INFLUENCE OF MANAGEMENT PRACTICES ON SOIL HEALTH IN COTTON CROPPING SYSTEMS

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Abstract

Soil health is receiving ever increasing attention due to various initiatives around the world. However, quantifying soil health and approaches on how to improve soil health vary greatly. Our goal for this paper is to introduce some concepts and potential approaches we have observed that can potentially improve soil conditions in semi-arid cotton cropping systems. We used research collected from replicated research trials at the Chillicothe Research Station within the Texas Rolling Plains, where conservation tillage and cover crop studies have been in place since 2008. Within subsurface drip irrigated trials, we have observed no significant differences in soil organic C, which is typically the standard in defining soil health, among various tillage treatments. However, although we have not observed increased SOC levels due to implementation of a terminated wheat cover crop into the cotton cropping system, we have observed significantly improved infiltration rates and improved soil strength over time. Incorporation of a high residue crop, through rotation or cover cropping, can improve some soil health parameters over a continuous cotton cropping system. To capture changes in soil health, multiple parameters should be observed rather than a single indicator.

Introduction

The term "soil health" has been revitalized in recent years. This term may also be better known to some as soil quality or soil condition. These terms have received increasing interest in part due to several initiatives such as the USDA-NRCS Soil Health Initiative, Global Soil Security Symposium, and more recently the French 4 per Mil Initiative. Carbon is often the center of discussion, and an increase in C sequestration is a positive step in achieving improved soil health. The French National Institute for Agronomical Research states that an annual increase of 0.4% each year of SOC would be enough to compensate for the global emissions of greenhouse gases. Soil health can be defined as the capacity of a soil to function, within land use and ecosystem boundaries, to sustain biological productivity, maintain environmental health, and promote plant, animal, and human health (Doran and Zeiss, 2000). McBrantley et al. (2014) states that there is little value in talking about the health of any given soil, unless there is an understanding of how 'healthy' it can actually be. The condition or health of a soil can be inferred by measuring specific soil properties (e.g., organic matter content) and by observing soil status (e.g., fertility). Practices that have the potential to improve soil condition include conservation tillage, cover crop implementation, and crop rotation. Thus, our objective was to measure specific soil properties in systems that have been under conservation tillage for at least five years and identify management practices that hold the greatest potential to improve soil health.

Materials and Methods

We collected data from private and university farms within semi-arid regions of Texas, which results were presented in DeLaune et al. (2015). The discussion within this paper will be limited to data collected from 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. Within this trial, we also began incorporating sorghum within the cropping system. Another trial includes cover crop evaluation in a dryland system consisting of consisting of seven treatments: 1) conventional tillage without a cover crop; 2) no-till without a cover crop; and no-till with cover crops consisting of 3) crimson clover (15 lb/ac); 4) Austrian winter field pea (35 lb/ac); 5) hairy vetch (20 lb/ac); 6) wheat (30 lb/ac), and 7) legume/grass mixture. The irrigated system consists of four treatments: 1) conventional tillage without a cover crop; 2) no-till without a cover crop; 3) no-tillage with a wheat cover crop (30 lb/ac); and 4) no-till with a legume/grass cover crop mixture. Measured properties included soil bulk density, soil resistance using a penetrometer, infiltration using a single ring infiltrometer, and soil total C and soil organic C.

Results and Discussion

Chemical Properties

Soil organic C is often the standard in measuring changes in soil health. We presented some data collected from Chillicothe Research Station at the 2015 Beltwide Cotton Conference. As seen in Table 1, concentrations of organic C are similar among treatments, even with implementation of winter wheat as a cover crop. While this is somewhat surprising, research Abreu et al. (2011) noted no impact on organic C when a monocrop system was used in low rainfall areas (western OK). More recently, Schwartz et al. (2015) reported that no-tillage alone did not slow the decline of SOC compared with stubble mulch tillage in Bushland, TX. They also noted that biomass accumulation rather than tillage is probably the principal driver governing the long-term changes in SOC storage. Within monoculture cotton systems, biomass accumulation is very difficult to achieve without the addition of rotational crops or cover crops.

Table 1. Organic carbon concentrations in the soil profile at the Chillicothe Research Station from plots under conservation tillage since 2008 (From DeLaune et al., 2015).

	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**

While changes in SOC were not noted, significant differences in soil physical properties were noted. Penetrometer data indicated no-till and no-till with a terminated cover crop reduced resistance compared with conventional tillage and strip-till beginning at a depth of about 5 inches (Figure 1A). Furthermore, infiltration rates were significantly higher for plots that had implemented a terminated cover crop program (Figure 1B). Interestingly, no-till alone did not differ from conventional tillage, which indicates the importance of added residue in low residue cropping systems.

Cover crops have received increased attention and are a focal point of the USDA-NRCS Soil Health Initiative. Soil moisture use by cover crops is a chief concern in semi-arid cropping systems. In Figure 2, stored soil moisture is shown in a dryland cotton system with various cover crops over a three year period. As with cash crops, water use varies by cover crop species and impacts stored soil moisture in different ways. During the first observed year, stored soil moisture during the spring (April, cover crop reproduction growth phase) was reduced where cover crops were grown. However, by observing the figure, it can be seen that stored soil moisture in winter and spring of 2015 was higher for cover crop treatments such as Austrian winter field pea, hairy vetch, and winter wheat compared with no-till and conventional tillage. These cover crop species also have been the highest biomass producers each year. Hence, the "soil condition" seems to be improving over time and is capturing precipitation as efficiently as a listed conventional till system or no-till system without a cover crop.

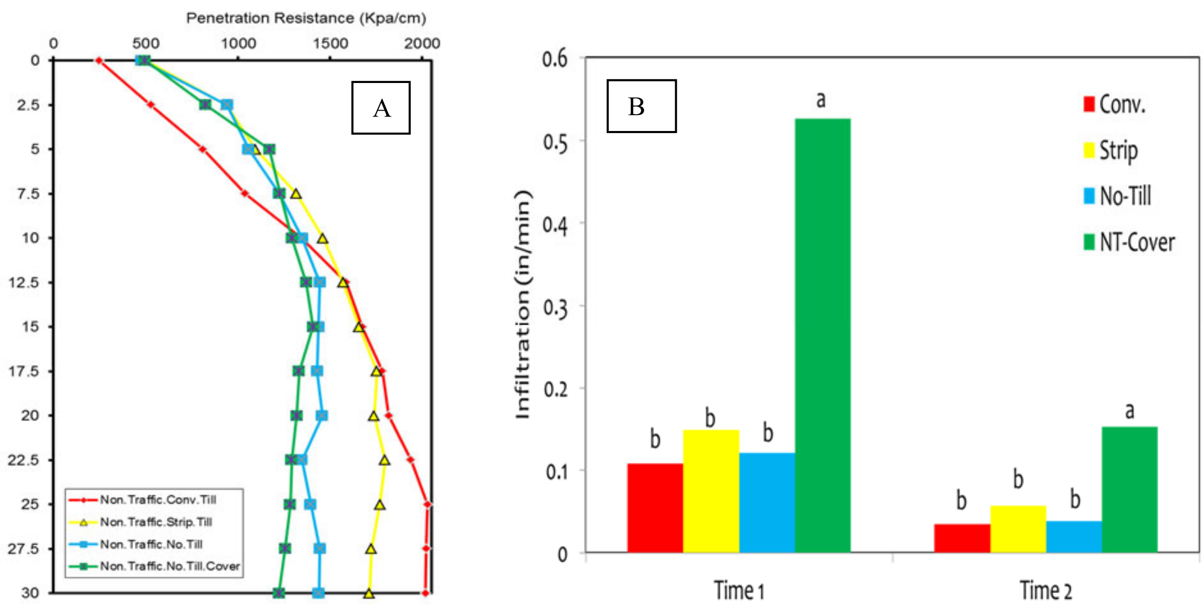

Figure 1. (A) Soil penetration resistance as measured by penetrometer (B) and infiltration at Chillicothe Research Station.

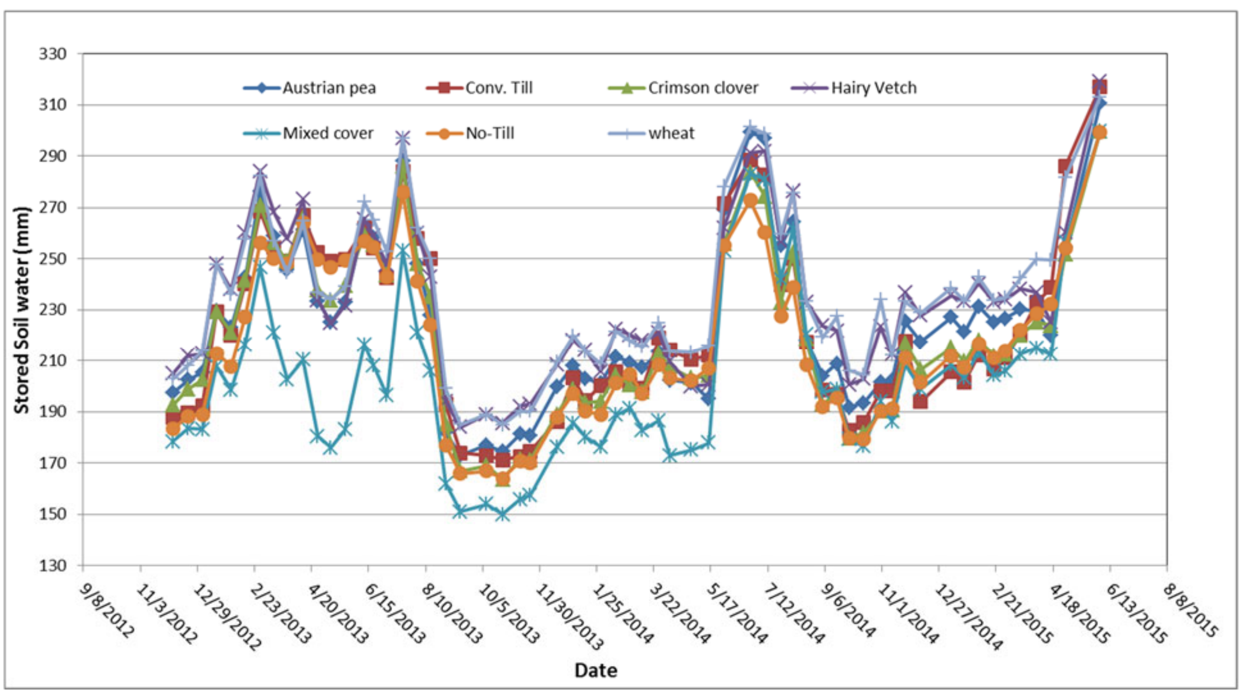

Figure 2. Stored soil moisture to a depth of 4.6 ft. in a dryland cotton system under various cover crops at Chillicothe Research Station.

Thus far, we have shown increased residue via cover crop implementation can benefit water capture and infiltration. However, there will still be concerns over soil water use by cover crops and a hesitation to implement in semi-arid environments. We also observed water extractable organic C levels in continuous cotton versus a cotton/sorghum rotation. Water extractable organic C (WEOC) is a parameter measured in the Haney Soil Health Assessment Test, which is a soil test supported by USDA-NRCS to provide a guide to the current status of soil health. In figure 3, water extractable organic C is shown for a three year continuous sorghum study followed by a cotton crop (sorghum implemented 2011). This is compared to the adjacent continuous cotton system described above (implemented 2008). For each tillage treatment, WEOC is higher for the cotton/sorghum system compared to the continuous cotton system (Figure 3). These data indicate that incorporation of a high residue rotational crop such as sorghum can result in more rapid soil organic C changes, even for a continuous cotton system with a terminated cover crop.

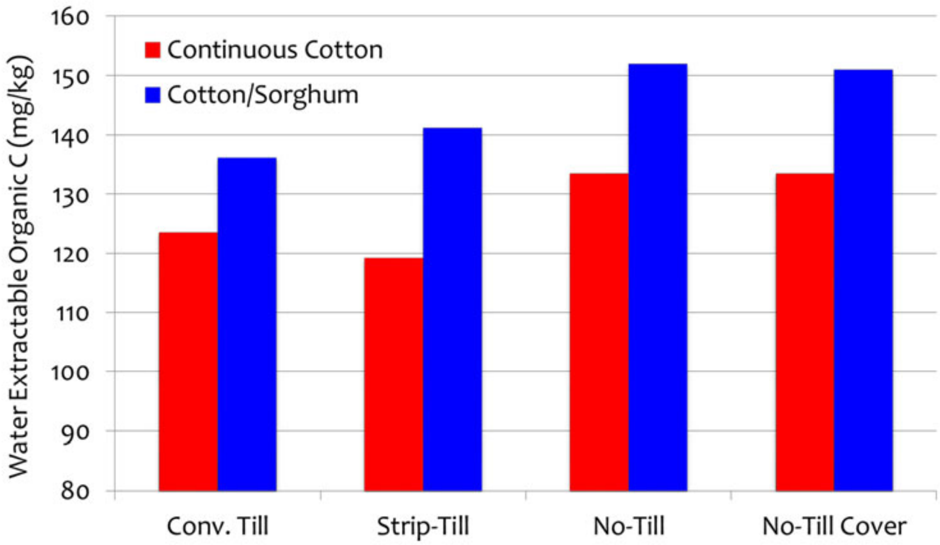

Figure 3. Water extractable organic carbon for continuous cotton and cotton/sorghum rotation systems at Chillicothe Research Station.

Summary

Soil organic C is often used as a soil health indicator, but other soil properties can be significantly changed even when no differences in SOC are measured. In our research, we have shown that cropping systems which increase surface residue can increase water infiltration, maintain or increase stored soil moisture, and elevate water extractable C. Most importantly, as soils and cropping systems are very complex, multiple parameters should be measured to quantify the impact a chosen system has on soil health.

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