Tillage timing of different conservation implements for cotton production in a coastal plain soil of central Alabama, USA.

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Abstract

Soils in the southeastern USA typically have low organic matter contents because of climatic and management factors. These soils are often prone to man-induced and natural hardpans, therefore creating the need for tillage operations. A study was initiated in fall 2003 to determine the impact of tillage timing (fall vs. spring) on cotton (*Gossypium hirsutum* L.) production. Three conservation tillage systems (no till, strip-till, and paratill) are under evaluation. Additionally, the use of rye (*Secale cereale* L.) as a winter cover crop is also being studied. Preliminary seed-cotton yield data for 2004 showed a significant tillage effect, with spring paratill producing highest yields, while no tillage produced the lowest. No significant differences in yields with tillage were observed in 2005, but a similar trend of greater yields with spring tillage was observed. Rye negatively impacted yield, possibly because of N immobilization and that both years were wet, reducing the benefits of winter covers typically observed in this region. Soil moisture data for 2005 showed increased soil moisture content during the summer months with winter cover use. Differences in soil moisture between tillage treatments are less clear, but in general they followed a similar pattern to cotton yields. It is expected that some form of conservation tillage and winter cover will benefit crop production of this region in the long-term.

Keywords: Conservation tillage; Cotton; Cover crop; Rye; Soil moisture

1. Introduction

Soils from the southeastern USA in general have low organic matter contents. Traditional soil management practices in the area promote organic carbon loss. Further, climatic conditions of the region are not conducive for carbon accumulation. For these reasons, these soils tend to have either natural or anthropogenic hardpan layers. Root development is often restricted by soil compaction, thus reducing yields. Cotton, commonly grown in the region, is sensitive to soil compaction. A properly developed root system is necessary for adequate nutrient and water uptake. Additionally, hardpan layers can reduce the downward flow of water and limit the recharge of the soil profile. Therefore, some form of tillage is often needed for these soils. Long-term management of soils in non-inversion tillage can increase soil organic matter content and improve soil physical properties (Endale et al., 2002).

Soil organic matter contents can also be increased with winter cover crops. Winter cover crops, such as rye, can be sown in the fall and terminated 3 to 4 weeks prior to planting cotton. The biomass produced by the winter cover crop can be rolled down to form a mat before spring planting of the cash crop. This mat is left on the soil surface to protect the soil from water and wind erosion, but it also increases soil organic matter content as it decomposes. Water evaporation is reduced (Lascano et al., 1994) and infiltration usually increases when a cover crop is utilized because soil crust formation is reduced and decomposing roots form channels where water can infiltrate.

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Surface soil disturbances must be kept to a minimum for maximum soil organic matter accumulation. However, because compacted soil layers are commonly found in these soils, some form of tillage is often necessary. Non-inversion tillage operations can break up hardpans below ground, while minimizing surface soil disturbance. Therefore, the objective of this study was to evaluate the timing (spring versus fall) of non-inversion tillage with and without a rye cover crop on cotton production and soil moisture.

2. Materials and Methods

An experiment was established in fall 2004 on a Compass loamy sand (coarse-loamy, siliceous, subactive, thermic Plinthic Paleudults) at the E.V Smith Agricultural Research Center near Shorter, Alabama, US. Three conservation tillage systems (no till, strip-till, and paratill) were evaluated. Timing of tillage operations included fall and spring; before planting the winter cover crop and before planting cotton. Two winter cover crops (winter fallow and rye) were compared across all tillage and timing combinations. The cover crop was terminated chemically four weeks before planting and flattened with a roller to facilitate planting operations. Rye and winter weed biomass was measured from a 0.25 m^2 area on each plot.

Plots were 4 m wide (four rows) by 15 m long in a split-plot arrangement with cover crop as the main-plot and tillage as the sub-plot with four replications. Fertilizer and pesticide applications were conducted as recommended by the Alabama Cooperative Extension Service. Rye was fertilized in late winter with 30 and 45 kg ha^{-1} of N in 2004 and 2005, respectively, as NH_4NO_3. Yield data were collected from the two middle rows of each plot.

Soil water content was measured during the growing season with commercially available capacitance soil probes. The probes were installed vertically in a middle row. Data were collected from 5- to 30-cm of depth below the soil surface with automated dataloggers every 15-min.

Data presented include the first two years of this four year experiment. Data were analyzed and means separated using the GLM procedure and Duncan’s mean test in SAS (1989). Discussion of preliminary results will focus on the main effects only, since no interactions were observed among treatments.

3. Results and Discussion

3.1. Cotton yield

Cotton yields were similar for all tillage treatments (Fig. 1). Nevertheless, during the 2004 season there were some significant differences with the no-till treatment producing the lowest yields, followed by the fall paratill and striptill. This lack of difference between no-tillage and fall tillage was probably caused by soil reconsolidation during the winter months. The highest yield was observed with the spring paratill, which was not significantly different from spring striptill. Paratilling tended to disturb the soil more effectively than striptill. There were no significant differences between tillage treatments for the 2005 season, but yields across all treatments were higher compared to the 2004 season.

Rye significantly reduced cotton yields both years (Fig. 2). There was considerable winter weed growth both seasons, which could have served as a “natural cover” (Table 1). The C/N ratio of the winter weeds was also lower than rye. This could immobilize N as rye decomposed, reducing N uptake by the cotton crop.

3.2. Soil water content

Differences in soil moisture content between tillage treatments were small (Fig. 3). However, greater soil water contents were observed in the no-till, followed by fall striptill and paratill, with spring striptill and paratill having the lowest water content for most of the season.

The 2005 growing season had periods with unusually high rainfall and some water accumulated on the soil surface. Spring tillage possibly improved drainage, but soil under fall tillage probably reconsolidated, as previously mentioned.

Table 1
Winter cover and weed biomass at termination and their respective C/N ratios

Year	Biomass (kg ha^{-1})		C/N Ratio (%)	
	Winter weeds	Rye	Winter weeds	Rye
2004	2142	5467	22.1	69.0
2005	1598	2183	25.0	44.5

The use of rye as a winter cover increased soil water content during the growing season (Fig. 3). Residue left on the soil surface from rye served as a mulch, protecting the soil from evaporation. Additionally, decomposing roots might have served as preferential flow paths for water to infiltrate. Since this soil has water drainage problems during wet years, it is possible that greater soil water contents negatively impacted cotton yields. This appears to be supported by the yield data.

4. Conclusions

Non-inversion tillage can help increase organic matter content over time by minimizing surface soil disturbance while breaking up consolidated soil layers. Preliminary results from this research suggest that non-inversion tillage can also improve soil drainage. However, timing of the tillage operation is important. Under the circumstances encountered here, spring tillage appears to have a greater effect than fall tillage, due to soil reconsolidation during the winter months.

The use of rye as a winter cover had a negative impact on cotton yields. It is possible that N was immobilized by microbes as rye decomposed, which could reduce the amount of N available for plant uptake. Nitrogen applications for cotton possibly need to be increased to counter act this effect. Also, rye increased soil water content during the growing season, and possibly had a negative impact on cotton yields during years with higher precipitation.

Conservation agriculture systems have great potential on degraded soils with low organic matter contents. The effects of such management are not immediate and will require a relatively longer period of time to show some benefits. It is expected that over time this type of management, or a similar alternative, will improve cotton production and profitability.

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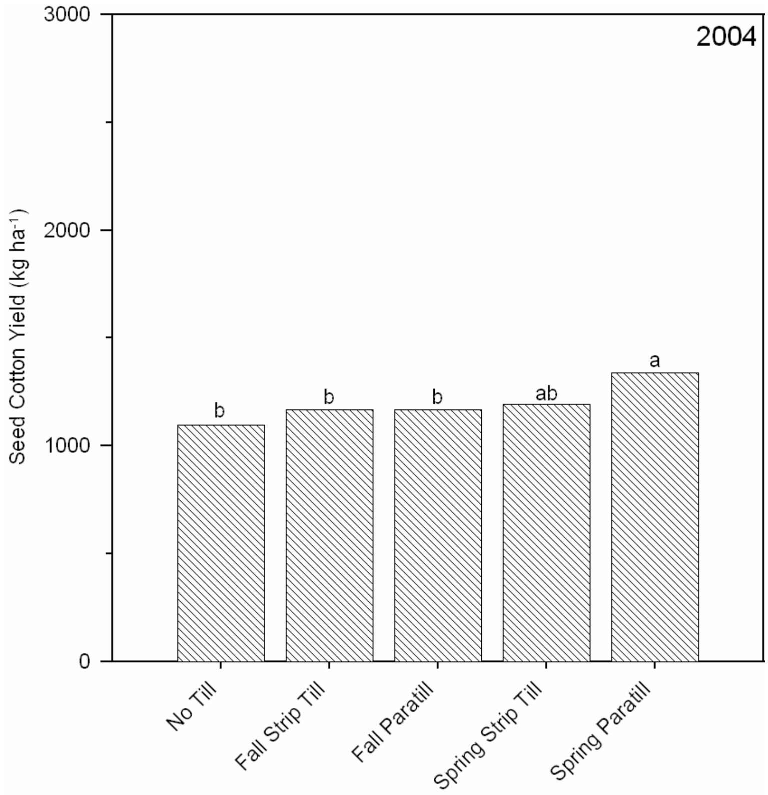

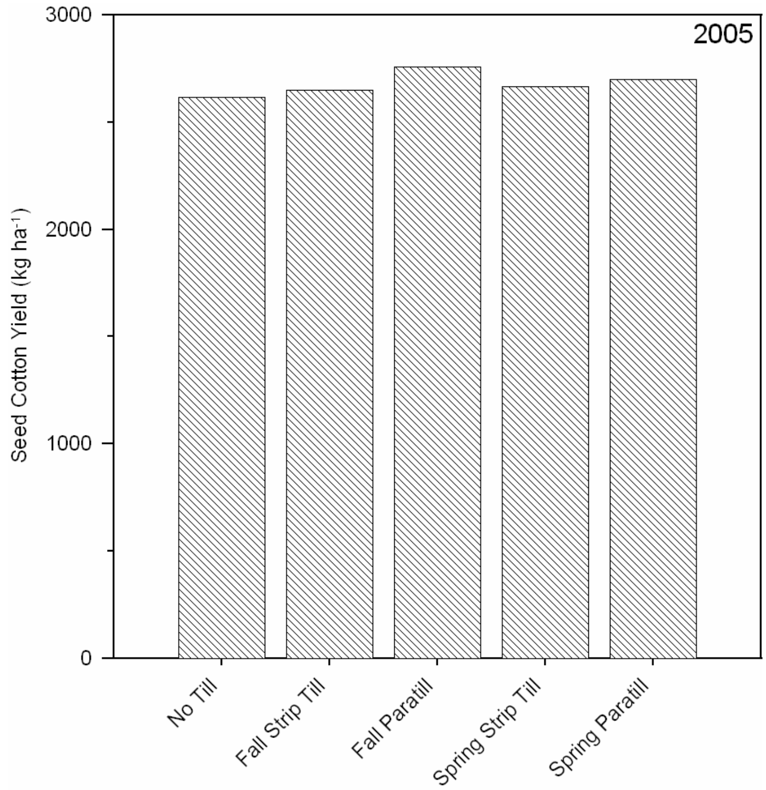

Fig. 1. Seed cotton yield as affected by non-inversion tillage treatment during the 2004 and 2005 seasons. Columns with different letters denote a significant difference between treatments.

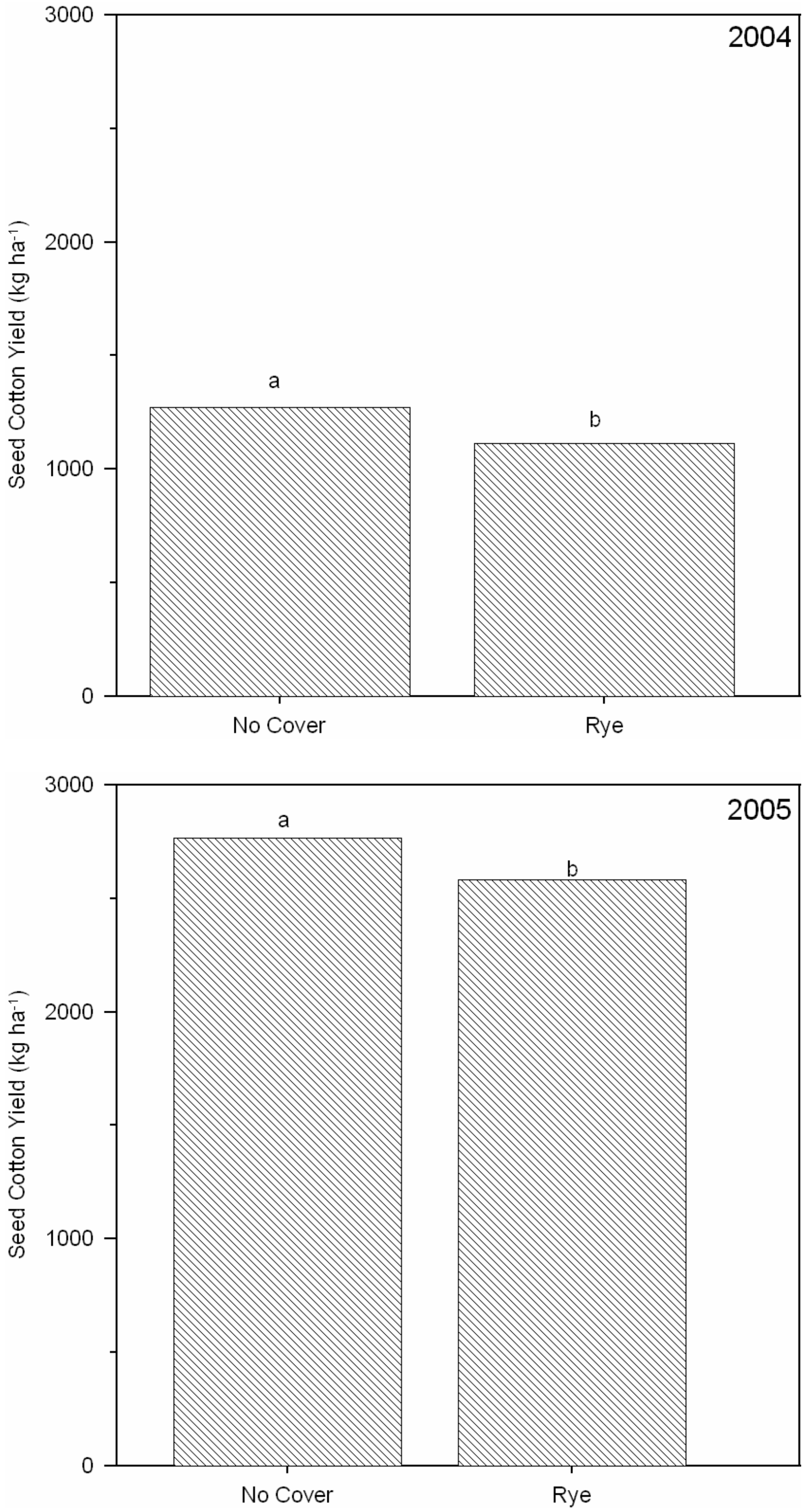

Fig. 2. Seed cotton yield as affected by winter cover treatment during the 2004 and 2005 seasons. Columns with different letters denote a significant difference between treatments.

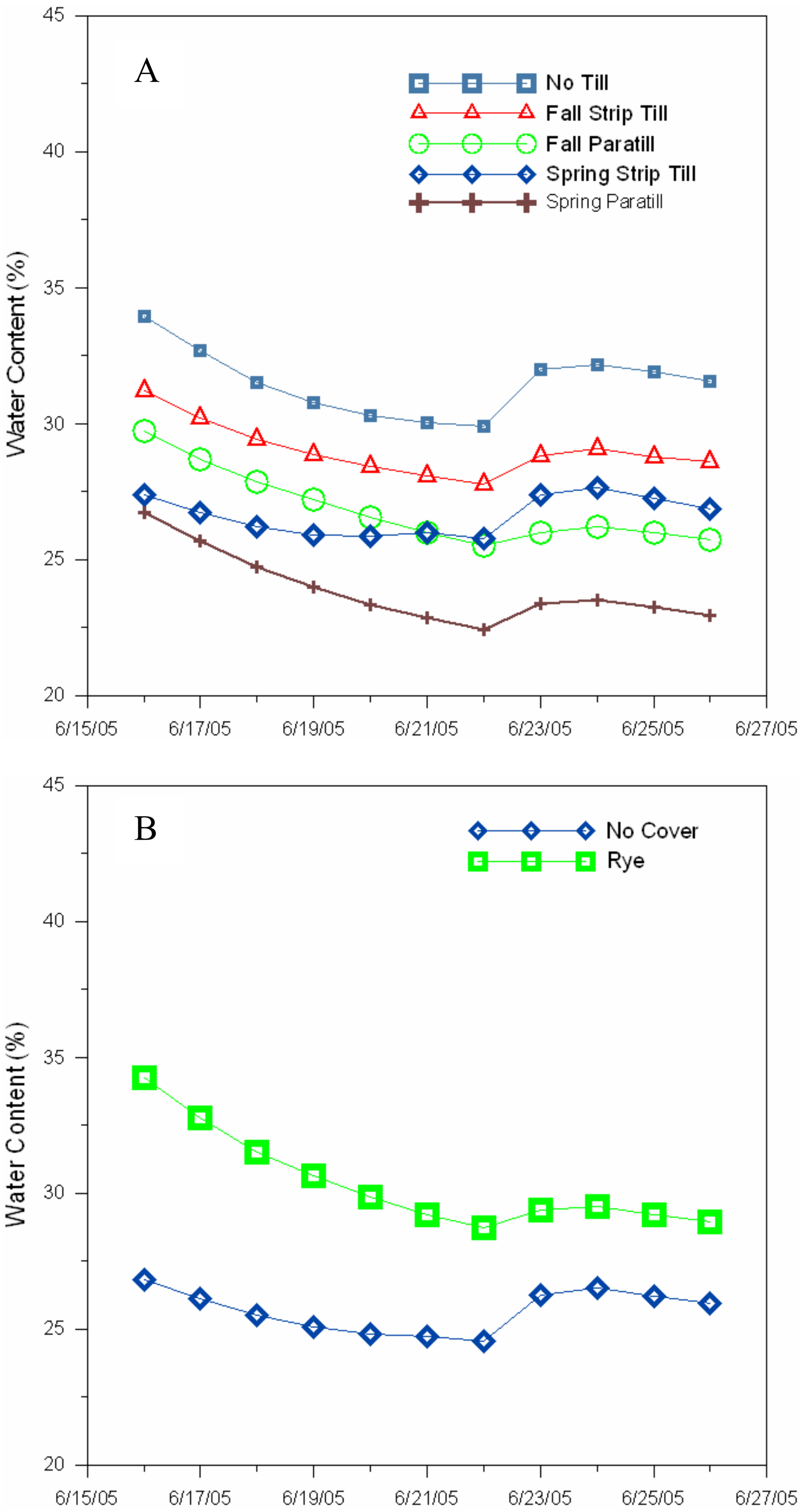

Fig. 3. Soil water content as influenced by tillage treatment (A) and winter cover (B) during the 2005 growing season.