

2018

Building the soil immune system: do cover crops increase soil health and resistance to climate change?

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Building the soil immune system: do cover crops increase soil health and resistance to climate change?

Abstract

The project examined the impact of cover crops on soil health, and evaluated the use of decomposition of household items (tea bags, cotton, and birch sticks) as alternative measures of more expensive soil health measurements. As a measurement of soil health, commercially available green and red tea bags were used to create soil decomposition indices for nine Iowa farms with and without replicated cover crop strips.

Faculty name: Marshall McDaniel

INRC Grant #: E2017-10

Title of project: Building the soil immune system: do cover crops increase soil health and resistance to climate change?

What was the key research question(s) you hoped to answer with your project? Yes

List collaborators, internal and external:

Teresa Middleton, Stefan Gailans, Sarah Carlson, Tom Kaspar, Mahdi Al-Kaisi, Mary Wiedenheft

INRC funding support (years, amount): \$75,427 (2 years)

List the project's main goals/objectives:

- Objective 1: Determine if cover crops are universally beneficial to soil health and yield, and how long does it take to see these benefits (with a focus on soil microbiology).
- Objective 2: Determine if adding a cover crop makes soils more resistant to extreme climate events.
- Objective 3: Test a new, cheaper and more scientifically-robust soil health indicator; thereby potentially revolutionizing how soil health is measured.

Impact statement 1: The key message(s) I want to share with Iowans and with the Iowa Legislature on the accomplishments or significance of my research on nutrient management is —

We examined the impact of cover crops on soil health, and evaluated the use of decomposition of household items (tea bags, cotton, and birch sticks) as alternative measures of more expensive soil health measurements. Cover crops do improve some soil health indicators, but effects were limited and the number of years of cover crop practice did not make much of a difference in improving soil health. Decomposing household items showed some promise as an inexpensive, scientifically robust indicator of soil health.

Photo? If you have images that help illustrate your research, please attach and submit.

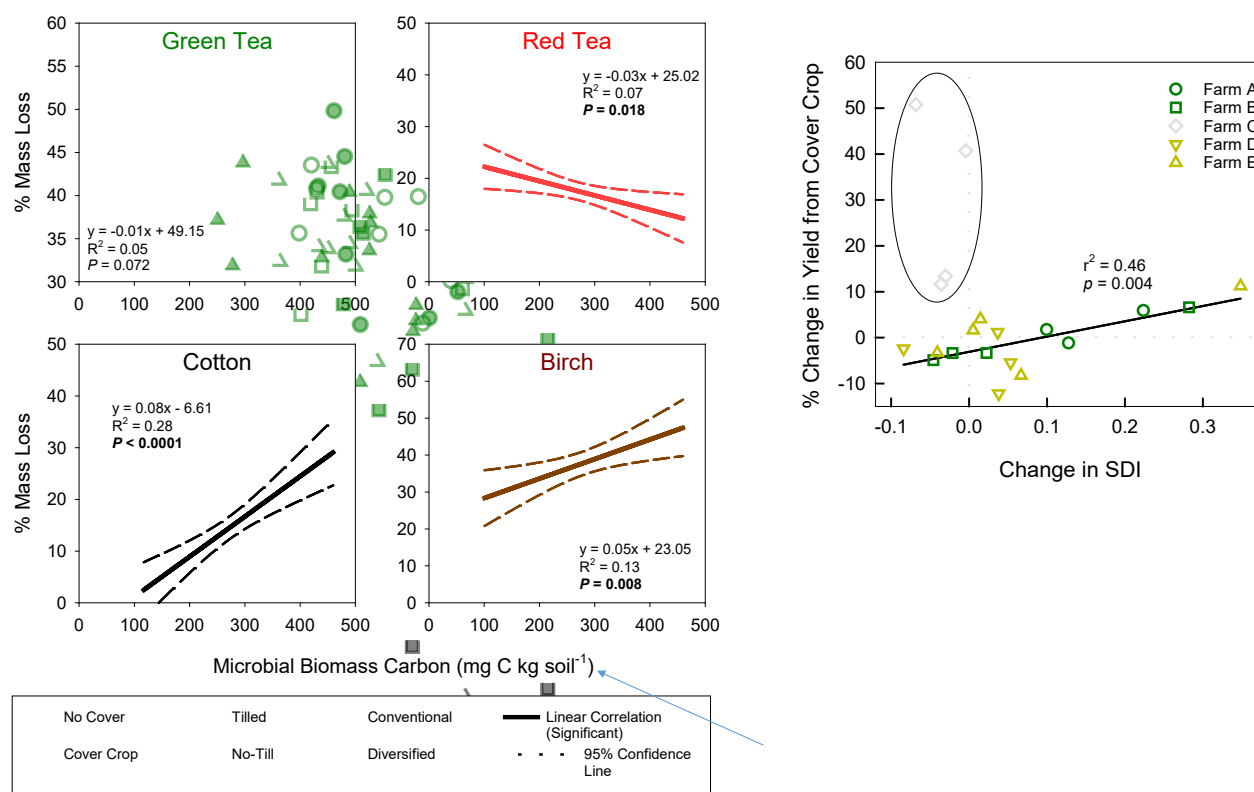


Figure 1. Featured findings from the study. **Left four panels:** The extent of decomposition (% mass loss) correlated with soil microbial biomass carbon (a traditional soil health indicator) from several experiments comparing cover crop vs. no cover crop, no-till vs. tilled, and diversified vs. conventional rotation. Decomposing these items in the field are a good proxy for microbial biomass C across all these soil types and management. **Right panel:** Change in decomposition index with % change in yield caused by cover crop. This illustrates yield is linked to soil health as measured with tea decomposition.

PUBLICATIONS and PRESENTATIONS:

In preparation...

Middleton, T.E. (*In Preparation*). Decomposition of Household Items as an Inexpensive, yet Scientifically-Robust Soil Health Indicator. M.S. Thesis. Iowa State University.

Davis, M.P., T.E. Middleton, M.D. McDaniel. (*In Preparation*). The Effects of Cover Crop on Soil Health from 1 to 15 years in Practice. Soil Science Society of America Journal.

Extension Publications

McDaniel, M.D. 2018. Potential of ‘Do-It-Yourself’ Soil Health Measurements. Annual Integrated Crop Management Conference (November 28th-29th) at Iowa State University.

McDaniel, M.D. 2017. What is soil health, how do we measure it, and why the emphasis on soil biology? Annual Integrated Crop Management Conference (November 29th-30th) at Iowa State University.

Oral Presentations

McDaniel, M.D. 2019. Decomposition of Household Items (Including Rooibos and Green Tea) as Indicators of Soil Health. Tea Bag Index Symposium in Umea, Sweden.

Middleton, T., **M.D. McDaniel**, M. Liebman, T.C. Kaspar, T.C., M.M. Al-Kaisi, K.J. Moore, K.J., K. Delate, C.A. Cambardella, D.L. Karlen. 2019. Decomposition of Household Items As a Low-Cost Soil Health Indicator. SSSA Meeting in San Diego, CA (Soils Across Latitudes).

Brehm, T.L., T.A. Middleton, and **M.D. McDaniel**. 2018. Using decomposition of household items as an indicator of soil health and educational tool in Kamuli distric, Uganda. Professional Agricultural Workers Conference (PAWC), Tuskegee, AL. [1st Place Undergraduate Student Oral Presentation](#)

Brehm, T.L., T.A. Middleton, and **M.D. McDaniel**. 2018. Decomposition of Household Items as a Soil Health Indicator in Agroecosystems. 12th Symposium on Undergraduate Research & Creative Expression.

(<http://www.undergradresearch.iastate.edu/symposium/includes/Forms/2018SymposiumAbstracts.pdf>)

McDaniel, M.D., T.A. Middleton, and T.L. Brehm. 2017. Decomposition of Tea Bags as a Soil Health Indicator in Agroecosystems. ASA-CSA-SSSA meetings in Tampa, FL. (Recording at:

<https://scisoc.confex.com/crops/2017am/webprogram/Paper106702.html>).

Poster Presentations

Middleton, T., **M.D. McDaniel**, M. Liebman, T.C. Kaspar, T.C., M.M. Al-Kaisi, K.J. Moore, K.J., K. Delate, C.A. Cambardella, D.L. Karlen. 2019. Decomposition of Household Items As a Low-Cost Soil Health Indicator. Soil Health Conference in Ames, IA. [1st Place Student Poster Presentation](#)

Brehm, T.L., T.A. Middleton, and **M.D. McDaniel**. 2018. Using decomposition of household items as an indicator of soil health and educational tool in Kamuli distric, Uganda. Borlaug Poster Session at World Food Prize in Des Moines, IA. [2nd Place Undergraduate Presentation](#)

McDaniel, M.D., S. Gailans, S. Carlson, D. Kwah-Mensah, and M. Al-Kaisi. 2017. Using Tea Decomposition to Assess Soil Health in the Midwestern United States. Soil Health Conference in Ames, IA.

McDaniel, M.D. 2017. Using the TBI to Assess Soil Health on Farms in Midwestern, United States. 2nd International TBI Workshop in Vienna Austria

Popular Press

Luft, C. Teabag test for soil quality. Forward – Iowa State University Foundation.

https://www.foundation.iastate.edu/s/1463/images/editor_documents/forward/vol7issue3.pdf

Gailans, S. 2018. Tea bag test for soil health. Wallaces Farmer and Corn+Soybean Digest.

<https://www.wallacesfarmer.com/soil-health/tea-bag-test-soil-health>

<https://www.farmprogress.com/soil-health/tea-bag-test-soil-health>

Gailans, S. 2018. Connecting Farmers and Researchers: Tea bag soil health project continues a collaborative tradition. *The Practical Farmer* (quarterly publication by Practical Farmers of Iowa), Summer 2018.

Thompson, S. 2018. Rock Creek Watershed Hosts Soil Health Workshop. *Mitchell County Press News in the Globe Gazette*. http://globegazette.com/mcpress/news/local/rock-creek-watershed-hosts-soil-health-workshop/article_0e0da880-0a93-525f-b4df-f53d668f852c.html

Schlater, T. (Ed. M.R. Licht). 2017. Tea Time for Soil Health. *Iowa State University College of Agriculture and Life Sciences STORIES Magazine*. Vol. 11 (2). <https://stories.cals.iastate.edu/2017/12/tea-time-soil-health/>

EDUCATION AND OUTREACH:

Extension Presentations

McDaniel, M.D. 2018. Potential of ‘do-it-yourself’ soil health measurements. 30th Annual Integrated Crop Management Conference. November 28th-29th at Iowa State University.

McDaniel, M.D. 2018. Burying Tea to Dig Up Soil Health. Iowa Learning Farms Webinar. <https://iowalearningfarms.wordpress.com/2018/08/14/august-webinar-exploring-soil-health-through-tea-decomposition/>

McDaniel, M.D. 2018. Practical Ways to Measure Soil Health. ISU Southeast Research Farm (SERF) Spring Field Day I. June 28th in Crawfordsville, IA.

McDaniel, M.D. 2018. What is soil health, how do we measure it, and why the emphasis on soil biology? Soil Health Meeting arranged by NRCS on January 30th near Osage, IA.

McDaniel, M.D. 2018. What is soil health, how do we measure it, and why the emphasis on soil biology? Crop Advantage Series on January 26th in Davenport, IA (two sessions via Zoom).

McDaniel, M.D. 2018. What is soil health, how do we measure it, and why the emphasis on soil biology? Crop Advantage Series on January 24th in Iowa City, IA (two sessions via Zoom).

McDaniel, M.D. 2018. What is soil health, how do we measure it, and why the emphasis on soil biology? Crop Advantage Series on January 5th in Burlington, IA.

McDaniel, M.D. 2017. What is soil health, how do we measure it, and why the emphasis on soil biology? 29th Annual Integrated Crop Management Conference. November 29th-30th at Iowa State University.

Gailans, S., Middleton, T.A., and **M.D. McDaniel**. 2017. Tea Bag Soil Decomposition Index. Watershed Academy at Field Education and Extension Laboratory (FEEL) near Boone, IA.

Middleton, T.A., and **M.D. McDaniel**. 2017. Tea Bag Soil Decomposition Index. Field Extension Education Lab Crop Management Clinic at Field Education and Extension Laboratory (FEEL) near Boone, IA.

McDaniel, M.D. 2017. Using Tea Bags to Assess Soil Health: The Protocol. Spring In-Service at Field Education and Extension Laboratory (FEEL) near Boone, IA.

McDaniel, M.D. 2017. Using Tea Bags to Assess Soil Health: The Protocol. Webinar from Practical Farmer’s of Iowa Offices in Ames, IA.

Extension Demonstrations

Farm Progress Show 2018 – soil health demonstration table	2018
Biofuels Science and Sustainability Tour (10 th Annual)	2018
– LAMPS presentation for congressional staff and industry representatives	
Soil Health Partnership: Soil Health Summit in Des Moines, IA	2017
– soil health demonstration table	
Farm Progress Show 2016 – soil health demonstration table	2016

COOPERATIVE EFFORTS:

(see attached farmer report we sent to Practical Farmers of Iowa participants. Titled: 2017 Study on Using Decomposition of Tea as an Indicator of Soil Health)

RESOURCES LEVERAGED:

(These are grants that are in-part funded with tea decomposition from the LCSA grant)

Gish-Hill,C., **M.D. McDaniel**, D. Winham, A. Nair. Reuniting the Three Sisters: Enhancing Community and Soil Health in Native American Communities. United States Department of Agriculture – National Institute of Food and Agriculture – Critical Agricultural Research and Extension (CARE), \$300,000, 7/1/2019–6/30/2022

R.M. Cruse, L.A. Schulte-Moore, M. Helmers, M.Z. Liebman, R.K. Kolka, B.A. Miller, and **M.D. McDaniel**. Prairie Strips for Healthy Soils and Thriving Farms. Foundation for Food and Agriculture Research, \$674,659 (\$150,000), 10/1/2018–9/30/2021.

Schulte-Moore, L.A., J.C. Tyndall, M. Helmers, M.Z. Liebman, R.M. Cruse and **M.D. McDaniel**. Estimating the Effect of Conservation Reserve Program (CRP) Contour Strips on Nutrient Retention, Water Quality, Grassland Birds, Soil Health, and Farm Finances. USDA Farm Service Agency, \$699,958 (\$100,827), 8/1/2018–7/31/2022.

Robertson, A., M. Licht, J. Arbuckle, M. Castellano, L. Dong, B. Hartzler, E. Hodgson, A. Lenssen, **M.D. McDaniel**, T. Moorman, A. Plastina. Improving cereal rye cover crop BMPs to increase adoption of cover crops by Iowa farmers. Iowa Nutrient Research Center, \$348,422 (\$24,107), 7/1/2018–6/30/2020.

Plastina, A., **M.D. McDaniel**, W. Zhang. Monetizing Soil Health: An innovative strategy to drive greater adoption of cover crops and no-till. Iowa Nutrient Research Center, \$103,334 (\$16,000), 7/1/2018–6/30/2020.

Gish-Hill,C., and **M.D. McDaniel**. Revitalizing Soils, Revitalizing Cultures: Three sisters intercropping in Midwestern Native American communities. ISU’s Bridging the Divide – an internal grant promoting interdisciplinary research among the natural sciences and the humanities. \$25,000, 8/16/2018–8/15/2020.

2017 Study on Using Decomposition of Tea as an Indicator of Soil Health

Teresa Middleton, Marshall McDaniel, Stefan Gailans, Sarah Carlson

Introduction

With the growing interest in soil health, it is important to develop a reliable yet inexpensive indicator of soil health but especially biological aspects. Our aim was to create a decomposition index that farmers could use without the high cost and inconvenience of sending a sample to a soil analysis lab. Using commercially-available Lipton tea bags as a standard substance for decomposition analysis allows for an inexpensive, easily-available substrate.

Previous research showed that soils under different diverse crop rotations differ in their ability to decompose the low-quality, or high carbon-to-nitrogen (C:N), residues. We expand on this idea by creating a decomposition index from the decomposition of a high-quality, low C:N tea (green tea, C:N=12) and a low-quality, high C:N tea (Rooibos or red tea, C:N = 43). We predict soils should be able to decompose the green tea at roughly the same level because there is little limiting the decomposition. However, we expect that a healthier soil will be able to decompose more of the low-quality red tea. So, the green tea acts as our baseline, and will fluctuate with differences in temperature, weather, etc. The Soil Decomposition Index is calculated as the amount of low-quality, red tea decomposed compared to that of the green tea – the closer to 1, the more healthy the soil.

Methods

We had two sets of studies from 2017:

- 1) Farmers with strip trials of cover crop and no cover crop.
- 2) Farmers willing to bury tea on their soils regardless of strip trials.

Here we present the findings from Study 1, and your individual farm results. The individual farm results cover both farmers in Study 1 (cover/no-cover strip trials) and also farmers participating in Study 2.

For both studies farmers buried 6 pairs of green and rooibos tea in each treatment (e.g. cover/ no cover). See our TB Protocol for more information on the burial method (can obtain from Teresa or PFI). One of each tea type was retrieved at 4, 7, 14, 30, 68, and 130 days after burial. Percent mass lost was calculated for each bag by comparing its pre-burial weight to its dried retrieval weight. From these values, a decomposition curve was constructed for both types of tea in each plot (see figures below). Soil temperature and moisture measurements (about 3") were also taken from farms in Study 1.

Results - 1) All Participating Cover Crop vs. No Cover Crop Farms

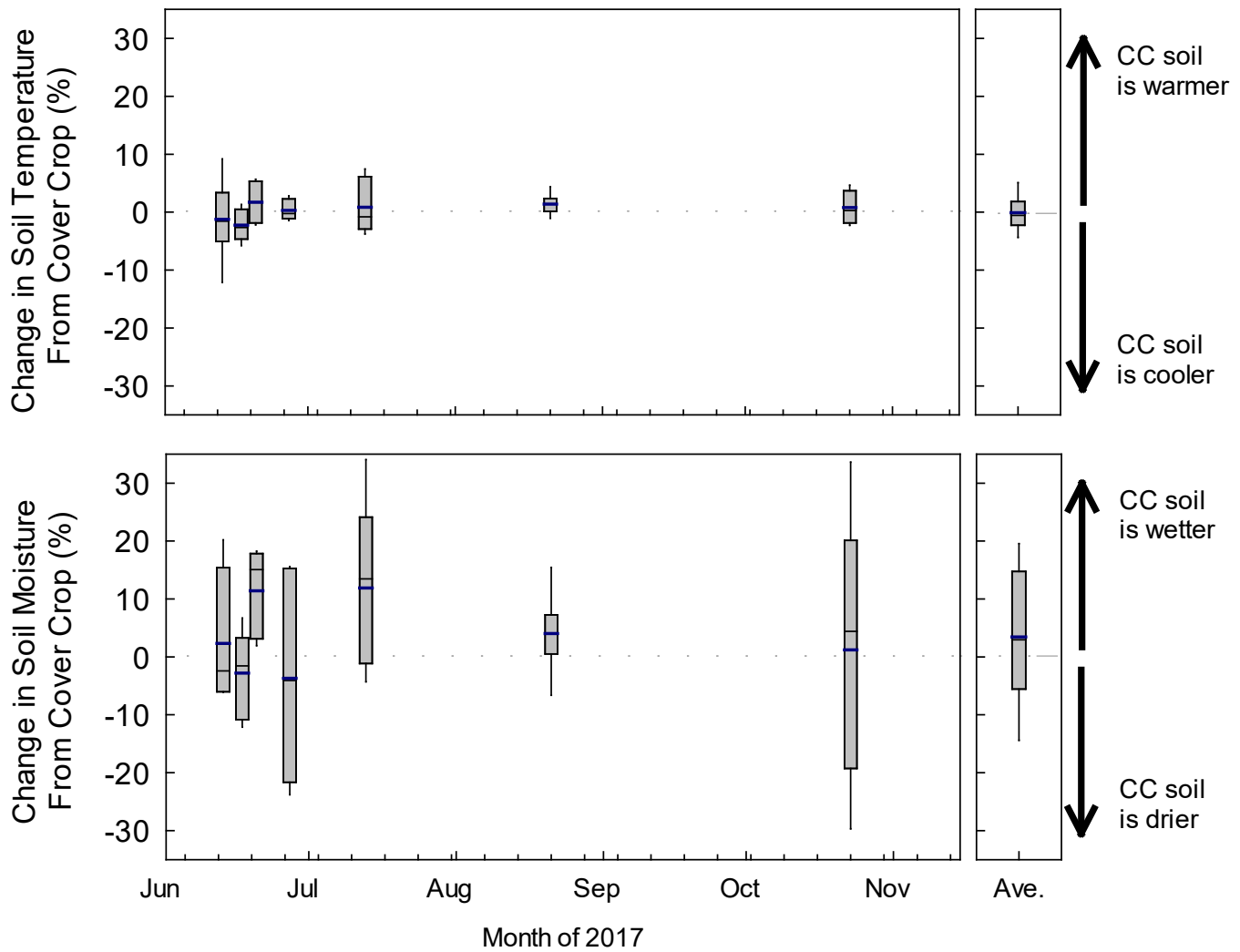


Figure 1 - Changes in soil temperature (top panels) and moisture (bottom panels) due to cover crop. Percent change is calculated as $[(\text{CoverCrop} - \text{NoCover}) / \text{NoCover}]$. **Take-home Message: Soil temperature is not affected by cover crops throughout the entire growing season. Soil moisture is sometimes higher in cover crops, overall a slight 3% increase.**

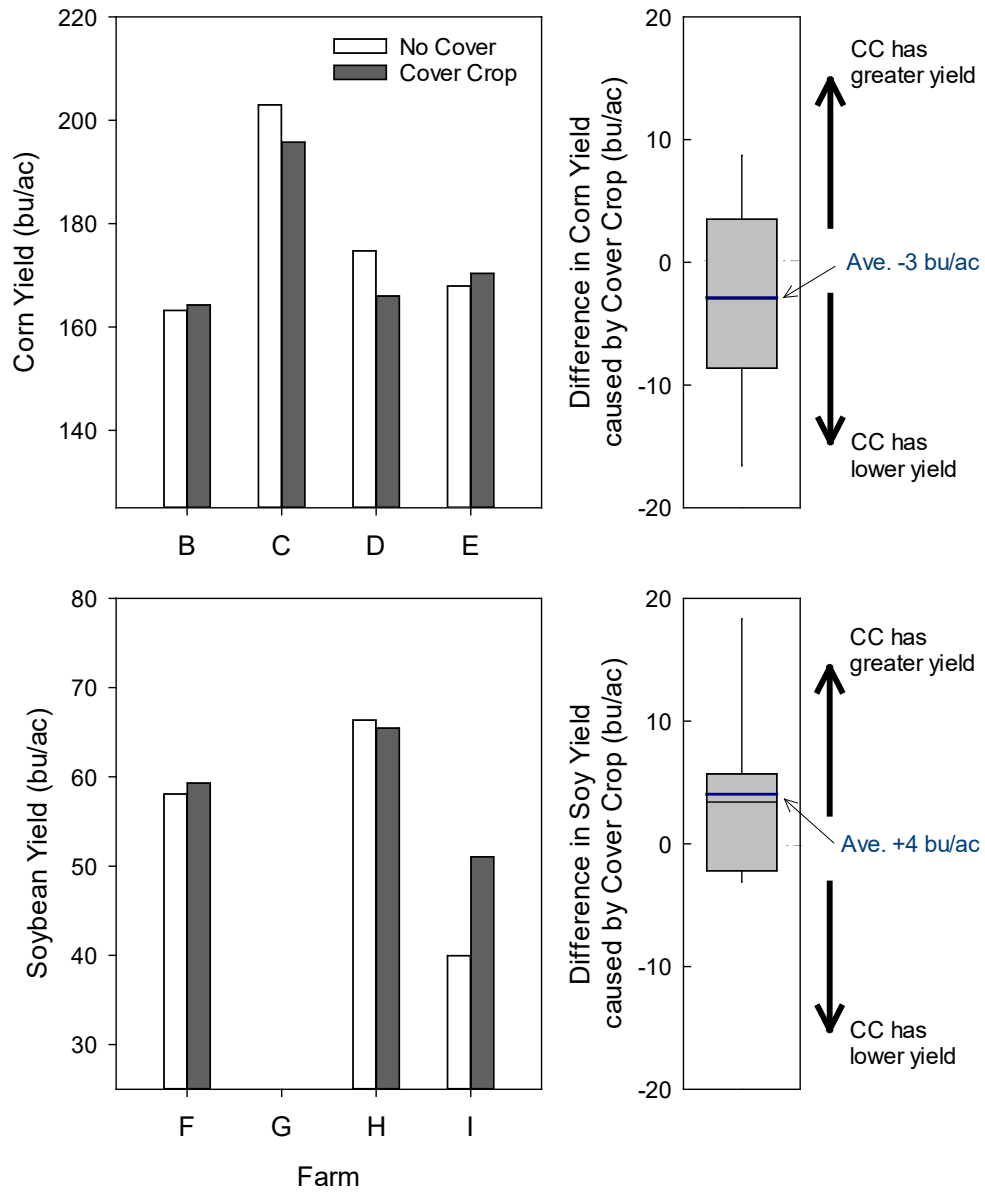


Figure 2 – Yield shown from farms that had strip trials. Corn yield (top panels) and Soybean yield (bottom panels). Percent change in yield is calculated as $[(\text{CoverCrop} - \text{NoCover}) / \text{NoCover}]$. **Take home message: Slight overall yield drag from cover crop in corn, 1-2% (or -3 bu/ac), but a yield boost in soybeans of 7 % (or +4 bu/ac, average driven mostly by Farm I).**

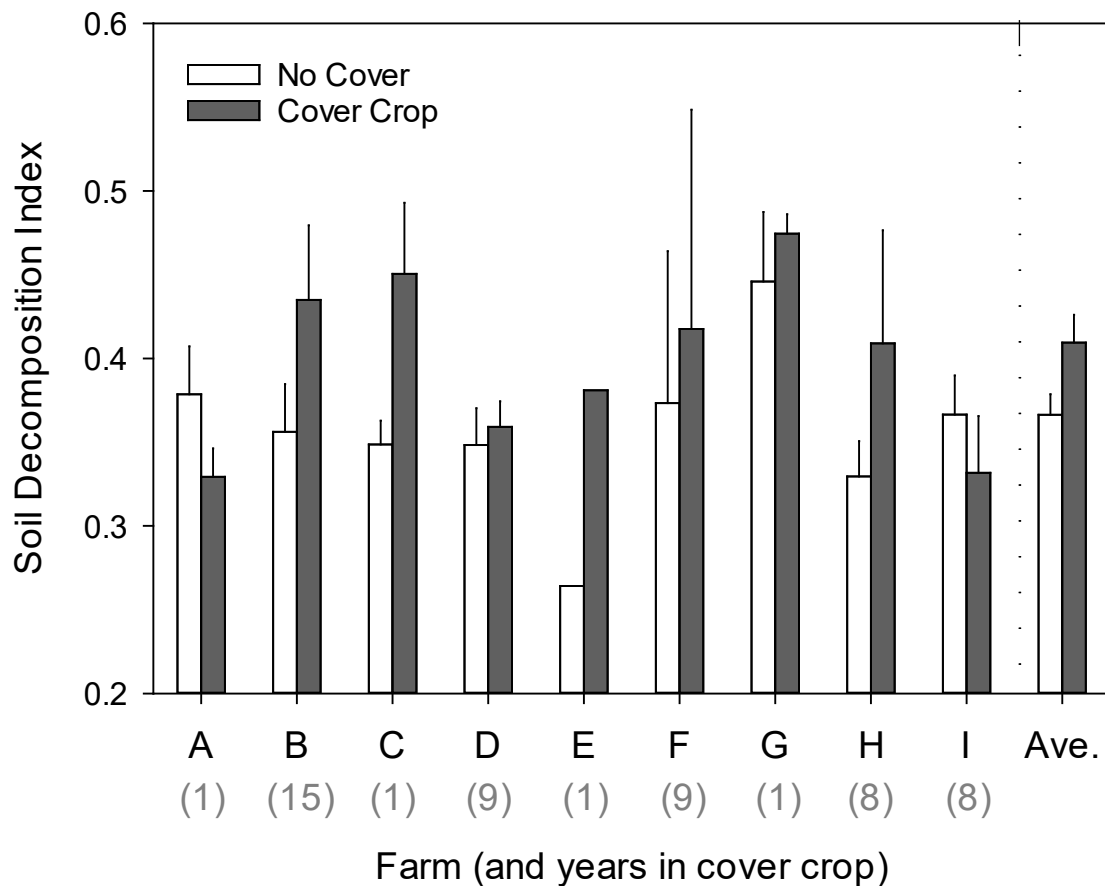


Figure 3. The Soil Decomposition Index (SDI) from day 68 after burying tea bags. SDI is calculated by subtracting the % decomposition of the red tea divided by % decomposition of the green tea. The closer to 1, the more healthy the soil. Shown are the nine Practical Farmers of Iowa farms that had strip trials of cover crops (A-I), and average SDI across the 9 farms (on the right). The decomposition index ranged from 0.26 to 0.48. **Take home message: There is a lot of variability, but the cover crop seems to improve the SDI by 11%. Interestingly, it did not seem to matter how long cover crops have been in place - whether 1 year or 15.**

Results – Your Farm (either Study 1 or 2)

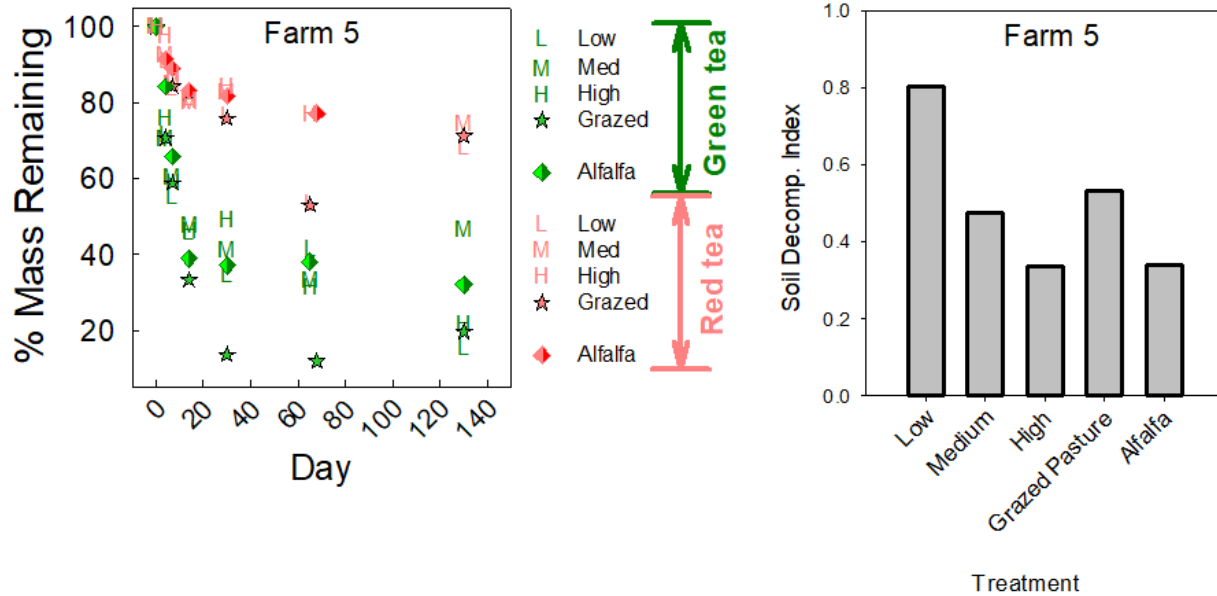


Figure 4. The tea decomposition curves and Soil Decomposition Index (SDI) from day 68 after burying tea bags. Shown is data from your personal farm. **Take home message: The green tea decomposed more rapidly and to a greater extent (11-43% mass remaining depending on treatment) than the red tea (53-78% mass remaining depending on treatment).** The SDI from your farm was 0.81 in the low productivity plot, 0.48 in the medium productivity plot, 0.34 in the high productivity plot, 0.54 in the grazed plot, and 0.34 in the alfalfa. The closer to 1, the more healthy the soil according to our index. Interestingly, this indicates that the low productivity plot has healthier soil than the medium productivity plot, and that both of those have healthier soil than the high productivity plot.

Conclusions

Overall, the Soil Decomposition Index (SDI) at 68 days did show an 11% increase with cover crops. **The use of tea decomposition, and the Soil Decomposition Index, to assess soil health seems promising at this stage but more research is needed!** We would like to determine the best way to calculate the SDI. For example, perhaps the rate of decomposition would be a better indicator. Or maybe using the relative decomposition at 7 or 14 days, or less, would be just as effective as 68 days. Therefore, there would be no need to collect as many data points, and over an extended period of time. Furthermore, we need to validate this method with other more traditional measures of soil health like soil microbial biomass, soil respiration, plant available nutrients, pH, etc... (which we did in 2017 and will do again in 2018).

We will be conducting another round of studies this field season in 2018. This will include more treatments that we expect to affect soil health, and more PFI cooperators whom would like to bury their own tea. Please contact us if you are interested in participating again or know of someone else whom might be interested.

Acknowledgements

Thank you to all of the farmers who let us bury tea bags in their fields, but especially to those of you that did the work themselves. We would also like to thank PFI staff that supported this project, and members of the McDaniel Lab that helped with sample collection and analyses.