SOIL QUALITY ON GEORGIA'S FARMS: IMPLICATIONS FOR WATER QUALITY

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REFERENCE: Proceedings of the 2003 Georgia Water Resources Conference, held April 23-24, 2003, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. Many Georgia farmers have reported noticeable soil quality improvements in their crop fields after several years of continuous conservation tillage. The farmers state that their soils are becoming richer in soil organic matter, resulting in less runoff, soil erosion, and sedimentation.

There is little on-farm data available in Georgia to document soil quality differences in fields under long-term conservation tillage as compared with those being farmed with conventional tillage. The Georgia Soil Management Team was formed to collect on-farm data and to educate farmers, agricultural professionals, and others on the effects of management on soil quality and water quality.

INTRODUCTION

Farmers that have used a continuous conservation tillage system for several years frequently report that the quality of their soil has improved. The farmers report that their soils have more soil organic matter resulting in reduced crusting, improved soil tilth, more earthworms, less soil erosion, and decreased runoff, all of which can result in improved production, crop quality, and water quality. These soil quality improvements are often discussed at grower meetings and Conservation Tillage Alliance meetings where farmers gather to learn from each other's experiences, but there is little on-farm data to validate the growers' reports.

Research has shown that continuous conservation tillage significantly improves soil surface characteristics (Bruce et al., 1995), decreases soil erosion, increases infiltration, decreases evaporation, and improves water use efficiency (Reicosky et al., 1995), and reduces nutrient losses (Seta et al., 1993) as compared with conventional tillage. Managing crop residues on the surface with no-till has resulted in the greatest improvement in soil and water management of the 20th century (Langdale and Moldenhauer, 1995).

There is significant research data available on the effects of long-term conservation tillage on improving many soil quality characteristics, but information from a nearby farm with similar soils is sometimes more effective in illustrating the long-term benefits of maintaining crop residue on the soil surface.

The Georgia Soil Management Team was formed in 1999 to collect on-farm soil quality data and help educate farmers, agricultural professionals, and others on the effects of residue management on soil tilth, crusting, runoff, crop yields, soil biology, water quality, and air quality. The Team has used the Soil Quality Test Kit developed by USDA-Natural Recourses Conservation Service (NRCS) and Agricultural Research Service (ARS) to compare selected soil quality characteristics in fields with similar soils using either conservation tillage or conventional tillage. The Team includes farmers and representatives from NRCS, University of Georgia (UGA), Georgia Conservation Tillage Alliance, Inc., and Georgia Organics, Inc.

We hoped to develop a database that would show farmers the soil quality improvements that can be made on soils similar to theirs over time with different management. The Team members also hoped to demonstrate the Soil Quality Test Kit for farmers, agricultural agency personnel, and others such as those in science, 4-H, and vocational agriculture classes.

METHODS

The Georgia Soil Management Team has collected information for the database since 1999. Team members visit a Georgia county or group of counties in late fall or early winter after crop harvest but before any additional tillage operations are made. The local NRCS conservationist and/or county extension agent is contacted and asked to recommend farmers using a conservation tillage system who may want to participate in the study.

Once a conservation tillage farmer's field is selected, the site location is documented on county soil survey maps and road maps so the site can be revisited. The county soil

survey maps are used to identify the dominant soil series in the selected field.

We then select a sample site that is representative of the field. We avoid areas that are distinctly different, such as farm equipment travel lanes, field borders, fertilizer bands, areas within 150 feet of gravel roads, potholes, eroded spots, old building sites, etc. The sample site has a maximum radius of 50 feet and has similar surface soil texture, slope, crop growth, and management. All of the sub-sampling and replicate sampling is conducted within that radius. Sub-sampling sites are randomly selected within the sampling area.

A subset of parameters is selected to evaluate the physical, chemical, and biological aspects of soil quality. Bulk density and the rate of water infiltration are measured as an indicator of the physical component of soil quality. Soil samples collected for routine soil nutrient analysis (pH and available Ca, K, Mg, Mn, P, and Zn), as well as percent carbon (C) are analyzed at the UGA Soil, Plant, and Water Laboratory as indicators of the chemical component of soil quality. Water stable aggregate samples are evaluated as an indicator of biological activity.

Bulk density is measured using ring method described in the Soil Quality Test Kit Guide (USDA, 1998). Four samples (at a depth of 0-3 inches) are collected in each field's sampling area. Two samples are collected in crop rows and two samples are collected in untracked middles. The average bulk density of the samples taken is calculated for each field.

Water infiltration rates are measured according to the instructions in the Soil Quality Test Kit Guide. The procedure is run twice in each ring in the crop row and twice in an untracked middle to obtain both a dry and wet rate of infiltration. The average of the wet infiltration rates is recorded in the database.

Composite soil sub-samples (six or more taken at a 0-6 inch depth) are collected for routine nutrient test analysis performed at the UGA lab. The soil pH is determined on a 1.5:1 soil/water paste (Thomas, 1996). Soil test Ca, K, Mg, Mn, P, and Zn are extracted with Mehlich I solution (AOAC Method 968.08, Cunniff, 1996) and analyzed on an emission ICP by EPA 200.7 (USEPA, 1994).

Water infiltrates faster with increased organic matter in the top 0.6 inch (15-mm) of soil (Langdale, et al. 1992). Therefore, four composite soil samples are collected at a 0-0.5 inch depth for C analysis. Total C is analyzed on a LECO analyzer (Nelson and Sommers, 1996) and the results are converted to percent organic matter using a 1.724 multiplier.

Water stable aggregates are determined using the Soil Quality Test Kit Guide. Four sub-samples are collected at a 0-6 in. depth and an average percentage is calculated for the field.

A nearby field with similar soil farmed with conventional tillage is sampled for each conservation tillage site visited.

RESULTS

A total of 43 fields from 15 Georgia counties have been sampled since the fall of 1999. Counties from which samples have been analyzed are Ben Hill, Brooks, Burke, Candler, Coffee, Colquitt, Crisp, Houston, Irwin, Jenkins, Macon, Randolph, Tift, Turner, and Worth. Soil series sampled are Cowarts, Carnegie, Dothan, Faceville, Grady, Norfolk, Orangeburg, Pelham, Tifton, and Tifton-Ocilla. Most of these soils have a loamy sand, sandy loam, or sandy surface layer.

Cotton was grown during the previous growing season in most of the fields, but some were used to grow peanuts. Fields in conservation tillage ranged from one to 18 years. Because conservation tillage is a growing practice in Georgia, a large number of the fields sampled have been in conservation tillage ten years or less.

The definition of conservation tillage is "growing crops while managing crop residue on the soil surface year-round" (NRCS, 1999). Most of the conservation tillage system (CTS) fields sampled are planted with a system whereby all of the summer crops and the winter cover crops, usually rye, are planted with continuous conservation tillage methods. Some fields, however, are planted in a conservation tillage summer crop, but the fields are harrowed intensively before the winter cover crop is planted (conservation tillage/fall tillage - CT/FT). The number of fields sampled in each category is shown in Figure 1.

Bulk density averages and water stable aggregate averages in the CTS and CT/FT fields are similar to that of the conventionally tilled (CONV) fields.

Average soil organic matter (SOM) in the sampled fields ranged from 1.4% in CONV fields to 2.7% in CTS fields (Figure 2). CTS SOM averages are higher than CT/FT averages. Soils farmed with CTS longer than 3 years have a significantly higher percent of SOM than CONV tilled fields.

Water infiltration data is shown as the number of minutes required for one inch of distilled water to move into pre-wetted soil (Figure 3). Due to extended drought conditions, most of the soils sampled in 1999-2001 were very dry. Measurements taken in 2002 were under wet conditions. As expected, variability in water infiltration measurements is high and no significant differences are

seen among tillage practices. However, the time to infiltrate water tends to decrease the longer the field is in CTS or CT/FT.

DISCUSSION

Research has shown leaving crop residue on the soil surface is a strong contributor to long-term improvements in soil, water, and air quality. Improvements in soil quality will result in less soil erosion, decreased runoff, cleaner runoff, and reduced pollution of our water resources. Continuous long-term conservation tillage systems enable us to improve our cropland while it is being farmed. Improved crop productivity will also result.

The soil quality database is helping generate on-farm data from Georgia to illustrate these points. The data from this study has been shared with farmers, agricultural professionals, and others at numerous meetings, field days, and workshops.

Conservation tillage farmers have been very interested in how the data from their farm compares to data from nearby farms that use conventional tillage. The process has helped increase awareness about the importance of soil quality and how it can be improved with changes in land management.

The data has been used as a springboard to discuss the important link between soil quality, water quality, and air quality. Increasing water infiltration rates and the soil's water holding capacity help to make better use of rainfall and more efficient use of all water resources, including irrigation. Education on these issues is becoming more critical in Georgia as state policies are beginning to address the quality and scarcity of our water resources.

Because of the small number of fields sampled in each county, soil series, and management category, our intent is to use this data to show soil quality improvement trends that can be made with changes in land management. As additional fields are sampled in the future and previously sampled fields are revisited, we hope to develop a larger database and provide more specific data to show that many important soil quality characteristics of Georgia soils can be improved with changes in management.

We plan to continue collecting data from additional fields each fall and also return to previously sampled fields on a three-year cycle to document changes in soil quality.

ACKNOWLEDGEMENTS

We would like to thank all of the farmers and agricultural agency personnel who have helped us gather this information. We would also like to acknowledge support from USDA-NRCS, Pollution Prevention Assistance Division of GDNR, and USDA SARE PDP.

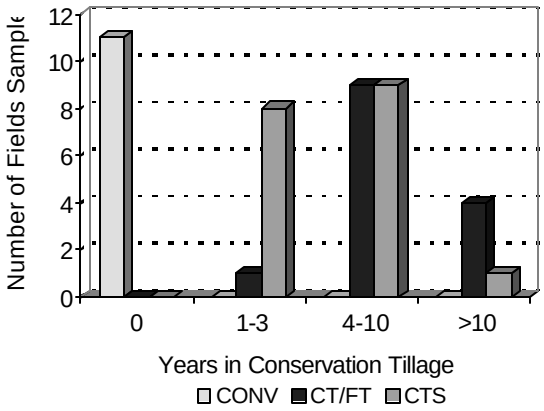

Figure 1. Number of fields sampled and analyzed for CONV-conventional tillage; CT/FT-conservation tillage/fall tillage; and CTS-conservation tillage system.

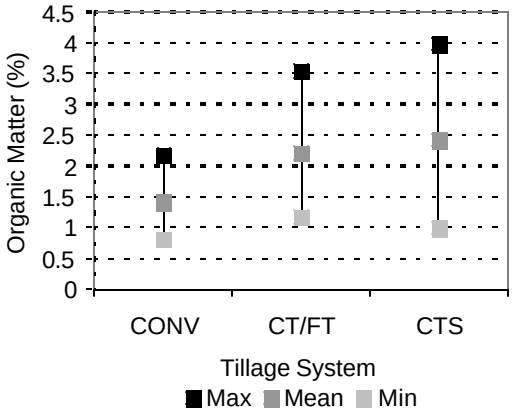

Figure 2. Ranges in percent organic matter from CONV-conventional tillage; CT/FT-conservation tillage/fall tillage; and CTS-conservation tillage system.

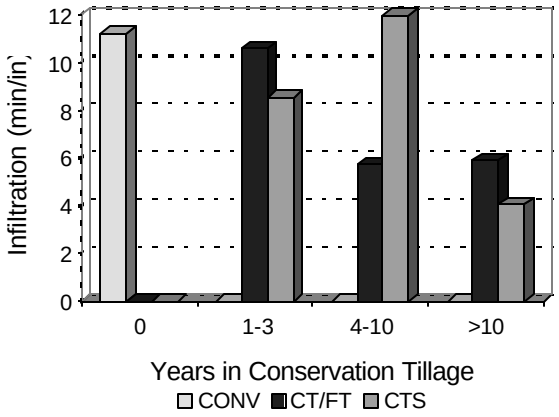

Figure 3. Average water infiltration rates (minutes/inch) for CONV-conventional tillage; CT/FT-conservation tillage/fall tillage; and CTS-conservation tillage system.

SELECTED REFERENCES

Bruce, R. R., G. W. Langdale, L. T. West, and W. P. Miller, 1995. Surface soil degradation and soil productivity restoration and maintenance. *Soil Science Society of America Journal* 59:654-660.

Cunniff, P. 1996. Official methods of analysis of AOAC International. 16th ed. AOAC International, Gaithersburg, MD.

Langdale, G. W., L. T. West, R. R. Bruce, W. P. Miller and A. W. Thomas, 1992. Restoration of eroded soil with conservation tillage. *Soil Tech*. 5:81-90.

Langdale, G. W. and W. C. Moldenhauer, 1995. Crop Residue Management to Reduce Erosion and Improve Soil Quality - Southeast. USDA-ARS Conservation Research Report Number 39, 53 p.

Nelson, D. W., and L. E. Sommers, 1996. Total carbon, organic carbon, and organic matter. In: Methods of Soil Analysis: Part 3. Chemical methods. SSSA Book Monogr. No. 5. Madison, WI, pp. 961-1010.

NRCS, 1999. National Handbook of Conservation Practices. USDA-NRCS. Washington, DC.

Reicosky, D. C., W. D. Kemper, G. W. Langdale, C. L. Douglas, Jr., and P. E. Rasmussen, 1995. Soil organic matter changes resulting from tillage and biomass production. *Journal of Soil and Water Conservation* 50:253-261.

Seta, A. K., R. L. Blevens, W. W. Frye, and B. J. Barfield, 1993. Reducing soil erosion and agricultural chemical losses with conservation tillage. *Journal of Environmental Quality* 22:661-665.

Thomas, G., 1996. Soil pH and acidity. In: Methods of Soil Analysis: Part 3. Chemical methods. SSSA and ASA Monogr. No. 5. Madison WI, pp.475-490.

USDA-Agricultural Research Service, Natural Resources Conservation Service, and Soil Quality Institute, 1998. Soil Quality Test Kit Guide. Auburn, AL.

USEPA, 1994. Methods for determination of metals in environmental samples. Supplement 1. EPA-600/R-94/111/May 1994. Environmental Monitoring Systems Lab, Office of Research and Development, Cincinnati, OH.