Timing of Deep Tillage for Wheat-Soybean Double Crop in the SE Coastal Plain

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ABSTRACT

Deep tillage disrupts subsoil hardpans that reform annually in many southeastern Coastal Plain soils. Generally, producers deep till annually, even when double-cropping. Our purpose was to find out whether fall tillage, spring tillage, or both would increase yield within a wheat(*Triticum aestivum*)-soybean(*Glycine max)* double-cropping system. We planted eight treatments in four replicates. Treatments were surface tillage (disked and not disked) and deep tillage (not deep tilled, paratilled before wheat planting, before soybean planting, and before both). Disked plots that were not paratilled had a pan at the 4- to 6-in depth, just below the disked zone. All non-deep-tilled treatments had a pan at 8- to 12-in depths. Treatments that had been deep-tilled most recently had lower mean profile cone indices. Within the range of soil strengths measured, wheat yield decreased approximately 2.5 bu/a for each atmosphere of increase in mean profile cone index measured at the beginning of the growing season. Soybean yields decreased between 1.6 and 2.7 bu/a for each atmosphere of increase on mean profile cone index. Deep tillage at the beginning of the season improved yields for both wheat and soybean.

INTRODUCTION

Many Coastal Plain soils require deep tillage to disrupt root-restricting subsoil hardpans. Annual subsoiling is currently recommended either prior to spring planting (Threadgill, 1982; Busscher et al., 1986) or prior to fall planting (Porter and Khalilian, 1995). Double-cropped wheat and soybean have become popular in South Carolina, with acreages ranging from 200,000 to 250,000 in the past 4 yr, with reduced surface tillage increasing from 24% to 46% of this acreage. Because planting early increases yield, soybean are planted as soon after wheat harvest as possible. To accommodate early spring planting, some farmers subsoil in the fall. Others believe that they need to subsoil twice, before planting both soybean and wheat.

We believed that the frequency and timing of subsoil tillage would affect crop production and soil strength. The purpose of this study was to determine whether subsoiling in the spring, in the fall, or both gave the greatest improvement in soybean and wheat yield and the greatest reduction in soil cone index.

METHODS

Wheat-soybean double-cropped plots were established in the fall of 1993 at the Pee Dee Research and Education Center near Florence, SC. We grew winter wheat cultivar Northrup King Coker 9134, a soft red winter wheat, and Haygood soybean, a Maturity Group VII cultivar. The soil was a Rains (typic Paleaquult) that had a hardpan below the plow layer. In the summer of 1993, 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 no paratilling and paratilling at soybean planting, at wheat planting, and at both soybean and wheat planting. The eight treatments were arranged in a randomized complete block design and replicated four times. Each plot was 10 ft wide and 50 ft 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-ft-wide Tufline[1] disk (Tufline Mfg. Co., Columbus, GA) pulled by a John Deere 4230 (Deere and Co., Moline, IL) 100 HP tractor with wheels on 64-in centers. A four-shank paratill (Tye Co., Lockney, TX) was used to deep till to approximately 16 in. Shanks were spaced 26 in apart. The paratill was pulled with a Case 2670 (now Case-IH, Racine, WI) 220 HP, 4-wheel-drive tractor with dual wheels on 75-in and 122-in centers.

Both wheat and soybean were drilled with a 10-ft-wide John Deere 750 No-till Planter pulled by a Massey Ferguson 398 (Massey Ferguson, Inc., Des

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[1]Mention of trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the U.S. Dept. of Agric. and does not imply its approval to the exculsion of other products or vendors that may also be suitable.

Moines, IA) 80 HP tractor with wheels on 75-in centers. Wheat was drilled in mid-November at a rate of 20 seeds/ft. Soybean were drilled in late May or early June at a rate of 4 seeds/ft in 7.5-in-wide rows and harvested in early November.

Data for wheat and soybean yield were taken from six 39-in sections of row where whole-plant samples were harvested from each plot. Wheat plots were subsequently cleaned with an Allis Chalmers (now Deutz-Allis, Norcross, GA) F3 Gleaner with a 13-ft header. The harvester wheels were on 8-ft centers. Soybean plots were cleaned with an IH 1420 axial flow combine (now Case-IH, Racine, WI) with wheels on 7.5-ft centers and a 13-ft header. Yield data were corrected to 13% moisture for both wheat and soybean.

Phosphorous and K were preplant broadcast for both wheat and soybean following Clemson University soil test recommendations. Ammonium nitrate was broadcast on all wheat plots at a rate of 30 lb N/a immediately after planting and 50 lb N/a side-dressed in late February to early March (the stem erect wheat growth stage). Fertilizer was applied with a 10-ft-wide Gandy spreader (Gandy Co., Owatonna, MN) pulled by the Massey Ferguson 298 tractor.

Non-disked plots were sprayed with Roundup (glyphosate) at a rate of 1.0 lb a.i./a before wheat planting or Bronco (alachlor plus glyphosate) at a rate of 3.5 lb a.i./a before soybean planting. Lasso (alachlor) preemergence was applied to disked plots at a rate of 2.3 lb a.i./a before soybean emergence.

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

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

We analyzed data using ANOVA in SAS (SAS Institute, 1990) and the least square mean separation 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

Wheat was planted three times and soybean three times. Cone index data were not taken at the beginning of the first wheat planting because timing of tillage for wheat or soybean or both had to be established. For the following, spring refers to operations done in association with soybean, fall refers to wheat, and season refers to both.

Cone index

Over the course of the experiment, mean profile soil cone indices were 0.6 atm higher for disked than for non-disked treatments (Table 1). On a season by season basis, only the spring 1994 and spring 1996 readings had higher cone indices for the disked than non-disked treatments. For the other data sets, these readings were not significantly different. Water contents might account for the differences in strength because wetter soils have lower cone indices, all other things being equal. However, water contents for the disked (11.8% on a dry weight basis) and non-disked (12%) treatments were not significantly different. Water content differences within season (data not shown) were also not significant.

Cone indices for the different seasons were significantly different, with spring having higher values than fall (Table 1). These values were in approximately the reverse order of the water contents (fall 1994 at 13.1%, fall 1995 at 12.4%, spring 1995 at 12.3%, spring 1996 at 11.8%, and spring 1994 at 9.9%, with an LSD of 0.2%). Differences could be at least partly due to the water content at the time of measurement.

Generally, the more recent or more frequently deep-tilled treatment had the lower cone index (Table 2). Over the course of the experiment, the treatment that was paratilled at the beginning of both seasons had the lowest soil strength. It had cone indices as low as the fall tillage in fall and the spring tillage in spring. Except for fall 1995, it did not have cone indices lower than the most recently tilled treatments. If treatment analyses were altered to look at more recent and less recent tillage instead of fall and spring, the treatment with no deep tillage had a mean cone index of 17.1 atm. The treatment with last season's deep tillage had a mean cone index of 12.8 atm. The more recently tilled treatment had a mean cone index of 9.8 atm. The treatment tilled both seasons had a mean cone index of 9.24 atm (LSD = 0.78 atm at 5% level). For this analysis, water contents were not significantly different and were not a complicating factor. Cone indices followed the order tilled in both seasons =

more recent tillage < last season's tillage < no tillage.

Averaged over all treatments, cone index increased with depth, with each 2-in-depth interval having a higher cone index than the one above it, through the top 22 in. However, when treatments with no deep tillage were analyzed alone, the zone of highest strength was at the 8- to 12-in depth. This was the hardpan that was the reason for deep tillage in the first place. Cone indices in this pan were 29 to 31 atm, 4 atm higher than the zones immediately above and below it (Fig. 1).

Cone indices varied significantly with position across the row. For all treatments, cone indices were higher by an average of 1.4 atm below the wheel-track (position=30 in, Fig. 1) than the non-wheel-track (position=0 in). Differences among positions were more significant for the deep-tilled treatments than the non-deep-tilled treatments.

The surface tillage x depth interaction was significant for both the wheat and soybean planting. This was a result of disking. The top 4 in of the disked treatment had a lower cone index than the non-disked treatment because of the disruption of the disk. Below that, the disked treatment had higher cone indices. This can be seen in Fig. 1 by a tillage pan near the surface of the treatment with no deep tillage. There was no pan (contours are further apart) for the non-disked treatments with no deep tillage (data not shown).

Yield

Generally, yield decreased with an increase in cone index. No significant relationship could be found when data from all seasons were analyzed together. However, when we analyzed data on a season-by-season basis, we found a decrease of yield with an increase of mean profile cone index, with r^2 ranging between 0.52 and 0.84 (Fig. 2). Within the range of cone indices measured and based on the slopes of these linear regressions, yields were reduced 2.6 and 2.3 bu/a for every atmosphere increase in mean profile strength for wheat in 1994 and 1995, respectively, and 2.3, 1.6, and 2.7 bu/a for soybean in 1994, 1995, and 1996, respectively.

CONCLUSIONS

Plots that were disked had a pan just below the disked zone. The pan was broken up during deep tillage. The lowest cone indices were recorded for the treatments that were tilled most recently.

Yields were correlated with mean profile cone indices. Reductions in wheat yield were about 2.5 bu/a for each atmosphere of increased mean profile cone index within the range of soil strengths measured here. For soybean, the decrease in yield ranged between 1.6 and 2.7 bu/a.

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Table 1. Mean surface tillage profile cone indices averaged over four treatments and four replicates.

Season	Surface tillage treatment		
	Disked	Non-disked	Mean
	- - - - - Atm - - - - -		
Spring 1994	15.1a*	13.9b	14.5a**
Fall 1994	11.0a	10.3a	10.6e
Spring 1995	12.6a	12.4a	12.5b
Fall 1995	11.0a	11.0a	11.0d
Spring 1996	12.0a	10.6b	11.3c
Mean	12.2a	11.6b	

* Means with the same letter are not significantly different by the LSD test at 5% between disked and non-disked treatments.
** Means within the column with the same letter are not significantly different by the LSD test at 5%.

Table 2. Mean treatment profile cone indices averaged over four replicates each of disked and non-disked plots.

Season	Timing of tillage			
	Both	Spring	Fall	None
	- - - - - Atm - - - - -			
Spring 1994	10.9c*	11.3c	16.8b	21.0a
Fall 1994	9.1b	9.5b	9.9b	14.7a
Spring 1995	8.9c	8.7c	15.4b	20.0a
Fall 1995	8.4d	11.8b	9.9c	14.8a
Spring 1996	9.0c	9.3c	11.8b	16.1a
Mean	9.2d	10.0c	12.5b	17.1a

* Means within rows with the same letter are not significantly different by the LSD test at 5%.

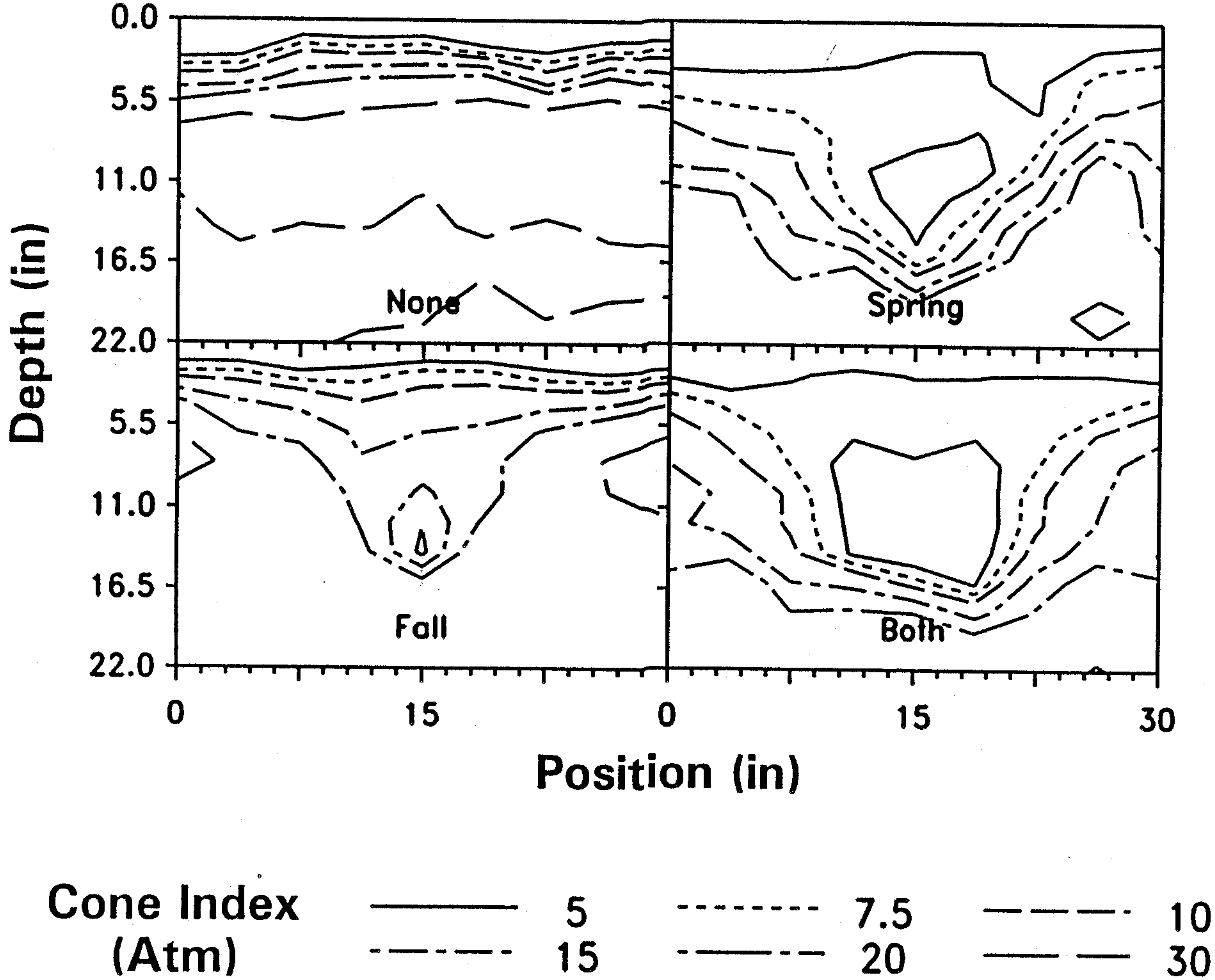

Figure 1. Soil strength contours for the spring 1995 soybean planting disked. The time of deep tillage is listed as none, spring, fall or both (spring and fall).

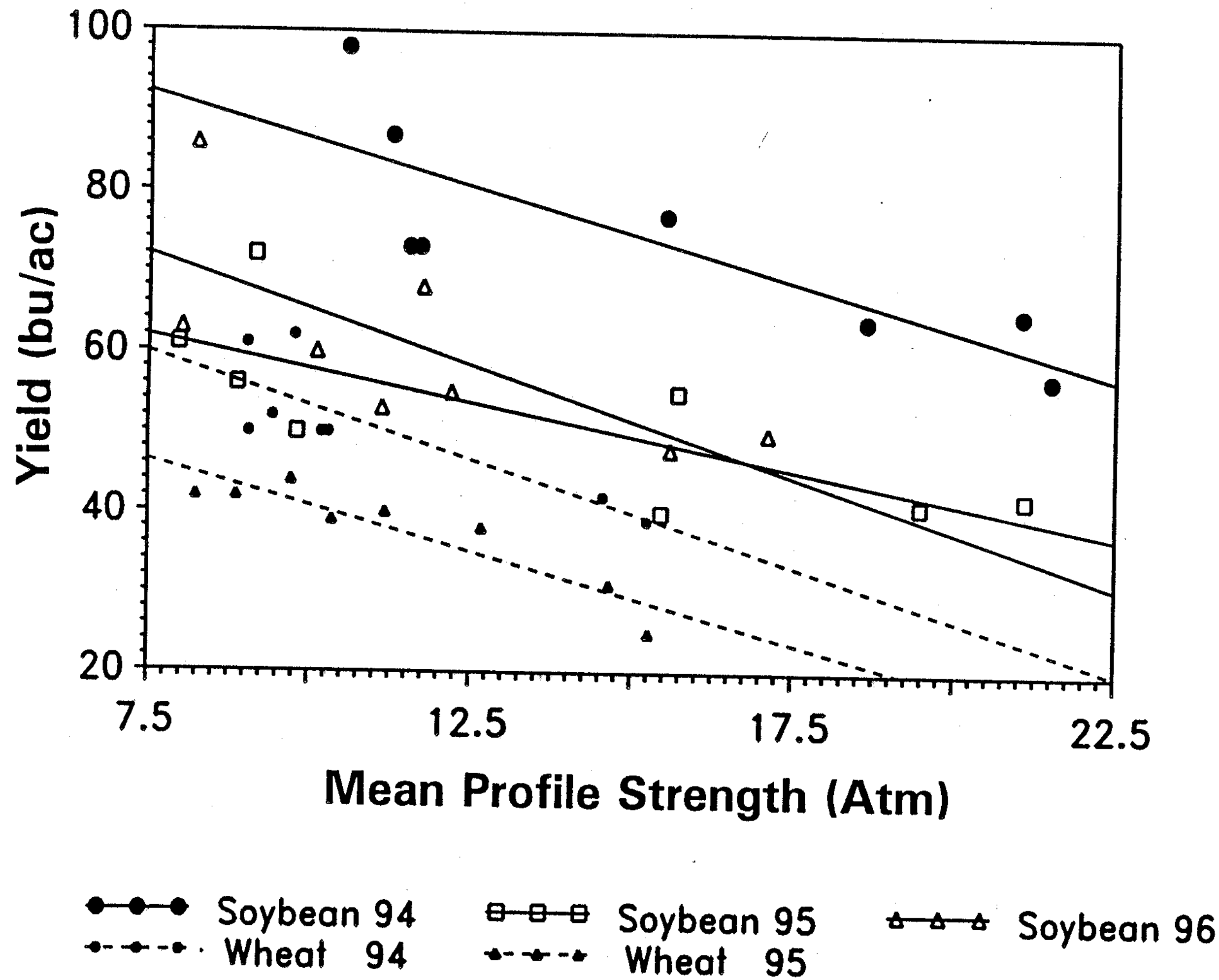

Figure 2. Yield variation with cone index analyzed on a season-by-season basis.