A Soil Carbon Survey of the Southern Part of Major Land Resource Area (MLRA) 54 of South Dakota

Larry J. Cihacek and Gayatri Yellajosula,
Soil Science Department, North Dakota State University, Fargo,USA

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 the Southern Part of Major Land Resource Area (MLRA) 54 in northwestern South Dakota 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 Reeder soil was higher than in the adjacent grassland area. For the Amor, Cabba, Rhoades and Shambo soils, organic C in the cultivated soil was lower than in the grassland soil as expected. Long-term use of no-till soil management in this area of MLRA 54 is most likely responsible for the higher levels of C in the Reeder soil.

Although inorganic C is not usually considered in estimating the C sequestration potential of soils, higher levels of inorganic C were observed in the cultivated Amor, Cabba, Reeder, and Rhoades soils. In some cases, however, inorganic C tended to be lower in the upper part of the profile reflecting a dynamic of solubilization and movement of inorganic C to deeper zones in the soil profiles. 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
Amor	Fine-loamy, mixed, superactive, frigid Typic Haplustolls
Cabba	Loamy, mixed, superactive,calcareous frigid, shallow Typic Ustorthents
Reeder	Fine-loamy, mixed, superactive, frigid Typic Argiustolls
Rhoades	Fine, smectitic, frigid Leptic Vertic Natrusolls
Shambo	Fine-loamy, mixed, superactive, frigid Typic Haplustolls

Results

Table 1. A comparison of organic, inorganic and total C for Amor soils 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	2.656	3.811	1.155	0.612	0.228	-0.384	3.268	4.039	0.771
6-12	2.395	3.242	0.847	1.309	1.108	-0.201	3.704	4.350	0.646
12-18	2.079	2.276	0.197	2.511	2.473	-0.038	4.590	4.748	0.158
18-24	1.484	2.018	0.534	2.403	2.621	0.218	3.887	4.639	0.752
24-30	1.816	0.801	-1.015	2.633	1.346	-1.287	4.448	2.147	-2.301
30-36	1.551	0.551	-1.000	3.256	1.433	-1.823	4.807	1.985	-2.822
Total	11.981	12.699	0.718	12.724	9.209	-3.515	24.704	21.908	-2.796

Table 2. A comparison of organic, inorganic and total C for Cabba soils 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	2.225	2.592	0.367	2.259	2.076	-0.183	4.483	4.668	0.185
6-12	1.104	2.070	0.966	3.417	2.062	-1.355	4.520	4.132	-0.388
12-18	0.747	2.087	1.340	2.552	1.664	-0.888	3.298	3.751	0.453
18-24	0.936	0.972	0.036	1.690	1.095	-0.595	2.626	3.545	0.919
Total	5.012	7.721	2.709	9.918	6.897	-3.021	14.927	16.096	1.169

Table 3. A comparison of organic, inorganic and total C for Reeder soils 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	3.014	2.845	-0.169	0.000	0.000	0.000	3.014	2.845	-0.169
6-12	1.710	1.502	-0.208	0.000	0.000	0.000	1.710	1.502	-0.208
12-18	1.430	1.124	-0.306	0.000	0.000	0.000	1.430	1.124	-0.306
18-24	1.105	0.887	-0.218	0.664	0.199	-0.465	1.769	1.006	-0.763
24-30	0.821	0.839	0.018	1.434	0.288	-1.146	2.255	1.127	-1.128
30-36	0.493	0.648	0.155	1.340	0.842	-0.498	1.833	1.490	-0.343
36-42	0.379	0.389	0.01	1.359	0.922	-0.437	1.738	1.311	-0.427
Total	8.952	8.234	-0.718	4.797	2.251	-2.546	13.749	10.405	-3.344

Table 4. A comparison of organic, inorganic and total C for Rhoades soils 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	4.104	5.226	1.122	0.000	0.000	0.000	4.104	5.226	1.122
6-12	2.953	3.608	0.655	0.074	0.000	-0.074	3.027	3.608	0.581
12-18	2.253	2.411	0.158	0.000	0.000	0.000	2.253	2.411	0.158
18-24	1.166	1.807	0.641	0.600	0.319	-0.281	1.766	2.127	0.361
24-30	1.167	1.549	0.382	0.103	0.449	0.346	1.270	1.998	0.728
Total	11.643	14.601	2.958	0.777	0.768	-0.009	12.420	15.370	2.950

Table 4. A comparison of organic, inorganic and total C for a Shambo soils 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	3.117	6.229	3.112	0.000	0.192	0.192	3.117	6.421	3.304
6-12	2.571	3.370	0.799	0.228	0.306	0.078	2.799	3.676	0.877
12-18	2.239	2.661	0.422	1.936	1.109	-0.827	4.186	3.770	-0.416
18-24	1.959	2.186	0.227	3.061	4.193	1.132	5.020	6.378	1.358
24-30	0.949	1.225	0.276	4.536	5.663	1.127	5.739	6.888	1.149
30-36	1.271	1.178	-0.093	4.279	5.352	1.073	5.550	6.530	0.980
36-42	1.015	1.593	0.578	2.859	4.107	1.248	3.874	5.699	1.825
Total	13.121	18.442	5.321	16.899	20.922	4.023	30.285	39.362	0.077

Procedures

Triplicate soil cores were collected at the selected sites in Corson, Harding, and Perkins Counties of northwestern South Dakota 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 Reeder soils was higher than the adjacent grassland areas.
- Organic C in the cultivated Amor, Cabba, Rhoades and Shambo soils was lower than the adjacent grassland areas.
- Inorganic C in the cultivated Amor, Cabba, Reeder and Rhoades soils was higher than the adjacent grassland area.
- Inorganic C in the cultivated Shambo soils was lower than the adjacent grassland areas.
- Total C was in the cultivated Amor and Reeder soils was higher than the adjacent grassland area.
- Total C in the cultivated Cabba, Rhoades and Shambo soils was lower than the adjacent grassland area.
- The higher levels of organic C in the cultivated Reeder soils is probably due to long-term no-till soil management in this area.
- Inorganic C levels in these soils, in some cases, represent solubilization and precipitation processes that are promoter 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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