



Estimating the contribution of soil microbiome the crop rotation effect

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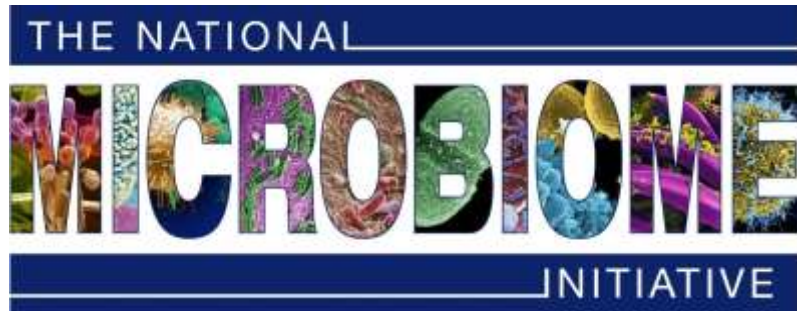
January 16th

Wisconsin Agribusiness Classic

**Department of Plant Pathology and Agronomy
University of Wisconsin-Madison**



Why should we care about the soil microbiome?



 MICROBIOME MOVEMENT
AGBIOTECH

February 26-28, 2019 | Raleigh Durham, North Carolina

**Discover, Translate & Commercialize the
Plant-Soil Microbiome into Agbiologicals
that Optimize Productivity, Increase Yield
& Ensure Environmental Sustainability**



BRIEFING

**Food Security from
the Soil Microbiome**

- Soil micro-organisms are vital for soil health and food security.
- Intensive agricultural production often impacts the soil microbiome at a cost to productivity, sustainability and the environment.
- Microbiologists are investigating how the soil microbiome can be harnessed as a tool for sustainable agricultural intensification.





What roles do soil microbes play in plant health and productivity?

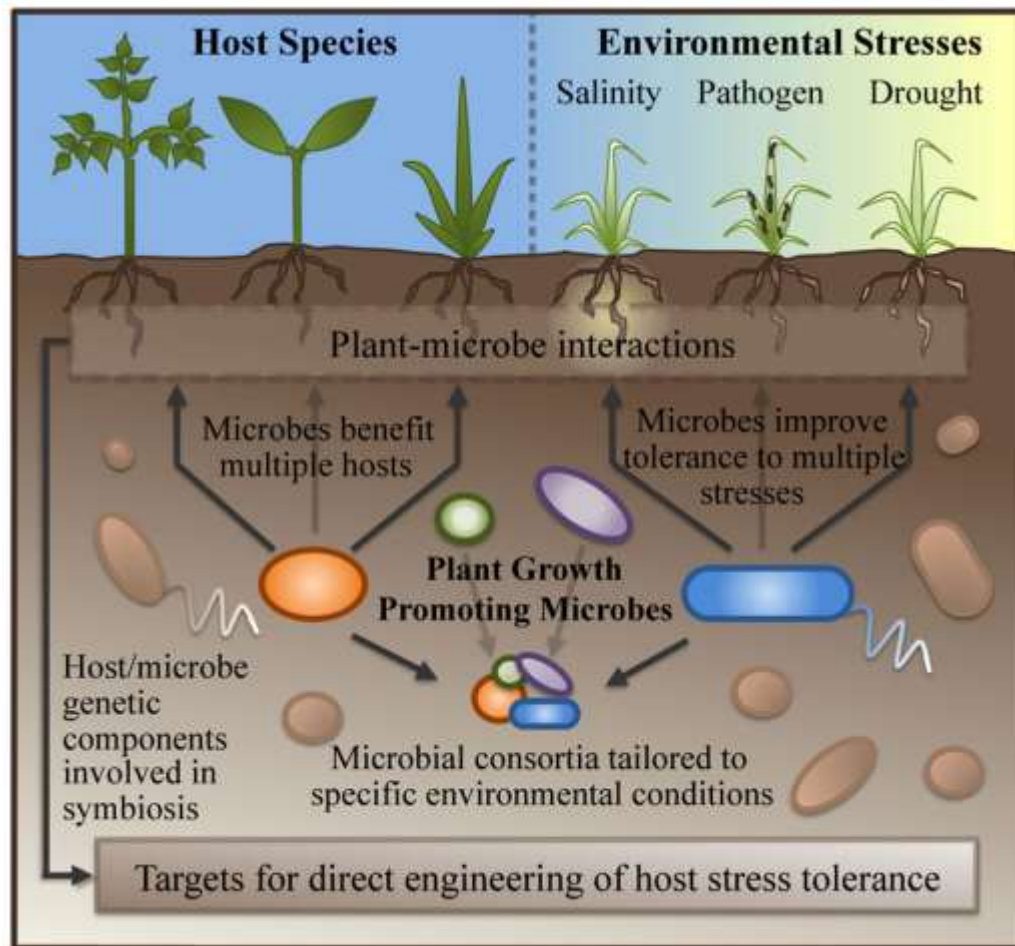


Image from: Tringe, Joint Genome Institute



Second genome



- Host genotype
- Developmental stage
- Plant health
- Plant Fitness (Biotic & abiotic stress)

Below ground

- Root exudates
- Chemotactic
- Recognition
- Colonization & Biofilm formation

Functional microbiome

Root microbiome

Root microbiome

Arabidopsis Maize Rice

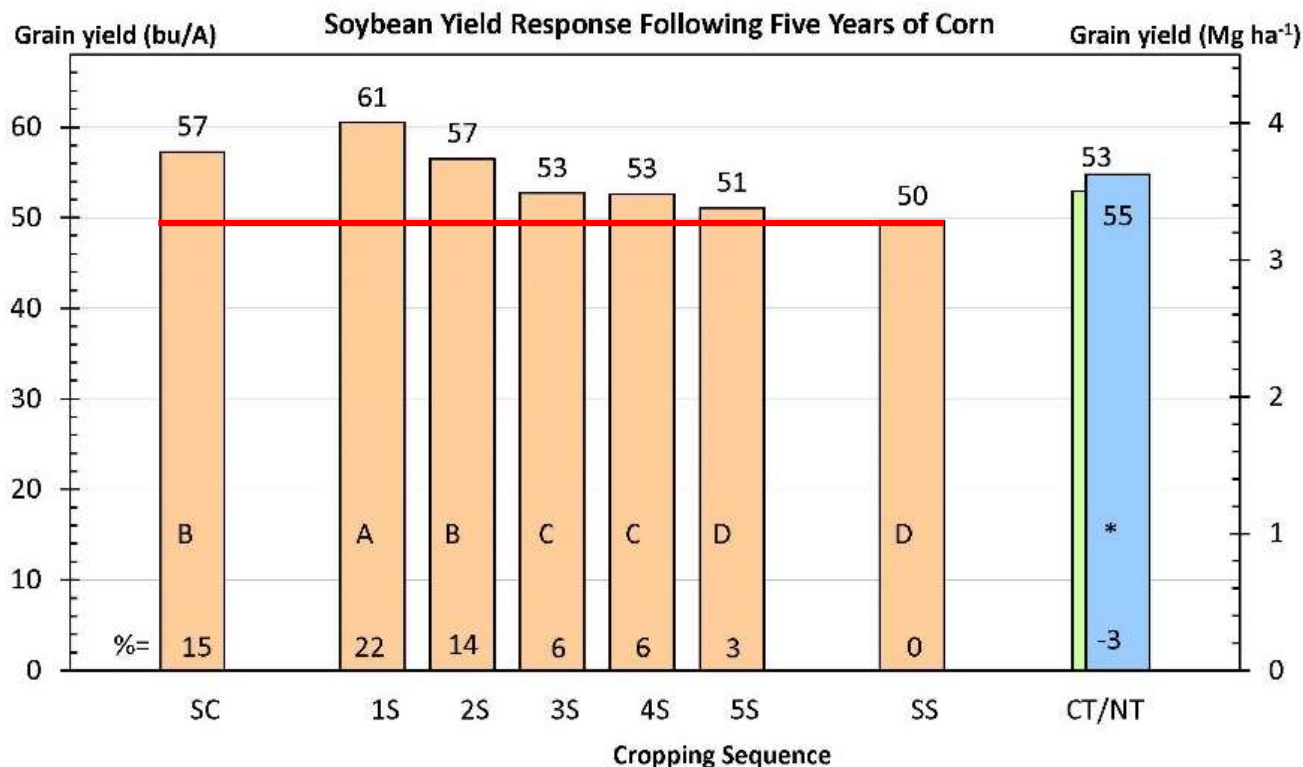
Abstract

- Chloroflexi
- Fibrobacteres
- Nitrospira
- Verrucomicrobia
- Spirochaetes
- Planctomycetes
- Firmicutes
- Gemmatimonadetes
- Bacteroidetes
- Cyanobacteria
- Acidobacteria
- Actinobacteria
- Proteobacteria

4



How does the soil microbiome play a role in the crop rotation effect?



C= Corn, S= Soybean, 1S= First year soybean, 2S= Second year soybean... SS= Continuous soybean

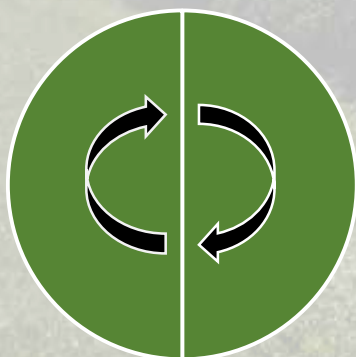


Long-Term Corn-Soy Rotation Experiment

- Arlington Research Station (since 1983)
- 14 total rotation phases present each season
- Four replications of each rotation phase
- No tillage plots

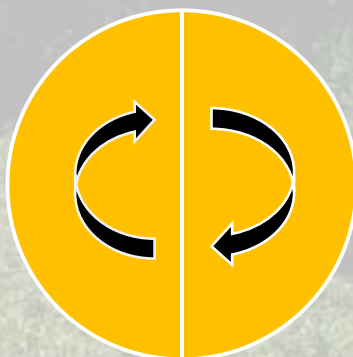
Rotation Schemes

Continuous
Soy



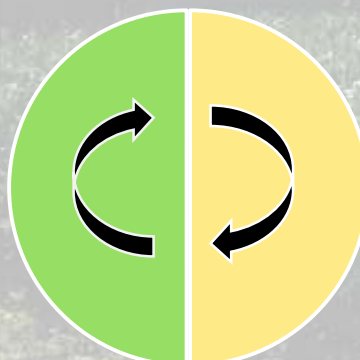
■ Soy

Continuous
Corn



■ Corn

Annual Corn
Soy



■ Corn ■ Soy

Five-Year Corn-
Soy Rotation



■ 1st Corn ■ 2nd Corn ■ 3rd Corn
■ 4th Corn ■ 5th Corn ■ 1st Soy
■ 2nd Soy ■ 3rd Soy ■ 4th Soy
■ 5th Soy



Research Objectives

Objective 1:

- a. Determine if rotation phase impacts soil bacterial community composition and structure.
- b. Determine if differences in bacterial community composition relate to differences crop yield.

Objective 2: Determine if rotation phase differentially impacts soil carbon usage of microbial communities.



Soil data collection and bacterial community analysis

1. Soil sampling timepoints

Planting



Midseason



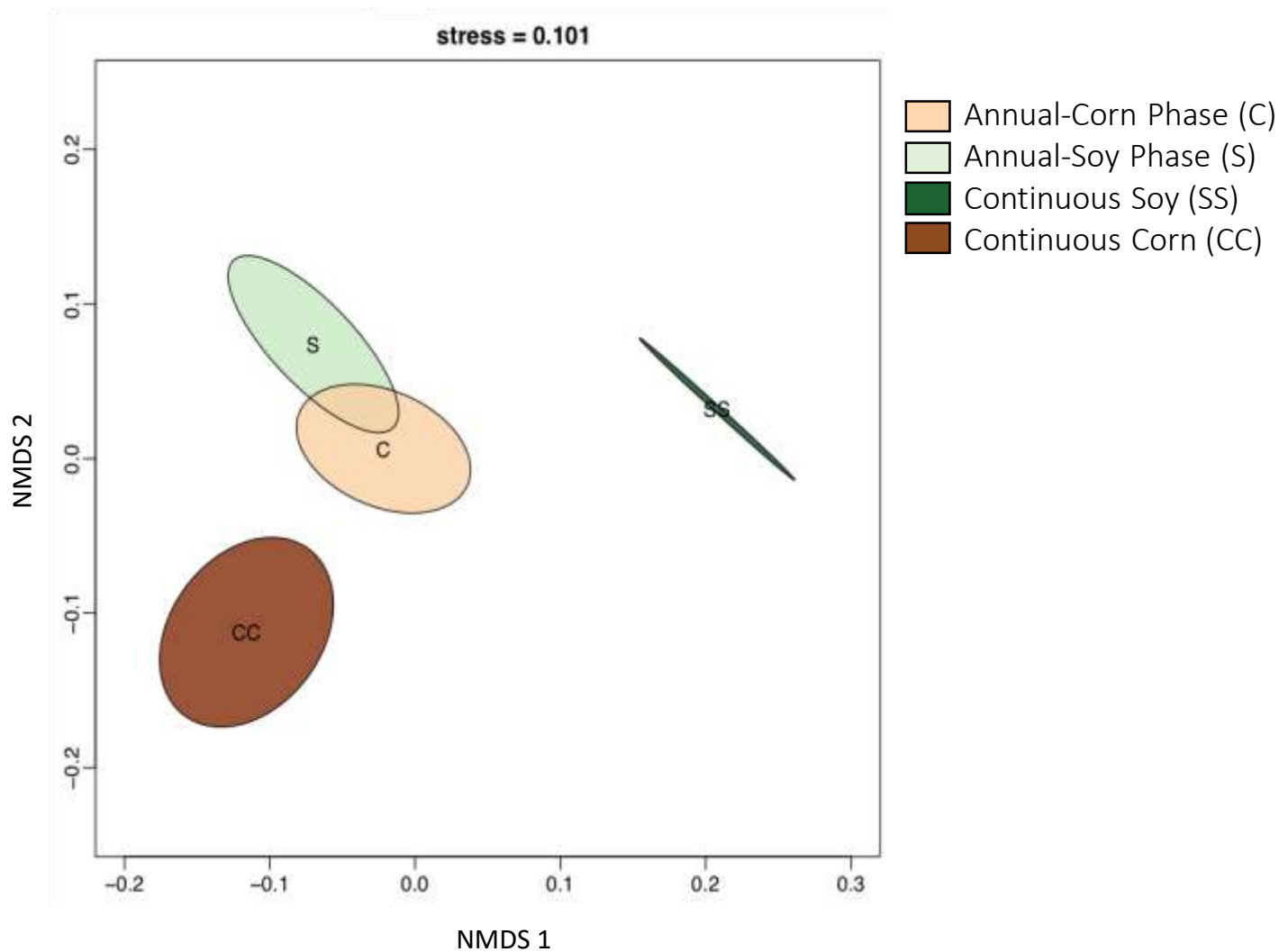
Harvest



John Greig

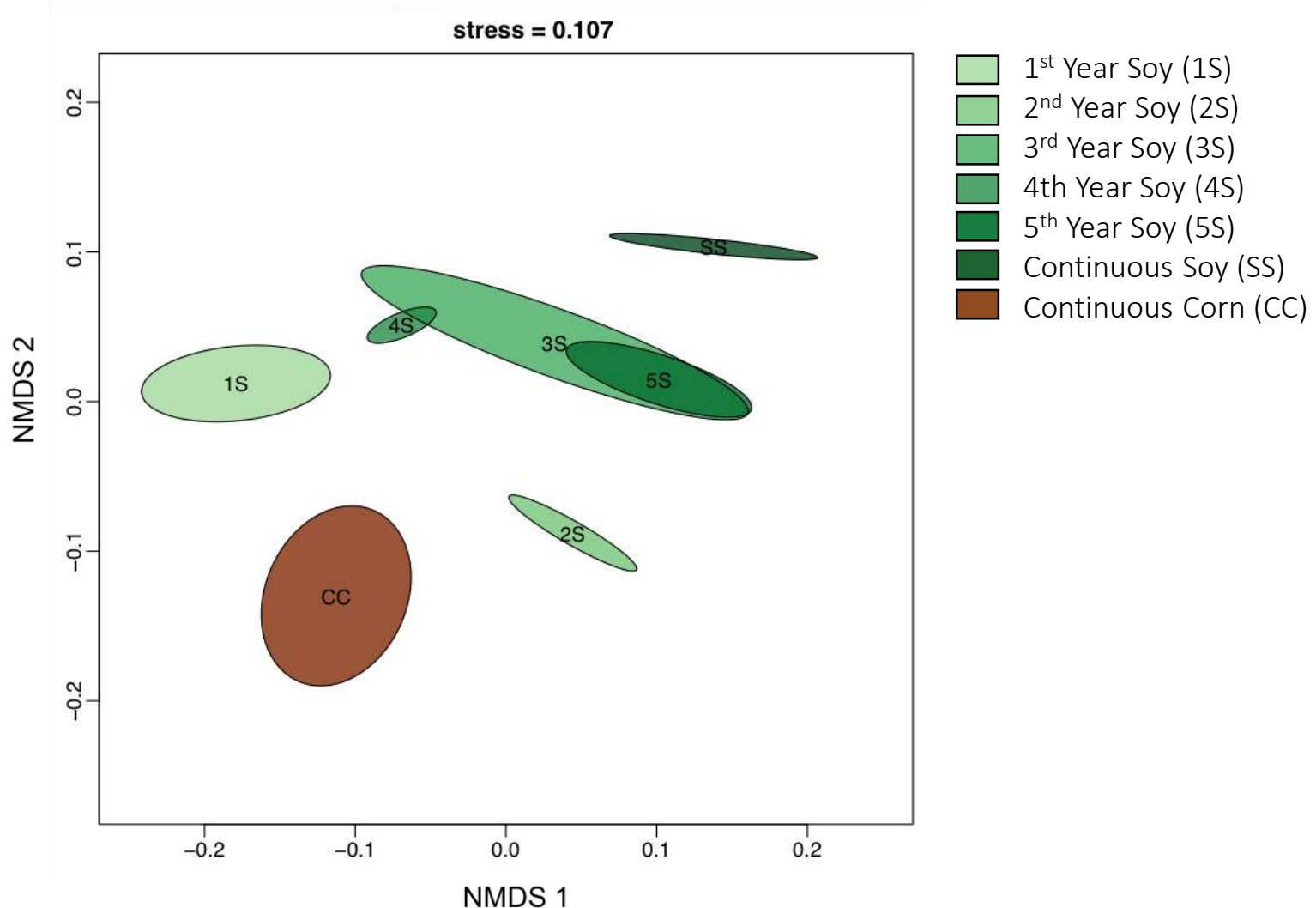


Bacterial communities differ between continuous rotations but not between phases of annual rotations



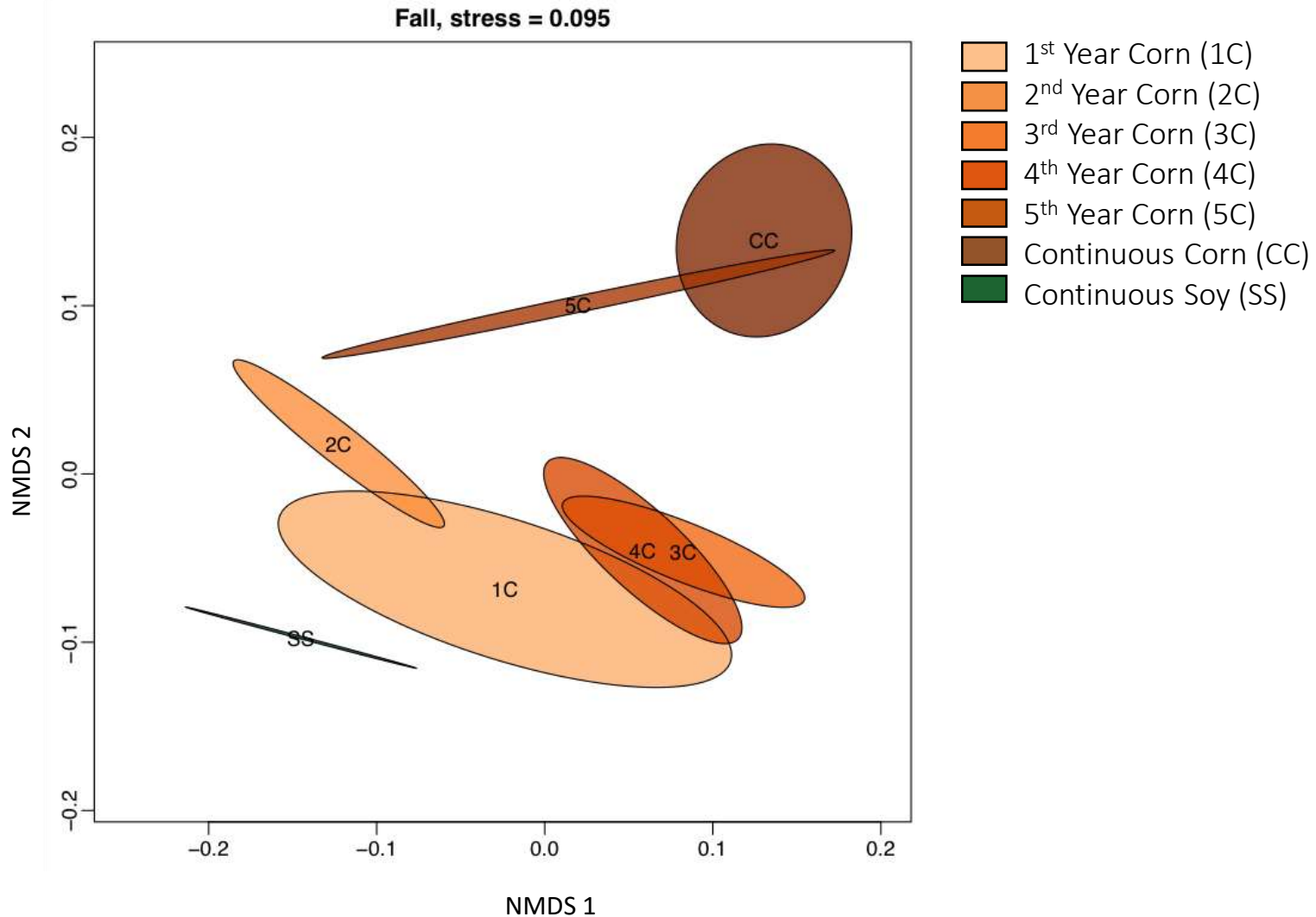


As years of soy increase, communities shift from a more “corn-like” to a more “soy-like” community



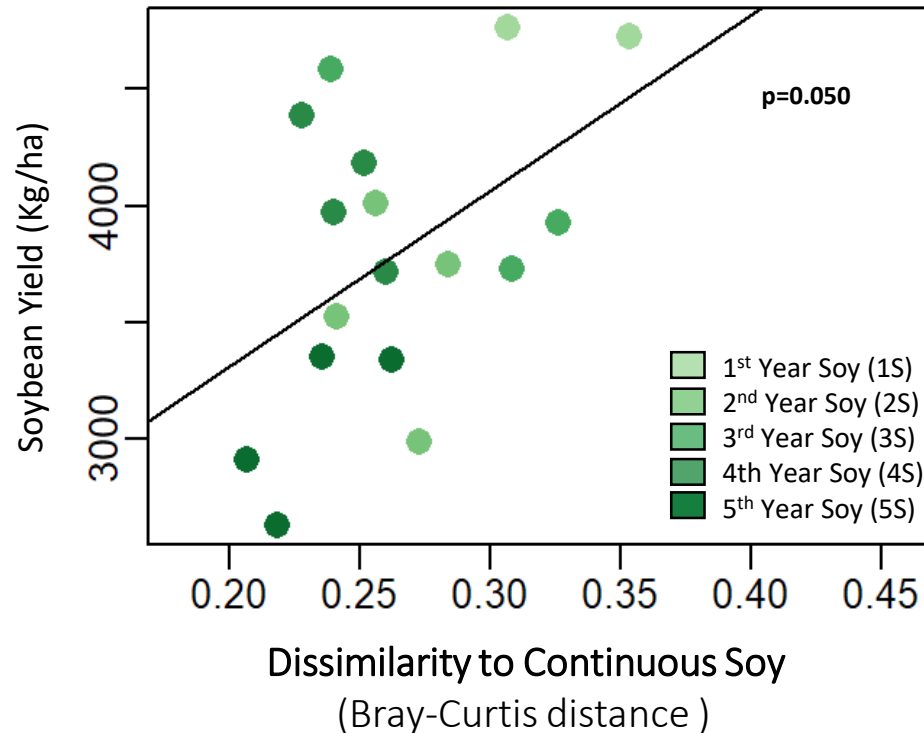


Bacterial communities of 5-year corn rotations shift later in rotation phase to “corn-like” community





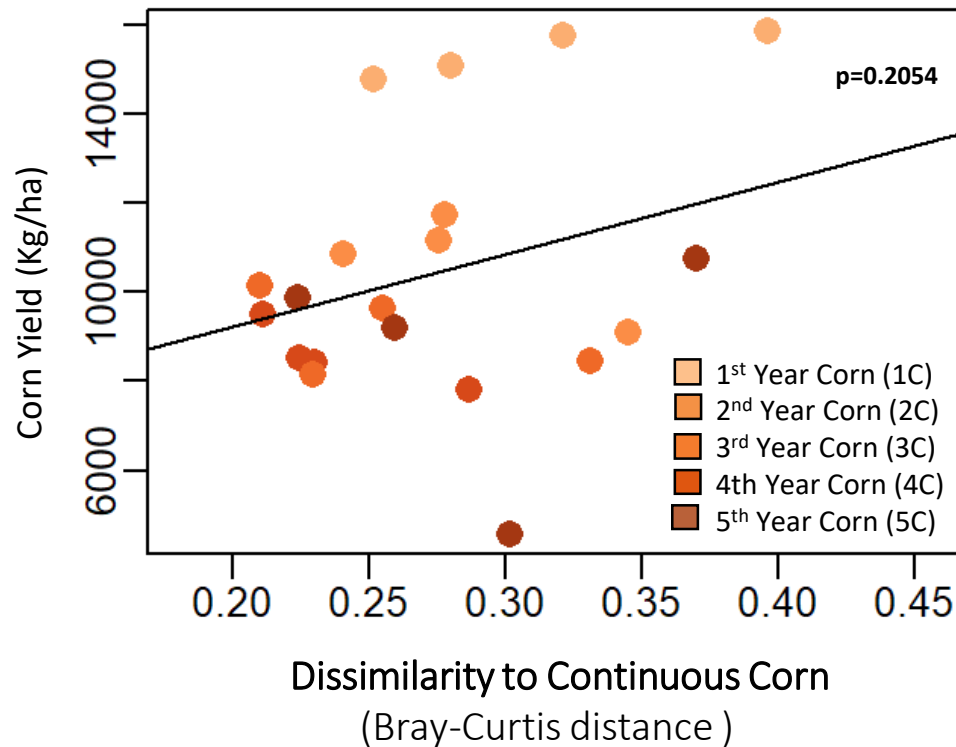
How do differences in bacterial communities relate to differences in soybean yield?



- The more bacterial communities differ from a “continuous soy (SS)-like” community, the higher the soybean yield.
- As years of soy planted increase, the more bacterial communities resemble the bacterial community of a continuous soy system.



How do differences in bacterial communities relate with differences in corn yield?



- **They don't correlate well...** no significant trend between how similar or dissimilar a bacterial community is from CC and corn yield.



Objective 1 Conclusions

1. The bacterial communities of CC and SS are significantly different from each other, while the bacterial communities two phases of the annual rotation are not.
2. As years of monoculture increase, the more the bacterial communities resemble that of a continuous monoculture system.
3. The more bacterial communities differ from a “continuous soy (SS)-like” community, the higher the soybean yield.



Research Objectives

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Objective 2: Determine if rotation phase differentially impacts soil carbon usage of microbial communities.

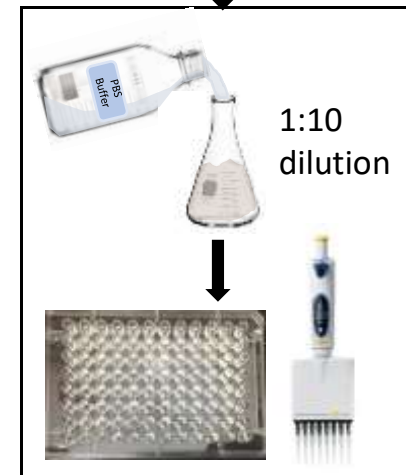
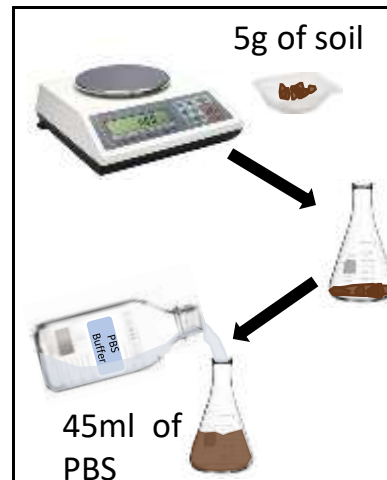


Methods for analysis of microbial carbon usage diversity



2017:
Midseason
& harvest

2018
Spring,
midseason
& harvest



Measure the changes in the
indicator dye for carbon usage
based on rotation phase

Biolog EcoPlate technology

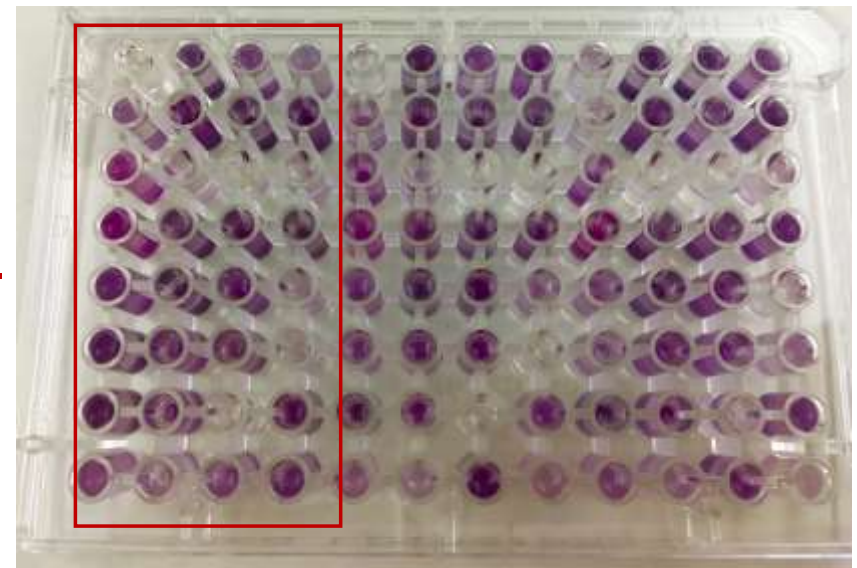


Does carbon usage differ between microbial communities of different rotation phases?

Biolog EcoPlate	1	2	3	4
A	Water	β -methyl-D-glucoside	D-galactonic acid γ -lactone	L-arginine
B	Pyruvic acid methyl ester	D-xylose	D-galacturonic acid	L-asparagine
C	Tween 40	D-erythritol	2-hydroxy benzoic acid	L-phenylalanine
D	Tween 80	D-mannitol	4-hydroxy benzoic acid	L-serine
E	α -cyclodextrin	N-acetyl-D-glucosamine	γ -hydroxy butyric acid	L-threonine
F	Glycogen	D-glucosamic acid	Itaconic acid	Glycyl-L-glutamic acid
G	D-cellobiose	Glucose-1-phosphate	α -ketobutyric acid	Phenylethyl-amine
H	α -D-lactose	D,L- α -glycerol phosphate	D-malic Acid	Putrescine

	Amines		Carboxylic acids
	Carbohydrates		Amino acids
	Complex carbon sources		Phosphate-carbon

Each plate represents ONE soil sample



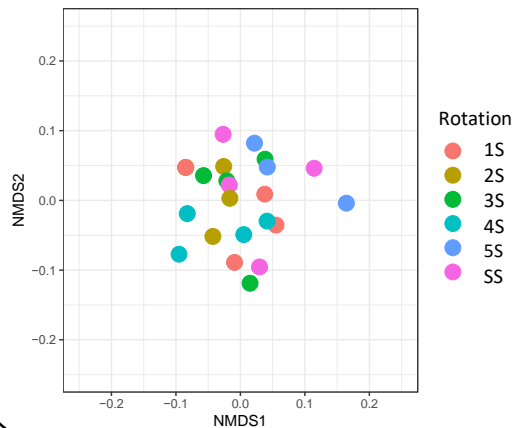
- The more the compound is consumed by the microbial community the darker the indicator dye becomes



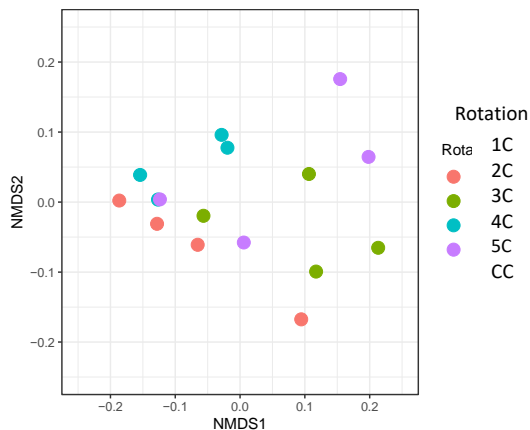
Differences in carbon use based on rotation scheme and time of season

Midseason (July)

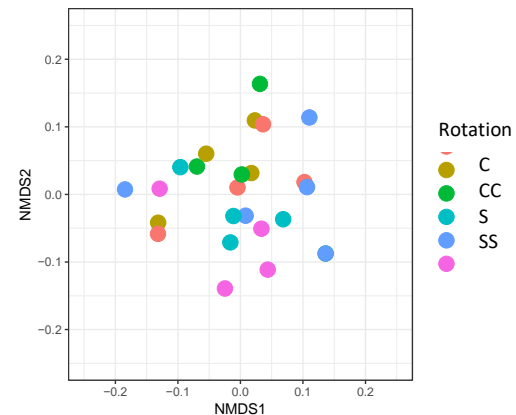
5-year Soy Rotations



5-year Corn Rotations



Annual vs. Continuous Rotations





Objective 2 Conclusions

1. The microbial communities do not significantly differ in their carbon usage based on rotation phase at either midpoint or harvest.
2. Environmental selection pressure of the Biolog EcoPlate could be playing a role.



Take-home points

1. Soil bacterial communities differ based on rotation phase and in the case of soybean these differences can explain a portion of the variation in soybean yield.
 2. More data is needed to really see if these relationships hold throughout the growing season and over years.
 3. 2017 and 2018 data (six total timepoints) are in the process of analysis now...so stay tuned!
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1. Soil microbial communities do not significantly differ in their carbon usage based on rotation phase at either midpoint or harvest.



Acknowledgements

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- Jean-Michel Ané
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