Selected Yield Components and Associated Properties of Upland Cotton Across Fruiting Zones

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RESEARCH PROBLEM

Cotton (Gossypium hirsutum L.) yields in Arkansas have fluctuated greatly over the last 10 years (U.S. Dept of Agriculture, 2009). The long-term effects of selection based upon lint percentage have decreased seed size and decreased stability (Lewis, 2001). Lewis suggested that yield and yield stability might be improved by increasing the fibers/seed and fibers/seed could be increased by selecting for higher lint index (i.e., weight of fiber/100 seed). Bednarz et al. (2006) suggested the use of an index such as lint frequency (Hodson, 1920), where seed surface area would be taken into account. The use of fiber density as a selection tool would incorporate the suggestions of Lewis (2001) and Bednarz et al. (2006), but the inheritance of such a component is unknown. In addition, inheritance may vary across the plant depending upon fruit age and exposure to various environmental occurrences.

BACKGROUND INFORMATION

Higher yielding cultivars for a given area typically display yield by location interactions and exhibit decreased stability across environments (Calhoun and Bowman, 1999). The improvement of multiple quantitative traits that contribute to lint yield has proven difficult. In addition to the basic genetic by environmental influences, fruiting zones on a plant may provide sub-environments. These sub-environments create an additional dimension that must be considered for the evaluation of traits. Many yield and fiber components have been shown to vary within the cotton crop canopy (Bennet et al., 1967). Differences in seed index have been observed within fruiting positions (Conkerton et al., 1993). An evaluation of yield component variables within zones might elucidate selection strategies and could shed light on inheritance patterns of yield component variables. Therefore, we hypothesize that differences exist between fruiting

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zones for seed index (SI), lint index (LI), fibers per seed (FPS), and fiber density (FDEN). In addition, we hypothesize these traits are heritable. The objectives of this study were to determine the variation for certain yield component variables among parents and \( F_1 \) populations across fruiting zones and over two environments.

**RESEARCH DESCRIPTION**

In 2007, a test was conducted to evaluate variation for selected yield component traits and to determine their inheritance patterns. The test included a full-diallel set of all \( F_1 \) combinations plus the parents and was planted into a Sharkey silty clay soil (very-fine, smectitic, thermic Chromic Epiaquerts) at Keiser on 30 April and a Hebert silt loam soil (fine-silty, mixed, thermic Aeric Ochraqualf) at Rohwer, Ark., on 15 May. Field plots consisted of two rows 6.7-m long on 0.96-m centers with two replications. Genotypes were randomized in each replication with reciprocal crosses in adjacent plots. After emergence, plants were thinned to a uniform density of about 6 plants/row-m. Plants were managed according to University of Arkansas recommended practices and soil moisture was supplemented by furrow irrigation.

Prior to harvest, 10 random plants per plot were mapped using COTMAP (Bourland and Watson, 1990). COTMAP is a modified whole plant mapping technique, which may be used to evaluate various plant structures, boll retention, and boll distribution variables. Bolls on each plant were assigned to six maturity zones based on standard vertical and horizontal flowering intervals. Bolls within zones were hand-harvested and bulked by plot. After ginning, fiber length, length uniformity, and micronaire were determined. Yield component variables included seed index (SI, weight of 100 fuzzy seed), lint index (LI) (weight of lint of 100 seed), fibers per seed (FPS, estimated using lint index fiber properties), and fiber density (FDEN, an estimate of the number of fibers per \( \text{mm}^2 \) of seed surface area).

SI, LI, FPS, and FDEN were each analyzed as a split-split plot with replication nested within location as the whole plot (fixed effect), genotype (fixed effect) as the subplot, and fruiting zone (fixed effect) as the sub-subplot. Means were separated using Fisher’s protected LSD at the 0.05 significance level. All data were analyzed using the PROC GLM procedure in SAS Version 9.1 (SAS Institute, Cary, N.C.). In addition, weighted means for each variable within each plot were calculated by multiplying the proportion of total bolls that occurred within each fruiting zone by yield component values obtained from each fruiting zone.

**RESULTS AND DISCUSSION**

Significant variation in location, genotype and zone methods was found for SI, LI, FPS, and FDEN. Location by genotype and location by zone interactions affected all traits. The lack of genotype by zone interaction indicated that genetic effects were consistent over zones and, therefore genetic analyses within zones was not needed. For each variable, whole-plant means (weighted by percentage of bolls in each zone as determined by COTMAP) were then calculated and used in subsequent genetic analyses.
Location by zone interactions for each variable suggested differences in the distribution of fruit between Keiser and Rohwer. Although significant variation among zones was observed at each location, the means exhibited a much smaller range at Rohwer than at Keiser. The relatively low variation between zones at Rohwer may be contributed to increased season length at this more southern location. SI at both locations and LI at Keiser declined from zone 1 (bolls from first week of flowering) to zone 4 (fourth week of flowering) while values for zone 5 (bolls in positions 3 or greater) and zone 6 (bolls from monopodial branches) were intermediate to values for zones 3 and 4. This variation relates closely to expected maturity of bolls with later maturing bolls producing lower SI and LI. FPS and FDEN at Keiser tended to increase, rather than decrease, from zones 1 to 4. Genotype by location interactions for each trait may be partly explained by relative values across locations of specific genotypes (the parents and F₁’s). Specific parents and associated F₁’s that most greatly affected the interaction varied among the traits.

Due to the genotype by location interactions, genetic analyses were conducted by location for each trait. Both general combining ability (GCA) and specific combining ability (SCA) were significant for SI, LI, FPS, and FDEN at each location (Table 1). Significant reciprocal effects were only found for LI at Keiser. For each trait, the influence of GCA greatly exceeded the influence of SCA. For SI and FPS, the relative values of GCA and SCA were similar at both locations. GCA had relatively stronger influence on LI at Rohwer than at Keiser, but had relatively stronger influence on FDEN at Keiser than at Rohwer.

**PRACTICAL APPLICATION**

The lack of an interaction of genotypes by fruiting zones verifies current boll sampling procedures for yield component traits. The general combining ability indicates strong additive effects for each trait, including FDEN. FDEN may be used in a cotton breeding program and should respond favorably to direct selection.

**ACKNOWLEDGMENTS**

Support for this research was provided by Cotton Incorporated.

**LITERATURE CITED**

Table 1. General combining ability (GCA), specific combining ability (SCA), and reciprocal effects for four yield component variables determined from eight parents and their complete set of F₁’s.

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<th>Trait</th>
<th>Location</th>
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<th>SCA</th>
<th>Reciprocal</th>
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<td>Rohwer</td>
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<td>0.17 *</td>
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