Impact of conservation management practices on soil carbon fractions on the Texas High Plains

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Introduction

The Challenges:

- Minimal soil organic matter (OM) levels, extreme climate variability, intensive tillage, and cotton monoculture cropping systems have led to degraded soils
- Dwindling water resources from the Ogallala Aquifer are forcing farmers to consider alternative cropping systems
- Limited information is available on active carbon (POxC) variability throughout a growing season

The Opportunities:

- Soil health management can potentially improve water-use efficiency and reduce top soil loss by increasing OM levels and subsequently aggregation
- Prospects for additional research funding in soil health management and monitoring
- Soils in semiarid environments with limited SOC have the potential to store atmospheric C (Bronson et al., 2004)

The Objective:

- Determine temporal variability of soil POxC fractions

Materials and Methods

Research Site:

Location: Agricultural Complex for Advanced Research and Extension Systems (Ag-CARES), Lamesa, TX

Soil Classification: Amarillo fine sandy loam; Fine-loamy, mixed, superactive, thermic Aridic Paleustalfs

Experimental Design:

RCBD arrangement of treatments within plots (3 reps.)

Tillage Treatments:

- Conventional Tillage (CT)
- No-Tillage (NT)

Cover Crop Treatments:

- No Cover (control)
- Rye Cover (*Secale cereale*)
- Mixed Cover: Hairy Vetch *(Vicia villosa)*, Winter Pea *(Pinsum sativum* x *arvense)*, Rye *(Secale cereale)*, and Radish (*Raphanus sativus*)

Measurements:

- Routine soil analysis
- Active Carbon (POxC), Weil et al., 2003
- Total organic carbon (TOC), McGeenhan and Naylor, 1988

Statistical Analysis:

Means separation was performed using Fisher's LSD (α = 0.05) after treatment effect significance was established using GLIMMIX procedure in SAS 9.3

Literature Review

- Bronson, K.F., T.M. Zobeck, T.T. Chua, V. Acosta-Martinez, R. Scott van Pelt, and J.D. Booker. 2004. Carbon and nitrogen pools of Southern High Plains cropland and grassland soils. Soil Sci. Soc. Amer. J. 68: 1695-1704.
- McGeenhan, S.L. and D.V. Naylor. 1988. Automated instrumental analysis of carbon and nitrogen in plant and soil samples. Commun. Soil Sci. Plant Anal. 15:759-772.
- Weil, R.R., K.R. Islam, M.A. Stine, J.B. Gruver, and S.E. Samson-Liebig. 2003. Estimating active carbon for soil quality assessment: A simplified method for laboratory and field use. Amer. J. Alternative Agric. 18: 3-17.

Results

Table 1. Soil Characterization (2015) at 0-16 cm Depth

Management	pH	EC	Org C	Total C	Total N	Nitrate-N	P	K	Ca	Mg	S	Na
Practice	-----	μmhos cm^{-1}	g kg^{-1}		mg kg^{-1}							
CT	7.7	131	1.9	3.0	370	9.8	40	265	591	619	2.7	26
NT-R	7.6	154	3.6	4.2	572	10.0	53	333	682	606	3.7	17
NT-M	7.6	148	2.7	3.9	536	10.0	48	350	655	649	3.7	18

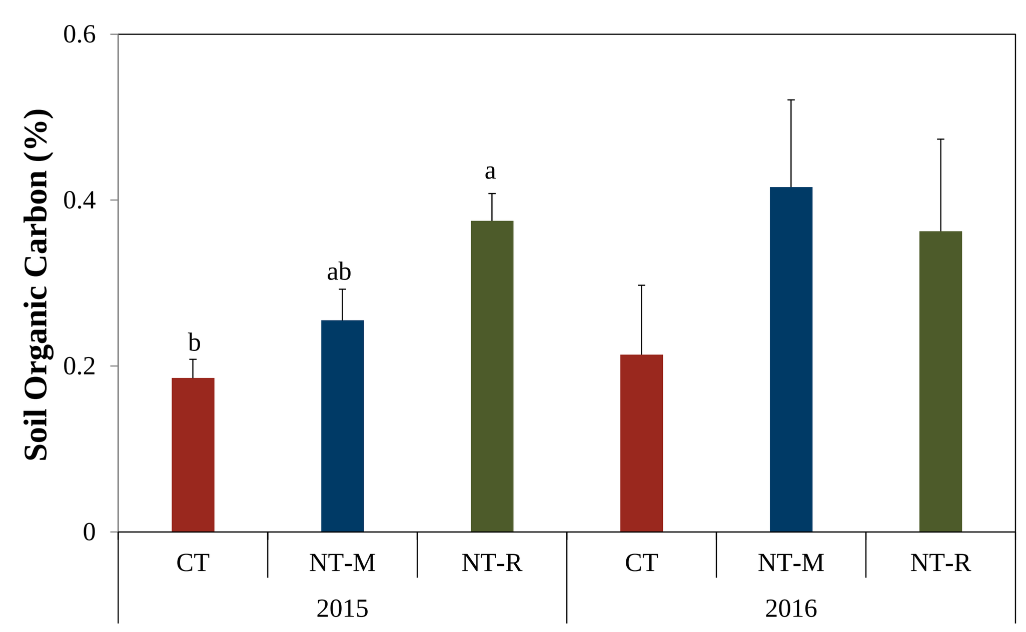

Figure 1. Concentrations of soil organic carbon (SOC) in April 2015 and April 2016. Differences existed between treatments in 2015 (*p*=0.024) but not in 2016 (*p*=0.111). CT: Conventional Tillage; NT-M: No-Tillage-Mixed Cover; and NT-R: No-Tillage-Rye Cover.

Figure 2. Fallow, CT (left) and recently planted rye, NT-R (right) at Ag-CARES, Lamesa, TX in fall 2015 following cotton *(Gossypium hirsutum*) harvest. Unprotected soil is highly susceptible to wind erosion on the Texas High Plains.

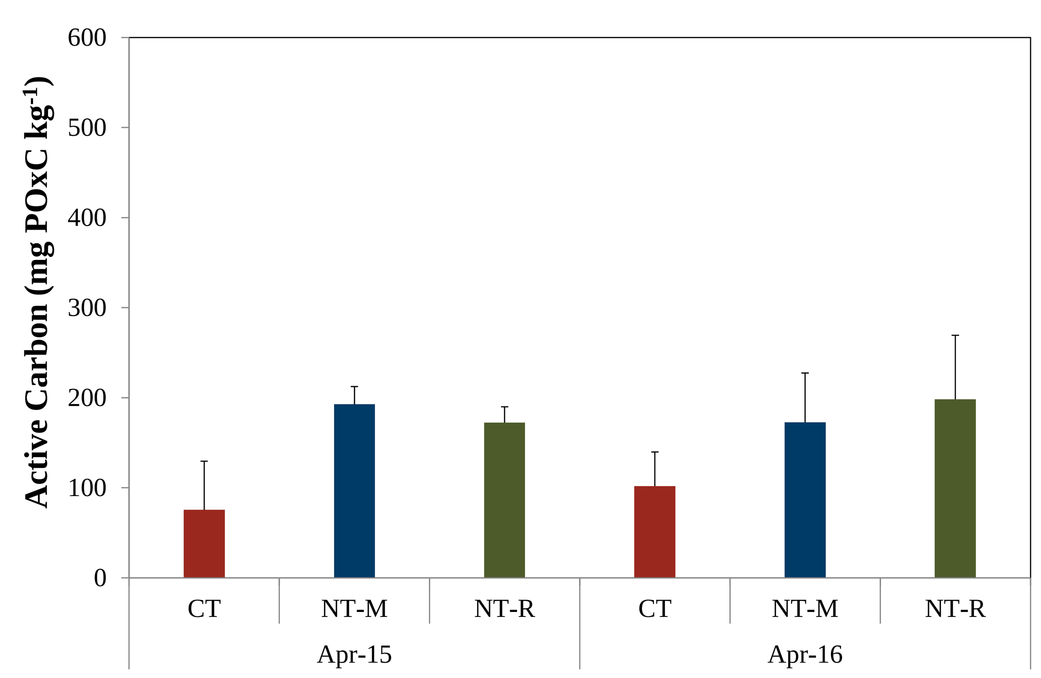

Figure 3a. Concentrations of POxC in April 2015 and April 2016. Differences did not exist between treatments within sampling years (2015: *p*=0.397; 2016 *p*=0.498) and between treatments over time (CT: *p*=0.152; NT-M: *p*=0.757; NT-R: *p*=0.583).

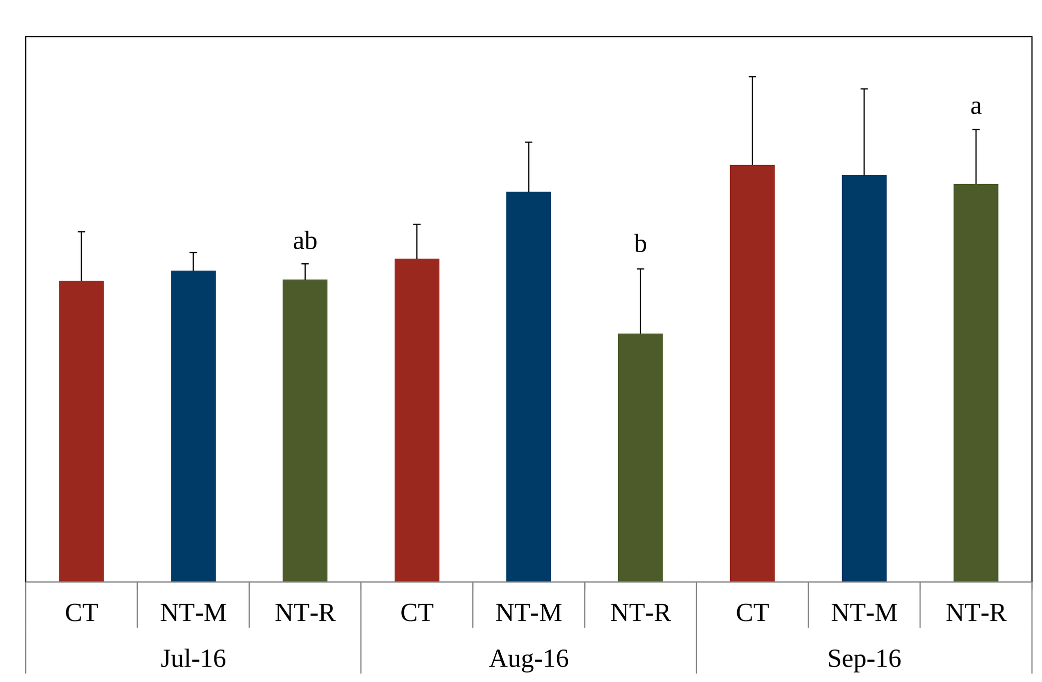

Figure 3b. Temporal variability of POxC from July 2016 to September 2016. There were no significant differences between treatments within sampling date (July: *p*=0.235; August: *p*=0.167; and September: *p*=0.790). Differences existed for NT-R cover over time (*p*=0.029); however, differences did not exist for CT (*p*=0.261) and NT-M (*p*=0.192) over time.

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Discussion

Conservation Management and Soil Carbon:

- SOC levels remained generally unchanged from 2015 to 2016 (**Figure 1**)
- SOC levels generally increased for NT-M and NT-R compared to CT in both years (**Figure 1**). This increase is most likely due to increased biomass production of cover crops in 2016.

Temporal Variability of Active Carbon:

- Active carbon (POxC) levels remained generally unchanged from April 2015 to April 2016 (**Figure 3a**)
- POxC levels generally increased for NT-M and NT-R compared to CT in both years (**Figure 3a**)
- POxC levels increased dramatically from April 2016 to July 2016; however, POxC levels remained generally unchanged between July and September 2016 (**Figure 3a** & **3b**). Potential increases could be due to measurement of root exudates in POxC fraction.
- We hypothesize POxC levels will return to April 2016 levels in April 2017 as microbes decompose crop residues, microbial activity decreases during winter months, and root exudates decrease.

Variability of Active Carbon:

- High levels of variability existed between POxC measurements leading to minimal statistical significance
- Variability within measurements was used to determine proper sampling size according to the following equation:

$$n = \left[\frac{z_{\alpha} \cdot \sigma}{E}\right]^2$$

where: *n*=sample size, z_{α}=z-score at specific confidence interval (two-tailed), σ=population standard deviation, and *E*= maximum difference between the observed sample mean ($\bar{x}$) and the estimated population mean (μ)

n=11 samples/plot, currently collecting 6 samples/plot

Conclusion

- Further research is needed to understand the source of active carbon in semiarid regions: current residue, root exudates, and/or older residue.
- POxC levels vary throughout the growing season and care should be taken when sampling to ensure validity of results

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