Use of Primitive Accessions in Cotton Improvement

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Abstract

Cotton, *Gossypium hirsutum* L., is an important cultivated crop that is grown throughout the world. Improvements in agronomic trait performance and quality are needed to ensure its economic viability. To improve economic traits genetic resources must be identified and utilized. Primitive accessions of cotton offer a wealth of genetic variability; however, since most of these accessions are photoperiodic (short-day responsive) they are not readily useable in breeding programs. Day-neutral lines have been developed and are being studied for use in cotton improvements programs. The study reported herein involved crossing 114 day-neutral derived lines as male parents with two commercial cultivars, Stoneville 474 and Sure-Grow 747. Parents and F_2-bulks were grown in field plots during 2001 and 2002 and agronomic and fiber traits were determined. The yield for most of the F_2-bulks was not greater than that of the high yield cultivars. All male lines had lint percentages that were significantly lower than the cultivars. The F_2-bulks had better fiber traits micronaire and fiber strength than the cultivars. These day-neutral derived accessions are a new source of genetic diversity that can be used in cotton breeding programs. They offer the potential to improve important fiber traits and expand genetic diversity among cultivars; however, their low lint percentages must be considered when they are used as sources to develop improved cultivars.

Media summary

Primitive accessions of cotton contain genetic diversity that can be used to improve yield, seed, fiber traits, and stress factors of cotton.

Key Words

Cotton, primitive accessions, genetic diversity, fiber traits and breeding.

Introduction

Cotton, *Gossypium* spp., is a viable renewable agricultural resource that is grown in warmer climates throughout the world. The cotton plant produces two important products, fiber and seed. The spinnable fibers are used by the textile industry to produce yarn and fabrics. The seeds are processed into oil, meal and hulls which in turn are used in food items, cooking oil, livestock feed, fish feed, and other products. Since cotton production is important to the economy of many countries, research must continue to insure its viability and sustainability.

To remain viable and meet the demands of producers and industry, cultivars with improved yield and quality must be developed. Producers are seeking higher yield with reduced inputs. The textile industry needs improved fiber quality to keep abreast with processing technology changes, especially changes in spinning speed. With increased speed stronger fiber is required to reduce yarn breakage. The cotton seed industry is seeking improvements in oil (quantity and quality), and protein to enhance their products. To improve these traits, seed yield, fiber yield, fiber quality, and seed quality genetic resources must be identified and utilized.

Genetic resources used in cultivar improvement may extend from currently grown cultivars to wild relatives. Genetic diversity must not be over looked when economic important traits are improved. Diversity can provide a buffer against environmental stresses and reduce the outbreak or spread of

disease epidemics. Therefore, it is important to use new and unrelated sources of germplasm in cotton breeding programs to maintain a measure of diversity.

The most widely grown species worldwide is *Gossypium hirsutum* L. This species is native to Mexico and Central America. Explorations in these areas and the Caribbean Islands particular during the mid and latter part of the last century have resulted in a large number of primitive *G. hirsutum* accessions being collected. Currently about 2500 primitive accessions are in the United States Cotton Germplasm Collection (Anonymous 1974, Percival 1987, Anonymous 1997). Evaluation information for primitive accessions was reviewed by McCarty and Percy 2001. Extensive variability was found for pest resistance, agronomic, morphological, and fiber traits. However, the extensive variability is not readily available for use in breeding programs because a large proportion of the accessions require short days to initiate flowers. Flowering occurs too late during the growing season for harvestable fruit to be set. A backcross breeding program can be used to move genes for day-neutrality into the primitive accessions (McCarty et al. 1979). The derived day-neutral accessions can be evaluated for desirable traits and then readily crossed in breeding nurseries.

Research has shown that day-neutral, primitive, accessions have a wide range of variability that can be used in cotton breeding programs (McCarty and Jenkins 1992, 1993, 2001, 2002, McCarty et al. 1995, 1998a, 1998b, 2003, and Basal et al. 2003). Different backcross generations for 16 day-neutral accessions were evaluated for several agronomic and fiber traits and results indicated useful genetic variability existed (McCarty et al. 1995, 1998a, and 1998b). McCarty et al. 2003 reported that 14 day-neutral derived lines from primitive accessions had fiber strength that exceeded that of commonly grown commercial cultivars and that when these lines were crossed to cultivars most of the F_2-bulks had improved fiber strength. They also reported (McCarty et al. 2004a, and 2004b) that these lines are valuable resources that may be used to improve fiber strength while maintaining good yields.

The objective of this report is to provide additional data to support the use of primitive accessions in cotton improvement programs. The current study was undertaken to evaluate 114 day-neutral accessions and their F_2-bulks that resulted from crosses with two commercial cultivars.

Methods

Plant material and field design

To develop day-neutral germplasm photoperiodic accessions were crossed as male parents to Deltapine 61, and day-neutral plants were selected in the F_2. Seeds from several day-neutral plants within each F_2 were bulked and increased. The F_4 or later generation lines were used to cross with cultivars. Two, conventional, commercial cultivars, Stoneville 474 and Sure-Grow 747 were crossed as female parents to 114 day-neutral derived primitive accession lines. The cultivars used in this study are mid to full season types with high yield potential that are adapted to the southern USA growing environments.

The 114 day-neutral male lines represent a broad group of photoperiodic accessions. The day-neutral lines were derived from 59 accessions collected from Mexico, 16 from the Caribbean Islands, 12 from Guatemala, 10 from Paraguay and 17 from 6 other countries. Morphological and fruiting habit differences were apparent during visual observations in the breeding nursery.

Crosses and field evaluations were conducted at the Plant Science Research Center, Mississippi State, MS, USA (33.4 N, 88.8 W). F_1 crosses were increased and advanced at a winter breeding nursery. The resulting 228 F_2-bulks and the 116 parents (114 male lines and 2 female cultivars) were grown and evaluated in field plots in 2001 and 2002. The F_2-bulks and male parents were grouped into 19 field experiments. Each field experiment consisted of 6 male lines, 12 F_2-bulks and the 2 female cultivars. The design for each test was a randomized complete block with six replicates. Plot size was a single row 12 meters long with row spacing of 0.97 meters (plant density was 10 plants per meter of row) and the planting was a two-planted, one-skip row pattern.

Prior to machine picking a 25-boll hand-harvested sample was collected from each plot. These samples were weighed and ginned to determine boll size (weight) and lint percentage. Fiber samples were measured for determination of micronaire, elongation, fiber strength, and fiber span length 2.5% and 50%. Fiber strength was measured with the 3.2 mm gauge stelometer and length was measured on a digital fibrograph.

Data analyses

SAS proc GLM version 8.0 was used for data analyses (SAS Institute, 1999). In the over-all analysis sources of variation were partitioned into year, field experiment within year, block within year and field experiment, entry, entry by year interaction, and random error effects. Additional data analyses were conducted for individual field experiment using ANOVA and LSD values were calculated for comparison of entry mean.

Results

The year source of variation made the largest contribution to the total and resulted in all traits measured being significantly affected by year. This is often seen in field experiments since differences often exist in temperature, rainfall and solar radiation between years. Least significant differences (LSD values) were similar for the different field experiments for all traits, indicating that the field conditions within each experiment were relatively uniform.

The two female cultivar parents yielded more seed cotton than most of the day-neutral derived male parents. Only seven of the 114 male parents produced more cotton than Stoneville 474; however the majority did not yield significantly lower than the mean of the two cultivars. When lint yields were examined we found that most male parents yielded significantly lower than the cultivars. This was expected since all males had lint percentages that were significantly lower than the cultivars. Forty-one and 12 out of 114 males produced larger bolls than Stoneville 474 and Sure-Grow 747, respectively; however 33 and 58 had smaller bolls than these two cultivars.

The fiber properties varied depending on the trait. Only one male parent had a micronaire reading that was significantly higher than the cultivars. Eighty and 63 out of 114 males had micronaire values significantly lower than Stoneville 474 and Sure-Grow 747, respectively. Most of the male parents had fiber length that was equal to or longer than the female cultivars. Many produced fibers stronger than Stoneville 474 and Sure-Grow 747.

None of the F_2-bulks yielded more lint than Stoneville 474. All 228 F_2-bulks had lint percentages that were significantly lower than Stoneville 474 and Sure-Grow 747. Sixty-one and 18 F_2-bulks had larger bolls and 69 and 122 F_2-bulks had significantly smaller bolls than the Stoneville 474 or Sure-grow 747, respectively.

Since most male parents had lower micronaire values than the female parents a large proportion of the resulting F_2-bulks produced fiber with lower values than the commercial parents. Very few F_2-bulks had micronaire values that were higher than the female cultivars. Many of the F_2-bulks had fiber length that was equal to or longer than the cultivars. None of the F_2-bulks produced fibers that were weaker than Sure-Grow 747 and only 10 were weaker than Stoneville 474. More than one-third of the 228 F_2-bulks had fibers that were stronger than Stoneville 474 and Sure-Grow 747. Results suggested that Sure-Grow 747 was a better general combiner for larger boll size, increased yield, longer 2.5% span length and higher percent elongation, while Stoneville 474 was a better general combiner for increasing fiber strength.

Since the mean of F_2-bulks for many desirable traits were equal to the commercial cultivars or above the mid-parent there is a good prospect of selecting transgressive segregants in the desired direction. Currently a detailed genetic analyses (genetic effects, variance components, correlations, and predicted genotypic values) is being conducted with this data set, to determine which crosses offer the best promise

for contributions to the breeding gene pool of domestic cotton. Even if only a few crosses are useful this would be important in widening genetic diversity.

Conclusion

The yield for most of the F_2-bulks was not improved from the high yield potential cultivars Stoneville 474 and Sure-Grow 747. These two cultivars have micronaire values that are in the high end of the acceptable range. The F_2-bulks showed improvement for micronaire. Also fiber strength for the F_2-bulks was greater than the cultivars. These day-neutral derived accessions are a new source of genetic diversity that can be used in cotton breeding programs. They offer the potential to improve important traits; however, their low lint percentages must be over considered when they are used.

References

Anonymous (1974). The regional collection of *Gossypium* germplasm. USDA Report ARS-H-2. U.S. Government Printing Office, Washington, D.C.

Anonymous (1997). Preservation and utilization of germplasm in cotton. Southern Cooperative Series Bulletin No. 386.

Basal H, Bebeli P, Smith CW and Thaxton P (2003). Root growth parameters of converted race stocks of upland cotton and two BC_2F_2 populations. Crop Science 43, 1983-1988.

McCarty JC and Jenkins JN (1992). Characteristics of 79 day-neutral primitive race accessions. Mississippi Agricultural and Forestry Experiment Station, Technical Bulletin 184.

McCarty JC and Jenkins JN (1993). Registration of 79 day-neutral primitive cotton germplasm lines. Crop Science 33, 351.

McCarty JC and Jenkins JN (2001). Primitive cotton germplasm: yield and fiber traits for 16 day-neutral accessions. Mississippi Agricultural and Forestry Experiment Station, Research Report, 22(19), 1-5.

McCarty JC and Jenkins JN (2002). Registration of 16 day length-neutral flowering primitive cotton germplasm lines. Crop Science 42, 1755-1756.

McCarty JC and Percy RG (2001). Genes from exotic germplasm and their use in cultivar improvement in *Gossypium hirsutum* L. and *G. barbadense* L. In 'Genetic improvement of cotton - Emerging technologies'. (Eds JN Jenkins, S Saha) pp. 65-80. (Science Publishers, Inc. Enfield, NH).

McCarty JC, Jenkins JN, Parrott WL and Creech RG (1979). The conversion of photoperiodic primitive race stocks of cotton to day-neutral stocks. Mississippi Agricultural and Forestry Experiment Station, Research Report, 4(19), 1-4.

McCarty JC, Jenkins JN and Tang B (1995). Primitive cotton germplasm: variability of yield and fiber traits. Mississippi Agricultural and Forestry Experiment Station, Technical Bulletin 202.

McCarty JC, Jenkins JN and Wu J (2003). Use of primitive accessions of cotton as sources of genes for improving yield components and fiber properties. Mississippi Agricultural and Forestry Experiment Station, Bulletin 1130.

McCarty JC, Jenkins JN and Wu J (2004). Primitive accessions derived germplasm by cultivar crosses as sources for cotton improvement: I. Phenotypic values and variance components. Crop Science 44, 1226-1230.

McCarty JC, Jenkins JN and Wu J (2004). Primitive accessions derived germplasm by cultivar crosses as sources for cotton improvement: II. Genetic effects and genotypic values. Crop Science 44, 1231-1235.

McCarty JC, Jenkins JN and Zhu J (1998a).? Introgression of day-neutral genes in primitive cotton accessions: I. Genetic variances and correlations.? Crop Science 38, 1425-1428.

McCarty JC, Jenkins JN and Zhu J (1998b).? Introgression of day-neutral genes in primitive cotton accessions: II. Predicted genetic effects.? Crop Science 38, 1428-1431.

Percival AE (1987). The national collection of *Gossypium* germplasm. Southern Cooperative Series Bulletin No. 321.

SAS Institute (1999). SAS software Version 8.0. SAS Institute, Cary, NC.