A Soil Carbon Survey of Major Land Resource Area (MLRA) 58A of Montana

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Abstract

Due to recent increased interest in carbon (C) sequestration and storage by soils to mitigate increasing atmospheric CO_2 levels, soil carbon surveys were conducted in the Plains CO_2 Reduction (PCOR) Partnership region to obtain information on soil C storage under cropland and native rangeland. This survey was done in an area where limited information on C sequestration potential presently exists.

Five soils that occur extensively or moderately extensively in Major Land Resource Area (MLRA) 58A in central Montana were surveyed for their potential for C sequestration. The sequestration potential was estimated from the difference in soil organic C between cropped (cultivated) soils and adjacent undisturbed grassland soils in the upper 12 inches of the soil profile. Organic C in the cultivated Ethridge and Megonot soils was higher than in the adjacent grassland areas of each soil. For the Kobase and the Yamacall soils, organic C in the cultivated soil was lower than in the grassland soil as expected. A cropland site for the Havre soil was not sampled. Long-term use of no-till soil management in this area of MLRA 58A is most likely responsible for the higher levels of C in the Ethridge and Megonot soils.

Although inorganic C is not usually considered in estimating the C sequestration potential of soils, the apparently lower inorganic C levels in the upper part of the soil profile in the cultivated portion of the Ethridge, Megonot and Yamacall soils reflect a dynamic of solubilization and movement of inorganic C to deeper zones in the profiles than in the grassland soils. This in turn reflects the effects of fallow on increasing water storage for crops and the movement of inorganic C as it moves with water percolating deeper into the soil than occurs under grassland. This type of dynamic should be investigated more thoroughly because as C is moved deeper into the soil profile, it is more resistant to "leakage" back into the atmosphere as CO_2.

Introduction

Soils have long been known to have the capacity to store carbon (C) as organic matter. However, with tillage of the Great Plains over the last century or more, the amount of stored soil C has been diminished. With recent concerns of the effects of CO_2 emissions on climate change, interest in the potential of agricultural soils to sequester and store C from atmospheric CO_2 to mitigate effects of anthropogenic CO_2 on climate change has also increased. The capacity of soils to sequester C is governed by soil or land management as well as the soils themselves. The potential capacity of soils to sequester C is difficult to define. However, where comparisons between native grassland and cropland can be made, it can be assumed that the C sequestration capacity of cropland is the difference between the C stored in the rangeland minus the C stored in the cropland.

Objective

This study was conducted to evaluate the status of C storage in soils under grassland and cropland management and to begin to develop estimates for the potential capacity of soils to sequester and store C.

The Soils

Soil Series	Classification
Ethridge	Fine, smectitic, frigid Torrertic Argiustolls
Havre†	Fine-loamy, mixed, superactive,calcareous frigid Aridic Ustifluvents
Kobase	Fine, smectitic, frigid Torrertic Haplustepts
Megonot	Fine, smectitic, frigid Torrertic Haplustepts
Yamacall	Fine-loamy, mixed, superactive, frigid Aridic Haplustepts

†The Havre soil is not being reported due to not having a cropland comparable.

Results

Table 1. A comparison of organic, inorganic and total C for an Ethridge soil under cropland or rangeland management.

Depth (inches)	Organic Carbon (kg m^{-2})			Inorganic Carbon (kg m^{-2})			Total Carbon (kg m^{-2})		
	Cropland	Rangeland	Difference	Cropland	Rangeland	Difference	Cropland	Rangeland	Difference
0-6	5.591	4.773	-0.818	0.338	0.449	0.111	5.979	5.222	-0.757
6-12	3.926	1.969	-1.957	1.655	1.895	0.240	5.581	3.864	-1.717
Total	9.517	6.742	-2.775	1.993	2.344	0.351	11.560	9.086	-2.474

Table 2. A comparison of organic, inorganic and total C for a Kobase soil under cropland or rangeland management.

Depth (inches)	Organic Carbon (kg m^{-2})			Inorganic Carbon (kg m^{-2})			Total Carbon (kg m^{-2})		
	Cropland	Rangeland	Difference	Cropland	Rangeland	Difference	Cropland	Rangeland	Difference
0-6	2.133	2.018	-0.115	0.709	0.609	-0.100	2.932	2.627	-0.305
6-12	1.079	1.586	0.507	1.114	1.080	-0.034	2.193	2.666	0.473
Total	3.212	3.604	0.392	1.823	1.689	-0.134	5.125	5.293	0.168

Table 3. A comparison of organic, inorganic and total C for a Megonot soil under cropland or rangeland management.

Depth (inches)	Organic Carbon (kg m^{-2})			Inorganic Carbon (kg m^{-2})			Total Carbon (kg m^{-2})		
	Cropland	Rangeland	Difference	Cropland	Rangeland	Difference	Cropland	Rangeland	Difference
0-6	2.593	2.962	0.369	1.381	0.735	0.646	3.973	3.697	0.276
6-12	2.431	1.722	-0.709	1.158	1.793	-0.635	3.589	3.515	0.074
12-18	2.193	1.185	-1.008	0.118	1.801	-1.683	2.563	2.986	-0.423
18-24	2.703	0.849	-1.854	0.016	1.842	-1.826	2.719	2.691	0.028
Total	9.920	6.718	-3.202	2.673	6.171	3.498	12.844	12.889	0.045

Table 4. A comparison of organic, inorganic and total C for a Yamacall soil under cropland or rangeland management.

Depth (inches)	Organic Carbon (kg m^{-2})			Inorganic Carbon (kg m^{-2})			Total Carbon (kg m^{-2})		
	Cropland	Rangeland	Difference	Cropland	Rangeland	Difference	Cropland	Rangeland	Difference
0-6	2.136	2.606	0.470	0.000	0.221	0.221	2.136	2.827	0.691
6-12	2.417	2.908	0.491	0.679	2.162	1.483	3.096	5.514	2.418
12-18	2.135	2.218	0.084	2.063	3.915	1.852	4.198	6.133	1.935
Total	6.688	7.732	1.044	2.742	6.298	3.556	9.430	14.474	5.044

Procedures

Triplicate soil cores were collected at the selected sites in Musselshell and Golden Valley Counties of central Montana using a truck-mounted hydraulic soil-coring device. The cores were collected with 4-foot-long (122-cm) 2 3/8-inch (59-mm) diameter steel sampling tube lined with a 2 ¼ (57-mm) acetate contamination liner to a minimum depth of 40-inches (1-meter) where soil conditions and soil depth permitted. Cores were collected on parallel transects from both the cropland and rangeland at a spacing of approximately 15 to 25 feet (4.5 to 7.5 meters) apart. Spacing between transects varied depending on the field border characteristics where transects were located to avoid any areas not typical of the soil being sampled or disturbed border areas along field edges. Transects were generally less than 150 feet (50-m) apart. The midpoint of each transect was identified by latitude and longitude using a Garmin GPS 76 hand-held GPS unit.

In preparing the cores for analysis, the acetate liners were cut open with a carpet knife, and the cores were cut into 6-inch (15-cm) increments beginning at the end of the core representing the soil surface. The core segments were weighed, hand-crushed and subsampled for moisture content. The remaining portion of each core segment was then air-dried, crushed to pass a 2-mm screen and bagged as individual soil samples. From the core segment weight and moisture content, core bulk density for each core segment was determined for use in C mass calculations.

A 10-15 gram subsample was taken from each well-mixed sample for C analysis. Each subsample was milled in a ball mill to pass a 100-mesh screen. Approximately 150 milligrams of each subsample were used for total C and inorganic C analysis. The C analysis was done by high-temperature (~1000º C) combustion, and inorganic C was done by CO_2 release from sample acidification using a Skalar Primacs™ carbon analyzer, which has the capability of performing both analyses. Organic C values were obtained by difference from the total C and inorganic C data.

Carbon mass was calculated for each depth increment for total C, organic C and inorganic C by multiplying the % C value obtained from the C analysis by the core bulk density. The C mass for all depths were summed up and adjusted by the appropriate factors to give C mass per unit area per depth of the soil.

Summary

- Organic C in the cultivated Ethridge and Megonot soils was higher than the adjacent grassland areas.
- Organic C in the cultivated Kobase and Yamacall soils was lower than the adjacent grassland areas.
- Inorganic C in the cultivated Kobase soil was higher than the adjacent grassland area.
- Inorganic C in the cultivated Ethridge, Megonot and Yamacall soils was higher than the adjacent grassland areas.
- Total C was in the cultivated Ethridge soil was higher than the adjacent grassland area.
- Total C in the cultivated Yamacall soil was lower than the adjacent grassland area.

- The higher level of organic C in the Ethridge and Megonot soils is probably due to long-term no-till soil management in this area.
- Inorganic C levels in these soils, in some cases, represents solubilization and precipitation processes that are promoted by water capture and storage in crop-fallow culture.
- Further investigation needs to be done on the dynamics of inorganic C under cultivated and grassland soil management and its contribution to total C sequestration and storage in soils in the northern Great Plains.

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