SOIL STRENGTH IN RYE AND FALLOW WINTER COVER IN THE SOUTHEASTERN COASTAL PLAIN

W.J. Busscher and P.J. Bauer[1]

ABSTRACT

On sandy coastal subsurface hardpan soils, cover crops have the potential to prevent erosion and scavenge nutrients. Our objective was to determine the effect of cover crops and tillage on soil strength and cotton yield. Treatments were surface tillage (disked or none), deep tillage (in-row subsoiled or none) and cover crop (rye or fallow). Soil strength (cone index) differences were measured for tillage treatments (deep tilled < none), depth (higher strength in the pan) and position across the row (in row < non-wheel track < wheel track). Lower cone indices were found in the non-tilled rye cover, suggesting that the cover helped maintain low strengths. Higher cone indices in the disked treatments suggested that the disking aided recompaction.

INTRODUCTION

In the southeastern Coastal Plains, winter cover is important for long-term conservation tillage crop production. Cool- and warm-season annual double crops are needed for successful conservation tillage production of grain sorghum [*Sorghum bicolor* (L.) Moench] and soybean [*Glycine max* (L.) Merrill] on southeastern Piedmont sandy loams (Langdale et al., 1990). However, because of the long southeastern cotton growing season, double cropping with continuous cotton is not possible for much of the region. In addition, low organic matter produced by cotton can leave a field bare for the winter.

Cover crops provide winter cover to improve erosion control and increase infiltration. They can also scavenge nutrients and reduce groundwater pollution. Cover crops might also provide the beneficial rotational effect of double crops seen by Langdale et al. (1990).

Because of the subsurface root-restricting E horizon of many Coastal Plain soils, in-row subsoiling is needed to help roots penetrate into the clay-textured B horizon. In-row subsoiling provides a narrow, soft zone below the row that roots can use to penetrate through the E and grow into the B horizon. By adding organic matter from both roots and cover, cover crops may also help maintain lower soil strength.

Our objective was to determine the influence of surface tillage, deep tillage and a rye cover crop on soil strength and cotton lint yield.

[1]USDA-ARS, Coastal Plain Soil, Water, and Plant Research Center, Florence, South Carolina.

MATERIALS AND METHODS

In 1990, we established cover crop plots at the Clemson University Pee Dee Research and Education Center near Florence, South Carolina. Bauer and Busscher (1993) reported the results from the 1991 and 1992 experiment. In 1993, cotton was grown on the plots but not harvested because of a drought. All plots were subsoiled in spring 1993.

In 1994 and 1995, we changed the treatments to subsoiling only half the plots. During these two years, experimental treatments were winter cover (rye and fallow), surface tillage (disking and none) and deep tillage (in-row subsoiling and none). The experimental design was split-split plot randomized complete block. Main plots were winter cover, subplots were surface tillage, and subsubplots were deep tillage. Subsubplots were 12.7 ft wide (four 38-in. rows) by 50 ft long. The experiment had four replicates. The soil was a Norfolk sandy loam (fine, loamy, siliceous, thermic, Typic Kandiudult).

In October 1993 and 1994, after the cotton stalks were shredded, half the plots were seeded with rye cover (110 lb of seed/acre). Plots were seeded in 7.5-in. rows using a John Deere 750 grain drill.

In a separate operation immediately prior to planting, half the subsubplots were subsoiled using a KMC four-row subsoiler within 6 in. of the previous year's rows. In mid-May, cotton ('DES 119') was seeded within 6 in. of the previous year's rows with a four-row Case-IH 900 series planter equipped with Yetter wavy coulters. We attempted to maintain the same wheel tracks and rows from year to year. However, because the old rows were no longer visible, locating wheel tracks was more difficult in the disked than in the non-disked plots

Nitrogen (80 lb N/acre as ammonium nitrate) was applied in a split application, half at planting and half one month after planting. For each application, N was banded approximately 4 in. deep and 6 in. from the rows. Lime, P, K, S, B and Mn were applied based on soil test results and Clemson University Extension recommendations. Weeds were controlled with a combination of herbicides, cultivation (disked plots only) and hand-weeding. Insects were controlled by applying aldicarb (0.75 lb ai/acre) in-furrow. Other insecticides were applied as needed.

Soil strength was measured in early June with a 0.5-in.-diameter, 30^{o} solid angle cone tip, hand-operated, recording penetrometer (Carter, 1967). Strength measurements were recorded to a depth of 24 in. at nine positions across a mid-plot row (from non-traffic midrow to traffic midrow). Each measurement was the mean of three probings from each subsubplot. Data were recorded on index cards and digitized into the computer using the method described by Busscher et al. (1986). Data were log transformed before analysis for normalization (Cassel and Nelson, 1979).

Along with the cone indices, water contents were measured at 4-in. depth increments in the non-wheel-track midrow and in the row. These selected water contents were considered representative of the water contents for each subsubplot.

In mid to late October, cotton was chemically defoliated. In early November, seed cotton yield was measured by harvesting two interior rows with a two-row spindle picker. Each harvest bag was subsampled, and the subsample was saw-ginned to measure lint percent. Seed cotton yield was multiplied by lint percent to estimate lint yield.

Data were analyzed using ANOVA and the LSD mean separation procedure (SAS Institute Inc., 1990). Unless otherwise specified, differences were significant at P = 0.05.

RESULTS AND DISCUSSION

In late summer 1994, hail ruined part of the field that included half of replicate one. After this, the replicate was ignored and the other three were used for analysis.

Depth

For both years and over all tillage treatments, cone index differed with depth (Table 1 and Fig. 1). The highest cone indices were found at the 12- to 16-in. depths, the bottom of the E horizon. This high subsoil strength was the main reason for implementing the deep tillage.

Some cone index differences with depth were caused by water content changes (Table 1). For example, the softer soil below the hard layer (> 16 in.) was also wetter. At this depth, soil type generally changed from loamy sand to sandy clay loam. The sandy clay loam held more water and had structure. The higher water content reduced cone index and provided nourishment for the root, if it could penetrate the pan above. The structural faces provided zones of weakness along which roots could grow, even if the soil dried and hardened.

Position

Cone index varied with position across the row (Table 2 and Fig. 1). These differences distinguished lower strength under the non-wheel-track midrow (Fig. 1, position = 0 in.) than the wheel-track midrow (position = 38 in.). The lowest cone indices were found in the midrows (position = 19 in.) because of this year's deep tillage or residual effects from past deep tillage in the non-deep-tilled treatments.

Tillage

Mean profile cone indices (M) did not differ between disked and non-disked treatments. An exception to this was the 1994 non-deep-tilled treatments where disked treatments had lower M (Table 3). This was a result of lower cone indices in the surface 4 in., caused by the disking. This zone of lower strength was apparent in the other cases (Fig. 1) but not significantly different.

As expected, M for the deep-tilled treatment was lower than for the non-deep-tilled treatment (Table 3). An exception to this was the disked treatment in 1994 where M's were about the same for both deep tilled and non-deep-tilled treatments. The similarity of the M's could be explained partly by the residual effects of 1993 subsoiling in the non-deep-tilled treatment, giving this profile a loosening pattern similar to the deep-tilled treatment (Fig. 1). Also, since both treatments were disked, the upper parts of both profiles were loosened.

Cover

Most strength interactions with cover were accompanied by water content differences. The higher strengths had lower water contents. Most of these differences were in the lower half of the measured profile.

In the non-disked treatments, the rye cover treatment had lower cone indices (and higher water content) than the fallow treatment (Table 4). This would be consistent with better infiltration usually associated with treatments that have better cover.

The opposite was seen in the disked treatments, where the fallow treatment had the lower cone indices (and higher water contents). This would be consistent with root uptake by the rye.

In 1994, cotton yield was higher for fallow cover in the non-disked treatments and for rye cover in the disked treatments (Table 4). This was a result of the large amount of cover in the 1994 rye cover treatments that made planting difficult in the non-disked rye cover and added a significant amount of organic matter to the disked treatment (Bauer et al. 1995).

In 1995, in the non-subsoiled treatments, cone indices were lower for the non-disked rye than fallow and higher for the disked rye than fallow (Table 4). Lower cone indices for the non-disked rye suggested that the cover (and the roots from the cover crop growing within the profile) helped maintain low strengths, even for soils with hardpans at 12- to 16-in. depth. Higher strengths for the disked rye suggest that disking can eliminate these reductions in strength. Since the profile as a whole was higher in strength and since disking loosened the upper part of the profile (as seen above), the lower part of the profile, the pan, would have had to be compacted. Lower cone indices suggest higher yields for the non-disked treatment. Higher yields were found, although they were not significantly different. Also not significantly different, the 1994 cone index data showed the same trend as the non-subsoiled 1995 cone index data. Water contents for these treatments were not significantly different.

Cover crops have a number of known advantages: reducing erosion, reducing leaching of nutrients and increasing organic matter. It is also advantageous to know that they can be used without reducing cotton yield (and perhaps increasing it) by helping maintain low soil strength.

ACKNOWLEDGMENT AND DISCLAIMER

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Table 1. Cone indices and water contents by depth.

Depth (in.)	Cone Index (Atm) 1994	Cone Index (Atm) 1995	Water Content (lb/100 lb) 1994	Water Content (lb/100 lb) 1995
2	10.3f*	8.9f	5.8e	10.6c
6	21.7e	18.6e	6.0de	10.0d
10	36.1d	24.5d	6.8c	10.0d
14	57.1a	38.5a	6.6cd	10.2cd
18	46.0b	30.3c	8.3b	11.6b
22	41.6c	31.3b	10.3a	12.9a

* Means by year with the same letter are not different (LSD at 5%).

Table 2. Cone indices by position across the row.

Position	Cone Index (Atm) 1994	Cone Index (Atm) 1995
Non-wheel track	24.3b	19.6b
In row	19.7c	11.9c
Wheel track	31.2a	22.3a

* Means by year with the same letter are not different (LSD at 5%).

Table 3. Mean profile cone index by tillage treatment.

Tillage Surface	Tillage Deep	Cone Index (Atm) 1994	Cone Index (Atm) 1995
Non-disked	Non-subsoiled	27.4a	21.4a
Non-disked	Subsoiled	23.1b	17.5b
Disked	Non-subsoiled	23.3b	20.7a
Disked	Subsoiled	22.6b	17.5b

* Means by year with the same letter are not different (LSD at 5%).

Table 4. Mean profile cone index and yield by deep tillage, surface tillage and cover.

Surface Tillage	Deep Tillage	Cover	Cone Index (Atm) 1994	Cone Index (Atm) 1995	Yield (lb/acre) 1994	Yield (lb/acre) 1995
Disked	Subsoiled	Fallow	21.2	16.1b	1060	665
		Rye	24.0	16.8b	1200	724
	Non-subsoiled	Fallow	22.3	18.3b	1110	695
		Rye	24.3	21.2a	1210	619
Non-disked	Subsoiled	Fallow	23.4	16.9b	1299	567
		Rye	22.8	16.2b	1010	724
	Non-subsoiled	Fallow	29.0	21.2a	1240	624
		Rye	25.9	19.6b	1000	838

* Means by year with the same letter are not different (LSD at 8%).

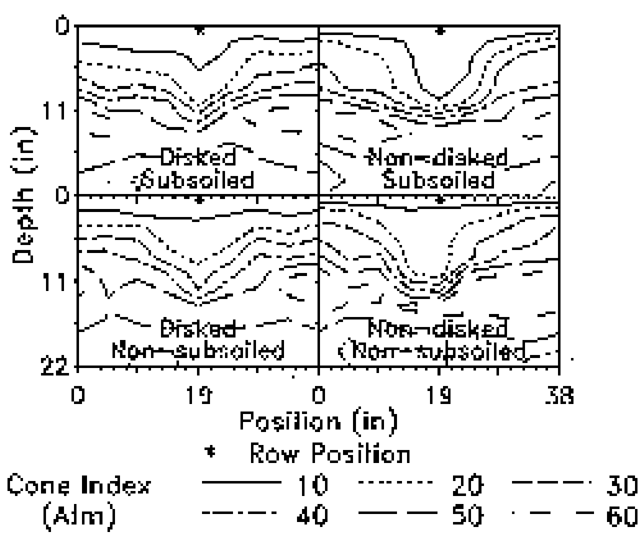

Fig. 1. Isostrength lines for treatment profiles in spring 1994 averaged over covers.