DEVELOPMENT OF NEW GLANDLESS COTTON GERMPLASM

Jinfa Zhang
New Mexico State University
Las Cruces, NM
Tom Wedegaertner
Cotton Incorporated
Cary, NC
S. Ed. Hughs
USDA-ARS Southwestern Cotton Ginning Research Laboratory
Mesilla Park, NM

Abstract

There were intermittent breeding activities for glandless cotton in the U.S. before 2000. The genetic potential in yield of existing/obsolete glandless cotton germplasm may be much lower than commercial transgenic cultivars, but there is no information available. Direct selection within the germplasm may result in improvement of yield, but the yield may not be on a par with commercial cultivars. Therefore, cross breeding is needed. This paper summarized the recent breeding activities for glandless cotton at New Mexico State University, including testing of existing U.S. glandless germplasm and gernplasm introductions, direct selections from these lines, and cross breeding.

Introduction

With the growth in population, increase in drought and salinity land, and reduction of damage in Lepidoptera insects, there is a renewed interest in research and use of glandless cottonseed as food and feed products. This calls for production of glandless cotton which is devoid of toxic gossypol. However, development of glandless cotton that is comparable in yield potential with the current commercial cultivars is the prerequisite.

In the late 2000s, the Cotton Breeding Program at New Mexico State University (NMSU) initiated a glandless breeding project aiming at improving both lint yield and fiber quality. The objectives of this study were to report: (1) Yield gaps between existing glandless cotton germplasm and commercial cultivars; (2) Progress in direct selection within the existing glandless germplasm; and (3) Progress in cross breeding for high yielding glandless cotton.

Materials and Methods

A total of eight replicated field tests were conducted in Las Cruces, NM in 2010-2013. All the tests were arranged using a randomized complete block design (RCBD) with 3 replications. The plot size was 1-row × 40 ft except for 2-rows × 40 ft in 2010. In 2010, 32 entries were used including 24 commercial transgenic cultivars, 7 conventional lines, and 1 glandless Acala GLS (Dobbs and Oakley 2000). In 2012, 34 entries were used including glandless germplasm lines released by other programs and new glandless breeding lines developed from a cross between Acala 1517-08 and glandless Acala. In 2013, There were six replicated tests each with 32 entries including Acala GLS and Acala 1517-08 (Zhang et al., 2011) as controls. Glandless lines included selections from the existing lines tested in 2012 and introductions from other nations, and further selections from the lines derived from Acala 1517-08 × glandless Acala.

Seeds were planted in early May each year with a seeding rate of 3 seed/ft using a 4-row planter. Crop managements followed local recommendations. At maturity, 20 open bolls were hand harvested from each plot and ginned using a 20-saw lab gin for measurements of boll weight and lint percentage. Fiber samples were tested for fiber quality by HVI 1000 in Cotton Incorporated, Cary, NC. Seed cotton in each plot was then mechanically harvested using a 2-row picker. An analysis of variance was performed for each test and the least significant difference (LSD) was used to compare entry means. Since segregation in glandless was observed in some germplasm lines and new breeding lines, data from these entries were still included in the data analysis but not included in the reported tables here.

Results and Analysis

Yield Gaps between existing or obsolete glandless cotton and commercial cultivars

2010: As shown in Table 1, Acala GLS yielded 80% of Acala 1517-08, 71-75% of PHY 375 WRF and PHY 499

WRF, and 61-67% of FM 1740B2F, DP 1044 B2RF, FM 9170B2F and DP0912 B2RF. Similar to Acala 1517-08, GLS had long and strong fibers, and it also had the largest bolls, and strongest and finest fibers.

Table 1. Field performance of the glandless Acala GLS and commercial cotton, Las Cruces, NM, 2010.

Cultivar	LY	Lint	Boll Wt.	UHM	UI	STR	ELO	MIC	SFC
	Lb/A	%	g/boll	inch	%	g/tex	%	unit	%
FM 1740B2F	1723	48.45	5.31	1.04	81.67	27.00	5.90	5.04	8.17
DP 1044 B2RF	1723	46.07	5.03	1.08	82.47	27.70	7.37	5.12	8.60
FM 9170B2F	1704	45.92	5.58	1.11	81.07	28.53	5.63	4.50	9.50
DP0912 B2RF	1587	48.19	5.46	1.02	80.93	26.63	5.80	5.55	9.07
PHY 499 WRF	1514	45.35	5.26	1.06	82.57	28.83	7.33	5.25	8.37
PHY 375 WRF	1425	48.04	5.06	1.01	80.60	25.80	5.70	5.09	9.37
Acala 1517-08	1333	41.34	5.52	1.13	82.00	32.53	5.83	4.90	7.83
Acala GLS	1071	43.24	6.05	1.12	83.80	34.40	5.27	4.50	7.80
LSD0.05	360	3.49	0.65	0.04	1.66	1.86	0.65	0.23	1.10

LY- lint yield; UHM- upper half length; UI- uniformity index; STR- fiber strength; MIC- micronaire; SFC- short fiber content.

2012: As compared to Acala 1517-08 (Table 2), of the 14 glandless germplasm lines tested, SA1482 had 22% more seed cotton yield, followed by SA2474 (11%) and SA1113 (2%). Due to its significantly higher lint percentage, SA1482 had 26% higher lint yield. However, the other two yielded less owing to significantly lower lint percentage. Most of the lines had lower yield than Acala 1517-08. All the lines had significantly larger bolls, especially SA2474 and SA1531 had boll sizes larger than 8 g/boll. All glandless lines had significantly lower fiber length than Acala 1517-08; except for SA2474, all lines had significantly lower fiber strength; and except for three lines with significantly coarser fibers (higher micronaire), all lines had similar micronaire to Acala 1517-08.

Table 2. Field performance of glandless cotton lines and a glanded cultivar Acala 1517-08, Las Cruces, NM, 2012.

Line	SCY	LY	Boll wt	Lint	UHM	UI	STR	ELO	MIC	SFC
	Lb/A	Lb/A	g/boll	%	inch	%	g/tex	%	unit	%
SA 1482	4105	1634	6.21	40.06	1.19	84.97	33.53	5.43	4.71	6.70
SA 2474	3755	1262	8.39	33.48	1.20	84.63	36.73	4.53	4.68	7.03
SA 2245	3281	1160	7.69	35.34	1.21	84.00	33.83	4.67	4.14	7.17
SA 2455	2850	1139	6.75	39.98	1.15	83.17	30.20	5.97	4.58	7.27
SA 2454	2670	1120	6.54	41.92	1.12	83.57	29.20	6.57	4.45	7.67
SA 1113	3419	1104	5.77	32.26	1.15	84.33	28.80	6.33	4.66	7.13
SA 1531	2627	1070	8.09	40.33	1.10	83.47	30.63	6.23	5.09	7.03
SA 2248	2686	1009	6.31	37.61	1.20	83.43	33.17	5.80	4.53	7.03
SA 2475	2367	980	6.53	41.54	1.02	83.10	27.97	6.27	4.79	7.47
SA 2246	2411	905	6.89	37.23	1.18	85.30	34.77	5.70	5.04	6.67
SA 2453	2251	902	7.11	39.96	1.14	84.03	31.73	4.57	4.84	7.77
SA 3833	2640	893	5.88	33.89	1.10	84.63	29.57	6.47	4.91	6.93
SA 1620	1901	767	7.41	40.28	1.11	82.67	29.67	4.70	5.11	7.73
SA 2244	1877	739	6.30	39.38	1.11	83.40	34.30	5.40	4.77	7.30
1517-08	3368	1302	4.38	38.65	1.27	84.53	37.40	6.13	4.60	6.93
LSD0.05	979	380	0.91	1.40	0.05	1.16	2.26	0.51	0.27	0.48

SCY- seedcotton yield; LY- lint yield; UHM- upper half length; UI- uniformity index; STR- fiber strength; MIC- micronaire; SFC- short fiber content; Lb/A- pounds/acre.

2013: As shown in Table 3, Acala GLS yielded 51-75% (with average of 62-65%) seed cotton and lint of Acala 1517-08, but only 46% seedcotton of PHY 375 WRF. JACO and STV GL had 12-21% higher seed cotton yield than Acala GLS but the differences were insignificant. Both yielded 57-63% and 51-55% seed cotton of Acala 1517-08 and PHY 375WRF, respectively, and the differences were significant. Similar to the results in 2010, as compared to 1517-08, Acala GLS had significantly larger bolls, and stronger and finer fibers. It also had slightly longer fibers.

Table 3. Field performance of glandless cotton in comparison with conventional glanded cultivars, Las Cruces, NM, 2013.

Trial	Line	SCY	LY	Boll	Lint	UHM	UI	STR	ELO	MIC	SFC
		Lb/A	Lb/A	g/boll	%	inch	%	g/tex	%	unit	%
S	Acala GLS	2602	1043	6.56	40.07	1.25	85.07	36.60	4.17	4.43	6.80
	Acala 1517-08	3894	1441	5.94	37.22	1.20	84.77	35.40	5.40	4.63	6.87
	LSD0.05	540	224	0.59	2.88	0.04	1.26	1.66	0.46	0.28	0.55
T	Acala GL	2100	846	6.34	40.37	1.23	85.23	37.83	4.30	4.28	6.73
	Acala 1517-08	3642	1483	5.51	40.77	1.21	84.87	35.73	5.13	4.64	7.10
	LSD0.05	677	270	0.60	1.76	0.05	1.42	1.81	0.44	0.29	0.55
U	Acala GLS	2593	998	6.84	38.49	1.23	86.17	37.97	4.03	4.26	6.57
	Acala 1517-08	4065	1589	6.19	39.09	1.22	84.60	35.90	5.33	4.59	7.07
	LSD0.05	529	205	0.66	2.26	0.04	1.42	2.32	0.44	0.26	0.61
V	Acala GLS	2261	914	6.33	40.38	1.25	85.87	36.83	4.33	4.25	6.67
	Acala 1517-08	3018	1240	5.54	41.13	1.23	83.90	34.23	5.13	4.64	7.43
	LSD0.05	761	283	0.43	1.33	0.05	1.30	1.87	0.49	0.27	0.55
W	Acala GLS	2499	969	6.64	38.81	1.24	86.00	36.13	4.47	4.27	6.50
	Acala 1517-08	4213	1630	6.08	38.71	1.25	84.10	34.77	5.37	4.61	6.97
	Acala 1517-99	3139	1177	6.24	37.68	1.21	83.27	33.73	5.07	4.56	7.63
	JACO	2733	1001	6.66	36.58	1.15	84.43	31.23	4.13	4.82	7.13
	LSD0.05	647	252	0.47	1.47	0.04	1.06	1.45	0.47	0.25	0.59
X	Acala GLS	2061				na	na	na	na	na	na
	STV GL	2298				na	na	na	na	na	na
	JACO	2497				na	na	na	na	na	na
	Acala 1517-08	4054				na	na	na	na	na	na
	PHY 375WRF	4474				na	na	na	na	na	na
	LSD0.05	667									
Mean	Acala GLS	2353	954	6.54	39.63	1.24	85.67	37.07	4.26	4.30	6.65
	Acala 1517-08	3814	1477	5.85	39.38	1.22	84.45	35.21	5.27	4.62	7.09

SCY- seedcotton yield; LY- lint yield; UHM- upper half length; UI- uniformity index; STR- fiber strength; MIC- micronaire; SFC- short fiber content; Lb/A- pounds/acre; na- not available.

Selections within the U.S. glandless germplasm

55 selections were made from 18 obsolete U.S. glandless germplasm lines in 2012 and tested in 2013 (Table 4).

SA1113: One selection (12G3009-1/3) was made, and it (in Trial V) yielded 73% seed cotton and 69% lint of Acala GLS, and 55% seed cotton and 51% lint of Acala 1517-08. It had relatively long and strong fibers.

SA1482: Four selections (12G1027-1, 12G1027-2, 12G2013-1 and 12G2013-2) were made, and they (in Trial S and T) yielded 109-128% seed cotton and 108-123% lint of Acala GLS, and 73-86% seed cotton and 74-89% of Acala

1517-08. Two selections (12G2013-1 and 12G1027-2) yielded 82-89% lint of Acala 1517-08, but yielded 23-44% more lint than Acala GLS. Two selections had relatively long and strong fibers.

SA1531: Five selections (12G1012-1, 12G2026-1, 12G2026-2, 12G3003-1 and 12G3003-1) were made, and they (in Trial S and U) yielded 45-74% seed cotton and 44-68% lint of Acala GLS, and 29-49% seed cotton and 28-49% lint of Acala 1517-08. Except for two selections, they had fiber length of 1.14-1.15 inches and fiber strength of 30.5-31.2 g/tex.

SA2244: One selection (12G3009-1/3) was made, and it (in Trial S) yielded 57% seed cotton and 53% lint of Acala GLS, and 38% seed cotton and lint of Acala 1517-08. It had short (1.06 inches) fibers, high micronaire (5.17) and strength of 31.8 g/tex.

SA2245: Seven selections (12G1006-1, 12G1006-2, 12G1006-3, 12G2001-1/4, 12G2001-5/7, 12G3008-2, and 12G3008-3) were made, and they (in Trial S, T and V) yielded 74-121% see dcotton and 70-118% lint of Acala GLS, and 56-80% seed cotton and 48-67% lint of Acala 1517-08. Except for one selection, the selections had long (1.18-1.28 inch), strong (32.7-35.9 g/tex) and fine (micronaire of 3.95-4.49) fibers.

SA2246: Three selections (12G1010-1, 12G1010-2, and 12G2012-1) were made, and they (in Trial S and T) yielded 90-143% see dcotton and 83-129% lint of Acala GLS, and 60-82% seed cotton and 60-74% lint of Acala 1517-08. They s had relatively long (1.15-1.17 inch) and strong (33.0-34.5 g/tex) but coarse (micronaire of 5.10-5.28) fibers.

SA2247: Five selections (12G1007-1, 12G1007-2, 12G1007-3, 12G2017-1, and 12G2017-2) were made, and they (in Trial S and T) yielded 87-118% seed cotton and 78-113% lint of GLS, and 57-74% seed cotton and 53-74% lint of Acala 1517-08. All selections had fine fibers with micronaire of 3.90-4.25, and three had relatively long (1.16-1.18 inch) and strong (32.9-33.4 g/tex) fibers.

SA2248: Four selections (12G2008-1, 12G2008-2, 12G2008-3, and 12G2008-4) were made, and they (in Trial T) yielded 71-121% seed cotton and 67-99% lint of Acala GLS, and 57-74% seed cotton and 38-56% lint of Acala 1517-08. All had relatively long fibers (1.17-1.20 inch), and two selections had relatively strong (33.6-34.1 g/tex) and fine fibers (micronaire of 3.89-4.21).

SA2454: Seven selections (12G1032-1, 12G1032-2, 12G1032-3, 12G2014-1, 12G2014-2, 12G2014-3 and 12G3012-1) were made, and they (in Trial S, T, U, and V) yielded 67-113% seed cotton and 69-112% lint of Acala GLS, and 42-65% seed cotton and 41-64% lint of Acala 1517-08. All had fine fibers (3.99-4.69); four had short (1.05-1.08 inch) and weak (26.8-28.3 g/tex) fibers; and three had longer (1.16-1.20 inch) and stronger (30.3-31.7 g/tex) fibers.

SA2455: One selection (12G1021-7) was made, and it (in Trial S) yielded 127% seed cotton and 118% lint of Acala GLS, and 85% seed cotton and 86% lint of Acala 1517-08. It also had good Acala type fiber qualities.

SA 2475: One selection (12G1033-1) was made, and it (in Trial V) yielded 34% seed cotton and lint of Acala GLS, and 25-26% seed cotton and lint of Acala 1517-08. It had very short and weak fibers.

8619-7 W-18: One selection (12Y1013-1/2) was made, and it (in Trial W) yielded 98% seed cotton and lint of Acala GLS, and only 26% seed cotton and 58% lint of Acala 1517-08. It fiber was weak (29.6 g/tex).

Acala 63: Three selections (12Y1019-1, 12Y1019-1 and 12Y1039-1) were made from its two sister lines (63-74 and 63-75, and they (in Trial W) yielded 92-103% seed cotton and 77-102% lint of Acala GLS, and 54-61% seed cotton and 46-61% lint of Acala 1517-08. All of them had relatively long (1.19 inch), strong (32.1-33.5 g/tex) and fine (4.12-4.56) fibers.

G8160: One selection (12Y1015-1/2) was made, and it (in Trial W) yielded 108% seed cotton and 100% lint of Acala GLS, and 64% seed cotton and 60% lint of Acala 1517-08. It had moderate fiber quality traits.

GP205: One selection (12Y1015-1/2) was made, and it (in Trial W) yielded 117% seed cotton and 106% lint of GLS, and 69% seed cotton and 63% lint of Acala 1517-08. It had long (1.24 inch) and relatively strong (32.6 g/tex) fibers.

Greg 45-M: One selection (12Y1017-1) was made, and it (in Trial W) yielded 91% seed cotton and 88% lint of Acala GLS, and 54% seed cotton and 52% lint of Acala 1517-08. It fibers were short (1.13 inch).

US F-12: One selection (12Y1012-1) was made, and it (in Trial W) yielded 111% seed cotton and lint of la , and 66% seed cotton and lint of Acala 1517-08. It had short (1.14 inch) and weak fibers (27.2 g/tex).

Acala GLS: Seven selections were made, and they (in Trial T and W) yielded 112-144% seed cotton and 102-144% lint of Acala GLS and 66-86% seed cotton and 63-86% lint of Acala 1517-08. Two selections yielded 82-86% of Acala 1517-08, but 138-142% of Acala GLS. Most of the selections maintained the premium fiber quality of Acala GLS (1.19-1.26 inch, 33.4-36.4 g/tex and micronaire of 4.36-4.61). The results indicate that selection within Acala GLS has improved lint yields in some selections.

Table 4. Field performance of selections from existing glandless cotton germplasm, Las Cruces, NM, 2013.

Trial	Selection	Source	SCY	LY	Boll	Lint	UHM	UI	STR	ELO	MIC	SFC
			Lb/A	Lb/A	g/boll	%	inch	%	g/tex	%	unit	%
S	12G1027-2	SA1482	3341	1282	6.35	38.31	1.16	84.17	33.47	4.30	4.97	7.10
	12G1027-1	SA1482	2843	1127	5.61	39.56	1.19	85.17	33.67	4.50	4.15	6.80
	12G1012-1	SA1531	1925	707	8.40	36.88	1.15	82.67	30.53	4.77	4.62	7.73
	12G1017-1	SA2244	1477	549	6.56	37.17	1.06	83.13	31.80	4.63	5.17	6.57
	12G1006-2	SA2245	2696	864	6.58	32.04	1.23	85.33	34.93	3.77	4.47	6.83
	12G1006-1	SA2245	2472	861	7.15	34.85	1.18	83.83	33.57	4.03	4.49	7.33
	12G1006-3	SA2245	2513	844	6.66	33.57	1.25	84.73	35.03	4.37	3.96	6.90
	12G1010-1	SA2246	2391	903	6.07	37.75	1.15	85.13	33.47	5.03	5.28	6.97
	12G1010-2	SA2246	2334	861	6.11	36.89	1.17	85.30	34.17	4.93	5.10	6.93
	12G1007-3	SA2247	2871	1068	6.57	37.20	1.17	82.93	32.90	4.63	3.98	7.70
	12G1007-1	SA2247	2376	825	6.56	34.91	1.14	82.60	31.45	5.30	4.31	7.95
	12G1007-2	SA2247	2273	811	7.11	35.78	1.13	82.73	30.40	4.67	3.90	7.83
	12G1032-1	SA2454	1846	764	6.57	41.39	1.05	81.43	26.80	5.93	4.69	8.47
	12G1021-1	SA2455	3312	1234	5.67	37.18	1.23	86.40	36.27	4.53	4.44	6.50
	Acala GLS	Acala GLS	2602	1043	6.56	40.07	1.25	85.07	36.60	4.17	4.43	6.80
	1517-08	Acala 1517-08	3894	1441	5.94	37.22	1.20	84.77	35.40	5.40	4.63	6.87
	LSD0.05		540	224	0.59	2.88	0.04	1.26	1.66	0.46	0.28	0.55
T	12G2005-1	Acala GLS	2769	1137	6.40	41.00	1.22	85.50	35.57	4.40	4.37	6.63
	12G2013-1	SA1482	3113	1222	6.15	39.42	1.19	85.03	33.53	4.67	4.61	6.77
	12G2013-2	SA1482	2873	1094	6.29	38.04	1.15	84.60	32.13	3.90	4.83	6.87
	12G2001-1/4	SA2245	2544	996	6.00	39.11	1.28	85.60	35.90	4.90	4.13	6.63
	12G2001-5/7	SA2245	2039	717	6.44	35.17	1.21	84.17	32.70	4.13	3.95	7.20
	12G2012-1	SA2246	2999	1094	6.33	36.49	1.16	84.80	33.03	5.17	5.14	7.03
	12G2017-1	SA2247	2479	936	5.55	37.80	1.18	84.73	32.87	4.47	4.25	7.07
	12G2017-2	SA2247	2066	783	5.73	37.76	1.16	82.97	33.37	4.90	4.15	7.53
	12G2008-4	SA2248	2532	837	5.96	32.92	1.17	85.30	34.07	4.80	4.21	6.90
	12G2008-1	SA2248	2166	719	6.57	33.25	1.18	83.60	33.57	4.17	3.89	7.43
	12G2008-2	SA2248	1679	652	6.03	38.84	1.20	84.07	30.27	6.23	4.73	7.20
	12G2008-3	SA2248	1497	568	5.35	37.84	1.18	83.83	29.93	6.10	4.75	7.50
	12G1032-2	SA2454	2366	944	6.27	39.95	1.16	83.90	30.30	5.43	4.41	7.43
	12G2014-1	SA2454	1655	679	6.58	40.88	1.08	82.07	26.97	6.17	4.55	8.47

	12G1032-3	SA2454	1657	656	6.10	39.58	1.09	81.93	28.17	5.57	4.12	8.57
	12G2014-3	SA2454	1538	609	5.86	39.74	1.20	83.93	30.90	5.43	3.99	7.23
	Acala GLS	Acala GLS	2100	846	6.34	40.37	1.23	85.23	37.83	4.30	4.28	6.73
	1517-08	Acala 1517-08	3642	1483	5.51	40.77	1.21	84.87	35.73	5.13	4.64	7.10
	LSD0.05		677	270	0.60	1.76	0.05	1.42	1.81	0.45	0.29	0.55
U	12G2014-2	SA2454	1794	692	6.67	38.56	1.18	83.03	31.70	5.07	4.20	7.73
	12G2026-1	SA1531	1648	623	7.69	37.70	1.14	83.50	31.17	4.50	4.89	7.47
	12G3003-2	SA1531	1376	514	8.70	37.23	1.11	81.67	29.97	4.40	4.71	8.77
	12G3003-1	SA1531	1295	491	8.43	37.86	1.08	82.13	28.17	4.93	5.01	8.57
	12G2026-2	SA1531	1164	438	8.19	37.65	1.15	82.97	31.20	4.70	4.76	7.90
	Acala GLS	Acala GLS	2593	998	6.84	38.49	1.23	86.17	37.97	4.03	4.26	6.57
	1517-08	Acala 1517-08	4065	1589	6.19	39.09	1.22	84.60	35.90	5.33	4.59	7.07
	LSD0.05		529	205	0.66	2.26	0.05	1.42	2.32	0.44	0.26	0.61
V	12G3009-1/3	SA1113	1656	627	6.09	37.81	1.18	85.33	33.43	5.17	4.97	6.70
	12G3008-2	SA2245	2405	828	7.36	34.37	1.24	84.57	35.33	4.20	4.32	7.17
	12G3008-3	SA2245	1676	643	6.81	38.38	1.13	83.60	29.33	4.90	4.46	7.57
	12G3012-1	SA2454	1522	643	6.54	42.02	1.08	83.00	27.80	6.53	4.53	7.63
	12G1033-1	SA2475	772	315	6.52	40.89	1.04	81.07	27.23	5.40	4.90	8.03
	Acala GLS	Acala GLS	2261	914	6.33	40.38	1.25	85.87	36.83	4.33	4.25	6.67
	1517-08	Acala 1517-08	3018	1240	5.54	41.13	1.23	83.90	34.23	5.13	4.64	7.43
	LSD0.05		761	283	0.43	1.33	0.05	1.30	1.87	0.49	0.27	0.55
W	12Y1013-1/2	8619-7 W-81	2446	946	7.17	38.65	1.18	84.00	29.57	5.90	4.66	7.57
	12Y1018-1	Acala 63-74	2563	989	7.39	38.55	1.19	84.07	32.13	4.83	4.56	7.17
	12Y1019-1	Acala 63-75	2500	974	8.15	39.00	1.19	84.03	33.53	5.03	4.43	6.97
	12Y1039-1	Acala 63-75	2290	745	7.10	32.43	1.19	84.50	33.30	4.27	4.12	7.37
	12Y1042-1	Acala GLS	3611	1395	6.60	38.63	1.23	84.90	35.77	5.17	4.58	6.80
	12Y1045-1	Acala GLS	3460	1334	6.04	38.52	1.23	85.07	35.10	4.83	4.61	7.03
	12Y1050-1	Acala GLS	3285	1189	6.74	36.19	1.26	85.77	36.40	4.03	4.58	6.63
	12Y1048-2	Acala GLS	2808	1077	6.16	38.36	1.22	84.67	33.37	4.73	4.61	7.10
	12Y1048-1	Acala GLS	2791	1023	5.78	36.66	1.19	85.17	35.70	4.80	4.52	6.70
	12Y1040-1	Acala GLS	2449	945	6.68	38.57	1.22	86.20	35.37	4.43	4.36	6.60
	12Y1033-1	BOY	2301	741	5.78	32.12	1.06	80.37	24.40	3.67	4.31	10.47
	12Y1037-1	French 86-1	2560	1036	8.05	40.26	1.18	84.43	30.77	4.73	4.89	7.17
	12Y1015-1/2	G8160	2688	970	6.88	36.20	1.17	84.63	31.30	4.37	4.74	7.17
	12Y1035-1	GP 205	2915	1029	6.88	35.26	1.24	83.47	32.60	3.37	4.55	7.73
	12Y1017-1	Gregg 45-M	2262	851	7.19	37.64	1.13	83.90	30.40	5.13	4.82	7.37
	12Y1034-1	ISA BC1	1698	671	6.07	39.49	1.17	84.20	31.33	4.87	5.57	7.00
	12Y1026-1	ISA BC2	3833	1553	5.99	40.61	1.22	84.23	31.20	4.50	4.96	7.50
	12Y1027-1	ISA BC3	3808	1581	6.24	41.54	1.18	83.47	31.77	5.57	4.63	7.33
	12Y1002-1/2	M7570	4301	1697	5.55	39.47	1.16	83.83	31.43	7.43	4.86	7.93
	12Y1004-1	M7895	4108	1775	6.80	43.10	1.13	83.13	29.47	5.37	5.31	7.97
	12Y1005-1/3	M9587	3911	1716	6.25	43.81	1.10	83.20	28.70	5.30	5.33	7.70
	12Y1012-1	US F-12	2769	1074	7.68	38.77	1.14	81.80	27.17	5.67	4.64	8.27

Acala GLS	Acala GLS	2499	969	6.64	38.81	1.24	86.00	36.13	4.47	4.27	6.50
JACO	JACO	2733	1001	6.66	36.58	1.15	84.43	31.23	4.13	4.82	7.13
1517-08	Acala 1517-08	4213	1630	6.08	38.71	1.25	84.10	34.77	5.37	4.61	6.97
1517-99	Acala 1517-99	3139	1177	6.24	37.68	1.21	83.27	33.73	5.07	4.56	7.63
LSD0.05		647	252	0.47	1.47	0.04	1.06	1.45	0.47	0.25	0.59

SCY- seedcotton yield; LY- lint yield; UHM- upper half length; UI- uniformity index; STR- fiber strength; MIC- micronaire; SFC- short fiber content; Lb/A- pounds/acre.

Selections from germplasm introductions

The results are also shown in Table 4 under Trial W.

Boy: One selection (12Y1033-1) was made, and it yielded 92% seedcotton and 76% lint of Acala GLS, and 55% seed cotton and 45% lint of Acala 1517-08. It had the shortest (1.06 inch) and weakest (24.4 g/tex) fibers in the tests.

French 86-1: One selection (12Y1037-1) was made, and it yielded 102% seed cotton and 107% lint of Acala GLS, and 61% seed cotton and 64% lint of Acala 1517-08.

ISA: Three selections were made from three backcross generations (BC1, BC2 and BC3). ISA BC1 only yielded 68-69% of Acala GLS and 40-42% of Acala 1517-08. However, two selections from ISA BC2 and BC3 yielded 152-154% seed cotton and 160-163% lint of Acala GLS, and 91-92% seed cotton and 95-97% lint of Acala 1517-08. Both had long (1.18-1.20 inch) fibers and their fiber strength and micronaire were also acceptable.

M7570: One selection (12Y1002-1/2) was made, and it yielded 172% seed cotton and 175% lint of Acala GLS, and 102% seed cotton and 104% lint of Acala 1517-08. It had acceptable fiber length (1.16 inch), strength (31.4 g/tex) and micronaire (4.86). Figure 1 shows its field performance at harvest.

M7895: One selection (12Y1004-1) was made, and it yielded 164% seed cotton and 183% lint of Acala GLS, and 98% seed cotton and 109% lint of Acala 1517-08. However, it had short (1.13 inch) and coarse fibers (micronaire of 5.31), and its fibers were also relatively weak (29.5 g/tex).

M9587: One selection (12Y1005-1/3) was made, and it yielded 157% seed cotton and 177% lint of Acala GLS, and 93% seed cotton and 105% lint of Acala 1517-08. Similar to MBC 7895, it also had short (1.10 inch), weak (28.7 g/tex) and coarse (micronaire of 5.33) fibers.

Cross breeding for glandless cotton

Eighteen lines were selected from a cross between Acala 1517-08 and glandless Acala in 2011 for a replicated test in 2012 (Table 5). The seedcotton yield of these lines ranged from 75 to 130% of Acala 1517-08, while their lint yield ranged from 77 to 138% of Acala 1517-08. Eight lines had lint yield higher than Acala 1517-08 by more than 10%, three of which yielded 28-38% more lint. Their yield advantage may be due to unexpected lower yield (1302 pounds/acre) from Acala 1517-08 in this test. Even though all of them had long and strong fibers, half of them had shorter fibers and two had weaker fibers as compared with Acala 1517-08. All the lines had fibers with similar or lower micronaire than Acala 1517-08.

Seventy lines were further selected from these 18 lines in 2012 and tested in 2013 in four replicated tests (Table 6). Twenty-eight lines had lint yield higher than Acala GLS by 13-36%; however, none of them had lint yield higher than one of the parents Acala 1517-08. Interestingly, 8 lines yielded 80-96% lint of Acala 1517-08, five of which were from three of these eight high-yielding lines in 2012.

Six lines had fibers longer than Acala GLS, and 16 lines had longer fibers than Acala 1517-08, while four had fibers shorter than Acala 1517-08. Many lines had similar fiber strength to Acala 1517-08 and Acala GLS including five lines with significantly stronger fibers than Acala 1517-08, but none was stronger than Acala GLS. However, 10 lines had significantly weaker fibers than Acala 1517-08. Seven lines had significantly lower micronaire (3.85-4.15)

Figure 1. Field performance of a glandless selection from M7570 at harvest, Las Cruces, NM, 2013.

Table 5. Field performance of breeding lines selected from a cross between Acala 1517-08 and glandless Acala, Las Cruces, NM, 2012.

Line	SCY	LY	Boll wt	Lint	UHM	UI	STR	ELO	MIC	SFC
	Lb/A	Lb/A	g/boll	%	inch	%	g/tex	%	unit	%
10NM11-1	3771	1482	6.48	39.28	1.20	85.60	36.57	5.27	4.75	6.80
10NM11-2	3282	1306	6.52	39.96	1.24	85.60	36.73	4.83	4.28	6.70
10NM11-3	4058	1665	6.26	41.09	1.23	85.03	36.43	5.70	4.34	7.10
10NM11-4	3112	1245	6.50	39.98	1.24	85.87	37.90	4.57	4.28	6.43
10NM11-5	3663	1508	5.97	41.24	1.21	84.80	37.87	5.83	4.21	7.17
10NM11-6	3499	1383	5.97	39.58	1.18	85.20	37.30	5.77	4.33	6.50
10NM11-7	3240	1326	6.04	41.07	1.20	84.67	34.73	5.37	4.67	6.97
10NM11-8	2598	1098	5.29	42.05	1.19	84.67	36.40	6.83	4.76	6.90
10NM11-9	3795	1503	6.33	39.62	1.19	85.23	38.07	6.43	4.33	6.83
10NM11-10	2514	1003	5.77	39.86	1.24	85.03	39.50	5.17	4.43	6.47
10NM11-11	3522	1461	5.64	41.52	1.27	85.70	37.83	5.40	4.02	6.63
10NM11-12	2773	1105	6.27	39.83	1.23	86.33	37.43	5.43	4.51	6.50
10NM11-13	3952	1674	7.15	42.33	1.25	84.50	37.30	5.20	4.17	6.93
10NM11-14	2609	1062	6.03	40.68	1.21	85.43	36.73	5.67	4.38	6.87
10NM11-15	3520	1437	6.20	40.86	1.19	85.13	37.70	5.80	4.41	6.70
10NM11-16	3309	1352	5.28	40.86	1.27	85.70	39.10	5.70	4.09	6.60
10NM11-17	4364	1801	6.42	41.42	1.22	85.27	37.63	5.43	4.30	6.87
10NM11-18	3262	1319	6.56	40.38	1.25	84.63	34.73	5.43	4.45	7.07
Acala 1517-08	3368	1302	4.38	38.65	1.27	84.53	37.40	6.13	4.60	6.93
LSD0.05	979	380	0.91	1.40	0.05	1.16	2.26	0.51	0.27	0.48

SCY- seedcotton yield; LY- lint yield; UHM- upper half length; UI- uniformity index; STR- fiber strength; MIC- micronaire; SFC- short fiber content; Lb/A- pounds/acre.

than Acala GLS; 28 lines had significantly lower micronaire (<4.32) than Acala 1517-08; and only one line had

significantly higher micronaire than Acala 1517-08. However, the lines with relatively high yield potentials (>80% of Acala 1517-08) usually had shorter and weaker fibers.

Table 6. Field performance of advanced breeding lines from cross between Acala 1517-08 and glandless Acala, Las Cruces, NM, 2013.

Trial	Selection	Source	SCY	LY	Boll	Lint	UHM	UI	STR	ELO	MIC	SFC
			Lb/A	Lb/A	g/boll	%	inch	%	g/tex	%	unit	%
S	12G1030-1/2	10NM11-10	2601	961	5.58	36.90	1.26	84.80	37.30	4.67	4.44	6.63
	12G1001-2	10NM11-11	2789	1091	5.84	39.15	1.30	86.37	35.73	4.83	4.06	6.33
	12G1001-3	10NM11-11	2482	1003	5.72	40.45	1.28	85.70	34.83	5.27	4.22	6.57
	12G1001-1	10NM11-11	2365	908	5.58	38.27	1.26	85.40	37.57	5.00	4.11	6.80
	12G1029-1	10NM11-14	2894	1181	6.46	40.64	1.16	84.30	32.73	4.10	5.05	7.07
	12G1026-1	10NM11-15	2963	1167	6.41	39.45	1.21	84.87	34.50	4.97	4.41	6.73
	12G1013-1	10NM11-16	2628	1070	5.25	40.38	1.24	85.63	35.53	5.33	4.15	6.63
	12G1004-1	10NM11-18	2908	1159	5.61	39.82	1.21	85.27	34.37	4.40	4.26	6.90
	12G1024-1/2	10NM11-2	3187	1179	6.04	37.05	1.28	84.83	36.23	5.37	4.26	6.60
	12G1016-1/2	10NM11-4	2715	1028	6.38	38.08	1.25	85.80	36.13	4.37	4.30	6.70
	12G1009-1	10NM11-5	2933	1122	6.50	38.26	1.25	84.37	34.40	5.90	4.47	7.00
	12G1014-1	10NM11-7	3261	1325	6.12	40.64	1.21	85.10	31.97	5.50	4.51	6.43
	12G1014-3	10NM11-7	2790	1100	5.84	39.46	1.18	84.53	34.23	4.77	4.74	7.13
	12G1014-2	10NM11-7	2619	1059	6.07	40.45	1.17	84.20	32.90	5.37	4.69	6.93
	12G1003-1	10NM11-8	3264	1305	4.79	39.97	1.18	83.93	32.17	6.57	4.59	7.20
	Acala GLS	Acala GLS	2602	1043	6.56	40.07	1.25	85.07	36.60	4.17	4.43	6.80
	1517-08	Acala 1517-08	3894	1441	5.94	37.22	1.20	84.77	35.40	5.40	4.63	6.87
	LSD0.05		540	224	0.59	2.88	0.04	1.26	1.66	0.46	0.28	0.55
T	12G2022-2	10NM11-1	2496	878	6.00	35.14	1.23	84.63	35.93	4.43	4.25	6.70
	12G2016-1	10NM11-12	2699	1000	5.89	37.07	1.22	85.77	36.30	4.67	4.31	6.60
	12G2002-1	10NM11-13	2922	1174	5.97	40.17	1.21	83.97	34.10	4.73	4.53	7.33
	12G2004-1	10NM11-16	2965	1146	5.20	38.70	1.28	86.47	37.20	5.40	4.00	6.37
	12G2018-1	10NM11-17	2593	1002	5.53	38.63	1.23	85.10	36.00	4.30	4.42	7.07
	12G2007-1	10NM11-2	2810	1127	6.36	40.07	1.22	85.33	35.07	4.87	4.45	6.70
	12G2010-2	10NM11-3	3729	1408	5.49	37.51	1.22	85.13	34.47	5.03	4.44	6.87
	12G2010-1	10NM11-3	3210	1298	6.46	40.44	1.20	83.80	33.60	4.87	4.32	7.57
	12G2019-1	10NM11-4	3018	1150	6.36	38.08	1.24	85.17	35.47	4.40	4.38	6.73
	12G2019-2	10NM11-4	2385	930	5.77	38.95	1.22	84.37	34.93	4.23	4.45	6.87
	12G2011-2	10NM11-5	2118	855	6.26	40.38	1.24	83.80	36.67	5.47	4.04	7.20
	12G2011-1	10NM11-5	1658	608	5.97	36.77	1.21	84.07	30.97	4.30	4.12	7.40
	12G2021-1/2	10NM11-7	2677	1064	6.16	39.82	1.22	85.43	34.30	5.10	4.50	6.57
	12G2015-1	10NM11-9	2581	944	5.58	36.60	1.23	85.87	37.50	5.23	4.23	6.60
	Acala GLS	Acala GLS	2100	846	6.34	40.37	1.23	85.23	37.83	4.30	4.28	6.73
	1517-08	Acala 1517-08	3642	1483	5.51	40.77	1.21	84.87	35.73	5.13	4.64	7.10
		LSD0.05	677	270	0.60	1.76	0.05	1.42	1.81	0.44	0.29	0.55
U	12G3001-5	10NM11-27	3153	1229	5.97	39.14	1.23	85.03	35.33	4.87	4.69	6.90
	12G2031-1	10NM11-6	3278	1161	5.92	35.41	1.20	85.10	37.87	5.03	4.13	6.90

	12G2023-1	10NM11-14	3051	1155	6.35	37.86	1.22	84.50	35.97	4.57	4.22	7.03
	12G2030-1	10NM11-8	3048	1151	5.48	37.79	1.20	84.83	35.17	5.23	4.29	6.97
	12G2033-1	10NM11-18	2938	1124	5.59	38.31	1.25	85.00	34.03	4.40	4.51	7.10
	12G3001-2	10NM11-17	2948	1111	5.93	37.68	1.27	86.43	34.87	5.13	4.29	6.47
	12G3005-4	10NM11-7	2723	1079	6.52	39.62	1.20	84.43	34.07	5.10	4.62	6.83
	12G3005-5	10NM11-7	2756	1031	6.70	37.42	1.19	84.30	32.70	5.00	4.69	7.17
	12G3001-1	10NM11-17	2787	1029	5.85	36.94	1.26	85.97	36.70	4.70	4.12	6.87
	12G2024-2	10NM11-11	2699	1006	6.65	37.23	1.24	85.50	37.50	4.57	3.98	6.67
	12G3001-3	10NM11-17	2709	989	5.75	36.45	1.25	84.40	35.40	4.57	4.15	6.97
	12G2025-2	10NM11-15	2460	985	6.39	40.03	1.16	84.13	36.87	4.40	4.73	6.60
	12G3005-2	10NM11-7	2578	985	5.97	38.18	1.19	84.97	34.53	4.60	4.70	7.00
	12G2024-1	10NM11-11	2458	968	5.82	39.35	1.28	85.03	36.67	4.90	3.85	6.80
	12G2025-1	10NM11-15	2427	944	6.31	38.80	1.17	84.80	36.20	4.30	4.40	6.93
	12G3005-1	10NM11-7	2443	928	6.58	38.09	1.22	84.90	34.90	4.47	4.48	6.97
	12G2025-4	10NM11-15	2567	918	5.92	35.76	1.22	85.50	35.23	4.27	4.19	6.67
	12G2031-2	10NM11-6	2477	916	6.13	36.95	1.27	85.50	37.40	4.83	4.03	6.60
	12G2033-2	10NM11-18	2629	895	5.49	34.46	1.24	85.67	36.13	4.67	4.51	6.67
	12G2023-4	10NM11-14	2425	893	5.93	36.79	1.20	84.83	33.50	4.57	4.46	6.83
	12G2033-3	10NM11-18	2375	889	5.58	37.35	1.23	84.93	35.33	4.60	4.45	6.87
	12G2025-6	10NM11-15	2279	845	5.75	37.05	1.20	85.27	36.23	4.13	4.30	6.70
	12G3005-6	10NM11-7	2081	798	6.46	38.22	1.20	84.23	33.33	5.03	4.46	7.13
	12G2025-3	10NM11-15	2180	787	5.97	36.03	1.21	85.73	35.23	4.43	4.03	6.70
	12G3005-3	10NM11-7	1816	712	6.40	39.18	1.27	85.03	34.80	4.53	4.42	6.63
	Acala GLS	Acala GLS	2593	998	6.84	38.49	1.23	86.17	37.97	4.03	4.26	6.57
	1517-08	Acala 1517-08	4065	1589	6.19	39.09	1.22	84.60	35.90	5.33	4.59	7.07
			529	205	0.66	2.26	0.04	1.42	2.32	0.44	0.26	0.61
V	12G3006-1	10NM11-1	2688	1077	5.58	40.07	1.20	84.60	32.97	5.10	4.67	7.10
	12G3016-2	10NM11-10	2030	750	5.62	36.89	1.27	85.27	35.90	4.93	4.24	6.60
	12G3016-1	10NM11-10	1840	662	5.32	35.99	1.28	85.83	37.60	4.00	4.18	6.50
	12G3030-2	10NM11-14	3017	1193	5.79	39.56	1.25	85.60	35.27	5.87	4.59	6.77
	12G3030-1	10NM11-14	2148	855	6.34	39.88	1.19	85.47	35.67	5.57	4.68	6.70
	12G3013-3	10NM11-15	2428	987	5.22	40.62	1.23	86.07	34.67	5.43	4.47	6.67
	12G3013-2	10NM11-15	1837	703	5.65	38.23	1.19	86.07	35.73	5.07	4.46	6.53
	12G3013-1	10NM11-15	1475	561	5.77	37.99	1.18	85.63	35.33	4.70	4.41	6.63
	12G3019-2	10NM11-16	2853	1069	5.15	37.58	1.27	86.57	36.63	5.10	3.95	6.43
	12G3019-1	10NM11-16	1599	634	5.08	39.89	1.21	85.00	35.53	5.70	3.87	6.83
	12G3028-3	10NM11-2	2491	972	6.24	39.00	1.22	85.17	36.43	4.80	4.20	6.93
	12G3028-1	10NM11-2	2429	883	5.97	36.30	1.28	84.33	34.73	4.13	4.12	7.00
	12G3011-3	10NM11-3	2760	1128	6.50	40.92	1.24	85.07	34.60	4.87	4.39	6.73
	12G3011-5/6	10NM11-3	2542	1025	5.81	40.48	1.20	84.23	33.57	5.23	4.57	7.03
	12G3011-2	10NM11-3	2480	964	5.16	38.85	1.21	84.80	34.53	6.00	4.66	6.93
	12G3011-4	10NM11-3	2155	878	6.07	40.72	1.18	83.60	31.60	4.60	4.63	7.50
	12G3011-1	10NM11-3	1899	717	5.93	37.79	1.25	85.30	34.33	5.27	4.11	7.00

12G3023-2	10NM11-4	2545	989	5.84	38.86	1.24	85.57	35.53	4.50	4.31	6.67
12G3023-1	10NM11-4	2057	807	6.00	39.18	1.23	84.83	36.07	4.03	4.17	7.00
12G3029-1	10NM11-5	1944	752	5.55	38.70	1.26	86.03	35.47	5.07	4.34	6.57
12G3029-2	10NM11-5	1751	654	5.15	37.36	1.20	85.23	34.63	5.33	4.20	6.60
12G3024-1	10NM11-8	2729	1108	5.85	40.58	1.21	85.27	34.23	6.60	4.68	6.63
12G3024-2	10NM11-8	2088	819	4.98	39.18	1.20	84.80	33.47	5.93	4.70	6.90
Acala GLS	Acala GLS	2261	914	6.33	40.38	1.25	85.87	36.83	4.33	4.25	6.67
1517-08	Acala 1517-08	3018	1240	5.54	41.13	1.23	83.90	34.23	5.13	4.64	7.43
LSD0.05		761	283	0.43	1.33	0.05	1.30	1.87	0.49	0.27	0.55

SCY- seedcotton yield; LY- lint yield; UHM- upper half length; UI- uniformity index; STR- fiber strength; MIC- micronaire; SFC- short fiber content; Lb/A- pounds/acre.

Summary

This progress report summarizes breeding activities for glandless cotton adaptable to the New Mexico cotton production conditions where Acala cotton has been traditionally grown. The major findings can be summarized as the following,

1. The glandless Acala GLS yielded 80% (in 2010) and 65% (in 2013) lint of glanded Acala 1517-08, and 61-75% (in 2010) and 46% (in 2013) lint of commercial transgenic cultivars.
2. Glandless JACO and STV GL yielded 12-21% more seed cotton than Acala GLS, but only produced 57-63% of Acala 1517-08 and 51-55% of PHY 375 WRF in 2013.
3. Of 14 obsolete U.S. glandless lines tested in 2012, three yielded 2-22% more seed cotton than Acala 1517-08, but the yield advantage was not confirmed in their selections which only yielded up to 82-89% of Acala 1517-08 in 2013.
4. Genetic variation existed in the existing 18 U.S. glandless lines, and selections within three lines (SA1482, SA 2455 and Acala GLS) brought the yield up to 80-90% of Acala 1517-08.
5. Five selections from four introduced glandless germplasm lines yielded 152-175% of Acala GLS and 91-109% of Acala 1517-08, but they had shorter, weaker and coarser fibers.
6. Several advanced glandless lines were developed from a hybrid between Acala 1517-08 and glandless Acala, and they yielded similarly to Acala 1517-08 with comparable fiber quality traits.

In conclusion, there is a significant yield gap between the existing/obsolete glandless germplasm and commercial conventional/transgenic cultivars. However, through direct pedigree selections from the obsolete U.S. glandless lines and introduced germplasm and cross breeding, significant progress in yield improvement has been achieved in a short period of time.

More field tests will be needed to evaluate the yield potential and adaptability of these promising glandless lines. Optimal cultural practice should be investigated based on their growth characteristics and maturity. Their responses to insect infestations and disease infections will also need to be determined.

Acknowledgements

This research has been supported in part by USDA-ARS, Cotton Incorporated and New Mexico Agricultural Experiment Station.

References

Dobbs, J.H., and R. Stephen. 2000. CPCSD Acala GLS: A glandless cotton variety for the San Joaquin Valley. Proc. Beltwide Cotton Conf., San Antonio, TX. 4-8 Jan. 2000. Natl. Cotton Counc. Am., Memphis, TN.

Zhang, J., R. Flynn, S. E. Hughs, S. Bajaj, C. Waddell, and D. C. Jones. 2011. Registration of 'Acala 1517–08'Cotton. J. Plant Registr. 5:156-163.