Conservation Systems for Cotton Production in Central Alabama.

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Abstract
Soils with low organic matter are susceptible to soil compaction, which inhibits root development and subsequent nutrient and water uptake. Previous surveys have identified fields with low organic matter contents and shallow compacted zones in the cotton (*Gossypium hirsutum* L.) production region of central Alabama, USA. We initiated a field experiment in 2003 on a Lucedale fine sandy loam (fine-loamy, siliceous, thermic Arenic Paleudult) to determine how conservation tillage systems and winter cover crops affect yields and moisture availability. Treatments were a factorial combination of tillage systems (no tillage, fall paratill, spring paratill, and spring strip tillage) and winter cover crops [no cover, rye (*Secale cereale* L.), and wheat (*Triticum aestivum* L.)] in a randomized complete block design with four replications. Soil moisture was monitored continuously during the growing season to a depth of 30 cm. In 2004, results indicate that tillage had no effect on lint yields, while rye and wheat increased lint yields 12 and 5% compared to no cover. Soil moisture contents were generally 5% higher than soil moisture contents measured from no cover plots. In 2005, some form of non-inversion tillage was superior to no-tillage. Lint yields across cover crops averaged 1512 kg ha^{-1} for wheat, 1444 kg ha^{-1} for rye, and 1299 kg ha^{-1} for no cover. Trends in soil moisture contents across tillage systems and covers were similar to 2004, but not as dramatic. These results indicate that a high residue cover crop is required on degraded soils of central Alabama to maximize lint yields and soil moisture.

Keywords: Cover crops; No-tillage; Paratill; Soil water content; Strip tillage

1. Introduction

Coastal Plain soils consist of highly weathered Ultisols with coarse textures, poor structure, and organic matter contents below 1.0 % (Radcliffe et al., 1988), which contributes to decreased cotton productivity. The inherent poor physical and chemical nature of these soils is exacerbated by conventional tillage practices (disk and chisel plow). However, switching to some form of conservation tillage can significantly improve soil physical, chemical, and biological properties (Langdale et al., 1990), by primarily increasing soil organic matter contents in the soil surface. However, a low residue crop, such as cotton, does not provide adequate residue to benefit the soil (Daniel et al., 1999). Winter cover crops, such as rye (*Secale cereale* L.) and wheat (*Triticum aestivum* L.), combined with the cash crop residue maximize residue production on the soil surface and protect the soil from erosion during the winter months when precipitation exceeds evapotranspiration and intensive runoff occurs. Cover crop residue combined with cash crop residue improve water management for cotton by reducing soil water evaporation and increasing infiltration of irrigation and rainfall (Lascano et al., 1994). Decomposing cover crop roots create channels through compacted soil layers, which enable subsequent crop roots to grow through the compacted zone (Williams and Weil, 2004), and improve infiltration.

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In addition to decomposing cover crop roots, non-inversion deep tillage can also be used to alleviate compacted zones in the soil profile. The elimination of compacted layers with non-inversion tillage also enables roots to explore a larger soil volume to obtain nutrients and moisture, while cover crop residue remains undisturbed on the soil surface (Busscher et al., 1988; Schwab et al., 2002). Therefore, the objective of this study was to evaluate a combination of conservation tillage systems and winter cover crops to increase organic matter content, soil moisture availability and reduce soil compaction, while improving cotton profitability.

2. Materials and Methods

A field experiment was initiated in the fall of 2003 at the Prattville Experimental Field in Prattville, Alabama, USA (86°:26'32" W, 32°:25'27" N) and the following results represent two growing seasons (the half-way point of the experiment). A factorial treatment combination of conservation tillage systems (no-till, fall paratill, spring paratill, and spring strip-till) and winter cover crops (no cover, rye, and wheat) were established on a Lucedale fine sandy loam (fine-loamy, siliceous, thermic Arenic Paleudult). All tillage and cover crop combinations were duplicated to enable each phase of a cotton and corn rotation to be present simultaneously during the growing season. Reported results will focus on the cotton. Cover crops were planted on 23 Nov. 2003 and 27 Oct. 2004 at a seeding rate of 101 kg ha^{-1} and the fall paratill operation was performed in subsequent plots immediately following cover crop planting. The cover crops were chemically terminated in the spring 3 weeks prior to cotton planting. A roller was used to flatten the cover crop residue to facilitate spring tillage and planting operations ahead of the cotton. Cotton varieties Stoneville 5242 BR and DPL 488 were planted 11 May 2004 and 13 May 2005, respectively. Soil moisture was monitored every 15 min with self-contained data loggers between 30 and 41 cm of depth in-row below the soil surface during the growing season using commercially available capacitance probes for measuring soil moisture.

3. Results and discussion

Cover crop biomass production for rye and wheat was greater in the 2005 growing season compared to the 2004 growing season (Table 1). The cover crop planting date was approximately one month earlier for the 2005 growing season, which enabled more early season growth that contributed to higher biomass production. Prior to cotton, rye biomass production averaged 40% and 45% more than wheat during the 2004 and 2005 growing seasons, respectively (Table 1).

Table 1
Average rye and wheat biomass production measured during the 2004 and 2005 growing seasons at the Prattville Experimental Field

	Biomass production	
Crop year	Rye	Wheat
	--------------------kg ha^{-1}--------------------	
2004	5160	3680
2005	7210	4960

Lint yields were affected by cover crops during the 2004 growing season and by tillage systems and cover crops during the 2005 growing season, however no interaction was observed between tillage systems and cover crops for either growing season (Fig. 1). Cotton lint yields measured during the 2004 growing season were negatively impacted by lint loss associated with the high winds of Hurricane Ivan. This lint loss probably contributed to the lack of response observed between tillage systems compared to the no-tillage system (Fig. 1A). Average lint yields following rye (794 kg ha^{-1}) and wheat (734 kg ha^{-1}) averaged 8% higher than lint yields following no cover crop (710 kg ha^{-1}) (Fig. 1B). In 2005, overall lint yields were greater than 2004 due to improved growing conditions and the absence of hurricane damage. Lint yields for each tillage operation (fall paratill-1469 kg ha^{-1}; spring paratill-1476 kg ha^{-1}; strip till-1483 kg ha^{-1}) were approximately equal and 19% higher compared to lint yields following no tillage (1245 kg ha^{-1}) (Fig. 1A). Cover crops affected lint yields with the highest yields following wheat (1512 kg ha^{-1}), then rye (1444 kg ha^{-1}), and no cover crop (1299 kg ha^{-1}) (Fig. 1B).

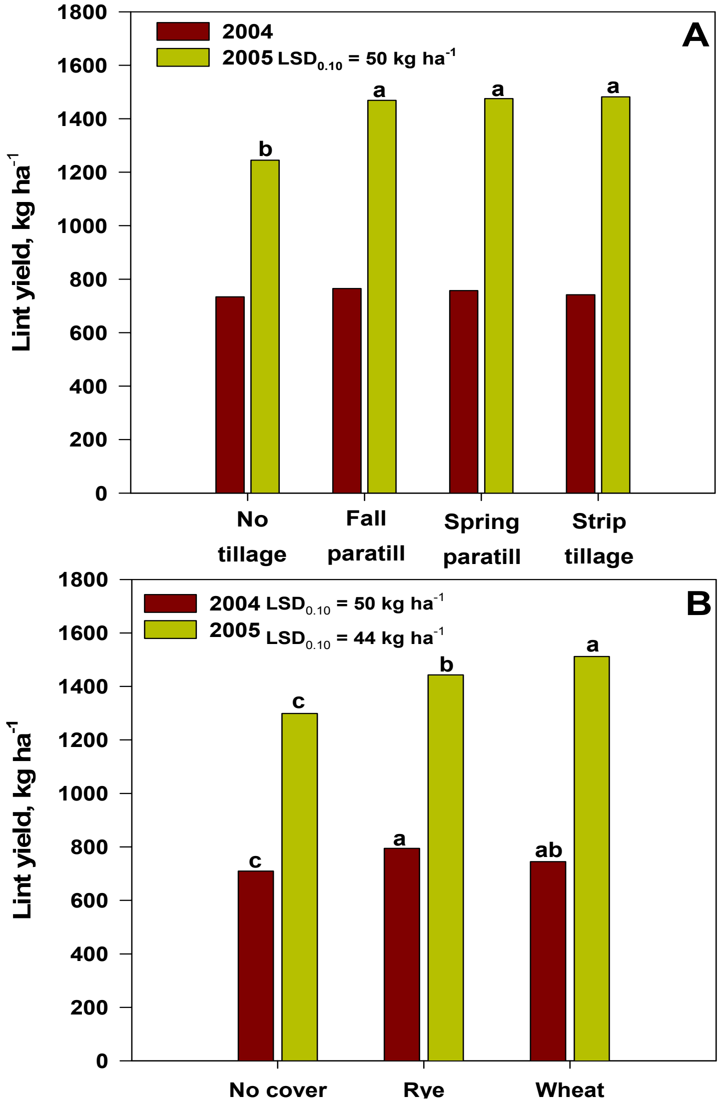

Figure 1. Lint yields measured across tillage systems (A) and cover crops (B) for the 2004 and 2005 growing seasons at the Prattville Experimental Field.

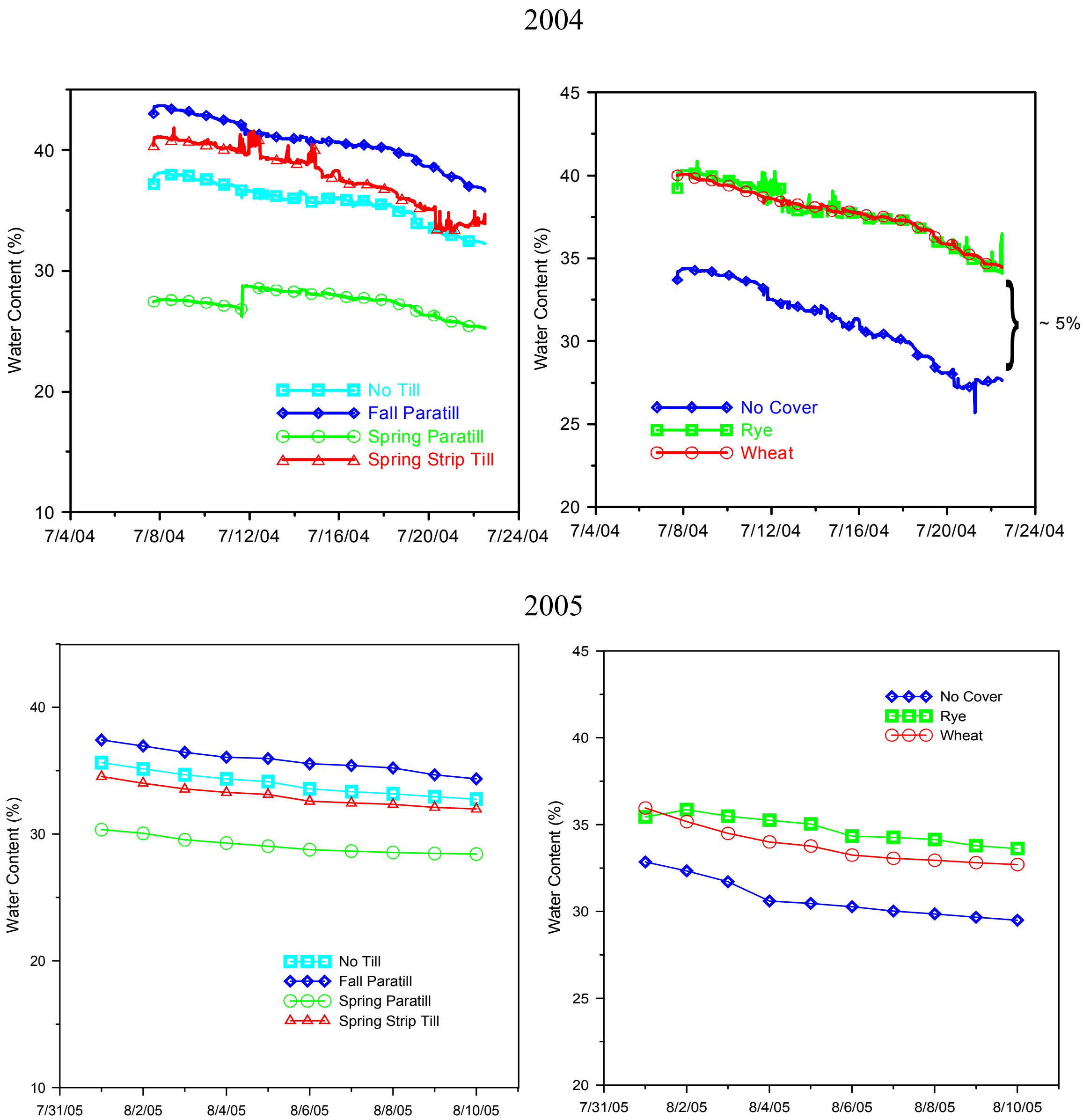

Figure 2. Measured soil water contents across tillage systems and cover crops during selected time periods of the 2004 and 2005 growing seasons at the Prattville Experimental Field.

Figure 2 illustrates a snapshot of the soil water content measured across tillage systems and cover crops during the 2004 and 2005 growing seasons. Soil water content was lower in the no-till plots compared to fall paratill and spring strip-tillage during most of the 2004 growing season, however differences in soil water content were not as pronounced during the 2005 growing season (Fig. 2). Soil moisture was lowest for the spring paratill treatment during both growing seasons. We have observed in the field some evidence that a slot created in the ground after paratilling can remain intact for a considerable period of time, potentially causing water to preferentially infiltrate into the ground. Because of the location of the soil moisture sensor in relation to the paratill slot, rainfall water was able to infiltrate; by-passing the sensor. The problem was not observed with fall paratill because some reconsolidation of the soil profile likely occurred during the winter.

Winter cover crop had a significant effect on soil water content, especially during the 2004 growing season (Fig. 2). Soil moisture in plots containing rye or wheat as a winter cover was about 5% greater than in those with no winter cover. Although measured soil moisture contents were higher in rye and wheat plots compared to no cover, the difference was not as pronounced in 2005. This increase in soil water content helped improve cotton lint yields. Greater differences in yield could be expected in dryer years.

4. Conclusions

The results to date indicate that cover crops can improve yields of cotton grown on the degraded, compacted, soils of Central Alabama. The type and timing of non-inversion tillage operations required to maximize corn and cotton productivity is not identifiable at this time, but some form of non-inversion tillage is superior to no-tillage on these soils. Results obtained from the remaining years of this experiment should help explain in more detail the beneficial effect these tillage and cover crop practices have on productivity of degraded soils.

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