Presented at the 31st Conservation Agricultural Systems Conference
held at the Eastern Shore of Virginia on 20-23 July 2009

CAN THE SOIL CONDITIONING INDEX PREDICT SOIL ORGANIC CARBON SEQUESTRATION WITH CONSERVATION AGRICULTURAL SYSTEMS IN THE SOUTH?

Alan J. Franzluebbers[1]*, Hector J. Causarano[2], M. Lee Norfleet[3]
[1]USDA–Agricultural Research Service, 1420 Experiment Station Road, Watkinsville GA 30677
[2]National University of Asuncion, San Lorenzo, Paraguay
[3]USDA–Natural Resources Conservation Service, 808 E. Blackland Road, Temple TX 76502
*alan.franzluebbers@ars.usda.gov

SUMMARY

The soil conditioning index (SCI) is a relatively simple model used by NRCS to predict changes in soil organic C. It is based on three important conditions: (1) organic material (OM), (2) field operations (FO), and (3) erosion (ER). Our objective was to develop quantitative relationships between (1) published soil organic C data derived from field experiments under various management systems and (2) SCI values predicted from those management systems. Within a field study, SCI was usually highly related to soil organic C content. The SCI appears to reasonably estimate changes in soil organic C with adoption of conservation agricultural systems in the southeastern USA.

INTRODUCTION

Rapid and reliable assessments of the potential of various agricultural management systems to sequester soil organic C are needed to promote conservation and help mitigate greenhouse gas emissions. A growing database is emerging from detailed field experiments on how conservation agricultural systems can sequester soil organic C (Franzluebbers, 2005; 2009). Unfortunately, many results appear to be site-, soil- and cropping system-specific, resulting in uncertainty of how to predict the effect of management in different environments, soil types, and crop management systems (Sainju et al., 2007; Franzluebbers and Stuedemann, 2008; Novak et al., 2009).

The soil conditioning index is a relatively simple model used by the USDA Natural Resources Conservation Service that could be useful to predict changes in soil organic C. It is based on three important conditions: (1) organic material (OM) grown or added to the soil, (2) field operations (FO) that alter organic material placement in the soil profile and that stimulate organic matter breakdown, and (3) erosion (ER) that removes and sorts surface soil organic matter. Our objective was to develop quantitative relationships between (1) published soil organic C data derived from field experiments under various management systems throughout the southeastern USA and (2) index values predicted from those management systems using the soil conditioning index.

MATERIALS AND METHODS

Soil organic C content data from various field studies comparing conventional and conservation agricultural management approaches were summarized in two recent publications

(Franzluebbers, 2005; 2009). The soil conditioning index (SCI) was run for individual management conditions under the soil and geographical conditions of sites listed in Table 1. Soil organic C and SCI values were analyzed separately by regression from within individual field studies with multiple management conditions. Multiple field studies were then pooled within the same major land resource and/or state to test if relationships were stable.

RESULTS AND DISCUSSION

On a Cecil sandy loam in Watkinsville GA, soil organic C increased with decreasing tillage intensity and time since last tillage (Franzluebbers et al., 1999). The SCI varied similarly and resulted in a curvilinear relationship between soil organic C content at the end of 4 years of management and SCI (Fig. 1). The hockey stick shape of the curve suggests that when SCI is positive, very large increases in soil organic C could occur (as compared to relatively small changes in soil organic C with large variations when SCI was negative).

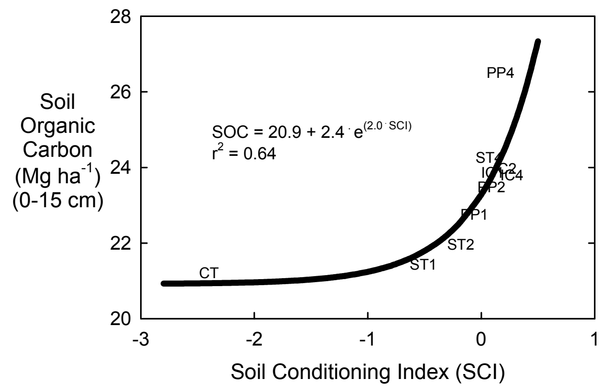

Figure 1. Relationship of soil organic C at the end of 4 yr of management to the soil conditioning index on a Cecil sandy loam in Watkinsville GA. Management was crimson clover / pearl millet rotated with crimson clover / cotton under conventional disk tillage (CT) and no-tillage planting with either paraplow (PP), in-row chisel (IC), or shallow cultivation tillage (ST) with frequencies of 1, 2, and 4 yr ago. Soil organic C data from Franzluebbers et al. (1999).

On a Pacolet sandy loam in Auburn AL, soil organic C increased in all crop rotations following 3.5 yr of conservation tillage (Siri-Prieto et al. (2002). The average rate of soil organic C sequestration was 1402 lb/acre/yr (1.57 ± 0.26 Mg C ha^{-1} yr^{-1} among the five rotations investigated). The SCI was linearly related to the soil organic C content in these cotton management systems that were previously managed for 100 yr under conventional tillage (Fig. 2). The SCI allowed only 800 lb/acre of dry matter accumulation with annual clover as cover crop. Changing the cover crop to wheat allowed 4080 lb/acre of dry matter accumulation and this increased the strength of the relationship between soil organic C and SCI from $r^2 = 0.40$ to $r^2 = 0.58$. This adjustment suggests that some modification is likely needed to adjust cover crop growth dynamics to the conditions prevalent in the southeastern USA (rather than the Pacific Northwest region, in which annual clover was derived in the SCI simulation).

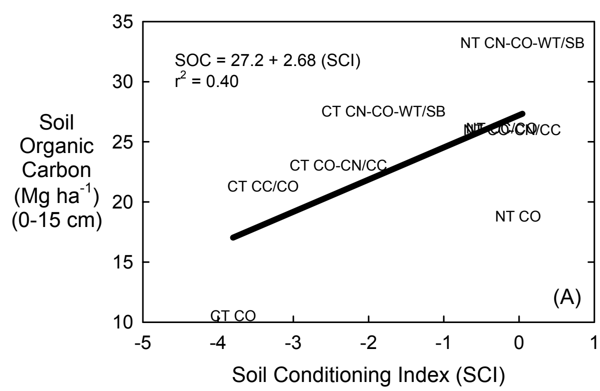

Figure 2. Relationship of soil organic C at the end of 3.5 yr of management to the soil conditioning index on a Pacolet sandy loam in Auburn AL. Management was continuous cotton (CO), crimson clover (CC) / cotton, crimson clover / cotton – crimson clover / corn (CN), and crimson clover / cotton – crimson clover / corn – wheat (WT) / soybean (SB) under conventional tillage (CT) and no tillage (NT). Soil organic C data from Siri-Prieto et al. (2002).

On a Weswood silty clay loam in College Station TX, soil organic C increased with a change from conventional tillage to no tillage and also with greater complexity of crop rotations (Fig. 3). The changes in soil organic C were highly related to the SCI values for these cropping systems. Since published studies varied in the depth of soil sampled and the number of years that cropping systems had been implemented, soil organic C were averaged over time and normalized to a common sampling depth. Soil organic C averaged 11.5 kg C m^{-3} under conventional tillage and 14.3 kg C m^{-3} under no tillage ($p < 0.01$), while SCI was -2.7 $\pm$ 0.7 under conventional tillage and -0.3 $\pm$ 0.3 under no tillage. The normalization step that was necessary in this evaluation suggests that consistency in estimating soil organic C sequestration (with regards to soil depth and time) is needed to obtain the most robust comparisons. Further work is needed to obtain peer-reviewed and verifiable relationships between soil organic C and SCI under a diversity of evaluation conditions.

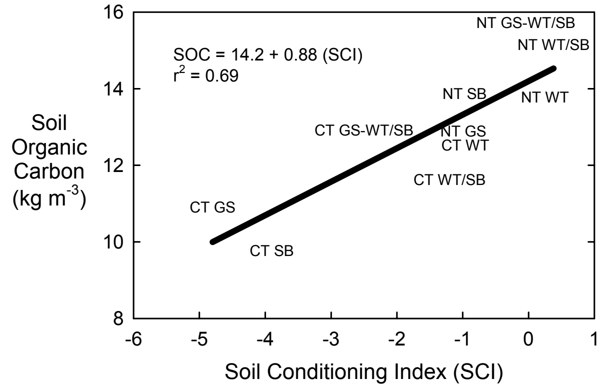

Figure 3. Relationship of soil organic C to the soil conditioning index on a Weswood silty clay loam in College Station TX. Management was continuous grain sorghum (GS), continuous soybean (SB), continuous wheat (WT), wheat / soybean, and sorghum – wheat / soybean under conventional tillage (CT) and no tillage (NT). Soil organic C data were collected at the end of 9, 10, and 20 yr of management at depths of 15, 20, and 30 cm from a number of studies, including Franzluebbers et al. (1994, 1995, 1998), Wright and Hons (2004, 2005), and Dou and Hons (2006).

Comparing across three locations in North Carolina and South Carolina, relationships of SCI to soil organic C were all linear within a location, but non-linear across locations (Fig. 4). Similar to the result in Georgia in Figure 1, a sharp increase in soil organic C was observed with a small change in SCI when positive. This curvilinear feature was also observed when SCI was compared against simulated soil organic C using the process-based model, EPIC (Abrahamson et al. 2007, 2009). Further work will be needed to explore cropping systems with positive SCI values to understand if soil organic C more typically follows a curvilinear or linear relationship with SCI. This will likely require more complex crop rotations, and especially with sod-based grasses and legumes in rotation with grain and fiber crops (Franzluebbers, 2007).

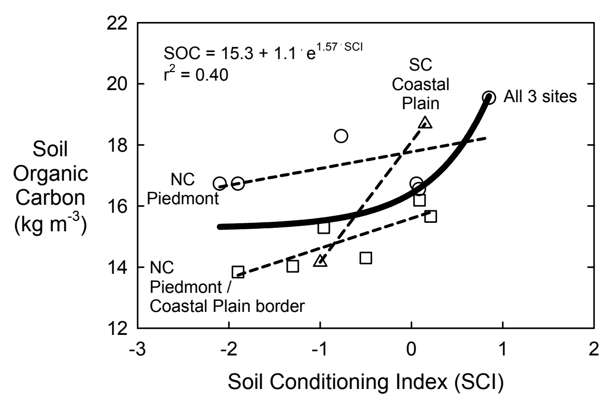

Figure 4. Relationship of soil organic C to the soil conditioning index at a Piedmont, Coastal Plain, and border location in North Carolina and South Carolina. Soil organic C data in South Carolina were from Karlen et al. (1989), Hun et al. (1996), Novak et al. (1996, 2007), Ding et al. (2002), and Bauer et al. (2006). Soil organic C data in North Carolina were from Naderman et al. (2004) and Franzluebbers and Brock (2007).

From 260 observations throughout the region, SCI was only weakly related to soil organic C (Fig. 5). However, soil organic C was greater ($p < 0.001$) under no tillage (14.7 $\pm$ 0.4 kg m^{-3})

than under conventional tillage (12.8 ± 0.5 kg m^{-3}). As well, SCI was greater under no tillage (0.2 ± 0.1) than under conventional tillage (-1.7 ± 0.2). The weak strength of all data together may be as much a function of how soil organic C inherently differs among locations and studies as much as the influence of SCI. We plan to further investigate how to better express soil organic C and SCI relationships, as there certainly may be other ways of presenting the strong differences in both SCI and soil organic C between these two contrasting tillage systems.

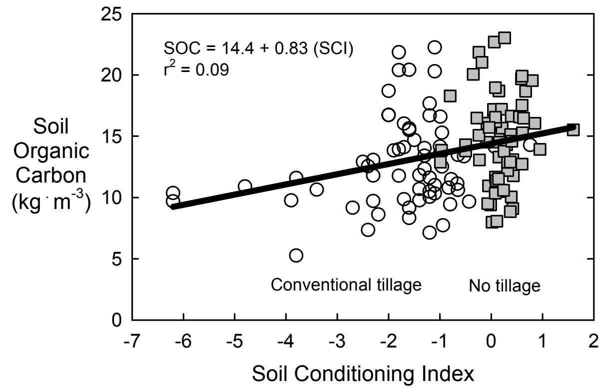

Figure 5. Relationship of soil organic C to the soil conditioning index across the 27 locations listed in Table 1.

CONCLUSIONS

The soil conditioning index was highly sensitive to the extent of tillage. This was especially true within each location investigated. When all data were compiled into a common analysis, only a weak relationship was found between soil organic C and SCI. However, there was clear separation between conventional and no tillage systems in both soil organic C content and SCI value.

Modifications to SCI management input variables may be necessary, since some conditions were not developed specifically for cropping systems in the southeastern USA. In addition, variations in soil organic C measurement protocol require some method of standardization to be able to pool data across studies, locations, and soil types.

Further work is needed to better define the relationships between soil conditioning index and soil organic C at higher index values, since variation in response was greatest and fewer observations were available at this end of the spectrum.

ACKNOWLEDGEMENTS

We gratefully acknowledge developmental collaboration in using the soil conditioning index with Deborah Beese. Financial support was provided in part by Cotton Incorporated (Agr. No. 05-712) and USDA-ARS GRACEnet Cross-Location Research Project.

REFERENCES

Abrahamson, D.A., M.L. Norfleet, H.J. Causarano, J.R. Williams, J.N. Shaw, and A.J. Franzluebbers. 2007. Effectiveness of the soil conditioning index as a carbon management tool in the southeastern USA based on comparison with EPIC. J. Soil Water Conserv. 62:94-102.

Abrahamson, D.A., H.J. Causarano, J.R. Williams, M.L. Norfleet, and A.J. Franzluebbers. 2009. Predicting soil organic carbon sequestration in the southeastern United States with EPIC and the soil conditioning index. J. Soil Water Conserv. 64:134-144.

Bauer, P.J., J.R. Frederick, J.M. Novak, and P.G. Hunt. 2006. Soil CO2 flux from a norfolk loamy sand after 25 years of conventional and conservation tillage. Soil Till. Res. 90:205-211.

Beare, M.H., P.F. Hendrix, and D.C. Coleman. 1994. Water-stable aggregates and organic matter fractions in conventional- and no-tillage soils. Soil Sci. Soc. Am. J. 58:777-786.

Ding, G., J.M. Novak, D. Amarasiriwardena, P.G. Hunt, and B. Xing. 2002. Soil organic matter characteristics as affected by tillage management. Soil Sci. Soc. Am. J. 66:421-429.

Dou, F., and F.M. Hons. 2006. Tillage and nitrogen effects on soil organic matter fractions in wheat-based systems. Soil Sci. Soc. Am. J. 70:1896-1905.

Edwards, J.H., C.W. Wood, D.L. Thurlow, and M.E. Ruf. 1992. Tillage and crop rotation effects on fertility status of a Hapludult soil. Soil Sci. Soc. Am. J. 56:1577-1582.

Feng, Y., A.C. Motta, C.H. Burmester, D.W. Reeves, E. van Santen, and J.A. Osborne. 2002. Effects of tillage systems on soil microbial community structure under a continuous cotton cropping system. p. 222-226. *In* E. van Santen (ed.) Making Conservation Tillage Conventional: Building a Future on 25 Years of Research, Special Report No. 1, Alabama Agric. Expt. Stn., Auburn Univ.

Fesha, I.G., J.N. Shaw, D.W. Reeves, C.W. Wood, Y. Feng, M.L. Norfleet, and E. van Santen. 2002. Land use effects on soil quality parameters for identical soil taxa. p. 233-238. *In* E. van Santen (ed.) Making Conservation Tillage Conventional: Building a Future on 25 Years of Research, Special Report No. 1, Alabama Agric. Expt. Stn., Auburn Univ.

Franzluebbers, A.J. 2005. Soil organic carbon sequestration and agricultural greenhouse gas emissions in the southeastern USA. Soil Till. Res. 83:120-147.

Franzluebbers, A.J. 2007. Integrated crop-livestock systems in the southeastern USA. Agron. J. 99:361-372.

Franzluebbers, A.J. 2009. Achieving soil organic carbon sequestration with conservation agricultural systems in the southeastern USA. Soil Sci. Soc. Am. J. (in press).

Franzluebbers, A.J., and B.G. Brock. 2007. Surface soil responses to silage cropping intensity on a Typic Kanhapludult in the piedmont of North Carolina. Soil Till. Res. 93:126-137.

Franzluebbers, A.J., F.M. Hons, and D.A. Zuberer. 1994. Long-term changes in soil carbon and nitrogen pools in wheat management systems. Soil Sci. Soc. Am. J. 58:1639-1645.

Franzluebbers, A.J., F.M. Hons, and D.A. Zuberer. 1995. Soil organic carbon, microbial biomass, and mineralizable carbon and nitrogen in sorghum. Soil Sci. Soc. Am. J. 59:460-466.

Franzluebbers, A.J., F.M. Hons, and D.A. Zuberer. 1998. *In situ* and potential CO_2 evolution from a fluventic Ustochrept in southcentral Texas as affected by tillage and crop management. Soil Till. Res. 47:303-308.

Franzluebbers, A.J., G.W. Langdale, and H.H. Schomberg. 1999. Soil carbon, nitrogen, and aggregation in response to type and frequency of tillage. Soil Sci. Soc. Am. J. 63:349-355.

Franzluebbers, A.J., H.H. Schomberg, and D.M. Endale. 2007. Surface-soil responses to paraplowing of long-term no-tillage cropland in the Southern Piedmont USA. Soil Till. Res. 96:303-315.

Franzluebbers, A.J., and J.A. Stuedemann. 2008. Early response of soil organic fractions to tillage and integrated crop-livestock production. Soil Sci. Soc. Am. J. 72:613-625.

Grofffman, P.M. 1984. Nitrification and denitrification in conventional and no-tillage soils. Soil Sci. Soc. Am. J. 49:329-334.
Hendrix, P.F., A.J. Franzluebbers, and D.V. McCracken. 1998. Management effects on C accumulation and loss in soils of the southern Appalachian Piedmont of Georgia. Soil Till. Res. 47:245-251.
Hu, S., D.C. Coleman, M.H. Beare, and P.F. Hendrix. 1995. Soil carbohydrates in aggrading and degrading agroecosystems: Influences of fungi and aggregates. Agric. Ecosys. Environ. 54:77-88.
Hu, S., D.C. Coleman, C.R. Carroll, P.F. Hendrix, and M.H. Beare. 1997. Labile soil carbon pools in subtropical forest and agricultural ecosystems as influenced by management practices and vegetation types. Agric. Ecosys. Environ. 65:69-78.
Hunt, P.G., D.L. Karlen, T.A. Matheny, and V.L. Quisenberry. 1996. Changes in carbon content of a Norfolk loamy sand after 14 years of conservation or conventional tillage. J. Soil Water Conserv. 51:255-258.
Karlen, D.L., W.R. Berti, P.G. Hunt, and T.A. Matheny. 1989. Soil-test values after eight years of tillage research on a Norfolk loamy sand. Commun. Soil Sci. Plant Anal. 20:1413-1426.
McCarty, G.W., and J.J. Meisinger. 1997. Effects of N fertilizer treatments on biologically active N pools in soils under plow and no tillage. Biol. Fertil. Soils 24:406-412.
Motta, A.C.V., D.W. Reeves, and J.T. Touchton. 2002. Tillage intensity effects on chemical indicators of soil quality in two Coastal Plain soils. Commun. Soil Sci. Plant Anal. 33:913-932.
Naderman, G.C., B.G. Brock, G.B. Reddy, and C.W. Raczkowski. 2004. Six years of continuous conservation tillage at the Center for Environmental Farming Systems (CEFS). Part I. Impacts on soil bulk density and carbon content for differing soils and crop rotations. Ann. Mtg. Soil Sci. Soc. North Carolina, 21 January 2004, Raleigh, NC.
Novak, J.M., P.J. Bauer, and P.G. Hunt. 2007. Carbon dynamics under long-term conservation and disk tillage management in a Norfolk loamy sand. Soil Sci. Soc. Am. J. 71:453-456.
Novak, J.M., J.R. Frederick, P.J. Bauer, and D.W. Watts. 2009. Rebuilding organic carbon contents in Coastal Plain soils using conservation tillage systems. Soil Sci. Soc. Am. J. 73:622-629.
Novak, J.M., D.W. Watts, and P.G. Hunt. 1996. Long-term tillage effects on atrazine and fluometuron sorption in Coastal Plain soils. Agric. Ecosys. Environ. 60:165-173.
Potter, K.N., and F.W. Chichester. 1993. Physical and chemical properties of a Vertisol with continuous controlled-traffic, no-till management. Trans. ASAE 36:95-99.
Potter, K.N., H.A. Torbert, O.R. Jones, J.E. Matocha, J.E. Morrison, Jr., and P.W. Unger. 1998. Distribution and amount of soil organic C in long-term management systems in Texas. Soil Till. Res. 47:309-321.
Reeves, D.W., and D.P. Delaney. 2002. Conservation rotations for cotton production and carbon storage. p. 344-348. *In* E. van Santen (ed.) Making Conservation Tillage Conventional: Building a Future on 25 Years of Research, Special Report No. 1, Alabama Agric. Expt. Stn., Auburn Univ.
Reicosky, D.C., W.A. Dugas, and H.A. Torbert. 1997. Tillage-induced soil carbon dioxide loss from different cropping systems. Soil Till. Res. 41:105-118.
Reicosky, D.C., D.W. Reeves, S.A. Prior, G.B. Runion, H.H. Rogers, and R.L. Raper. 1999. Effects of residue management and controlled traffic on carbon dioxide and water loss. Soil Till. Res. 52:153-165.

Rhoton, F.E. 2002. Influence of time on soil response to no-till practices. Soil Sci. Soc. Am. J. 64:700-709.

Rhoton, F.E., M.J. Shipitalo, and D.L. Lindbo. 2002. Runoff and soil loss from midwestern and southeastern US silt loam soils as affected by tillage practice and soil organic matter content. Soil Till. Res. 66:1-11.

Sainju, U.M., H.H. Schomberg, B.P. Singh, W.F. Whitehead, P.G. Tillman, and S.L. Lachnicht-Weyers. 2007. Cover crop effect on soil carbon fractions under conservation tillage cotton. Soil Till. Res. 96:205-218.

Sainju, U.M., Z.N. Senwo, E.Z. Nyakatawa, I.A. Tazisong, and K.C. Keddy. 2008. Tillage, cropping systems, and nitrogen fertilizer source effects on soil carbon sequestration and fractions. J. Environ. Qual. 37:880-888.

Sainju, U.M., B.P. Singh, and W.F. Whitehead. 2002. Long-term effects of tillage, cover crops, and nitrogen fertilization on organic carbon and nitrogen concentrations in sandy loam soils in Georgia, USA. Soil Till. Res. 63:167-179.

Sainju, U.M., B.P. Singh, W.F. Whitehead, and S. Wang. 2006. Carbon supply and storage in tilled and nontilled soils as influenced by cover crops and nitrogen fertilization. J. Environ. Qual. 35:1507-1517.

Salinas-Garcia, J.R., F.M. Hons, and J.E. Matocha. 1997. Long-term effects of tillage and fertilization on soil organic matter dynamics. Soil Sci. Soc. Am. J. 61:152-159.

Siri-Prieto, G., D.W. Reeves, and R.L. Raper. 2007. Tillage systems for a cotton-peanut rotation with winter-annual grazing: Impacts on soil carbon, nitrogen and physical properties. Soil Till. Res. 96:260-268.

Siri-Prieto, G., D.W. Reeves, J.N. Shaw, and C.C. Mitchell. 2002. Impact of conservation tillage on soil carbon in the ‘Old Rotation’. p. 277-282. *In* E. van Santen (ed.) Making Conservation Tillage Conventional: Building a Future on 25 Years of Research, Special Report No. 1, Alabama Agric. Expt. Stn., Auburn Univ.

Spargo, J.T., M.M. Alley, R.F. Follett, and J.V. Wallace. 2008. Soil carbon sequestration with continuous no-till management of grain cropping systems in the Virginia coastal plain. Soil Till. Res. 100:133-140.

Terra, J.A., D.W. Reeves, J.N. Shaw, and R.L. Raper. 2005. Impacts of landscape attributes on carbon sequestration during the transition from conventional to conservation management practices on a Coastal Plain field. J. Soil Water Conserv. 60:438-446.

Torbert, H.A., S.A. Prior, and G.B. Runion. 2004. Impact of the return to cultivation on carbon (C) sequestration. J. Soil Water Conserv. 59:1-8.

Truman, C.C., D.W. Reeves, J.N. Shaw, A.C. Motta, C.H. Burmester, R.L. Raper, and E.B. Schwab. 2003. Tillage impacts on soil property, runoff, and soil loss variations from a Rhodic Paleudult under simulated rainfall. J. Soil Water Conserv. 58:258-267.

Weil, R.R., P.W. Benedetto, L.J. Sikora, and V.A. Bandel. 1988. Influence of tillage practices on phosphorus distribution and forms in three Ultisols. Agron. J. 80:503-509.

Weil, R.R., K.A. Lowell, and H.M. Shade. 1993. Effects of intensity of agronomic practices on a soil ecosystem. Am. J. Altern. Agric. 8:5-14.

Wright, A.L., and F.M. Hons. 2004. Soil aggregation and carbon and nitrogen storage under soybean cropping sequences. Soil Sci. Soc. Am. J. 68:507-513.

Wright, A.L., and F.M. Hons. 2005. Soil carbon and nitrogen storage in aggregates from different tillage and crop regimes. Soil Sci. Soc. Am. J. 69:141-147.

Zibilske, L.M., J.M. Bradford, and J.R. Smart. 2002. Conservation tillage induced changes in organic carbon, total nitrogen and available phosphorus in a semi-arid alkaline subtropical soil. Soil Till. Res. 66:153-163.

Table 1. Locations and conditions for comparing soil organic C and soil conditioning index in the southeastern USA.

Location	*Soil*	*Management variables*	*Source*
AL Escambia Co.	*Benndale fSL*	*Tillage*	*Motta et al. (2002)*
AL DeKalb Co.	*Hartsells fSL*	*Tillage, rotation*	*Edwards et al. (1992), Fesha et al. (2002)*
AL Henry Co.	*Norfolk LS*	*Tillage*	*Siri-Prieto et al. (2007)*
AL, Lee Co.	*Blanton LS, Pacolet SL*	*Tillage, rotation, cover crop*	*Siri-Prieto et al. (2002), Torbert et al. (2004)*
AL Limestone Co.	*Decatur SiL*	*Tillage, rotation, manure*	*Feng et al. (2002), Truman et al. (2003), Sainju et al. (2008)*
AL Macon Co.	*Compass LS*	*Tillage, rotation, manure*	*Reicosky et al. (1999), Terra et al. (2005), Reeves and Delaney (2002)*
GA Bartow Co.	*Dothan SL*	*Tillage*	*Sainju et al. (2007)*
GA Clarke Co.	*Wehadkee L*	*Tillage*	*Groffman (1984), Beare et al. (1994), Hu et al. (1995, 1997), Hendrix et al. (1998)*
GA Oconee Co.	*Cecil SL*	*Tillage, rotation, cover crop*	*Franzluebbers et al. (1999, 2007), Franzluebbers and Stuedemann (2008)*
GA Peach Co.	*Norfolk LfS*	*Tillage, rotation, cover crop*	*Sainju et al. (2002, 2006)*
GA Spalding Co.	*Cecil SL*	*Tillage*	*Hu et al. (1997), Hendrix et al. (1998)*
GA Tift Co.	*Tifton LS*	*Tillage*	*Sainju et al. (2007)*
MD Howard Co.	*Delanco SiL*	*Tillage, fertilizer*	*McCarty and Meisinger (1997)*
MD Prince Georges Co.	*Woodstown SL*	*Tillage*	*Weil et al. (1993)*
MD Queen Annes Co.	*Matapeake SiL*	*Tillage, fertilizer*	*McCarty and Meisinger (1997)*
MD Wicomico Co.	*Mattapex SiL*	*Tillage*	*Weil et al. (1998)*
MS Tate Co.	*Grenada SiL*	*Tillage, rotation*	*Rhoton (2002), Rhoton et al. (2002)*
NC Iredell Co.	*Iredell L*	*Tillage, rotation*	*Franzluebbers and Brock (2007)*
NC Wayne Co.	*Altavista fSL*	*Tillage, rotation*	*Naderman et al. (2004)*
SC Florence Co.	*Norfolk LS*	*Tillage*	*Karlen et al. (1989), Hunt et al. (1996), Novak et al. (1996, 2007), Ding et al. (2002), Bauer et al. (2006)*
TX Bell Co.	*Houston Black C*	*Tillage, rotation*	*Potter and Chichester (1993), Reicosky et al. (1997), Potter et al. (1998)*
TX Brazos Co.	*Weswood SiCL*	*Tillage, rotation*	*Franzluebbers et al. (1994, 1995, 1998), Wright and Hons (2004, 2005), Dou and Hons (2006)*
TX Hidalgo Co.	*Hidalgo SCL*	*Tillage*	*Zibilske et al. (2002)*
TX Nueces Co.	*Orelia L*	*Tillage*	*Salinas-Garcia et al. (1997), Potter et al. (1998)*
VA Richmond Co.	*Altavista fSL, Pamunkey L, Emporia L*	*Tillage, manure*	*Spargo et al. (2008)*

C is clay, fSL is fine sandy loam, L is loam, LfS is loamy fine sand, LS is loamy sand, SCL is sandy clay loam, SiL is silt loam, and SL is sandy loam.