Management and Landscape Position Effects on Soil Physical Properties of a Coastal Plain Soil in Central Alabama, USA

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Abstract
Improved crop management is necessary due to raising production costs and environmental concerns. Input optimization from precision crop management might provide some solutions to these issues. Spatial variability of soil physical properties can significantly affect the implementation of precision agriculture techniques. A study was established in 2007 to determine the effect of management practices and landscape variability on soil physical properties (infiltration, aggregate stability and total C) of a 9 ha 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 with (NT+M) or without (NT) 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 62% greater soil C content when manure was applied to CT, and 39% greater when applied to NT. Infiltration was greatest on the summit (14.5 cm/h), followed by backslope and accumulation zones (8.6 and 7.1 cm/h, respectively). No significant difference ($P = 0.69$ and 0.39, respectively) was found for aggregate stability and carbon between 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.

Key Words
Conservation agriculture, manure, soil physical properties, spatial variability.

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 practices and landscape variability on selected soil physical properties of a Costal Plain soil in Alabama, USA.

Methods
The study site was located in the Alabama Agricultural Experiment Station's E.V. Smith Research Center, near Shorter, Alabama, USA. Four management treatments were established in late summer of 2000 on a corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.) rotation that had 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.) was used as winter cover before cotton, and a mixture of crimson clover

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(*Trifolium incarnatum* L.) with white lupin (*Lupinus albus* L.) and fodder radish (*Raphanus sativus* L.) was used as winter cover before corn. Four strips per crop with an average length of 244 m were established across the landscape, with each strip having one of the four management systems. Each strip was further divided into cells to simplify sampling and field measurements. A total of six replications were established on the 9 ha field, with one replication consisting of eight strips (four management systems x two crops). Maximum slope was 8% with 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 (Figure 1).

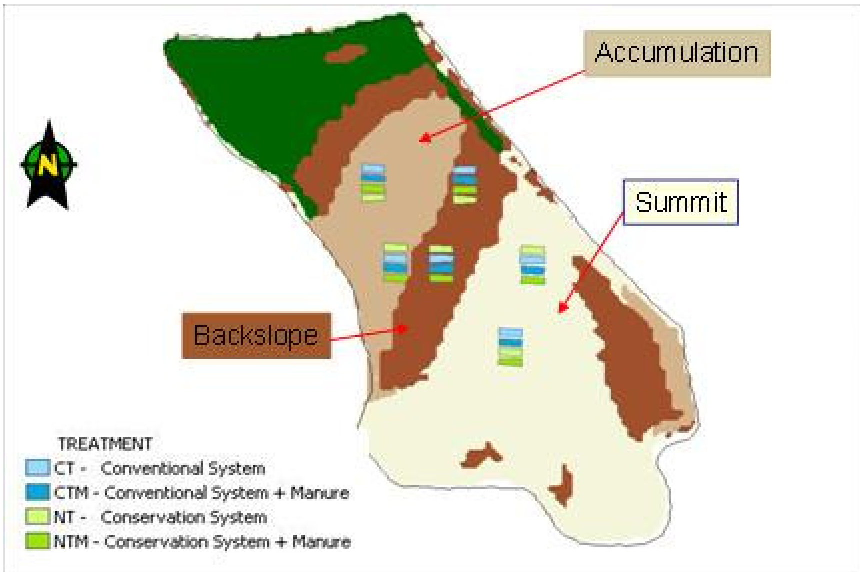


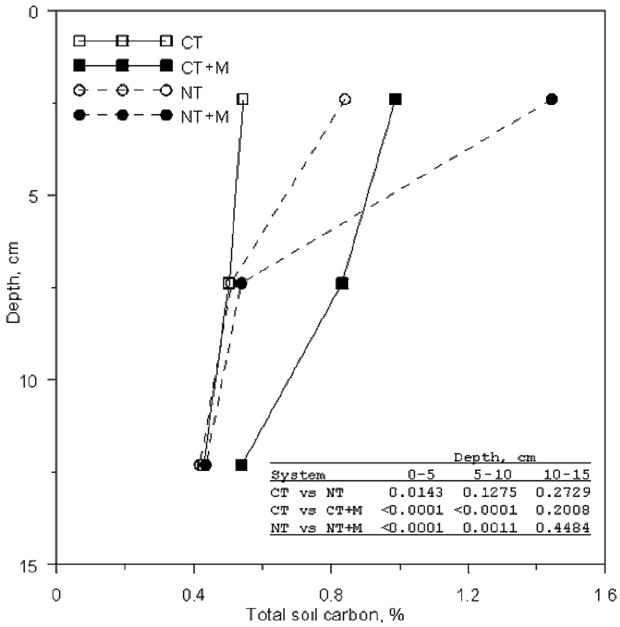
Figure 1. Location of sampling cells for each of the three landscape zones used in this study. The green region in the northern section of the field is an intermediate zone not included in this research.

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

On the surface 5 cm of soil, total C was greatest in the NT+M followed by CT+M, NT, and CT (Figure 2). Differences in C content between CT and NT were significant at the 0-5 cm of depth only. Non-inversion tillage increased C content by 54.7% on the surface soil, and by 1.3% from 5-10 cm of depth. However, C content was 2.5% lower in the NT than in the CT at the 10-15 cm 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 ($P \leq 0.001$) 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 (Figure 2).

Manure application significantly increased C content for CT+M and NT+M when compared to CT and NT on the top 10 cm of soil (Figure 2). Carbon content was increased by 81.9, 65.7, and 26.2% from 0-5, 5-10 and 10-15 cm 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 0-5, 5-10 and 10-15 cm of depth, respectively. Landscape position had no significant effect ($P = 0.39$) on soil C content (Figure 3).



System	Depth, cm 0-5	5-10	10-15
CT vs NT	0.0143	0.1275	0.2729
CT vs CT+M	<0.0001	<0.0001	0.2008
NT vs NT+M	<0.0001	0.0011	0.4484

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 three depths is depicted in the table insert.

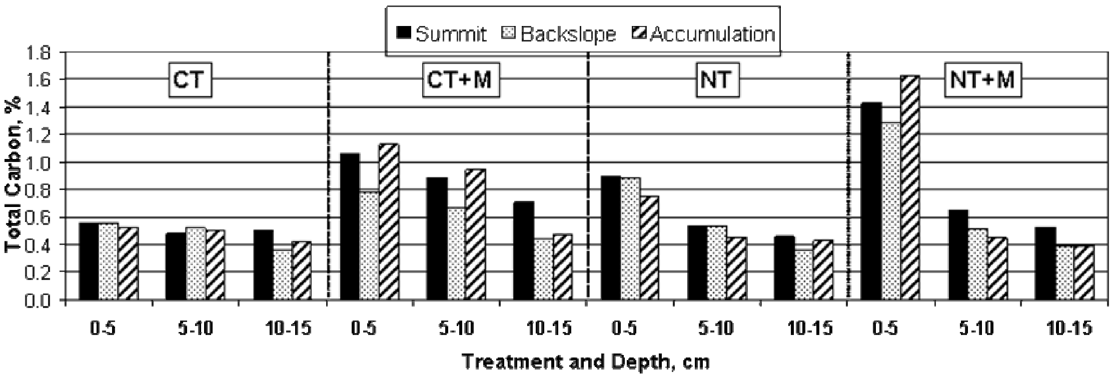


Figure 3. Total soil carbon content by landscape position, depth and management system (CT - conventional; CT+M - conventional with manure; NT - no-till; NT+M - no-till with manure)

Overall, non-inversion tillage increased infiltration in all zones. 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. Manure application did not improve infiltration within tillage system in the study area, suggesting tillage had a greater influence on infiltration. No main effect for treatment ($P = 0.51$) and zone ($P = 0.27$) was observed for aggregate stability. This may be attributed to the large variability in aggregate stability measurements.

Conclusion

Manure significantly increased C content in CT and NT treatments, especially in the 0-5 cm 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.

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