Tillage Effects on Canopy Position Specific Cotton Fiber Properties on Two Soils

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ABSTRACT

The benefits of conservation tillage on soil water availability are well established, but this soil management practice generally does not affect cotton (*Gossypium hirsutum* L.) fiber properties of the whole crop. The objective was to determine whether soil management practices affect canopy position specific fiber properties on two soils. A 3-yr field study was conducted with plots on two soil types [Bonneau loamy sand (loamy, siliceous, thermic Arenic Paleudult) and Norfolk loamy sand (fine-loamy, siliceous, thermic Typic Kandiudult)]. Treatments in the study were cover crop [none and rye (*Secale cereale* L.)] and tillage system (disk tillage and conservation tillage). Fiber properties were determined from hand picked samples at three canopy positions (first sympodial position bolls at Mainstem Nodes 6 and 7, 9, and 10, and 12 and 13). Yield and fiber properties of the whole crop were determined after machine harvesting. In two of the 3 yr, conservation tillage had 34% higher yield than disk tillage. Conservation tillage had higher fiber length uniformity every year, but no consistent differences between tillage systems occurred for the other fiber properties. Cover crop did not influence within-canopy fiber properties. When differences occurred between tillage systems for fiber length at specific canopy positions, fibers from conservation tillage were about 1 mm longer than fibers from disk tillage. Fiber length uniformity results were similar to those for fiber length. Disk tillage resulted in cotton with 0.22 lower micronaire units than conservation tillage at Mainstem Nodes 6 and 7 when rainfall was plentiful in 1997, but had micronaire that was 0.82 units higher than conservation tillage at that canopy position during the dryer year of 1998. Within canopy variability for micronaire was greater on the more drought susceptible Bonneau soil than on the Norfolk soil. Results indicate that tillage management can influence canopy position specific fiber property distribution.

The soil management practices of cover crops and conservation tillage do not appear to substantially affect the fiber physical properties of a cotton crop (Baker, 1987; Bauer and Busscher, 1996; Daniel et al., 1999; Smith and Varvel, 1982). Pettigrew and Jones (2001) found differences between conventional and no-tillage for some fiber properties in a 2-yr study, but the results were inconsistent across years. They suggested that the differences found in their study were probably not a direct response to tillage management, but rather resulted from slightly different environments during flowering as cooler soils delayed emergence and early growth in the no-tillage system.

The value of cotton for yarn and textile manufacture is determined by the length, tensile strength, and fineness of the fibers. These fiber properties are determined by the genetic potential of the cultivar and the environmental conditions existing during the development of the boll that allow expression of that genetic potential (Ramey, 1986). Cotton bolls are initiated over a long period of time during the season, and fiber properties of bolls on the same plants can differ because of different environmental conditions during boll growth and development. Bennett et al. (1967) found substantial differences in fiber quality among bolls due to the week during the season that flowering occurred. Also, Meredith and Bridge (1973) hand-harvested all open bolls weekly and found fiber properties differed among the weekly harvested samples.

Fiber quality can also vary across fields. Johnson et al. (2002) reported considerable variation for fiber micronaire and fiber length in a 0.5-ha portion of a field in South Carolina. They found significant correlations between several fiber properties and soil pH, soil P, and soil organic matter. Emphasis has been placed lately on reducing the amount of fiber property variability within a cotton crop (May, 2002), as processing techniques require a more uniform fiber to increase throughput and yarn production. A greater understanding of the amount and causes of fiber quality variation may lead to better management practices for improved fiber quality.

We hypothesized that soil management practices influence fiber properties of bolls when measured at specific fruiting positions. We tested this hypothesis on two soil types that differ in soil water holding capacity and historical yield potential. Our objective was to determine whether soil management practices affect canopy position specific fiber properties on two soils.

MATERIALS AND METHODS

This field study was conducted in 1997, 1998, and 1999 at Clemson University's Pee Dee Research and Education Center near Florence, SC. In the early 1990s, soil scientists with the USDA-NRCS conducted a soil survey of the fields on the property, using a 30.5-m grid sampling pattern. For this experiment, a 3.6-ha field was selected that contained a substantial area of Bonneau sand and a substantial area of Norfolk loamy sand that were adjacent to each other. Besides surface texture, a major difference between these soils is the depth to the sandy clay loam B horizon. For the Bonneau soil, depth to the B horizon is about 1 m, while depth to the B horizon in the Norfolk soil is about 0.4 m. Corn (*Zea mays* L.) was grown on the site by conventional tillage during the summer of 1996.

The crop management treatments were winter cover (rye or none) and tillage (disk or conservation tillage). A randomized complete block experimental design was used. There were three replicates of each crop management treatment combination. The experiment was arranged in the field so that both soil types occurred within each plot. Each plot was twelve 1-m-wide cotton rows that ranged from 122 to 213 m in length. Plot lengths varied because all plots ended at the field edge which was irregular and the variation in length allowed for

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both soils to be included in each plot. Each plot was divided into 13.7-m-long subsections. Soil type was assigned to each subsection from the USDA-NRCS soil map and from inspection in the field.

In the rye winter cover plots, 134 kg ha^{-1} of 'Gurley Grazer' rye seed was planted directly into the previous crop residues with a no-tillage grain drill on 17 Oct. 1996, 12 Nov. 1997, and 12 Nov. 1998. Each year in the spring, lime, P, K, and Mn were broadcast applied to the entire experimental area at rates based on soil test analysis. The fertilizer application also included 22.4 kg S ha^{-1} and 2.24 kg B ha^{-1}. Rye and the winter weeds in all conservation tillage plots were sprayed with paraquat dichloride (1-1′dimethyl-4-4′-bipyridinium dichloride) (0.17 kg a.i. ha^{-1}) on 30 April in 1997 and with glyphosate [*N*-(phosphonomethyl)glycine)] (1.12 kg a.i. ha^{-1}) on 27 April 1998 and 15 April 1999. At this time, the disk tillage plots were disked twice (to a depth of 15 cm) and then smoothed with an S-tined harrow. A six-legged paratill was used (to a depth of 40 cm) to alleviate subsoil compaction in all plots. The paratill was used just before planting cotton on 2 May 1997 and on 11 May 1999. For the cotton grown in 1998, the paratill was used in the fall before planting rye on 10 November 1997.

Cotton was planted with a four-row planter equipped with wavy coulters on 7 May 1997, 18 May 1998, and 12 May 1999. 'DPL Acala 90' was planted in 1997 and 1998 and 'DPL 675' was planted in 1999. Seeding rate each year was approximately 10 seeds m^{-1} of row. Weeds were controlled using herbicides and handweeding, and for the conventional tillage plots, a cultivator was used at least once each year. Insects were regularly scouted and controlled with insecticides as needed. Fertilizer N was applied to the cotton in a split-application of NH_4-NO_3 each year. Within one week of planting, 45 kg N ha^{-1} was applied each year using a four-row applicator equipped with fertilizer coulters with rear knives. A subsequent application of 45 kg N ha^{-1} was made with the same applicator on 20 June 1997, 18 June 1998, and 18 June 1999.

In the fall of each year, bolls were hand-harvested by canopy position from one subsection of the Norfolk soil and one subsection of the Bonneau soil within each plot. Three canopy positions were evaluated by harvesting bolls at the first node on two adjacent fruiting branches (sympodial branches). These canopy positions were Mainstem Nodes 6 and 7, Mainstem Nodes 9 and 10, and Mainstem Nodes 12 and 13. Boquet and Moser (2003) reported little difference in boll weight among first position bolls at adjacent sympodia. Because there is an approximate three-day difference in age between bolls on adjacent sympodia at the first fruiting position (Mauney, 1986), these fruiting sites were chosen since first position bolls at these three canopy positions roughly correspond to anthesis dates during the first, second, and third week of flowering. Bolls were bulk harvested from 3 m of row in 1997, 6 m of row in 1998, and 12 m of row in 1999. Each canopy position was harvested at separate times, except in 1999 when the two upper canopy positions were harvested at the same time. Hand harvests were made in September and early October each year.

The cotton in the plots was chemically defoliated with thidiazuron (*N*-phenyl-*N′*-1,2,3-thiadazol-5-ylurea), S,S,S-tributyl phosphorotithioate, and bolls were opened with ethephon [(2-chloroethyl) phosphonic acid] at the recommended rates each year. Two rows from each subplot not used for hand harvesting were harvested with a spindle picker on 30 Oct. 1997, 26 Oct. 1998, and 12 Nov. 1999. After weighing the bags of seedcotton, samples were taken from the harvest bags for determination of lint percentage and fiber property analysis. Cotton hand-harvested by canopy position and the machine-harvested samples from the harvest bags were ginned in a 10-saw laboratory gin. Samples of the fibers were sent to Starlab, Inc. (Knoxville, TN) for high volume instrumentation analysis of fiber properties.

Precipitation and temperature were measured with a weather station located within 2 km of the field. Square initiation dates for each of the three canopy positions were estimated using the findings of Constable (1991) on plant morphological development to heat unit accumulations. To evaluate the weather effects on the three canopy positions, the square initiation date for the canopy positions was set to midpoint in heat units between the two mainstem node positions that were harvested together at each canopy position.

Data were analyzed by year because the cultivar used in 1999 was different from the first two years. For the lint yield and whole-crop fiber property data from the machine harvest, data were analyzed as a split-plot design. Soil types were considered main plots and subplots were the cover crop and tillage combinations. The position-specific fiber property data from the hand-harvested samples were analyzed as a split-split plot design. Main plots were soil type, subplots were the crop management treatments and sub-subplots were the canopy positions. Because the soils were in fixed positions in the field, testing of the main effect of soil type is irrelevant, but subplot main effects and interactions involving soil types are valid (Cochran and Cox, 1957). Tests for homogeneous variance were conducted between the two soil types for all variables in each year to determine if subplot error variance could be used to compare crop management and canopy position combinations within a soil type. None of the tests indicated heterogeneous variance, so all mean comparisons were made using the pooled error variance. Sources of variation were considered significant when probability of greater *F* values were ≤ 0.05. Means were separated by calculating a least significant difference (LSD) when sources of variation were significant ($P = 0.05$).

RESULTS AND DISCUSSION

Whole Crop

Yields of the two soil types were as expected from historical records of these two soils. Over the 3 yr of this study, lint yield on the Bonneau soil averaged 151 kg ha^{-1} lower than yield on the Norfolk soil under both tillage systems (Table 1). There were no consistent differences for the fiber properties between these two soil types. The lint yield and fiber quality responses to tillage of the whole crop (machine-harvested) were similar for both soil types as no soil type × tillage interactions were significant in any year of the study.

Tillage had no effect on lint yield in 1997 (Table 1). In the other two years, yields for cotton grown with conservation tillage were 34% higher than cotton grown with disk tillage in 1998 and 35% higher than disk tillage in 1999. Conservation tillage production generally has higher soil water contents than conventional tillage before canopy closure (Phillips et al., 1980), and the higher yields with conservation tillage in 1998 and 1999 were probably related to greater soil water availability. In 1997 when yields were similar between tillage treatments, precipitation was higher and heat unit accumulations were lower in June and July than in the other two years (Table 2). In both 1998 and 1999, substantial dry periods occurred during flowering and boll develop-

Table 1. Effect of tillage on cotton fiber properties and lint yield for each soil map unit after machine harvest in 1997, 1998, and 1999.

		Fiber length		Fiber length uniformity		Micronaire		Fiber strength		Lint yield	
Year	Soil	Disk	Conservation	Disk	Conservation	Disk	Conservation	Disk	Conservation	Disk	Conservation
		mm		%		units		kN m kg^{-1}		kg ha^{-1}	
1997	Bonneau	28.4	28.3	82.5	83.0	3.98	3.98	294	291	758	735
	Norfolk	28.5	28.3	83.1	83.1	4.29	4.17	297	300	976	989
	Mean	28.4	28.3	82.8	83.1**	4.14	4.08*	295	295	872	868
1998	Bonneau	29.1	29.4	82.8	83.2	4.33	4.02	314	312	601	766
	Norfolk	28.9	29.2	82.6	83.3	4.31	4.18	306	309	640	896
	Mean	29.0	29.3	82.7	83.2*	4.32	4.10*	310	311	621	834**
1999	Bonneau	26.2	27.5	80.6	81.4	5.10	5.03	312	315	236	360
	Norfolk	27.1	27.8	81.5	82.1	4.97	4.95	320	314	384	479
	Mean	26.7	27.7**	81.1	81.8*	5.03	4.99	316	315	313	422**

* Indicates tillage means within year differed at $P \leq 0.05$.
** Indicates tillage means within year differed at $P \leq 0.01$.

ment. This was especially so in 1999, when yields were extremely low.

As has been found in previous work (Pettigrew and Jones, 2001), the fiber property response of the entire crop to tillage was inconsistent (Table 1). Cotton grown with conservation tillage had longer fibers than cotton grown with disk tillage in 1999, but not in the other two years. In 1997 and 1998, cotton grown with conservation tillage had lower micronaire than cotton grown with disk tillage but there were no differences between tillage systems in 1999. Fiber strength was not affected by tillage in any year. Fiber length uniformity was the only fiber property that was affected by tillage in all 3 yr of the study. In each year, uniformity was on average 0.75% greater for cotton grown with conservation tillage than for cotton grown with disk tillage (Table 1).

Cover crop had only a small influence on yield and fiber properties of the whole crop in this study (data not shown). There were no significant interactions between cover crop and soil type or tillage for lint yield in any year. Averaged over both soil types and both tillage systems, cotton lint yield was 933 kg ha^{-1} following fallow and 803 kg ha^{-1} following rye in 1997 ($P > F = 0.02$), but there were no differences between rye and fallow for yield in 1998 (722 kg ha^{-1} following fallow and 733 kg ha^{-1} following rye) or in 1999 (369 kg ha^{-1} following fallow and 365 kg ha^{-1} following rye). Winter cover influenced fiber length only in 1997 when a significant cover crop × tillage interaction occurred. In that year, fiber length of cotton grown following rye was 0.2 mm longer than cotton grown following winter fallow when conservation tillage was used, but with disk tillage, fiber length following rye was 0.5 mm shorter than following winter fallow (LSD 0.05 = 0.2 mm). A significant cover crop × tillage interaction occurred for fiber length uniformity in both 1997 and 1998, but the nature of the interaction differed between years. In 1997, fiber length uniformity of cotton grown following rye with disk tillage was approximately 0.7% less than the other three tillage-winter cover combinations (rye with conservation tillage, disk tillage with both rye and fallow) while in 1998, cotton grown following rye with conservation tillage was approximately 0.9% higher than the other three tillage-winter cover treatment combinations. Micronaire and fiber strength were not affected by cover crop treatment in any year of the study.

Canopy Position Specific Fiber Properties

Rye, either as a winter cover crop in the conservation tillage system or as a green manure in the conventional tillage system, did not influence the canopy position specific fiber property response in any of the 3 yr of this study. No interactions that included both rye and canopy position were significant for any fiber property in any year (data not shown).

The influence of tillage on fiber length at each canopy position is shown in Table 3. The response of fiber length to tillage was similar for both soil types. Averaged over soil types, the canopy position specific response of fiber length to tillage was quite different for the 3 yr. In 1997, fiber length did not differ between tillage systems at any canopy position (Table 3). In both 1998 and 1999, significant tillage × canopy position interactions occurred for fiber length, but the nature of the interactions was different for the two years. With conservation tillage, fibers were 1 mm longer than fibers from cotton grown with disk tillage at Mainstem Nodes 6 to 7 in 1998, but there was no difference between the two tillage systems at the other two canopy positions. Conversely,

Table 2. Monthly total rainfall and heat units (base temperature of 15.5 C†) during the growing season for 1997 through 1999 at Florence, SC.

	Rainfall					Heat units				
	Month									
Year	May	June	July	August	September	May	June	July	August	September
	cm					°C				
1997	4.3	8.2	20.7	2.7	12.5	147	261	398	348	273
1998	8.4	5.8	9.4	4.7	7.7	269	377	443	389	303
1999	4.4	3.9	7.6	6.4	20.5	205	308	420	443	239

† Daily heat units were calculated as ((Maximum Temperature + Minimum Temperature)/2)-15.5 C.

Table 3. Effect of tillage on cotton fiber length and fiber length uniformity of first sympodial position bolls at three canopy positions in 1997, 1998, and 1999. Data are averaged over both soil types.

		Fiber length (mm)				Fiber length uniformity			
		Canopy position (mainstem nodes)				Canopy position (mainstem nodes)			
Year	Tillage	6–7	9–10	12–13	LSD	6–7	9–10	12–13	LSD
1997	Disk	29.7	29.3	26.7	ns†	85.4	84.6	81.9	ns
	Conservation	29.7	28.8	27.1		85.1	84.1	83.0	
	Mean	29.7	29.0	26.9	0.5‡	85.3	84.4	82.5	0.7
1998	Disk	27.6	29.2	29.0	0.6	81.6	83.3	83.1	0.6
	Conservation	28.6	29.5	28.9		82.9	83.6	83.1	
	Mean	28.1	29.3	28.9	0.4	82.3	83.4	83.1	0.4
1999	Disk	26.4	25.8	25.1	0.4	82.8	82.2	81.0	0.5
	Conservation	26.6	26.0	26.1		82.8	82.4	82.1	
	Mean	26.5	25.9	25.6	0.3	82.8	82.3	81.5	0.4

† LSD (0.05) for comparing tillage means within a canopy position. NS indicates that the tillage X canopy position interaction was not significant in that year.
‡ LSD (0.05) for comparing canopy position means.

in 1999 fibers from cotton grown with conservation tillage averaged 1 mm longer than fibers grown with disk tillage at Position 12 to 13 with no differences between tillage systems at the other two canopy positions.

Cotton blooms open approximately 21 d after square initiation, and fiber elongation occurs from 3 to 20 d following anthesis (Stewart, 1986). Water status of the plant during the elongation period influences fiber length (Ramey, 1986), and timing of rainfall may partially explain the fiber length responses that we found in this study. In 1997, fiber length of Position 6 to 7 (averaged over soils and tillage systems) was 0.7 mm longer than fiber length at Position 9 to 10. A large reduction of 2.1 mm occurred between Position 9 to 10 and Position 12 to 13 (Table 3). In that year, 13 cm of rainfall occurred shortly after bolls at Position 6 to 7 began fiber elongation and just before the time that bolls from Position 9 to 10 flowered (Fig. 1a). However, this rainfall occurred about 10 d before bolls from Position 12 to 13 flowered (Fig. 1a), and there was little precipitation throughout the rest of the boll development period.

In contrast to 1997, bolls at the lower canopy position (Position 6–7) in 1998 were subjected to the greatest amount of moisture stress at the time of fiber elongation of the three canopy positions. In that year, about 10 cm of rainfall occurred between 20 and 30 d after square formation for Position 9 to 10, and this rainfall occurred just before flowering at 10 to 20 d after square formation for Position 12 to 13 (Fig. 1b). Most of this precipitation occurred late in the fiber elongation phase for the bolls at Position 6 to 7. Fiber length was reduced more in disk tillage than in conservation tillage at Position 6 to 7. Since there was little rainfall for the 20 d preceding flowering for that canopy position in that year, this suggests that the conservation tillage management was better able to capture and/or retain the rainfall that did occur during the 20- to 40-d period following square initiation (Fig. 1b).

In 1999, when yield was lowest of the 3 yr (Table 1), rainfall was low during the fiber elongation phase for all canopy positions. Although a different cultivar was grown in 1999 than in the other two years, it is likely that the lack of rainfall in 1999 was the main factor causing the substantially shorter fibers in that year compared with the other two years (Fig. 1c). Better capture and/or retention of the rainfall that did occur was again likely the reason for conservation tillage having higher fiber length than conventional tillage at Position 12 to 13 (Table 2). The reason for conservation tillage having higher fiber length than disk tillage at that canopy position in 1999 but not 1997 (where bolls were also subjected to water-deficit stress) is likely at least partially

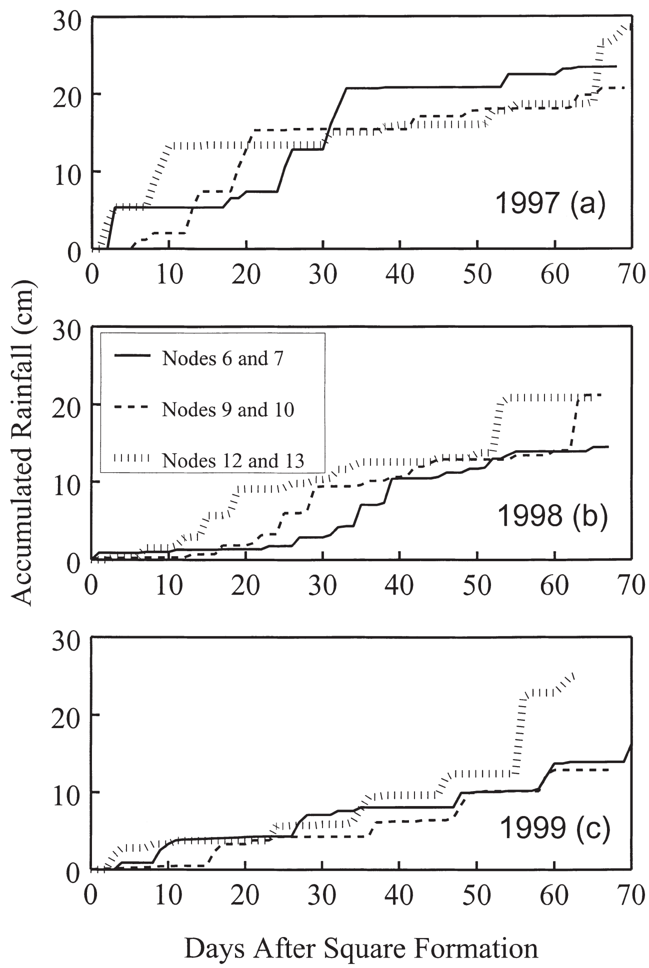

Fig. 1. Cumulative precipitation from heat-unit predicted square formation through boll development for three canopy positions in 1997 (a), 1998 (b), and 1999 (c). Predicted anthesis date is 21 d after square initiation.

Table 4. Effect of tillage on cotton fiber micronaire and fiber strength of first sympodial position bolls at three canopy positions in 1997, 1998, and 1999. Data are averaged over both soil types.

		Micronaire (units)				Fiber strength (kN m kg^{-1})			
		Canopy positon (mainstem nodes)				Canopy position (mainstem nodes)			
Year	Tillage	6–7	9–10	12–13	LSD	6–7	9–10	12–13	LSD
1997	Disk	4.14	4.04	3.92	0.18	319	331	300	ns†
	Conservation	4.36	4.02	3.75		320	319	300	
	Mean	4.25	4.03	3.84	0.13	320	325	300	7‡
1998	Disk	5.07	4.32	3.91	0.22	327	332	316	ns
	Conservation	4.25	3.84	3.75		321	321	313	
	Mean	4.66	4.08	3.83	0.15	324	326	314	6
1999	Disk	4.16	4.94	5.21	ns	330	341	315	ns
	Conservation	4.28	5.08	5.08		346	356	320	
	Mean	4.22	5.00	5.15	0.17	338	348	318	8

† LSD (0.05) for comparing tillage means within a canopy position. NS indicates that the tillage × canopy position interaction was not significant in that year.
‡ LSD (0.05) for comparing canopy position means.

due to 1999 being a much dryer year than 1997. Although canopy light interception was not measured in this study, we suspect that canopy closure did not occur by the time this canopy position flowered and began fiber elongation in 1999, so the benefits of conservation tillage on soil water supply were still present at this relatively late time in the season. In 1997, ample early precipitation resulted in a vigorously growing crop with early canopy closure and therefore there may have been little benefit of conservation tillage practices on soil water content when flowering occurred at Position 12 to 13 in that year.

The effect of tillage on fiber length uniformity mirrored the results for fiber length (Table 3). Conservation tillage had higher fiber length uniformity than disk tillage at canopy Position 6-7 in 1998 and Position 12 to 13 in 1999, and there were no differences between tillage systems at any other canopy position in any year.

Somewhat overlapping with the fiber elongation phase of development, fiber secondary wall deposition occurs from about 15 to 45 d after anthesis (Stewart, 1986). Micronaire is an estimate of the amount of secondary wall deposition. Fiber micronaire was greater for conservation tillage than for disk tillage at canopy Position 6 to 7 in 1997 and at Positions 6 to 7 and 9 to 10 in 1998 (Table 4). There were no differences between tillage systems at the other canopy positions in those years or at any canopy position in the very dry year of 1999. It is not apparent why conservation tillage had higher micronaire than disk tillage at the lowest canopy position in 1997. Lint yields were similar between the two tillage systems in that year and the micronaire of the entire crop was slightly lower in conservation tillage than in disk tillage (Table 1). Fiber length values at that canopy position were similar for the two tillage systems (Table 4) suggesting that soil water supply, at least early in the development of micronaire for these bolls, did not differ between the two tillage systems. Higher fiber micronaire at Positions 6 to 7 and 9 to 10 with disk tillage than with conservation tillage in 1998 (Table 4) may have been due to the better soil water conditions with conservation tillage (conservation tillage also had longer fibers than disk tillage at canopy Position 6–7). Bauer and Roof (2004) found highest micronaire in cotton grown in the driest of a 3-yr study.

In contrast to 1997 and 1998, fiber micronaire in 1999 was greater at the two higher canopy positions and there were no differences between tillage systems at any canopy position (Table 4). Increasing micronaire with the higher canopy position bolls appears due to the lack of rainfall (Fig. 1c) and high heat unit accumulations in both July and August (Table 2), which increased evaporative demand and intensified crop water stress. Lack of differences between the two tillage systems may be due to the high level of water deficit stress. Cotton grown with conservation tillage had longer fibers than disk tillage at Position 12 to 13 in that year (Table 3). Evidently the benefits of conservation tillage when bolls at that canopy position were developing did not extend long enough or in substantial quantities into the fiber secondary wall deposition phase of development to result in an impact of tillage on micronaire.

Table 5. Effect of soil type on fiber length, micronaire, and fiber strength of first sympodial position bolls at three canopy positions in 1997, 1998, and 1999. Data are averaged over both tillage systems.

		Fiber length (mm)				Micronaire (units)				Fiber strength			
		Canopy position (mainstem nodes)				Canopy position (mainstem nodes)				Canopy position (mainstem nodes)			
Year	Soil	6–7	9–10	12–13	LSD	6–7	9–10	12–13	LSD	6–7	9–10	12–13	LSD
1997	Bonneau	29.2	28.5	26.2	ns†	4.11	3.73	3.47	0.19	320	331	291	10
	Norfolk	30.1	29.4	27.4		4.36	4.27	4.13		319	320	306	
1998	Bonneau	27.9	29.2	28.9	ns	4.78	3.97	3.67	0.22	324	330	310	ns
	Norfolk	28.2	29.5	29.0		4.56	4.16	3.95		324	323	317	
1999	Bonneau	26.2	25.5	25.4	ns	4.01	5.02	5.42	0.24	335	344	316	ns
	Norfolk	26.8	26.2	25.9		4.43	5.00	4.87		341	353	319	

† LSD (0.05) for comparing canopy position means within a soil type. NS indicates that the tillage × canopy position interaction was not significant in that year.

Cotton fiber strength was least affected by tillage in this study. Tillage had no influence on cotton fiber strength of the entire crop (Table 1) and there were no differences between disk tillage and conservation tillage at any canopy position in any year (Table 4). In contrast to the results for the other fiber properties, there was a consistent canopy position response for fiber strength across years. Bolls from Position 12 to 13 had lower fiber strength than bolls at the two other canopy positions each year.

The canopy position specific responses for fiber length and strength (Table 5) and fiber length uniformity (not shown) were generally similar for the two soil types within each year of this study. Genetic determination of these fiber properties is quite high (compared with environmental determination) (Meredith, 1984). Thus, it is not particularly surprising that the direction and magnitude of differences between canopy positions on these two soils were similar each year. On the other hand, environment plays a relatively larger role in determining micronaire compared with fiber length and strength (Meredith, 1984). Although the direction of response with canopy position for micronaire was similar for the two soils each year, the magnitude of difference between the highest and lowest value within each soil each year was much greater for the Bonneau soil than for the Norfolk soil (Table 5). These results expand the findings of Johnson et al. (2002) who found there are spatial relationships with soils for individual fiber properties. This study suggests that the amount of within canopy fiber property variability, at least for micronaire, may also be soil specific.

In summary, these results suggest conservation tillage can affect cotton fiber properties at specific positions within the canopy. When differences between tillage systems did occur at specific canopy positions, they were generally at positions where bolls developed before canopy closure when the effect of tillage management on soil water would have been greatest. This finding, along with the finding that there was less within-canopy variability on the Norfolk soil than the Bonneau soil for micronaire, suggests improved water management may be important in developing long-term strategies aimed at reducing within crop variability for fiber quality.

REFERENCES

Baker, S.H. 1987. Effects of tillage practices on cotton double cropped with wheat. Agron. J. 79:513–516.

Bauer, P.J., and W.J. Busscher. 1996. Winter cover and tillage influences on coastal plain cotton production. J. Prod. Agric. 9:50–54.

Bauer, P.J., and M.E. Roof. 2004. Nitrogen, aldicarb, and cover crop effects on cotton yield and fiber properties. Agron. J. 96:369–376.

Bennett, O.L., L.J. Erie, and A.J. Mackenzie. 1967. Boll, fiber, and spinning properties of cotton as affected by management practices. USDA-ARS Bull. 1372. Washington, DC.

Boquet, D.J., and E.B. Moser. 2003. Boll retention and boll size among intrasympodial fruiting sites in cotton. Crop Sci. 43:195–201.

Cochran, W.G., and G.M. Cox. 1957. Experimental designs, 2nd ed. John Wiley & Sons, New York.

Constable, G.A. 1991. Mapping the production and survival of fruit on field-grown cotton. Agron. J. 83:374–378.

Daniel, J.B., A.O. Abaye, M.M. Alley, C.W. Adcock, and J.C. Maitland. 1999. Winter annual cover crops in a Virginia no-till cotton production system: II. Cover crop and tillage effects on soil moisture, cotton yield, and cotton quality. J. Cotton Sci. 3:84–91.

Johnson, R.M., R.G. Downer, J.M. Bradow, P.J. Bauer, and E.J. Sadler. 2002. Variability in cotton fiber yield, fiber quality, and soil properties in a southeastern coastal plain. Agron. J. 94:1305–1316.

Mauney, J.R. 1986. Vegetative growth and development of fruiting sites. p. 11–28. *In* J.R. Mauney and J. McD. Stewart (ed.) Cotton physiology. The Cotton Foundation, Memphis, TN.

May, O.L. 2002. Quality improvement of upland cotton (*Gossypium hirustum* L.). J. Crop Prod. 5:371–394.

Meredith, W.R., Jr. 1984. Quantitative genetics. p. 131–150. *In* R.J. Kohel and C.F. Lewis (ed.) Cotton. ASA, CSSA, and SSSA, Madison, WI.

Meredith, W.R., Jr., and R.R. Bridge. 1973. Yield, yield component and fiber property variation of cotton (*Gossypium hirustum* L.) within and among environments. Crop Sci. 13:307–312.

Pettigrew, W.T., and M.A. Jones. 2001. Cotton growth under no-till production in the lower Mississippi river valley alluvial flood plain. Agron. J. 93:1398–1404.

Phillips, R.E., R.L. Blevins, G.W. Thomas, W.W. Frye, and S.H. Phillips. 1980. No-tillage agriculture. Science (Washington, DC) 208: 1108–1113.

Ramey, H.H., Jr. 1986. Stress influences on fiber development. p. 351–359. *In* J.R. Mauney and J. McD. Stewart (ed.) Cotton physiology. The Cotton Foundation, Memphis, TN.

Smith, C.W., and J.J. Varvel. 1982. Double cropping cotton and wheat. Agron. J. 74:862–865.

Stewart, J. McD. 1986. Integrated events in the flower and fruit. p. 261–300. *In* J.R. Mauney and J. McD. Stewart (ed.) Cotton physiology. The Cotton Foundation, Memphis, TN.