TILLAGE AND N-FERTILIZER SOURCE EFFECTS ON COTTON FIBER QUALITY

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ABSTRACT

Cotton lint yield along with fiber quality determines the value of the crop to growers since tests of fiber are a key consideration in sales of cotton to processing plants. Most cotton research has focused on impacts of genetic, environmental, and management factors on production and yield. More research is needed to describe the impact of these variables on cotton fiber quality. We analyzed two years of fiber quality data from a cotton-rye cropping system under a factorial set of tillage and fertilizer treatments (conventional till, no-till, conventional fertilizer, and poultry litter). Cotton fiber fineness, strength, length, uniformity index, and the 2.5% and 50% span lengths were measured partially using high volume instrumentation equipment. The data were classified and used in evaluating cotton quality according to industry standards. Categorical analysis showed that the production treatments impacted fiber quality. Fiber quality variation occurred over narrow ranges and differences were generally small. We found from our data that shifts had occurred from one class to another as a result of production treatments. These shifts may impact the economics of cotton production.

INTRODUCTION

Cotton fiber has a 60% share of the total retail market for apparel and home furnishings, excluding carpets, in the U.S. (Marek, 2001). Fiber quality determines the value of a bale of cotton to the processor. Most mills now use high-speed spinning equipment, which favors higher quality fiber. Short, inconsistent fibers do not run well through these spinners and can jam them, costing mills time and money (Haire, 2004). High volume instrument (HVI) testing gives managers of mills an efficient way to gage the processing quality of incoming bales of cotton. Low quality cotton fiber that cannot be processed successfully can be returned to growers with no compensation for production cost (Bradow and Davidonis, 2000). A differential pricing system is also in place that favors lint falling in a narrow optimum quality range, while penalizing fiber that falls outside this range through discount pricing. Hence the net value of a crop to a producer is determined not only by yield, but lint quality, cotton prices, and quality-based discounts.

There is concern about cotton quality across the Cotton Belt (Marek, 2001). Georgia's cotton crop quality has declined in recent years because of low scores in two important qualities, short fibers and inconsistent fibers, which might have deprived Georgia growers of $43 million in potential income in 2002 (Haire, 2004). At the same time, availability of higher quality cotton continues to increase from countries that compete against U.S. producers, particularly from those that use labor-intensive harvesting methods.

Fiber quality is expressed using a composite of both quantitative and qualitative parameters that include fiber length, length uniformity, fineness and maturity, strength, color, and trash content, partially determined using HVI (Bradow and Davidonis, 2000; USDA-AMS, 2001). Natural and environmental variations in fiber shape and maturity at bale, plant, boll, and seed level (Bradow et al., 1997) complicate this process.

Fiber length is reported in several ways: upper-half-mean (UHM) length, 2.5% span length, and 50% span length. It influences yarn strength and evenness, fineness, and the efficiency of the spinning process (Moore, 1996). Extreme temperatures, water stress, or nutrient deficiencies during cotton production may influence this quality (USDA-AMS, 2001). Length uniformity is the ratio between the mean length and the upper half mean length of test fibers expressed as a percentage. It influences yarn evenness and strength, and the efficiency of the spinning process (USDA-AMS, 2001). Fiber fineness and maturity, expressed in micronaire, an indirect measure of the airflow through a test specimen fiber, is also a very important determinant of yarn strength and uniformity. It can be influenced by environmental conditions during the growth period such as moisture, temperature, sunlight, plant nutrients and extremes in plant or boll population (USDA-AMS, 2001). Fiber strength determines yarn strength. It may be affected by plant nutrient deficiencies and weather (USDA-AMS, 2001). Color grade is determined by the degree of reflectance (bright or dull) and yellowness (the degree of color pigmentation). Color measurements appear to be correlated with overall fiber quality (USDA-AMS, 2001). Trash is a measure of the amount of non-lint material in the cotton.

Most cotton production research has focused on enhancing yield. Fiber quality has generally been considered a genetic trait. Faircloth et al. (2003) reported that cotton yield and quality are influenced by both genetics and environmental conditions. Bradow and Davidonis (2000) indicate that a broad range of fiber properties can occur at the crop and whole-plant levels, as a result of fluctuations of the macro- and micro-environment around the plants. Johnson and Bradow (2000) found correlation between soil properties and a number of fiber properties including micronaire, short fiber content, and fiber color. Coolman (2001) highlights the importance of adequate potassium levels in the soil as key to avoiding micronaire problems.

Cotton producers in the Southeast are increasingly using no-till and poultry litter fertilizer, which together have been shown to enhance lint yield (Endale et al., 2002a) and induce better infiltration (Endale et al., 2002b). These particular management practices may influence cotton fiber quality because of their impact on soil water and nutrient availability. Bauer et al. (1999) found that in the Coastal Plain of South Carolina, cotton grown with conservation tillage had fibers that were 0.02 inches longer than cotton grown with conventional tillage, regardless of soil type. And fiber properties were more uniform in conservation tillage than in conventional. Bauer and Busscher (1996) found that cotton lint quality was not affected by tillage system or winter cover, but a 0.1 decrease in micronaire was observed in cotton following rye compared with legumes. Daniel et al., (1999) found that cotton fiber quality (length, uniformity, strength and micronaire) was not affected by tillage system (no-till versus conventional till).

The Southern Piedmont has unique sets of environmental characteristics including, climate and soils. Research is needed on the impact of cropping systems and management on cotton fiber quality in this region. In this paper we compare two years of cotton fiber quality from a cotton-rye cropping system managed under either no-till or conventional tillage and fertilized with either poultry litter or conventional inorganic fertilizer near Watkinsville, GA. Endale et al. (2002a) have reported impact of this system on soil water and lint yield.

MATERIALS AND METHODS

Experimental details for the research from which the 1997 and 1998 fiber quality data were determined are given in Endale et al. (2002a). The field details are also described in these proceedings for a corn-rye cropping system (Endale et al., 2004). Briefly, the research was conducted in 1997 and 1998 at the USDA-ARS J. Phil Campbell Sr. Natural Resource Conservation Center in Watkinsville, GA (83°24' W and 33°54' N) on 12 (30 x 100 ft) plots. The site is located on nearly level (<2% slope) Cecil sandy loam (fine, kaolinitic thermic Typic Kanhapludult). The experiment was laid out as a randomized complete block with a split plot feature with three replications. Conventional-till (CT) and no-till (NT) were main plots. Fertilizer subplots consisted of ammonium nitrate as, conventional fertilizer (CF), or poultry litter (PL). The CT consisted of a 12 in. deep chisel plowing, followed by a one to two diskings to a depth 8 inches and a subsequent disking to 3 inches to smooth the seed bed. The only soil disturbance in NT was during planting with a four-row no-till planter equipped with fluted coulters to cut through surface residue, followed by double disk openers to make a narrow slit for the seed and press wheels to firmly cover the seed.

The cropping system consisted of winter cereal rye (*Secale cereale* L. cv. Hy-Gainer) as cover crop followed by summer cotton (*Gossypium hirsutem*). The cotton cultivar was 'Stoneville 474' and the cotton seasons lasted from May 14 to November 4, 1997, and May 14 to November 12, 1998. Nitrogen fertilizer rate for cotton was 60 lbs N acre^{-1} amounting to 2 tons acre^{-1} for the poultry litter. Other fertilizer rates were based on soil test recommendations. Pesticides and rates followed standard practice for the region. Fertilizers and pesticides were surface applied in no-till plots, but in conventional till systems were surface applied and then disked. Standard production management practices were followed for the rest of a season. In 1997 five random cotton lint samples were collected from each plot at harvest for fiber quality analysis. Sample numbers were tripled in 1998 by collecting five random samples from each third of a plot. Lint samples were sent to the Louisiana Agricultural Experiment Station, Cotton Fiber Testing Laboratory, in Baton Rouge, LA, for fiber quality determination using partially HVI equipment.

RESULTS AND DISCUSSION

Distributions of the fiber quality parameter values are presented in Figures 1 to 3. Fiber quality parameter frequency class in percent is presented in Table 1. Analysis of the proportions within each class indicated that micronaire and USDA UHM class were affected by production practice (Table 1). Analysis of variance also indicated that tillage impacted 50% span length ($P = 0.048$) but other analyses of variance did not detect significant effects on fiber quality ($0.208 < P < 0.856$). Figures 1 to 3 also show that the range of observations often were very small. For example, 80% of the data (10th to 90th percentiles) for upper half mean length (Fig 2, B) have a range of only 0.1 to 0.13 for treatments. This range is about 4 for the uniformity index (Fig. 2, A) and strength (Fig. 1, B). Only the fineness values of the CT treatments have relatively larger data ranges (Fig. 1, A). We found a strong correlation between the 2.5% span length (Fig. 3, A) and the upper half mean length (Fig. 2, B) ($R^2 = 0.93$).

In practical terms, HVI and other measurement values are used to create classes of fiber quality data, which are then used as quality evaluating guides (Table 1). The NT treatments shifted the fineness classes to higher micronaire values. This has implications for fiber processing and quality of yarns. In addition, micronaire values are used to set price differentials in bales of cotton, whereby values in the range 3.7 to 4.2 attract premium prices and those below 3.5 or greater than 4.9 evoke price deductions (USDA-AMS, 1991). The tillage treatments shifted micronaire values from the premium toward the base range (Table 1). No-till also shifted the upper half mean length into the USDA UHM code class of 36 and 37 (1.11 to 1.17 inches) (Table 1). The impact of the treatments on fiber strength was limited to no-till in CF plots, where fiber strength has shifted from the intermediate to the average class (Table 1), but this did not prove significant.

These demonstrated shifts impact the fiber processing and yarn quality arena, and ultimately have implication on the economics of the fiber processing plant, and the grower. Data were pooled for two years for these analyses. Year to year variations could impact fiber quality and treatment effects. Pending data from other years will be included in future analysis in due course.

CONCLUSIONS

The two years of fiber quality data showed that no-till and poultry litter affect the proportions of pooled mean fiber quality parameter values. However, the effects were relatively small and this is good news to growers since Endale et al. (2002a) reported that no-till and poultry litter individually and in combination significantly enhanced yield during the same years as these analyses at this site. Degraded fiber quality would have lessened the value of this yield enhancement.

ACKNOWLEDGMENTS

This research was supported in part by a grant from NRICGP, USDA-CSREES. We thank Stephen Norris for his expert assistance. We appreciate assistance by Dr. Dwight Fisher with statistical analysis.

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Table 1. Percents within frequency class for fiber quality parameters by treatment.

Fiber quality parameter, class and class range in parenthesis		Parameter frequency class in percent CTCF	CTPL	NTCF	NTPL
Fiber fineness in Micronaire					
Very Fine	**(< 3.0)**	**0.0**	**0.0**	**0.0**	**0.0**
Fine	**(3.0 to 3.9)**	**21.7**	**16.7**	**0.0**	**0.0**
Medium	**(4.0 to 4.9)**	**70.0**	**83.3**	**100.0**	**90.0**
Coarse	**(5.0 to 5.9)**	**8.3**	**0.0**	**0.0**	**10.0**
Very Coarse	**(> 5.9)**	**0.0**	**0.0**	**0.0**	**0.0**
Test of Mean Scores (*P*>Value)†			***P*<0.01**		
Micronaire Market Value					
Discount Range	**(< 3.5 or > 4.9)**	**8.3**	**0.0**	**0.0**	**0.0**
Base Range	**(3.5 to 3.6)**	**50.0**	**55.0**	**71.7**	**91.7**
Premium Range	**(3.7 to 4.2)**	**41.7**	**45.0**	**28.3**	**8.3**
Test of Mean Scores (*P*>Value)†			***P*<0.01**		
Fiber Strength					
Weak	**(< 18)**	**6.7**	**10.0**	**1.7**	**5.0**
Intermediate	**(18 to 21)**	**40.0**	**35.0**	**20.0**	**35.0**
Average	**(22 to 25)**	**50.0**	**50.0**	**75.0**	**51.7**
Strong	**(26 to 29)**	**3.3**	**5.0**	**3.3**	**8.3**
Very Strong	**(> 30)**	**0.0**	**0.0**	**0.0**	**0.0**
Test of Mean Scores (*P*>Value)†			***P*=0.14**		
Uniformity Index					
Very Low	**(< 77)**	**0.0**	**0.0**	**0.0**	**0.0**
Low	**(77 to 79)**	**1.7**	**5.0**	**1.7**	**5.0**
Average	**(80 to 82)**	**56.7**	**65.0**	**50.0**	**56.7**
High	**(83 to 85)**	**40.0**	**30.0**	**46.7**	**33.3**
Very High	**(> 85)**	**1.7**	**0.0**	**1.7**	**5.0**
Test of Mean Scores (*P*>Value)†			***P*=0.26**		
USDA UHM Code					
31	**(0.96 to 0.98)**	**1.7**	**3.3**	**0.0**	**1.7**
32	**(0.99 to 1.01)**	**6.7**	**6.7**	**3.3**	**3.3**
33	**(1.02 to 1.04)**	**10.0**	**13.3**	**18.3**	**13.3**
34	**(1.05 to 1.07)**	**20.0**	**26.7**	**10.0**	**18.3**
35	**(1.08 to 1.10)**	**38.3**	**25.0**	**11.7**	**15.0**
36	**(1.11 to 1.13)**	**20.0**	**21.7**	**40.0**	**33.3**
37	**(1.14 to 1.17)**	**3.3**	**3.3**	**15.0**	**11.7**
38	**(1.18 to 1.20)**	**0.0**	**0.0**	**1.7**	**1.7**
39	**(1.21 to 1.23)**	**0.0**	**0.0**	**0.0**	**1.7**
Test of Mean Scores (*P*>Value)†			***P*<0.01**		

† Test based on Cochran-Mantel-Haenszel Statistic for row mean scores.

Figure 1. Lint fiber quality in terms of fineness expressed as micronaire (A) and strength (B), based on two years of pooled data. Each box shows the 25th percentile, median, and 75th percentile. Means are shown as dotted lines inside boxes. Whiskers show the 10th and 90th percentiles. Outliers beyond these limits are shown as dots.

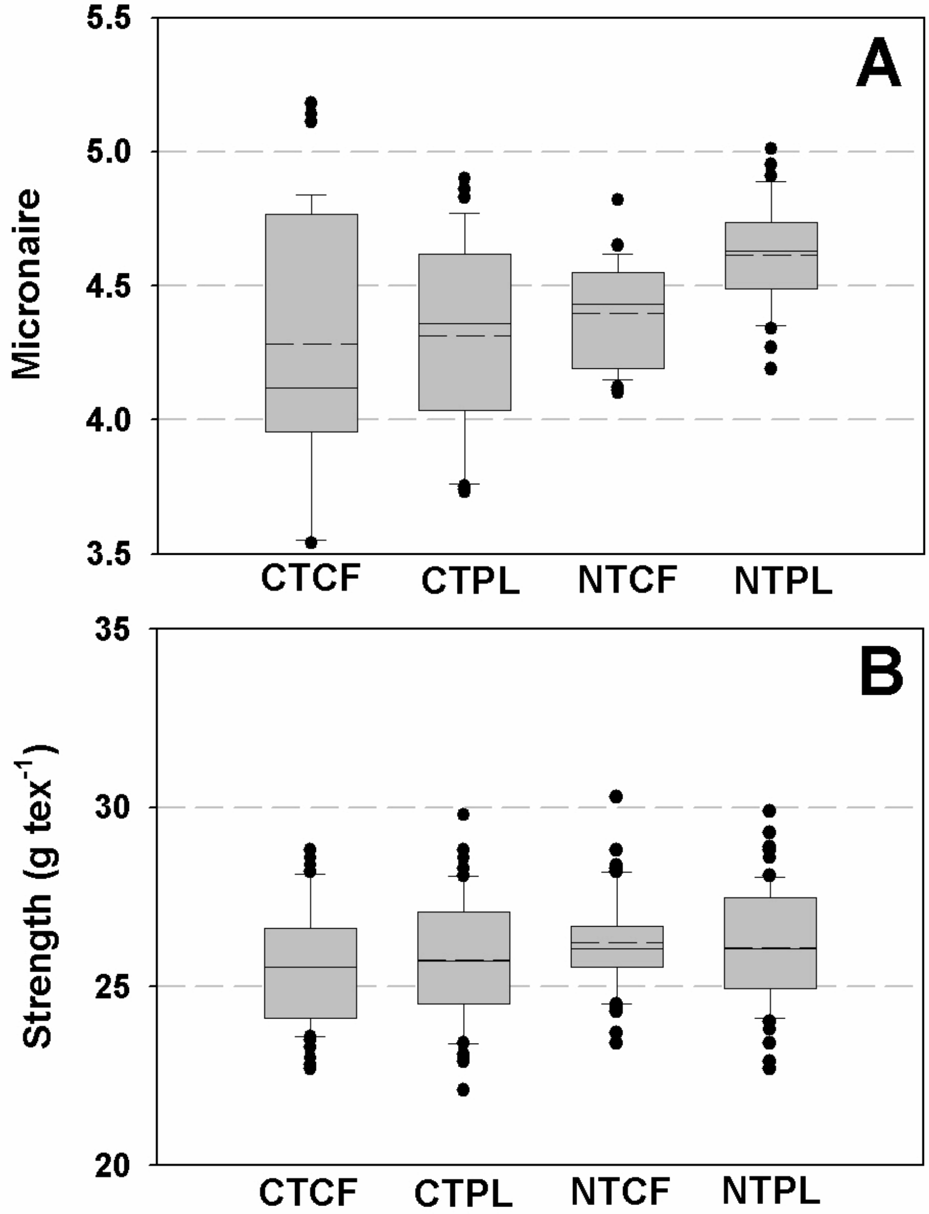

Figure 2. Lint fiber quality in terms of uniformity index (A) and length (B), based on two years of pooled data. Each box shows the 25th percentile, median, and 75th percentile. Means are shown as dotted lines inside boxes. Whiskers show the 10th and 90th percentiles. Outliers beyond these limits are shown as dots.

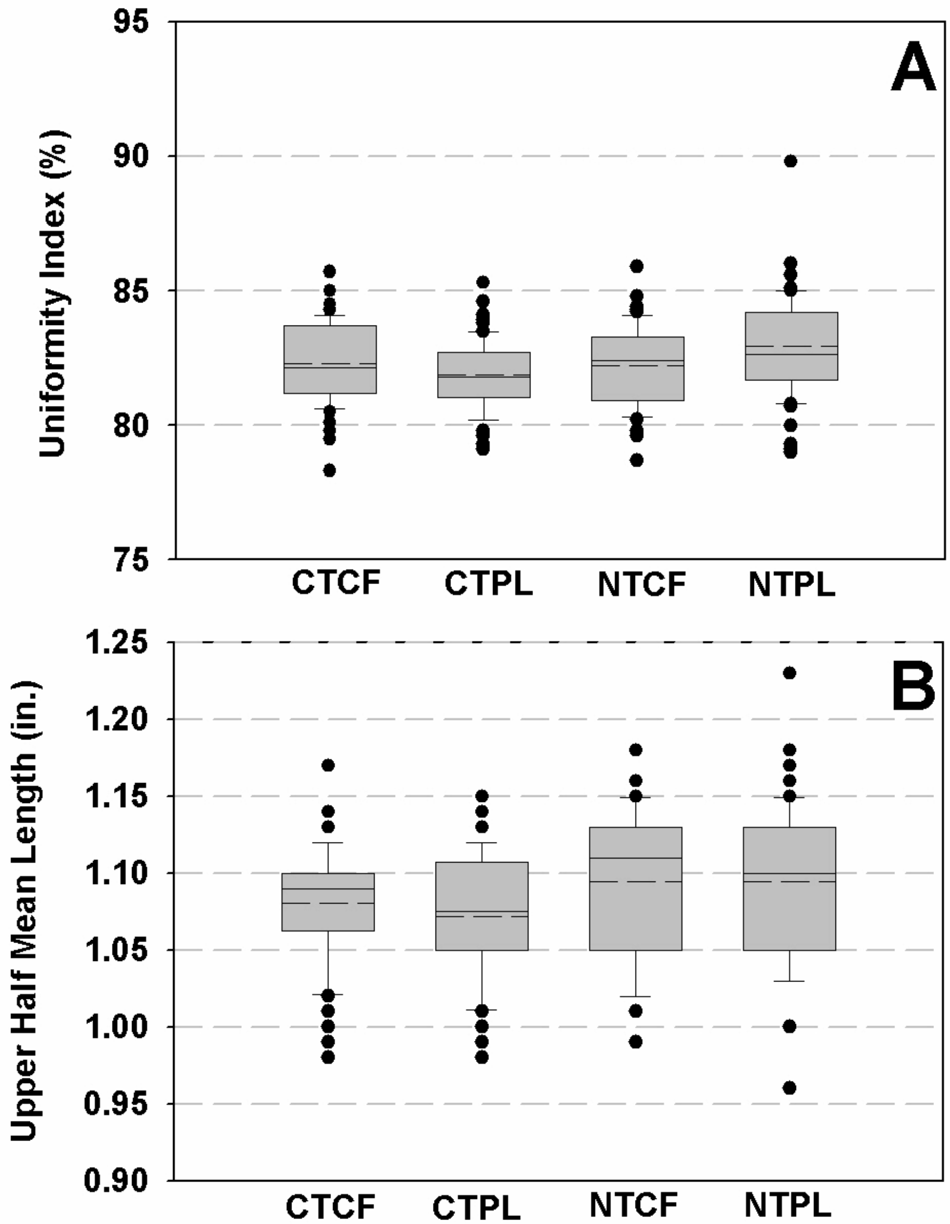

Figure 3. Lint fiber quality in terms of 2.5% span length (A) and 50% span length (B), based on two years of pooled data. Each box shows the 25th percentile, median, and 75th percentile. Means are shown as dotted lines inside boxes. Whiskers show the 10th and 90th percentiles. Outliers beyond these limits are shown as dots.