Soil Strength for Deep-Tilled Wheat and Soybean Doublecrop in the Southeastern Coastal Plain

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Abstract

Deep tillage is needed to disrupt subsoil hardpans that form in many Coastal Plain soils. Some producers deep till before planting every crop, even when doublecropping. The purpose of this study was to find out whether fall tillage, spring tillage, or both were most beneficial for a wheat/soybean doublecropping system. We planted eight treatments in each of four replicates. Treatments were combinations of surface and deep tillage. Surface tillage treatments were disked and not disked. Each surface tillage was not deep tilled or paratilled before wheat planting, soybean planting, and both. Disked plots had a pan at the 4- to 6-inch depth, just below the disked zone, unless it was disrupted during deep tillage. Treatments with deep tillage at spring only and both spring and fall had 1 to 7 atm lower soil strengths than the fall only and no deep tillage treatments. Yields were 10 to 20 bu/A higher for the deep tilled treatments. Additional monitoring of soil strength and yield is needed to find more precise differences among treatments.

Introduction

Deep tillage is needed in many Coastal Plain soils to disrupt subsoil hardpans that restrict root growth. Annual deep tillage, usually subsoiling, is recommended at spring planting (Threadgill, 1982, Busscher et al., 1986). For the past 2 years, the Coastal Plain's acreage of doublecropped soybeans planted after small grains has grown from 239,000 acres in 1993, with 24% in reduced tillage, to 255,000 acres in 1994, with 30% in reduced tillage. Because planting early lengthens the soybean growing season and increases yield, soybean planting closely follows wheat harvest. To facilitate the early spring planting, some farmers subsoil in the fall. Others believe that they need to subsoil twice, before planting both soybeans and wheat.

It was our objective to determine whether subsoiling in the spring, in the fall, or both resulted in the greatest improvement in soybean and wheat yield and soil cone index. Our hypothesis was that a producer's choice of subsoil frequency and timing would affect crop production and cone index.

Methods

Wheat-soybean doublecropped plots were established in 1993 at the Pee Dee Research and Education Center near Florence, SC. The winter wheat cultivar grown was Northrup King 'Coker 9134,' a soft red winter wheat. The soybean grown was 'Haygood,' a Maturity Group VII cultivar. The soil was Rains (typic Paleaquult) with a hardpan below the plow layer. In the previous summer, the field had been planted in soybean.

We established two surface tillage and four deep tillage treatments. Surface tillage treatments were either not disked or disked twice before planting. Deep tillage treatments included paratilling at soybean planting, at wheat planting, at both soybean and wheat planting, or no paratilling. The eight treatments were arranged in a randomized complete block design and replicated four times. Each plot was 10 feet wide and 50 feet long.

Surface tillage, deep tillage, and planting were done in separate operations. We used the same wheel tracks as much as possible for all these operations and for harvesting. Surface tillage was done with a 10-foot wide Tufline disk (Tufline Mfg. Co., Columbus, GA) pulled by a John Deere 4230 100-HP (Deere and Co., Moline, IL) tractor with wheels on 64-inch centers. A four-shank paratill (Tye Co., Lockney, TX) was used to deep till to 16 inches. Shanks were spaced at 30 inches. The paratill was pulled with a Case 2670 (now Case-IH, Racine, WI) 220-HP 4-wheel drive tractor with dual wheels on 75-inch and 122-inch centers.

Both the wheat and the soybeans were drilled with a 10-foot wide John Deere 750 No-till Planter pulled by a Massey Ferguson (Massey Ferguson, Inc., Des Moines, IA) 398 80-HP tractor with wheels on 75-inch centers. Wheat harvesting was done with an Allis Chalmers F3 (now Deutz-Allis, Norcross, GA) Gleaner with a 13-foot wide header. The harvester had wheels on 8-foot centers.

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Wheat was drilled on Nov. 18, 1993 at a rate of 20 seeds/ft and harvested as whole plots on May 26, 1994. Soybeans were drilled on May 30, 1994 at a rate of 4 seeds/ft in 7.5-inch wide rows and harvested Nov. 14, 1994.

Soybean yield data were collected by hand from six 3-foot sections of rows near the center of the plot. Plot cleanup was done with an IH 1420 axial flow combine (now Case-IH, Racine, WI) with wheels on 7.5-foot centers and a 13-foot header. Yield data were corrected to 13% moisture for both wheat and soybeans.

Following soil test recommendations, 80 lb/A of both P and K were preplant broadcast onto all wheat plots. Ammonium nitrate was broadcast onto all plots at a rate of 30 lb N/A immediately after wheat planting and 50 lb N/A sidedressed March 8, 1994 (the stem erect wheat growth stage). Fertilizer was applied with a 10-foot wide Gandy spreader (Gandy Co., Owatonna, MN) pulled by the Massey Ferguson 298 tractor.

Nondisked plots were sprayed with Roundup® (glyphosate) at a rate of 1 lb ai/A before wheat planting. Nondisked plots were sprayed with Bronco® (alachlor plus glyphosate) at a rate of 3.5 lb ai/A before soybean planting. Lasso® (alachlor) preemergence was applied to disked plots at a rate of 2.3 lb ai/A before soybean emergence.

To control annual broad leaves and nutsedge, Classic® (chlorimuron) was applied to all plots at a rate of 0.012 lb ai/A 21 days after planting. To control annual grasses, Poast Plus® (sethoxydim) was applied to all plots at a rate of 0.19 lb ai/A 30 days after planting.

Soil strength was measured with a 0.5-inch diameter, cone-tipped penetrometer (Carter, 1967). Strength was measured from the middle of the plot outward at intervals of 3.75 inches to a distance of 30 inches (the distance between paratill shanks) and to a depth of 22 inches. Data were digitized into the computer and log transformed according to the recommendation of Cassel and Nelson (1979) before analysis. Data for all positions across the plot and depth were combined to produce cross-sectional contours of soil cone indices for each plot using the method of Busscher et al. (1986).

We analyzed data using ANOVA in SAS (SAS Institute, 1990) and the least square difference procedure. Cone index data were analyzed using a split-split plot randomized complete block design. The first split was on position across the row and the second on depth. The 5% level of significance was used.

Results

General

Yields were taken for the winter wheat crop of 1993-1994 and the soybean crop of 1994 (Table 1). Soil cone indices shown below were from the spring soybean and fall wheat crops of 1994 (Table 2). Please, note for the sake of terminology, that spring tillage and fall tillage are deep-tillage treatments. Spring planting and fall planting are soybeans and wheat planting.

Table 1. Mean yields for 1993-94 wheat and 1994 soybeans.

Deep Tillage	Wheat: Disked	Wheat: Non-disked	Wheat: Mean	Soybeans: Disked	Soybeans: Non-disked	Soybeans: Mean
	bu/A					
Spring	—	—	—	73.4	86.8	80.1ab
Fall	66.0	66.1	66.1a*	63.8	77.2	70.5bc
Both	—	—	—	72.5	97.8	85.1a
None	59.2	53.1	56.2b	57.3	64.5	60.9c
Mean	62.6a	59.6b	66.7b	81.6a		

* Soybeans or wheat, surface or deep-tilled means with the same letter are not significantly different using the LSD separation procedure.

Table 2. Mean cone indices of for 1994 soybeans and 1994 wheat.

Deep Tillage	At soybean planting: Disked	At soybean planting: Non-disked	At soybean planting: Mean	At wheat planting: Disked	At wheat planting: Non-disked	At wheat planting: Mean
	Atm					
Spring	11.6	11.2	11.4c*	10.1	9.0	9.5b
Fall	18.4	15.3	16.8b	10.2	9.7	9.9b
Both	11.4	10.5	10.9c	9.3	8.9	9.1b
None	21.3	20.8	21.1a	15.0	14.4	14.8a
Mean	15.1a	14.0b	11.0a	10.3a		

* Soybeans or wheat, surface or deep-tilled means with the same letter are not significantly different using the LSD separation procedure.

Yield (Fall 1993 and Spring 1994)

For the wheat planted in 1993, yields were 3 bu/A higher for disked than for nondisked treatments (Table 1). This was probably a result of poorer stand in nondisked plots. For deep-tillage treatments, there was no difference between spring or no deep-tillage treatments and between fall or both deep-tillage treatments since they were the same treatments for this first crop. Fall deep-tillage treatments yielded significantly more (9.9 bu/A) than no deep-tillage treatments.

For the 1994 soybean, yields were 14.9 bu/a higher for nondisked than for disked treatments (Table 1). This could be at least partly a result of the 1.1- atm lower cone indices measured in nondisked treatments (Table 2). A trend is noticeable among the deep-tillage treatments. Treatments with most recent deep-tillage yielded most. Highest yield was for the treatment that had been deep tilled in both fall and spring, next highest was for the treatment deep tilled in spring, next was the fall deep-tilled treatment, and lowest was the treatment that had not been deep tilled (Table 1).

Cone Index (Spring 1994 and Fall 1994)

Mean profile soil cone indices are 1.1 atm higher for disked than for nondisked treatments for measurements taken at soybean planting (Table 2). Disked treatment cone indices were also higher but not significantly different for the measurements taken at wheat planting.

The surface tillage by depth interaction was significant for both the wheat and soybean planting. For the top 4 inches, the disked treatment had a lower cone index. Below that, its cone index was higher. For both wheat and soybean plantings, a tillage pan near the surface of the disked treatment with no deep tillage existed, while there was none (soil strength contours are further apart) for the nondisked treatments with no deep tillage. This is shown at soybean planting in Figure 1; contours for wheat planting are not shown.

Nondeep-tilled treatments had 4- to 10-atm higher cone indices than deep-tilled treatments. This was true for both wheat and soybean planting (Table 2). This difference can be seen in Figure 1 by the loosened zones of deep disruption for the deep-tilled treatments and higher, more uniform cone indices across the profiles of the treatments not deep tilled.

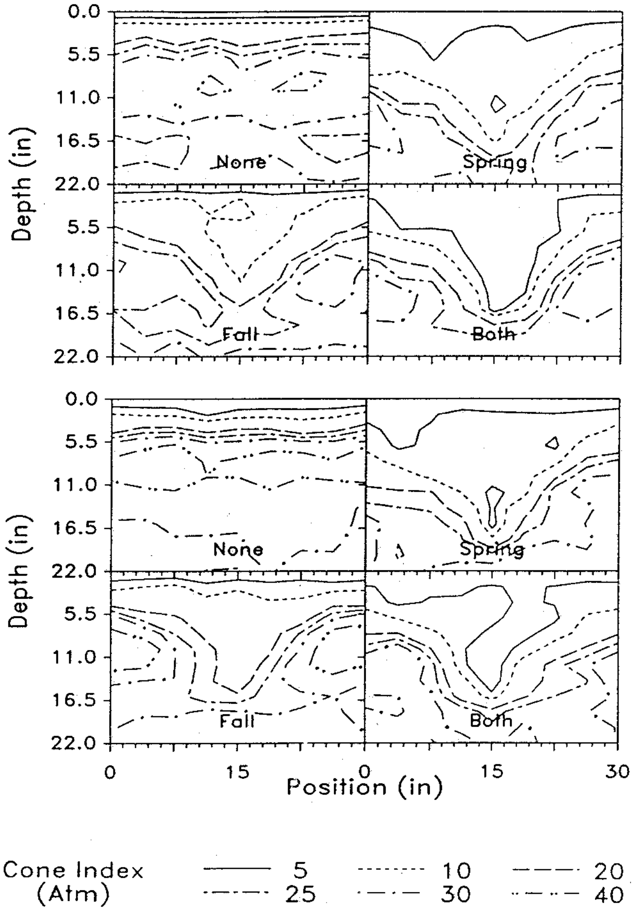

Figure 1. Soil strength contours for the soybean spring 1994 planting nondisked (top) and disked (bottom) treatments. The time of deep tillage is listed as none, spring, fall, or both (spring and fall).

Position across the plot and depth had significant interactions with deep tillage. The interaction of deep tillage by position can be seen by more uniform cone indices across the plots that were not deep tilled (Figure 1). Treatments with deep tillage had v-shaped or u-shaped zones of disruption to about the 16-inch depth caused by paratill shanks.

The interaction of deep tillage and depth can be seen in treatments that had no deep tillage as a pan at the 8- to 12-inch depths in both the wheat and soybean plantings. For deep-tilled plots, cone index generally increased with depth. An exception to this was in the cone indices taken at soybean (spring) planting for the fall-tilled plot. This treatment had maximum cone indices near the 10- to 15-inch depths. Busscher et al. (1986) similarly reported pan reformation over winter, especially in treatments with surface tillage. Mean profile cone indices were higher for the fall deep tillage than the spring or both spring and fall deep tillage (Table 2). Nevertheless, even in this treatment the subsoiled zone (contours not shown) was still evident.

Conclusion

Plots that were disked had a pan just below the disked zone. This pan was broken up during deep tillage. At both wheat and soybean planting the order of cone index was not-deep-tilled > fall-paratilled > spring-paratilled > fall-and-spring-paratilled. Yields were generally higher for the treatments with lower cone indices.

Preliminary results for this experiment indicate that less surface tillage and more deep tillage leads to lower overall soil profile cone indices and higher yields. It is not clear yet how the lower cone indices caused by tillage and higher yields inter act. Cone index, yield, and plant property monitoring will continue.

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