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Cover Crop, Tillage, and N Rate Effects on Cotton Grown in Ultra-Narrow Rows

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Abstract

There has been recent renewed interest in growing cotton (*Gossypium hirsutum* L.) in ultra-narrow rows (≤10 inch wide row spacing). Residue management information is needed for this cotton production system. The objective of this field study was to determine the effect of winter cover, tillage, and N rate on plant stands, yield, and fiber properties of cotton grown in 7.5-inch row widths. Field experiments were conducted near Auburn, AL [Compass loamy sand (coarse-loamy, siliceous, subactive, thermic Plinthic Paleudult)] and near Florence, SC [Wagram sand (loamy, siliceous, thermic Arenic Paleudult)] in 1996 and 1997. Treatments were winter cover (cereal, legume, and fallow), tillage (conventional and conservation) and N rate (0, 40, 80, and 120 lb N per acre). Averaged over tillage and N rates, cotton stands following the legumes were 10% and 25% lower than following the fallow and cereal winter covers at Auburn and Florence, respectively. Stands tended to be lower for conservation tillage than for conventional, though differences between tillage systems were only significant in 1997 at Auburn. Tillage did not have a big impact on yield at either location. The response of cotton to N was cover crop specific. The greatest response to N occurred following the cereal cover crop at both locations and the smallest response occurred following the legume. Treatments did not substantially affect fiber quality. These data suggest that seeding rates for UNR cotton on these soils should be 15 to 20% above desired stands with conventional tillage and 20 to 25% above desired stands with conservation tillage. Nitrogen fertilizer application rates should be those recommended for wide-row production systems.

Introduction

In recent years, interest has grown considerably across the southern United States about ultra-narrow row (UNR) cotton production (row widths of 10 inches or less). In this production system in the southeast USA, typical spindle-picker type cultivars adapted to the region are grown in narrow rows and harvested with a finger-stripper. Research across the cotton producing states has been done to evaluate the UNR system against conventional wide row spacing and to determine optimum production practices for this system. Numerous studies have been conducted investigating weed control (6,7,9,22), varieties (11,12,18,26), N fertilization rates (10,16,17), plant populations (11,12,13,14), insect management (5,19,23), and fiber quality (15,25). This paper summarizes four site-years of research investigating cover crops and tillage for cotton grown in ultra-narrow row widths.

Ultra-narrow row production seems especially suited for marginal soils or soils prone to erode (3). These are the same soils that benefit most from improvements in soil quality that winter cover crops and conservation tillage can provide. In conventional row spacing systems, both cover crops and conservation tillage can result in reduced cotton stands. This is especially true for cotton grown following legumes (4,8,21). Because in UNR systems cotton is planted with a grain drill rather than precision planters, stand establishment may be even more affected by planting into heavy residue. Also, since cover crops influence the N fertilizer requirements of a succeeding cotton crop grown in conventional row widths (1,20,24), the influence of N fertilizer in cover crop systems with UNR needs to be examined. Our objective was to determine the effects of cover crops, tillage, and N fertilization on plant stands, lint yield, and fiber properties of cotton grown on marginal soils in the southeast.

Field Experiments

Experiments were initiated in the fall of 1995 and cotton was grown during the summers of 1996 and 1997 near Auburn, AL and near Florence, SC. Soil types were Compass loamy sand at Auburn and Wagram sand at Florence. The experiments were conducted on the same sites at each location each year. At Auburn, the site had been in a traffic and tillage study using a corn (*Zea mays* L.) - soybean (*Glycine max* L. Merr.) rotation with a winter cover crop of crimson clover (*Trifolium incarnatum* L.) for the previous eight years. Conventional-tillage grown winter wheat (*Triticum aestivum* L.) followed by summer fallow was the previous cropping history at Florence in 1995.

Treatments were winter cover (fallow, cereal, and legume), tillage (conventional and conservation), and N rate (0, 40, 80, and 120 lb N per acre). A split-split plot design was used at Auburn. Main plots were winter cover, subplots were tillage, and sub-subplots were N rates. Tillage treatments were assigned to maintain the conventional and conservation tillage plots from the previous experiments. Sub-subplots were 75 ft long and 20 ft wide. At Florence, a split plot design was used. Main plots were the cover by tillage combinations and subplots were the N rates. Subplots were 35 ft long and 20 ft wide. The experiments at both locations had four replicates.

Cover crops were seeded in November each year at both locations. Species of cereals and legumes used at the two locations differed. At Auburn in 1995, the cereal cover was black oat (*Avena strigosa* Schreb.) seeded at 100 lb per acre. Consecutive low temperatures of 9°F on 5 and 6 February 1996 killed the black oat plants, so the same seeding rate was used to replant the plots in mid-February that year. In 1996, the winter cereal treatment at Auburn consisted of a black oat-rye (*Secale cereale* L.) mixture (60% black oat, 40% rye) that was planted at 100 lb/acre. The legume winter cover at Auburn both years was white lupin (*Lupinus albus* L.). Seeding rate was 120 lb per acre. The fallow treatment consisted of previous crop residues and winter weeds. Due to the fear of stand reductions of lupin caused by disease when growing that legume two years in succession, the cereal and legume plots were interchanged between the 1996 and 1997 experiment. Fallow treatments and all N-rate assignments remained the same through the two years of the experiment at Auburn. At Florence, the cereal was black oat and the legume was winter pea (*Pisum sativum* L.). Seeding rates were 50 lb/acre for black oat and 40 lb per acre for pea. Main and subplot treatments were assigned in the fall of 1995, and all plot assignments were kept constant throughout the two-year study at Florence.

The conventional tillage treatment consisted of disking, chisel plowing, disking again, and then field cultivating at Auburn. At Florence, the conventional tillage treatment consisted of disking twice and then field-cultivating. The conservation-tillage treatments consisted of drilling directly into the residues. The experimental areas were tilled with a paratill to a depth of 14 inches in October 1995 at Auburn and in November 1995 (just before seeding the cover crops) and in May 1997 (just before seeding the cotton) at Florence.

A burn-down application of glyphosate [N-(phosphonomethyl)glycine] at Auburn and paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) at Florence was made prior to seeding the cotton. At Auburn only, the cover crops were mowed with a flail mower in the conventional-tillage plots and rolled to lie flat on the soil surface in the conservation-tillage plots. The roller was operated in the same direction as the drill used to plant the cotton. At both locations, fertilizer N (in the form of NH_4NO_3) was surface-applied at the treatment rates with a drop spreader prior to planting the cotton each year. Cotton varieties were Stoneville

132 at Auburn in 1996, Paymaster 1330 BG/RR at Auburn in 1997, and Stoneville 474 at Florence both years. Cotton planting dates ranged from 27 May to 4 June. The same drills were used to plant the cover crops and the cotton at each location each year. Planting was with a Marliss Brand drill (see Acknowledgments and Disclaimer) at Auburn and a John Deere 750 drill at Florence. The seeding rate at Auburn was 250,000 seeds per acre in 1996 and 200,000 seeds per acre in 1997. At Florence, the seeding rate was 145,000 seeds per acre in 1996 and 130,000 seeds per acre in 1997.

Weeds were controlled with a combination of herbicides and handweeding. Insects were controlled with insecticides as infestations occurred. Lime, P, K, S, Mn, and B applications were made before desiccating the winter covers. Application rates were based on soil test results and university Extension recommendations for non-irrigated cotton. Mepiquat chloride (N,N-dimethylpiperidinium chloride) was applied four times at Auburn to control excessive vegetative growth. Applications were made at 10-day intervals, beginning when the first flower buds on the plants were the size of match-heads. At Florence, only one application of mepiquat chloride was made each year. These applications were made in July 1996 and early August 1997 (cotton growth stages were approximately first flower in 1996 and mid-flowering in 1997).

Because the cotton at Auburn was mechanically harvested, a more aggressive harvest aid chemical application program was used than at Florence. All applications were with label-recommended rates. At Auburn in 1996, defoliation was initiated on 27 September by applying glyphosate and ethephon [(2-chloroethyl) phosphonic acid]. Three days later thidiazuron (N-phenyl-N'-1,2,3 -thiadazol-5-ylurea), S,S,S-tributyl phosphorotithioate, and dimethipin (2,3-dihydro-5,6-dimethyl-1,4-dithiin 1,2,4,4-tetraoxide) with crop oil concentrate were applied. In 1997 at Auburn, an application consisting of ethephon, S,S,S-tributyl phosphorotrithioate, and thidiazuron was made on 21 October. Eight days later, a single application of paraquat was made to desiccate the cotton stems. At Florence, cotton was defoliated in with S,S,S-tributyl phosphorotrithioate and ethephon on 17 October 1996. No harvest-aid products were applied at Florence in 1997. Harvest dates in Auburn were 24 October 1996 and 7 and 8 November 1997. At Florence, the plots were harvested between 25 and 31 October 1996 and between 9 and 15 October in 1997.

Stand counts were made just prior to harvest each year at Auburn, then cotton was stripper-harvested (Allis-Chalmers model 760 XTB cotton stripper equipped with a 7 foot broadcast, finger type head). Harvesting at Florence consisted of counting all plants in a randomly selected 18.75 ft^2 area of each plot (three 10-ft-long rows) and then counting and hand-picking all bolls in that area. After harvest, seedcotton samples at Auburn and all of the seedcotton at Florence were weighed and saw-ginned on a laboratory gin. The lint was then weighed to calculate lint percent and determine lint yield.

Fiber properties were measured by high-volume instrumentation on lint samples from all plots. For cotton grown at Auburn, these fiber properties were measured at the Auburn University Textile Engineering Department. Fiber properties for the cotton lint harvested at Florence were determined at StarLab, Inc., Knoxville, TN. Processing quality of the fiber was further evaluated with a production model Advanced Fiber Information System (AFIS-A2, Zellweger-Uster, Knoxville, TN) to determine short fiber content (percentage of fibers less than 0.5-inch long) and immature fiber fraction as described by Bradow et al., 1997 (2).

Analyses of the data were conducted by location because the method of harvest differed between the two locations. 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. Means were separated with an LSD when sources of variation were significant.

Cotton Plant Stands

Cotton plant stands differed between years at both locations because of the different seeding rates used each year. As was somewhat anticipated, cotton plant stands were lower following the legume than following the cereal or fallow at both locations. Averaged over both years at Auburn, mean plants per acre were 165,000 following lupin, 178,000 following the winter cereal, and 184,000 following winter fallow (LSD = 10,000). At Florence averaged over both years, mean plants per acre were 90,000 following peas, 115,000 following the winter cereal, and 122,000 following winter fallow (LSD = 15,000).

Conservation tillage had significantly lower stands than conventional tillage only in 1997 at Auburn where stands were 164,000 plants per acre for conventional tillage and 133,000 plants per acre for conservation tillage (LSD = 16,000). At Auburn in 1996, stands for conventional tillage were 206,000 plants per acre while conservation tillage averaged 200,000 plants per acre. At Florence, there was a trend for stands to be lower ($P \leq 0.10$) with conservation tillage compared to conventional. Averaged over the two years, stands were 114,000 plants per acre with conventional tillage and 103,000 plants per acre with conservation.

Although actual plant populations differed considerably between years and locations, stands as a percent of seeding rate were actually quite similar between the locations. For conventional tillage, stands were 82% of the seeding rate both years at Auburn. At Florence, stands in conventional tillage were 85% of the seeding rate in 1996 and 81% of the seeding rate in 1997. For conservation tillage, stands were 80% of the seeding rate in 1996 and 66% of the seeding rate in 1997 at Auburn and 74% of the seeding rate in 1996 and 75% of the seeding rate in 1997 at Florence. Thus, these data suggest that in the UNR system, growers might want to consider planting rates to be about 15 to 20% above desired stands with conventional tillage and 20 to 25% above desired stands with conservation tillage, using the higher percentage when following legumes and the lower percentage when following winter cereals or fallow.

Lint Yield

Tillage did not have a consistent influence on lint yield in this study. At Florence, conservation and conventional tillage did not differ for yield either year. At Auburn, conventional tillage averaged 155 lb lint per acre higher than conservation tillage in 1996 but conservation tillage averaged 204 lb lint per acre higher than conventional tillage in 1997 (LSD = 91 lb per acre).

The yield response to N within each winter cover was similar across locations. Yields averaged over both years and tillage treatments are shown in Table 1. Yield for the 40, 80, and 120 lbs N per acre levels did not differ following the winter cereal at Florence and for the fallow treatment at Auburn. Cotton grown with 120 lbs N per acre following the winter cereal had higher yield than the cotton grown with 40 lbs N per acre at Auburn. Following winter fallow at Florence, highest yield occurred with 80 lbs N per acre. Yields tended to be high regardless of N level following the legumes, but average yield with 80 lbs N per acre were higher than 0 or 40 lbs N per acre at Auburn. At Florence, there was no difference in yield at the three lowest N levels following the legume. Excessive vegetative growth occurred resulting in yield reduction occurred following the legume when 120 lbs N per acre was applied at Florence. These yield responses to N following the different winter cover treatments for this UNR system are quite similar to those found for wide row production methods on marginal coastal plain soils (1,24).

Table 1. Effect of cover crop and N rate on lint yield of UNR cotton at Auburn, AL and Florence, SC. Data are averaged over two tillage systems and two years.

Location	N rate (lb/acre)	Winter cover (lb lint per acre)			
		Fallow	Legume[a]	Cereal[b]	Mean
Auburn	0	724[c]	1029	608	789
	40	968	1072	884	978
	80	993	1222	923	1051
	120	956	1141	1040	1052
	Mean	866	1119	910	--
Florence	0	598	773	438	605
	40	685	935	909	846
	80	958	873	913	918
	120	840	679	881	803
	Mean	773	818	788	--

[a] The legume winter cover crop was lupin at Auburn and peas at Florence.

[b] Blackoat was the winter cover cereal in 1996 at Auburn and both years in Florence. A mixture of blackoat and rye were the winter cover in 1997 at Auburn.

[c] LSD (0.05) for comparing N rates within a winter cover is 134 lb per acre at Auburn and 178 lb/acre at Florence.

By counting all harvested bolls at Florence, the relative contribution of boll number, boll size, and lint percent to lint yield could be measured. Although treatments did affect boll size and lint percent (especially N, data not shown), boll number made the largest contribution to explaining yield. About 97% of the variation in yield among the two years of data was explained by boll number (Fig. 1).

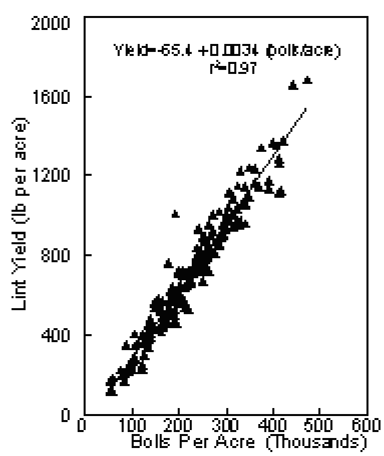

Fig. 1. Influence of boll number on yield of UNR cotton at Florence, SC. Data are plot observations, and data from both years are included.

Fiber Properties

Fiber properties were not greatly impacted by the management factors we studied. Although some main effect and interaction sources of variation were significant for some fiber properties, within each location differences between means were not substantial enough to alter the suitability of the cotton for processing or impact the price a grower would receive.

Fiber properties for the 80 lb N per acre treatments, averaged over all winter cover and both tillage treatments are shown in Table 2. As can be seen in Table 2, micronaire was very low at Auburn both years and this would have resulted in substantial price penalties for the cotton from that location. We are not sure why this occurred. One might suspect that early application of ethephon (a harvest aid chemical which stimulates boll opening) before all bolls were mature could be a cause of the low micronaire. However, 50 boll samples were hand-harvested before any harvest aid chemicals were applied in 1997, and they had low micronaire readings (*data not shown*). This indicates that the low micronaire values were a result of physiological effects on the cotton during the growing season rather than a management effect. We are unaware of other reports for micronaire of UNR cotton being this low, though others have reported micronaire of UNR cotton to be somewhat lower than cotton grown in wide rows (15,25).

Table 2. Mean fiber properties of cotton grown in ultra-narrow row widths with 80 lb N per acre at Auburn, AL and Florence, SC. Standard errors of means are in parentheses.

	Auburn		Florence	
Fiber property	**1996**	**1997**	**1996**	**1997**
Fiber length (inches)	1.1 (0.01)	1.1 (0.01)	1.1 (0.00)	1.0 (0.01)
Length uniformity (%)	81 (0.4)	82 (0.2)	83 (0.1)	82 (0.4)
Fiber strength (gm per tex)	26.3 (0.5)	29.5 (0.2)	27.2 (0.2)	27.9 (0.4)
Micronaire (units)	3.0 (0.05)	2.8 (0.03)	3.6 (0.05)	4.4 (0.09)
Elongation (%)	9.8 (0.06)	6.5 (0.07)	9.9 (0.05)	9.9 (0.07)
Rd (%)	65 (0.6)	68 (0.3)	77 (0.2)	68 (0.3)
+b (%)	7.1 (0.1)	7.6 (0.1)	8.1 (0.1)	8.4 (0.1)
Short fiber content (%)	7.2 (0.2)	5.6 (0.1)	8.8 (0.1)	8.5 (0.3)
Immature fiber fraction (%)	18.0 (0.3)	13.6 (0.4)	17.9 (0.4)	12.5 (0.4)

Conclusion

Conservation systems with UNR cotton appear to be a viable option for growers. These data suggest seeding rates of 15 to 20% above desired stands with conventional tillage and 20 to 25% above desired stands with conservation tillage, using the higher percentage when following legumes.

We found that the yield response of cotton to N fertilization rate following the different winter cover crops is similar to findings for cotton grown wide rows, suggesting that existing recommendations be used for these soils when growing UNR cotton.

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