A COMPARISON OF TILLAGE SYSTEMS FOR WITHIN-FIELD VARIABILITY OF COTTON YIELD AND FIBER PROPERTIES

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ABSTRACT

There is considerable variability for lint yield within cotton (*Gossypium hirsutum* L.) fields in the southeastern Coastal Plain. The objective of this experiment was to determine if soil management techniques and in-furrow application of an insecticide/nematicide influence the amount of variability in cotton yield and fiber properties. Treatments in the study were tillage (conservation vs. conventional) and aldicarb application (1.07 lb ai/acre vs. none). In 1997, 'DPL Acala 90' was planted into large plots (ranging in length from approximately 400 to 800 ft, plots were six 38-in.-wide rows) that spanned across several soil map units. Two harvesting methods were used to determine variability. First, the large plots were subdivided into 44-ft-long sections, and two of the rows in each section were harvested with a spindle picker. Second, a 6-ft sample was hand-harvested from each of three soil map units (Bonneau sand, Eunola loamy sand and Norfolk loamy sand) within each plot. Neither aldicarb application nor tillage system affected the variability for yield or micronaire among the machine-harvested samples. Variability for fiber length was less in conservation tillage than in conventional tillage only when aldicarb was applied. For fiber strength, conservation tillage had lower variability than conventional tillage for the plots without aldicarb. Soil map unit was responsible for much of the variation in yield, with the Bonneau sand having lower yield than the other two soil map units. Variability for fiber properties was less than variability for yield.

INTRODUCTION

A large amount of variation in cotton growth and productivity can occur within the cotton fields of the southeastern Coastal Plain. One of the largest sources appears to be variation due to soil map unit. Fields in this region generally have many soil map units and a range of physical and chemical properties that influence crop growth (Karlen et al., 1990). The primary productivity differences among soil map units may be in differences in ability to supply water to crops. Sadler et al. (1998) found a significant relationship between canopy minus air temperature and soil map unit in corn (*Zea mays*) during a severe water deficit year, which implied that soil physical differences caused differences in water stress.

Many of the benefits of conservation tillage, especially when used with adequate residue cover, are related to improving soil water conditions. Benefits often cited include increased rainfall infiltration, reduced runoff and reduced evaporation from the soil surface. Thus, conservation tillage techniques may reduce the amount of field variability for cotton yield by reducing the amount of in-field variability for soil water.

Besides soil map unit, pest infestations are a source of variability in the southeastern Coastal Plain cotton fields. Although seldom random, infestations of weeds, insects and nematodes do not tend to be uniformly distributed throughout a field. Though pests are rarely uniformly distributed, pest control measures are usually applied uniformly throughout a field. Part of the reason for this is the uncertainty of where pest infestations will occur. Also, there is very little spatial data available on the efficacy of pest control products.

A six-year study was established in the fall of 1996 with the overall objective to determine the effects of residue amount, tillage system and in-furrow insecticide application on cotton yield and fiber properties. In this report, we describe our results from the first year of converting a field to a conservation tillage production system. The objective is to determine if soil management techniques and in-furrow application of an insecticide/nematicide influence the amount of variability in cotton yield and fiber properties.

MATERIALS AND METHODS

Seven acres of a 40-acre field at Clemson University's Pee Dee Research and Education Center near Florence, South Carolina, were used for the experiment. The area was chosen because of the diversity in soil map units and the ability to have at least two soil map units represented in each plot. Treatments were tillage (conventional or conservation) and in-furrow insecticide/nematicide application (aldicarb or none). Experimental design was split-plot with main plots in a randomized complete block. There were three blocks. Main plots were the tillage treatments, and subplots were the in-furrow insecticide application treatments. Main plot size was twelve 38-in.-wide rows that ranged in length from approximately 400 ft to more than 800 ft. Six of the rows received an in-furrow applica-

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tion of 1.07 lb ai/acre aldicarb, while the other six were planted without insecticide/nematicide protection to serve as controls.

In previous years, the field was in a two-year rotation of corn followed by winter wheat (*Triticum aestivum*) double-cropped with soybean (*Glycine max*). Corn was grown in the field during the summer of 1996. Following corn harvest, stalks were mowed. The experiment was originally designed to include a rye cover crop (both with and without tillage) treatment. Rye was planted 20 November 1996, but because of poor cover crop growth, these plots were pooled with the no-cover-crop main plots for this analysis. In the spring of 1997, paraquat was applied to the conservation tillage plots while the conventional tillage plots were disked and then smoothed with a harrow equipped with S-shaped tines and rolling baskets. On 2 May, a paratill with shanks spaced 26 in. apart was used to deep-till the entire experimental area to a depth of 16 in.

Cotton ('Deltapine Acala 90') was planted 7 May using a four-row planter equipped with waved coulters. Seeding rate was four seeds per row-ft. Preemergence herbicides (fluometuron and pendimethalin) were applied 8 May. Post-emergence herbicides included pyrithiobac, cyanazine and monosodium methanearsonate. All herbicides were applied at recommended rates. Plant nutrients (other than N) were broadcast applied before cotton planting at rates based on soil test results and Clemson University Cooperative Extension Service recommendations. All N was side-dress applied in a split application, with 40 lb N/acre being applied 13 May and 40 lb N/acre applied 20 June. All N applied was NH_4NO_3.

Two methods of harvest were used to assess the yield and fiber property variability. The first method involved separating each subplot into 50-ft-long sections and removing plants from 3 ft of row from each end of the sections so that the harvested area within each section was 44 ft long. A two-row spindle picker was used to harvest two of the rows in each section. A grab sample of seedcotton from each harvest bag was collected at harvest for fiber property determinations. The second method involved hand-harvesting 6 ft of row from individual soil map units within each plot. The map units chosen were Bonneau sand (BoB; loamy, siliceous, thermic Arenic Paleudult), Eunola loamy sand (EuB; Fine-loamy, siliceous, thermic Aquic Hapludult) and Norfolk loamy sand (NoA; fine-loamy, siliceous, thermic Typic Kandiudult). All three soil map units were present in all plots in two of the blocks. In the other block, the EuB soil map unit was in each main plot, while the BnA soil map unit was present in only one of the four main plots, and the NoA map unit was present in only three of the four main plots. All seedcotton samples were ginned on a 10-saw laboratory gin. Samples of the lint samples were sent to Star-Lab, Inc (Knoxville, Tennessee) for HVI fiber property determinations.

Bartlett's F test for homogeneity of variance was conducted to determine if the amount of variability differed between conventional tillage and conservation tillage for both levels of aldicarb application. Since the experimental design was split-plot with main plots in a randomized complete block design, variance components for each subplot treatment consisted of variation due to blocks and to within-plot variation. Therefore, an analysis of variance for treatment combination (tillage x aldicarb) was conducted to remove the variance component due to blocks, and the residual mean square was used as the estimate of σ^2 for conducting Bartlett's F test. For the hand-harvested samples, data were analyzed by analysis of variance using the general linear models (PROC GLM) procedure of SAS.

RESULTS AND DISCUSSION

Estimates of variance and Bartlett's F test for heterogeniety of variance among the machine-picked samples for lint yield, fiber length, strength and micronaire are given in Table 1. The amount of variability for cotton yield did not differ between conventional tillage and conservation tillage either with or without aldicarb application (Table 1). Similarly, variability did not differ for micronaire between the tillage systems either with or without aldicarb. Heterogeneity of variance was found for both fiber length and fiber strength. In both cases, the conservation tillage had lower variance than did conventional tillage. For fiber length, variance was lower for conservation tillage than for conventional tillage when aldicarb was applied (Table 1). For fiber strength, variance of the conservation tillage was less when aldicarb was not applied.

For the machine-harvest sampling method, a significant ($P < 0.10$) tillage x aldicarb interaction occurred for lint yield (Table 2). With aldicarb, the conventional and conservation tillage production systems had similar yield (Table 2), averaging 859 lb lint/acre. The interaction was caused by magnitude differences between aldicarb-treated and untreated cotton within each tillage system. In conservation tillage, yields of cotton without aldicarb were only 131 lb/acre less than the cotton treated with aldicarb. In conventional tillage, the difference between aldicarb-treated and untreated was 212 lb lint/acre (Table 2). Early-season counts indicated that thrips populations were less in the conservation tillage than in the conventional (data not shown). Only small, and probably inconsequential, mean differences among treatments occurred for fiber properties with the machine harvest sampling method. As expected, it appears that much of the within-plot variability found with the machine-harvest method was due to soil map unit.

Yield and fiber properties from the hand-harvested samples are given in Table 3. Averaged over tillage systems and aldicarb levels, lint yields were 694 lb/acre for the Bonneau, 913 lb/acre for the Eunola and 1020 lb/acre for the Norfolk. The average yield increase due to aldicarb was 158 lb lint/acre. The micronaire response was similar to yield, with lower micronaire occurring on the Bonneau soil map unit than on the other two and aldicarb-treated cotton having higher micronaire than untreated. As for the machine-harvested samples, variability for fiber length and strength was small, even when treatment means were significantly different. Notably, the cotton produced with conservation tillage on the Bonneau soil grown without aldicarb was substantially lower for yield and fiber quality than the other treatment combinations in the experiment.

Although the tillage x aldicarb x soil map unit interaction was not significant for lint yield ($P = 0.198$), inspection of the means provides some indication of why the tillage x aldicarb interaction occurred for yield with the machine-picked data. As discussed earlier, yield reductions without aldicarb were less in the conservation tillage production system than in the conventional tillage system. Aldicarb did not increase yield for the Eunola and Norfolk soils in the conservation tillage system but resulted in a substantial yield increase on these two soils in conventional tillage (Table 3). For the Bonneau soil, aldicarb treatment increased yield in both the conservation and conventional tillage treatments. Unfortunately, insect pest monitoring was not conducted on an individual soil map unit basis in 1997.

These preliminary data suggest that there can be substantial yield and fiber property variation within fields for cotton in the southeastern Coastal Plain. Additionally, although within-field variation for yield was not reduced with conservation tillage, conservation tillage did decrease the within-plot variation for fiber length and strength. Application of aldicarb did not reduce within-plot variability, nor did it have much of an effect on variability among soil types. More in-depth monitoring of insect and nematode pests is planned.

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Table 1. Estimates of variance for yield and selected fiber properties of each tillage x aldicarb combination in the experiment and Bartlett's F test for homogeneity of variance. Estimates are for the machine-harvested samples.

			Estimate of σ^2			
Tillage	Aldicarb	n	Yield	Length	Strength	Micronaire
Conservation	Yes	54	25112	0.00050	0.9222	0.0767
	No	54	20665	0.00052	0.9820	0.0629
Conventional	Yes	58	21976	0.00086	1.3951	0.0688
	No	58	25963	0.00054	1.7355	0.0712
Bartlett's F-test Values for Homogeneity of Variance between Tillage Systems						
	Yes		1.14	1.72*	1.51	1.11
	No		1.26	1.04	1.77*	1.13

*Indicates F value significant at $P = 0.05$ (F values for determination of significance were estimated from F table values of $F_{0.05\ 40,40} = 1.69$ and $F_{0.05\ 60,60} = 1.53$ [Steel and Torrie, 1980]).

Table 2. Average cotton yield and selected fiber properties as affected by tillage and aldicarb application. Data are from machine-picked samples.

Tillage	Aldicarb	Yield	Fiber Length	Fiber Strength	Micronaire
		lb lint/acre	in.	g/tex	units
Conservation	Yes	849	1.12	30.0	4.1
	No	718	1.11	30.3	4.1
Conventional	Yes	868	1.12	30.3	4.2
	No	656	1.11	30.4	4.1
Significance Level (Prob > F Value) From Analysis of Variance					
Tillage		0.788	***	***	0.469
Aldicarb		<0.001	***	***	0.213
Tillage x Aldicarb		0.066	***	***	0.859

*** Hypothesis testing for these variables is invalid because of heterogeniety of variance.

Table 3. Average cotton yield and selected fiber properties as affected by tillage, aldicarb application and soil map unit. Data are from hand-harvested samples.

Tillage	Aldicarb	Soil Map Unit	Yield	Fiber Length	Fiber Strength	Micronaire
			lb lint/acre	in.	g/tex	units
Conservation	Yes	Bonneau	795	1.09	32.6	3.7
		Eunola	912	1.11	32.4	4.0
		Norfolk	1056	1.12	32.7	4.1
	No	Bonneau	527	1.07	29.9	3.2
		Eunola	908	1.11	32.6	4.2
		Norfolk	1030	1.11	32.2	3.8
Conventional	Yes	Bonneau	785	1.12	33.8	3.7
		Eunola	1085	1.12	32.5	4.1
		Norfolk	1110	1.13	32.8	4.2
	No	Bonneau	658	1.10	32.5	3.7
		Eunola	749	1.11	32.3	3.9
		Norfolk	880	1.09	31.7	3.8
Significance Level (Prob > F Value) From Analysis of Variance						
Tillage			0.704	0.295	0.127	0.259
Aldicarb			0.007	0.031	<0.001	0.049
Soil			<0.001	0.482	0.775	0.003
Tillage x Aldicarb			0.273	0.622	0.787	0.890
Tillage x Soil			0.736	0.066	0.002	0.460
Aldicarb x Soil			0.929	0.627	0.012	0.241
Tillage x Aldicarb X Soil			0.198	0.357	0.208	0.205