CONSERVATION TILLAGE IMPROVES SOIL PHYSICAL PROPERTIES ON DIFFERENT LANDSCAPE POSITIONS OF A COASTAL PLAIN SOIL

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ABSTRACT

Improved crop management is necessary due to raising production costs and environmental concerns. Spatial variability of soil physical properties can significantly affect management approaches. A study was established in 2007 to determine the effect of management practices and landscape variability on selected soil quality parameters (infiltration, aggregate stability and total C) of a 22 acre field located in the central Alabama Coastal Plain. The field was divided into three zones - summit, backslope and accumulation, using elevation, electrical conductivity and traditional soil survey data. Four management systems - conventional system with (CT+M) or without (CT) dairy manure, and conservation system, consisting of strip-tillage and a winter cover crop, with (ST+M) or without (ST) dairy manure – were established on a corn (*Zea mays* L.)-cotton (*Gossypium hirsutum* L.) rotation in 2001. Infiltration, aggregate stability and C content were generally lower in CT. Manure significantly increased the C content ($P \leq 0.001$), with an overall 62% increase in soil C content when manure was applied to CT, and 39% greater when applied to ST. Infiltration was greatest on the summit (5.7 in/h), followed by backslope and accumulation zones (3.4 and 2.8 in/h, respectively). No significant differences ($P = 0.69$ and 0.39, respectively) were found for aggregate stability and carbon between zones. Conservation tillage improved water infiltration and increased soil C content, whereas manure has only increased soil C content.

INTRODUCTION

Soil physical properties affect water and chemical movement in the soil and can have a significant impact on crop productivity and the environment. Certain landscapes can have significant differences in soil physical properties due to spatial variability and can be the major cause of spatial variability in crop yields (Terra et al., 2005). Topography is a significant factor for soil differentiation (Jenny, 1941). Conventional tillage practices in areas with steep slopes can lead to erosion and soil degradation. Additionally, nutrient distribution within a soil profile can change with landscape position (Balkcom et al., 2005). Another important factor is the spatial distribution of soil C, since soil C can significantly affect soil chemical and physical properties. Landscape position plays an important role in C sequestration (Terra et al., 2005). Conservation tillage practices, such as non-inversion tillage (strip-tilling), can benefit production systems of southeastern United States. Conservation systems that include strip-till and winter cover crops can increase the soil organic C content and provide protective crop residue on the soil surface. Therefore, the objective of this work was to determine the effect of management practice and landscape variability on selected soil quality parameters of a Coastal Plain soil in Alabama.

MATERIALS AND METHODS

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

Four zones were established at the site by other researchers using a digital elevation map, electrical conductivity survey and traditional soil mapping techniques (Terra et al., 2004). Three of these zones were selected (summit, backslope and accumulation) for this study. Two cells per management and zone were selected to conduct soil physical properties characterization (Fig. 1).

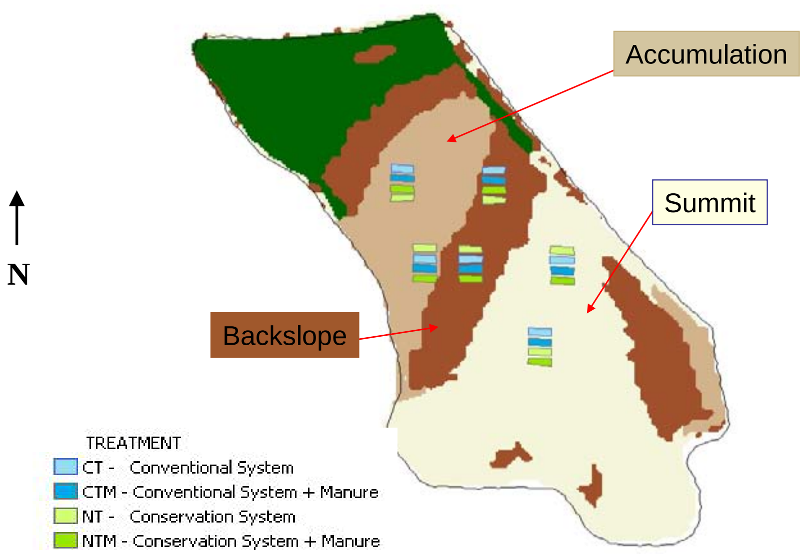

Figure 1. Map of the zones in the research site and the sampling cells used in this study. The green zone in the northern section of the field is an intermediate transitional zone not included in this research.

Soil properties studied included total soil C by dry combustion at three depths, water infiltration with a mini-disk infiltrometer, and water stable aggregates (Nimmo and Perkings, 2002). Other data were collected, including soil bulk density and water retention, 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

Total C was greatest in the ST+M followed by CT+M, ST, and CT from 0-2 in of depth (Table 1). Soil C content was only affected by tillage at the 0-2 in depth, where total C was 56% greater with ST compared to CT. There were no differences in soil C in the lower two depths. Overall, soil C sequestration was greater with ST since soil respiration was probably lower than in the CT. There was a significant interaction ($P \leq 0.01$) between all management systems and depth, except CT. Conventional tillage operations tend to incorporate plant materials, increasing soil C breakdown and mixing it to lower soil depths creating a dilution effect (Table 1).

Total soil C content increased significantly with manure application for both tillages on the top 2 inches of soil (Table 1). However, soil C only increased significantly with manure application at the 2-4 in depth with CT. This can be attributed to the incorporation of the manure deeper into the soil profile by the mixing action of the CT practices. A similar trend was observed at 4-6 in of depth. Soil C content was not affected by landscape position ($P = 0.39$).

Table 1. Total soil C content for conventional, conventional with manure, strip-till, and strip-till with manure management systems in the research site near Shorter, AL.

	Total Soil Carbon			
	Conventional Tillage		Strip Tillage	
	No manure	Manure	No manure	Manure
Depth, in	------------------------------	%	------------------------------	
0 – 2	0.54	0.99	0.84	1.44
2 – 4	0.50	0.83	0.51	0.54
4 – 6	0.43	0.54	0.42	0.43

	Pr > F		
Depth	Tillage	Manure	Tillage x Manure
0 – 2	0.041	< 0.001	0.419
2 – 4	0.918	0.655	< 0.001
4 – 6	0.856	0.774	0.285

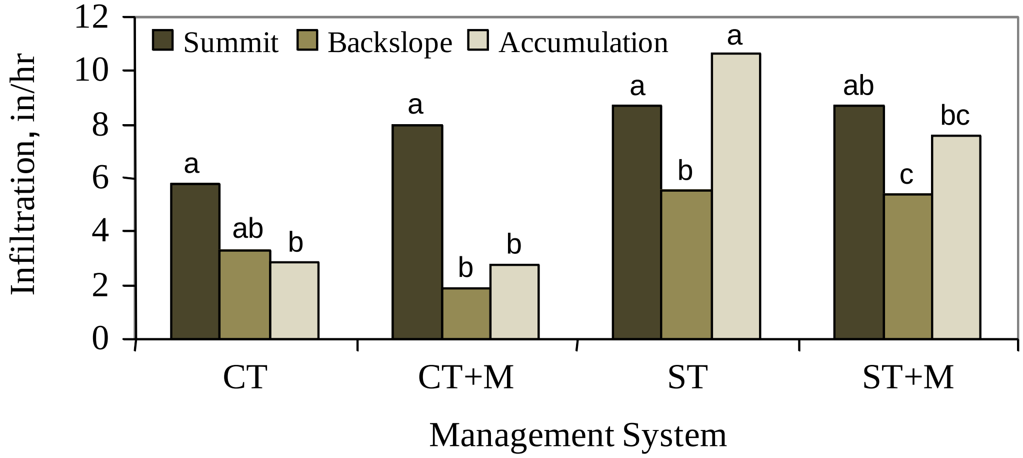

Figure 2. Infiltration rate as affected by landscape position for conventional tillage with and without manure (CT+M and CT), and strip tillage with and without manure (ST+M and ST) in the research site near Shorter, AL. Different letters indicate statistical significance between landscape positions within the same management system.

In general, water infiltration was increased by non-inversion tillage practices in all landscape positions (Fig. 2). Water infiltration was greater in the summit and accumulation positions than in the backslope of the ST management system. Similarly, infiltration was lowest in the backslope of the ST+M management, but it wasn't significantly different to the infiltration rate of the accumulation zone. A similar pattern was observed with CT+M. This reduced water infiltration rate in the backslope position can be attributed to lower C accumulation in the backslope position. Infiltration in the summit and backslope for the CT treatment was greater than in the accumulation zone. Water infiltration was not affected by manure application within tillage system. Water stable soil aggregates were not affected by management system ($P = 0.51$) or zone ($P = 0.27$). This may be due to the large variability in aggregate stability measurements.

CONCLUSION

Manure significantly increased the soil C content of the topsoil in CT and ST treatments. Soil C content was increased with manure application deeper in the profile for the CT treatment only. However, manure application did not appear to improve water infiltration or water stable aggregates. Similarly, there were no significant differences in water stable soil aggregates between treatments or zones. Water infiltration tended to be greater in the summit position for all the treatments, with the exception of ST. In general, it seems that conservation systems had a greater impact on improving measured soil quality parameters on this landscape than manure application.

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