Yield Component Comparison of Modern Versus Obsolete Cultivars for Explaining Yield Stagnation and Variability

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RESEARCH PROBLEM

The U.S. Cotton industry has faced very difficult times in recent years due to problems with year-to-year variability in yield. According to Helms (2000), there is clearly a significant problem with the lack of uniformity in current yields. Recent literature and hypotheses indicate that the yield variability is mostly related to extreme environmental conditions (i.e., particularly high temperatures and drought) as well as a peak in genetic improvements in yield (Meredith, 1995). It is speculated that modern cultivars partition dry matter and energy pools differently within the boll and at the seed level than obsolete cultivars making them potentially more sensitive to environmental stress. It is assumed that modern cultivars produce smaller bolls with smaller seeds but more seeds per boll than obsolete cultivars. Under adequate growing conditions this allows for more seeds per unit area and the potential for more fiber per unit area, i.e., higher yields. However, under poor environmental conditions, i.e., drought and high temperatures, the modern cultivars are unable to tolerate the added carbohydrate stress and fail to fill seed and produce fiber necessary for optimal yield. Given the potential differences between partitioning aspects of modern and obsolete cultivars, the main objective of this study was to evaluate boll and yield components of these cultivars in relation to water-deficit stress to gain insight into the sensitivity of yield development.

BACKGROUND INFORMATION

Cotton yields in Arkansas as well as much of the U.S. increased steadily during the 1980s, but in the 1990s there has been a leveling off and lately a decrease in yields (Meredith, 1998; Lewis and Sasser, 1999). Of more concern, however, is the extreme year-to-year variability. Three out of five seasons from 1995 to 1999 were extremely disappointing with unusually low yields (Oosterhuis, 1999). The 1998 and 1999 crop

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yields were the poorest in recent history and much of this was related to extreme weather conditions and less on insect pressure. Generally, each year the cotton crop appears to have good yield potential at mid-season, but this potential is not always achieved at harvest due to combinations of moisture stress and high temperatures during the boll development period. Besides environmental conditions, changes in breeding objectives over the past few decades may also be an underlying reason for yield variability. Increased yield variability may be the result of differential partitioning of metabolites between fiber and seed of modern and obsolete cultivars as a result of environmental stress during early boll development.

RESEARCH DESCRIPTION

A field study was designed at Clarkedale in northeast Arkansas on a Dundee silt loam in 2001 and 2002 to determine if water-deficit stress differentially impacted lint yields or the components of yield of modern versus obsolete cultivars. The study contained water and cultivar as the two factors tested. Water was the whole-plot factor and consisted of either well-watered or water-deficit conditions. The sub-plot factor was cultivar and consisted of eight cultivars (four modern and four obsolete). The modern cultivars evaluated were ST 474, SG 747, DP 33B, and Acala Maxxa and the obsolete cultivars evaluated were ST 213, DP 16, REX, and SJ2. Each of these eight cultivars was subjected to both water treatments and was replicated six times. At final harvest, a two-meter subsample of seedcotton was collected from each 4-row plot in order to evaluate boll and yield components. Boll and yield components included average boll weight, boll number per unit area, seeds per boll, seeds weight, seeds per unit area, and weight of fiber per seed. Following the subsample for yield components, lint yields were determined from mechanically harvesting the center two rows of each 4-row plot.

RESULTS AND DISCUSSION

Since there were no significant interactions between water treatments and cultivars, all data will be presented by looking at the main effects, i.e. modern cultivars versus obsolete cultivars averaged over water treatments, and well-watered versus water-deficit averaged over cultivars.

Lint Yields

Yield results from the 2002 field study indicated no significant differences ($P<0.05$) in lint yield between modern and obsolete cultivars when averaged over water treatments (Table 1), or differences between water treatments averaged over cultivars (Table 2). At the cultivar level, the modern cultivars numerically yielded higher than the obsolete cultivars (Table 1), which was expected given optimal rainfall during the crucial first three to four weeks of boll development. Modern cultivars produce smaller bolls with
smaller seeds but more seeds per boll, i.e. more seeds per acre, than do obsolete cultivars. Thus, under adequate growing conditions (adequate rainfall) this allows for modern cultivars to produce more fiber per unit area (higher yields). However, under poor environmental conditions (i.e. drought and high temperatures) it is believed that the modern cultivars would be unable to tolerate the added carbohydrate stress and fail to fill seed and produce fiber necessary for optimal yield. The yield data from the 2002 season support data from the past season, in which rainfall during boll development was adequate, resulting in higher yields by the modern cultivars (Brown et al., 2001).

**Boll and Yield Components**

When averaged over water treatments in 2002, boll component values indicated that the numerical increase in yield by the modern cultivars was due to significant ($P<0.05$) improvements in gin turnout and fiber per seed (Table 1). As expected, boll weight and seed weight were significantly higher for the obsolete cultivars compared to the modern cultivars (Table 1). In terms of yield components, there were no differences between modern and obsolete cultivars for changing boll number or seed number per acre at the cultivar level when averaged over water treatments. There were no differences in yield or boll components at the water treatment level averaged over cultivars, which was expected due to the similarity between well-watered and water-deficit plots given adequate rainfall during boll development. Boll and yield component data were very similar to the data from the 2001 season in which the weather patterns were also optimal during boll development (Brown et al., 2001).

**PRACTICAL APPLICATION**

It is speculated that the reason for the stagnant yields and year-to-year yield variability is a combination of poor environmental conditions during boll development coupled with changes in the way that modern cultivars partition energy and carbohydrate pools between seed and fiber. Therefore, we urgently need to understand why cotton yields are so variable from year to year and how this variability differentially affects contrasting genotypes as measured through yield components. By accomplishing this goal it may be possible to formulate management strategies before yields are adversely affected. This study will be repeated at two locations in 2003.

**LITERATURE CITED**


Table 1. Genotypic effect on yield, boll components, and yield components averaged over water treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (lb lint/acre)</th>
<th>Boll weight (g/boll)</th>
<th>Gin turnout (%)</th>
<th>Seed weight (g/100 seed)</th>
<th>Bolls (#/acre)</th>
<th>Seeds (g)</th>
<th>Seeds Fiber/seed (mg/mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern</td>
<td>656</td>
<td>3.59</td>
<td>36.8*</td>
<td>8.94</td>
<td>219,000</td>
<td>8,220,000</td>
<td>0.59*z</td>
</tr>
<tr>
<td>Obsolete</td>
<td>622</td>
<td>3.95*</td>
<td>34.7</td>
<td>9.94*</td>
<td>192,000</td>
<td>7,890,000</td>
<td>0.52</td>
</tr>
</tbody>
</table>

* Treatment means followed by an * are significantly different at P<0.05.

Table 2. Environmental effect on yield and components of yield averaged over cultivars.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (lb lint/acre)</th>
<th>Boll weight (g/boll)</th>
<th>Gin turnout (%)</th>
<th>Seed weight (g/100 seed)</th>
<th>Bolls (#/acre)</th>
<th>Seeds (g)</th>
<th>Seeds Fiber/seed (mg/mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well-watered</td>
<td>637</td>
<td>3.69</td>
<td>35.9</td>
<td>9.46</td>
<td>209,000</td>
<td>8,370,000</td>
<td>0.56</td>
</tr>
<tr>
<td>Water-stressed</td>
<td>641</td>
<td>3.86</td>
<td>35.6</td>
<td>9.41</td>
<td>202,000</td>
<td>7,740,000</td>
<td>0.55</td>
</tr>
</tbody>
</table>