Minimum Tillage Cultivation in a Hardpan Soil

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Abstract: To reduce strength in a hardpan soil, a high-residue cultivator with 8-in deep mid-row disruption was compared to chemical weed control with in-row subsoiling. Treatments included no tillage, subsoiling, cultivation, and both subsoiling and cultivation. Cotton *(Gossypium hirsutum)* was planted into standing winter ryegrass *(Lolium multiflorum* Lam.) or winter fallow. Cultivation significantly lowered soil strength over not tilling. When performed with subsoiling, it lowered strength over subsoiling only. Yield was increased by subsoiling. Yields in cultivated plots were similar to those in non-cultivated plots. Yields for the fallow plots were higher than for the rye cover. Though the cultivator decreased soil strength, it did not improve plant characteristics or yield.

Introduction

The top two soil horizons, the Ap and E, in many productive southeastern Coastal Plains soils are structureless, sandy in texture, and low in organic matter. These horizons, especially the E, can have soil strengths that reduce or prevent root growth (Box and Langdale, 1984). The E horizon can become dense enough to prevent root growth even when soil water content is at field capacity (Campbell et al., 1974). Most conventional and reduced tillage management systems include deep profile disruption (subsoiling). Increased yield has been attributed to these tillage practices (Sojka et al., 1991). Once the roots get through the E horizon, they can grow into the B horizon which has good structure. Even when the B horizon gets hard, roots can grow along its ped faces.

Weed control by either mechanical cultivation or chemical application is necessary to prevent excessive plant competition. The Brown Chiselvator[1] is a conservation tillage (high residue) cultivator. It tills the soil just below the surface leaving the residue on the surface. Depth of cultivation is controlled with a shallow (eight in deep) shank and gauge wheels that run in the mid rows. Beyond its activity as a cultivator, the Chiselvator's mid-row soil disruption has the potential to increase growth and yield.

The objective of this experiment was to evaluate the Chiselvator as a tillage tool: measure mid-row disruption of the Chiselvator and compared it with subsoiling.

Methods

In 1993 and 1994, we grew cotton on Norfolk loamy sand soil at the Pee Dee Research and Education Center of Clemson University in Florence, SC. Winter cover treatments included fallow (winter weeds) and rye. Tillage treatments were subsoiled and non subsoiled each of which was cultivated with a Chiselvator or not tilled. Non-subsoiled treatments were planted after killing the winter cover with Gramoxone. Subsoiled treatments were in-row subsoiled to a depth of 16 to 18 in (to the top of the B horizon) before planting. Cover and tillage treatments were arranged in a randomized complete block design within each of four replicates.

In mid November, rye was seeded with a grain drill at a rate of 110 lbs/a. In mid-to-late April, plots were sprayed to kill winter vegetation. We deep-tilled half the plots with a KMC subsoiler. Cotton was planted within 15 days of killing winter vegetation at five seeds/ft in four 35-ft long, 30-in wide rows. Because of problems with stand establishment, we replanted all plots in mid May 1994.

Plots received 70 lbs N/a. Lime, P, K, S, B, and Mn were applied to meet Clemson University Extension recommendations (Parks, 1989). Herbicides (fluometuron, monosodium or disodium methanearsonate, sethoxydim, cyanazine) and pesticides (aldicarb, pyrethriod and organophosphate insecticides) were applied at labeled amounts, as needed.

Six weeks after germination, half the plots were cultivated with the Brown Chiselvator. Soil strength and soil water content were measured within four days of cultivation. Soil strength (cone index) was measured with depth as the pressure needed to push a 0.5-in diameter cone-tipped metal rod into the soil. These measurements were taken to a depth of 22 in at five uniformly spaced positions across the row from non-wheel-track mid row to wheel-track mid row. Cone index data were log transformed as recommended by Cassel and Nelson (1979). Soil water content samples were taken in the non-wheel-track mid row and in row with a 1-in diameter sampling tube at 8-in depth increments to 24 in.

Plant samples were taken from 3 feet of each of the two mid-plot rows in mid September. Sampling included plant height, weight, and number of plants. In early to mid

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

November, seed cotton yields were taken from the two mid-plot rows.

Plant sample and yield data were analyzed as a randomized complete block design using SAS (SAS Inst., 1990). Cone index and water content data were analyzed as a randomized complete block design with position across the row and depth as splits.

Results

Yield

Average lint yield was greater in 1995 than in 1994 at 723 vs. 537 lbs/a (Table 1). Problems in 1994 included poor seed quality and erratic germination, leading to a replanting after two weeks of growth. Lint yield for fallow cover was higher than rye cover (690 vs 570 lbs/a). This difference was mainly due to a 2.75 tons/a rye cover in 1994 that made planting difficult. Subsoiled plots outyielded non-subsoiled plots by 697 to 564 lbs/a. Non-cultivated plots had non significantly higher yields than cultivated plots (667 to 592 lbs/a). This is somewhat in agreement with Reeves and Touchton (1989). They found no advantage to mid-row deep disruption five weeks after planting.

Soil Water Content

Water contents taken along with the cone indices showed no differences among cover crop, subsoiling, or cultivation treatments. Water contents in 1995 were higher than they were in 1994. Significant increases were seen with depth in both years (Table 2).

Soil Strength

Because of mechanical loosening, lower cone indices were measured for subsoiled vs. non-subsoiled and cultivated vs. non-cultivated plots (Table 3). Soil strength patterns for selected treatments can be seen in Figure 1. The cone index of the subsoiled treatment was lower under the row. Cultivated plots showed shallow zones of disruption in the mid rows. Data analysis showed a significant cone index difference with position across the row because of the loosening effect of the implements.

Although both subsoiling and cultivating lowered soil strength below the non-tilled treatment, cultivated treatments (with subsoiling) had lower cone indices than subsoiled-only treatments, especially near the surface (Figure 1). The ranks of cone indices for the treatments shown in Figure 1 are cultivating and subsoiling < cultivating only < subsoiling only < no tillage (12.2 atm < 14.8 atm < 17.8 atm < 20.3 atm with an LSD = 4.5 atm at 5%). Soil strength for cultivating-only teratment was not significantly lower than subsoiling-only treatment. The overall higher strength of the subsoiled plots, when compared to the cultivated plots, may be at least partially due to settling since plots were subsoiled six to eight weeks before cone index measurements were taken. Cultivated treatments had significantly lower soil strength than not-tilled treatments. Cultivated-and-subsoiled treatments also had lower strengths than treatments that were subsoiled only.

Table 1. Cotton lint yield (lbs/a)*.

Cover	Tillage		1994	1995
Rye	Subsoiled	Cultivated	407	800
		Non cultivated	628	790
	Non subsoiled	Cultivated	395	579
		Non cultivated	254	707
Fallow	Subsoiled	Cultivated	717	749
		Non cultivated	740	742
	Non subsoiled	Cultivated	355	740
		Non cultivated	801	680

* LSD = 94 lbs/a at the 5% level.

Table 2. Water contents taken with cone indices.

	1994	1995
Depth (in)	Water content (lb/lb)	
0-8	7.6b*	10.7c
8-16	7.7b	13.9b
16-24	10.8a	18.3a

* Water content is on a dry weight basis. LSD at 0.05 is 2.5.

Table 3. Cone indices for cover, subsoil, and cultivated treatments.

	1994	1995
Treatment	Cone index (atm)*	
Subsoiled	16.2	11.7
Non subsoiled	18.0	14.8
Cultivated	14.6	10.6
Non cultivated	19.9	16.2
Rye	16.2	13.0
Fallow	18.0	13.4

* LSD = 2.4 atm at the 5% level

Plant Characteristics

Even after replanting, stands were still spotty in 1994. At the time of measurement, plants in subsoiled treatments were taller than in non-subsoiled treatments (40 vs. 37 in), plants in fallow treatments were taller than in rye treatments (41 vs. 35 in), and plant heights in cultivated treatments were

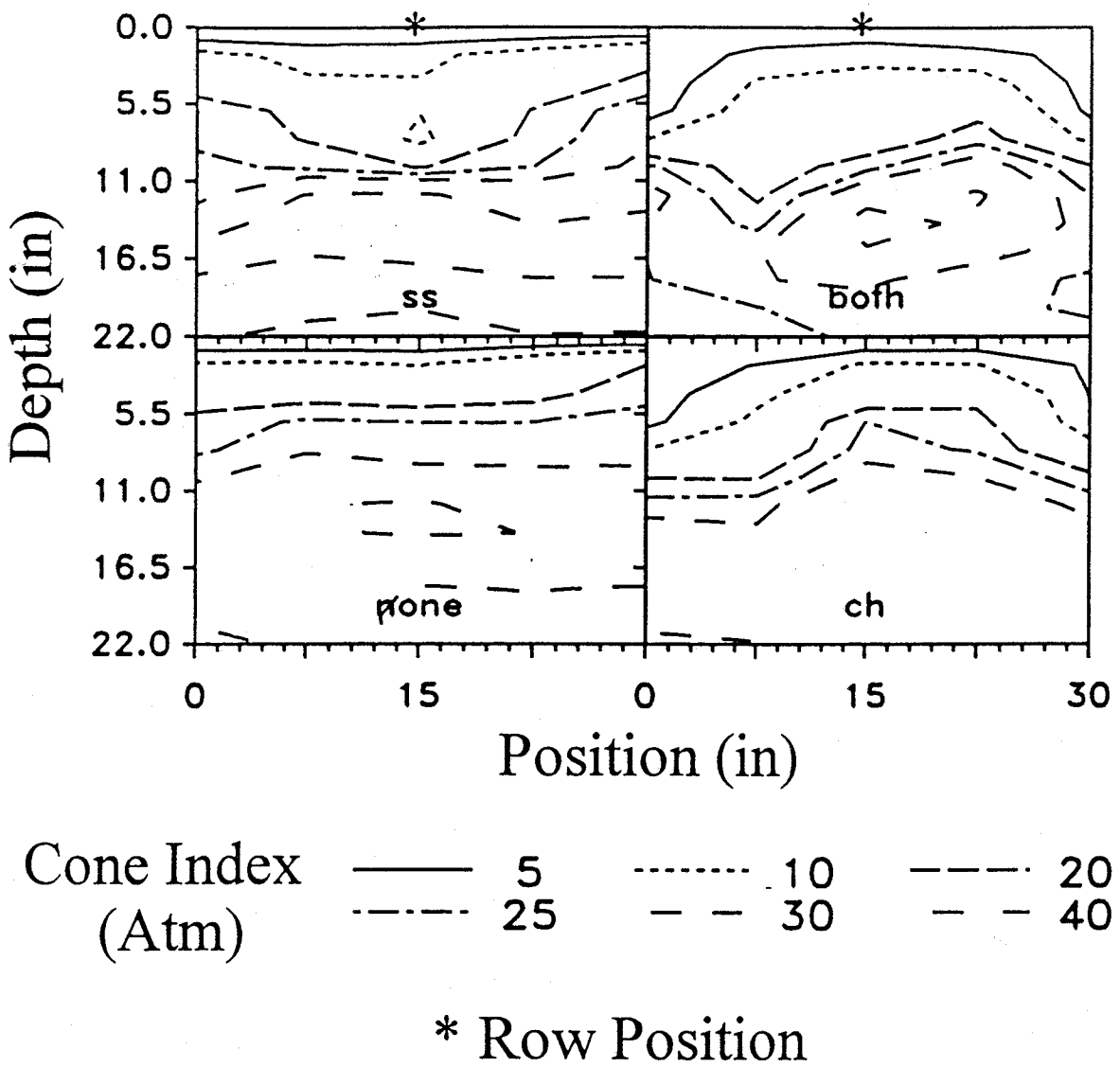

Figure 1. Cone index contours of the soil profile for treatments that were subsoiled (ss), cultivated with the Chiselvator (ch), subsoiled and cultivated (both), and not tilled (none).

Table 4. Plant height (in)*.

Cover	Tillage		1994	1995
Rye	Subsoiled	Cultivated	34.9	41.6
		Non cultivated	40.6	35.2
	Non subsoiled	Cultivated	33.0	30.0
		Non cultivated	30.5	36.2
Fallow	Subsoiled	Cultivated	41.1	43.4
		Non cultivated	40.8	43.7
	Non subsoiled	Cultivated	41.8	42.1
		Non cultivated	43.3	37.9

* LSD = 6.5 in at the 5% level.

mixed (Table 4).

For plant weights taken from the 3-ft sample sections of row, the fallow, non-subsoiled, cultivated treatment had the heaviest weights while the rye, non-subsoiled, cultivated treatment had the lightest weights. Both were among the poorer yielding treatments. Plant weights for the 3-ft section samples of the non-subsoiled rye were significantly lower than for the non-subsoiled fallow treatment (1.1 vs. 1.9 lbs with an LSD = 0.75 lbs at 5%). The subsoiled rye and fallow treatments were similar at 1.6 lbs each. Subsoiling could have helped eliminate the effect of the rye cover by a limited amount of in-row tillage. However, this was not substantiated by stand counts of the 3 ft section which was not significantly different.

Conclusions

Cultivating only did not reduce soil strength more than subsoiling only. Cultivation did significantly lower strength over no tillage. Cultivating and subsoiling had lower soil strengths than subsoiling only. Yield was increased by subsoiling but not by cultivation. Yields for fallow plots were higher than for rye cover. This could be a result of thick rye cover and difficulty with stand establishment, though this was not verified by stand count of the sampled section. Though the cultivator decreased soil strength, it did not increase plant characteristics or yield.

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