Exploring soil carbon sequestration potential through plant-soil-microbial interactions

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Background

- Terrestrial carbon cycling is greatly influenced by plant-soil-microbial interactions
- Plant contributions to soil organic matter (SOM) and microbial mineralization of SOM influence soil carbon dynamics
- A varied combination of plant inputs can support a more diverse microbial community with enhanced potential for varied carbon usage
- Examining plant-soil-microbial relationships provides insight into land use management activities to enhance carbon sequestration

Questions

(1) Has long-term agricultural management of field crops influenced soil organic matter in the root zone?

(2) To what extent do past carbon additions (i.e., plant inputs) contribute to soil carbon?

(3) Does the soil microbial community vary in carbon usage potential due to long-term management?

Hypothesis: Long-term land use management influences soil carbon sequestration potential due to differences in plant-soil-microbial interactions.

Experimental Design

Kellogg Biological Station Main Cropping System Experiment

We compared soil organic matter content (0-10 cm, composited from two cores (2-cm dia.) from five sampling stations for Reps 1-3), crop and non-crop biomass (Reps 1-3) across the following treatments:

T1: Conventional corn/soybean/wheat
T2: No-till corn/soybean/wheat
T3: Reduced-input corn/soybean/wheat
T4: Biologically-based/organic C-S-W
T6: Alfalfa
T7: Early successional community

Preliminary Results (soil)

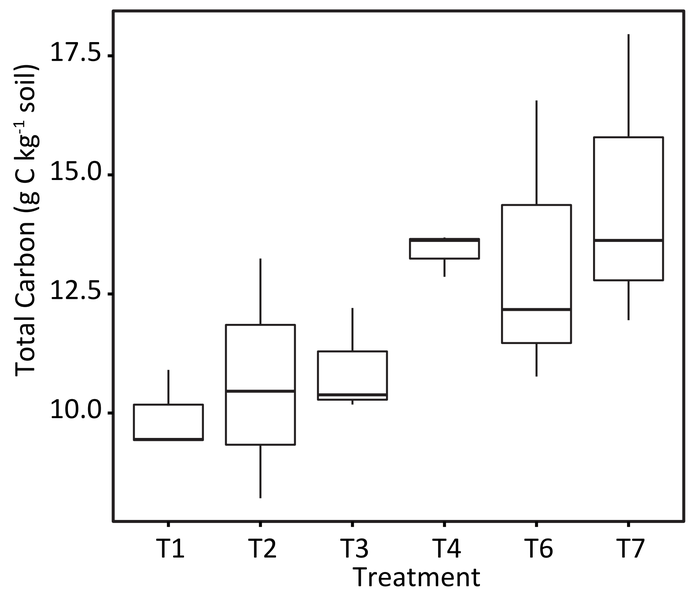
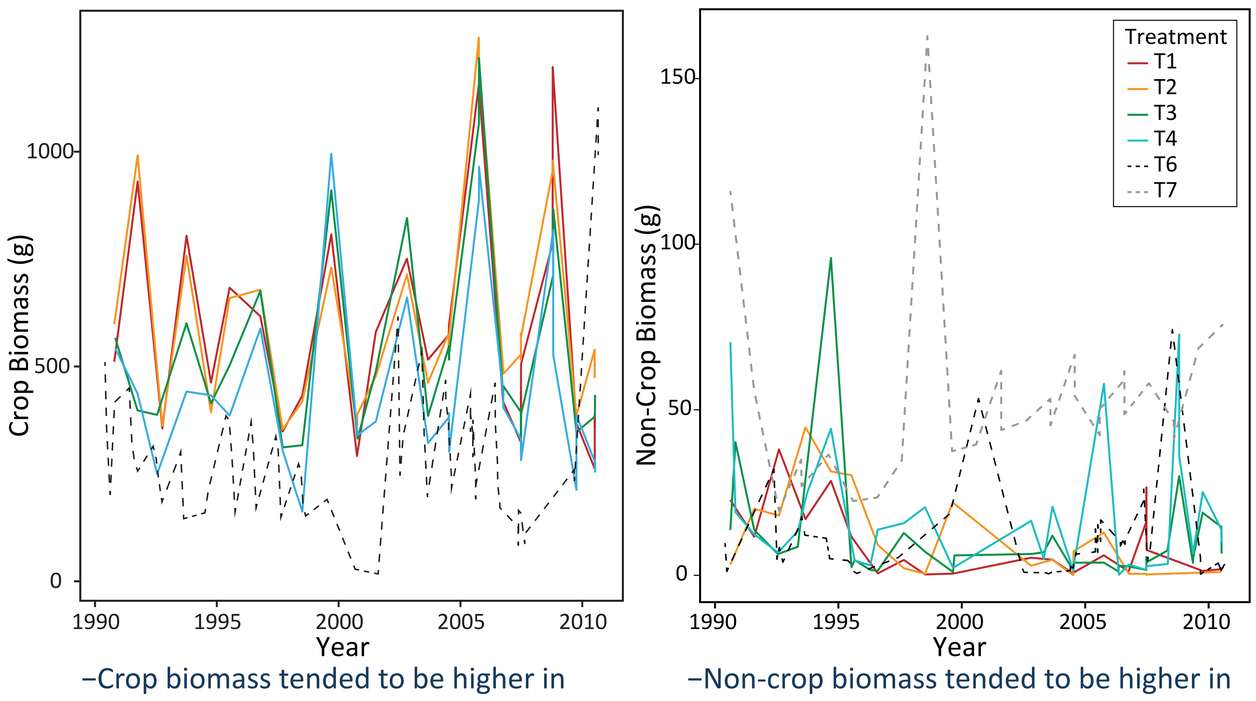


Figure 1. Boxplots of total soil carbon (mean +/- SEM) across management treatment.
–Soil carbon content was higher in the biologically-based/organic, continuous alfalfa and early successional plots compared to conventional, no-till and reduced-input plots.
–*Posthoc* linear contrasts:
T1-T3 vs T4, T6-T7: $P = 0.008$
T1 vs T4: $P = 0.070$
T1 vs T4, T6-T7: $P = 0.021$

(*Schmidt Lab collected and processed soil samples from field. M. Freeman completed elemental analysis of SOM.)

Preliminary Results (plant)

Figure 2. Scatterplot of crop biomass (left) and non-crop biomass (right) across land use treatments from 1990 - 2010. Annual net primary production was estimated from biomass clippings collected from 1-m^2 plots (averaged across Reps 1-3).



–Crop biomass tended to be higher in conventional and no-till plots (T1,T2) compared to other treatments.

–Non-crop biomass tended to be higher in biologically-based/organic (T4) compared to other treatments.

Next step: *Estimate belowground root inputs based on annual net primary production (crop + non-crop biomass) across land use treatments.*

Summary & Future Directions

Preliminary findings:

(1) Total soil carbon increased with decreasing chemical inputs/mgmt intensity

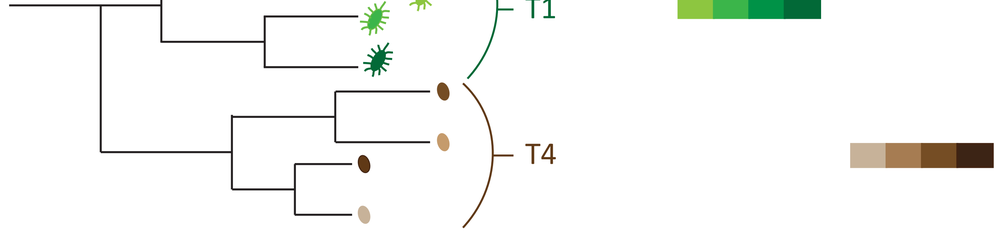
(2) In progress: Examine the extent to which aboveground biomass and estimated belowground inputs are related to soil carbon in the soil surface

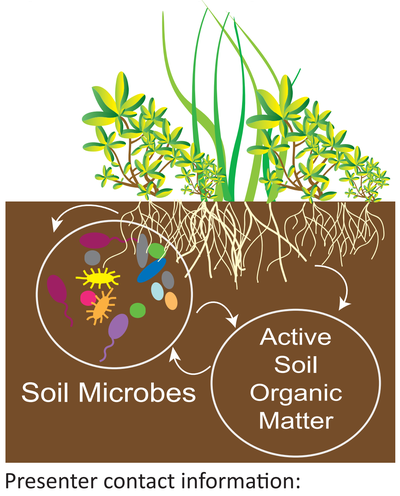
(3) In progress: Assess bacterial community structure and diversity of C usage

Next steps (in collaboration with the Schmidt Lab):

- Compare relative abundance of carbon cycling genes identified by shotgun soil metagenomics across land use treatments
- Estimate carbon usage 'breadth' by identifying carbon usage potential of individual bacterial taxa (based on targeted 16S sequences)

Conceptual prediction:





Enhancing carbon sequestration potential in agroecosystems

- Soil organic matter decomposition can be accelerated or delayed due microbial activity.
- Plant inputs can be used to manipulate quality and quantity of nutrients and carbon that contribute to different soil organic matter pools (active, slow, recalcitrant).
- Manipulation of plant-soil-microbial interactions through management has potential for enhancing carbon sequestration in soils.

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