2004 BELTWIDE COTTON CONFERENCES, SAN ANTONIO, TX – JANUARY 5-9

INCORPORATION OF ACALA AND PIMA QUALITY INTO COTTON VARIETIES ADAPTED TO THE TEXAS SOUTH PLAINS

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Abstract

The fiber length of cotton varieties grown across the state of Texas has historically reduced the price received in both domestic and international markets. The future of the Texas cotton industry is dependent upon the development of commercial varieties that produce superior fiber quality and commercially competitive lint yields. Mutagenesis has allowed us to quickly incorporate superior lint quality into cotton varieties adapted to the rigorous condition of the Texas High Plains. These enhanced fiber quality mutants look almost identical to the original varieties and have the same relative maturity. We also used these mutants in crosses with high fiber quality germplasm populations to simultaneously improve lint yield and quality. The lines with enhancement in fiber quality developed throughout this program will allow our growers to compete in both domestic and export markets previously reserved for Acala and Pima cotton varieties.

Introduction

There is an increased emphasis on growing cotton varieties whose fiber meets or exceeds the minimal standards of the export market. To be considered as “Export Class A” a bale must have an HVI analysis in which Micronaire is between 3.5 and 4.9; stable length of 35/32 or greater; and a minimum strength of 26 g/tex (Watson, 2002). Cottons failing to meet these standards are sold at a substantial discount in foreign markets. However, only 35% of the 2001 Texas cotton crop met minimum export staple length (USDA – Ag Marketing Service, 2002). Of the 2.55 million cotton bales analyzed at the Lamesa and Lubbock classing offices in 2001, less than 30% had a staple length of 35/32 or greater. Varieties with improved fiber length must be developed or Texas cotton will be as severely penalized in export markets as it historically has been in domestic textile manufacturing markets.

Chemical mutagenesis has been shown to be an effective way to enhance fiber quality in cotton without diluting either the short season adaptation or storm-proof qualities of existing varieties (Auld, et al., 1998). This process was used to develop TTU 202-1107-B and TTU 271-2155-C, which were distributed as public germplasm lines to over 40 breeders across the U.S. (Auld et al., 2000). These lines have also found a successful home as commercial varieties in the Texas High Plains' organic cotton market where a substantial premium is paid for high quality fiber grown from non-transgenic varieties. In trials conducted in 2001, several mutants were identified that had HVI fiber lengths exceeding 1.20 inches and strength values exceeding 34 g/tex. Several of these mutants also produced lint yields in excess of two bales per acre under irrigated conditions. Several of these lines produced fiber quality exceeding that expected of Acala varieties and approaching length and strength standards of Pima cotton. Use of these lines in developing future varieties will play a critical role in ensuring Texas cotton growers receive a premium in both domestic and export markets while optimizing their profits with high lint yields.

In recent years, major seed companies have obtained plant patents as well as PVP (Plant Variety Protection) for new commercial varieties. PVP protection allowed breeders to make crosses with varieties developed in other programs. However, Plant Patent Protection prevents breeder from using patented varieties in crosses to develop new varieties (Nolan, 2003). The increasing use of Plant Patents in cotton will greatly restrict the movement of new germplasm between public and private cotton breeding programs. This has placed an urgent need for the development of broad-based germplasm populations that combine high lint yield with enhanced fiber quality. These germplasm populations need to be developed using parental material that provides both private and public breeders the “greatest freedom to operate.” Since 1998, Texas Tech University has used chemical mutagenesis for fiber quality enhancement in combination with conventional breeding techniques to develop the public germplasm populations and elite lines necessary to keep the cotton growers of Texas globally competitive.

Chemical Mutagenesis

During 2001 and 2002, 19 M_5 lines were compared to six check cultivars at Lubbock, New Deal, and College Station, TX for fiber quality and lint yield. The mutants were derived from chemical mutagenesis of the commercial varieties Holland 338, SC 9023, Sphinx, Tejas, and Atlas. In 2001, 54 M_6 space plants were selected from several M_5 lines based on lint yield, fiber length, and fiber strength. One hundred and forty-four individual M_7 lines were evaluated at Lubbock, TX during the 2002 growing season and thirty-one of these lines were evaluated in the 2003 growing season at Lubbock, TX, under drip irrigation. Based on these results, the five best M_7 lines selected on the basis of 1) lint yield; 2) lint yield + HVI fiber length; and 3) HVI fiber length and strength were compared (Table 1). Our results showed that it was possible to select M_7 lines with excellent lint yields on the basis of either lint yield or the combination of lint yield and enhanced fiber length. However, when selecting for enhanced HVI length and strength, there was almost a 200 lb. per acre decline in lint yield. Selected M_7 lines from Sphinx, Tejas, and Holland 338 had HVI fiber length equivalent to Fiber Max 958, and Fiber Max 989 with higher or equivalent lint yields. Of particular interest was the performance of the M_7 lines derived from Hol 338-276, which segregated for both fiber length and strength. Phenotypic observations made during the 2003 growing season and conversations with the breeders of the original Holland 338 cultivar, indicate this line may actually be the result of a spontaneous cross with a Sea Island accession of *G. barbadense*. The pedigree selection program used to identify stable mutants may have serendipitously allowed us to develop stable interspecific lines from the M_3 line Holland 338-276, which carries unique alleles for fiber quality. These lines offer tremendous potential for improving fiber quality produced on the Texas South Plains.

Acala Crosses

While at New Mexico State University, Dr. Roy Cantrell crossed two high fiber quality mutants TTU 202 and TTU 1722, which were developed by Texas Tech University with Acala 1517-95 and NMSU 24052. From 2000 to 2003, these populations were advanced using single plant selection in a pedigree breeding program that emphasized lint yield, HVI fiber quality, and enhanced storm proofness (Figure 1). In 2002, six individual F_4 plants harvested from 29 entries with good lint yield and storm-proofness at Lubbock, TX, were evaluated for HVI fiber quality (Table 2). The nineteen F_5 elite lines selected plus 56 individual plants were evaluated at Lubbock in 2003. The crosses between the TTU mutants and Acala quality parents have generated lines that produce excellent lint yields and good fiber quality on the South Plains of Texas. Selected F_6 lines from this program have HVI fiber length in excess of 1.30 inches and HVI fiber strength greater than 36 g/tex (Table 3).

Superior Fiber Quality Crosses

In 2002, additional crosses were made to incorporate the lint yield and fiber quality of 18 M_6 lines with seven germplasm populations. Dr. Cantrell at NMSU provided seed Acala 1517-99 and NM 24016 for these crosses, while Dr. May at University of Georgia provided seed of PD 94042. Dr. Percy at the USDA-ARS facility in Maricopa, AZ provided seed of 89590 and 8810. The last two parents, TTU 202-1107B and TTU 271-2155C were germplasm releases of our own program at Texas Tech University. A total of 154 combinations were made and individual F_2 plants were harvested at Lubbock, TX in the fall of 2003. Simultaneous selection for lint yield and superior fiber quality during the segregating generations of these crosses should allow us to develop lines which consistently produce fiber length in excess of 1.35 inches and HVI strength over 38 g/tex.

Conclusion

The combination of mutagenesis; an aggressive program of hybridization, and the identification of interspecific lines have allowed us to develop an exciting germplasm base at Texas Tech University. This material is generating elite lines with excellent lint yields and superior fiber quality. Utilization of this material as germplasm or commercial varieties could help ensure the continued competitiveness of Texas South Plains cotton in both domestic and export cotton markets.

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Table 1. Lint yield of the five top M_7 lines selected for 1) lint yield; 2) lint yield and HVI fiber length; and 3) HVI fiber length and strength in comparison to six commercial cultivars of cotton when grown at Lubbock, TX, in 2002 and 2003.

Selection Criteria: Entry	Lint Yield	HVI Fiber Length		
		Length	Strength	Micronaire
	- lbs/acre -	- in. -	- g/tex -	
Lint Yield:				
Hol 338-276-1-4	1332	1.15	33.1	4.6
Sphinx 11-5-9	1290	1.15	31.3	4.5
Sphinx 299-3-3	1252	1.11	32.3	5.0
SC 9023-155-1-3	1021	1.17	31.7	4.9
Tejas 94-5-3	1226	1.14	32.1	4.2
Ave.	**1224**	**1.14**	**32.1**	**4.6**
Lint Yield + Length:				
Hol 338-276-1-3	1299	1.25	34.7	4.3
Tejas 94-6-6	1331	1.19	31.4	4.6
Tejas 94-2-2	1283	1.19	31.4	4.7
Tejas 6	1211	1.19	31.0	4.4
Sphinx 299-5-7	1207	1.20	32.9	4.6
Ave.	**1266**	**1.20**	**32.3**	**4.5**
Length + Strength:				
Hol 338-276-3-4	1106	1.25	37.3	4.4
Hol 338-276-2-2	1074	1.22	36.4	4.4
Hol 338-276-2-7	1080	1.25	38.1	4.3
Hol 338-276-2-4	1016	1.24	37.4	4.4
Hol 338-276-3-3	1016	1.25	38.7	4.5
Ave.	**1058**	**1.24**	**37.6**	**4.4**
Original Cultivars:				
Holland 338	1130	1.16	33.0	4.6
Tejas	1094	1.08	31.7	5.2
Sphinx	923	1.10	31.7	4.9
PM 330	1021	1.13	33.0	4.8
FM 958	963	1.19	32.7	4.7
FM 989	974	1.18	33.8	4.2
Ave.	**1018**	**1.14**	**32.7**	**4.7**
$LSD_{(0.05)}$:	353	0.04	2.9	0.3

Table 2. Lint yield, storm proofness, and HVI fiber quality for 8 selected F_5 lines and two commercial cultivars grown at Lubbock, TX, in 2002.

Entry	Lint Yield	HVI Fiber Quality			Storm Proofness[†]
		Micronaire	Length	Strength	
	-lbs/acre-		---in---	--g/tex--	Rating[†]
0817-1-3	1421	4.4	1.25	35.9	4.5
0774-3	1351	4.6	1.22	34.6	2.5
0779-1-5	1243	4.9	1.19	35.1	3.5
0775-5	1202	4.6	1.22	36.0	4.5
0808-1-6	1191	4.8	1.20	35.4	3.0
0824-1	1184	4.6	1.26	36.2	4.0
0808-2-5	1177	4.6	1.22	36.0	4.0
0817-1-6	1155	4.6	1.24	36.2	3.5
HS 200	1321	4.4	1.24	35.8	3.5
PM 330	1037	5.0	1.16	33.5	3.5
$LSD_{(0.05)}$	516	0.38	0.07	5.1	1.8

[†]Storm proofness rates as 1 = very storm proof (Stripper type) to 5 = lack of storm proofness (Picker type).

Table 3. HVI fiber quality of three F_6 individual plants selected from 8 F_5 lines in 2002 evaluated as F_6 lines at Lubbock, TX in 2003.

	HVI Quality Data		
Entry	**Micronaire**	**Length**	**Strength**
		--in--	**--g/tex--**
0774-3-3	4.3	1.34	38.0
0774-3-6	3.9	1.31	38.3
0774-3-9	4.0	1.35	37.2
Average	**4.1**	**1.33**	**37.8**
0775-5-1	4.6	1.24	35.7
0775-5-3	4.2	1.36	38.0
0775-5-8	4.3	1.25	35.0
Average	**4.4**	**1.28**	**36.2**
0779-1-5-1	3.7	1.36	38.2
0779-1-5-4	4.1	1.31	36.8
0779-1-5-7	4.5	1.26	35.8
Average	**4.1**	**1.31**	**36.9**
0808-1-6-1	4.4	1.36	40.5
0808-1-6-4	4.5	1.29	36.2
0808-1-6-7	4.8	1.28	36.6
Average	**4.6**	**1.31**	**37.8**
0808-2-5-2	4.8	1.28	35.7
0808-2-5-5	4.5	1.27	37.6
0808-2-5-7	4.4	1.29	34.9
Average	**4.6**	**1.28**	**36.1**
0817-1-3-5	4.7	1.34	34.9
0817-1-3-7	4.4	1.26	42.6
0817-1-3-8	3.9	1.28	38.2
Average	**4.3**	**1.29**	**38.6**
0817-1-6-1	4.3	1.36	34.8
0817-1-6-4	4.5	1.28	33.6
0817-1-6-7	3.8	1.44	40.8
Average	**4.2**	**1.36**	**36.4**
0824-1-2	4.2	1.34	34.7
0824-1-5	4.3	1.30	32.5
0824-1-7	4.3	1.28	36.1
Average	**4.3**	**1.31**	**34.4**

Figure 1. Selection sequence used for the incorporation of Acala fiber quality into cotton varieties adapted to the Texas South Plains.

Date / Location	Population A	Selection Sequence	Population B
1998 Las Cruces, NM	Acala 1517-95 X TTU 202 → F_1		NM 24052 X TTU 1722 → F_1
1999 Las Cruces, NM	F_2		F_2
2000 Las Cruces, NM	F_3 → 22 F_4	42 Single Plants Selected HVI Fiber Quality	F_3 → 20 F_4
2001 Lubbock, TX	22 F_4 → F_5 Lint Yield and Proofness	228 Single Plants Selected HVI Fiber Quality	16 F_4 → F_5 Lint Yield and Proofness
2002 Lubbock, TX	16 F_5 → F_6 Lint Yield and Storm Proofness	174 Single Plants Selected HVI Fiber Quality	F_5 → F_6 Lint Yield and Storm Proofness
2003 Lubbock, TX	16 F_5 lines 48 F_6 lines Lint Yield and Storm Proofness	87 Single Plants Selected HVI Fiber quality	13 F_5 lines 39 F_6 lines Lint Yield and Storm Proofness
2004		Regional and National Tests	