Tillage, Cover Crop and N Effects on Cotton Grown in 19 cm Row Widths

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ABSTRACT

In areas of the USA where cotton (Gossypium hirsutum L.) is traditionally harvested with a spindle picker, there is widespread interest in producing cotton in narrow rows and harvesting with a stripper harvester. Optimum management practices with this system are not well-defined. This study was conducted to determine the effects of residue management and nitrogen fertilization on cotton grown in 19-cm-row widths. Similar experiments were conducted in Florence, SC and Auburn, AL, USA, over two growing seasons. Treatments at both locations were tillage system (conventional vs. conservation), winter cover crops (cereal, legume, or none), and N fertilizer rates (0, 45, 90, 135 kg N/ha). Tillage system had only a small effect on yield and fiber properties. The availability of N (either through fertilizer or cover crop) had the greatest impact on the cotton crop. At both locations, optimum N rate for cotton following either no cover crop or following the winter cereal was between 45 and 90 kg/ha. Following the legumes, N rate had a small effect on yield. Overall, there was an average of 2 to 3 bolls per plant. Short fiber length at Florence in 1997 (2.57 cm) and low micronaire at Auburn both years (3.0 micronaire units) suggest that environment during boll development may play a more important role in determining fiber properties in narrow-row systems than in wide-row systems.

Introduction

Many growers are evaluating narrow-row production systems for cotton in areas of the USA where wide-row spacing is normally used. Optimizing row width has been a research topic in cotton for many years (Robinson, 1993). Many research reports have found optimum yield with plants grown in more equidistant spacing than are currently used. Spindle-picker technology, lack of adequate weed control, and lack of control of cotton vegetative growth have been the main reasons cotton row spacing remain in the 70- to 101-cm range throughout most of the USA. Recent advances in the herbicide and plant growth regulator technologies, as well as in herbicide-resistant cotton varieties, have sparked a renewed interest in developing narrow-row cotton production systems. Systems being developed for row widths of 25 cm or less require a broadcast stripper for harvest.

Many questions need to be investigated for optimizing cotton production when the crop is grown in these narrow-row widths. This is especially true for cotton produced with conservation tillage techniques. In the south-eastern USA, many of the soils have low organic matter, and conservation tillage systems appear to require large amounts of residue biomass for optimal production (Langdale *et al.*, 1990; Bauer and Busscher, 1996). Nitrogen fertilizer management is difficult, yet critical, for obtaining high lint yield in conservation systems that include winter cover crops.

Grower returns from a cotton crop depend on both yield and lint quality. Information regarding fiber properties, as well as yield, is needed for cotton grown in narrow-row spacing. The objective of this study was to determine the effects of residue management and nitrogen fertilization on cotton yield and fiber properties when cotton is grown in 19-cm-row widths.

Material and Methods

The experiment was initiated in the fall of 1995, and cotton was grown in the summers of 1996 and 1997 at Clemson University's Pee Dee Research and Education Centre, Florence, SC, and at the Alabama Experiment Station's E.V. Smith Research Centre, Auburn, AL. Treatments were winter cover (cereal, legume, and fallow), tillage (conventional and conservation), and N rate (0, 45, 90, and 135 kg N ha^{-1}). Soil type was Wagram sand (loamy, siliceous, thermic Typic Kandiudult) at Florence and Norfolk loamy sand (fine-loamy, siliceous, thermic Typic Kandiudult) at Auburn.

The cereal cover crop was *Avena strigosa* at Florence and an *Avena strigosa/Secale cereale* mixture at Auburn. The legume cover crop was *Pisum sativum* at Florence and *Lupinus albus* at Auburn. Cover crops were planted at recommended rates in the fall each year. The following spring, the winter covers in the conservation tillage treatment plots were chemically desiccated while the plant material in the conventional tillage plots was incorporated with a

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tandem disk harrow. Fertilizer N (NH_4NO_3) was surface applied to plots with a broadcast applicator at treatment rates. Cotton planting dates ranged from 27 May to 4 June. The varieties were Stoneville 474 at Florence both years and Stoneville 132 in 1996 and Paymaster 1330 BG/RR in 1997 at Auburn. Seeding rate at Florence was approximately 358,000 seeds/ha in 1996 and 316,000 in 1997. At Auburn, seeding rate was 617,000 seeds/ha in 1996 and 494,000 in 1997.

Lime and fertilizers (other than N) application rates were based on soil test results and recommendations for rainfed cotton. The experimental areas was deep-tilled to eliminate soil compaction to a depth of 0.4 m with toolbar-mounted bent-legged shanks, causing very little soil surface residue disturbance. Four applications of mepiquat chloride were made each year at Auburn to control vegetative growth but only one was necessary each year at Florence where excessive vegetative growth was minimal.

At Auburn in both years and at Florence in 1997, plant map measurements were made in early October. All plants in a 2-m section of row from each plot were cut at the soil surface and removed from the plots. Plant height, node of first boll, total mainstem nodes, number of bolls in the first sympodial fruiting position, total number of harvestable bolls, and number of barren plants were counted.

Each year, all bolls in a 1.74-m^2 area of each plot (three 3.05-m long rows) were hand-harvested at Florence. At Auburn, cotton was harvested with a broadcast stripper. After harvest, the seedcotton samples were weighed and saw-ginned on a laboratory gin. The lint was then weighed to determine lint yield. Samples of the lint from Florence were sent to Star-Lab, Inc. (Knoxville, TN) for high volume instrumentation fiber property analysis. Analysis of the lint from Auburn was conducted at the International Textile Centre in Lubbock, TX.

A split plot experimental design was used at Florence with four replicates of each treatment combination. Main plots were the cover by tillage combinations and subplots the N rates. The experimental design at Auburn was split-split plot with four replicates. Main plots were cover crop, subplots were tillage, and sub-subplots the N rates. All data were subjected to analysis of variance, and sources of variation were considered significant if the probability of a greater F value was ≤ 0.05. Treatment means were separated with an LSD ($P=0.05$). Because of the different harvest methods and cover crops used, the data from the two locations were analyzed separately.

Results

Lint Yield. A year X winter cover X tillage X N rate interaction occurred for lint yield at Auburn. This appeared to be mainly caused by differences in soil N availability at the low N rates between the winter covers, tillage systems, and years. At the higher N fertilizer rates, differences between treatments were smaller. At Florence, tillage system did not impact yield as neither the main effect nor any interactions were significant for lint yield. Averaged over all other variables and years, average lint yield for the conservation tillage treatment was 1096 kg ha^{-1} at Auburn and 866 kg ha^{-1} at Florence while the conventional tillage yields were 1067 kg ha^{-1} at Auburn and 917 kg ha^{-1} at Florence.

A winter cover X N rate interaction occurred for lint yield at both locations (Table 1). Immobilization of N by the winter cereals probably caused the following cotton crop to have a greater yield response to 45 kg N ha^{-1} than the cotton following winter fallow at both locations. The legume at both locations provided almost the entire N needed for optimum yield.

Morphological Characteristics. Bolls per plant, plant height, and main-stem nodes per plant tended to mirror the responses found for lint yield. As N increased, these values tended to increase. Main-stem node of first fruiting branch did not differ among treatments.

For presentation purposes (and since this would be close to recommended N rates based on the yield results of this study), the plant morphological characteristics for the 90 kg N ha^{-1} treatment, averaged over all winter cover and tillage treatments, are presented in Table 2. At both locations, there were 2 to 3 bolls per plant. The plants tended to be similar in the two years of the study at Auburn. The plants at Florence were taller, had more mainstem nodes, and fruited at a higher node than the plants at Auburn.

Fiber Properties. In general, none of the treatments (winter cover, tillage, or N rate) had a significant impact on fiber properties at either location. When sources of variation were significant, mean differences tended to be small. One exception was a year X winter cover X N rate interaction for micronaire ($P<0.001$) at Florence. In 1996, there was little difference between the N rates for micronaire following any winter cover. Averaged over all tillage and N treatments, micronaire averaged 3.7 following the winter cereal, 3.6 following fallow, and 3.5 following the legume in that year. In 1997, micronaire increased with increasing N rate for both the winter cereal and winter fallow treatments (from approximately 3.7 for the 0 kg N/ha rate to 4.5 for the 135 kg N/ha rate), while there was no difference among the N rates following the legume (average 4.5).

Fiber properties from the 90-kg/ha treatments in this study are shown in Table 3. The low value for elongation at Auburn in 1997, the low value for fiber length at Florence in 1997, and the low micronaire values at Auburn both years and at Florence in 1996 are most noteworthy. The low micronaire values are of special concern because they indicate a high amount of immature fiber present in the harvestable lint.

Discussion

This study indicates that cotton grown in 19-cm rows needs between 45 and 90 kg/ha of applied N for optimal production on the sandy Coastal Plain soils of the south-eastern USA. This is comparable to what has been found for cotton grown in wide-row culture on these soils. Conventional and conservation tillage had similar cotton yield and fiber properties in this study.

Cotton seeded in narrow rows may be more sensitive to short-term environmental conditions than cotton grown in wide rows. When seeded at normal planting dates and grown in conventional row widths, cotton produces flowers for a four-to-six week period in the south-eastern USA. Thus, the harvested cotton crop consists of bolls that developed over a wide range of environments. Plant mapping studies have shown that this variation in environment can result in a large variation in fiber properties for bolls on the same plant (Bradow *et al.*, 1997). As long as there are enough bolls of acceptable quality in the harvested crop, bales will have acceptable fiber properties. In our study, there were only 2 to 3 bolls per plant. Thus, the bulk of the bolls in this study probably flowered over a six-to nine-day period. Environmental conditions during pollination, fiber elongation, and fiber filling thus should have a much greater effect on ultimate fiber properties of the crop than cotton grown in wide rows. The instances of low micronaire, low elongation, and low fiber length that we found may be evidence of this. Though variation among the bolls may be decreased with narrow-row widths (and fewer bolls per plant), variation will still occur within the crop due to within-boll and within-seed fiber differences (Bradow *et al.*, 1997; Davidonis *et al.*, 1996). Also, the increasing micronaire with increasing N rate at Florence in 1997 may indicate that there is an optimum leaf area (plant size) for optimum fiber properties in these narrow-row systems. This aspect needs further research.

Previous problems with fiber quality have been increases in trash and bark due to stripper harvest technology. This is the first report that we are aware of indicating possible problems with fiber properties in cotton grown in row widths of 25 cm or less. Research is needed on reducing the risk of the narrow flowering window and its impact on fiber properties.

References

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Table 1. Effect of winter cover and fertilizer nitrogen on cotton lint yield. Data are averaged over conventional and conservation tillage systems and two years (1996 and 1997).

Location	N Rate	Winter Cover			$LSD_{0.05}$
		Cereal	Fallow	Legume	
			kg ha^{-1}		
Auburn	0	683	814	1156	
	45	993	1089	1204	
	90	1037	1117	1373	
	135	1168	1074	1282	142
Florence	0	492	672	868	
	45	1021	769	1051	
	90	1049	1076	995	
	135	990	944	781	200

LSD is for comparing N rate means within a cover crop.

Table 2. Plant morphological characteristics averaged over all cover crop and tillage treatments receiving 90 kg N ha-1 in 1996 and 1997 at Auburn and Florence.

Location	Year	Bolls per Plant	Plant Height (cm)	Mainstem Nodes per Plant	Mainstem Node of First Fruit
Auburn	1996	2.7 (0.1)	45.5 (9.8)	10.3 (1.3)	6.3 (0.7)
	1997	2.5 (0.7)	45.7 (7.8)	10.5 (1.3)	5.9 (0.6)
Florence	1996	2.8 (0.9)	---	---	---
	1997	2.2 (0.9)	62.2 (11.7)	15.6 (1.3)	9.3 (1.1)

Values in parentheses are standard deviations of means.

Table 3. Cotton fiber properties averaged over all cover crop and tillage treatments receiving 90 kg N ha^{-1} in 1996 and 1997 at Auburn and Florence.

Location	Year	Elongation (%)	Fiber Length (cm)	Fiber Strength (kn m kg^{-1})	Micronaire (units)	Uniformity (%)
Auburn	1996	9.8 (0.3)	2.79 (0.07)	258 (23)	3.0 (0.2)	80.5 (1.8)
	1997	6.5 (0.3)	2.85 (0.05)	289 (11)	2.8 (0.2)	82.0 (0.9)
Florence	1996	9.9 (0.2)	2.80 (0.05)	267 (10)	3.6 (0.3)	83.1 (0.7)
	1997	9.9 (0.3)	2.57 (0.11)	273 (20)	4.4 (0.4)	81.7 (1.8)

Values in parentheses are standard deviations of means.