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RELEASE OF THREE UPLAND COTTON GERMPLASM LINES POSSESSING HIGH FIBER QUALITY

Richard Percy
USDA-ARS
Maricopa, AZ
Roy Cantrell
Cotton Incorporated
Cary, NC
Mauricio Ulloa
USDA-ARS
Shafter, CA

Abstract

Modern spinning techniques and new end uses have created demands for improved fiber quality in upland cotton. However, genetic variation available for fiber improvement is restricted in commercial upland cotton (*Gossypium hirsutum* L.), and occurs in genotypes that exhibit high levels of heat sensitivity. Three lines (AGC85, AGC208, and AGC375) possessing superior fiber length and strength characteristics and improved yield performance under heat stress environments have been developed by the USDA-ARS and Cotton Incorporated and released in 2005. All three germplasm lines originate from the cross of the commercial cultivars 'FiberMax958' and 'SG248'. Individual plant selection within early generation progeny (F_2 and F_3) was practiced under heat stress conditions at the low desert location of Maricopa, AZ in 2001 and 2002. Progeny testing was conducted in 2003 and 2004 at Maricopa, AZ and Tifton, GA, and Shafter, CA. Averaged over locations, the lint yields of AGC85 (2021 kg ha^{-1}) and AGC375 (1874 kg ha^{-1}) were equivalent to that of SG747 (1938 kg ha^{-1}), a high yield performance check. The fiber lengths (UHM) of AGC85, AGC208 and AGC375 were greater than or equal to the high fiber quality parent FiberMax958 (28.7mm). The fiber length of AGC208 was superior to that of the Acala cultivar, Phytogen 72 (29.5mm). Fiber bundle strengths of AGC85, AGC208 and AGC375 were stronger than the FiberMax 958 parent (31.4cN). Two lines, AGC85 and AGC375, exhibited fiber strength equivalent to that of Phytogen 72 (34.0cN). The lines have been made available to public and private breeders as resources for concurrent improvement of fiber quality and heat tolerance in upland cotton.

Introduction

Historically, four species of *Gossypium* have been cultivated for fiber (Brubaker et al., 1999). Of these species, the tetraploid *Gossypium hirsutum* L. and *Gossypium barbadense* L. currently dominate commercial cotton production, with *G. hirsutum* accounting for over 90% of the production. Although *G. hirsutum* dominates fiber production, modern spinning techniques and end uses have created demands for improved fiber quality in that species (McCreight, 1992; Felkner, 2001). Traits that have been identified as desirable include greater fiber strength, greater length, increased uniformity of length, and finer fiber at maturity (McCreight, 1992; Deussen, 1992). Germplasm resources currently available for fiber quality improvement frequently display excessive susceptibility to heat stress, and there is a general need for improvement in heat tolerance within *G. hirsutum*. Calhoun and Bowman (1999) report that elite genotypes have been evaluated for adequate pollen production under the hot conditions at low elevation locations in Arizona to ensure adequate performance under those conditions. However, little has been done in the way of systematic evaluation of germplasm or breeding for increased heat tolerance. In 2002 a germplasm improvement effort was initiated to simultaneously improve fiber quality and heat tolerance. The germplasm lines described here are the results of this ongoing effort.

Methods

Lines AGC85, AGC208, and AGC375 originate from the cross of the commercial cultivars 'FiberMax958' and 'SG248'. The pedigree of FiberMax958 is CS6S/Siokra S-324//Sicala V-1, and the pedigree of SG248 is Mo 89-117/'DP 5415' (Bowman el al., 2005). SG248 had been identified from prior test data as possessing good yield performance in heat stress environments. The cultivar FiberMax958 has good fiber attributes, but its performance is poor under the high temperature environments of the southwestern United States. Individual plant selection within early generation progeny (F_2 and F_3) was practiced at the low desert location of Maricopa, AZ in 2001 and 2002. The selection criterion for individual plants was primarily for fruit retention under a heat stress environment.

Reselection for fiber quality (primarily fiber length and fiber bundle strength) was made among field selected individual plants in both the F_2 and F_3 generations. Fiber samples of selected plants were analyzed using high volume instrumentation (HVI) in the Fiber Quality Laboratory of Cotton Incorporated, Cary, NC. In 2003, a total of 70 $F_{3:4}$ progeny lines were selected for evaluation in non-replicated tests at Maricopa, AZ and Tifton, GA, and a subset of 35 lines were evaluated at Shafter, CA. Lines were evaluated for yield performance and fiber quality as determined by HVI and Advanced Fiber Information System (AFIS) instrumentation. Fourteen of the 70 lines tested in 2003 were selected for further evaluation (along with seven parent and check cultivars) in replicated tests at Maricopa, AZ and Tifton, GA, and Shafter, CA in 2004. FiberMax 958 and Phytogen 72 were included in the trials as high fiber quality checks, and SG747 was included as a high yield performance check. Lines AGC85, AGC208, and AGC375 (tested under the designations FMax958/SG248-08-5, FMax958/SG248-20-8, and FMax958/SG248-37-5, respectively) were selected for release on the basis of overall agronomic and fiber performance across locations.

Results

Across locations, the lint yields of AGC85 and AGC375 exceeded the yields of the high fiber quality parent FiberMax 958 and high fiber quality check Phytogen 72 (Table 1). Lines AGC85 and AGC375 were statistically equivalent in yield to the check cultivar SG747. The lower yielding AGC208 produced an across location yield equivalent to its FiberMax 958 parent and superior to the high fiber quality check cultivar Phytogen 72. Under the heat stress environment of Maricopa, AZ, all three AGC lines out-yielded the heat sensitive lines FiberMax 958 and Phytogen 72; and line AGC85 was equivalent in yield to the high yielding, heat tolerant cultivar SG747. Poor yield differentiation was obtained at the Shafter, CA location. All three of the AGC lines were statistically equivalent in yield to the locally adapted high fiber quality cultivar Phytogen 72 in the Shafter test. Among the AGC lines, AGC85 consistently produced the highest yield and AGC208 the lowest yield at the three locations.

Lint percent, a yield component, was highest in the check cultivar SG747 across locations. Lines AGC85 and AGC375 were statistically equivalent to their parent cultivar FiberMax 958, and superior to Phytogen 72 for lint percent. Line AGC208 produced a lower lint percent, equivalent to Phytogen 72, across locations. At the Tifton, GA and Shafter, CA locations, AGC85 and AGC375 produced lint percentages equivalent to both the parent cultivar FiberMax 958 and the check cultivar SG747. Among AGC lines, AGC375 consistently produced the highest lint percent and AGC208 the lowest lint percent in the three tests.

Table 1. Lint percentages and fiber yields of the advanced progeny evaluation across locations and at the individual Tifton, GA, Maricopa, AZ and Shafter, CA locations in 2004.

	Fiber Yield (lbs/ac.)				Lt%			
Designation	**Across**	**GA**	**AZ**	**CA**	**Across**	**GA**	**AZ**	**CA**
AGC85	1805	1606	1984	1825	42.2	42.0	41.1	43.6
AGC208	1564	1275	1729	1687	39.9	41.2	38.6	40.0
AGC375	1673	1454	1755	1811	43.4	42.8	43.4	44.1
FiberMax 958	1474	1374	1523	1524	42.7	43.3	41.2	43.6
Phytogen 72	1309	814	1413	1702	40.8	40.7	40.5	41.2
SG747	1730	1183	1999	2008	44.0	43.3	44.3	44.4
LSD[1]	148	175	179	375	0.7	1.3	1	1.1

[1]Reported least significant differences are from a means test of 21 entries, from which the above six entries have been extracted.

Table 2. Pollen sterility rating and fruit retention,of entries in the advanced progeny evaluation at Maricopa, AZ in 2004.

Designation	**Pollen sterility[1]**	**Fruit retention (%)**
AGC85	1.84	25.1
AGC208	2.03	26.4

AGC375	1.78	29.8
FiberMax 958	2.80	.
Maxxa	2.63	18.1
Phytogen 72	2.73	18.4
SG 248	1.46	25.8
SG747	1.31	.
LSD[2]	0.39	3.1

[1]Average of pollen sterility ratings taken on 7/30, 8/3, and 8/10.
[2]Reported least significant differences are from a means test of 21 entries, from which the above has been extracted.

Ratings of pollen sterility due to heat stress were recorded on three dates at the Maricopa location in 2004 (Table 2). Averaged across three dates, lines AGC85, AGC208, and AGC375 exhibited pollen sterility rates slightly higher than that of SG747, but significantly lower that those of the high fiber quality cultivars Fibermax 958 and Phytogen 72. Fruit retention rates on the first and second fruiting-branch positions were obtained from plant mapping at season's end. Fruit retention rates were significantly higher in the SG248 parent and the AGC lines than in the high fiber quality check cultivars Maxxa and Phytogen 72. Line AGC375 had a fruit retention rate that exceeded the SG248 parent and AGC208 and AGC85.

Fiber micronaire was high in the Maricopa, AZ and Shafter, CA tests, leading to high micronaire measurements across locations (Table 3). Across locations and within locations, the SG747 check cultivar consistently produced the highest micronaire. At the individual locations, lines AGC85, AGC208, and AGC375 produced fiber micronaires that were equivalent to or finer than that of their parent cultivar FM 958 or the high fiber quality check Phytogen 72. Among the AGC lines, AGC208 produced the lowest micronaire by rank. Fineness measurements, made by AFIS, did not distinguish between lines as well as micronaire did (Table 4). Among the AGC lines, AGC208 was the finest fibered by rank. The fiber of AGC208 also was finer than that of Phytogen 72. All AGC lines were significantly finer than the SG747 check.

Table 3. Fiber micronaire, length, and strength of entries in the advanced progeny evaluation across locations and at the individual Tifton, GA, Maricopa, AZ, and Shafter, CA locations in 2004.

	Micronaire				Length (UHM)				Strength (g/tex)			
Designation	**Acr.**	**GA**	**AZ**	**CA**	**Acr.**	**GA**	**AZ**	**CA**	**Acr.**	**GA**	**AZ**	**CA**
AGC85	5.28	4.58	5.38	5.88	1.15	1.18	1.18	1.10	34.0	35.5	34.5	32.0
AGC208	4.95	4.48	5.10	5.28	1.19	1.23	1.22	1.12	33.6	35.8	35.3	29.7
AGC375	5.33	4.75	5.38	5.85	1.16	1.21	1.16	1.11	34.3	36.8	34.3	32.0
FM 928	5.30	4.83	5.43	5.65	1.13	1.15	1.14	1.09	32.0	33.8	33.4	28.7
Phytogen 72	5.28	4.83	5.33	5.68	1.16	1.18	1.18	1.11	34.7	34.3	35.8	33.9
SG747	5.83	5.25	6.00	6.25	1.09	1.14	1.07	1.06	28.1	27.5	28.8	28.0
LSD[1]	0.15	0.24	0.16	0.26	0.03	0.04	0.04	0.04	1.1	1.7	1.4	1.7

[1]Reported least significant differences are from a means test of 21 entries, from which the above six entries have been extracted.

Table 4. AFIS fiber length, short fiber content, and fiber fineness of entries in the advanced progeny evaluation across locations and at the individual Tifton, GA, Maricopa, AZ, and Shafter, CA locations in 2004.

	Length L2.5%(n)				Short Fiber SFC(n)				Fineness millitex			
Designation	**ACR**	**GA**	**AZ**	**CA**	**ACR**	**GA**	**AZ**	**CA**	**ACR**	**GA**	**AZ**	**CA**
AGC85	1.51	1.53	1.52	1.47	23.2	23.7	25.3	20.7	181	170	183	189
AGC208	1.56	1.59	1.56	1.53	24.3	23.3	26.2	23.2	174	167	176	179
AGC375	1.53	1.58	1.53	1.49	24.9	25.4	26.9	22.4	181	169	183	191
FM958	1.46	1.50	1.47	1.41	25.3	24.6	24.2	27.2	181	174	182	186
Phytogen 72	1.53	1.55	1.56	1.49	21.9	22.4	22.2	21.0	178	171	180	184

SG747	1.40	1.46	1.39	1.35	20.3	20.1	20.7	20.2	196	185	199	205
LSD[1]	0.03	0.04	0.05	0.06	1.7	2.8	2.7	3.3	3.5	6.3	5.4	6.8

[1]Reported least significant differences are from a means test of 21 entries, from which the above six entries have been extracted.

The UHM fiber lengths of AGC208, and AGC375 exceeded that of the check cultivar SG747 at all locations and across locations (Table 3). Across locations, the UHM lengths of AGC85 and AGC375 were equivalent to those of their FM 958 parent and the fiber quality check cultivar Phytogen 72. Line AGC208 produced a UHM fiber length that exceeded that of its parent cultivar, FM 958, at Tifton, GA, Maricopa, AZ, and across locations. All UHM fiber lengths were short at the Shafter, CA location – perhaps due to water stress. The 2.5% fiber length by number measured by AFIS was in general agreement with UHM fiber lengths (Table 4). The AGC lines produced 2.5% fiber lengths that exceeded that of their FiberMax 958 parent. The 2.5% fiber lengths of all three AGC lines were statistically equivalent to that of the high fiber quality check, Phytogen 72. Short fiber contents of AGC85, AGC208, and AGC375 were equivalent to their FM958 parent at Tifton, GA and Maricopa, AZ, and across locations. In California, all AGC lines had significantly lower short fiber content than FM958. Within and across test locations, the AGC lines produced higher short fiber contents than the Phytogen 72 check.

All AGC lines, their FM958 parent, and the Phytogen 72 check exceeded SG747 in fiber strength across locations (Table 3). The AGC lines exceeded their FM958 parent in fiber strength across locations, and were equivalent in strength to the high fiber quality cultivar Phytogen 72. Among the AGC lines, AGC375 exhibited the highest fiber strength, by rank.

The Agricultural Research Service, United States Department of Agriculture and Cotton Incorporated have announced the release of AGC85, AGC208, and AGC375 possessing superior fiber length and strength characteristics and improved yield performance under heat stress environments. The lines provide public and private breeders with resources for concurrent improvement of fiber quality and heat tolerance in upland cottons for the mid-south and southeastern United States. The lines also serve as genetic resources for improving heat tolerance in Acala cottons of the southwestern and western United States.

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