USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

Research Brief

Temporal Patterns and Drivers of Soil Microbial Activities in Cropping Systems

Michael Lehman[1], Shannon Osborne[1], Patrick Ewing[2]

[1]USDA-ARS Integrated Cropping Systems Research Unit, Brookings, South Dakota, USA
[2] USDA-ARS Food Systems Research Unit, Burlington, Vermont, USA

Key Findings:

- Cellulose decomposition activities increased rapidly following spring thaw, peaked in May, and declined to lowest values by end of July, remaining low through harvest
- Temperature or precipitation did not predict cellulose decomposition activities
- Soil microbial activities were affected by crop rotation, the previous crop, and the current crop.

Background

You can't manage what you can't measure. Soil biology is an integral component of soil health. Despite widespread availability of commercial "soil health tests", there is little scientific consensus on proper measurement of the soil biological components of soil health. Scientific literature demonstrates common biologically-based measures often vary in their response to cropping management. The timing of soil sample collection with respect to season and crop development stage varies widely across studies.


Seeding


Early Season


Mid-Season


Late Season

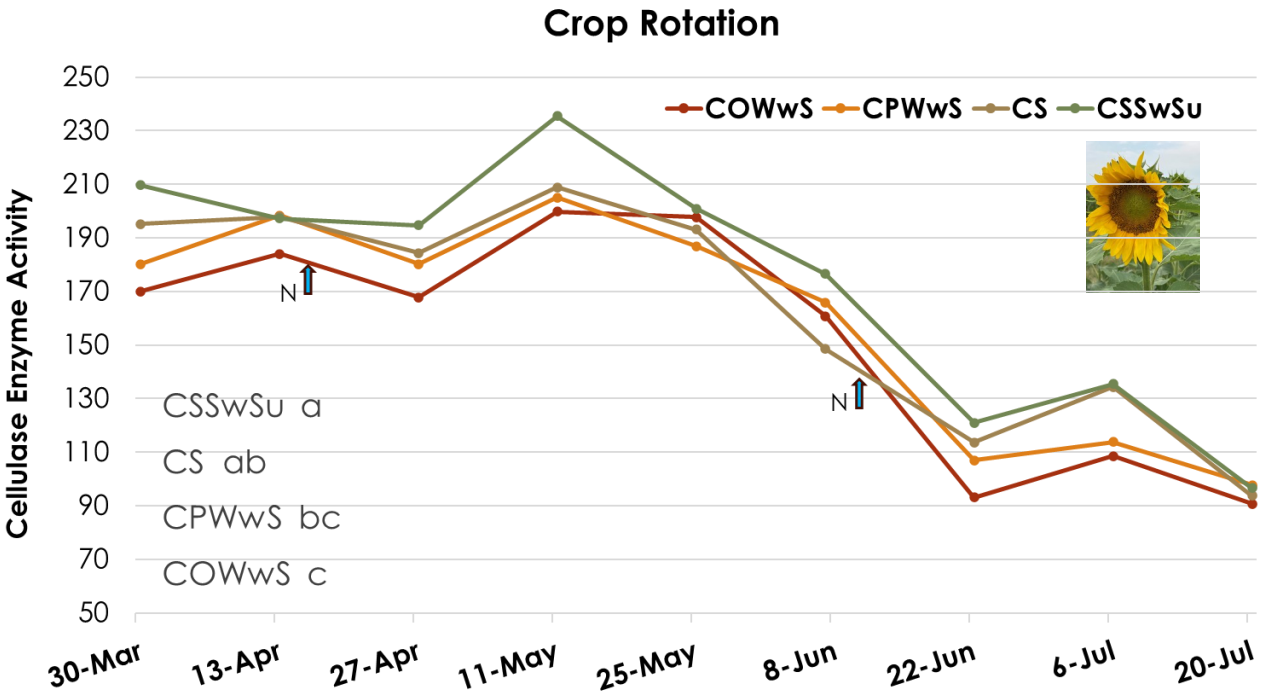
Objectives

> Assess temporal patterns of cellulose decomposition enzyme activities which are frequently used as an indicator of soil health.
> Determine if cellulose decomposition enzyme activities are related to current crop, previous crop, or crop rotation diversity.
> Determine if these activities can be predicted by temperature or precipitation.
> Determine best sampling time to detect management effects on enzyme activities.

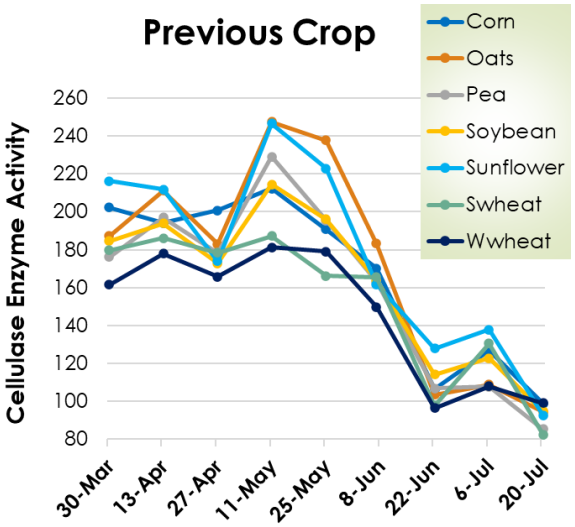
Methods

Soil beta-glucosidase enzyme activities, associated with cellulose decomposition, were measured biweekly over the growing season and at harvest in all crops within four different crop rotation systems. Temperature and precipitation were from an on-site weather station.

Results



Cellulase enzyme activities were high after thaw and stable for 6 weeks, followed by a peak in May and then a decline to lower values in the summer. Corn-soybean-spring wheat-sunflower had the greatest activity and corn-oats-winter wheat-soybean had the least. Crop abbreviations with different letters were significantly different (lower left hand corner). “N” represents timing of N fertilization for non-legume crops.



Soil enzyme activities were greatest in crops following sunflower and oats.

The lack of correlation of cellulase activity with temperature/precipitation and the strong effect of previous crop on cellulase were unexpected. These results illustrate the importance of soil sample timing and the need to further understand the drivers of soil microbial activities.

Next Steps

Based on the completed study, the best time to sample may be early in the vegetative phase. However, we only measured one type of microbial activity. A follow-on study expanded on the current study to include multiple years (2) of data collected from an increased number (15) of biweekly sampling events spanning March to November. We assessed three very different soil microbial activities: carbon mineralization (respiration), cellulose decomposition, and lignin decomposition. The goal of this research is to understand the drivers and patterns of differing soil microbial activities to enable appropriate timing of soil sampling events for assessing soil biological properties and soil health in cropping systems.

Reference: Lehman, R. M., Osborne, S. L., & Ewing, P. M. (2024). When are you measuring soil β-glucosidase activities in cropping systems? Agricultural & Environmental Letters, 9, e70002. https://doi.org/10.1002/ael2.70002

Mike Lehman
Soil Microbiology

Questions or comments?
Email: Michael.Lehman@usda.gov
Phone: 605-693-5205

About NCARL

The North Central Agricultural Research Laboratory (NCARL) is a USDA-Agricultural Research Service laboratory located in Brookings, SD. The goal of NCARL is to develop, document, and promote soil, crop, and pest management practices that are ecologically sustainable while maintaining producer profitability.