Characterizing Soil Organic Carbon and Winter Wheat Root Biomass after Twelve Years of Chisel Plow and No-till Management

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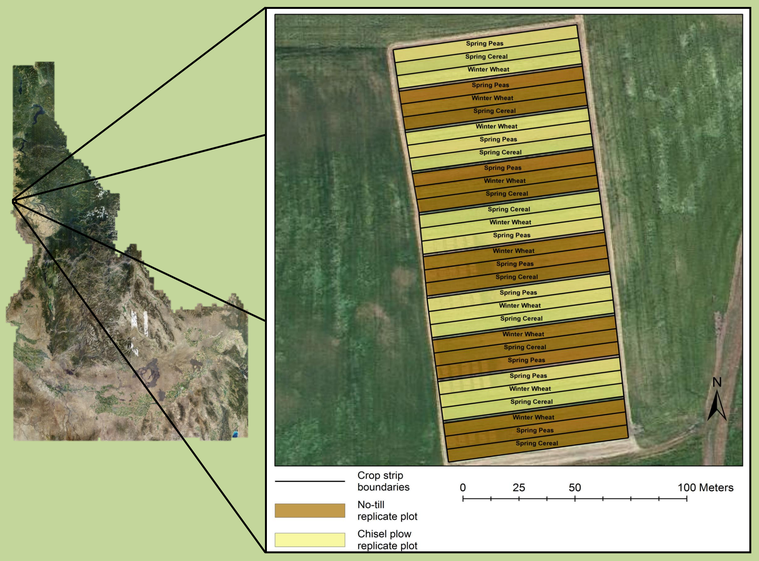
Introduction

Root growth and turnover are important processes that result in the transfer of carbon from recent photosynthesis to the soil. Despite the importance of roots as an input to the terrestrial carbon pool, they are often not measured. The impact of management practices such as tillage on the distribution of root carbon is important in understanding the mechanisms behind carbon sequestration in agroecosystems, especially when deep rooted plants such as wheat are grown. A better understanding of the relationships among roots, tillage and whole-profile soil organic carbon (SOC) stocks may also help to explain inconsistent reports of carbon sequestration rates in reduced tillage systems.

Objectives

The overall objectives of this study were to 1) gain a better understanding of carbon storage with depth under chisel plow (CP) and no-till (NT) management practices and 2) determine if tillage impacts the density of roots at different depths within the soil profile.

Study Site



- Randomized complete block design initiated in 2000 at the University of Idaho Kambitsch experimental farm near Genesee, ID.
- The main soil type is Palouse silt-loam.
- Tillage plots (18 m x 80 m), include CP and NT treatments.
- Three subplots (6 m x 80 m) within each tillage plot are planted and rotated annually through spring pea (*Pisum sativum*), winter wheat (*Triticum aestivum*), and spring barley (*Hordeum vulgare*).
- MAT = 8.3°C MAP = 605 mm

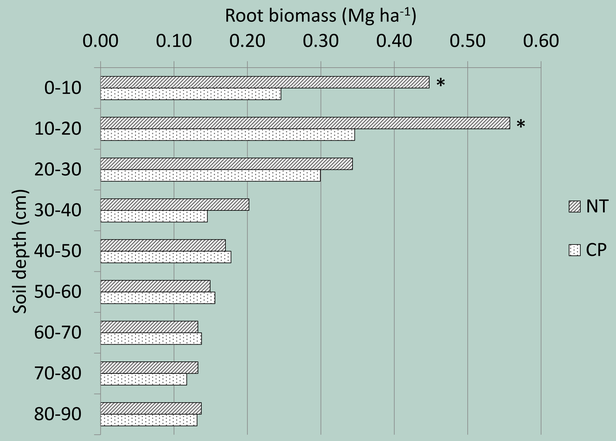
Methods

- Two replicate, 1.5-m deep soil cores were taken following harvest (October 2012) in each winter wheat crop subplot in both tillage treatments using a hydraulic-driven soil probe from Giddings Machine Company (Windsor, CO).
- Bulk density, pH and soil organic carbon was analyzed for each depth increment (0-10, 10-20, 20-30, 30-60, 60-90, 90-120 and 120-150 cm).

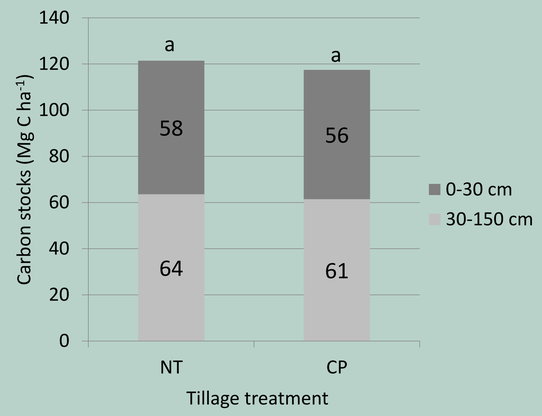
- Root density cores were taken from inter-rows in winter wheat subplots in both tillage treatments in 10-cm increments to a depth of 90 cm.

- Roots were separated from soil using a hydropneumatic elutriation system from Gillison's Variety Fabrication (Benzonia, Michigan).
- Soil organic carbon was measured with a Vario MAX CNS analyzer (Elementar, Hanau, Germany) using 900 mg of finely ground (<250 µm) soil from the replicate soil cores.
- The ash-free dry root mass was calculated for each root sample after placing the sample into a muffle furnace at 650 °C for 6 hours.

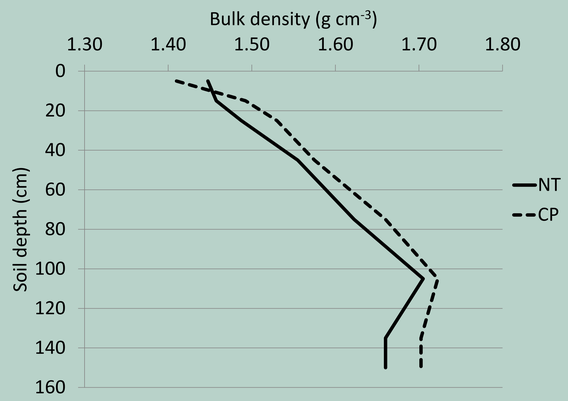
Results and Discussion



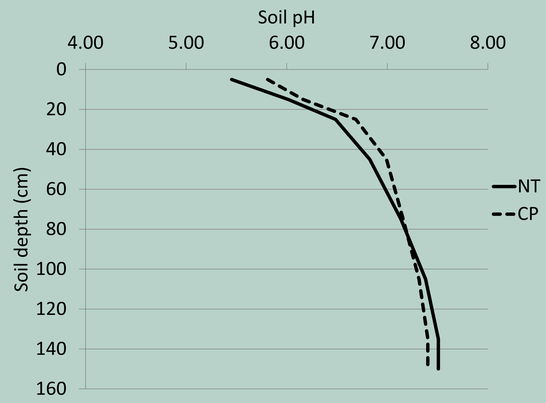
Mean, ash-free root biomass in the top 20 cm was significantly greater in NT than in CP (P=0.01). * indicates significant difference between treatments within the same depth interval.



Approximately 47% of the SOC stored in both treatments was within the top 30 cm of both NT and CP soils. Mean SOC stock to 150-cm in NT (121 Mg C ha^{-1}) was not significantly different than that measured in CP (117 Mg C ha^{-1}) (P=0.66), despite the fact that carbon, on a percentage basis was significantly greater under NT.



There were no significant differences in bulk density between 2012 NT and CP winter wheat cropping strips treatments.



Soil pH of NT and CP 2012 winter wheat cropping strips was only significantly different (P=0.05) in the first 10 cm of the profile. This is likely a result of the use of N-containing fertilizers and the lack of vertical mixing in NT soil.

Summary

- Results indicate that NT promotes a greater abundance of fine roots near the soil surface than does CP, but does not appear to result in greater total soil organic carbon storage on an equivalent mass basis within the first 30 cm or on a whole profile basis.
- With nearly half of the carbon stored in the first 30 cm of both treatments, practices that effect this depth zone may have a large effect on the SOC stored within 150 cm of the surface.
- The difference in root biomass and similar SOC stocks indicates that carbon from the root biomass in NT treatments is being lost through respiration and leaching of dissolved organic carbon.
- The divergence in soil pH in the 0 to 10 cm depth between NT and CP could represent a significant concern in the future if pH continues to descend towards a pH of 5 to 4.5 where available aluminum can reach phytotoxic levels for wheat and inhibits the ability of soil bacteria and fungi to break down crop residues.

Acknowledgements

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