SOIL PROPERTIES IN LONG-TERM CONSERVATION COTTON CROPPING SYSTEMS

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Abstract

Adoption of reduced tillage and no-till cotton is one of the most rapidly growing conservation areas in the United States. As conservation tillage expands in use, understanding the impact of transitioning to such systems on nutrient cycling and soil compaction becomes paramount. Our objective was to measure the impact of long-term conservation tillage systems in cotton production systems on soil chemical and physical properties. Soil physical properties measured include bulk density, soil strength using penetrometers (cone index values), and infiltration. Soil cores were taken to a depth of 3 ft and segmented for analysis of soil chemical properties. Soil carbon was higher in the upper 4 inches for systems that had been in no-till for more than 10 years. We also observed that carbon sequestration was higher in systems that incorporated crop rotation, particularly wheat, versus a continuous cotton system. Among locations through west Texas, infiltration rates were generally higher in conservation tillage systems that adjacent conventional tillage systems.

Introduction

Adoption of reduced tillage and no-till cotton is one of the most rapidly growing conservation areas in the United States. Soil compaction has been shown to reduce cotton yields in the southeastern United States; however, little information exists within the top cotton producing state of Texas. Cotton has been found to be particularly susceptible to soil compaction with many studies indicating significant yield reductions as a result of excessive vehicle traffic or naturally occurring conditions (Raper et al., 2007). No-till soils are often susceptible to compaction due to lack of disturbance and field equipment traffic. In contrast, some studies have reported that soils under long-term no-till systems can be less susceptible to compaction than plowed soils due to no-till induced increases in soil organic carbon (Thomas et al., 1996; Blanco-Canqui et al., 2009; Blanco-Canqui et al., 2010). Cover crops have also been shown to reduce the effects of soil compaction, increase infiltration and increase water holding capacity of the soil. It has also been hypothesized that increasing soil organic matter in the soil profile is better able to support vehicle traffic. Nutrient stratification, particularly P and to a lesser extent K, is also a concern in conservation tillage systems. Therefore, an evaluation of the impact of cropping systems on soil physical and chemical properties is warranted to better understand potential effects on cotton production within the Texas Rolling Plains and West Texas.

Materials and Methods

Two research locations were selected to meet the objective. One location was at the Texas A&M AgriLife Chillicothe Research Station consisting of an Abilene clay loam soil. Tillage treatments at Chillicothe included conventional tillage, no-till, no-till with a terminated wheat cover crop, and strip-till. No-till treatments have been in place since 2007; whereas strip-till was implemented in 2011. The second location was at the AG-CARES farm in Lamesa consisting of an Amarillo fine sandy loam soil. Treatments at Lamesa include conventional tillage and no-till with a terminated rye cover crop, with no-till being implemented for 15 years. We also evaluated tillage effects on private farms at 6 locations in west Texas, some having been in no-till for 15 years. Due to space limitations, discussion will focus on the replicated sites at Chillicothe and Lamesa. Soil samples were taken from each site in 2013 and 2014. Cores were taken to a depth of 36 inches and segmented into 0-4, 4-8, and 8-12, 12-24, and 24-36 inch samples. Soil samples were sent the Texas A&M AgriLife Extension Service Soil, Water, and Forage

Laboratory in College Station, TX for analysis of nitrate, total N, total C, organic C, Mehlich III P, and extractable K, Ca, Mg, S, Na, Fe, Zn, Mn, and Cu. Sites were visited during the growing season (June/July) to evaluate soil physical properties. Measured properties included soil bulk density, soil resistance using a penetrometer, and infiltration using a single ring infiltrometer. One inch of water was placed within a 9.6 inch ring and the time of infiltration was recorded. Immediately thereafter, the procedure was repeated. In dry conditions, the second reading may provide a more accurate reading. However, in wet conditions, the second reading can be less accurate if field capacity has been reached. In most cases, readings were taken in very dry conditions.

Results and Discussion

Chemical Properties

Our main focus was nutrient stratification and carbon sequestration. We did not see evidence of significant phosphorus stratification as a result of long-term conservation tillage at Lamesa or Chillicothe (results no presented). At Chillicothe, concentrations of soil carbon did not significantly differ (Table 1). It may be expected that the no-till with a cover crop would have the highest C levels; however, this was not observed. Similarly, Abreu et al. (2011) noted no impact on organic C when a monocrop system was used in low rainfall areas (western OK). In contrast, organic C levels were 40% higher in the upper 4 inches at Lamesa where no-till had been implemented for 15 years (Table 2). The increase in C was evident to a depth of 24 inches.

Table 1. Organic carbon concentrations in the soil profile at the Chillicothe Research Station from plots under conservation tillage since 2008.

	Conventional Till	Strip-Till	No-Till	No-Till/Cover Crop
Depth (in)		**Organic C (ppm)**		
0-4	**8476**	**7242**	**6972**	**8346**
4-8	**6472**	**6155**	**5743**	**5872**
8-12	**6103**	**6002**	**5838**	**5684**
12-24	**5688**	**6375**	**5297**	**5275**
24-36	**6516**	**6848**	**4534**	**4404**

Table 2. Organic carbon concentrations in the soil profile at AG-CARES facility in Lamesa, TX under no-till for 15 years.

	Conventional Till	No-Till
Depth (in)	**Organic C (ppm)**	
0-4	**1540**	**2595**
4-8	**1421**	**1577**
8-12	**1407**	**1525**
12-24	**1738**	**1925**
24-36	**1449**	**1475**

Soil Physical Properties

In general, bulk density did not significantly differ among treatments at Chillicothe and Lamesa. However, surface bulk density at the surface was lower at each site when measurements were taken shortly after a tillage event. When a precipitation or irrigation event was recorded prior to measurement, bulk density measurements were not significantly different at the surface (data not shown). Penetrometer data indicated a tillage effect at each location. At Chillicothe, no-till and no-till with a terminated cover crop treatments indicated reduced resistance compared with conventional tillage and strip-till beginning at a depth of about 5 inches (Figure 1A). Conventional tillage on the subsurface drip irrigated plots generally consists of disking at a 6 inch depth. Hence, the change in resistance is evidence of a plow pan. Similar results were observed at Lamesa, where resistance became significantly lower beginning at the 5-6 inch depth (Figure 1B). These data suggests that plow pans can be reversed over time with no-till.

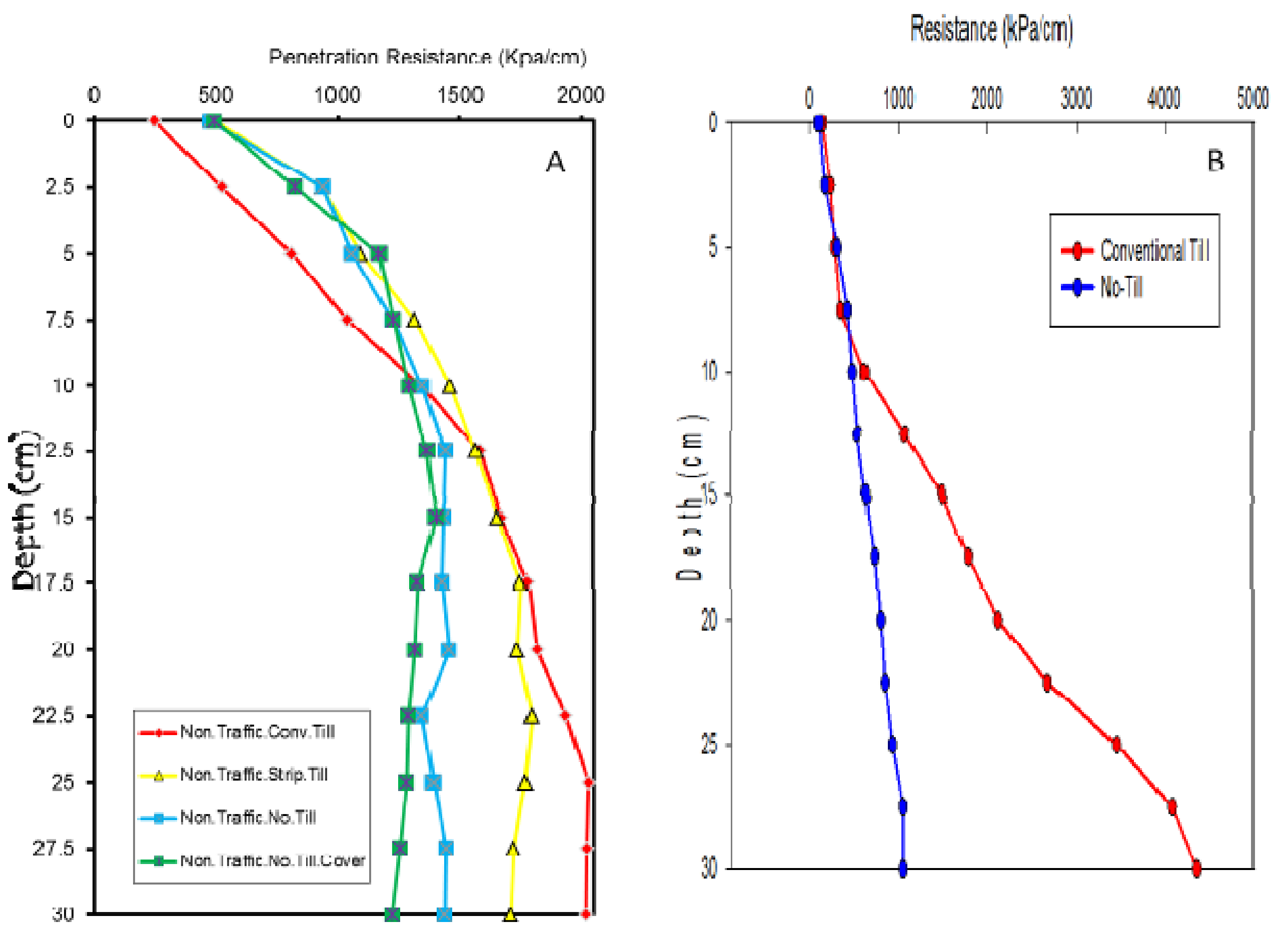

Figure 1. Soil penetration resistance as measured by penetrometer at A) Chillicothe Research Station and B) AG-CARES in Lamesa.

Infiltration rates are presented in Figure 2. Although no differences in soil organic C was observed at Chillicothe, infiltration rates indicated a response to conservation tillage. No-till with a terminated wheat cover crop resulted in significantly higher infiltration rates compared with all other treatments (Figure 2A). At Lamesa, no-till with a terminated rye cover crop resulted in significantly higher infiltration rates compared to conventionally tilled plots (Figure 2B). These data indicate that long-term conservation tillage systems have the capability to capture and store moisture more efficiently than conventionally tilled systems.

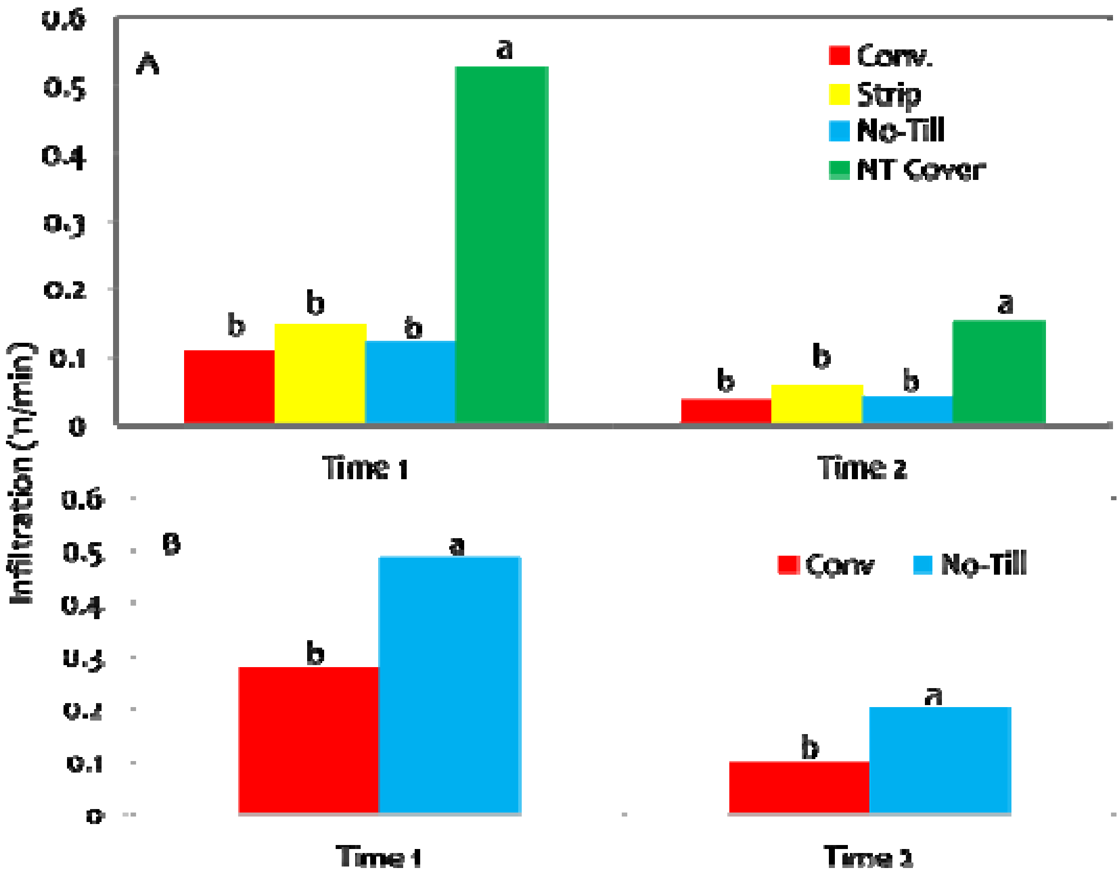

Figure 2. Infiltration rates at for two consecutively timed trials using single ring infiltrometers at A) Chillicothe Research Station and B) AG-CARES in Lamesa.

Summary

Long-term conservation tillage systems have the capability to sequester C, improve soil structure, decrease soil resistance, and improve water infiltration rates. In semi-arid environments, soil C is very difficult to build up and may take multiple years to see improvements (>10 years). Increased soil C levels were observed where no-till had been implemented for 15 years but not in the area where no-till had been implemented less than 10 years. Soil resistance measurements indicated plow plans were alleviated under no-till conditions. Infiltration rates were also increased under no-till conditions.

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