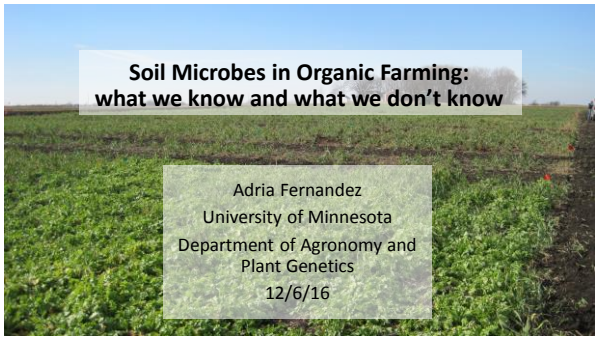


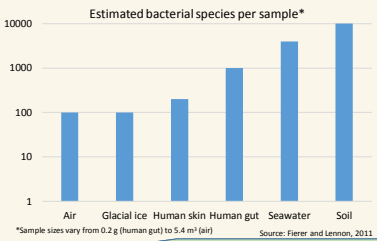
Soil Microbes in Organic Farming: what we know and what we don't know

Adria Fernandez
University of Minnesota
Department of Agronomy and Plant Genetics
12/6/16

Overview

- Functions of soil microbes in crop production
- Organic farming systems
- Our research
- Big unanswered questions
- Considering commercial products

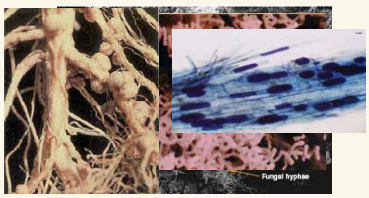
Soil: the most diverse environment



Who lives in the soil?

- Bacteria
- Fungi

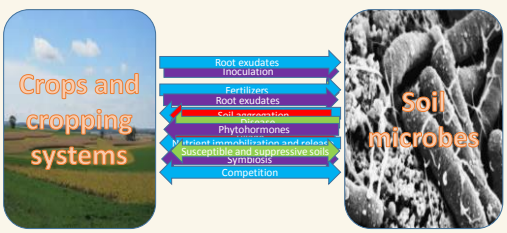
- Free-living
- Symbiotic



The soil microbial community: Jack of All Trades

Bacteria and fungi have diverse metabolic capabilities

- Grow on different materials
- Produce different materials



Organic Farming: "Feed the soil, not the crop"

- USDA standards: growers must "maintain or improve the physical, chemical, and biological condition of soil"
- "Soil health/biology:" #1 research priority in a 2010 survey of MN organic farmers
- Soil functions of interest:
  - N, C, P cycling
  - Plant disease and pathogen suppression
  - Crop mineral nutrition (nutrient solubilization)

What happens to soil microbes when you go organic?

Warning: broad generalizations

- Overall greater microbial diversity and abundance
  - Organic matter additions: compost, manures, green manures
  - Crop diversity
  - No pesticides
- Changes in soil function
  - Greater phosphate solubilization
  - Faster and more complete decomposition of plant material
  - Mixed effects on carbon: higher inputs, more tillage

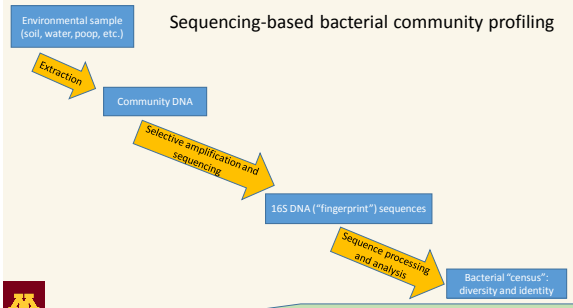
Our research: Using sequencing-based microbial community profiles to predict soil function in organic systems

CERES TRUST

USDA

MnDRIVE

Sequencing-based bacterial community profiling



The Big Question:

DNA sequencing gives us new information on *who* is in our soil. Can we make this information useful?

Bacterial community structure and nutrient cycling experiment: 2012-2013

Treatments

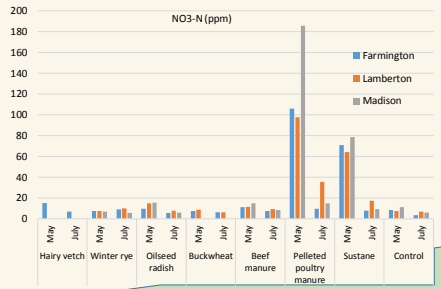
- 4 cover crops
  - Hairy vetch (*Vicia villosa*)
  - Winter rye (*Secale cereale*)
  - Oilseed radish (*Raphanus sativus*)
  - Buckwheat (*Fagopyrum esculentum*)
- 3 approved fertilizers
  - Beef manure
  - Pelleted poultry manure
  - Sustane 8-2-4 (compost, feather meal)
- No-amendment control

www.rodalesinstitute.org, www.ecolibrary.org, preferredseed.com, covercropsolutions.com

Datasets

Standard soil tests	Functional profile	Bacterial community profile
Moisture	Net N mineralization	Relative abundances
pH	Total respiration	Diversity and richness
Organic matter (OM)	Corn yield	
Bray-P	Enzyme activities	
K		
NO3-N		
SO4-S		
Exchangeable Mg, Ca and Na		

- Fertilizers caused large short-term nitrate spike
- Covers increased mid-season nitrate at Farmington only



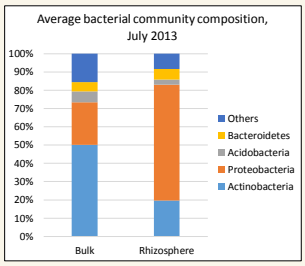
Cover crop and fertilizer effects on nutrient cycling activities

	Farmington		Lamberton		Madison	
	May	July	May	July	May	July
Vetch						
Rye						
Radish						
Buckwheat						
Poultry pellets						
Beef manure						
Sustane						

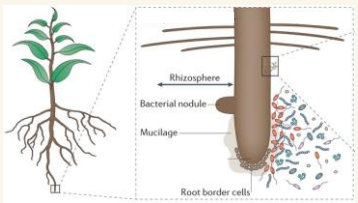
Measured: C, N, and P-cycling enzymes; soil respiration

Bacterial community summary

- Up to 5,506 OTUs (types of bacteria) per sample
- Location and time of sampling had strongest effects



Rhizosphere soil



http://www.nature.com/nrmicro/journal/v11/n11/full/nrmicro3109.html

Bacterial community richness and diversity

- Greater diversity in bulk soil than rhizosphere
- Amendments tended to *reduce* diversity early in season
  - Organic matter addition favors fast-growing bacteria
- Covers increased diversity later in season (at Farmington)
- Effects persisted more in rhizosphere than bulk soil

Conclusions

1. Soil bacterial community structure is largely driven by soil conditions/site
2. Bacterial community structure and nutrient-cycling functions are extremely variable at all scales
3. Cover crops and fertilizers affect nutrient cycling
4. Abundances of particular bacteria are correlated with nutrient cycling
5. Diversity is…complicated
6. Organic amendments can change crop rhizosphere, even when changes are no longer evident in bulk soil
7. Bacterial community structure data *does* improve prediction of soil function compared to routine soil tests alone

So…what does this mean for me?

For now:

- Cover crops and organic matter additions can affect your soil life and may increase nutrient cycling
- Nutrient cycling is related to microbial communities, not just soil conditions

Source: Corn and Soybean Digest

More research before we make recommendations:

- Research across soil and farm types
- Create and test predictive models

New project: cover crops and weed seed demise

Multi-site experiment

- Many farms
- Various rotations and cover crop histories

Future research using microbial profiling

- Modeling: translating information to predictions and recommendations
- Identification of indicator species
- Improved sampling methods
- Someday, maybe…tests for:
  - Fertilizer need
  - Disease susceptibility
  - Weed pressure
  - ???

Other Big Unanswered Questions About Soil Life

Uncultured organisms: what are they like?

How do all these microbes interact?

What organisms can be used as inoculants, and when will they be successful?

Microbial products

Types of products:
- Rhizobium inoculants for legumes
- Other bacterial and fungal inoculants
  - EM® (Effective Microorganisms)
  - Mycorrhizal fungi
  - Trichoderma fungi
- Compost tea

Claims made:
- Increased yields
- Improved root systems
- Soil fertility
- Increased organic matter

Using microbial products wisely: buyer beware

- Find products with claims backed by 3rd party research
- Analyze the cost compared to the promised benefits
- Do your own experiments
- Watch out for products produced using genetic engineering (not permitted in organic). Look for OMRI listing

OMRI LISTED
For Organic Use

Conducting a controlled experiment

- Replication
- Randomization