selected lines, whereas fiber elongation, earliness of crop maturity, stormproofness, and seed index did not show the same degree of relationship with fineness in the parental and selected lines.

Additional index words: *Gossypium hirsutum* L., Cotton breeding, Dryland cotton production.

FIBER length and fineness are important quality characteristics that may affect the choice of cotton (*Gossypium hirsutum* L.) cultivars grown in nonirrigated, semiarid environments. The cultivars most often grown in semiarid regions, where irrigation water is limited or not available, have short and often fine lint. Christidis and Harrison (1955) suggested that short-staple cultivars are probably preferred by producers in semiarid regions because they usually mature earlier and yield somewhat more consistently than longer stapled cultivars. Jones et al. (1956) associated short-staple cultivars with the low annual rainfall, relatively low temperatures, and short growing seasons of the Texas High Plains. These cultivars, although inferior in staple length when compared to cultivars grown under irrigation or in higher rainfall regions, performed well in the relatively adverse climate of the Texas High Plains.

In this research, we evaluated the influence of selection for fiber length and fineness in a nonirrigated, semiarid environment on other agronomic characters in upland cotton. The relationships established may aid in the determination of what realistic limits should be set for fiber length and fineness when developing cotton cultivars for nonirrigated, semiarid cotton production regions.

MATERIAL AND METHODS

In 1960, a composite-cross population was developed at the Tex. A&M U. Agric. Res. and Ext. Cen. at Lubbock. Approximately 2,500 F_2 plants from all possible crosses between five experimental strains and one commercial cultivar were grown. The five experimental strains (NR-AHA, H257, CA 396, CB 3106A, and GI 249-2) represented a diverse group of material that included a foreign introduction (CB 3106A), an experimental Acala (NR-AHA), and a glandless (GI 249-2) line. The commercial cultivar was 'Gregg 35.'

From the 2,500 plants of the composite-cross population, approximately 500 plants were placed into four groups, based on fiber length and fineness. These groups were composed of: i) long, coarse; ii) long, fine; iii) short, coarse; and iv) short, fine fiber. Fiber length and fineness values from 'Blightmaster' were used as the standard for these fiber groups. Seeds from each selected plant were planted in progeny rows; the fiber length and fineness for each row was determined; and the progeny rows were again classified in the proper fiber group by comparison with Blightmaster. The process of selective grouping of the material continued for 4 years.

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Table 1. Character means from the parental cultivars used in the development of the original composite-cross population.

Character	Parental cultivar NR-AHA	H 257	CA 398	CB 3106A	Gl 249-2	Gregg 35
Fiber						
Length, in.	1.06 bc*	1.14 a	1.09 ab	1.03 cd	1.02 cd	1.00 d
Fineness, micronaire	4.4 a	3.3 b	2.7 c	3.7 b	3.5 b	3.6 b
Strength, gf/tex	2.27 a	1.65 b	1.79 b	1.66 b	1.70 b	1.79 b
Elongation, %	5.9 c	10.0 ab	8.4 b	11.9 a	9.2 b	9.1 b
Lint yield, kg/ha	423 cd	381 d	597 b	835 a	470 cd	530 bc
Earliness (MMD), days	166 abc	170 a	167 ab	161 c	165 c	162 c
Stormproofness, rating	2.8 a	2.2 ab	1.0 b	2.4 ab	2.8 a	1.2 b
Lint Percent, %	34.8 c	34.9 c	34.1 c	40.1 a	36.5 b	37.1 b
Lint index, g/100 seed	7.2 a	6.7 a	5.5 b	7.1 a	6.6 a	7.1 a
Seed index, g/100 seed	13.2 a	12.4 a	10.6 b	10.6 b	9.8 b	12.3 a

* Means within rows followed by different letters are significantly different at the 0.05 level, according to a Duncan's new multiple range test.

Table 2. Mean squares from the analyses of variance of lines with fiber groups.

Source of variation	df	Character: Fiber length	Fiber fineness	Fiber strength	Fiber elongation	Lint yield	Earliness	Storm-proofness	Lint, %	Lint index	Seed index
Lines/groups	36	0.0025**	0.202**	1.86**	1.26**	24,657**	12.16	0.80**	3.99**	1.12**	0.391**
Long-coarse	9	0.0013	0.170*	3.14**	1.99**	11,559	7.26	0.95**	2.78**	2.00*	0.436**
Long-fine	9	0.0014	0.068	1.05	1.26**	7,197	14.85	0.37	5.07**	0.82	0.271
Short-coarse	9	0.0015	0.420**	2.60**	0.54**	53,815**	13.98	0.98**	4.90**	0.97*	0.544**
Short-fine	9	0.0059**	0.211*	0.63	1.23**	26,058	12.54	0.37	3.20**	0.68	0.312*
Error	72	0.0010	0.070	0.59	0.02	11,950	10.30	0.23	0.70	0.43	0.163

*, ** Statistically significant at the 0.05 and 0.01 probability levels, respectively.

In 1965, 20 progeny rows that best met the selection criteria were selected from each group and evaluated in replicated tests for fiber length and fineness. After 3 years of testing, each group was further reduced to 10 lines, and seed of each line was increased in 1971. All selections and evaluations were conducted under nonirrigated (dryland) field conditions at Lubbock.

In 1972, the 10 lines from each of the four groups were planted on May 20, in a randomized, complete block design with three replications. The experimental plots were 1 $\times$ 10-m rows with 1 m between rows. After seedling emergence, each row was thinned to approximately 64,000 plants/ha. Sufficient soil moisture for plant establishment was available at planting, and approximately 28 cm of rain fell during the growing season. Irrigation water was not applied, and recommended cultural and tillage practices were followed during the growing season. The parental cultivars used to develop the original composite-cross population were planted separately for comparative purposes.

The following characters were measured.

Fiber length, by the Digital Fibrograph as the length (in.) of the longest 2.5% of the fibers by weight.

Fiber fineness, by the micronaire in micronaire units and defined as the resistance of a given quantity of fiber to air flow.

Fiber strength, force (gf/tex) required to break a fiber bundle with the clamps of the stelometer set 3.2 mm apart.

Fiber elongation, percentage of stretch a fiber bundle displayed before breakage while being measured for fiber strength.

Lint yield, by hand-harvesting each plot, mechanically removing the lint from the seed, and converting the lint weight/plot to kg/ha.

Earliness of crop maturity, by the mean maturity date (MMD) formula from multiple harvests of seedcotton from each plot (Christidis and Harrison, 1955).

Stormproofness, subjectively, how tightly the fiber adhered to the carpel walls of the dry bolls. The seedcotton was removed by hand from 25 bolls of each plot. As the seedcotton was removed from each boll, a value from 1 to 3 was assigned. A value of 1 (fiber tightly adhered to the carpel wall, fiber very difficult to remove from the boll) was stormproof and a value of 3 (very little, if any, fiber adherence to carpel wall, easily removed from the boll) was nonstormproof. The mean value from the 25 bolls represented the stormproof value assigned to a plot.

Lint percentage, calculated from 25-boll sample as:

$$\frac{\text{wt of lint}}{\text{wt of seedcotton}} \times 100$$

Lint index, the weight of lint (g) from 100 seeds.

Seed index, the weight (g) of 100 seeds.

These characters were analyzed by the use of orthogonal comparisons based on the fiber length and fineness groups (Ostle, 1963). If an orthogonal comparison was statistically significant, it indicated that the character was associated with either fiber length or fineness. The degree of association was estimated by calculating simple correlation coefficients (r) between fiber length and fineness and each of the other characters measured for parental and selected lines.

RESULTS AND DISCUSSION

Variation among the parental lines used to generate the composite-cross population was significant for all characters measured (Table 1). NR-AHA had the coarsest fiber and H 257 had the longest fiber. CA 398 had the finest fiber and Gregg 35 had the shortest fiber.

Significant genetic variance for most characters still existed among the selected lines within the fiber groups (Table 2). The short-fine lines retained variability in fiber length, and all groups, with the exception of the long-fine, were variable in fiber fineness. No group varied in earliness of crop maturity (MMD), but all groups had significant variation in fiber elongation and lint percentage. Seed index varied in all but the long-fine group. Fiber strength, stormproofness, and lint index varied significantly in both coarse-fibered groups but not in the fine-fibered groups. Lint yield varied only among the short-fibered lines.

Selection separated the material into four discrete groups (Table 3). The long-coarse and long-fine groups were not statistically different in fiber length, but the short-coarse and short-fine groups did differ in length. Each of the groups was significantly different in fiber fineness. Significant differences also occurred among the groups for each of the other characters measured.

Orthogonal comparisons provided measurements of association between either fiber length or fineness and other agronomic characters (Table 3). Associated with selection for long-fiber were fine fiber, low fiber elongation, low lint yields, low lint percentage, stormproofness, and large seeds. The coarse-fiber groups were associated with high fiber strength, low fiber elongation, lateness of crop maturity, nonstormproofness, low lint percent, high lint index, and large seeds.

Correlation coefficients calculated for the parental and selected lines, were used to estimate the changes

Table 3. Character means and orthogonal comparisons from the fiber groups.

	Character									
Groups	Fiber length	Fiber fineness	Fiber strength	Fiber elongation	Lint yield	MMD	Storm-proofness	Lint, %	Lint index	Seed index
Long-coarse	1.09 a*	3.8 b	19.1 a	7.9 c	481 b	165 a	1.7 b	33.7 d	6.2 a	12.1 a
Long-fine	1.07 a	3.1 d	17.5 b	8.8 b	482 b	164 a	1.2 c	34.8 c	5.8 c	10.9 b
Short-coarse	0.96 c	4.2 a	19.3 a	8.2 c	526 ab	166 a	2.2 a	35.9 b	6.0 b	10.5 c
Short-fine	1.00 b	3.4 c	17.3 b	9.7 a	559 a	161 b	1.4 c	36.6 a	6.0 b	10.3 c
Long	1.08 a†	3.5 a	18.3 a	8.3 b	482 b	165 a	1.5 b	34.3 b	6.0 a	11.5 a
Short	0.98 b	3.8 b	18.3 a	8.9 a	542 a	163 a	1.8 a	36.3 a	6.0 a	10.6 b
Coarse	1.03 a	4.0 a	19.2 a	8.0 a	504 a	166 a	2.0 a	34.8 b	6.1 a	11.3 a
Fine	1.03 a	3.2 b	17.4 b	9.3 b	521 a	162 b	1.3 b	35.7 a	5.9 b	10.6 b

* Means within columns followed by different letters are statistically different at the 0.05 level, according to a Duncan's new multiple range test. † Means within columns followed by different letters are significantly different at the 0.05 probability level based on F test of orthogonal comparison.

Table 4. Correlation coefficients between fiber length and fineness and the other agronomic characters for the parental and selected lines.

	Fiber length		Fiber fineness	
Character	Parents†	Lines	Parents	Lines
Fiber strength	-0.17	-0.12	0.59**	0.88**
Fiber elongation	-0.14	-0.16	-0.39	-0.65**
Lint yield	-0.68**	-0.40**	-0.07	-0.12
Earliness	0.53*	0.05	-0.21	0.33**
Stormproofness	-0.33	-0.56**	0.54*	0.87**
Lint, %	-0.74**	-0.75**	0.18	0.13
Lint index	-0.52*	0.20	0.85**	0.43**
Seed index	0.17	0.79**	0.68**	0.10

*, ** Statistically significant at the 0.05 and 0.01 probability levels, respectively.
† Number of parental cultivars was 18 and lines within fiber groups was 120.

that occurred in character relationships during selection. In the parental lines, fiber length was significantly correlated with lint yield, earliness of crop maturity, lint percentage, and lint index (Table 4). In the selected lines, the correlations were significant between fiber length and lint yield, stormproofness, lint percentage, and seed index. A significant association between fiber length and lint percentage occurred in the parental lines, but not with seed index. Lint percentage is a function of seed index and lint index, and will increase if either lint index increases or seed index decreases. In the parental lines, the long fiber-low lint percentage association appeared to be related to reduced lint index; however, the association between fiber length and lint index was negative and significant in the parents and positive and nonsignificant in the selected lines. Thus, selection for longer fibers under nonirrigated conditions apparently will significantly increase seed index and slightly increase lint index, but the net result will be lower lint percentage.

The negative relationship between fiber length and lint yield in the parents persisted throughout the selection process. The correlation between fiber length and stormproofness was not significant in the parental population, but was highly significant in the selected lines.

Another difference noted between the parental and selected lines was the fiber length-earliness of crop maturity relationship. Longer fiber was significantly associated with lateness of maturity in the parental population, whereas the correlation was nonsignificant in the selected lines. Fiber length was not correlated with either fiber strength or elongation in either the parental or the selected lines.

In the parental lines, fiber fineness was significantly correlated with fiber strength, stormproofness, lint index, and seed index (Table 4). In the selected lines, fiber fineness was associated with fiber strength and elongation, earliness of crop maturity, stormproofness, and lint index. Fiber strength, stormproofness, and lint index had the closest relationship to fiber fineness in both the parental and selected lines. Coarse fibers were associated with high fiber strength, and fine fibers were associated with stormproofness. A negative relationship existed between fiber fineness and fiber elongation in both the parental and selected lines, but was significant only in the selected lines. The relationship between fiber fineness and earliness of crop maturity changed from an insignificant negative correlation in the parental cultivars to a highly significant positive correlation in the selected lines. In the parents, a strong, positive correlation was found between fiber fineness and both lint and seed index. In the selected lines, the lint index correlation was significant, but the seed index relationship was not. Fiber fineness was not significantly correlated with lint yield or lint percentage in either the parental or selected lines.

A potential problem associated with the interpretation of the data from this study was that some genetic correlations or linkage relationships remained intact in the selected lines because of inadequate opportunities for genetic recombination. Miller and Rawlings (1967) have shown that in cotton repeated intermating is required to allow random gene recombinations. Comparisons of the correlation coefficients between the parental and selected lines showed that the associations between fiber length and both lint yield and lint percentage did not change, and that the associations between fiber fineness and both fiber strength and lint index remained intact. However, four correlations with both fiber length and fiber fineness changed in either the intensity or the direction of the relationship. Those relationships that changed from the parental to the selected lines were the associations between fiber length and earliness of crop maturity, stormproofness, lint index, and seed index. The relationships between fiber fineness and fiber elongation, earliness of crop maturity, stormproofness, and seed index also changed during the selection process if 18 samples of the parents provided a true measure of these relationships.

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