SOIL STRENGTH OF CONVENTIONAL- AND CONSERVATION-TILLAGE COTTON GROWN WITH A COVER CROP

Warren J. Busscher and Philip J. Bauer[1]

INTRODUCTION

In many productive southeastern Coastal Plains soils, the top two horizons (Ap and E) are structureless, sandy in texture and low in organic matter. These horizons, especially the E, can have soil strengths that inhibit or prevent root growth (Box and Langdale, 1984). Both horizons are softer when wet. However, the E horizon can become so dense that roots cannot grow in it even when the soil water content is at field capacity (Campbell et al., 1974). To insure root growth through the E horizon, most conventional- and conservation-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 below it. The B horizon has good structure. Even if it gets hard, roots can grow along its ped faces.

It has been know for a long time that winter cover crops protect soil from erosion and improve soil nutrient and water status. To help us design optimum tillage systems, we need to know how cover crops affect cotton root penetration.

This experiment compared soil strength distributions throughout the profile for cotton grown with conventional and conservation tillage, both with and without winter cover crops.

METHODS

Between 1989 and 1994, cotton was grown on Norfolk loamy sand soil at the Pee Dee Research and Education Center of Clemson University in Florence, South Carolina. Tillage treatments were conventional (spring disked and in-row subsoiled before planting cotton) and conservation (in-row subsoiled and planted after killing the winter cover with Gramoxone). Winter cover treatments included fallow (winter weeds) and either rye or hairy vetch. We used vetch cover in 1989, 1991 and 1992 and rye in 1993 and 1994.

Cover crops were seeded with a grain drill except in 1989 when seeding was by hand. We used rates of 110 lb/acre for rye and 25 lb/acre for vetch. In mid to late April, conventional-tillage plots were disked, and conservation-tillage plots were sprayed to kill winter vegetation. Cotton was planted within 15 days.

All plots were deep tilled with a subsoiler, and cotton was planted in four-row plots at a rate of approximately four seeds/ft in 30-ft-long, 38-in.-wide rows. No N fertilizer was applied to the vetch plots; the fallow and rye received 70 lb N/acre. Lime, P, K, S, B and Mn were applied to meet Clemson University Extension recommendations (Parks, 1989). Herbicides (Cotoran, MSMA, DSMA, sethoxydim, Bladex) and pesticides (aldicarb, pyrethriod and organophosphate) were applied at labeled amounts as needed.

Soil strength and soil water content were measured within one month after cotton planting. Soil strength was measured continuously with depth as the pressure needed to push a 0.5-in. diameter cone-tipped metal rod into the soil. These measurements were taken at nine uniformly spaced positions across the row from non-wheel-track mid-row to wheel-track mid-row to a depth of 22 in. Soil water content samples were taken in the non-wheel-track mid-row and in-row with a 1-in.-diameter sampling tube at 4-in. depth increments to 24 in.

RESULTS

Water Content

Soil water contents (data not shown) increased with depth but were unaffected by tillage or winter cover treatments. This means that the cover crops were killed soon enough to prevent them from using the water needed for proper cotton growth. It also means that conservation tillage was as good as

[1]USDA-ARS, Coastal Plain Soil, Water and Plant Research Center, P.O. Box 3039, Florence, South Carolina 29502-3039.

conventional tillage in storing water for the summer crop. It should be noted that this soil is sandy and holds little water. On the one hand, small losses of water can be harmful, and, on the other hand, it does not take much water (3 to 4 in.) to refill the profile.

Soil Strength

In four of the five years, soil strengths in the fallow plots were higher than in the cover plots (Table 1). However, the differences were within 1.4 atm (1 atm = 1.01 bar). This is not a significantly higher strength value for root penetration. Similarly, the differences were lower for the conventional-tillage treatment in three of the five years. These differences were significantly lower only in 1993 when the conventional-tillage soil strength was almost 5 atm lower than the conservation-tillage soil strength. Lower conventional-tillage strengths were a result of the disking, which caused lower strengths in the surface 6 in. This has an advantage that roots will grow there more easily. Whether these differences are enough to increase yield is still being researched. In these plots, yields were not significantly different.

Soil strength values were also different for depth and position across the row. Soil strength generally increased with depth (see Fig. 1 in which lighter areas represent softer soil and darker areas represent harder soil). This difference is not diminished by water content that increased with depth. (Increased water contents would actually reduce strength with depth.) An exception to the increase with depth was the high strength at the 11-in. depth, shown in Fig. 1. This is the pan in the E horizon, which has its strength reduced by the subsoiler.

Highest strengths were measured in the wheel-track mid-rows, next highest strengths were measured in the non-wheel-track mid-rows, and lowest strengths were in-row. High strengths under the mid rows were greater than 20 to 30 atm. These strengths are usually associated with severe root restrictions. Lower strength below the row, caused by the disruption of the subsoiler, permitted the roots to grow through the pan. The soil within the pan had no structure. There were no weak ped faces along which the roots could grow. This makes subsoiling necessary.

SUMMARY

We grew cotton with or without winter cover crops in the southeastern Coastal Plains for five years between 1989 and 1994. Soils were conventionally tilled (disked in spring) or conservation tilled (not disked). Winter cover crops and conservation tillage had higher soil strengths than no winter cover or conventional tillage, respectively. These differences were generally not enough to reduce yield. Despite the increase in water content with depth, soil strength increased with depth except for a high strength pan at 11 in. This pan is the reason for the in-row subsoiling requirement of most tillage-management systems. Soil strength was highest in the wheel-track mid-row, next highest in the non-wheel-track mid row, and lowest in-row where the subsoiler had disrupted the soil. Subsoiler disruption is enough to allow root growth through the pan into the softer, structured soil below it.

LITERATURE CITED

1. Box, J.E., and G.W. Langdale. 1984. The effects of in-row subsoil tillage on corn yields in the southeastern Coastal Plains of the United States. Soil and Tillage Research 4:67-78.
2. Campbell, R.B., D.C. Reicosky and C.W. Doty. 1974. Physical properties and tillage of paleudults in the southeastern Coastal Plains. Journal of Soil Water Conservation 29:220-224.
3. Parks, C.L. 1989. Soil fertility for cotton. Clemson University, Cooperative Extension Service, Information Leaflet 33
4. Sojka, R.E., D.L. Karlen and W.J. Busscher. 1991. A conservation tillage research update from the Coastal Plain Soil and Water Research Center of South Carolina: A review of previous research. Soil and Tillage Research 21:361-376.

Table 1. Average strength for the soil profile.

	Cover		Tillage	
Year	fallow	rye/vetch	conventional	conservation
	atmospheres[z]			
1989	9.65a	8.74a	9.99a	8.43a
1991	10.4a	11.8a	10.6a	11.6a
1992	10.5a	11.0a	10.2a	11.2a
1993	17.5a	18.5a	15.9b	20.3a
1994	21.8a	22.9a	23.2a	21.5a

[z]Averages with the same letter are not significantly different for cover or tillage treatments for each year ($P \leq 0.05$)

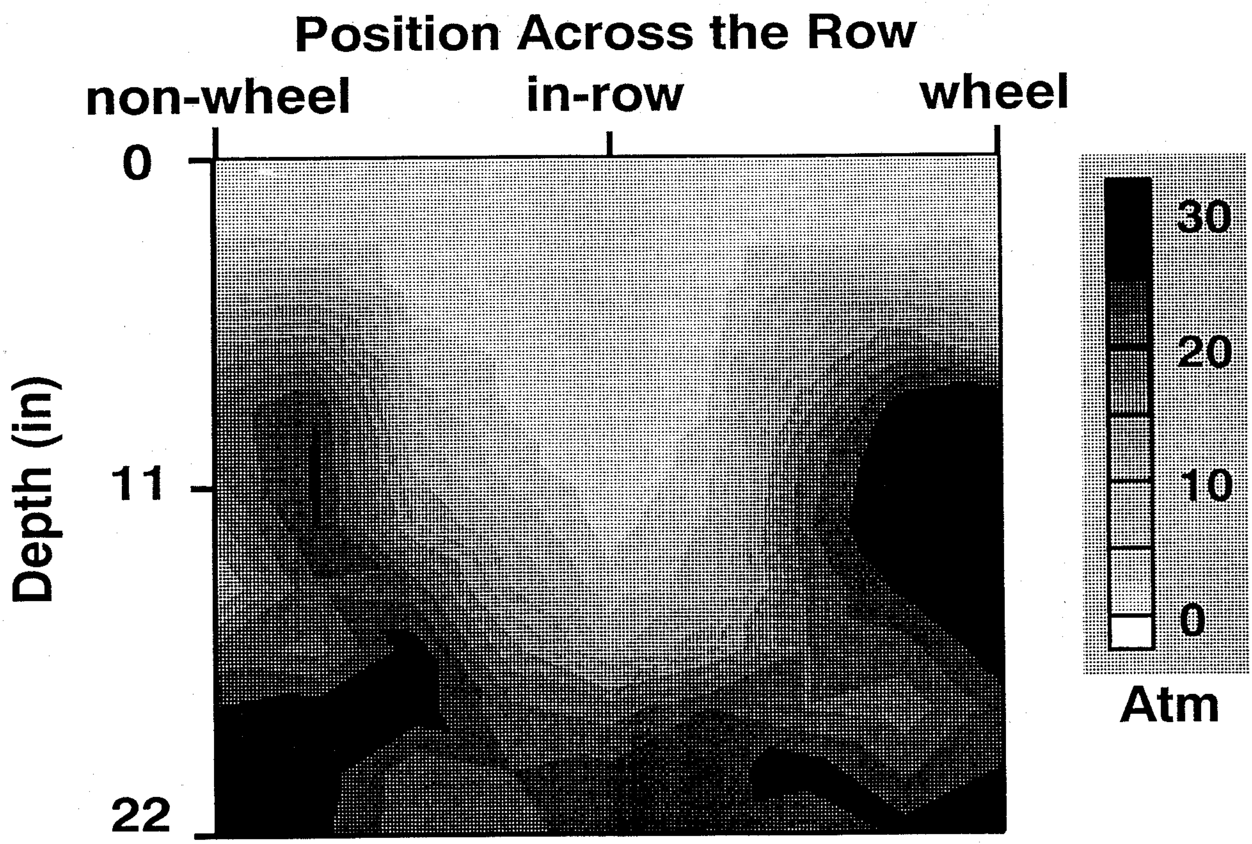

Fig. 1. Strength profile, vetch, conservation tillage, 1991, for in-row and non-wheel-track and wheel-track mid-rows.