ASSESSMENT OF SOIL PHYSICAL PROPERTIES ON DIFFERENT MANAGEMENT PRACTICES AND LANDSCAPE POSITIONS

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ABSTRACT

Crop production has become more costly every year, and improving recommendations and implementation of site-specific crop management can help farmers achieve input optimization and consequent savings. The use of precision agriculture techniques is completely dependent on understanding the spatial variability of soil physical properties. In order to assess management practices and landscape variability effects on soil physical properties, infiltration, aggregate stability and total carbon (C) were measured in a 22 acre field in the central Alabama Coastal Plain. Based on the local soil properties, the field was separated into three zones - summit, backslope and accumulation. Four tillage systems treatments - conventional system with (CT+M) or without (CT) dairy manure, and conservation system with (NT+M) or without (NT) dairy manure - and corn-cotton rotation have been established in the study area since 2001. Overall, infiltration, aggregate stability and C content were lower in CT. The C content was significantly higher (P = 0.001) for treatments with manure, where CT+M was 62% greater than CT, and NT+M was 39% greater than NT. Infiltration was highest on the summit (5.7 in/h), followed by backslope and accumulation zones (3.4 and 2.8 in/h, respectively). No significant difference (P = 0.69 and 0.39, respectively) was found for aggregate stability and carbon among the zones. Conservation tillage for 6 crop years thus far has improved infiltration and increased soil C content, whereas manure has only increased soil C content.

INTRODUCTION

The movement of water and chemicals is greatly affected by soil physical properties, which in turn have a great impact on crop productivity. The physical properties of soil can vary significantly within a field. Soil spatial variability is often related to changes in landscape position, and is usually the major cause of spatial variability in crop yields (Terra et al., 2005). As a soil-forming factor, topography leads to differentiation in soils (Jenny, 1941). Steep slopes associated with conventional tillage practices may lead to erosion and soil deterioration. Nutrient distribution within a soil profile can change with landscape position (Balkcom et al., 2005). Soil C can significantly affect soil chemical and physical properties, and landscape position plays an important role in C sequestration (Terra et al., 2005). Further, conservation tillage systems, such as non-inversion tillage practices like strip-tilling, can benefit production systems of southeastern U.S. The use of conservation systems benefits soils by increasing organic C content and providing protective crop residue on the soil surface, which is a prominent issue for these soils. Therefore, the objective of this work is to assess the effect of management practices and landscape variability on selected soil physical properties.

MATERIALS AND METHODS

The study site is located at the Alabama Agricultural Experiment Station's E.V. Smith Research Center, near Shorter. Four management treatments were established in late summer of 2000 on a corn and cotton rotation that has both crops present each year. The management systems included a conventional tillage system (chisel- followed by disc-plow) with (CT+M) and without (CT) manure, and a conservation tillage system (non-inversion tillage) that incorporated the use of winter cover crops with (NT+M) and without manure (NT). A mixture of rye (*Secale cereale* L.) with black oat (*Avena strigosa* Schreb.), and a mixture of crimson clover (*Trifolium incarnatum* L.) with white lupin (*Lupinus albus* L.) and fodder radish (*Raphanus sativus* L.) were typically used as winter cover before cotton (*Gossypium hirsutum* L.) and corn (*Zea mays* L.), respectively. Four strips with an average length of 800 ft were established across the landscape to represent the four management systems for each crop per each replication. Each strip was further divided into cells to simplify sampling and field measurements. A total of six replications were established on the 22 ac field. Maximum slope is 8% and 9 soil map units are contained within this landscape.

Prior research work at the same field site delineated four distinct zones using a digital elevation map, electrical conductivity survey, and traditional soil mapping techniques. For this study, three of these zones were selected and recognized as summit, backslope, and accumulation zones in the landscape. Two cells per management and zone were selected to conduct soil physical properties characterization (Fig. 1). Soil properties studied included total soil C by dry combustion at three depths, water infiltration with a mini-disk infiltrometer (Decagon Devices Inc., Pullman, WA)[1], and water stable aggregates (Nimmo and Perkings, 2002). Other data was

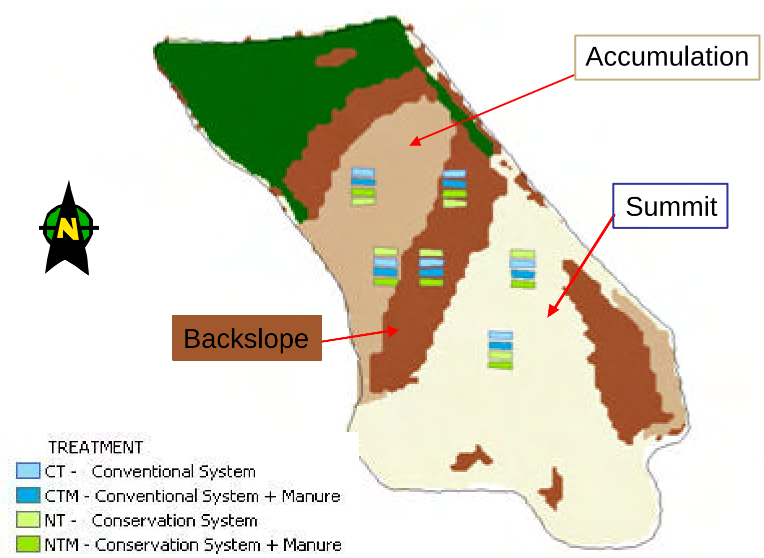

Figure 1. Location of sampling cells for each of the three landscape zones used in this study. The green region in the northern section of the field is an intermediate zone not included in this research.

1- Mention of a company name or trademark does not constitute endorsement by Auburn University and/or USDA-Agricultural Research Service to the exclusion of others.

collected, including soil bulk density, water retention, and crop yields, but will not be presented here.

Data were analyzed with the MIXED model procedure in SAS (SAS Institute Inc., Cary, NC). Management system, landscape position, depth, and their interactions were considered as fixed effects.

RESULTS AND DISCUSSION

On the surface 2 inches of soil, total C was greatest in the NT+M followed by CT+M, NT, and CT (Fig. 2). Differences in C content between CT and NT were significant at the 0-2 inches of depth only. Non-inversion tillage increased C content by 54.7% on the surface soil, and by 1.3% from 2-4 inches of depth. However, C content was 2.5% lower in the NT than in the CT at the 4-6 inch depth. This lower C content can be attributed to the lack of soil mixing in the NT system. Nevertheless, soil C accumulation is greater with NT since C is broken down by increased soil respiration from CT operations. Small differences in C were observed with depth in CT, with C content ranging from 0.54 to 0.43%. All management systems had significant interaction (P = 0.001) with depth, except CT. The lack of difference in soil C content with depth in CT can be attributed to low C additions, greater C breakdown, and mixing of the surface soil (Fig. 2).

Manure application significantly increased C content for CT+M and NT+M when compared to CT and NT on the top 4 inches of soil (Fig. 2). Carbon content was increased by 81.9, 65.7, and 26.2% from 0-2, 2-4, and 4-6 inches of depth, respectively, when comparing CT and CT+M. A similar trend was observed for NT and NT+M, with C content increasing by 71.8, 5.7, and 4.2% for 0-2, 2-4, and 4-6 inches of depth, respectively. Landscape position had no significant effect (P = 0.39) on soil C content (Fig. 3).

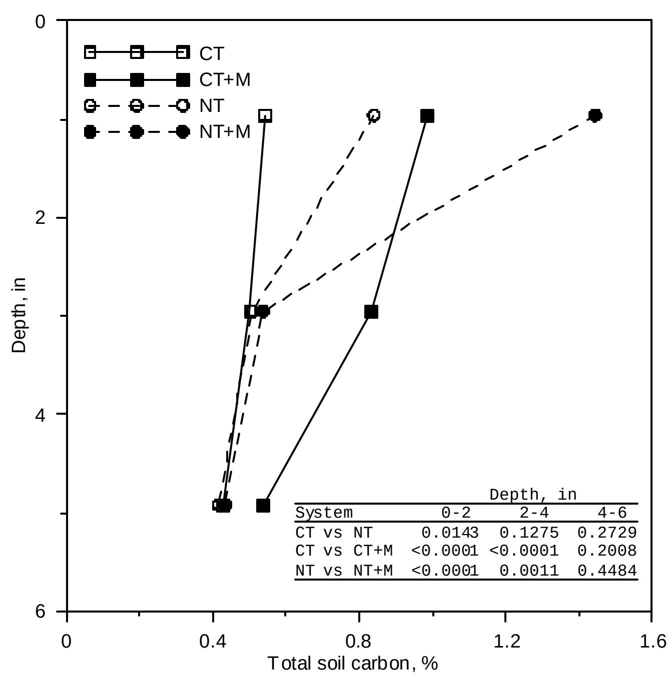

Figure 2. Total soil C content for the conventional (CT), conventional with manure (CT+M), no-till (NT), and no-till with manure (NT+M) management systems. Statistical significance between management systems of interest at a given depth is depicted in the table insert.

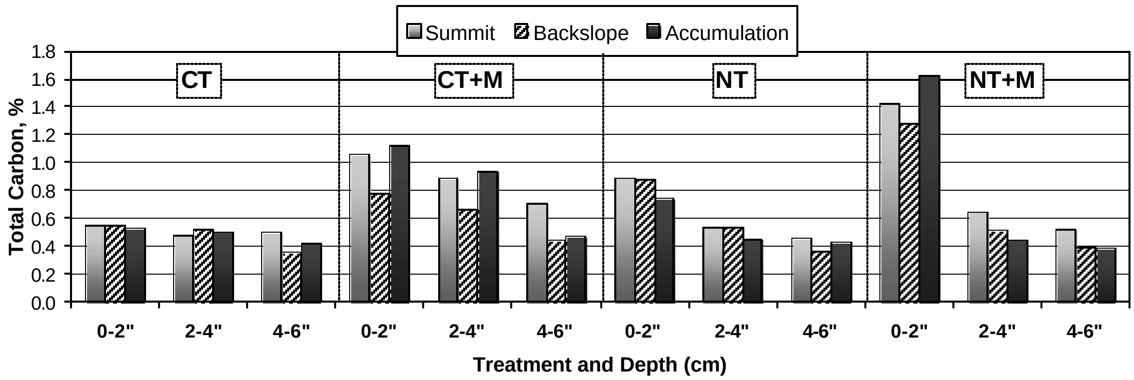

Figure 3. Total soil carbon content by landscape position, depth and management system (CT - conventional; CT+M - conventional with manure; NT - no-till; NT+M - no-till with manure).

Overall, non-inversion tillage increased infiltration in all zones (Fig. 4). The NT system had greater infiltration in the summit and accumulation zones than in the backslope. A similar trend was noted with NT+M. The backslope position is a transitional zone where C deposition and accumulation is less likely to occur. Infiltration in the summit for the CT treatment was greater than in the accumulation and backslope zones (Fig. 4). Manure application did not improve infiltration in the study area. No main effect for treatment (P = 0.51) and zone (P = 0.27) was observed for aggregate stability (Fig. 5). This may be attributed to the large variability in aggregate stability measurements.

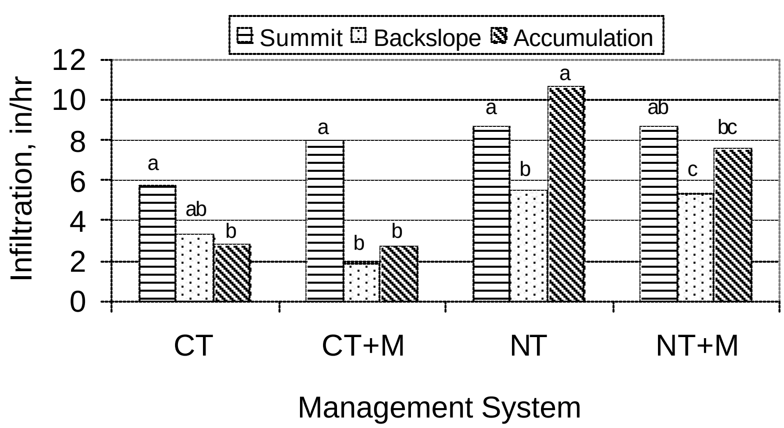

Figure 4. Infiltration rate for four management systems (CT – conventional; CT+M – conventional with manure; NT - no-till; NT+M – no-till with manure) and landscape position. Different letters denote a significant difference between landscape positions within the same management system.

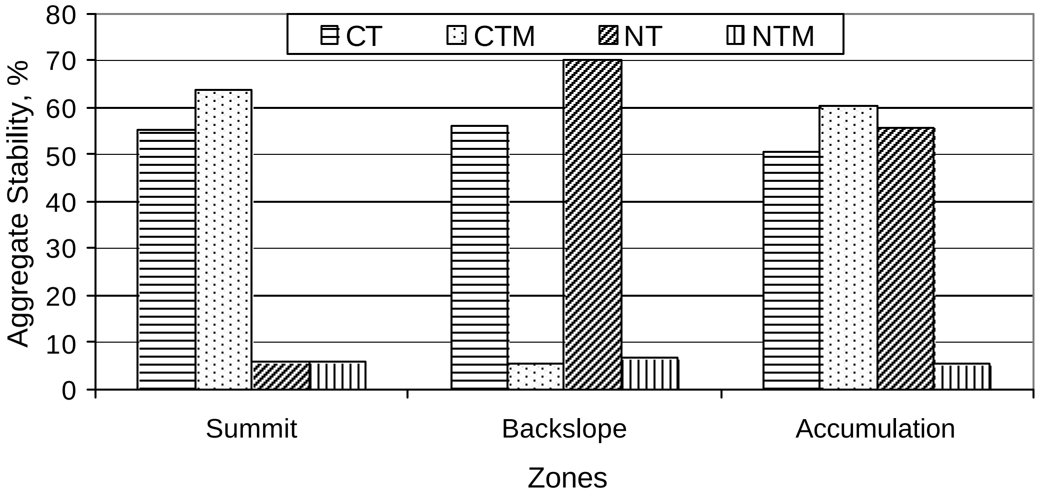

Figure 5. Water stable aggregates for four management systems (CT – conventional; CT+M – conventional with manure; NT - no-till; NT+M – no-till with manure) and landscape position.

CONCLUSIONS

Manure significantly increased C content in CT and NT treatments, especially in the 0-2 inches of depth. However, it did not improve infiltration or aggregate stability. There were no significant differences between treatments and zones in aggregate stability. Infiltration tended to be higher in the summit position for all the treatments, with the exception of NT. Overall, conservation systems have improved C contents and infiltration of this landscape. It is expected that by the end of this experiment a more representative set of data will better characterize soil physical properties for the treatments and landscape positions of this research field.

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