

Tea Bags as a Low-Cost, Scientifically-Robust Soil Health Indicator



2018 Revival – Practical Farmers of IA

January 20, 2018



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The Practical Farmers of Iowa



Overview

I. State of Soil Health and Soil Health Tests

II. Origin of an Idea: A Soil Health Test Based on Decomposition

- a) Proof-of-concept from my incubation study
- b) Soil-Your-Undies
- c) Tea bags used for citizen science, education, and understanding decomposition

III. Preliminary Results from PFI Farms

IV. Final Thoughts & Next Steps



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The Agenda
AGENDA 2020

**Can American soil be brought
back to life?**

Why bother with soil health tests?

1. Comprehensive assessment of a soil's productivity and sustainability
2. Helps to evaluate effect of management practices on soils, and provide incentives for keeping soils healthy
3. May help assess land value (similar to CSR2)
4. Public and private soil health initiatives are sweeping the nation



California's "Healthy Soils Action Plan"



Maryland House Bill 1063 –
Maryland Healthy Soils Program

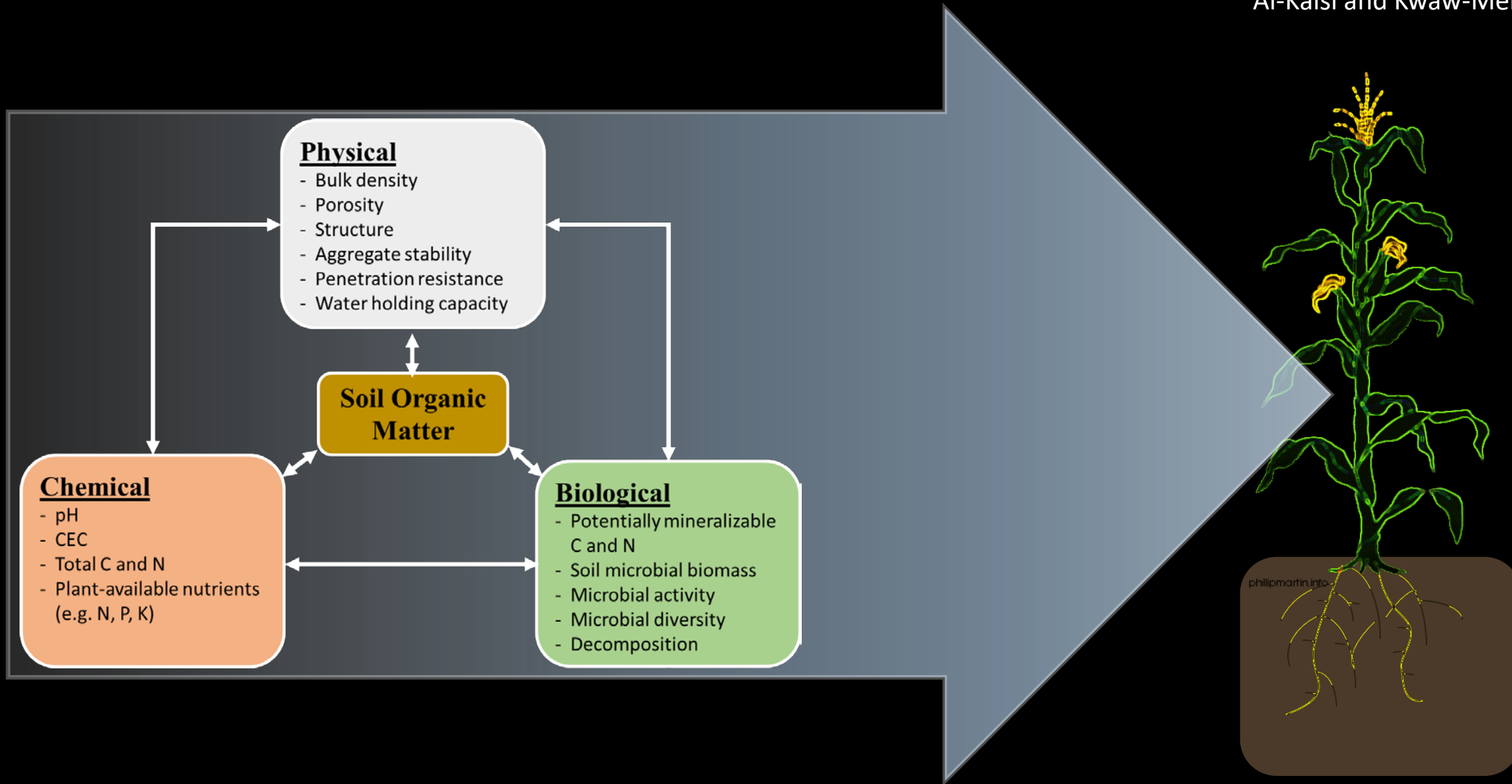


SOIL HEALTH
— INSTITUTE —

Ingredients in a good soil health test...

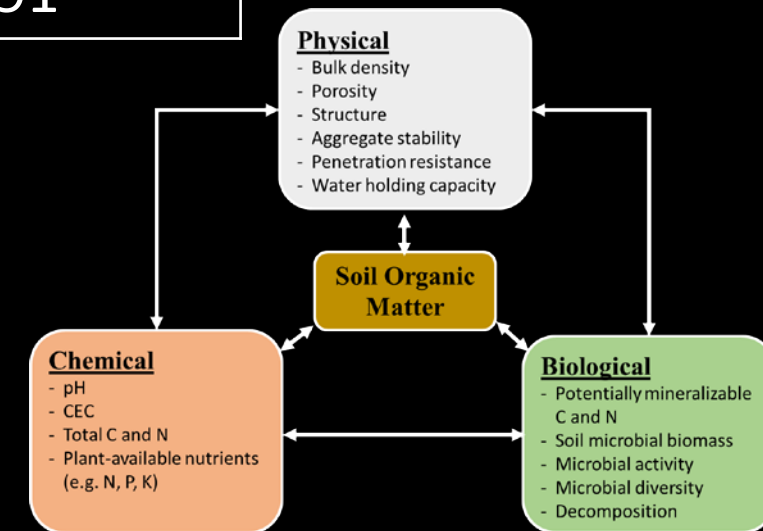
- ✓ Soil health test should be based in rigorous research
- ✓ Be broadly applicable across soil types
- ✓ Incorporate physical, chemical, and biological aspects of soil health
- ✓ Should have consistent, robust methods across laboratories
- ✓ Should relate to yield
- ✓ Should be relatively inexpensive



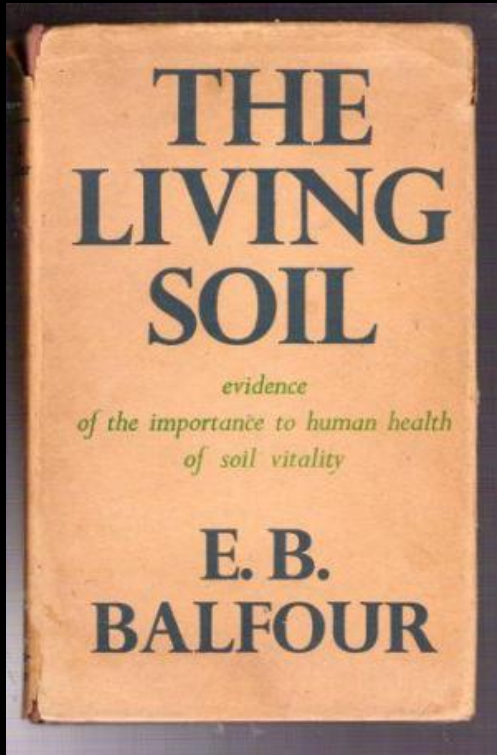


Who is measuring soil health?

Organization/Test	Range in Cost (per sample)
Cornell Comprehensive Assessment of Soil Health (CASH)	\$50 - \$150
Woods End Laboratories	\$60 - \$90
Ward Laboratories, Inc. (Haney Soil Health Test)	\$25 - \$60
Midwest Laboratories	\$55 - \$65
Average	\$48 - \$91



II) Origin of an Idea: Soil Decomposition Index




“The soil is so [healthy] that it would eat almost anything thrown at it from a gunny bag to corn stover.”

- Eve Balfour in *The Living Soil* (1943)


a) Proof-of-Concept of a soil decomposition index (SDI) from...


Soil Biology & Biochemistry 78 (2014) 243–254

Contents lists available at ScienceDirect

 Soil Biology & Biochemistry

journal homepage: www.elsevier.com/locate/soilbio



Crop rotation complexity regulates the decomposition of high and low quality residues 

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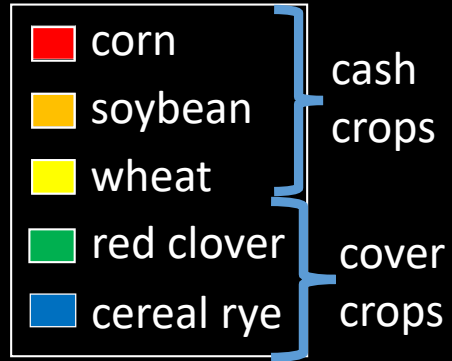
Keywords:
Plant biodiversity
Carbon mineralization
Extracellular enzymes

ABSTRACT

While many ecosystem processes depend on biodiversity, the relationships between agricultural plant diversity and soil carbon (C) and nitrogen (N) dynamics remains controversial. Our objective was to examine how temporal plant diversity (i.e. crop rotation) influences residue decomposition, a key ecosystem function that regulates nutrient cycling, greenhouse gas emissions, and soil organic matter formation. We incubated soils from five long-term crop rotations, located at W.K. Kellogg Biological Station LTER in southwestern Michigan, USA, with and without four chemically diverse crop residues. Increasing crop biodiversity increased soil potentially mineralizable C by 125%, increased hydrolytic enzyme activity by 46%, but decreased oxidative enzyme activity by 20% in soils before residue was added. After residue additions, soils from more diverse cropping systems decomposed all residues more rapidly (0.2–8.3% greater mass loss) compared to monoculture corn. The fast-cycling, 'Active C' pool and

Cropping Biodiversity Gradient

Kellogg Biological Station LTER



- 12 years of treatments
- Same tillage - 6" disc
- No external inputs

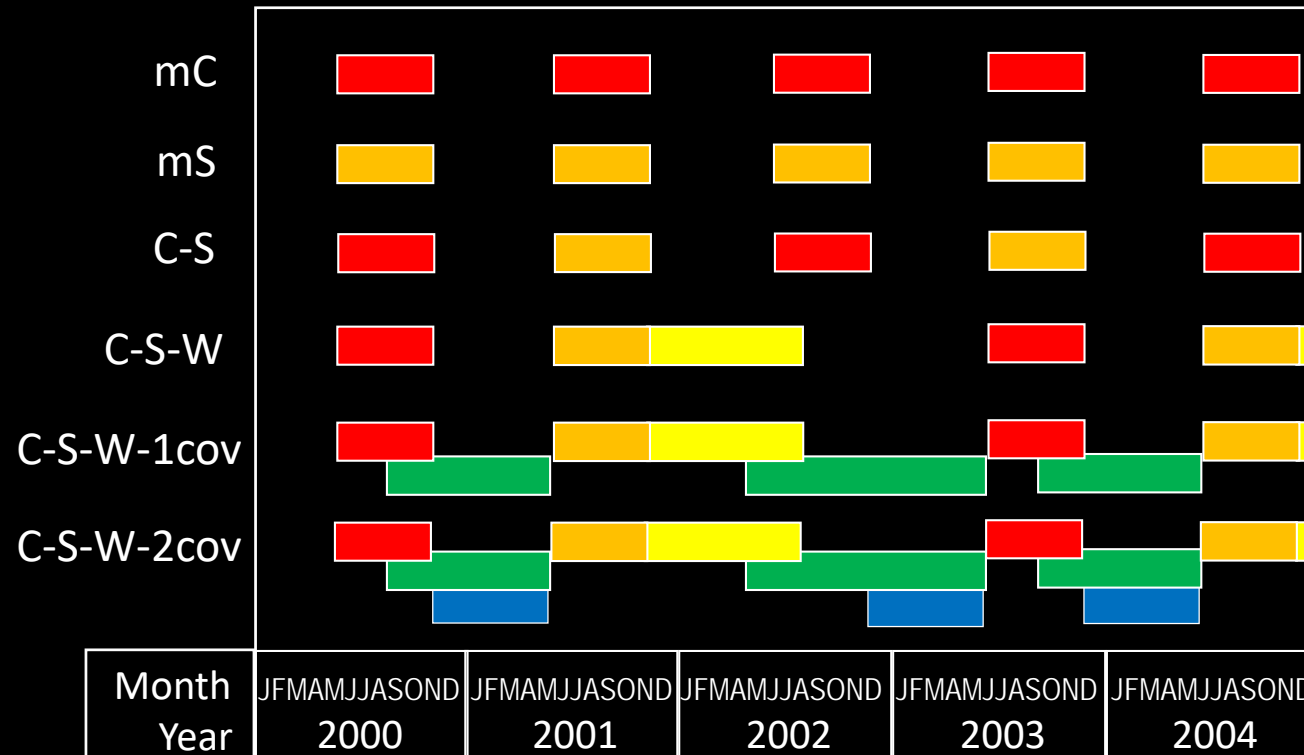
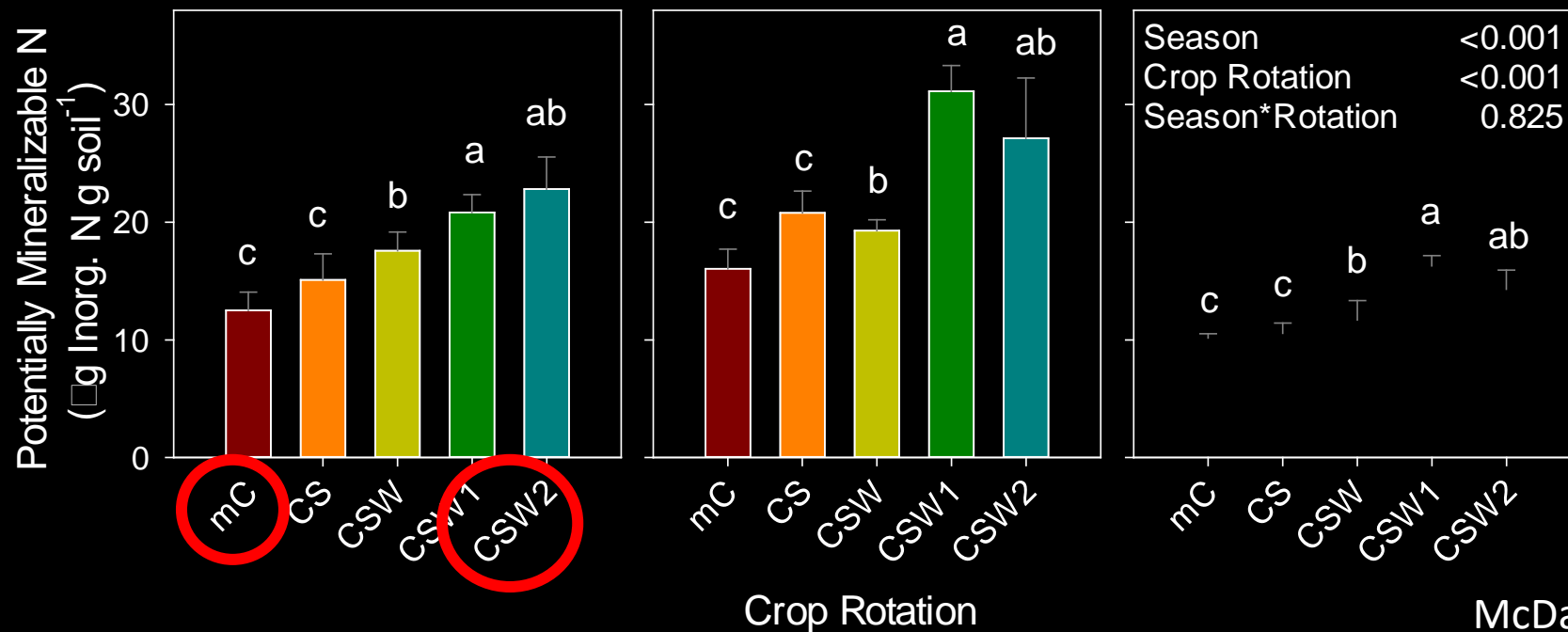
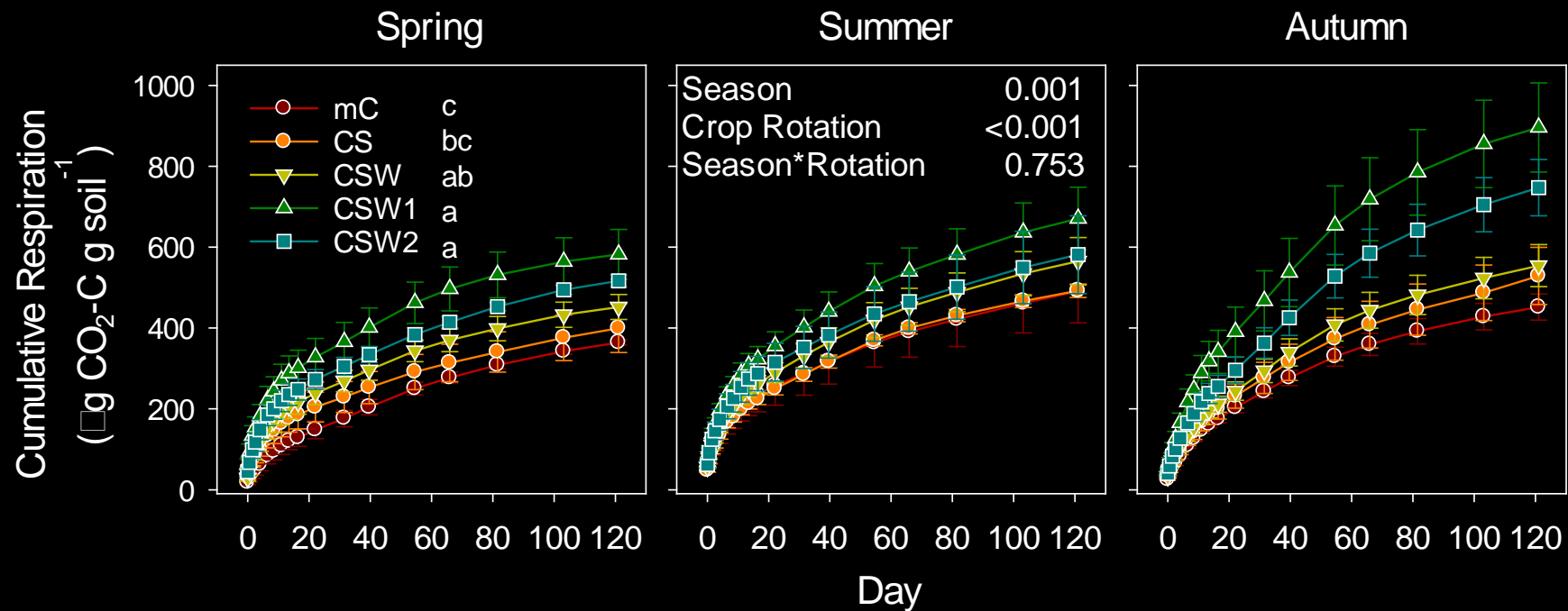
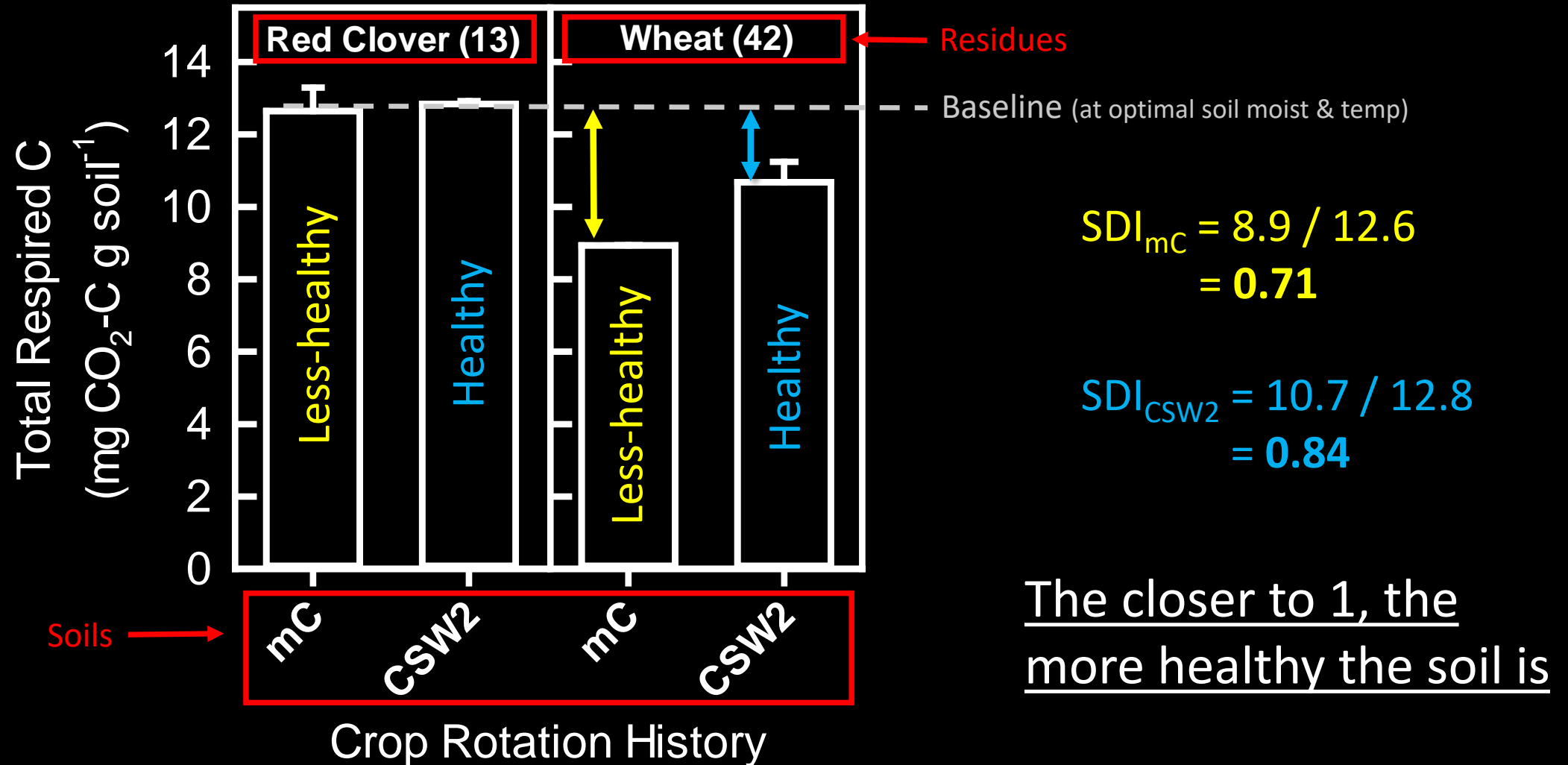


Figure Adapted from R. Smith (2008)

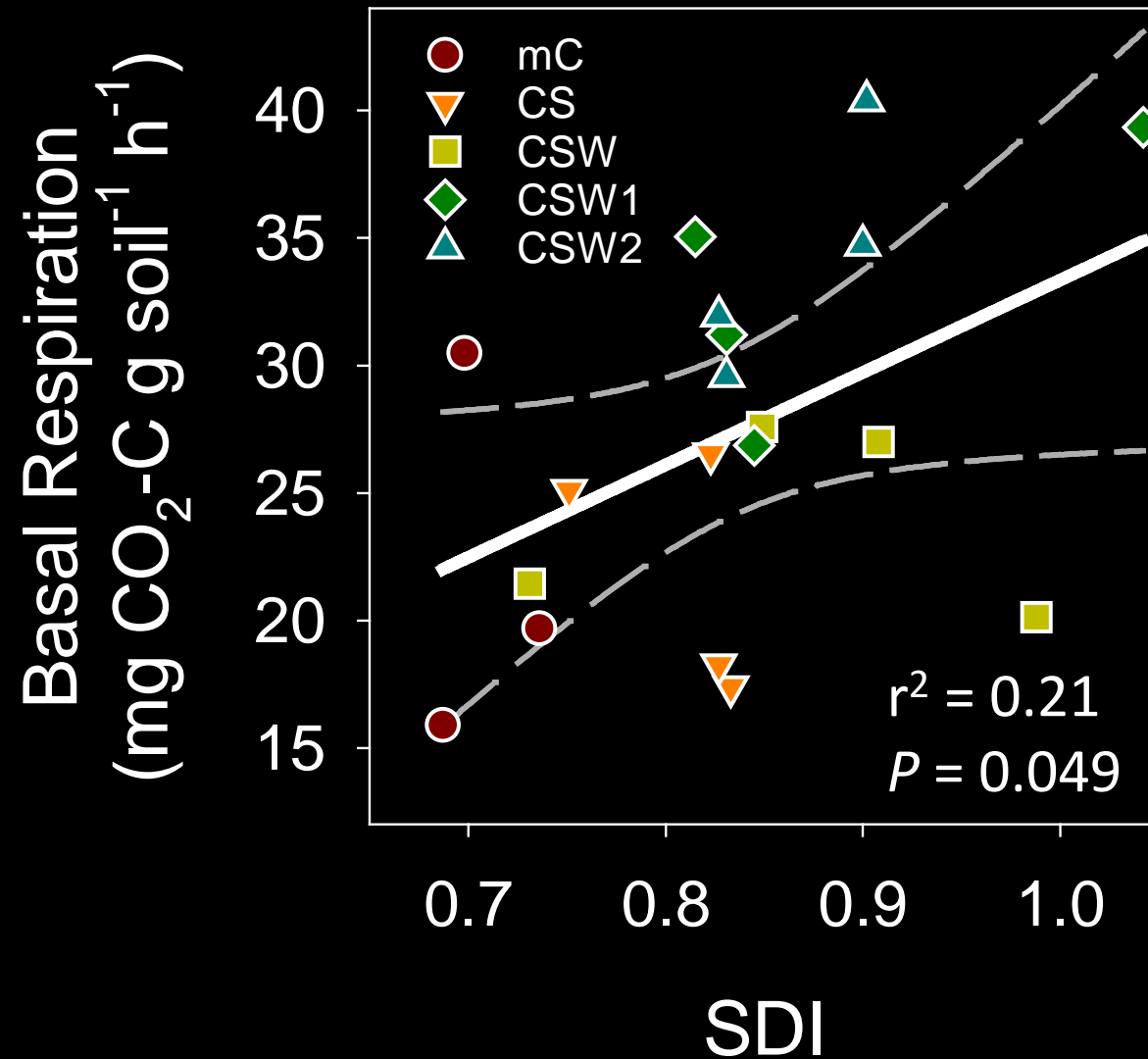


Soil decomposition index (SDI):

New soil health index incorporating difference in decomposition between high- and low-quality residue



SDI relates to other soil health indicators



However,
It's not easy (or cheap) for just anyone to do
this type of experiment!

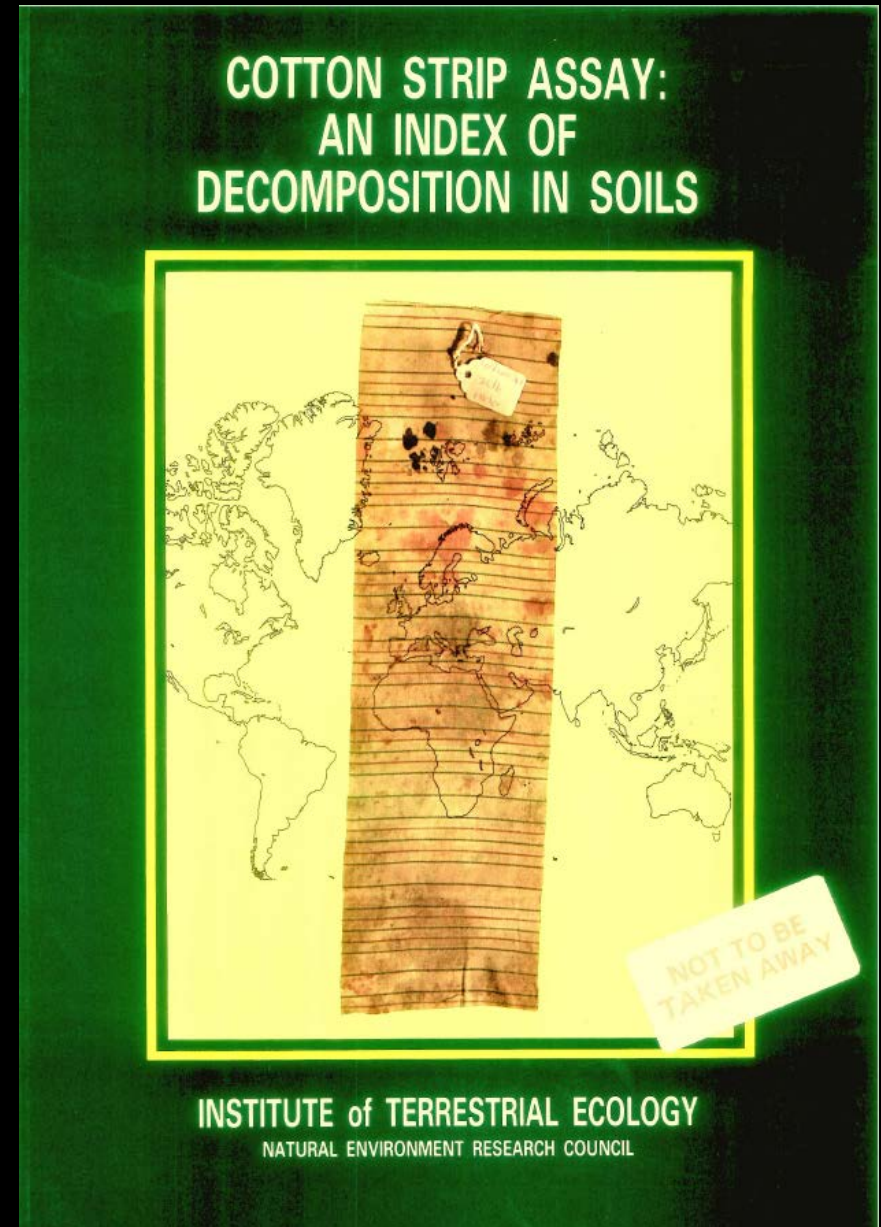


> \$10,000.00

b) Cotton is a cheap substance to decompose

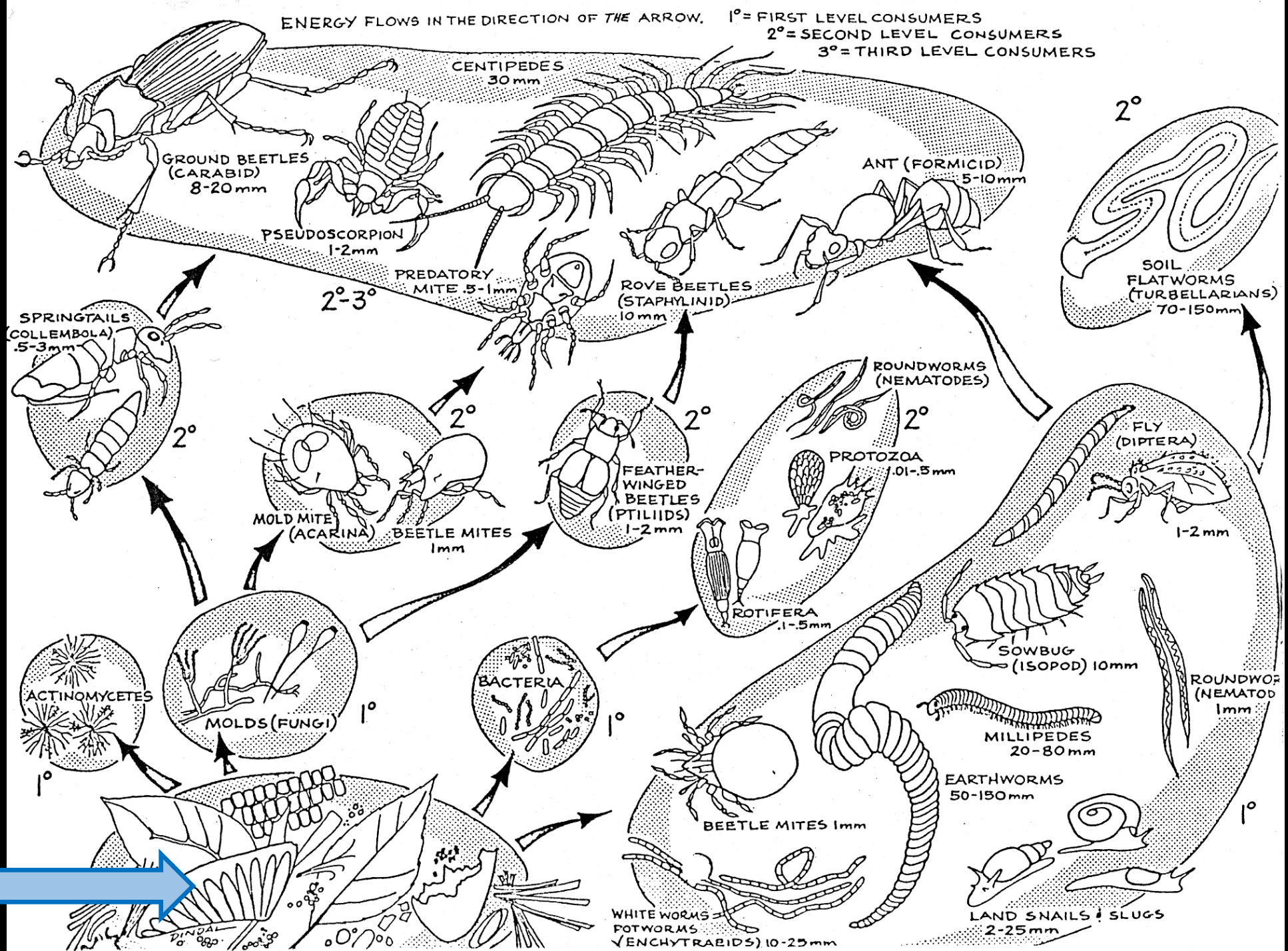


2016

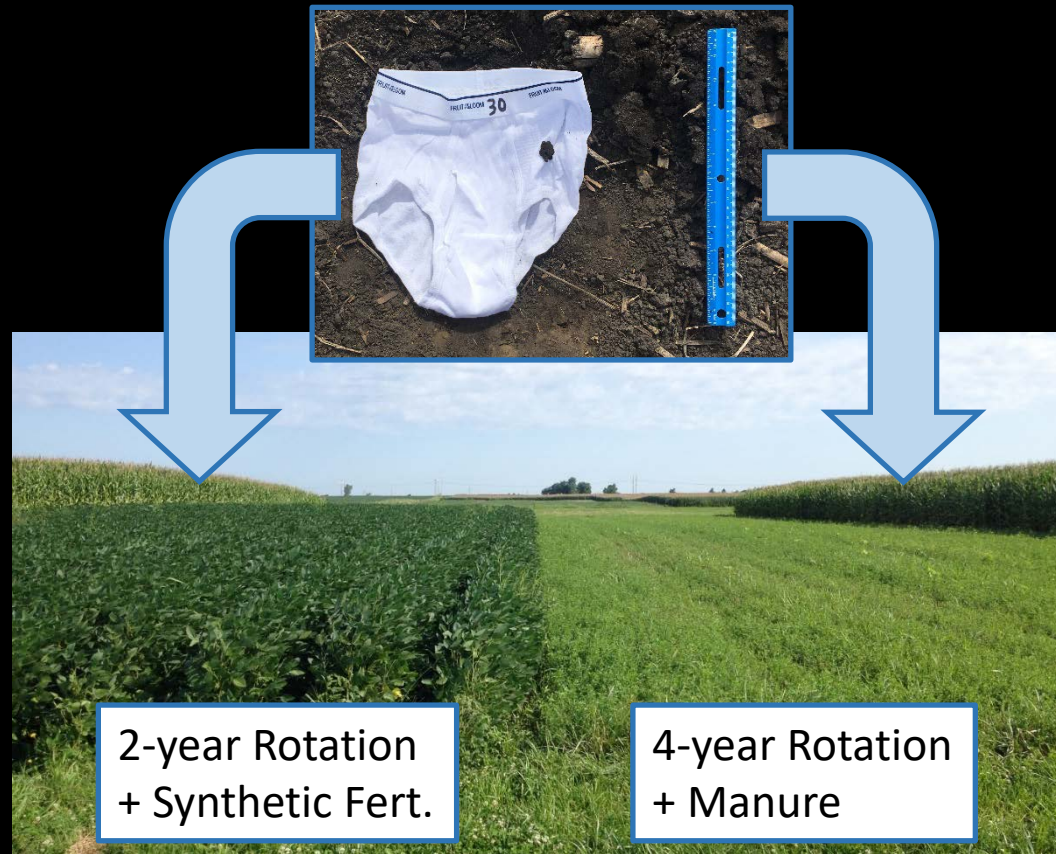


1988

The Soil Food Web



What treatment had greater decomposition of cotton underwear?



Source: Matt Woods

7 weeks later

Percent decomposed:

7 %



2-year Rotation
+ Synthetic Fert.

20 %



4-year Rotation
+ Manure

Soil Your Undies

- 100% cotton undies
- Bury 2 inches in ground
- Leave band sticking out
- 6 weeks in ground
- Demonstrate biological activity in soil

33%

Permanent
Pasture

24.4%

No till
Soybeans
with Cereal Rye
Cover Crop

45.1%

Alfalfa

0.5%

Conventional
Corn

22.1%

No till
Soybean

Legend:

% Undies lost
by weight

Demo & Photo by:
Neil Sass
Soil Survey Office
Waverly, IA

Soil Your Undies

Works great as a demonstration tool, but not as a scientifically-robust indicator of biological activity...

1. It's messy and inconvenient to retrieve underwear
2. Soil temperature and moisture are stronger regulators
 - ✓ adds lots of variability (problem with Haney & Solvita too)
 - ✓ difficult to compare among soils/treatments

Can we develop a more scientifically-robust soil health (biology) indicator, but is still inexpensive?

c) Tea bag decomposition as inexpensive education and citizen science tool

Methods in Ecology and Evolution



Methods in Ecology and Evolution 2013, **4**, 1070–1075

doi: 10.1111/2041-210X.12097

Tea Bag Index: a novel approach to collect uniform decomposition data across ecosystems

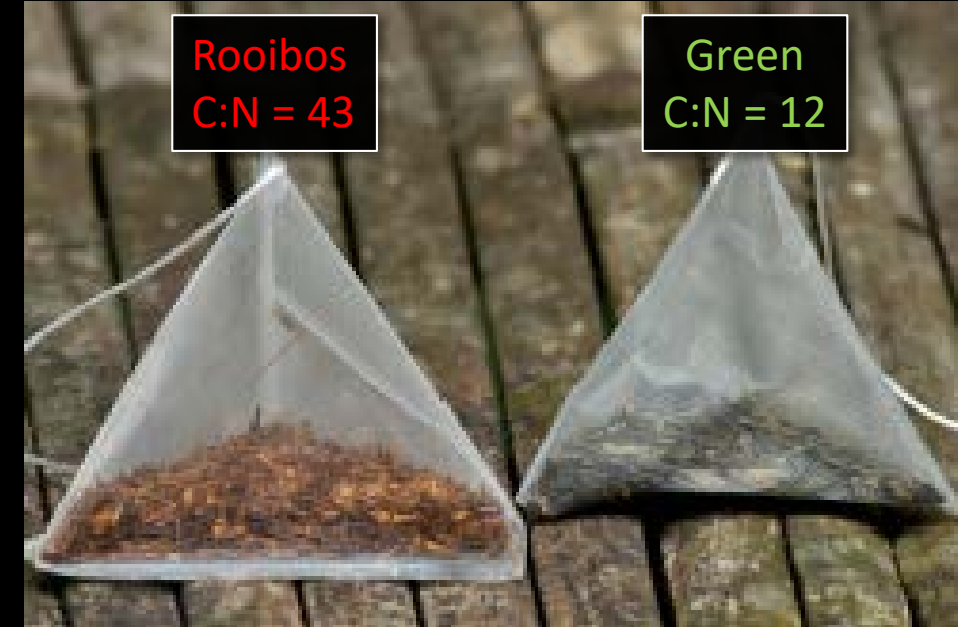
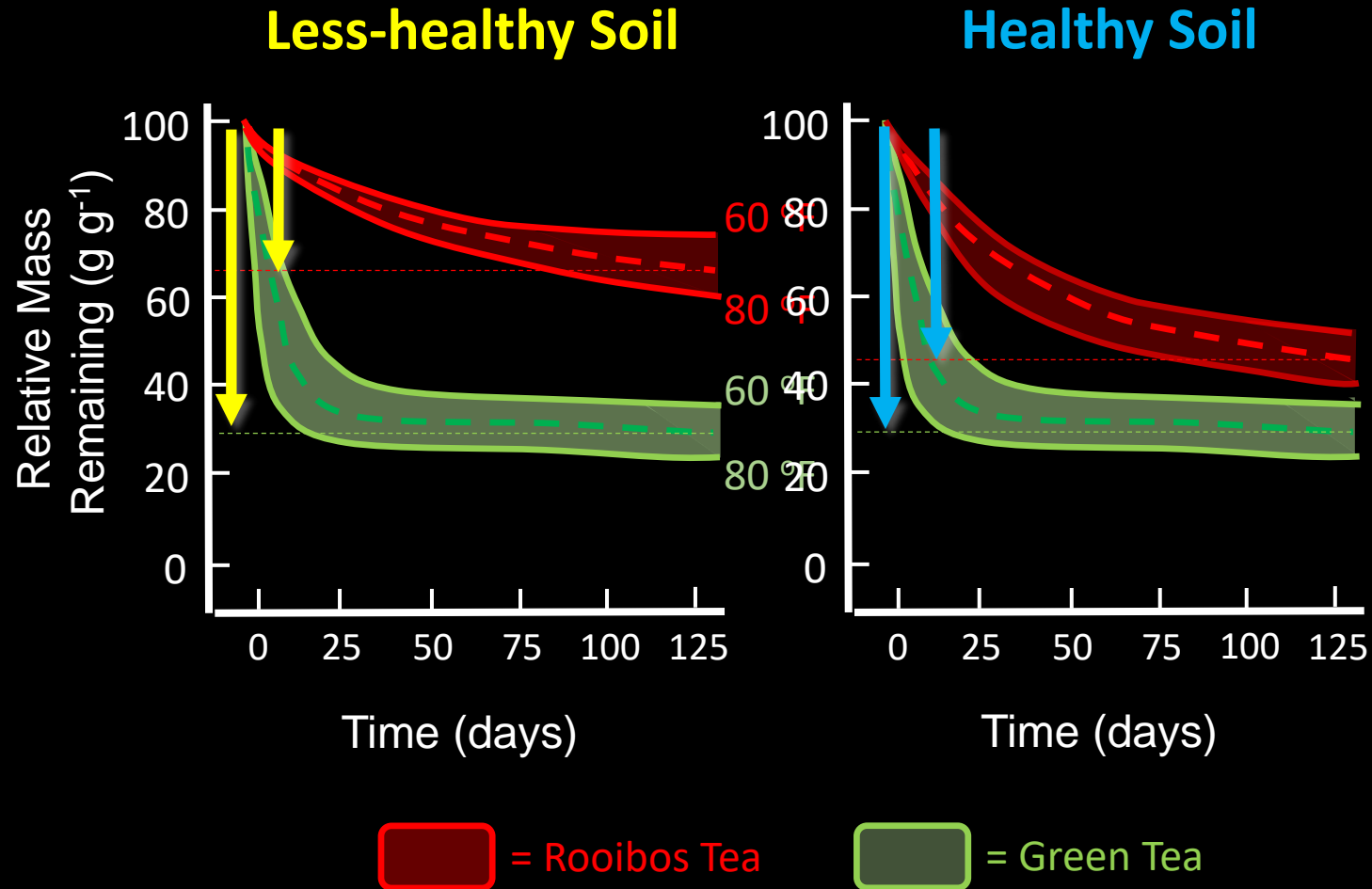
Joost A. Keuskamp^{1*†}, Bas J. J. Dingemans^{1†}, Taru Lehtinen^{2,3}, Judith M. Sameel^{4,5} and Mariet M. Hefting¹

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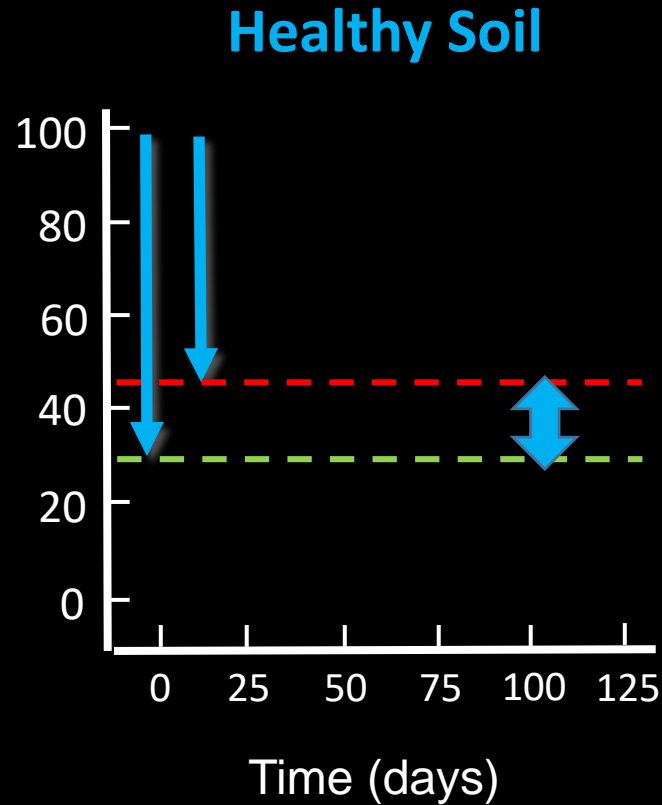
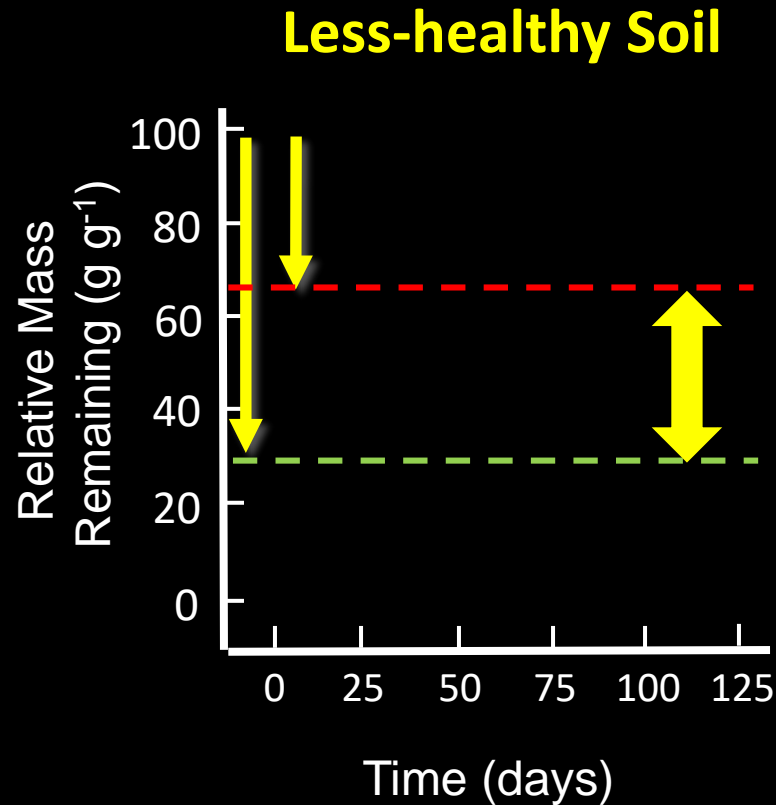
Summary

1. Changes in the balance between soil carbon storage and release can significantly amplify or attenuate global warming. Although a lot of progress has been made in determining potential drivers of carbon release through large-scale decomposition experiments, climate predictions are still hampered by data limitation at a global scale as a result of high effort and measurement costs of comparative litter decomposition studies.

SDI with two tea bags to measure Soil Health



Calculating SDI with two tea types



$$SDI_{US} = \frac{(100 - 65)}{(100 - 30)} = 0.50$$

$$SDI_{HS} = \frac{(100 - 45)}{(100 - 30)} = 0.79$$

The closer to 1, the more healthy the soil is

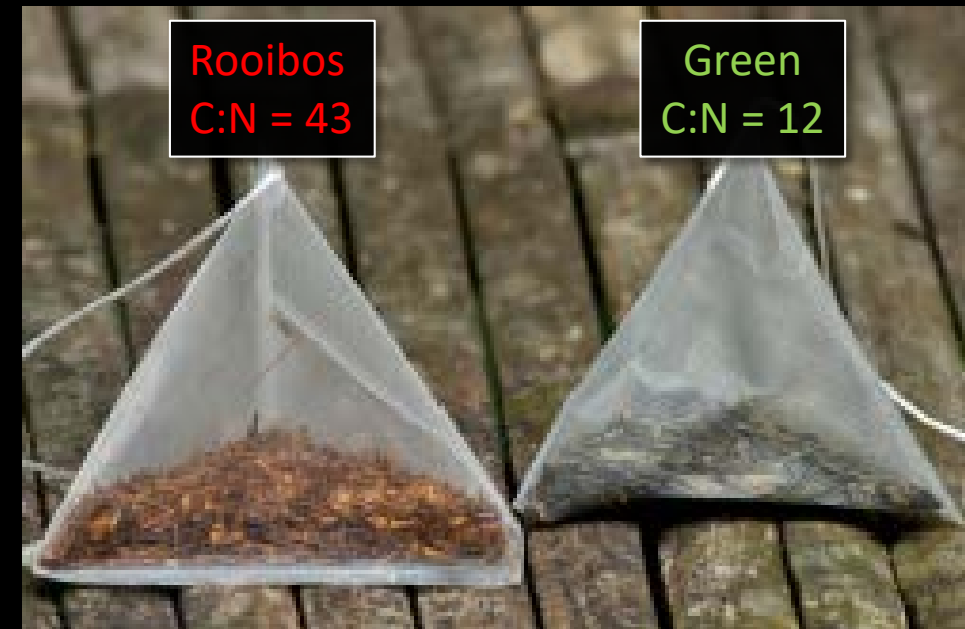
= Rooibos Tea

= Green Tea

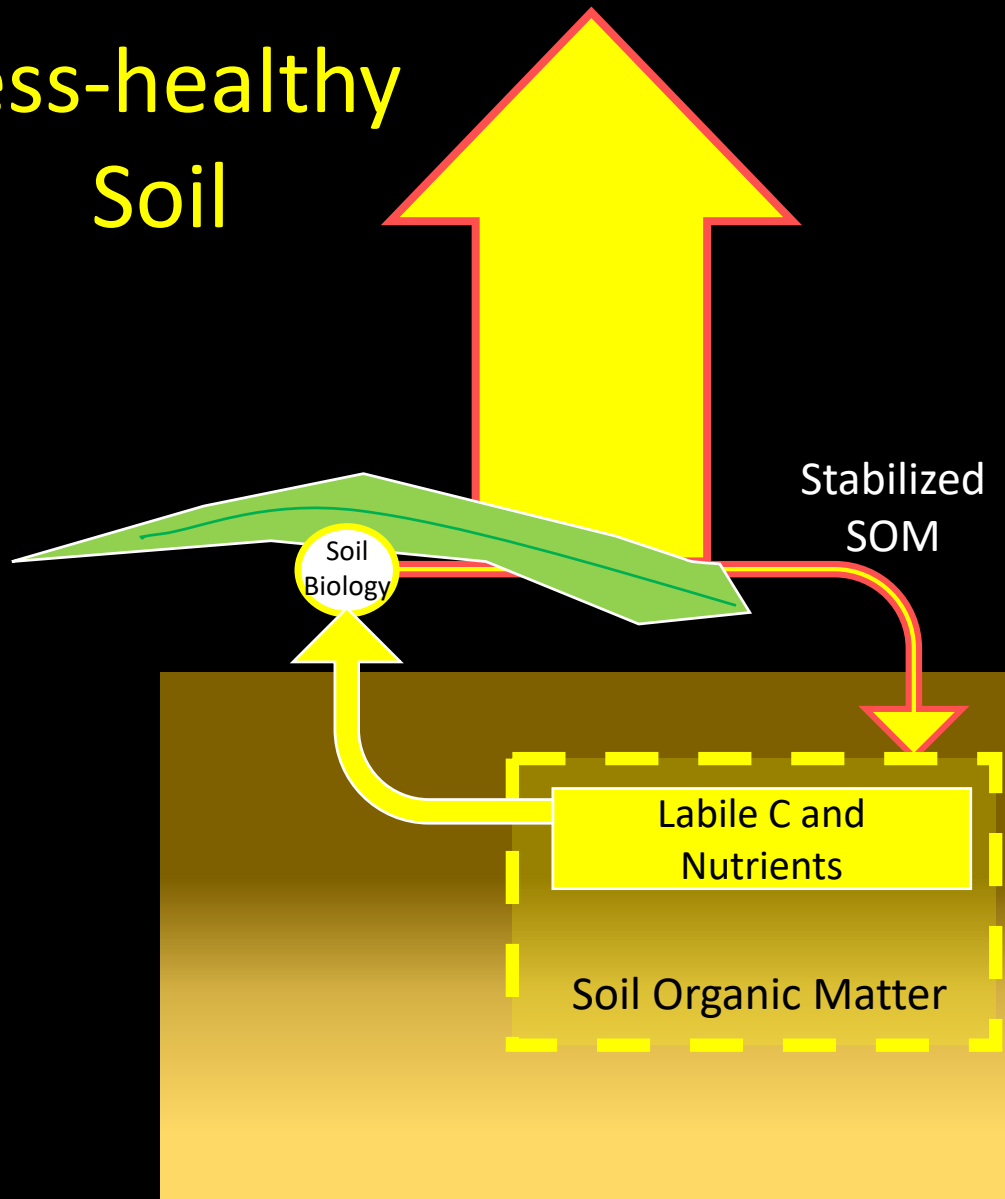
Benefits of SDI with two teas

- It's very inexpensive!!!
- Tea is in a convenient 'litter bag'
- Using two teas, with **Green Tea** as the baseline, might 'correct' for any temperature or moisture variability
- Integrated measure of soil biological activity and resources available to soil microbes (carbon and nutrients)

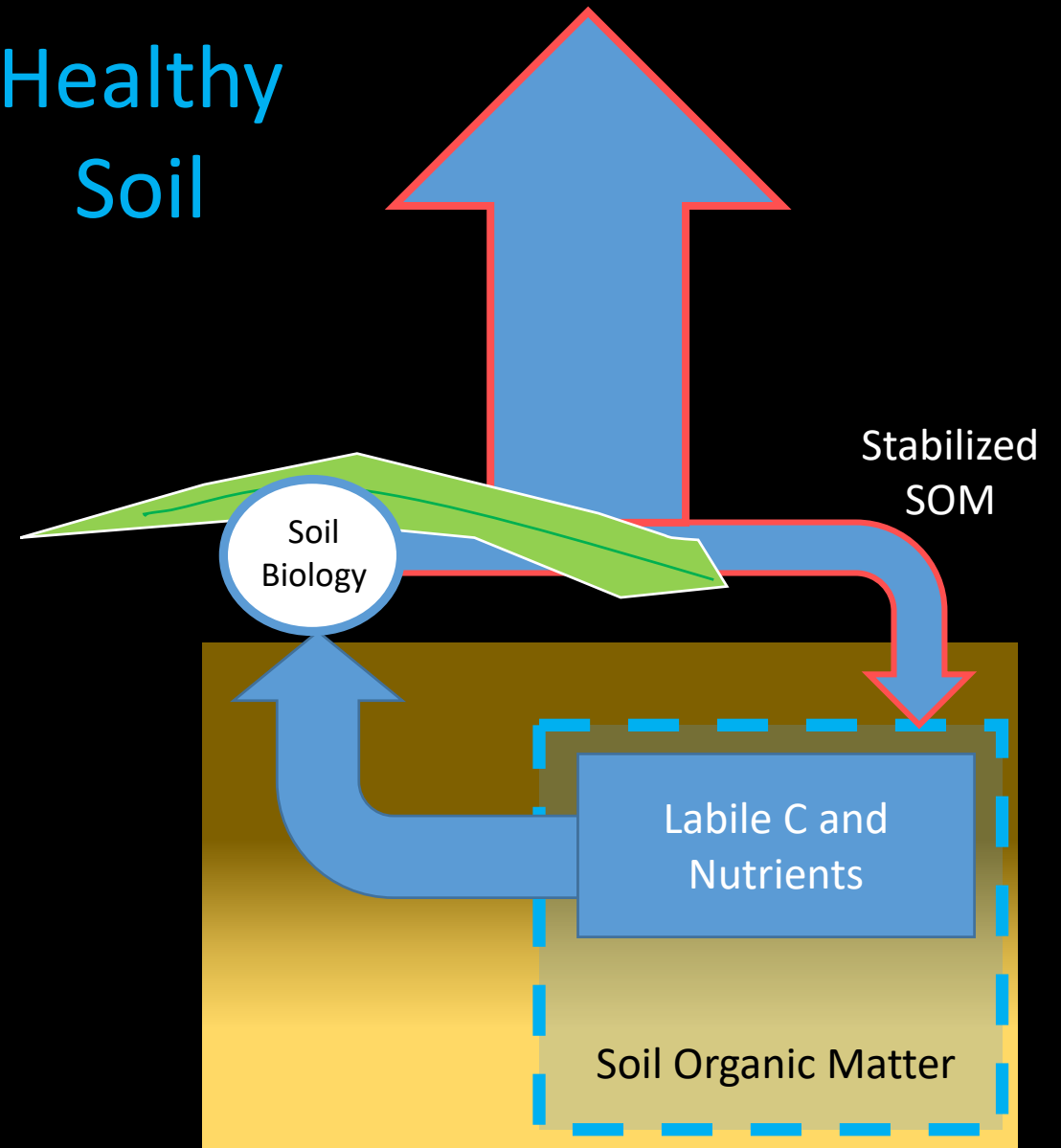
~\$20 for 60 pyramids



Less-healthy
Soil



Healthy
Soil

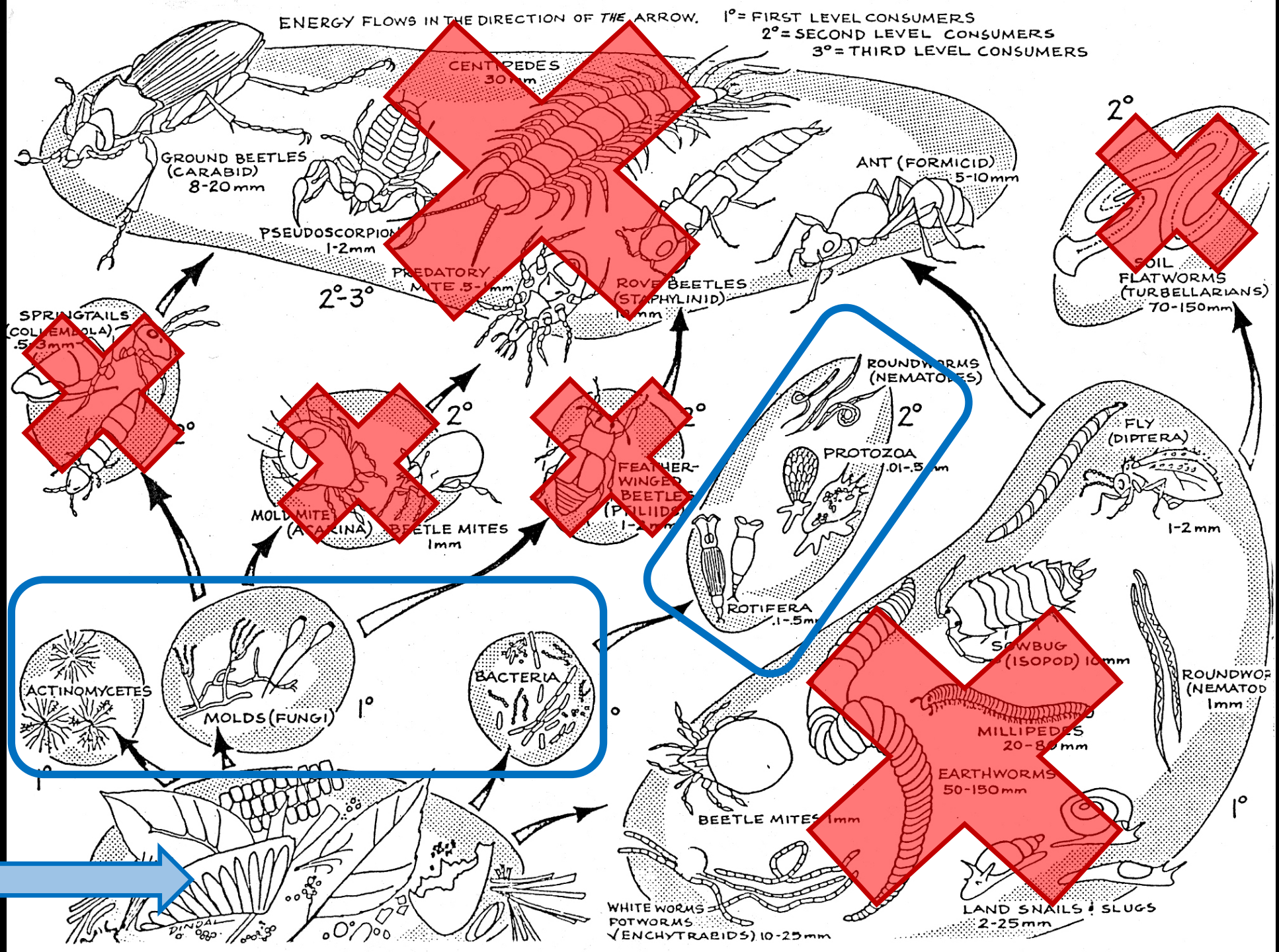


Initial Stage of Decomposition

Limitations of the SDI with tea bags

1. Does not measure abundance/activity of larger soil fauna
 - mesh size 0.25 mm
2. Lipton has discontinued the original nylon mesh teabags
 - New tea bags are even be decomposable!
3. Rooibos tea is not easily available in the U.S., so it must be ordered overseas
4. The effects of temperature and moisture may still make comparisons difficult (like other biological tests)

The Soil Food Web

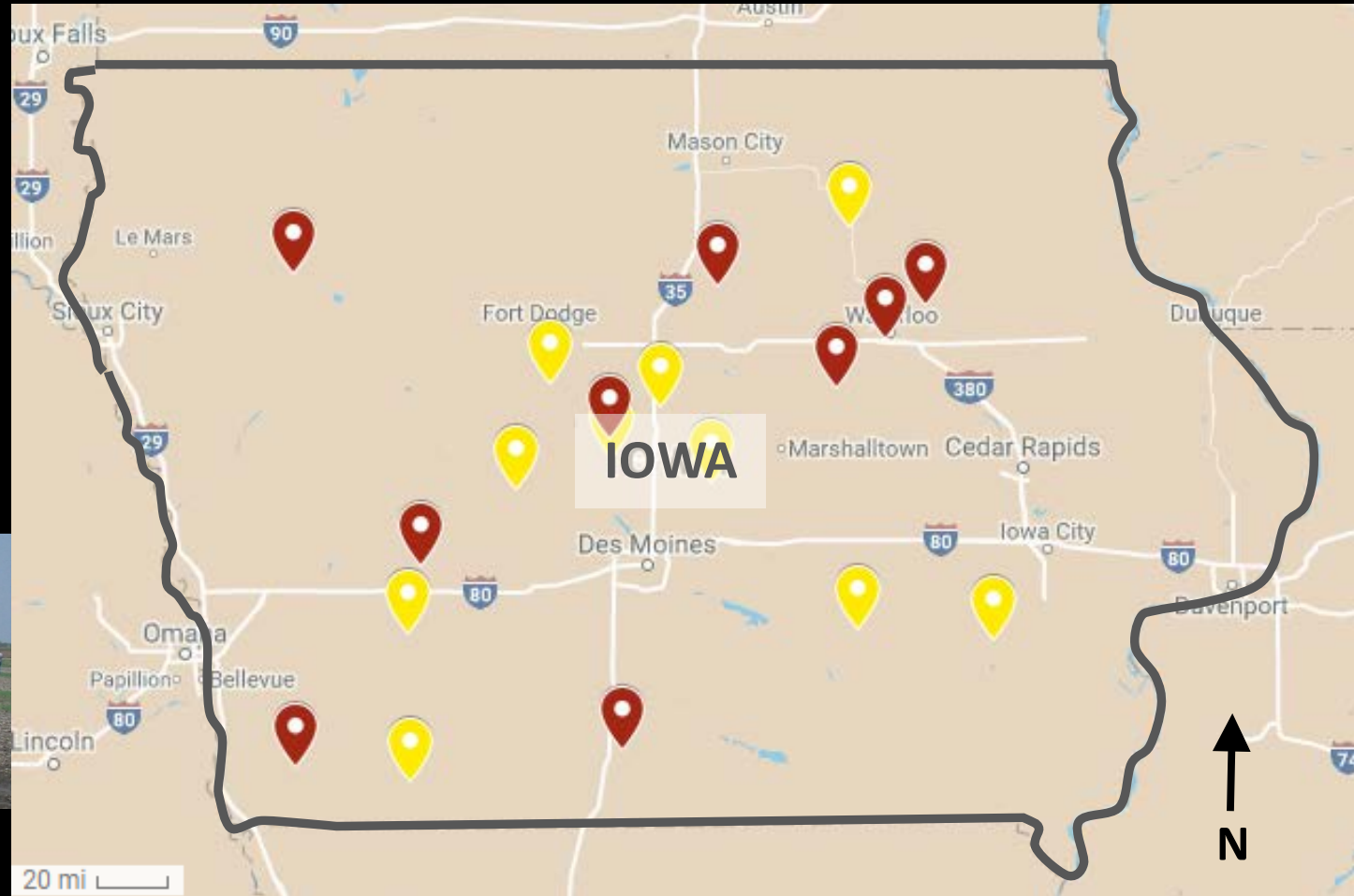


Preliminary Results from PFI Farms

- 📍 = Replicated Strip Trials (n = 10)
(cover crop vs. no cover)
- 2 soil samples
 - Soil temp. & moisture
 - Other soil health measurements



Source: <http://practicalfarmers.org/blog/2014/04/16/cover-crop-affect-corn-soybean-yields/>



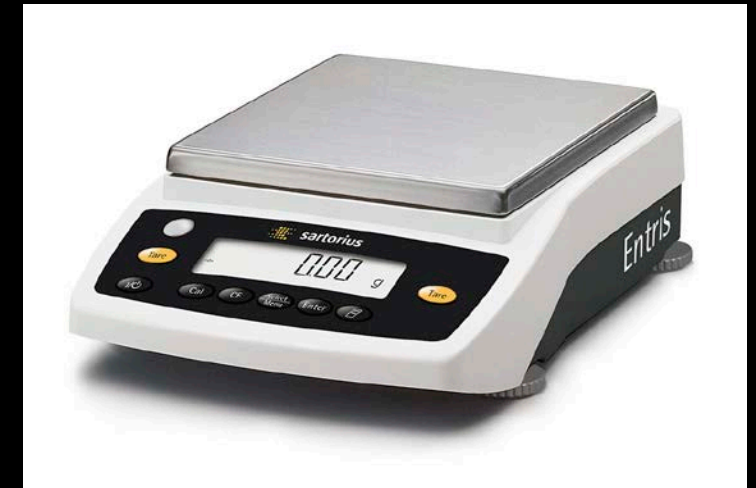
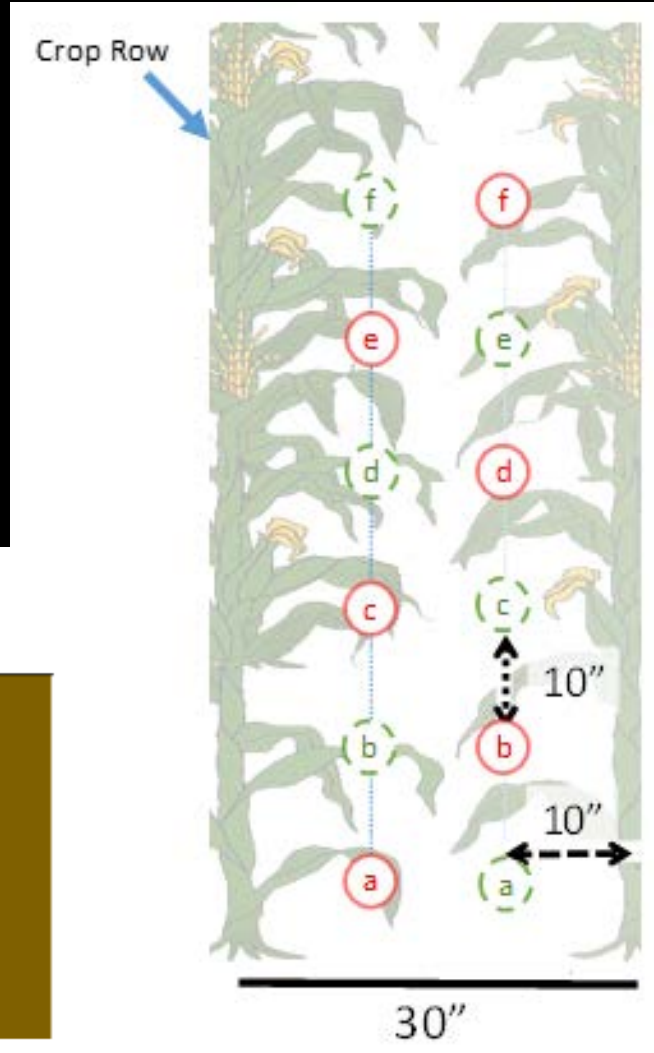
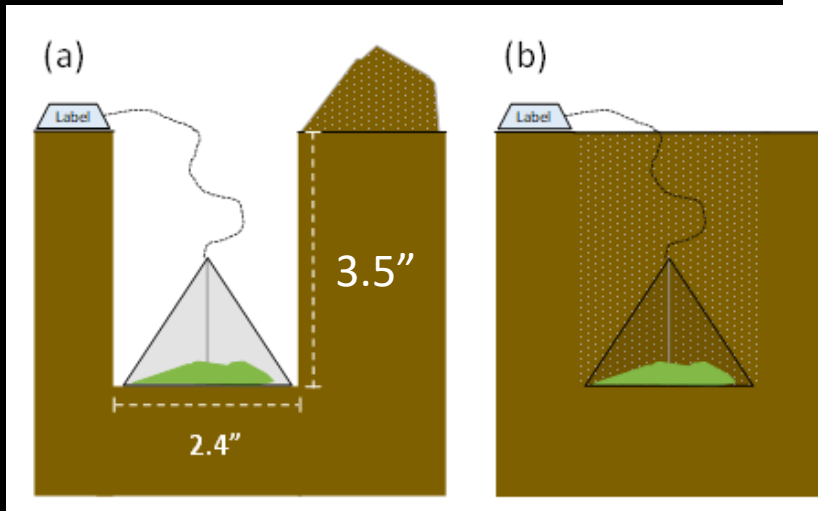
- 📍 = Farmer-collected data (n = 10)
- Voluntary soil samples
 - Recorded observations

Focused Study on Replicated Cover Crops

Farm	Years in CC	# of strips	Dominant Soil Series	Cash crop in 2017	CC Seeding Rate/Method (lbs ac ⁻¹)	N Fertilizer Method/Rate and Source	Other Mgmt Practices
A	1	5	Brownton silty clay loam	Corn	??%/Aerial	Split/200 manure, 70 AA	Strip till
B	15	5	Clarion loam	Corn	70/Drill	Split/200 UAN	No till
C	1	4	Webster clay loam	Corn	56/Drill	Split/???	???
D	9	3	Nicollet loam	Corn	60/Drill	Banded pre-plant/?? AA	???
E	1	4	Ladoga silt loam	Corn	50/Drill	Pre-plant/ 110 manure	???
F	9	4	Kenyon loam	Soybean	56/Aerial	Banded/98 manure	No till
G	1	5	Marshall silty clay loam	Corn	56/Drill	Split/20-30 manure + 150 banded, 6 UAN (side-dress)	???
H	8	5	Kalona silty clay	Soybean	56/Drill	???	???
I	8	4	Colo silty clay loam	Soybean	56/Drill	???	???

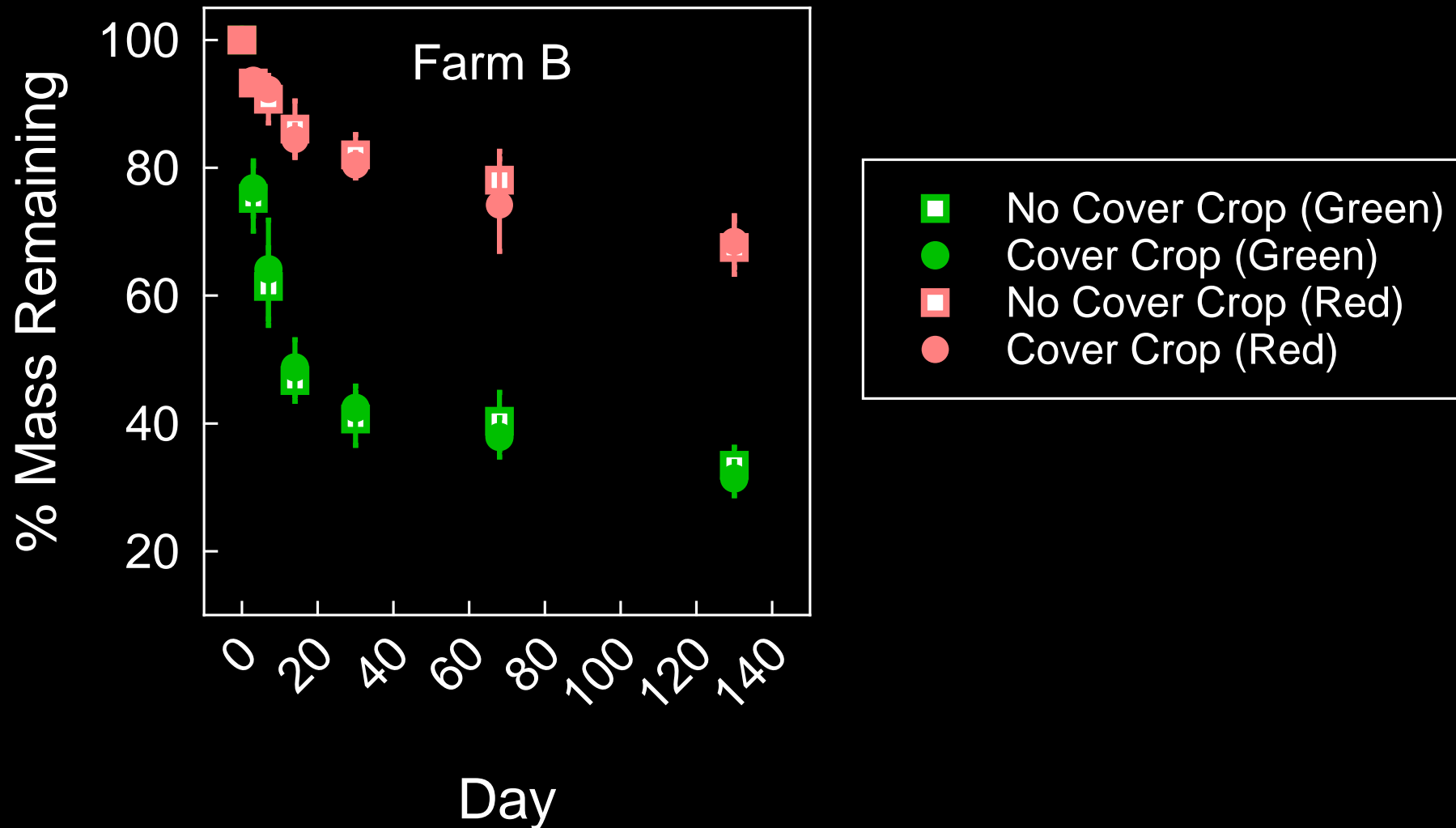
TB Decomposition Methods

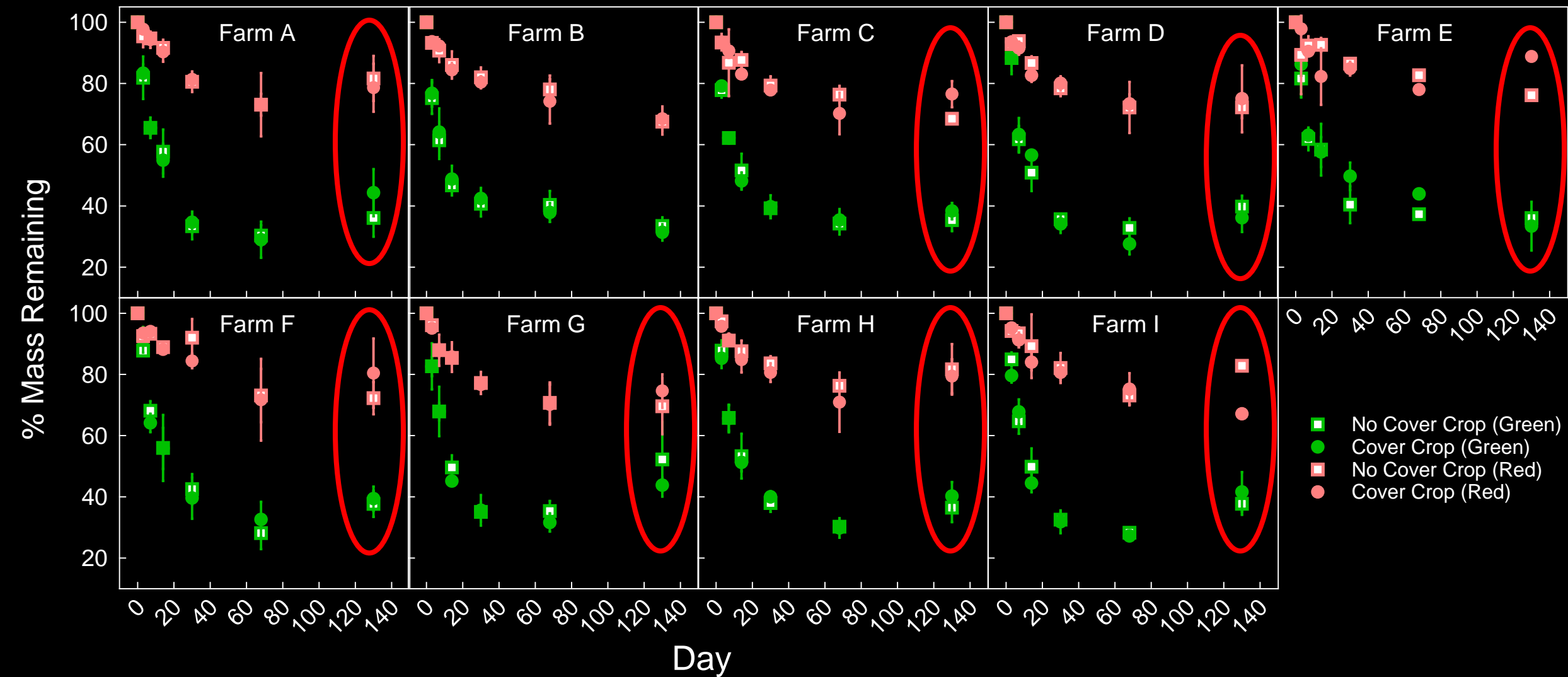
1. Twelve tea bags (6 × **Green** and 6 × **Rooibos** tea) buried 3.5" deep, between May and June
2. Retrieved tea bags at 4, 7, 14, 30, 68 and 130 days of decomposition.
3. Dry tea bags
4. Weighed the mass loss of tea



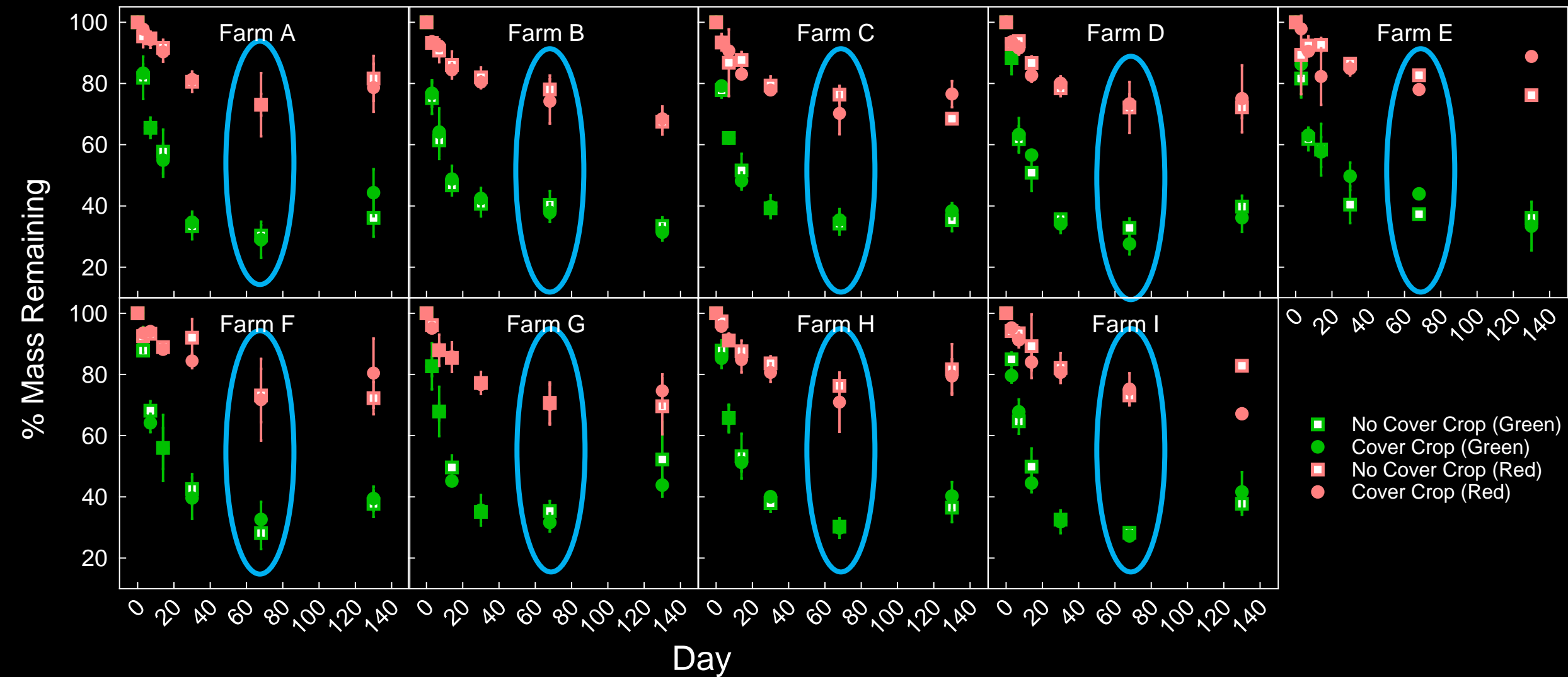


III) Preliminary Data from PFI Farms

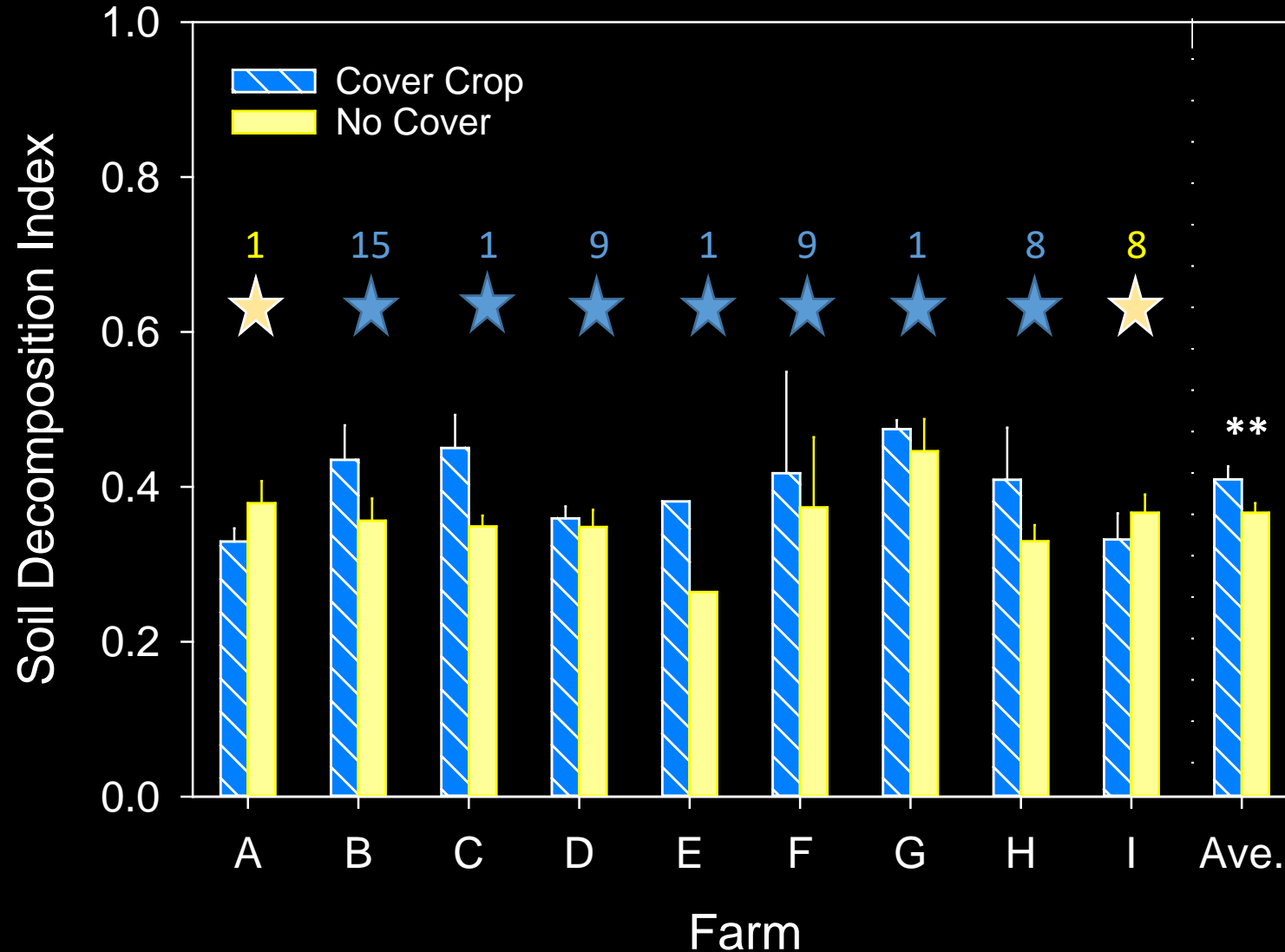






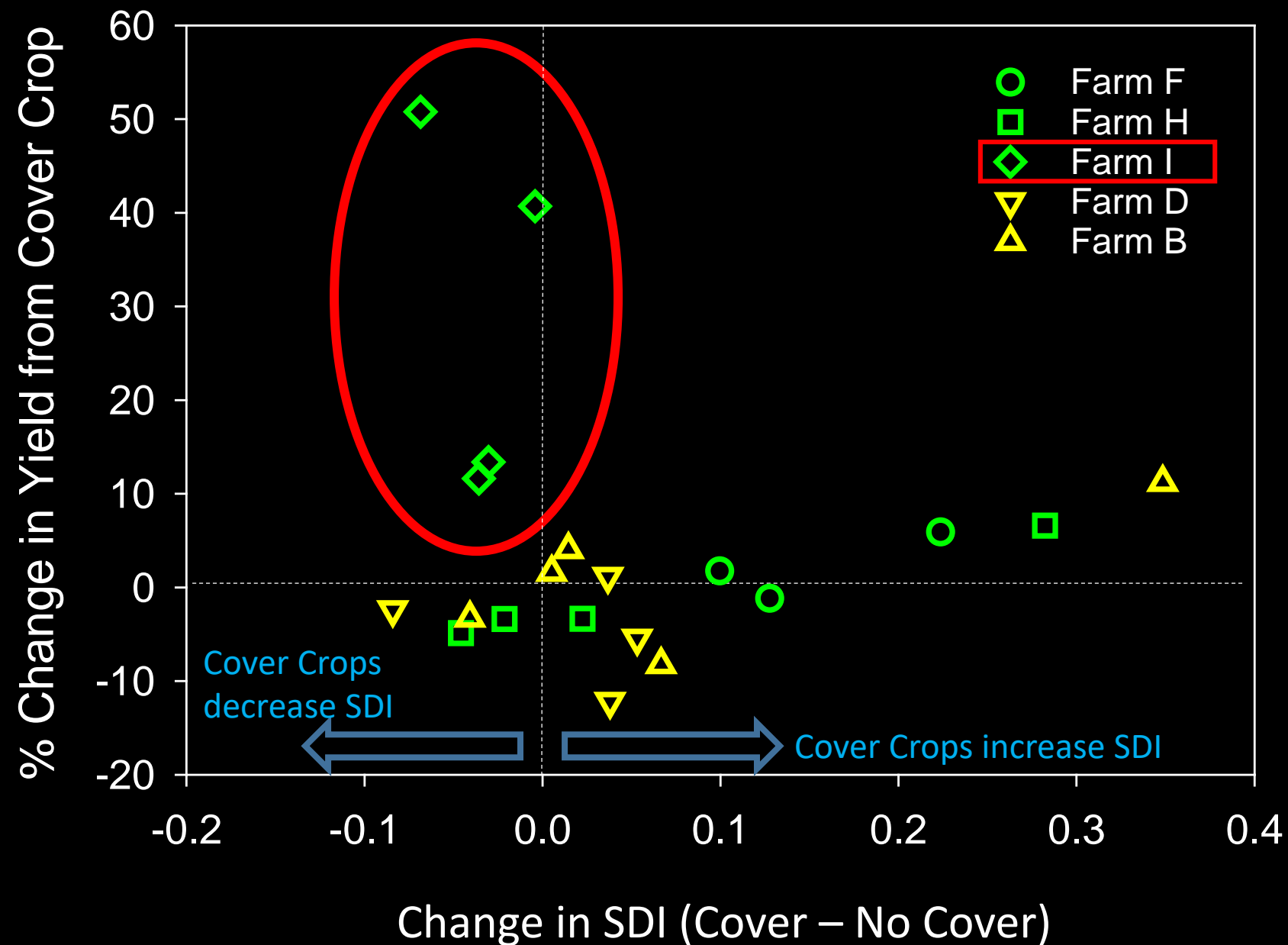


7/9 farms have higher SDI with cover crops, but a lot of variability



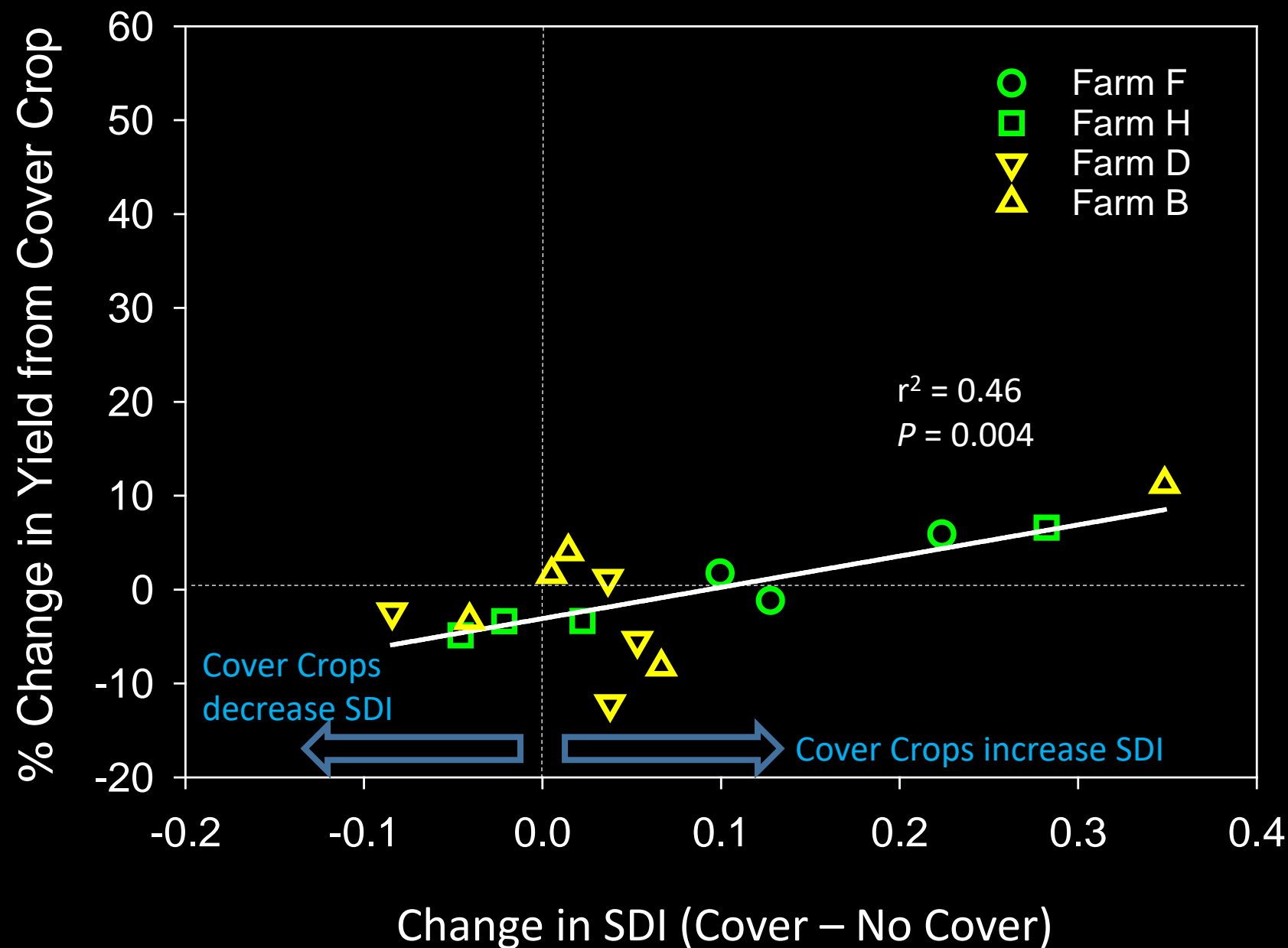
Soy and Corn

SDI does
somewhat
relate to yield



Soy and Corn

SDI does
somewhat
relate to yield



Citizen (i.e. Farmer) Science

20R-6-b

6-11-17

Last Name: [REDACTED] Farm Location: [REDACTED]

Initial in bag burial date: 6-2-17

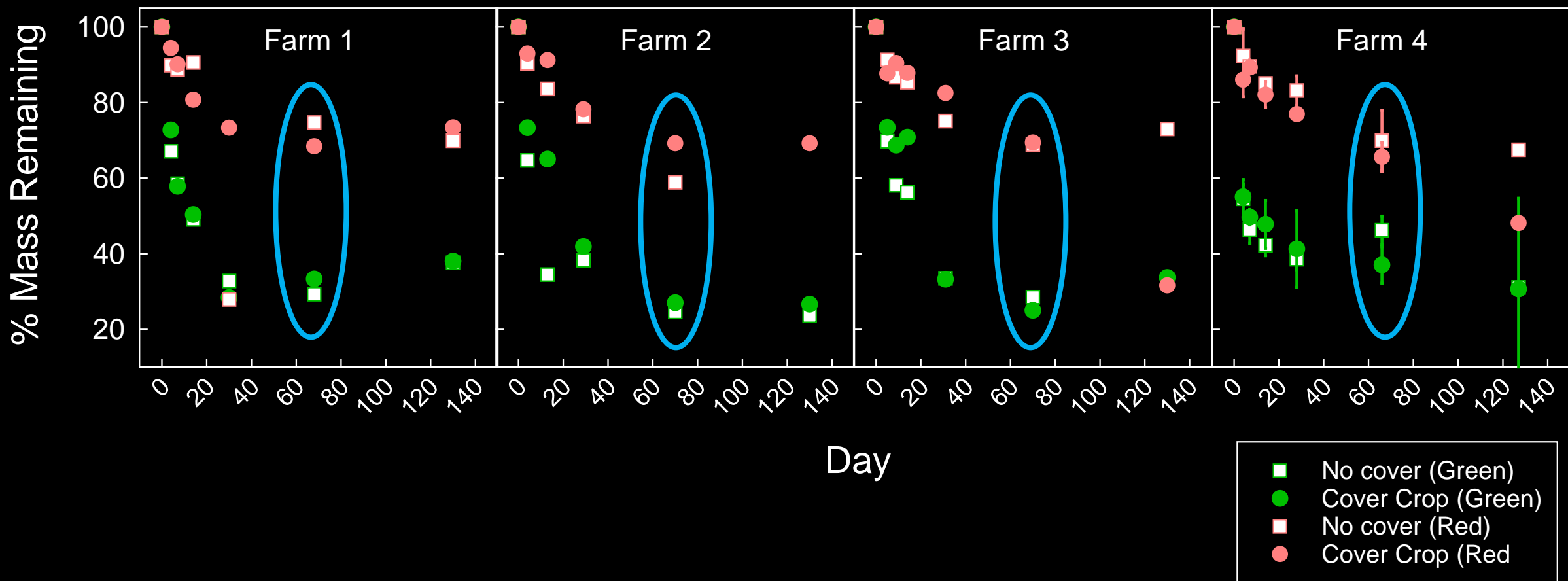
Notes on General Field and Weather Conditions (air temperature if known, cloudy, rained yesterday, etc...):
Hot with high winds (85-90 temp). Soil dry. No till soil has ~~heavy~~ heavy crust on it, much debris as not enough rain to encourage decomposition

Treatment	Replicate	Notes on individual strips (or plots) - Any soil or crop observations
C	N/A	see above - cover crop soil is also no-till.
NC	N/A	see above - same Soil dry + powdery. less subsoil moisture than cover crop ground

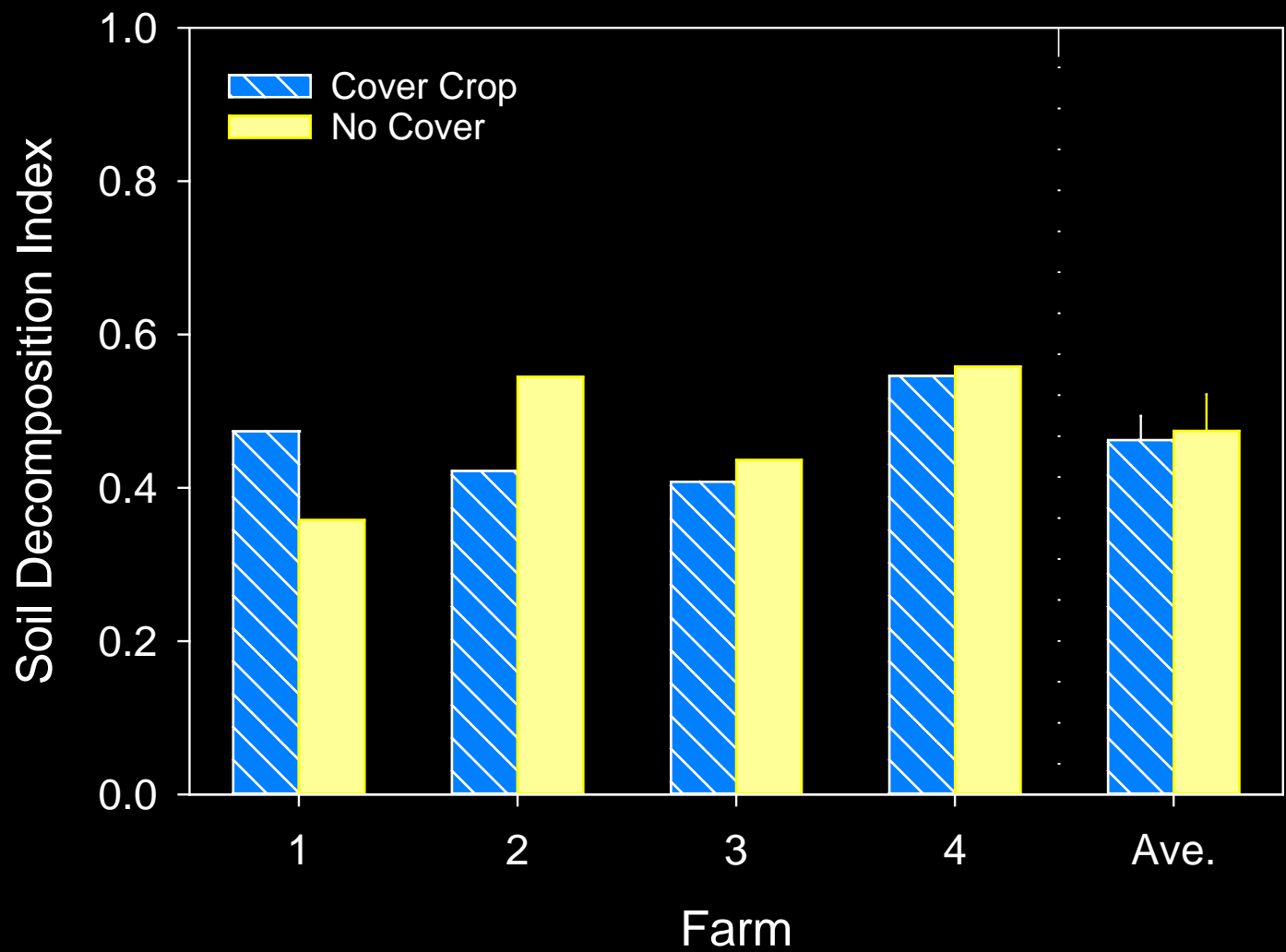
24 1/2" x 34 1/2" 100%

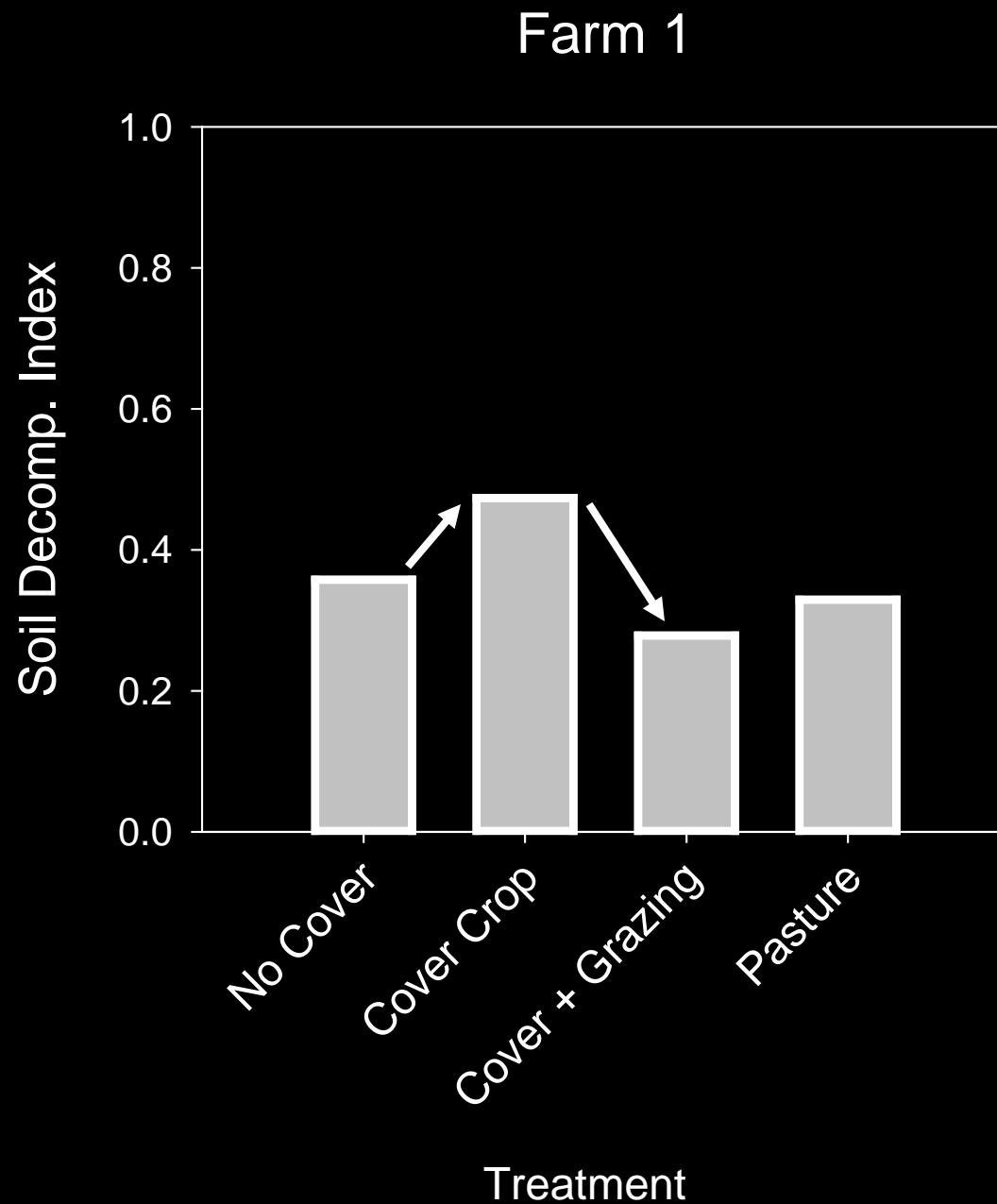
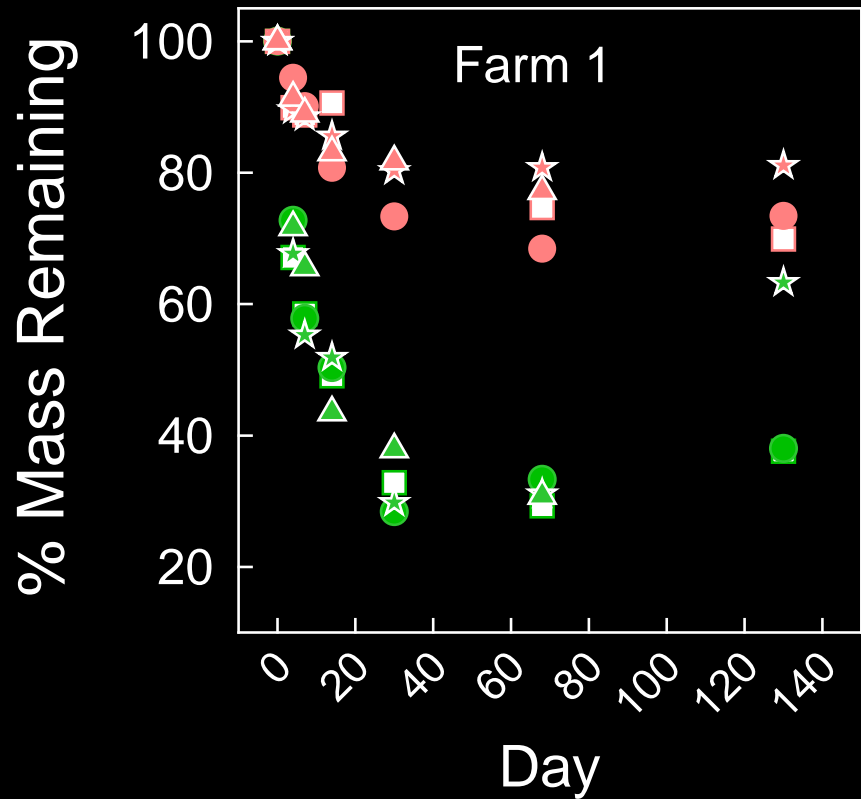
BM

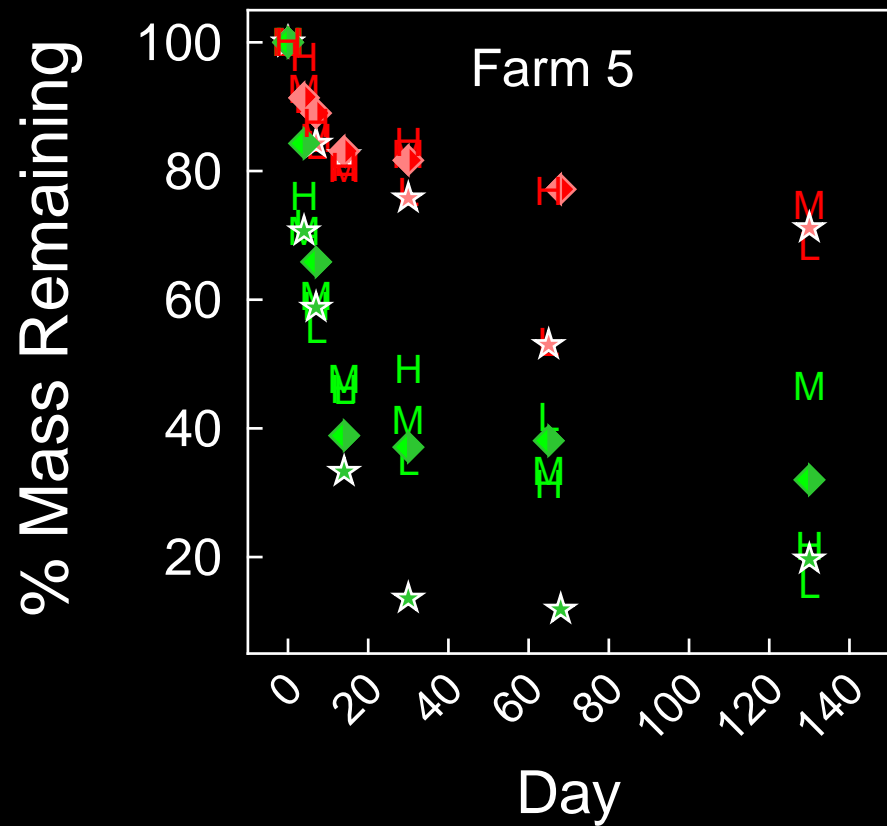
Cover Crop vs. No Cover → via Citizen (i.e. Farmer) Science



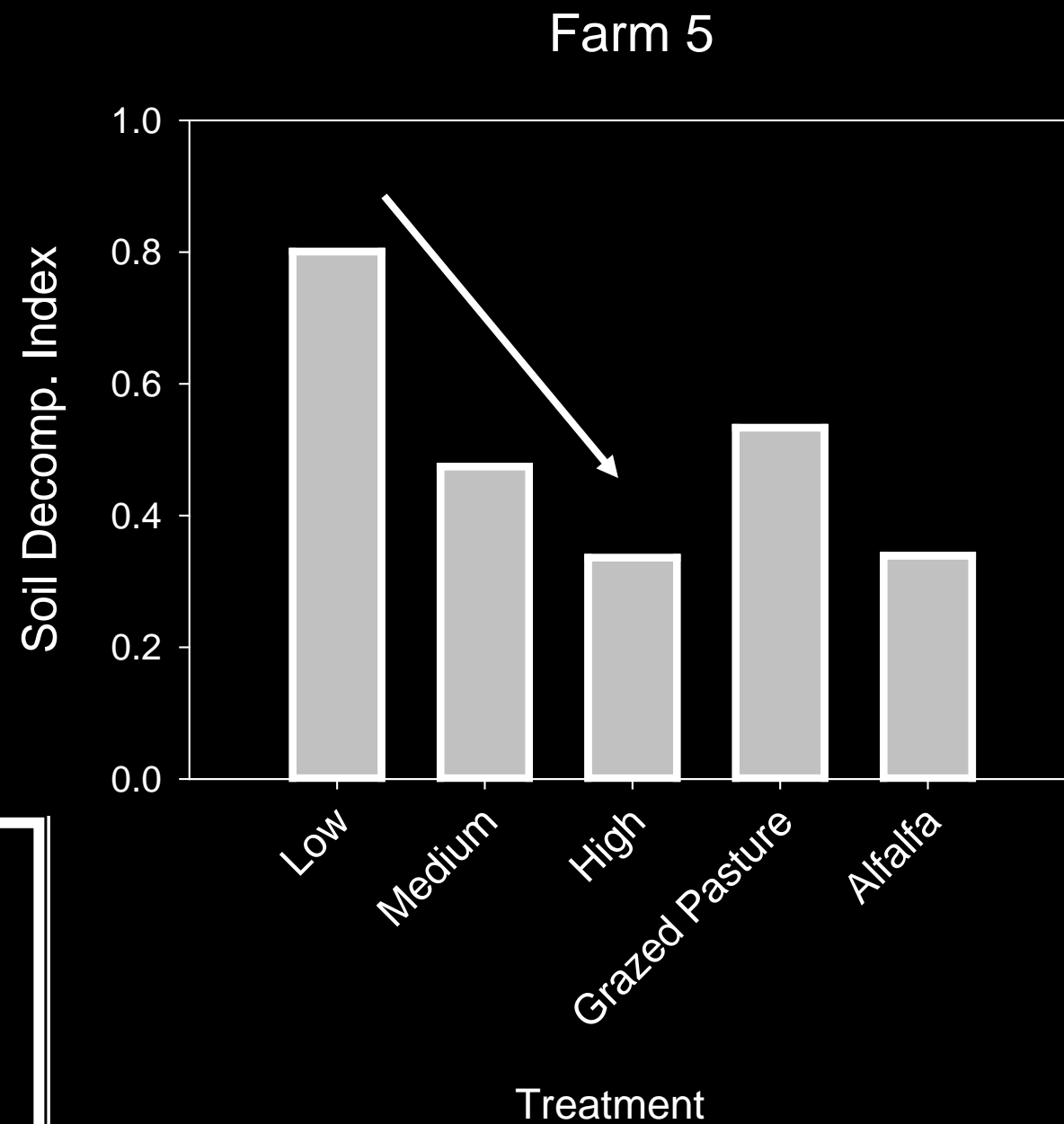
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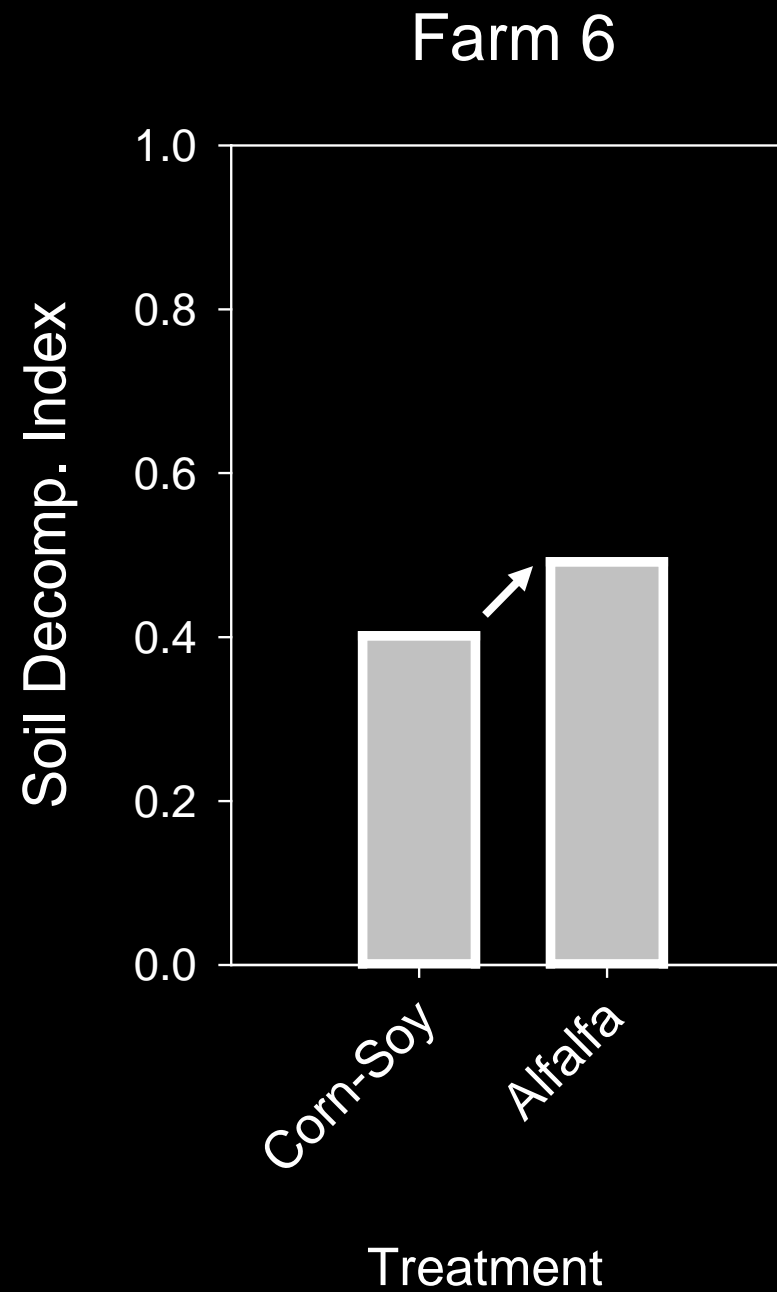
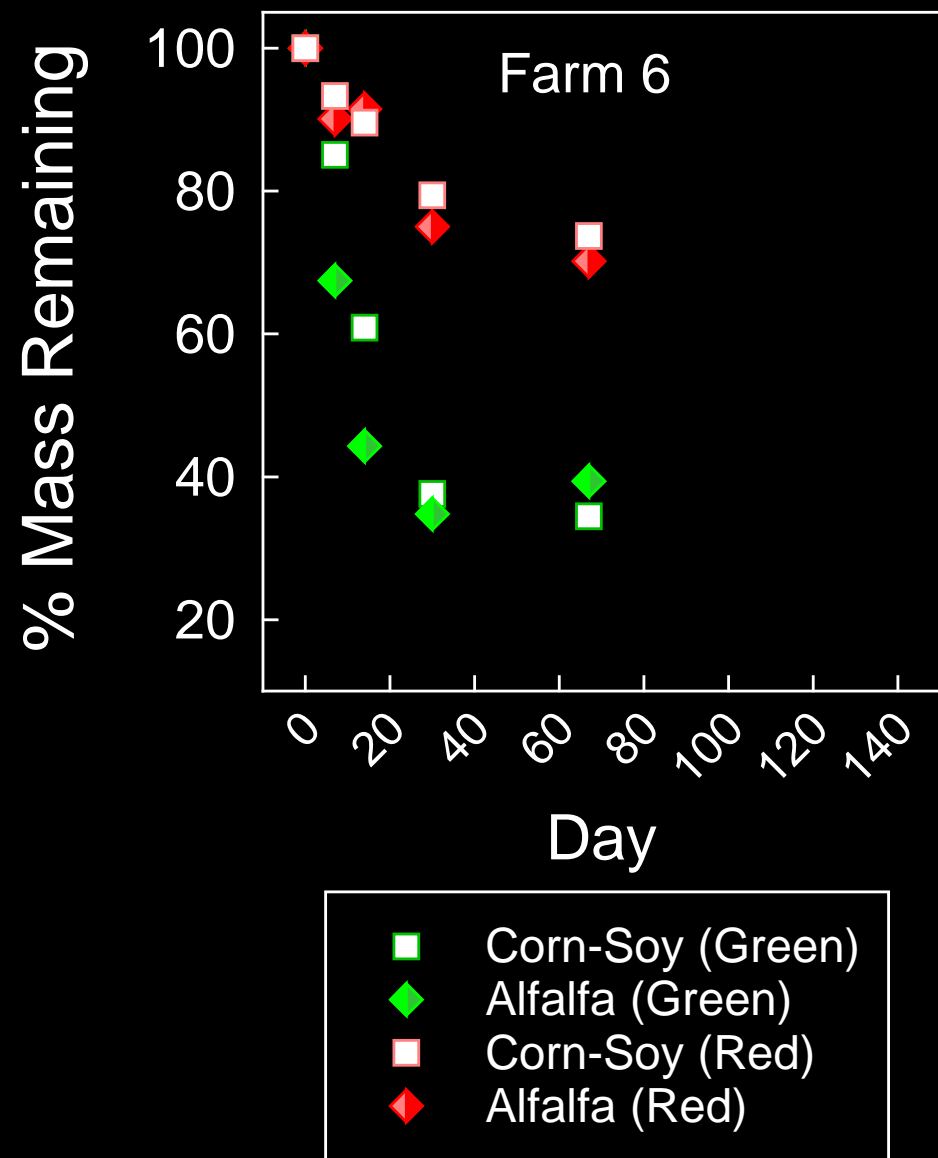




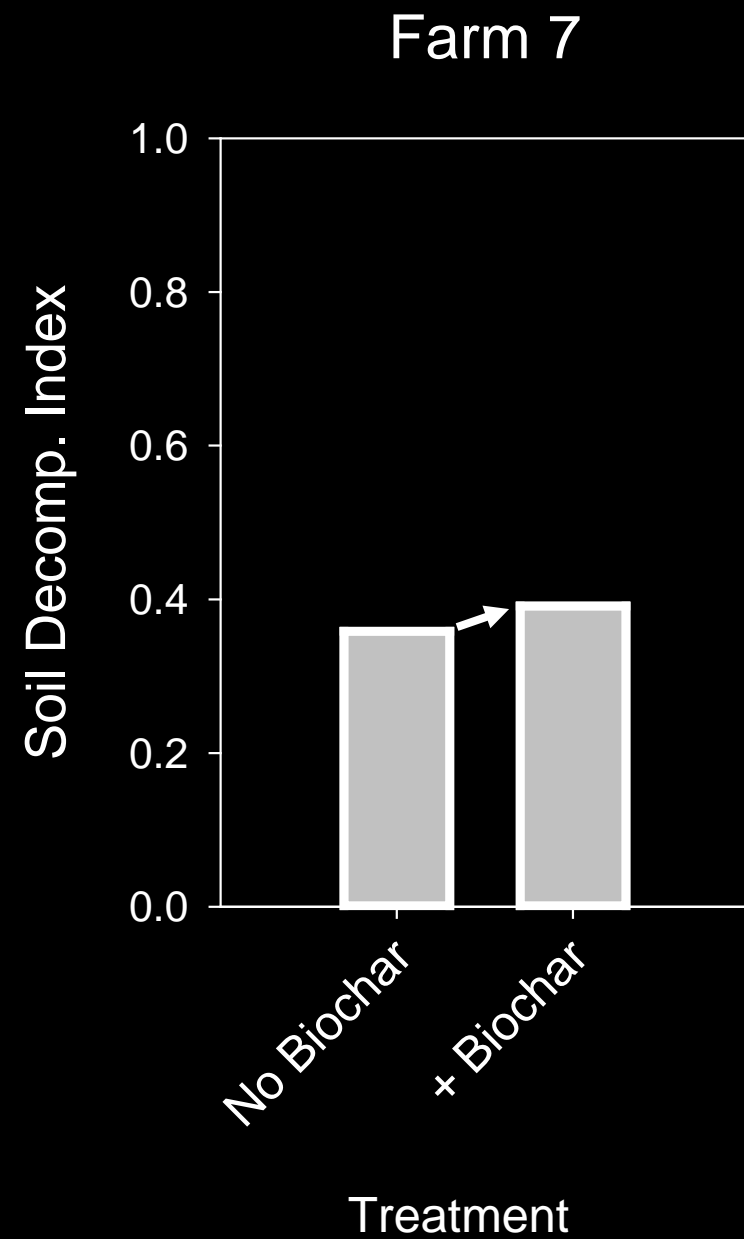
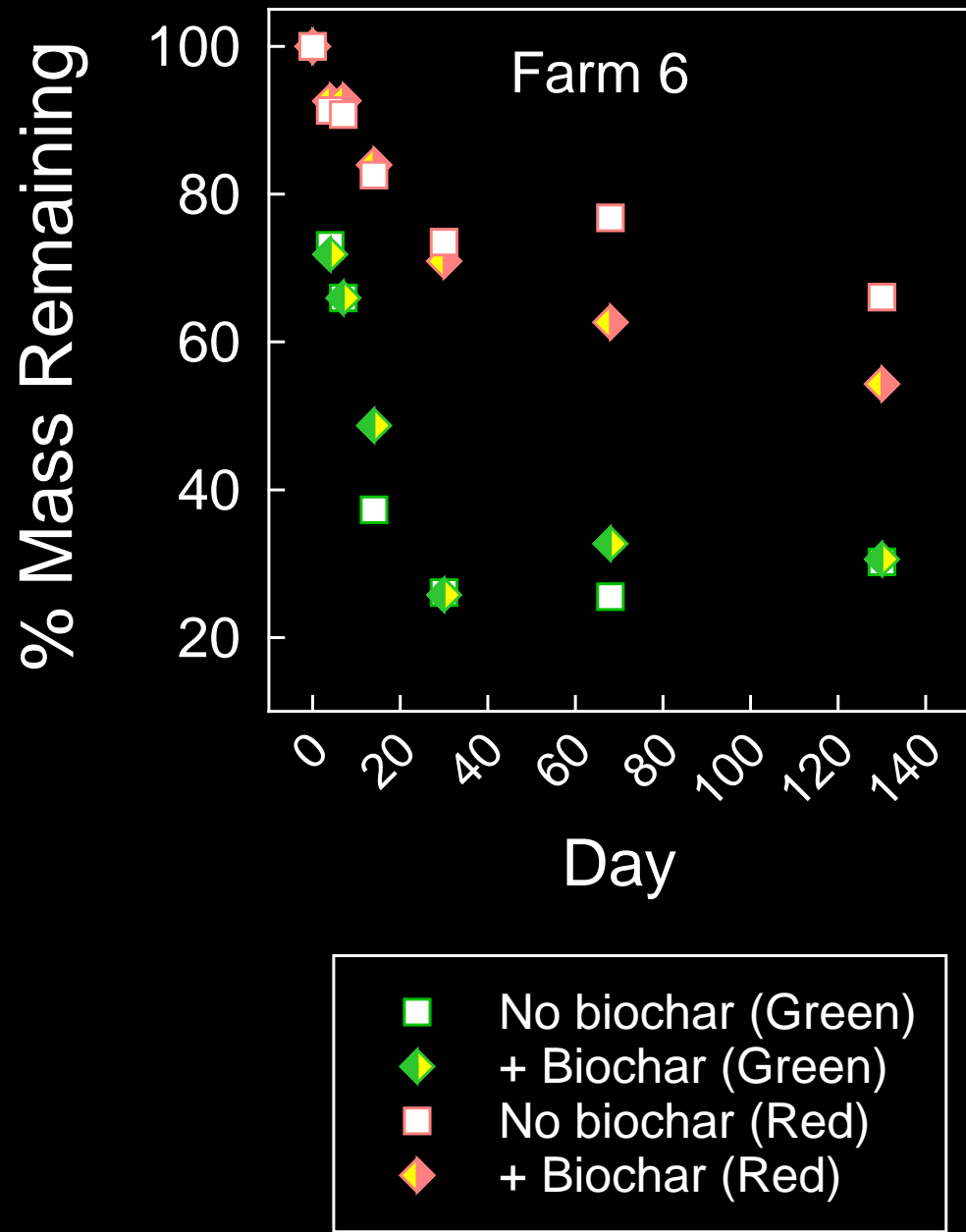


- | | | | |
|---|-----------------|---|---------------|
| L | Low (Green) | L | Low (Red) |
| M | Med (Green) | M | Med (Red) |
| H | High (Green) | H | High (Red) |
| ★ | Grazed (Green) | ★ | Grazed (Red) |
| ◆ | Alfalfa (Green) | ◆ | Alfalfa (Red) |









The SDI with Tea Bags Shows Some Promise!

Next Steps...

- ❑ More data analysis. Look further into...
 - other ways to measure SDI (e.g. rate, other dates than 68 d)
 - our other data to explain variation in SDI (climate, management, and soils)
- ❑ Validate SDI with more traditional soil biology tests (microbial biomass, CO₂, PMN, etc...)
- ❑ Expand to other long-term experiments in Iowa and beyond!
 - Including the Austrian's enormous data set
- Please contact me if you'd like to participate in this year's study!

Farmer science can lead to a greater understanding of soil health, and increased adoption of conservation practices

~\$20 for 60 pyramids



\$12



~\$32 to assess soil health

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- **ISU Team:**
Teresa Middleton, The McDaniel Lab, Daniel Linton, Matt Liebman, David Kwaw-Mensah, Mahdi Al-Kaisi, Keith Kohler, and Tom Kaspar.



- **Iowa Soybean Association (ISA):**
Peter Kyveryga, Nathan Paul



- **PFI Collaborators:**
Stefan Gailans, Sarah Carlson, and especially the 10 farmers that allowed us to bury tea bags in their fields, and 6 that sent them in themselves!



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Questions?



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The McDaniel Lab ([@Soil_Plant_IXNS](https://twitter.com/Soil_Plant_IXNS))
on Twitter

