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Summary of the Soil Carbon Sequestration Assessment Program

Jason Warren
Soil and Water Conservation
Extension Specialist

Chad Godsey
Cropping Systems
Extension Specialist

The initiation of the Oklahoma Carbon Program facilitated the need for expansion of research and Extension activities by the Department of Plant and Soil Sciences related to soil carbon sequestration in Oklahoma soils. Prior to the initiation of the Oklahoma Carbon Program, few data were available to validate the sequestration rates used to calculate carbon offsets generated by changes in management such as grass plantings in cultivated cropland or conversion of cropland to no-till management. Therefore, in 2008, research to evaluate sequestration potential in Oklahoma soils was initiated.

This research currently focuses on soil carbon sequestration potential of no-till crop management and grass plantings in previously cultivated soils. These efforts focus on sampling both small plot experiments located on Oklahoma State University Agricultural Research Stations and producer cooperator's fields. The small plot data will allow for the assessment of how different management strategies influence carbon storage under no-till or established grass. In contrast, the on-farm sampling provides an assessment of the variation in carbon stocks and sequestration potential on a wide variety of soil types and environmental conditions.

On-Farm Sampling

On-farm sampling was initiated in 2008 with two objectives in mind. The first objective is to collect soil samples from no-till and grassland fields to provide a set of baseline data to allow changes in soil carbon stocks to be monitored. The second objective is to compare soil carbon stocks in soils under these two management scenarios to conventionally tilled production systems, which will provide a preliminary assessment of carbon sequestration potential.

Materials and Methods

Producer cooperator fields are sampled to provide "paired field" comparisons. Efforts are made to maximize the similarities between each of the two fields with respect to soil type and slope class. One field of each pair represents no-till crop production or established grasslands and one represents conventional tillage management for the region. When paired fields are not available, samples are collected from fields where no-till or planted grasslands were recently established. Samples collected from all no-till and grassland fields provide baseline data for potential long-term monitoring of soil carbon storage.

Soil samples collected from each field are analyzed for bulk density, total SOC, inorganic C and pH. Surface slope and condition (residue cover, erosion class) are also assessed at each sample location. In addition to these field and soil characteristics, management information is acquired from land managers. This information includes, but is not limited to, the following: five-year history of tillage, crop rotation, and yield. Efforts are also made to document and determine what production or economic situations will encourage land managers to revert back to conventional production practices or adopt new ones. This information will be valuable when evaluating the viability of a state wide carbon credit program. The ultimate number of fields to be included will depend on the availability of cooperative land managers and funds required to collect and process samples. Land manager contact is achieved through local Oklahoma Cooperative Extension Service personnel and collaborative interaction with Oklahoma Conservation Commisssion and Oklahoma Association of Conservation District personnel.

Preliminary Results

On-farm soil samples have been collected from 30 fields in nine counties across the state (Table 1). Data from these samples demonstrate the diversity of Oklahoma soils with respect to soil carbon stocks. The mass of carbon found in the top 16 inches of soils in Oklahoma ranges from 40 to 110 Mtons CO_2 $acre^{-1}$ in Goodwell and Miami, respectively. This wide range in carbon values results in variability that makes it difficult to find a significant difference between the carbon content of no-till soils and cultivated soils using the paired field approach. Soil samples collected from below 16 inches were not used in the current analysis because we assume management has little impact on carbon stocks below this depth. However, these samples will be useful for long-term monitoring purposes.

Table 1: Soil types and locations of fields included in on-farm sampling program.

Soil Type	*Location*	*Number of Fields Sampled**	*Average number of Years in NT*
Bethany Silt Loam	N. Canadian Watershed (Blaine and Canadian Co.)	7	3.5
Dale Silt Loam	N. Canadian Watershed	2	3.0
Grant Silt Loam	N. Canadian Watershed and Garfield Co.	5	6.3
Taloka Silt loam	Ottawa Co.	2	5.0
Port Silt loam	Noble Co.	2	7.0
Kirkland Silt loam	Noble Co.	2	5.0
Pond Creek Silt loam	Garfield and Woods Co.	4	3.5
Gruver Clay loam	Texas Co.	2	5.0
Grandfield Fine Sandy loam	Washita Co.	2	18.0
Tillman Loam	Cotton Co.	2	12.0
Average	Oklahoma	30	5.9

*The number of fields listed includes conventionally tilled fields.

The current data from 30 fields show the average difference between no-till (average age of no-till fields is 5.9 years) and conventional tillage soils is 4.4 Mtons CO_2 acre^{-1}. The average sequestration potential based on this limited data set is then 0.53 Mtons CO_2 acre^{-1} year^{-1} (± 0.77 Mtons CO_2 acre^{-1} at the 90 percent confidence level). This estimate assumes the carbon stocks of the no-till fields prior to conversion were the same as the current carbon stocks in the conventional tillage fields used for comparison. The current estimates used in the Oklahoma Carbon Program range between 0.2 and 0.6 Mtons CO_2 acre^{-1} year^{-1}. Therefore, the data collected thus far are in agreement with current estimates. However, the observed sequestration rates are highly variable therefore continued sampling is required to ensure an accurate assessment of carbon sequestration potential in OK.

Current efforts will result in the collection and analysis of soil samples from an additional 34 fields. These additional fields will provide improved representation of the carbon sequestration potential of our croplands. Additionally, future re-sampling of these fields will be much more useful in accurately evaluating the accumulation of carbon in no-till cropland compared to the “paired field” method currently used to assess sequestration potential.

Small Plot Research

No-till Field Crops

Long-term no-till field crop experiments are located in Altus, Goodwell, Lahoma, and Stillwater. The experiments at each of these locations include crop rotations that are commonly utilized in the perspective regions. For example, the Lahoma experiment contains continuous wheat under conventional and no-till management. The remaining treatments include intensified rotations that include full season summer crops such as corn, soybeans, or sorghum combined with wheat, which is followed by double crops such as soybean, sunflower, and sorghum.

Currently, data have been collected, analyzed, and compiled from the Goodwell location. The Altus location has been sampled but the data has not yet been complied. The two locations with the shortest history of no-till management (Lahoma and Stillwater) have yet to be sampled.

At each location, soil cores are collected to a target depth of 43 inches and analyzed for bulk density and organic carbon as described above. These experiments provide an opportunity to evaluate the influence crop rotation intensity and crop yield may have on carbon sequestration. They also provide for future opportunity to evaluate residue carbon resilience under various no-till rotations in different environments.

Preliminary Results-No-till Field Crops

Data from samples collected at Goodwell from dryland wheat-fallow-sorghum, and sunflower-sorghum rotations have been compiled. Both rotations were managed in continuous tilled or no-till treatments and replicated three times. At this location, only samples from the surface 8 inches of soil have been analyzed. These samples revealed that eight years of no-till management resulted in organic carbon contents of 25.5 and 23.6 Mtons CO_2-C acre^{-1} for the wheat-fallow-sorghum, and sunflower-sorghum rotations, respectively. In contrast the conventional tillage treatments contained 23.8 and 23.9 Mton CO_2-C acre^{-1} for the wheat-fallow-sorghum and sunflower-sorghum rotations, respectively. Comparison of the no-till and conventional tillage treatments suggest an annual carbon sequestration rates of 0.21 and -0.04 Mton CO_2-C acre^{-1} in the wheat-fallow-sorghum and sunflower-sorghum rotations, respectively, assuming the carbon stocks of the no-till treatments prior to initiation of the experiment were the same as the current carbon stocks in the conventional tillage treatments. The lack of C accumulation in the sunflower-sorghum rotation can be attributed to the fact that no successful sunflower crop was harvested during the eight years of the study, which reduced residue input into this no-till system compared to the wheat-fallow-sorghum rotation.

Grassland Plantings

In 2009, efforts to evaluate the carbon sequestration potential of cellulosic bioenergy feedstock production systems were initiated by collecting samples from a long-term (six-year) experiment evaluating production options for perennial grasses, in Stillwater, OK. The experiment included switchgrass, miscanthus, and eastern gamagrass, with each being harvested at two frequencies. The first harvest treatment was a single harvest after frost kill. The second harvest treatment included harvest at physiological maturity (approximately July) followed by a second harvest after frost kill.

In 2009, a four-year project was initiated to develop the practices and technologies necessary to ensure efficient, sustainable and profitable production of cellulosic biomass in Oklahoma. Assessment of soil carbon sequestration potential resulting from various biomass production options is included in this project. Briefly, in the spring of 2010 baseline soil samples were collected from two experiments, each of which are located at five sites in Oklahoma. The objective of the first experiment is to evaluate the biomass production potential of mixed grass production systems. The objective of the second experiment is to evaluate nitrogen requirements, and water use of switchgrass, mixed native grass, and forage sorghum. Soil cores were collected to a target depth of 43 inches from these two experiments located in Goodwell, Stillwater, Woodward, Chickasha, and Lane, OK. The samples were process as describe above for organic carbon and bulk density. In the fall of 2012, these ten experiments will again be sampled and carbon sequestration rates for the production systems will be assessed.

Preliminary Results-Grassland Plantings

Soil samples collected to a depth of 16 inches from the switchgrass, miscanthus, and eastern gamagrass plots located in Stillwater, OK were compared to soil samples collected from the fallow border area surrounding the experiment. There was no significant difference in carbon content to this depth among the three grass species with an average organic carbon content of 63.7 Mtons CO_2 $acre^{-1}$. The border area contained 57.6 Mtons CO_2 $acre^{-1}$. Assuming the border area did not accumulate or lose carbon during the six years after plot establishment, we can estimate the average sequestration rate to be 1 Mton CO_2 $acre^{-1}$ yr^{-1}. Also, harvest frequency did not significantly influence the carbon content of the soil to this depth with an average carbon content of 64.1 Mton CO_2 $acre^{-1}$, and 63.3 Mton CO_2 $acre^{-1}$, for the single harvest and two harvest frequencies, respectively.

Summary

The carbon content of Oklahoma soils varies widely as a function of soil type and environmental conditions. This variation, along with the large mass of carbon found in surface soils, make it difficult to accurately assess the impacts of the multiple variables that influence carbon sequestration in a short period of time. However, the ongoing research as outlined above will provide an improved understanding of carbon cycling in Oklahoma soils so sound recommendations can be made to optimize carbon sequestration and ensure the value of carbon credits generated in Oklahoma.

The Oklahoma Cooperative Extension Service
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Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

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