Yield Comparison of Modern Versus Obsolete Cultivars as a Measure of Yield Variability

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RESEARCH PROBLEM

Year-to-year variability in yield is a major concern in U.S. cotton production. Anecdotal reports indicate that this yield variability is mostly related to extreme environmental conditions during boll development, coupled with genetic changes in modern cultivars. Under stress environments, the presumption is that obsolete cultivars would gain the yield advantage because modern cultivars have smaller seeds and would have less tolerance to the stress thus partitioning less carbon to the developing fiber. The goal of this four-year field study was to quantify the effect that water-deficit stress had on yield variability between modern versus obsolete cultivars.

BACKGROUND INFORMATION

The U.S. cotton industry has faced very difficult times in recent years due to problems with yield variability. According to a report by Helms (2000), there is a significant problem with the lack of uniformity in current yields. Cotton yields in Arkansas as well as much of the U.S. increased steadily during the 1980s, but leveled off during the nineties (Chaudhry, 1997; Lewis and Sasser, 1999). Of more concern, however, was the extreme year-to-year variability during the 1990s. In Arkansas, three out of five seasons from 1995 to 1999 were extremely disappointing with unusually low yields (Oosterhuis, 1999). The 1998 and 1999 crop yields were the poorest in recent history, and much of this was related to extreme weather conditions and less to insect pressure. Generally, each year the cotton crop appeared to have good potential at mid-season, but this potential was not always achieved at harvest due to combinations of moisture stress and high temperatures during flowering and boll development (Oosterhuis, 1990). Besides environmental conditions, genetic factors also appeared to

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be a culprit in the stagnation and variability in yield trends throughout the Cotton Belt. Meredith (1995) indicated that genetic improvements in cotton yield peaked around the mid-to-late 1980s.

Yield variability can be summarized as any factor causing a periodic change in the outcome of yield. Many factors can influence yield or the variability in yield from year to year. Climatic factors such as moisture availability, length of the growing season, and temperature extremes can affect yield and cause variability. Other sources of yield variability include soil type, soil moisture, pH, fertility levels, organic matter, weed pressure, insect pressure, disease pressure, growth regulators, crop termination, and wildlife damage (Elms et al., 2001). Also, it has been determined that variability can occur within a field even if climate, cultural practices, and moisture status are constant (Elms et al., 2001). It appears there are many factors that cause variability in yield, however, recent literature and hypotheses indicate that the main cause of year-to-year yield variability is extreme environmental conditions, particularly high temperatures and drought, coupled with the peak of genetic improvements in yield (Meredith, 1995) and changes in yield components (Lewis et al., 2000). The main objective of this four-year study was to determine if modern cultivars are, in fact, more variable than cultivars grown over three decades ago.

RESEARCH DESCRIPTION

Field studies were designed in northeast Arkansas at Clarkedale in 2001-2003 and in northwest Arkansas at Fayetteville in 2003 to evaluate the effect that water-deficit conditions coupled with genotypic differences had on yield variability. Cotton was planted each season in early to mid May as soon as the soil temperatures warmed to above 20°C, the soil was dry enough to plant with a favorable three to five day weather forecast. The field studies included two factors, i.e., cultivar and water. The whole-plot factor was water, consisting of either well-watered or water-deficit conditions. The water was applied by a specially designed randomized furrow irrigation system based on data from an irrigation scheduler program (Ferguson et al., 1996). The sub-plot factor was cultivar and consisted of eight cultivars (four modern and four obsolete cultivars). The modern cultivars selected were ‘SureGrow’, ‘Stoneville’, ‘Deltapine NuCotn 33B’, and ‘Acala Maxxa’. The obsolete cultivars were ‘Rex 213’, ‘Stoneville 213’, ‘Deltapine 16’, and ‘Acala SJ2’. Each of the eight cultivars was subjected to both water treatments in a split-plot arrangement and treatments were replicated six times. At harvest, the plots were mechanically harvested for lint yields by harvesting the middle two rows of each four-row plot.

RESULTS AND DISCUSSION

Lint Yields

Due to a significant year-by-treatment effect, and to better illustrate the effect that water-deficit stress had on modern versus obsolete cultivars, lint yield data are presented for the individual years (Fig. 1). Unfortunately, the 2001 to 2003 seasons represented
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years with near optimal rainfall and mild day and nighttime temperatures during boll development. This made testing our hypothesis difficult, i.e. that obsolete cultivars would better tolerate environmental stress conditions than modern cultivars, therefore giving the obsolete cultivars a yield advantage. The 2000 season was very stressful in terms of both temperature and water-deficit stress, making that season an excellent year to test this research hypothesis. Results from the 2000 season indicated that under well-watered conditions, there were no significant differences in yield between modern and obsolete cultivars; however, under water-deficit conditions the obsolete cultivars had significantly higher yields (Fig. 1). Furthermore, averaged over cultivars there was a significantly higher yield under well-watered conditions as opposed to water-deficit conditions, but more importantly there was a significant cultivar-by-water interaction (Fig. 1). This indicated that modern and obsolete cultivars responded differentially to the water-stress. These results confirmed our hypothesis that obsolete cultivars are better able to adapt to severe environmental conditions, and thus have an improved ability to maximize yield potential. Results from the 2001 to 2003 seasons showed that under optimal (or minimal) stress conditions, modern cultivars provided the highest yields under both well-watered and water-deficit conditions, and their yields were significantly greater in 2003 (Fig. 1).

Yield Variability

Numerous authors have expressed concern that even though modern cultivars have greater yield potential they also appear to have more year-to-year variability (Lewis and Sasser, 1999; Chaudry, 1997; Elms et al., 2001). Results from our 2000 to 2003 study indicated that yield variability is, in fact, increasing in our modern cultivars compared to the variability that exists in the obsolete cultivars, but not by a significant amount (Fig. 2). These results indicated greater variability in the modern cultivars under both well-watered and water-deficit conditions.

PRACTICAL APPLICATION

Field studies from 2000 to 2003 showed a 7.2% increase in yield by the modern cultivars averaged across water treatments and years. This increase was mostly due to favorable temperature and moisture levels in three of the four seasons. However, in the more stressful 2000 season the obsolete cultivars had significantly higher yields under water-deficit stress conditions compared to the modern cultivars. This finding supports our research hypothesis that obsolete cultivars can better tolerate environmental stresses and contribute to higher yields. Furthermore, it was determined that under both well-watered and water-stress conditions the modern cultivars have greater year-to-year variability in yields compared to obsolete cultivars.
LITERATURE CITED


Fig. 1. Lint yields of modern and obsolete cultivars under well-watered and water-deficit conditions. P-values show statistical differences between the paired treatments. * indicates a significant difference at the water treatment at $P < 0.01$, and † indicates a significant Cultivar X Water interaction at $P < 0.05$. 
Fig. 2. Year-to-year variability in lint yields of modern and obsolete cultivars under well-watered and water-deficit conditions. Yield variability was calculated using coefficient of variation analysis for the 2000-2003 seasons.