INHERITANCE OF FIBER LENGTH IN TWO MUTANTS OF COTTON

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Abstract

The relatively short fibers of many varieties of cotton (*Gossypium hirsutum* L.) adapted to Texas limit the profitability and utilization of cotton in this state. Two M_5 lines (TTU 202-1107-B and TTU 271-2155-C) selected for improved fiber length were crossed with two cultivars (Explorer and SC 9023) adapted to the Texas High Plains. The parents, F_1 and F_2 of each cross were grown at Lubbock, TX in 1999 and fiber from individual plants harvested. Duplicate estimates of fiber length were determined using High Volume Instrument (HVI) analyses. Despite adverse environmental conditions during fiber elongation in 1999, the mutant lines had an average fiber length 0.14 inches (3.5 mm) longer than the adapted cultivars. An average of 29.5% of the individual plants of the four F_2 populations had fiber length that exceeded 1.19 inches (30.2 mm). All four F_2 populations had significant, positive correlations between fiber length and fiber strength r = 0.34 ** to r = 0.61 **). These results indicate that TTU 202-1107-B and TTU 271-2155-C could be useful germplasm to improve fiber length of commercial cotton cultivars adapted to short growing season areas.

Introduction

Over 20% of U.S. cotton (*Gossypium hirsutum* L.) production occurs on the High Plains of Texas (Cotton Incorporated, 1999). The 2.5 million bales grown in this region in 1998 had an average fiber length of only 1.04 inches which reduced the profitability and utilization of this cotton crop. Texas cotton growers lost an estimated $60 million in short staple discounts in marketing the 1998 cotton crop (Anderson, 2000). Development of cotton cultivars with improved fiber length and equivalent yield potential of historic cultivars would enhance the economic competitiveness of our growers and improve acceptance of High Plains Cotton with textile manufacturers.

Genetic studies have shown fiber length in cotton is a quantitative trait thought to be controlled by two or more major genes which have not been identified (Meredith, 1984). Heritability estimates for fiber length have ranged from $h^2 = 0.23$ to $h^2 = 0.81$ depending upon the genetic background and the environment where this critical fiber trait was evaluated (Meredith, 1984; Konoplya et al, 1974; Simongulyan and Kosba, 1975). Recent research has shown that selection for improved fiber length with High Volume Instrument (HVI) analyses was as effective as selection with conventional fiber testing techniques (Latimer et al, 1996; May and Jividen,1999).

Historically, cotton breeding programs used intraspecific and interspecific crosses to improve fiber quality traits such as fiber length in cultivars adapted to short growing season areas (Meredith, 1984). Conventional improvement programs would often require several years and additional crosses to recover lines with improved fiber characteristics and competitive yields under short growing seasons conditions. Consequently, improvement of fiber quality in these cultivars has been slow. Over the past decade, breeders have had the opportunity to use transformation to improve fiber quality without impacting the yield potential of short season cultivars. The lack of identified genes which could improve fiber quality combined with the expense and time required for such a program have limited progress. Over the past few months, concern of consumers on the safety of "Genetically Modified Organism" has reduced interest in development of transgenic cotton cultivars with improved fiber quality.

Mutagenesis has the potential to modify a relatively simply inherited trait such as fiber length without impacting the yield or adaptation of the original cultivar. However, this technique has not been commonly used by U.S. cotton breeders because of the need to screen large populations and lack of successful examples of mutagenesis in cotton. Chemical mutagenesis was used to develop two M_5 lines (TTU 202 and TTU 271) with improved fiber length in a short season adapted cultivar (Paymaster HS 200) (Auld, et al, 1998). These lines have produced fiber 8 to 9% longer and 5% stronger than HS 200 at Lubbock, TX. The purpose of our studies was to determine if the increased fiber length in these lines could be transmitted to progeny by sexual hybridization and to determine the inheritance of this trait.

In 1997, crosses were made at Lubbock, TX between two cultivars adapted to the Texas High Plains (SC 9023 and Explorer) and two M_5 mutants selected for increased fiber length (TTU 202 and TTU 271). The F_1 generation was advanced to the F_2 in 1998. The four parents, four F_1 populations and four F_2 populations were planted on 20 May in 1999 in rows spaced 1m apart. The plants were furrow irrigated with 7.7 inches (196 mm) of water to supplement 19.4 inches (494 mm) of precipitation during the growing season (May 1 - Nov. 30). Plants were fertilized with 80 lbs. N/acre (90kg N/ha) and 20 lbs. P/acre (22 kg P/ha) on 17 June. In November, fiber was harvested and ginned from 10 plants of each parent and F_1 population, as well as 75 plants of each F_2 population. Fiber quality was determined using HVI analyses at the Texas Tech University - International Textile Center using single determinations for micronaire and

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:518-520 (2000)
National Cotton Council, Memphis TN

duplicate determinations for fiber length and strength. Plants with less than 12g of fiber were not included in the analyses.

Discussion

Adverse environmental conditions during fiber elongation at Lubbock, TX during the 1999 growing season reduced fiber length of all the lines evaluated in this study (Fig. 1). However, the difference in average fiber length of the two adapted cultivars (Explorer and SC 9023) was 0.14 (3.5 mm) inches shorter than the average fiber length of the two M_5 lines (TTU 202 and TTU 271) compared to 0.08 (2.0 mm) inches in 1997 and 0.10 (2.5 mm) inches in 1998. Incorporation of the increased fiber length trait available in these mutants into commercial cultivars could have avoided severe fiber quality problems which have cost growers on the Texas High Plains millions of dollars in both 1998 and 1999.

Both Explorer and SC 9023 produced average fiber length of 1.02 (25.9 mm) inches or less while TTU 202 and TTU 271 had average fiber length of 1.16 (29.5 mm) and 1.14 (29.0 mm) inches, respectively (Table 1). The plants in three of the four F_1 populations produced average fiber lengths intermediate to the parents. The F_1 population of Explorer X TTU 271 had an average fiber length similar to Explorer. All four of the F_2 populations had continuous distributions that were skewed toward increased fiber length. The lack of discreet phenotypic classes in the F_2 populations prevented the testing of qualitative phenotypic ratios. Three of the four F_2 populations had transgressive segregation for increased fiber length. The percent of individual F_2 plants with average fiber length greater than 1.19 (30.2 mm) inches ranged from 14 to 57% across the four F_2 populations. The relatively high proportion of F_2 plants that equaled or exceeded the long fiber mutants (Ave. = 29.5%) indicated that a relatively small number of genes controlled the increased fiber length observed in these crosses. This would agree with earlier work that suggested as few as two major genes control fiber length in cotton (Meredith, 1984). Phenotypic analyses of the cross between TTU 202 and TTU 271 will allow us to determine if the same gene or genes are responsible for increased fiber length in both mutants.

The four parents evaluated in these crosses had minimal differences in other fiber quality traits such as micronaire and strength. It was interesting to note that fiber length and fiber strength had positive and significant correlation coefficients in all four of the F_2 populations (Table 2). The positive association between fiber length and strength agrees with earlier research (Kloth,1998). This would indicate that breeders could select simultaneously in crosses with these mutants for both fiber length and strength. The two mutant lines (TTU 202-1107-B and TTU 271-2155-C) with enhanced fiber length will be formally released in Crop Science in 1999. Use of these lines may allow cotton breeders to quickly increase fiber length in short growing season cultivars.

Acknowledgment

Funding for this research was provided by the Texas Tech University - PSS Research Line Item and the Texas A&M University - TxCOT Program.

Bob Dumas, Brownfield Seed and Delinting Company; Jim Morris, Delta Pine Land Company; Richard Sheetz, Paymaster Cottonseed; Dilbert Hess, SeedCo Corporation; Steve Calhoun, Stoneville Texas, Inc.; Jane Dever, AgrEvo, USA; Tommy Thrash, Associated Farmers Delinting, Inc.; Pauline Williams, Texas Tech University - International Textile Center; as well as David Becker; Scott Moffett; Amber Basinger; and Cory Artho of Texas Tech University - Plant and Soil Science Department contributed to this research.

References

Anderson, C. 2000. Personal Communications. Dept. of Ag. Economics. Texas A&M University. College Station, TX.

Auld, D.L., M.D. Ethridge, J.K. Dever and P.D. Dotray. 1998. Chemical mutagenesis as a tool in cotton improvement. pp. 550-551. *In* P. Dugger and D.A. Richter (eds.) Proc. Beltwide Cotton Conf. San Diego, CA. 5-9 Jan. Natl. Cotton Council. Memphis, TN.

Cotton Incorporated. 1999. Final Report - Fiber Quality. http://www.cottoninc.com

Kloth, R.H. 1998. Analyses of commonality for traits of cotton fiber. Journal of Cotton Science. 2:17-22.

Konoplya, S.P., V.N. Fursov, A.A. Druzhkov and G.N. Nuryeva. 1974. Heritability of Several Quantitive Characters in Cotton. Soviet Genetics 10:1462-64.

Latimer, S.L., T.P. Wallace and D.S. Calhoun. 1996. Cotton breeding: high volume instruments versus conventional fiber quality testing. p. 1681. *In* P. Dugger and D.A. Richter (eds.) Proc. Belt. Cotton. Res. Conf., New Orleans, LA. 9-12 Jan. Natl. Cotton Council. Memphis, TN.

May, O.L. and G.M. Jividen. 1999. Genetic modification of cotton fiber properties measured by single and high volume instruments. Crop Sci. 39:328-333.

Meredith, W.R. Jr. 1984. Quantitative genetics. pp. 131-150. *In* R.J. Kohel and C.F. Lewis (ed.) Cotton. ASA, CSSA, and SSSA. Agronomy Monograph No. 24. Madison, WI.

Simongulyan, N.G. and Z.A.M. Kosba. 1975. Heritability and Genetic Correlations in Cotton. Soviet Genetics 11:19-23.

Table 1. HVI analyses of fiber length of four parents, four F_1 and four F_2 populations of cotton grown at Lubbock TX in 1999.

		Fiber Length		
Entry	**Plants**	**Ave.**	**Std. Dev.**	**Range**
	no.	- - - - - - - - inches	- - - - - - - -	
Parents:				
Explorer	10	1.02	0.04	0.95-1.06
SC 9023	9	1.01	0.07	0.87-1.09
TTU 202	9	1.16	0.06	1.06-1.24
TTU 271	10	1.14	0.06	1.04-1.20
F_1 Populations:				
Explorer X TTU 202	9	1.06	0.04	0.96-1.10
Explorer X TTU 271	3	1.02	0.03	0.99-1.05
SC 9034 X TTU 202	10	1.12	0.06	1.05-1.20
SC 9023 X TTU 271	4	1.04	0.03	1.00-1.08
F_2 Populations:				
Explorer X TTU 202	68	1.13	0.07	0.96-1.29
Explorer X TTU 271	71	1.14	0.06	0.99-1.24
SC 9023 X TTU 202	70	1.18	0.05	1.04-1.28
SC 9023 X TTU 271	68	1.10	0.08	0.92-1.26

Table 2. Correlation coefficients of fiber length and strength in four F_2 populations of cotton grown at Lubbock, TX in 1999.

Cross	**Plants Evaluated**	**Correlation Coefficients**
	- no. -	- - - - r - - - -
SC 9023 X TTU 202	70	0.34 **
SC 9023 X TTU 271	64	0.61 **
Explorer X TTU 202	68	0.59 **
Explorer X TTU 271	71	0.48 **

** significant at the 0.01 level of probability

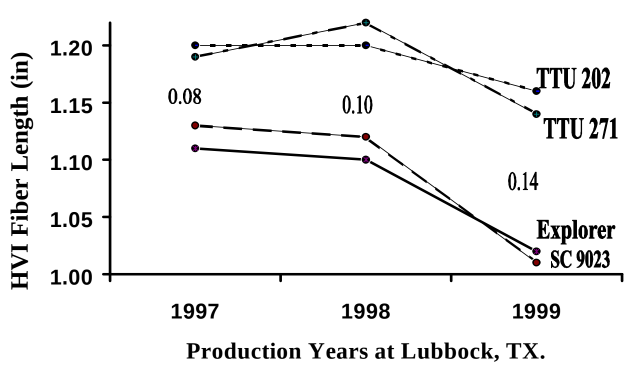

Figure 1. Fiber length of two mutants (TTU 202 and TTU 271) and two commercial cultivars (Explorer and SC 9023) grown at Lubbock, TX in 1997, 1998, and 1999.