CONE INDEX AND YIELD IN CONVENTIONAL- AND CONSERVATION-TILLED COTTON

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Abstract

Conventional tillage in the southeastern Coastal Plains usually includes disking to a depth of 0.15 to 0.20 m. Both conventional and conservation tillage include deep profile disruption to break up root-restricting, subsurface pans. Winter cover crops are often grown to prevent nutrient leaching by winter rains. However, winter cover crops can also dry the soil and make the pan even harder. Cotton (*Gossypium hirsutum* L. var Coker 315) was grown for two years in plots with or without a vetch (*Vicia villosa* Roth var. Cahaba white) cover crop. Plots were split into sections that were annually disked and bedded (conventional tillage) or non-disked (conservation tillage). Soil strength was 4.3% lower in the conventional tillage plots because of the loosening of the surface layer of the soil. Soil strength was 11.6% higher in the vetch cover crop plots. This higher strength was caused at least partially by dryer plots. Despite this, seed cotton yield was greatest in the conventional tillage, vetch cover crop plots (2161 kg/ha) and least in the conservation tillage, no-cover crop plots (1436 kg/ha). Higher yield in the conventional tillage plots is attributed to lower surface layer soil strength and better weed control. Higher yield in the vetch cover crops is probably a result of a rotational effect, increased infiltration, or better water holding capacities.

Introduction

Some of the more productive soils of the southeastern Coastal Plains have Ap and E horizons that are single-grained or massive in structure, sandy in texture, and low in organic matter. These horizons, especially the E, can produce strengths that inhibit or prevent root growth (Box and Langdale 1984). For example, the E horizon can have natural bulk densities as high as 1.7 g/cm^3. They can also have strengths that prevent root growth at water contents as high as field capacity (Campbell *et al.*, 1974).

Some E horizons are shallow and are incorporated into the Ap horizon. However, in many fields they are deeper than 40 cm (16 in). To disrupt the E horizon and insure root growth through it, most management systems (both conventional and conservation) include deep profile disruption, e. g. subsoiling. Increased yield has been attributed to these tillage practices (Gerard *et al.*, 1982; Ide *et al.*, 1984).

Winter cover crops can reduce nutrient leaching in these sandy soils as well as decrease erosion. They can also provide increased residue, green manure, winter forage, and increased yield of summer annuals (Campbell *et al.*, 1984a, 1984b). However, if the Spring is draughty or the cover crops are killed late, they can decrease soil water and reduce early growth, stand, and yield of the summer annual.

The objective of this experiment was (1) to compare cotton yield for reduced (conservation) and conventional tillage and (2) to determine the influence of cover crop on soil strength.

Methods

Cotton was grown during the summers of 1991 and 1992 at the Clemson Pee Dee Research and Education Center in Florence, SC. The soil in the cotton field was a Norfolk loamy sand (fine, loamy, siliceous, thermic, Typic Kandiudult). Cotton was grown on beds which rose 5 cm to 10 cm above the mid-rows. Row widths were 0.75 m.

The experimental field design was randomized complete block in a split-split plot arrangement. The main plots were cover crop, vetch and no cover. Subplots were tillage (conventional and conservation tillage) and sub-subplots were date of cover crop incorporation/desiccation (5 and 15 days before planting). Main plots were 8-m wide by 30-m long.

Conventional tillage plots were spring disked and annually rebedded. Conservation tillage plots were not disked. Conservation tillage plots were sprayed with Gramoxone (paraquat dichloride) to kill the cover crop and weeds. In these plots, beds were formed in the fall of 1990. In the fall of 1991, bedders were used to place a small amount of soil (2.5 cm or less) onto the existing beds of the conservation tillage plots prior to seeding the cover crop. Both conventional and conservation tillage included in-row subsoiling to a depth of 25 to 30 cm at the time of planting.

Soil strength readings (cone indices) were taken at the beginning and at the end of the growing seasons: May 16 and October 1, 1991; June 8 and October 26, 1992. Cone indices were taken with a 13-mm diameter, 30° solid angle cone tip, hand-operated, recording penetrometer (Carter, 1967). The penetrometer recorded cone indices to 0.60-m depths at 2 positions: one in the mid-row and one in the row. Three probings were taken at each position along the row and digitized into the computer using the method of Busscher *et al.* (1985). Data were log transformed before analysis for normalization as recommended by Cassel and Nelson (1979). Soil water content was taken at 10-cm depth intervals, along with the cone index readings.

Lime was applied to maintain a pH of 6.0. P, K, and micronutrients were applied following the recommendations of the Clemson University Extension Service. No N was applied to the plots with the vetch cover crop and 78 kg/ha of N were applied to the plots with no cover crop. Cotton was planted on May 8, 1991 and May 10, 1992 and harvested with a two-row spindle picker on October 9, 1991 and October 22, 1992.

Yield data were analyzed by analysis of variance. Cone index data were analyzed by expanding the statistical design to include water content as a covariate (SAS 1989).

Results and Discussion

Yield

Seed cotton yields were higher ($P \leq 0.01$) in 1991 (2420 kg/ha) than in 1992 (1040 kg/ha). In 1992 rainfall was greater than 1991. However, it was more sporadic in 1992 with a 16-day period of no rain in early July and a 9-day period with 342 mm of rain in August (starting August 9th with 115 mm).

Date of cover crop incorporation/desiccation did not influence yield or soil strength (cone index). Date of cover crop incorporation could have been a problem if the later date reduced soil moisture for the seedlings. However, rainfall for the 5 days before planting was greater than that of the 6-15 day period before planting eliminating any differences that might have existed. For the 5 days before planting, rainfall was 41 mm in 1991 and 27 mm in 1992. For days 6 to 15 before planting, rainfall was 13 mm in 1991 and 11 mm in 1992.

Yield (Table 1) was higher for the conventional than for the conservation tillage treatment ($P \leq 0.05$). This was probably a result of better weed control in the conventional tillage treatment. Visual observations showed late season (October) weed populations to be on the average 3.5 times greater in 1991 (84% of the plot area) and 2 times greater in 1992 (57% of the plot area) for the conservation tillage plots.

Yield for the treatment with a vetch cover crop was higher than for the treatment with no cover crop ($P \leq 0.10$). The reasons for the increase may be improved fertility caused by the increased organic matter or increased soil water throughout the growing season caused by decreased crusting and increased infiltration in the vetch plots.

Soil

These sandy coastal plain soils have naturally poor available water holding capacities (0.06 to 0.10 g/g) and have low cation exchange capacities caused by low organic matter (½ to 1%) (Campbell *et al.* 1974). The vetch cover crop could have provided more than the 78 kg/ha of nitrogen applied to the plots with no cover; however, Bauer *et al.* (1992) showed that maximum yield would be obtained with 55 kg/ha of N on this soil.

Soil Strength

In-row soil strengths (cone indices) for the top 40 cm were essentially the same for both conservation and conventional treatments for both years. This was a result of the subsoiling in both treatments. Figures 1 and 2 show this effect for cone index readings from selected treatments. These data were taken in the spring. There was also no difference between tillage treatments for in-row cone index in the fall (data not shown).

Cone index readings (Figure 1) from the beginning of the growing season analyzed for both in-row and mid-row positions together were significantly higher for vetch cover crop treatments than for the treatments with no cover crop in 1991 ($P \leq 0.06$). Though cone index means were higher for the vetch cover treatments in 1992, they did not differ significantly. The higher cone index readings and higher yield indicate that the increased yield was not related to soil strength (even though cone indices were higher than 1-2 MPa, a root-impeding strength [Campbell *et al.*, 1988]).

Water contents were slightly lower for the vetch cover crop treatment in 1991 and the same in 1992 (0.10 g/g in 1991 and 0.10 g/g in 1992) than for the treatment with no cover crop (0.11 g/g in 1991 and 0.10 g/g in 1992). Though these differences were not significantly different, they can explain at least a part of the higher cone indices for the vetch cover crop plots.

In addition, cone index readings (Figure 2) taken at the beginning of the growing season were significantly lower for the conventional than for the conservation tillage treatment in 1992 ($P \leq 0.05$). Cone indices for the conventional tillage treatment were lower in 1991, but not significantly. The lower cone indices, located mainly near the soil surface and in the mid-row, would be a result of soil loosening caused by the disking of the conventional tillage treatment. The conservation tillage treatments were not disked. Yields of the conventional tillage treatment were significantly higher than for the conservation tillage treatment. Unfortunately, poor weed control in the conservation tillage plots may have masked any yield response to the cone indices.

Cone index readings taken at the end of the growing season were not significantly different for cover crop and tillage treatments. The tilled soil in the conventional treatment had time to settle throughout the summer increasing in bulk density and, therefore, cone index.

Conclusions

The reduced tillage treatment included deep profile disruption by a subsoil shank which has been shown to increase yields in many of the southeastern Coastal Plain soils. Reduced tillage did not yield as well as the conventional disking and rebedding. This yield difference was probably due to reduced weed control in the conservation tillage plots.

Despite higher strengths, cotton yields following vetch were higher than following fallow. These differences were not due to weed control. Some possibilities for the differences are a rotational effect from the winter cover, increased nitrogen from the cover crop, increased infiltration, or improved soil water holding capacities in the cover crop plots. The aspects of improved soil-water relationships is the object of ongoing researched by these investigators.

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Table 1. Seed cotton yield means. Each non-mean is the average over four replicates and two dates of cover crop incorporation or spraying.

Cover	Vetch		None		
	1991	1992	1991	1992	Mean
Tillage		-------- kg/ha --------			
Conventional	2996	1326	2678	1097	2024
Conservation	1776	1099	2232	641	1437
Mean	1799		1662		

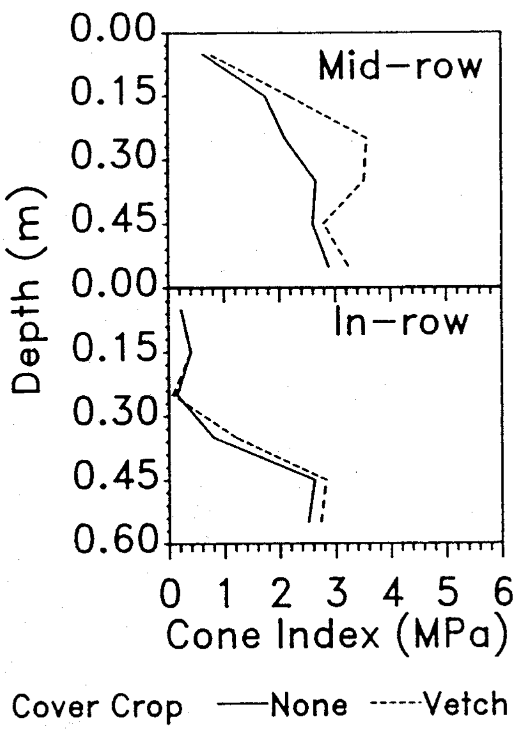

Figure 1. Cone indices by cover crop for spring 1991.

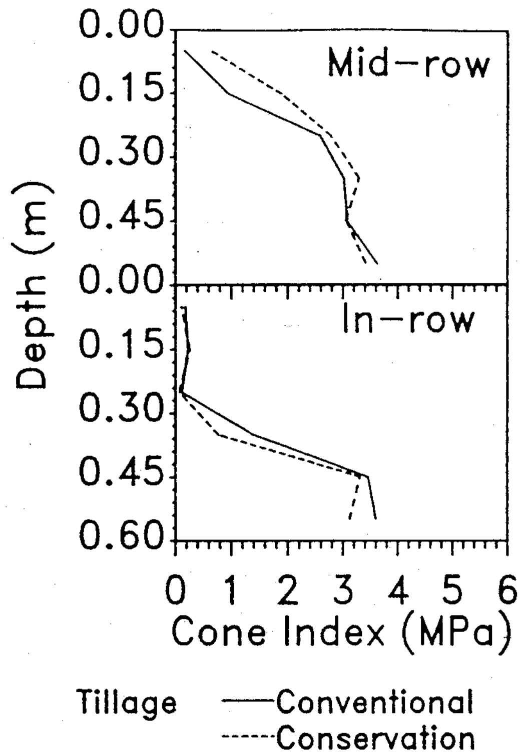

Figure 2. Cone indices by tillage treatment for spring 1992.