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Primitive Cotton Germplasm:

Yield and Fiber Traits for 16 Day-Neutral Accessions

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ABSTRACT

Improvement of cotton, *Gossypium hirsutum* L., requires genetic resources that may extend from primitive or exotic species to commonly grown cultivars. The introduction of desirable traits from germplasm sources to adapted cultivars is an ongoing process. The cotton collection of primitive accessions contains a wealth of genetic variability; however, many of the accessions are photoperiodic. The photoperiod response and failure to flower and set fruit under the long-day regime of the temperate-zone growing seasons is a major hurdle to the use of most primitive cotton germplasm. Accessions have been converted to day-neutrality using a backcross breeding approach. Useful genetic variability has been measured in the day-neutral lines for agronomic and fiber traits. The day-neutral accessions are now available for use in breeding programs for cultivar development and to expand genetic variability.

INTRODUCTION

Cotton, *Gossypium* spp., is an important crop that is grown in warmer climates throughout the world. It is grown primarily for lint fibers, which are used in the textile industry. Oil, meal, seed hulls, and linters are also important cotton products. Research efforts are essential for cotton to remain a viable competitive renewable agricultural resource.

Cotton breeding and research have resulted in vast improvements in yield and fiber quality. To improve agronomic and fiber traits, plant breeders must identify sources of genetic variability for the trait of interest. Sources of genetic variability may be cultivars commonly grown by farmers or they may be found in wild or exotic species.

Cotton germplasm collection trips have resulted in a storehouse of genetic diversity. The primitive accessions in the *Gossypium* collection currently number almost 2,500 as a result of collection trips during the last 50 years (Anonymous, 1974; Percival, 1987; Anonymous 1997). The primitive accessions are part of the U.S. National Cotton Germplasm Collection, which is maintained by USDA-ARS in cooperation with Texas A&M University in College Station, Texas. As accessions were added to the collection, they were routinely assigned a number with a "T" prefix, which has been referred to as the Texas number. Today the "T" accession number is the one most frequently used by researchers to refer to the primitive cottons. A plant inventory (PI) number has recently been assigned to all accessions in the collection.

Genetic variability has been found for many traits in the collection of primitive accessions of *G. hirsutum* L. This

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genetic variability has not been extensively used because most of the primitive accessions require short days to initiate flowers and produce fruit. Because of this flowering response to day length, their genes are not readily available for incorporation in cotton-breeding programs.

A program has been in place to incorporate day-neutral genes in the primitive accessions. McCarty and Jenkins (1992, 1993) presented data for 79 day-neutral accessions. This report presents data for 16 additional accessions, which have been converted to day-neutral flowering types.

Materials and Methods

The day-neutral (DN) lines were developed by crossing short-day primitive accessions as male parents to 'Deltapine 16' (day-neutral donor parent) at a Cotton Winter Nursery located at Tecoman, Colima, Mexico. The F1 generation was self-pollinated at the Winter Nursery, and the F2 generation was grown at Mississippi State University, where segregation for flowering response occurred. One plant that set fruit at a low node and continues to fruit was selected from each F2 population. The F3 progeny from this plant was backcrossed to the accession at the Winter Nursery. The same procedure was followed for each backcross generation. Equal numbers of open-pollinated bolls were harvested from each BC4F2 plant that set fruit, and the seed were bulked for each population to provide seed for increase and testing. Except for selection for day-neutrality after each backcross cycle, no other selection pressure is applied. The procedure for developing DN lines was described in detail by McCarty, et al. (1979).

Day-neutral BC4F5 lines of 16 primitive accessions of cotton and four commercial cultivars were grown and evaluated in field plots at Mississippi State University's Plant Science Research Center from 1997 through 1999. The 1998 test was not carried to completion due to extreme insect pressure, which severely impacted plant growth, yield, and quality. The commercial cultivars were chosen to represent currently grown cottons and included 'Deltapine 50' (DPL 50), 'Deltapine 5415' (DP 5415), 'Sure-Grow 125' (SG 125), and 'Sure-Grow 501' (SG 501).

The DN lines and cultivars were grown in single-row plots (40 feet long, 38-inch row spacing). The experimental design was a randomized complete block with four replicates. The soil type was a Leeper silty clay loam (fine, montmorillionitic, nonacid, thermic Vertic Haplaquepts). Field plots were maintained with standard culture practices.

Seed cotton yield was determined by mechanical harvest. A 25-boll sample was hand-harvested from each plot before mechanical picking. Boll samples were weighed and ginned on a laboratory 10-saw gin to determine boll weight (grams of seed cotton per boll), lint percentage, and seed index (weight of 100 seeds). Lint samples were sent to Starlab, Inc., in Knoxville, Tennessee, for determination of micronaire, elongation (E1), fiber tenacity (FT), 2.5% span length (2.5% SL), and 50% span length (50% SL).

Data for all traits were subjected to analysis of variance. Means were separated according to Fisher's protected least significant difference (LSD).

Results and Discussion

Collection and evaluation information for the cotton accessions is presented in Tables 1-3. Most of the data in these tables have been published previously (Anonymous, 1974; Percival, 1987) and are accessible through the USDA's Germplasm Resources Information Network (GRIN) database (http://www.ars-grin.gov). However, it is useful to repeat the data here to compare the primitive accessions with the day-neutral backcross derived lines. A wide range of variability exists in the primitive accessions for the characteristics that have been evaluated.

Agronomic and fiber data for 1997 and 1999 are presented in Tables 4 and 5. The day-neutral lines produced bolls that tended to be smaller and seeds that were larger than the commercial cultivars in the test. Deltapine 5415 produced the smallest seeds among the cultivars, which is one of its characteristics. Lint percentage for the cultivars was in the high 30s, while that for most of the day-neutral lines was in the low 30s. This difference was consistent for both years of testing. Most of the day-neutral lines produced seed cotton yields that were significantly lower than the cultivars. As expected, lint yields were low for the day-neutral lines because they had low lint percentages.

Most day-neutral lines produced fibers significantly shorter than those produced by cultivars. Fiber micronaire values tended to be higher, while fiber strength tended to be similar to the cultivars evaluated. T-242 DN tended to produce stronger fibers than the cultivars during both years of testing.

The converted primitive accessions are useful for the diverse germplasm they contain. Researchers looking for new traits can now exploit the day-neutral lines. These lines can also be used to expand the genetic base of cotton.

Table 1. Identification and origins of the 16 primitive accessions of cotton.

T #	Race	Plant inventory no.	Year collected	Country of origin	State of origin	Site of origin	Latitude	Longitude
27	*punctatum*	154037	1946	Mexico	Chiapas	Berraizabel		
29	*punctatum*	154040	1946	Mexico				
73	*latifolium*	153967	1946	Guatemala				
83	*latifolium*	153972	1946	Guatemala		Mazatenango	14.31N	91.30W
89	*latifolium*	153977	1946	Guatemala		San Rafel Panan		
116	*latifolium*	163702	1948	Guatemala	Taxisco	Santa Rosa		
188	*latifolium*	163732	1948	Guatemala	Baja Verapaz	Sanarate		
195	*latifolium*	163611	1948	Guatemala	Jutiapa	San Antonio		
199	*latifolium*	163655	1948	Guatemala	Jutiapa	Santa Catarinamita		
216	*latifolium*	163647	1948	Guatemala	Jutiapa	Horcones		
224	*latifolium*	165323	1948	Mexico	Oaxaca	Tototapan		
235	*latifolium*	163638	1948	El Salvador				
238	*latifolium*	163674	1948	Guatemala	Jalapa	San Pedro Pinual		
240	*latifolium*	163708	1948	Guatemala	Chiquimula	Jocoton	14.50N	84.32W
242	*latifolium*	163607	1948	Guatemala	Huehuetenango	San Mateo Ixtaton	15.50N	89.32W
250	*latifolium*	163717	1948	Guatemala	Zacapa			

Race – classification below the species level.
Plant inventory number – number assigned to foreign accessions that are introduced.

Table 2. Physiological and fiber characteristics of the 16 primitive accessions of cotton.

T #	Plant height	Matu-rity	Produc-tiveness	Pubes-cence	Flower score	Boll weight	Seed index	Lint pct.	Lint index	UHM	Mean	T0	T1	E1	Micro-naire	AREO A	AREO D
27	1.2	3	3	1	0.0	4.0	11.8	26	4.1	1.05	0.95	36.0	18.7	9.4	4.60	428	22
29	0.9	3	2	2	0.0	4.7	10.4	27	3.8	0.98	0.88	36.6	18.3	8.5	5.60	364	9
73	0.9	2	3	4	0.0	3.7	11.8	27	4.4	0.91	0.81	41.0	21.2	9.2	5.68	382	16
83	1.2	1	2	4	1.5	6.8	13.8	30	5.9	0.91	0.79	40.3	18.9	5.7	6.68	326	6
89	1.2	2	3	4	0.0	5.1	11.8	34	6.1	0.85	0.74	35.7	16.1	7.4	6.57	341	10
116	1.2	1	2	2	4.5	9.9	14.2	42	10.1	1.09	0.97	33.2	16.6	11.4	4.60	446	26
188	0.9	2	2	3	1.5	3.4	9.0	31	4.0	0.91	0.77	35.2	16.4	8.9	4.28	459	45
195	1.2	3	3	3	0.0	4.8	12.0	29	4.8	0.87	0.76	40.2	15.2	7.8	5.25	400	15
199	0.9	1	2	3	1.5	3.8	12.8	25	4.3	0.84	0.75	34.2	16.7	9.4	5.50	390	25
216	1.2	2	2	4	0.0	5.4	11.2	33	5.5	0.91	0.83	33.1	16.9	9.1	6.80	316	13
224	0.9	2	3	3	2.5	5.8	14.8	33	7.4	0.84	0.74	35.3	15.9	6.0	6.03	353	12
235	0.9	1	3	3	0.0	4.4	10.2	33	5.0	0.76	0.65	31.8	–	–	6.30	345	12
238	0.9	3	3	4	0.0	4.2	9.4	33	4.6	0.92	0.80	31.0	15.7	7.6	4.90	419	31
240	1.2	2	3	3	1.5	3.3	10.0	29	4.1	0.92	0.81	34.4	17.3	7.6	5.05	405	14
242	1.2	2	3	4	0.5	5.8	12.6	38	7.7	0.93	0.82	40.0	22.7	9.7	5.75	371	16
250	0.9	2	3	4	0.5	3.0	8.8	33	4.3	0.85	0.74	32.7	14.4	8.5	5.05	417	30

Plant height – measured in meters, as grown in Tecoman or Iguala, Mexico.
Maturity – relative maturity of entries when earliest cotton had all bolls open: 1 = all bolls open; 2 = half bolls open; 3 = mostly green bolls; 4 = no bolls open; and 5 = no flowers.
Productiveness – relative productiveness: 1 = most productive; 2 = good production; 3 = fair production; 4 = poor production; and 5 = no production.
Pubescence – hairiness of plant: 1 = no plant hairs; 2 = few plant hairs; 3 = hairy plant; and 4 = very hairy plant.
Flower score – flowering score when grown at College Station, Texas: 0.0 = no flowers during growing season; 1.0, 2.0, 3.0, and 4.0 = flowers 8, 6, 4, and 2 weeks later (respectively) than Upland variety; and 5.0 = flowers as early as Upland variety.
Weight – measured in grams per boll; average weight of a 10-boll sample.
Seed index – weight of 100 seed, in grams.
Lint percent – weight of lint ginned from a sample of seed cotton, expressed as a percentage of the weight of seed cotton.
Lint index – weight of lint from 100 seed, in grams.
UHM – length, in inches, of the half of the fibers, by weight, that contains the longer fibers. Values of UHM approximate classer's sample and also 2.5% span length.
Mean – average length, in inches, of all fibers longer than 1/4 inch.
T0 – fiber strength of a bundle of fibers measured on a Stelometer with the two jaws holding the fiber bundle tightly appressed. Strength is expressed in terms of grams force per tex.
T1 – fiber strength of a bundle of fibers measured on the Stelometer with the two jaws holding the fiber bundle separated by a 1/8-inch spacer. Strength is expressed in terms of grams force per tex.
E1 – percentage elongation at break of the center 1/8-inch of the fiber bundle measured for T1 strength on the Stelometer.
Micronaire – fineness of the sample taken from the ginned lint but measured by the Micronaire and expressed in standard (curvilinear) micronaire units.
AREO A – Arealometer A is a measure of the external surface area of the fibers of a given volume of fibrous material, expressed in terms of square millimeters per cubic millimeter of fibrous material.
AREO D – Arealometer D is the difference between the value of the specific area determined at high pressure (AH) and the value of the specific area determined at standard pressure (the A from AREO A). D is presumably a measure of the flatness of the fiber ribbon; that is, the higher the D value, the more ribbonlike are the fibers.

Table 3. Seed and disease characteristics of the 16 primitive accessions of cotton.

T #	Protein pct.	Seed oil pct.	Embryo oil pct.	Seed coat pct.	Embryo pct.	Seed coat index	Embryo index	*Coletotrichum* resistance	*Verticillium* resistance
27	22.04	22.91	40.53	43.47	56.52	4.161	5.409	3.6	5.0
29	21.83	–	–	–	–	–	–	–	–
73	18.68	26.71	50.35	46.94	53.05	4.000	4.520	3.5	4.7
83	28.50	24.74	47.58	47.99	52.00	4.246	4.600	2.3	4.7
89	26.11	24.36	39.99	39.07	60.92	3.594	5.603	2.8	4.4
116	18.01	27.27	53.05	48.59	51.40	2.958	3.129	4.0	4.8
188	30.26	27.69	47.82	42.09	57.90	3.007	4.137	3.5	4.9
195	24.48	26.67	46.43	42.48	57.51	4.183	5.662	3.3	4.8
199	23.63	27.81	45.60	39.01	60.98	3.642	5.694	3.2	4.8
216	22.45	23.93	42.77	55.95	44.04	3.583	4.551	1.5	4.7
224	25.74	25.62	44.49	42.40	57.59	4.818	6.544	4.0	4.6
235	23.03	25.82	45.57	43.33	56.66	4.124	5.393	2.8	4.7
238	20.73	24.89	43.22	42.40	57.59	3.258	4.425	3.1	5.0
240	23.66	25.66	44.99	42.95	57.04	3.343	4.439	2.4	4.6
242	23.98	26.17	44.71	41.46	58.53	3.947	5.571	2.8	5.0
250	26.61	25.54	43.87	41.77	58.22	3.185	4.440	4.0	4.8

Protein percent – determined by automated microkjeldahl Technicon.
Seed oil percent – percentage of oil by weight in 10-gram sample of seeds.
Embryo oil percent – percentage of oil by weight in 10-gram sample of dehulled seeds.
Seed coat percent – weight of seed coat over weight of whole seed.
Embryo percent – weight of embryo over weight of whole seed.
Seed coat index – weight in grams of seed coats per 100 seeds.
Embryo index – weight in grams of embryos per 100 seeds.
***Colletotrichum gossypii* resistance –** 1 = immune; 2 = resistant; 3 = moderately resistant; 4 = susceptible; and 5 = highly susceptible.
***Verticillium dahliae* resistance –** 1 = immune; 2 = resistant; 3 = moderately resistant; 4 = susceptible; and 5 = highly susceptible.

Table 4. Agronomic and fiber characteristics of BC4F5 day-neutral accessions grown at Mississippi State University in 1997.

Entry	Boll size	Lint pct.	Seed index	Seed cotton yield	Lint cotton yield	Micronaire	50% SL	2.5% SL	Elongation	Strength
	g	*%*	*g*	*lb/A*	*lb/A*		*in*	*in*	*%*	*g/tex*
T-27 DN	3.78	33.91	9.73	1956	663	3.98	0.56	1.13	8.25	20.06
T-29 DN	4.07	31.51	10.55	1400	441	4.20	0.57	1.13	8.44	20.81
T-73 DN	4.06	31.65	9.63	1568	496	4.30	0.55	1.06	8.00	20.34
T-83 DN	4.48	30.40	10.63	1289	392	4.45	0.54	1.06	7.69	20.78
T-89 DN	4.54	32.07	10.38	1670	536	4.53	0.55	1.09	8.00	20.90
T-116 DN	5.19	31.28	10.60	1351	423	4.38	0.56	1.12	8.19	20.70
T-188 DN	4.22	31.64	10.20	1526	483	4.25	0.55	1.11	7.69	21.06
T-195 DN	4.48	31.51	9.50	1401	441	4.33	0.55	1.12	7.50	20.84
T-199 DN	4.06	30.45	10.48	1231	375	4.38	0.56	1.11	8.13	21.09
T-216 DN	4.56	33.18	10.28	1366	453	4.40	0.56	1.08	8.06	20.08
T-224 DN	4.76	31.29	11.00	1343	420	4.75	0.55	1.06	8.19	20.16
T-235 DN	4.69	32.38	10.70	1503	487	4.85	0.55	1.04	7.81	20.21
T-238 DN	4.47	33.97	10.53	1742	592	4.33	0.56	1.08	7.94	20.35
T-240 DN	4.24	33.37	9.68	1674	559	4.00	0.55	1.11	7.81	20.14
T-242 DN	4.61	32.60	10.60	1637	534	4.38	0.56	1.09	7.63	21.84
T-250 DN	4.40	33.19	10.73	1339	444	4.18	0.57	1.15	8.06	20.39
DPL 50	4.70	37.64	9.58	2400	903	3.93	0.54	1.14	9.56	18.73
DP 5415	4.71	39.18	8.25	2182	855	4.15	0.56	1.14	9.19	21.18
SG 501	5.01	40.84	9.08	1964	802	4.03	0.58	1.16	8.94	22.46
SG 125	4.96	39.81	9.83	2497	994	4.03	0.57	1.16	9.19	19.79
F	**	**	**	**	**	**	ns	**	**	**
LSD 0.05	0.53	1.374	0.84	389	127	0.37	0.02	0.04	0.96	1.42

Table 5. Agronomic and fiber characteristics of BC4F5 day-neutral accessions grown at Mississippi State University in 1999.

Entry	Boll size	Lint pct.	Seed index	Seed cotton yield	Lint cotton yield	Micronaire	50% SL	2.5% SL	Elongation	Strength
	g	*%*	*g*	*lb/A*	*lb/A*		*in*	*in*	*%*	*g/tex*
T-27 DN	3.61	33.52	9.43	1902	637	4.68	0.54	1.09	7.69	20.00
T-29 DN	3.95	31.03	10.70	1768	549	4.58	0.54	1.06	7.44	20.71
T-73 DN	4.05	32.57	10.28	1819	592	5.08	0.53	1.02	6.88	22.19
T-83 DN	4.30	30.26	10.63	1807	547	4.90	0.53	1.01	7.06	21.83
T-89 DN	4.24	32.21	9.83	1864	600	5.35	0.53	1.00	7.38	20.64
T-116 DN	4.33	31.63	9.78	1916	606	5.23	0.53	1.01	7.31	20.66
T-188 DN	3.98	32.64	10.50	1593	520	5.05	0.54	1.06	6.94	20.84
T-195 DN	4.02	31.06	9.25	1928	599	5.38	0.51	0.99	7.44	19.30
T-199 DN	4.18	30.50	10.20	1875	572	5.05	0.53	1.03	7.56	20.09
T-216 DN	4.22	33.00	9.90	1545	510	5.33	0.53	1.01	7.56	19.88
T-224 DN	4.40	32.53	10.85	2077	676	5.50	0.53	1.01	7.00	22.05
T-235 DN	3.92	31.04	10.08	1589	493	5.23	0.53	1.01	7.31	20.15
T-238 DN	4.26	33.67	10.00	1832	617	5.30	0.54	1.04	8.00	20.43
T-240 DN	4.20	31.56	10.70	2281	720	5.03	0.54	1.05	7.56	21.78
T-242 DN	4.43	32.50	10.75	2049	666	5.00	0.54	1.03	7.56	23.20
T-250 DN	3.21	27.87	9.50	1427	398	4.38	0.55	1.06	7.38	20.98
DPL 50	4.35	37.06	10.08	2142	794	4.90	0.55	1.11	7.88	18.46
DP 5415	4.25	40.76	8.65	2114	862	5.23	0.54	1.09	7.94	20.58
SG 501	4.18	39.78	9.38	2323	924	4.78	0.57	1.11	7.56	22.63
SG 125	4.48	40.17	9.15	1879	755	4.78	0.55	1.08	8.13	19.41
F	**	**	**	**	**	**	**	**	*	**
LSD 0.05	0.46	1.33	0.73	496	165	0.29	0.02	0.04	0.65	1.38

SUMMARY

The primitive accessions in the U.S. Cotton Collection are a valuable source of genes for diversity and crop improvement. Converting their flowering habit to day-neutrality will facilitate their use. Sixteen day-neutral germplasm lines have been developed, evaluated, and made available for use in cotton improvement programs.

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