Management to Reduce N2O Emissions in Organic Vegetable Production

Ann-Marie Fortuna
North Dakota State University
Douglas Collins, Washington State University

February 25, 2014

Welcome to the webinar!

- The webinar will start at the top of the hour.
- If you'd like to type in a question, use the question box on your control panel and we will read the questions aloud after the c. 45 minute presentation
- The webinar will be recorded and you can find the recording and a pdf handout of the slides at http://www.extension.org/pages/70280

Craig Cogger

Ann-Marie Fortuna

Douglas Collins

Management to reduce N_2O emissions in Organic Vegetable Production Systems

Part 2:
Current research on alternative organic farming systems

Ann-Marie Fortuna, NDSU
Doug Collins, WSU
Craig Cogger, WSU

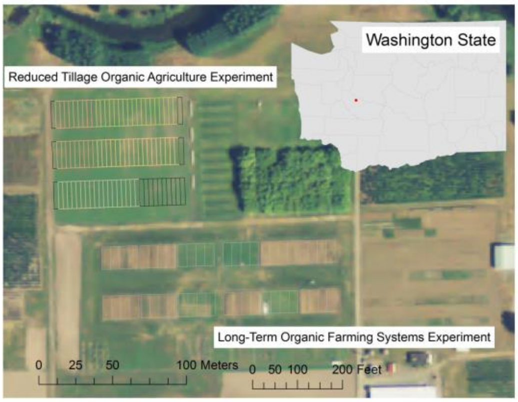
Washington State University Extension

Outline
Part A – Doug Collins

- History and development of organic farming systems research in Western Washington
- Review our sampling strategy for trace gases, including CO_2 and NO_2
- Preliminary flux analyses

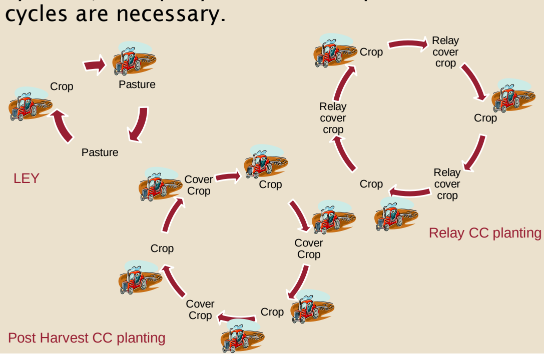
Outline
Part B – Ann-Marie Fortuna

- Understanding the fundamental processes that drive the release of N from organic sources.
- Identify and quantify, key microbial community members that control nitrification and denitrification in different organic farming systems.
- Link best management practices to soil quality and the microbiology underpinning C and N cycling.



The systems project was designed based on farmer listening sessions, surveys, and visits to small-scale farms.

To evaluate soil changes in complex management systems, multiple years and multiple rotation cycles are necessary.



Three Cover Crop Treatments

Relay planted Legume **(RLY)**

Post-Harvest Cereal & legume **(PH)**

Short-term Grass-legume Pasture **(LEY)**

Pastured poultry (Freedom Rangers) in traveling cages

Sheep in plots during ley rotation

Soil amendments include High-C compost and Low-C broiler litter.

Chicken (Broiler) litter: **(CKN)**
Low C application (1.8 - 3.1 dt/ac)

Mixed on-farm compost: **(OFC)**
High C application (8 - 17 dt/acre)

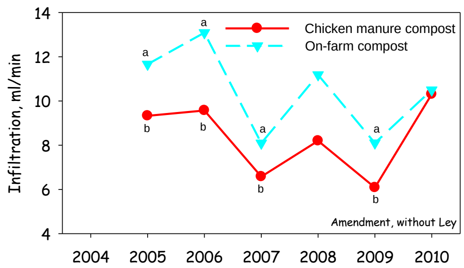
In Systems plots, gas measurements are taken on LEY, High C application, and Low C application

Event	Event Date	GC Gas/Soil samples
Amendment Application	June 18th	Pre-till (day -1), Post-till (days 0,1,2,3,7,15)
Irrigation	July 16th	Preirrigation (day 0), Postirrigation (days 1,2)
Incorporation	September 26th	Preincorporation (day -6), Postincorporation (day 1)
Freeze/Thaw1	November 22nd	Frozen (day 0), Thawed (day 3)
Freeze/Thaw2	December 5th	Frozen (day 0), Thawed (day 11)

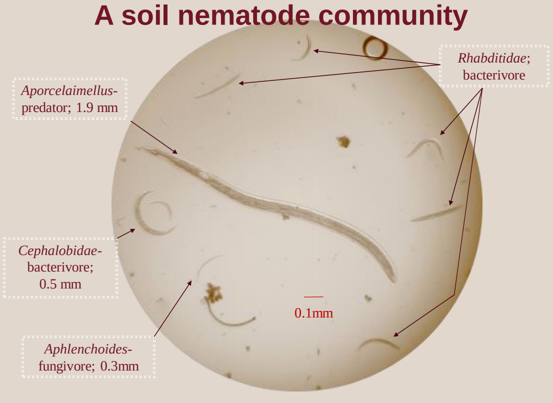
Soil quality measurements include physical, chemical, and biological indicators

Bulk Density
Infiltration
Compaction
Particulate OM
Enzyme activity
Nematodes
Collembola
Microbial biomass
Nitrogen cycling
Microbial community structure
Nutrients and carbon

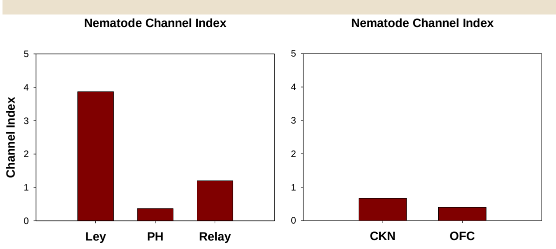
Infiltration is usually faster in plots treated with high-C compost.



A soil nematode community

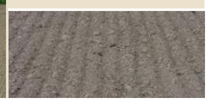


The nematode channel index is an indication of the fungal population in the soil. A higher CI means greater Fungi:Bacteria ratio.



What does tillage do?

- Manage residue
- Manage weeds
- Prepare seed bed
- Aeration
- Modify moisture
- Modify temperature



Why reduce tillage?

↓	↑
Soil Compaction	Organic Matter
Erosion	Soil Organisms
Surface Crusting	Soil Structure
Dust	Aggregate Stability
Sediment	Water Holding Capacity
Fuel Use	Water Infiltration
Greenhouse Gases	Carbon Sequestration
	Field Access
	Profitability?

Progress on reduced tillage research in organic production

- 2008-09 On farm- cereal rye
- 2009-10 WSU Puyallup- barley, wheat
- 2010-11 WSU Puyallup- barley, vetch
- 2011-12 WSU Puyallup & Mt Vernon, 3 On farm sites 19 varieties and mixes barley, rye, oats vetch peas triticale
- 2012-13 WSU Puyallup & Mt Vernon 3 on farm sites 16 varieties and mixes rye, barley vetch

Development of a reduced tillage in organic agriculture experiment

Zadoks Stages of grain development

“Early”= Late anthesis
69

“Late” = Early milk
73

Zadoks et al., 1974

Photos by Sandra Wayman

Mischler vetch development

“Early”= 60% flowering

“Late” = 100% flowering

Mischler et al., 2009

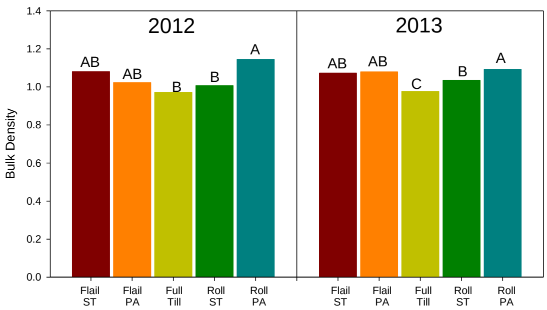
Photos by Sandra Wayman

Preparing for transplant/seeding with
No-till planting aid

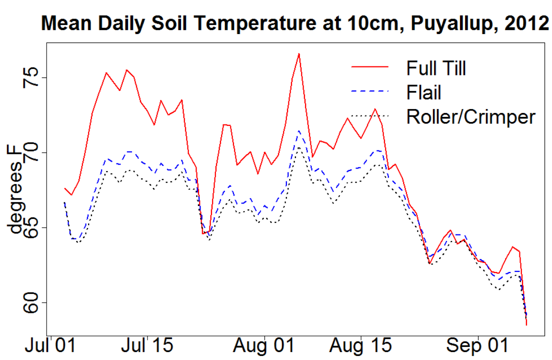
No-till planting aid

Preparing for transplant/seeding with
Yetter Strip Builder

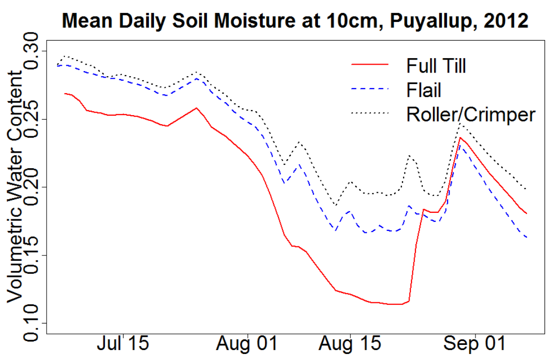
Bulk density tends to be greater in reduced till plots



Soil temperature is greater in full till plots



Soil moisture is greater in reduced-till plots

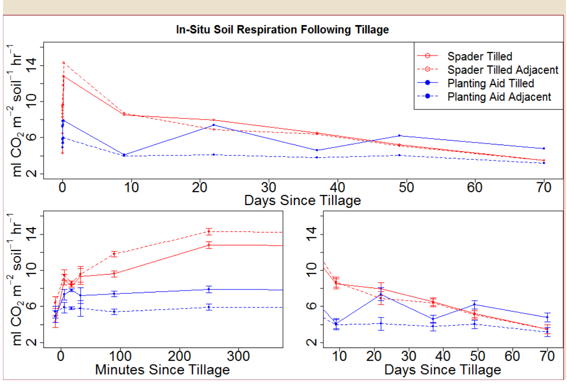


In reduced-tillage plots, gas measurements are taken on full till and roller/crimper + plant aid.

Sampling events in reduced tillage plots, 2013

Event	Event Date	GC Gas/Soil samples	IRGA Gas samples
Tillage	June 4th	-1d (Pre-till), 1-31 min; 1,3,7,15 days	pre-till, 1,5,10,15,20,30 min 1.5, 5 hr, 1, 3, 7, 15 days
Irrigation	July 23rd	0 (Preirrigation), 1,2	0 (Preirrigation), 1,2
Incorporation	October 9th	-21d(Preincorporation), day 1	-21 d, 1, 5 min 1.5, 3.5 hr, day 1

Soil Respiration Through Season with IRGA, 2012



NO_2 Flux Calculations are being done with R package HMR[1]

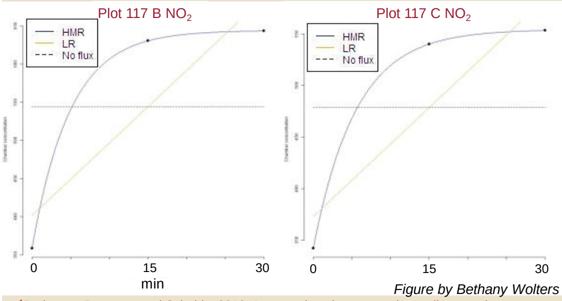


Figure by Bethany Wolters

[1]Pederson, Petersen, and Schelde. 2010. A comprehensive approach to soil-atmosphere trace-gas flux estimation with static chambers. Eur J. Soil Sci. 61:888-902.

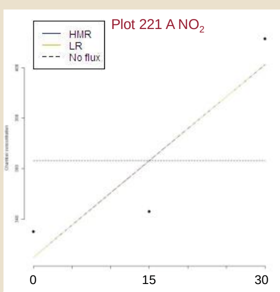
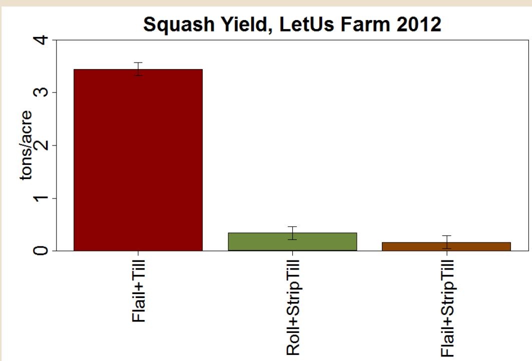


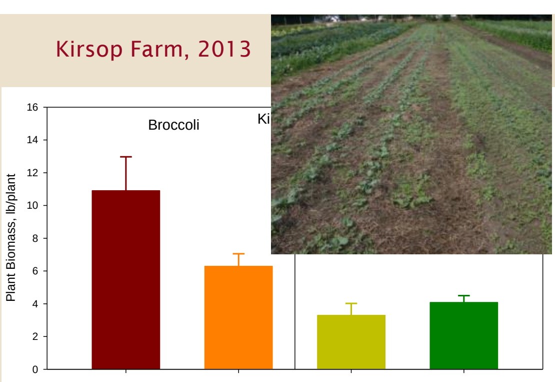
Figure by Bethany Wolters

Adoption and On-Farm Trials

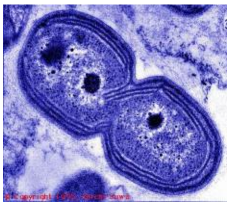
Steve Hallstrom, Let Us Farm



Kirsop Farm, 2013



Microbial Matters, the Link Between Soil Quality and microbial processes regulating N_2O production

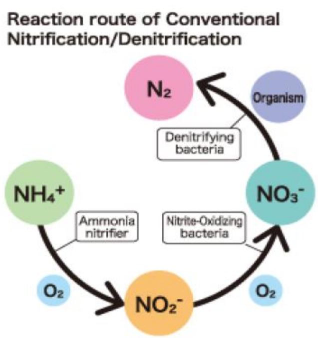



- Understand processes that drive the release of N from organic sources, identify and quantify microbial community members controlling nitrification and denitrification
- Which short-term biological indicators can be used to assess seasonal & long-term changes in soil quality & GHGs?

Biological & Chemical Indicators of Soil Quality

- Enzyme activity (nitrifier, denitrifier)
- Nitrogen cycling (nitrogen mineralization)
- Nutrients (P, K) (fertililty)
- total organic soil carbon
- Particulate organic matter
- Microbial community structure

- Biological measures of soil quality such as **nitrifier and denitrifier rates & gene copy numbers** (**~biomass**) are indicators of N fertility, soil quality & relate to the potential for N_2O production
- Nitrification and nitrifiers are sensitive indicators that **reflect short and long-term management** in organic systems



http://nett21.gec.jp/gesap/themes/themes4_8_2.html

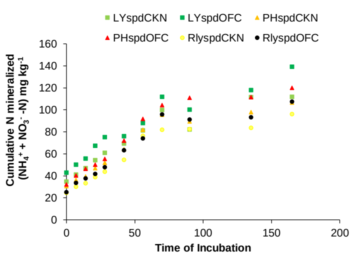
The process of nitrification produces nitrate that can undergo denitrification to produce N_2O & N_2

Environmental Factors Affecting Nitrification & Denitrification

- **Sufficient Nitrifier & Denitrifier populations (biomass measured ascopy numbers)**
- **Soil aeration, water filled pore space** – bulk soils near field capacity or about **60% water-filled pore space** optimal for **nitrification**, **<80% denitrification**.

- **Soil pH**, **Temperature**, **salinity** -
- **available nutrients** other than N,P,K, micronutrients etc.
- **Ammonium (substrate availability source of energy nitrification)** – typical soil concentrations of ammonium and nitrite are sufficient
- **Nitrate** (substrate availability, energy source) and **Carbon Availability** (heterotrophic denitrification)

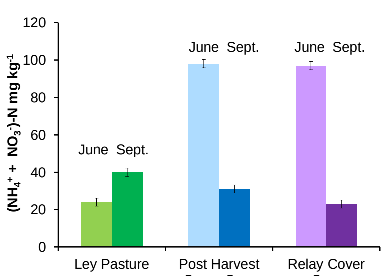
Figure 1. Net nitrogen (N) mineralized from a 150 day incubation



The pool of potentially mineralizable N was estimated to be 93 mg kg^{-1} and the average turnover rate was 71 days (approximately equivalent to a growing season).

[1]A non linear regression equation was fitted using a nonlinear regression analysis in SAS.

Figure 2. The Effect of Cover Crop Management on Plant Available Nitrogen



Error bars represent the standard error of the mean of inorganic N (*P*=0.01)

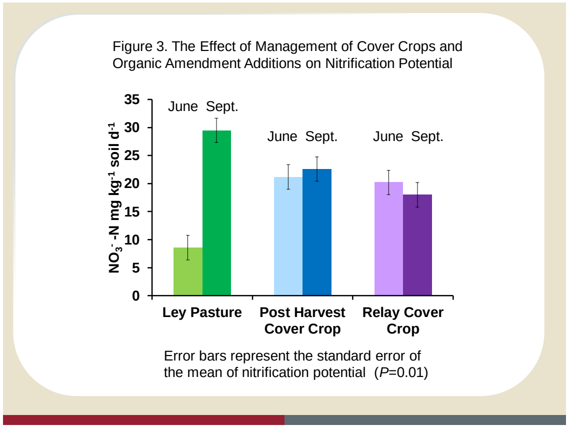


Figure 3. The Effect of Management of Cover Crops and Organic Amendment Additions on Nitrification Potential
NO3- -N mg kg-1 soil d-1
35
30
25
20
15
10
5
0
June Sept.
June Sept.
June Sept.
Ley Pasture
Post Harvest Cover Crop
Relay Cover Crop
Error bars represent the standard error of the mean of nitrification potential (P=0.01)

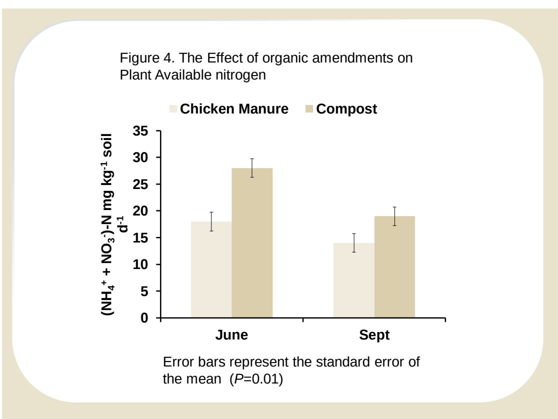


Figure 4. The Effect of organic amendments on Plant Available nitrogen
Chicken Manure
Compost
(NH4+ + NO3-)-N mg kg-1 soil d-1
35
30
25
20
15
10
5
0
June
Sept
Error bars represent the standard error of the mean (P=0.01)

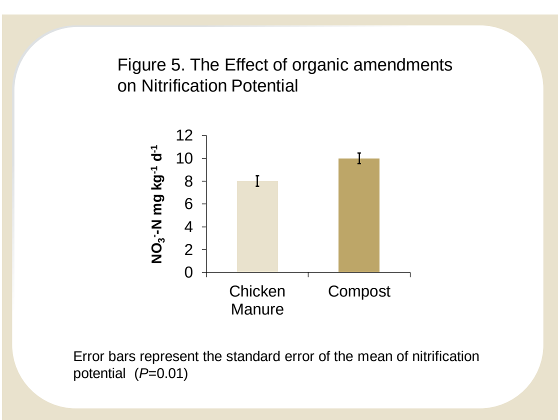


Figure 5. The Effect of organic amendments on Nitrification Potential
NO3- -N mg kg-1 d-1
12
10
8
6
4
2
0
Chicken Manure
Compost
Error bars represent the standard error of the mean of nitrification potential (P=0.01)

Ammonia oxidizing bacteria gene copies per ng of DNA per g^{-1} dry soil		
Treatment	June	Sept.
Chicken Manure	1.6×10^5 a	1.7×10^5 a
Compost	7.0×10^4 b	7.7×10^4 b

Values in the row labeled June followed by different letters are significantly different (*P*=0.02).
Values in the row labeled June followed by different letters are significantly different (*P*=0.01).

Ammonia oxidizing archaea gene copies per ng of DNA per g^{-1} dry soil		
Treatment	June	Sept.
Chicken Manure	2.2×10^5 a	2.4×10^5 a
Compost	1.6×10^5 a	1.7×10^5 a

Values in a row representing sample dates were not followed by a different letter and not are significantly different.

- Nitrification potential in organic systems test of N fertility, biological soil quality and potentially related to losses of reactive N

- Basic research may lead to improved Nitrogen Use Efficiency and improve our understanding of reactive N losses in organic systems

- Find all upcoming and archived webinars at http://www.extension.org/pages/25242.
- Find the recording and pdf handout for this webinar at http://www.extension.org/pages/70280
- Have an organic farming question? Use the eXtension Ask an Expert service at https://ask.extension.org/groups/1668/ask
- We need your feedback! Please respond to an email survey about this webinar which you'll receive later.
- Thank you for coming!