Today's Webinar Moderator
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US Department of Agriculture
Agricultural Marketing Service

USDA Natural Resources Conservation Service
Science and Technology

2015 Conservation Webinars

Date	2015 Conservation Webinars Topics
August 27	Environmental Benefits of Organic Agriculture: Soil
Sept 23	Environmental Benefits of Organic Agriculture: Water Quality
Oct 6	Climate Change and Organic Agriculture
Dec 1	Natural Resource and Biodiversity Conservation in Organic Production

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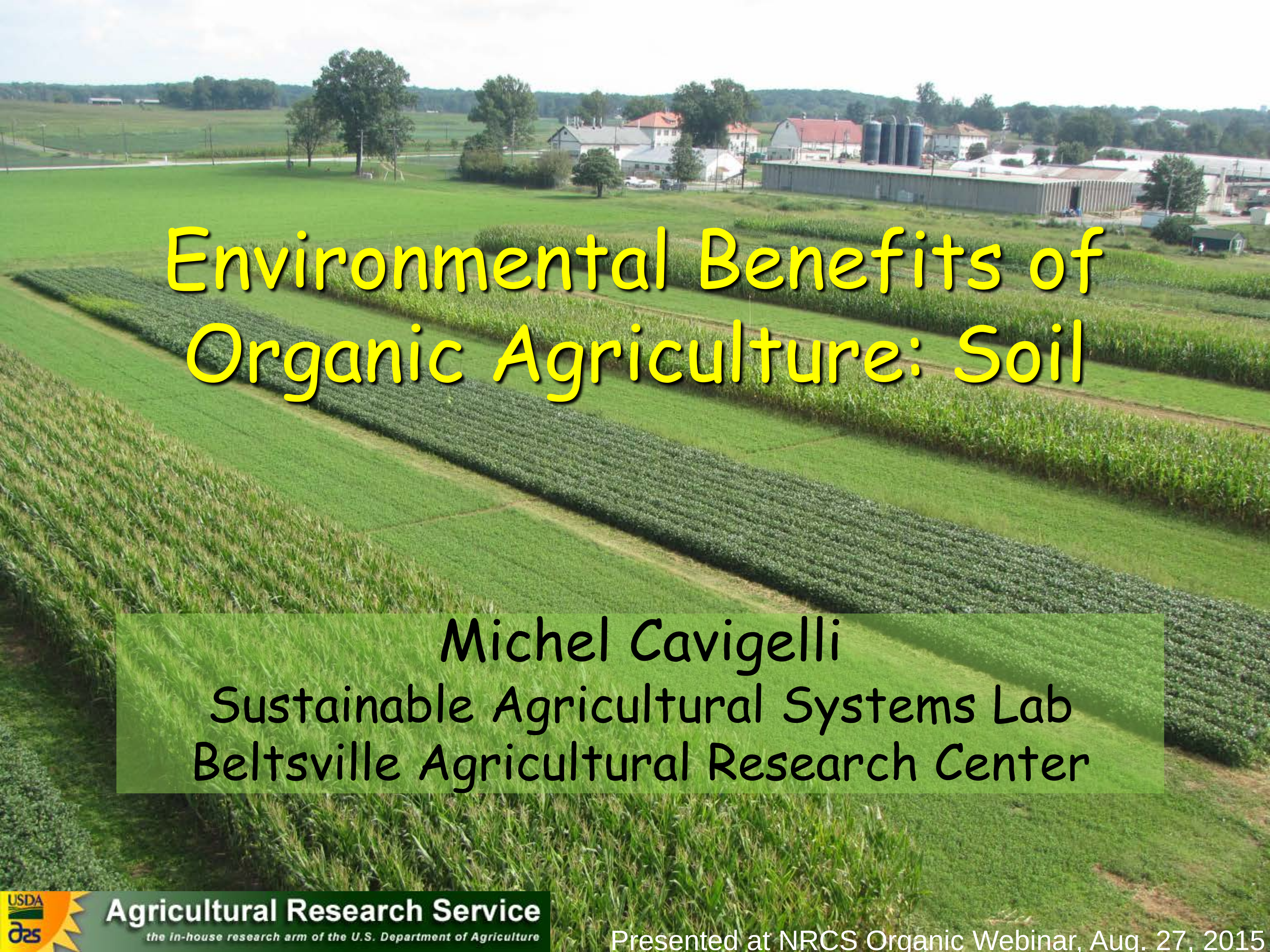


Environmental Benefits of Organic Agriculture: Soil

Michel Cavigelli
Sustainable Agricultural Systems Lab
Beltsville Agricultural Research Center

Presented at NRCS Organic Webinar, Aug. 27, 2015

Organic Farming

Not Allowed

- No synthetic fertilizers
- No synthetic pesticides
- No GMOs

Fundamental Tools

- Crop rotations
- Cover crops
- Animal manures
- Tillage

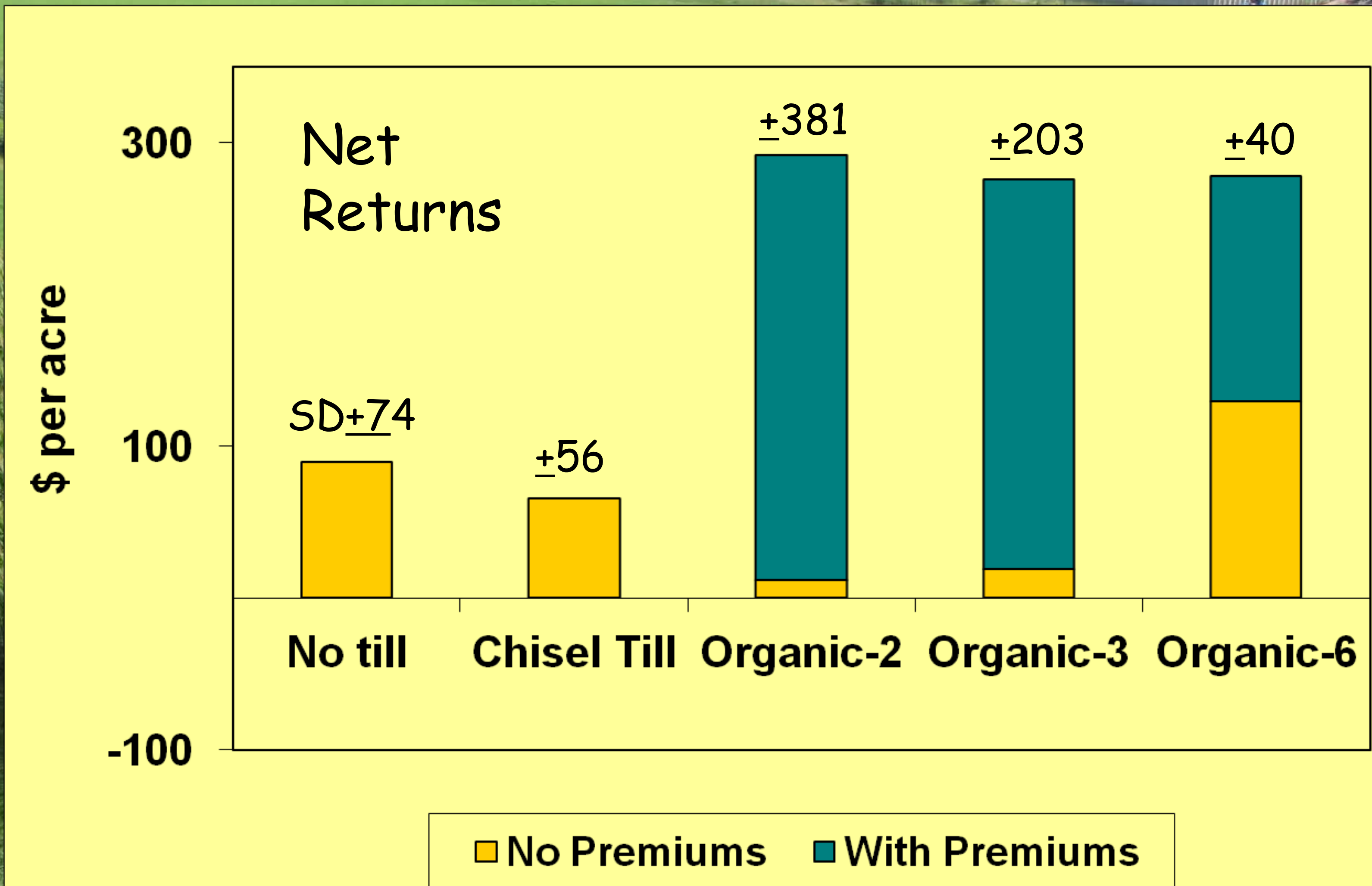
The Beltsville Farming Systems Project

- Plots established 1996
- 4 replicated blocks
- All rotation entry points present each year
- Commercial scale farming equipment
- One of 5 US LTARs with NT and Organic
- Only US LTAR with 3 different organic treatments and NT

FSP Cropping Systems

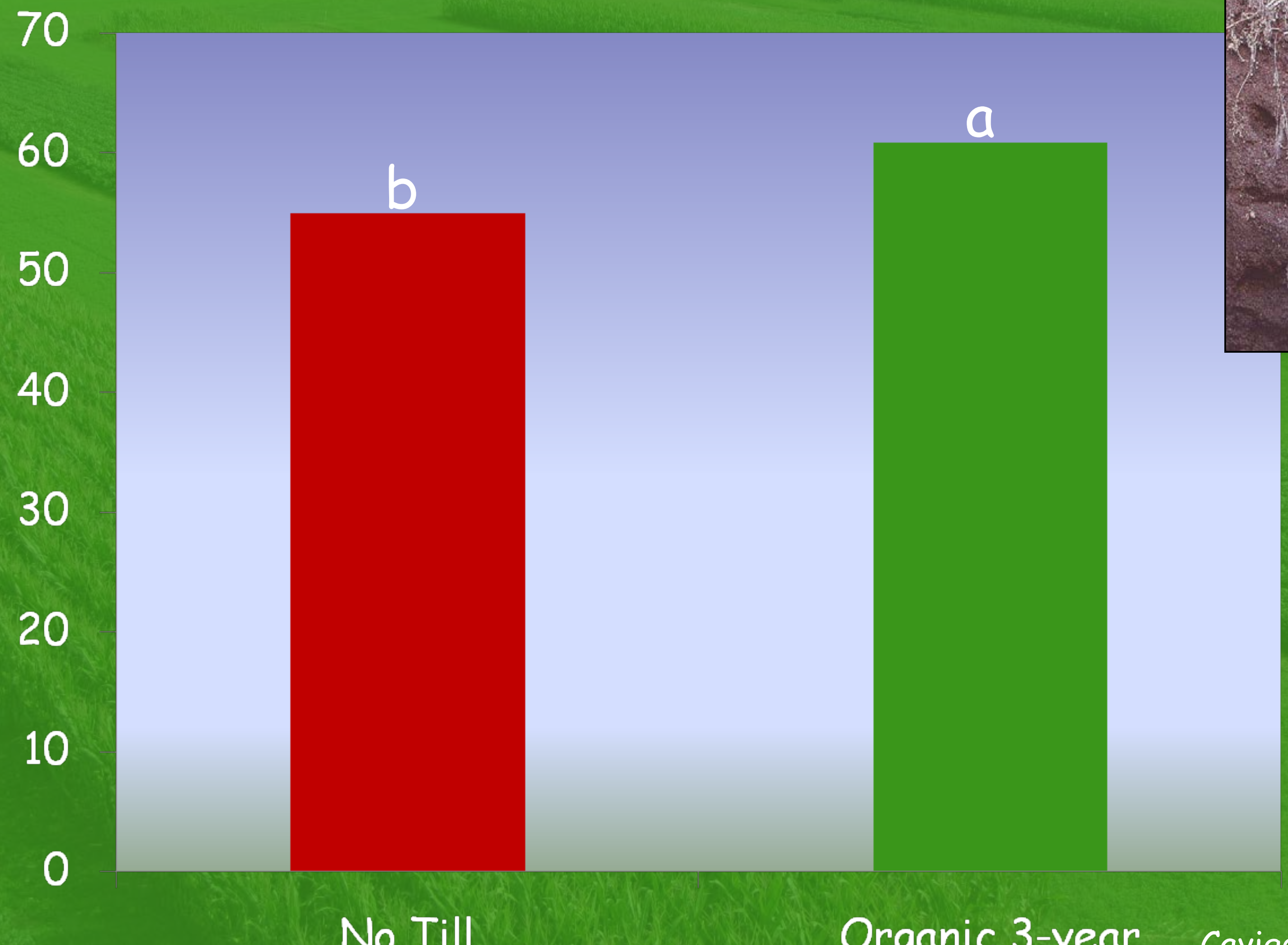
NO TILL	Corn-*rye*-Soybean-Wheat/Soybean
CHISEL TILL	Corn-*rye*-Soybean-Wheat/Soybean
ORGANIC, 2-YEAR	Corn-*rye*-Soybean-*vetch*
ORGANIC, 3-YEAR	Corn-*rye*-Soybean-Wheat/*vetch*
ORGANIC, 6-YEAR	Corn-*rye*-Soybean-Wheat/Alfalfa

Economic Performance



Cavigelli et al., 2009

Soil Organic Carbon to 1 m Depth ($Mg\ C\ ha^{-1}$)

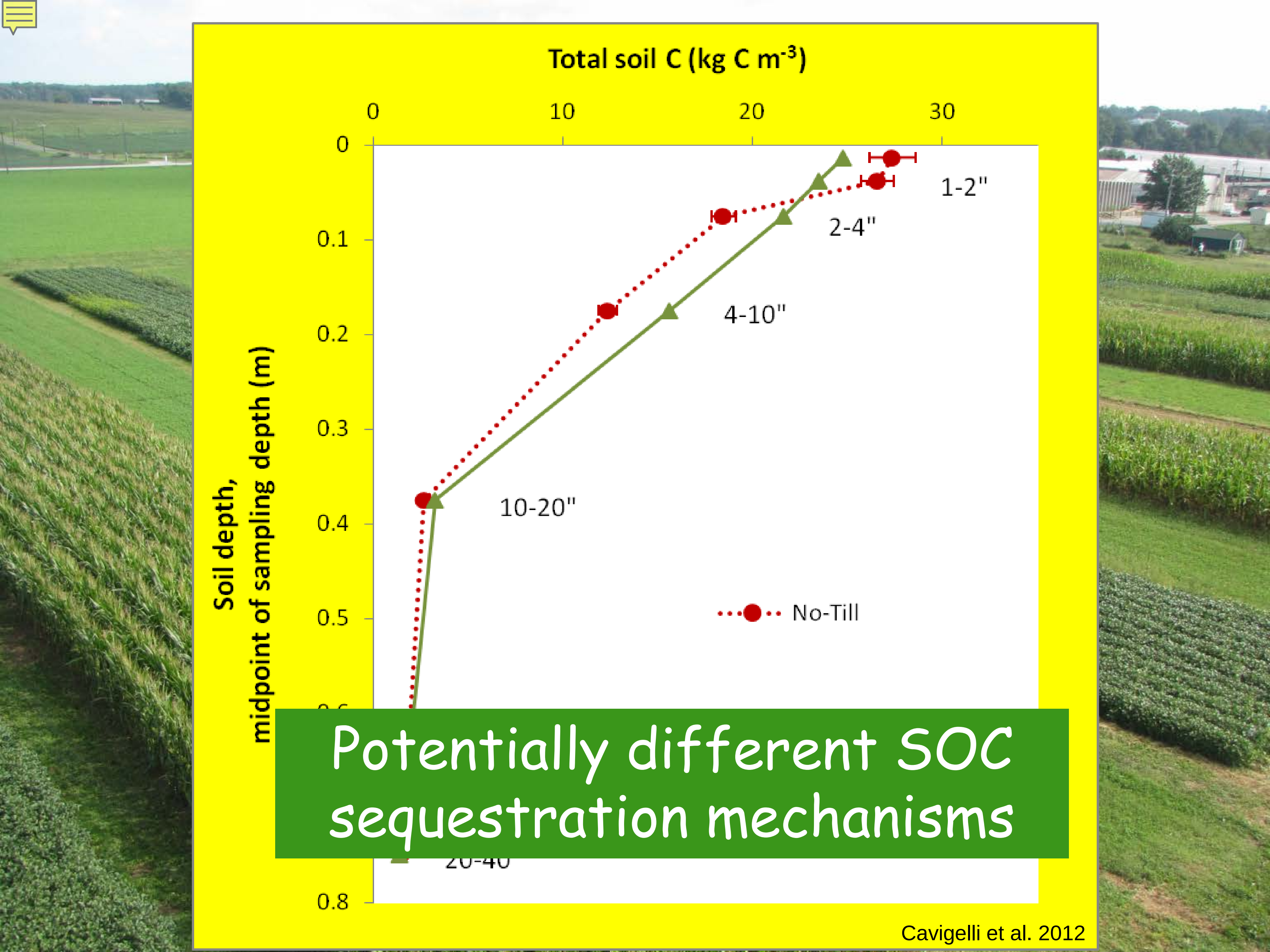


Cavigelli et al., 2013

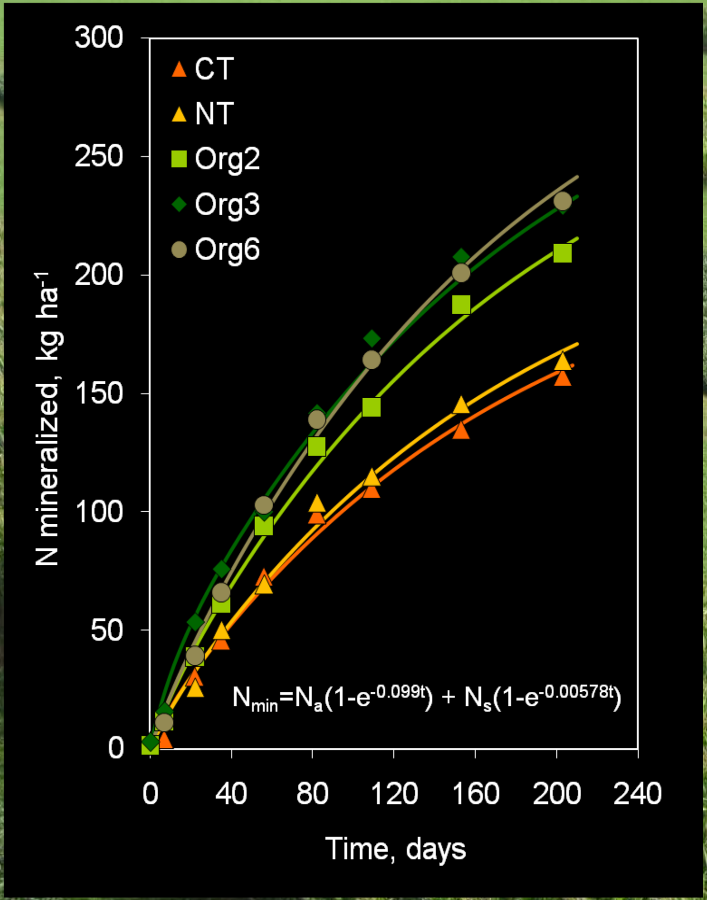
Actual vs. Predicted SOC

System	Soil Carbon in 1 m soil profile g C m^{-2}	Soil Conditioning Index (from RUSLE2*)
No-till	5555 ab	0.75
Chisel Till	5195 b	0.07
Organic, 2-yr C-r-S-v	5736 ab	-0.83
Organic, 3-yr C-r-S-W-v	6158 a	-0.34
Organic, 6-yr C-r-S-W-A-A-A	5921 a	0.18

RUSLE2 K Factor = 0.28, western MD, 2-5% slope; Pilkowski and Cavigelli. 2008. unpub'd


Total soil C (kg C m-3)
0
10
20
30
0
0.1
0.2
0.3
0.4
0.5
0.8
Soil depth,
midpoint of sampling depth (m)
1-2"
2-4"
4-10"
10-20"
No-Till
Potentially different SOC sequestration mechanisms
Cavigelli et al. 2012

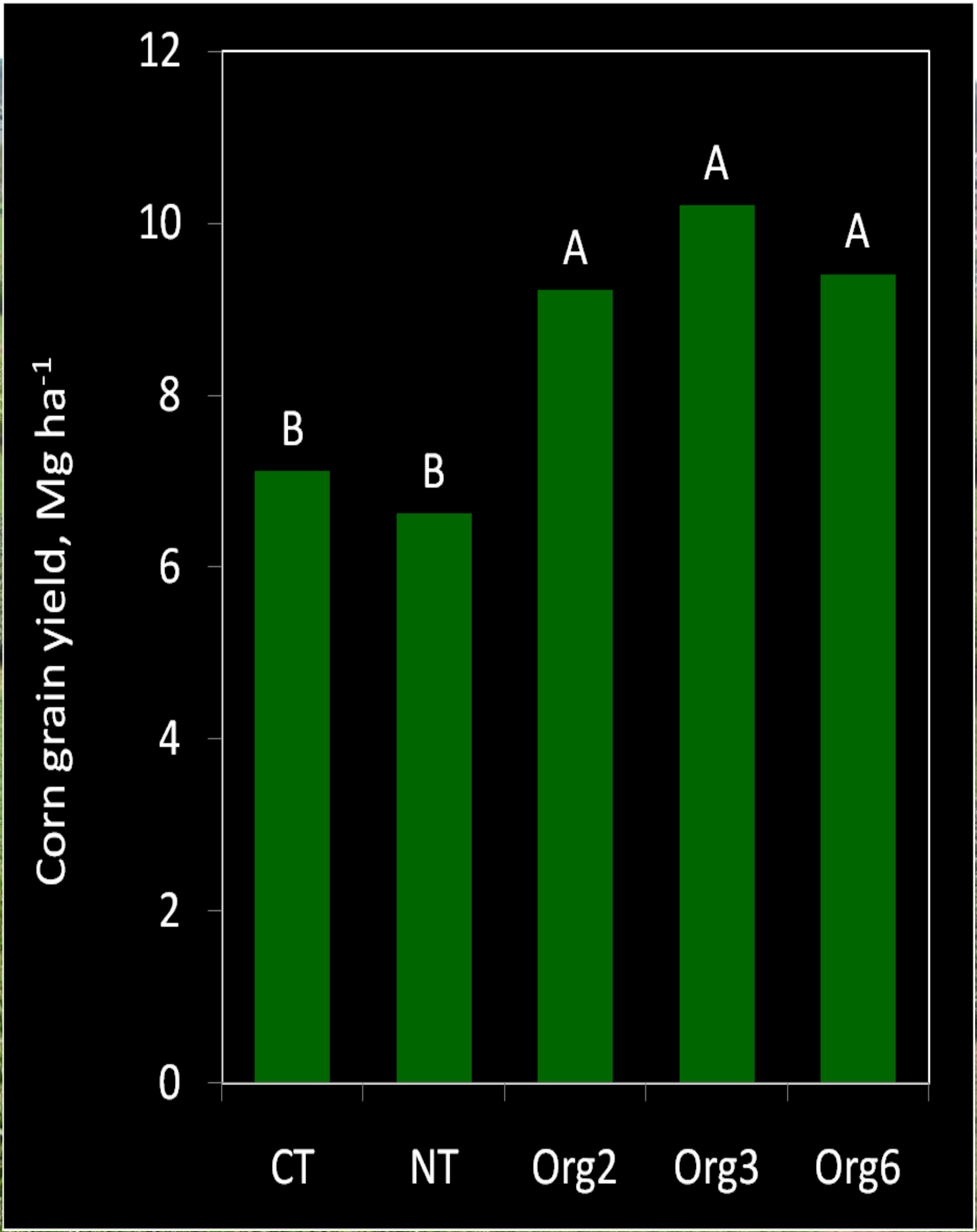
SOC and Soil Fertility



System	Potentially mineralizable N	Frequency of manure application
CT	229 b	NA
NT	241 b	NA
Org2	297 a	1 of 2 yrs
Org3	323 a	2 of 3 years
Org6	325 a	2 of 6 years

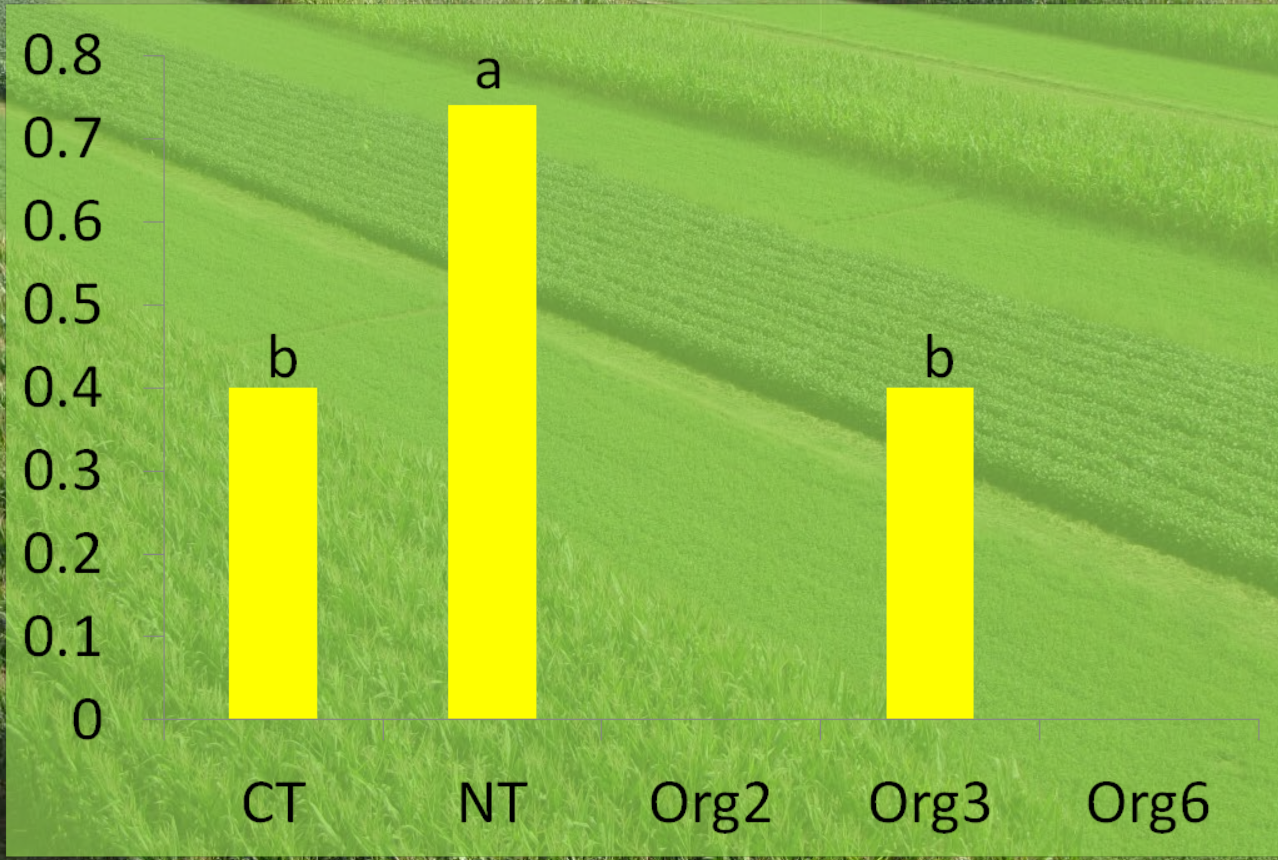
Spargo et al., 2011

Soil fertility impacts on crop yield



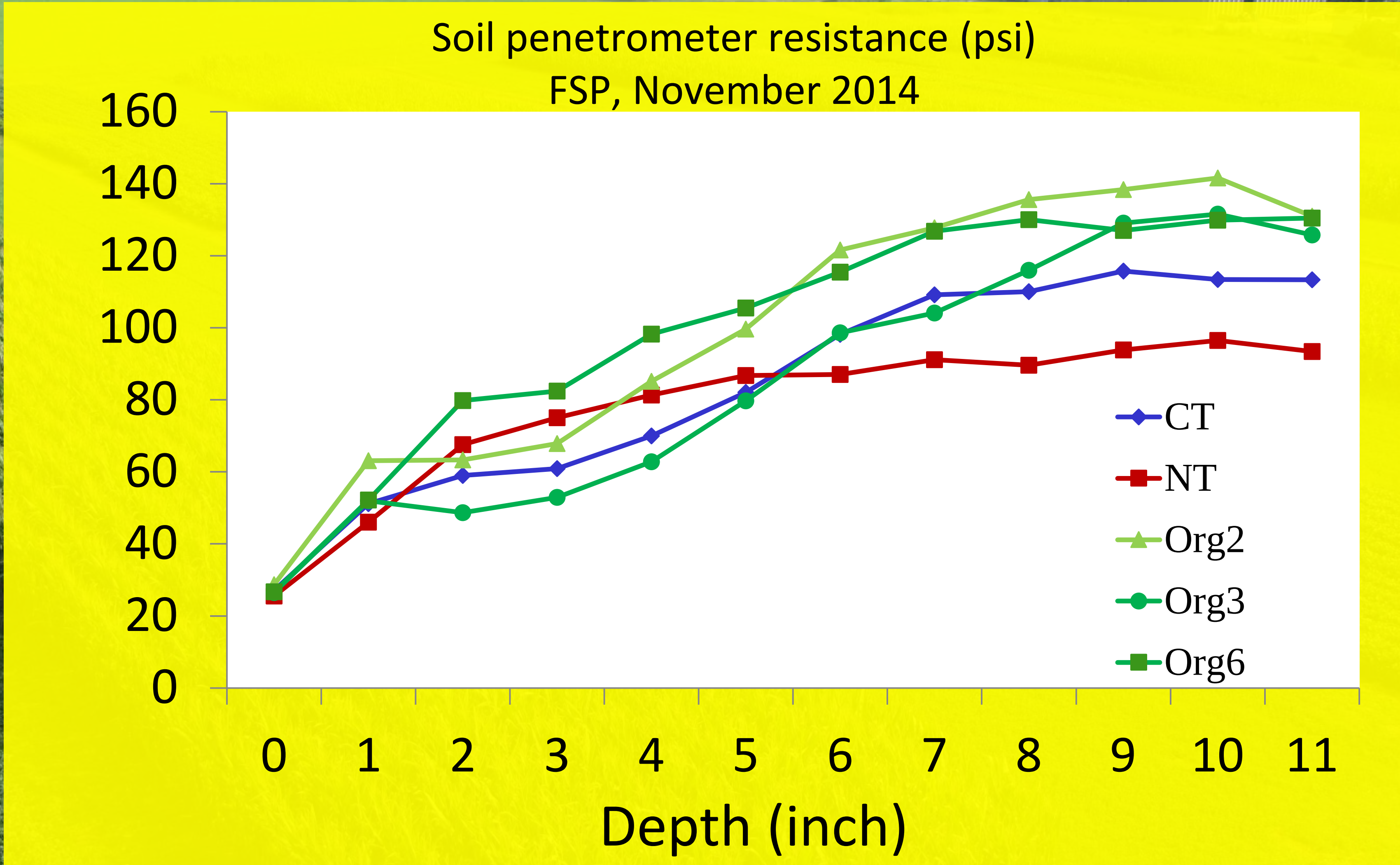
Spargo et al. 2011

Aggregate Stability (%)
0-5 cm



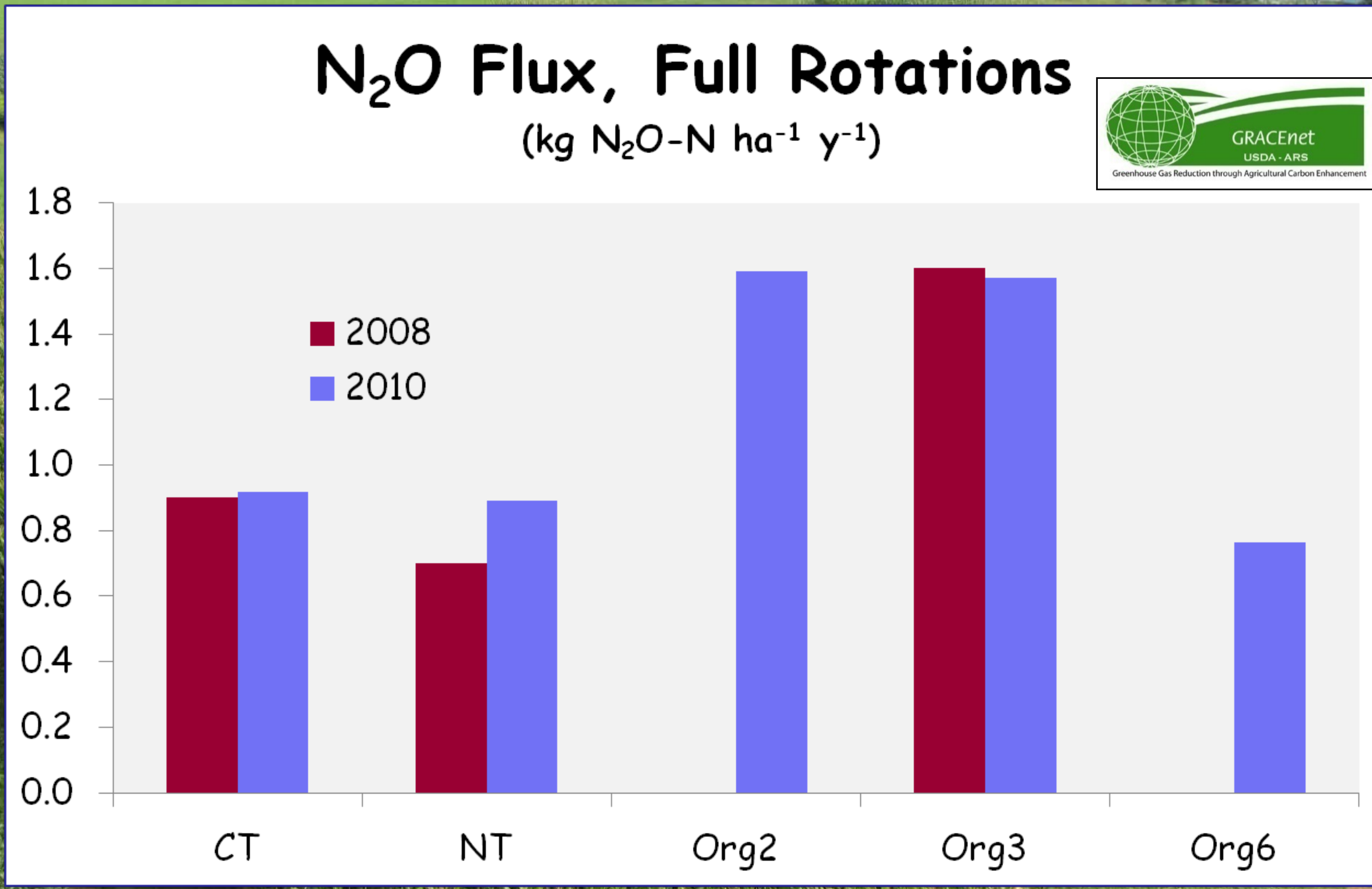
Green et al. 2005

Soil Hardness



Data collected by Jude Maul

Soil N_2O emissions



Cavigelli et al. 2012

Global Warming Potential

	$CO_{2\ eqvt}$ ($kg\ CO_{2eqvt}\ ha^{-1}\ yr^{-1}$)			
System	ΔSoil C*	N_2O	Energy + Lime	GWP*
Chisel Till	1080 a	406 ab	862	2348 a
No-Till	0 b	303 b	807	1110 b
Organic	-1953 c	737 a	344**	-872 c**

* Negative value indicates mitigation of global warming
** Strongly dependent on manure transportation distance

Cavigelli et al. 2009

Providing Ecosystem Services: Multiple Tradeoffs

Service/Characteristic	Comparison
Crop Yield	**Conv** > Org
Soil Erosion	**NT** < Org < CT
Net Returns	Conv < **Org**
Soil Carbon	Conv < **Org**
Soil Fertility	Conv < **Org**
Fertilizer Use	Conv > **Org**
Herbicide Use	Conv >> **Org**
Energy Use	Conv, Org2 > **Org3,6**
GHG Emissions	Conv, Org2 > **Org3,6**

Improving Organic

- Longer, more complex crop rotations in organic systems have
  - Greater corn yields (30%)
  - Less economic risk (4-7 fold)
  - Lower weed pressure (68%)
  - Reduce dependence on manure (and P loading) (33-50%)
  - Reduced soil N_2O emissions (50%)
  - Reduced soil erosion (37-62%)

Cavigelli et al. 2013

Combining NT and Organic

Vetch-rye cover crop mix

Subsurface banding poultry litter

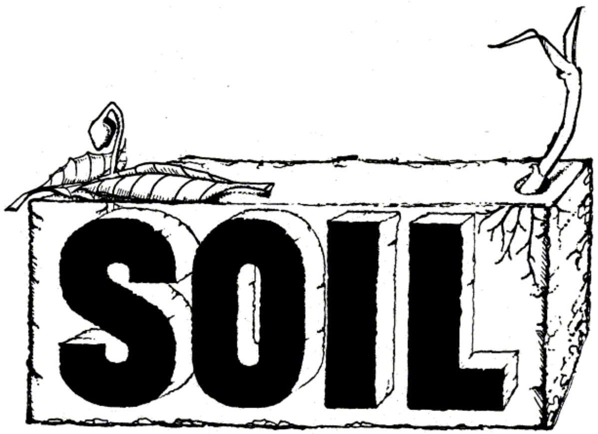
- Cuts through residue, places PL in slit, covers slit
- Provides N in synchrony with crop demand
- Prevents N losses by volatilization (Kleinman 2009)
- N Delivered below zone of mulch decomposition
- Initiated by USDA-ARS, Auburn, AL

Courtesy of Steven Mirsky

Conclusions

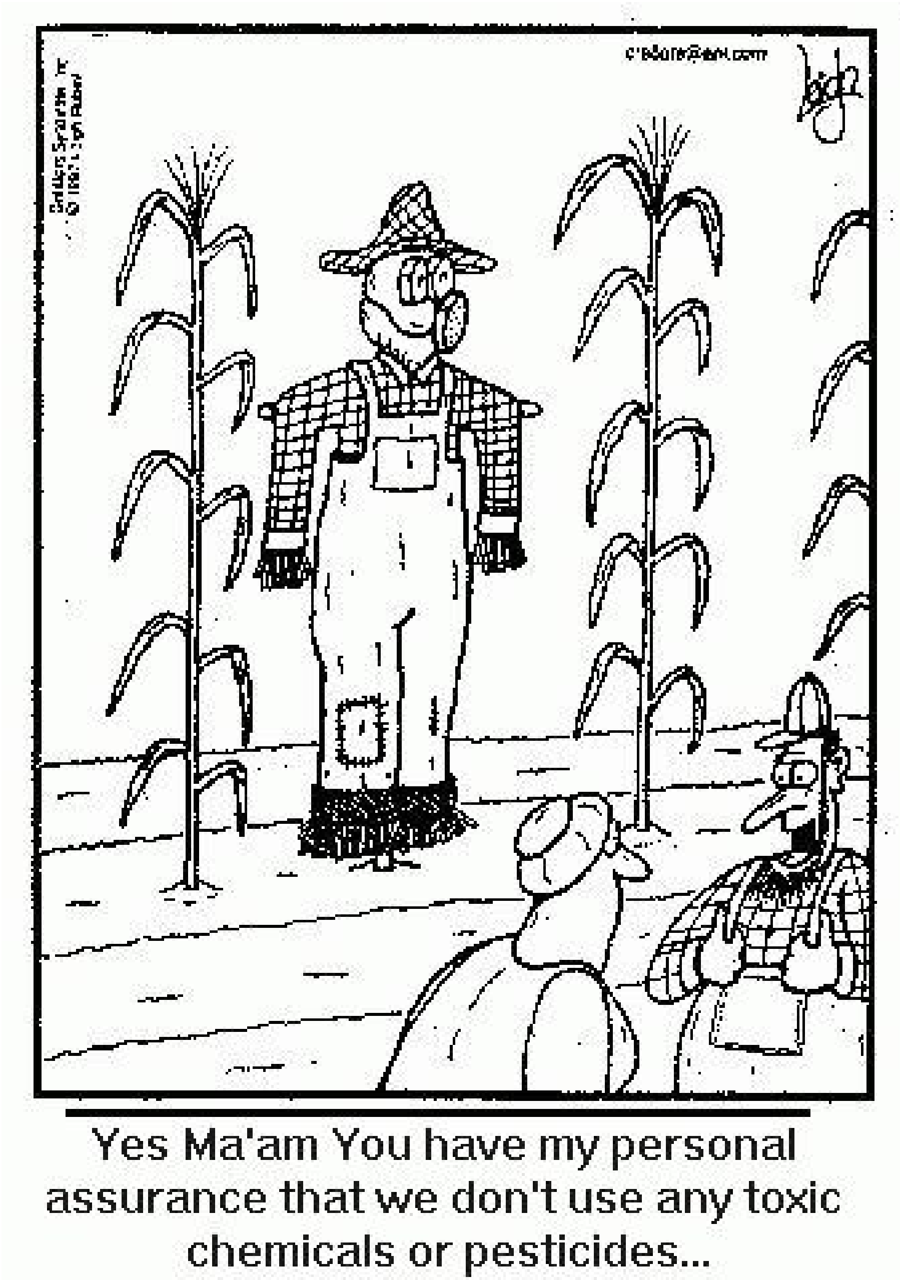
- BMPs required to ensure organic systems are managed sustainably
- Limited long-term data to assess sustainability
- Lessons learned from organic research can help improve sustainability of all systems
- Organic systems can benefit from adopting some technologies developed for conventional systems

Organic



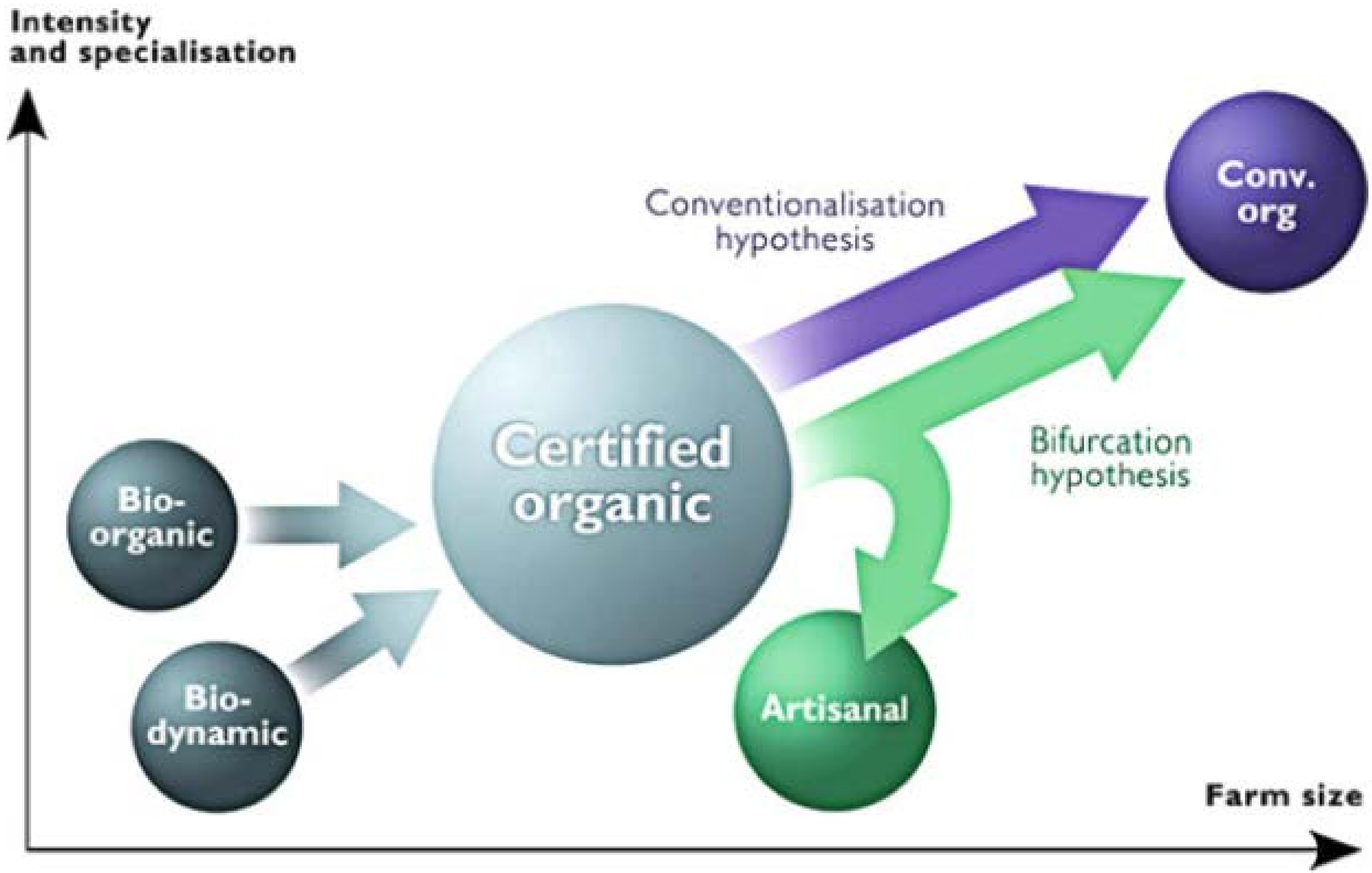
Stewardship

Michelle Wander
mwander@illinois.edu
University of Illinois



Q1. Organic certification means?

1. Food purity
2. Environmental protection
3. Social responsibility
4. All of the above
5. Other



Darnhofer et al. 2011

Part 1. How the benefits of organic farming are tied to soils and their stewardship

Part 2. How organic systems measure up

Part 3. Getting organic ‘Best Practices’ into use

Part 1: Organic Soil Stewardship Paradigm

Soil and soil management is the foundation of organic production.

Organic growing systems are soil based, they care for the soil and surrounding ecosystems and provide support for a diversity of species while encouraging nutrient cycling and mitigating soil and nutrient losses.

IFOAM Norms, 2002

‘Organic’ is an **aspirational standard** achieved through soil stewardship

A. **Soil Fertility-** The relative ability of a soil to supply the nutrients essential to plant growth.

B. **Soil Productivity-** The capacity of a soil to produce a certain yield of crops or other plants with a specified system of management.

C. **Soil Quality-** The capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health.

Conceptual framing soil stewardship paradigm

Nature and the Oeconomy

4th Century BCE	Aristotle	On Generation and Corruption
29 BCE	Virgil	The Georgics
1563	Bernard Palissay	Recette Veritable
1924	Rudolf Steiner	Spiritual Foundations for the Renewal of Agriculture
1940	Lord Northbourne	Look to the Land
1949	Aldo Leopold	A Sand County Almanac
1977	Wendell Berry	The Unsettling of America: Culture and Agriculture
1985	Masanobu Fukuoka	The Natural Way of Farming: the Theory and Practice of Green Philosophy
1996	Mohan Deshpande	Organic Farming wrt Cosmic Energy

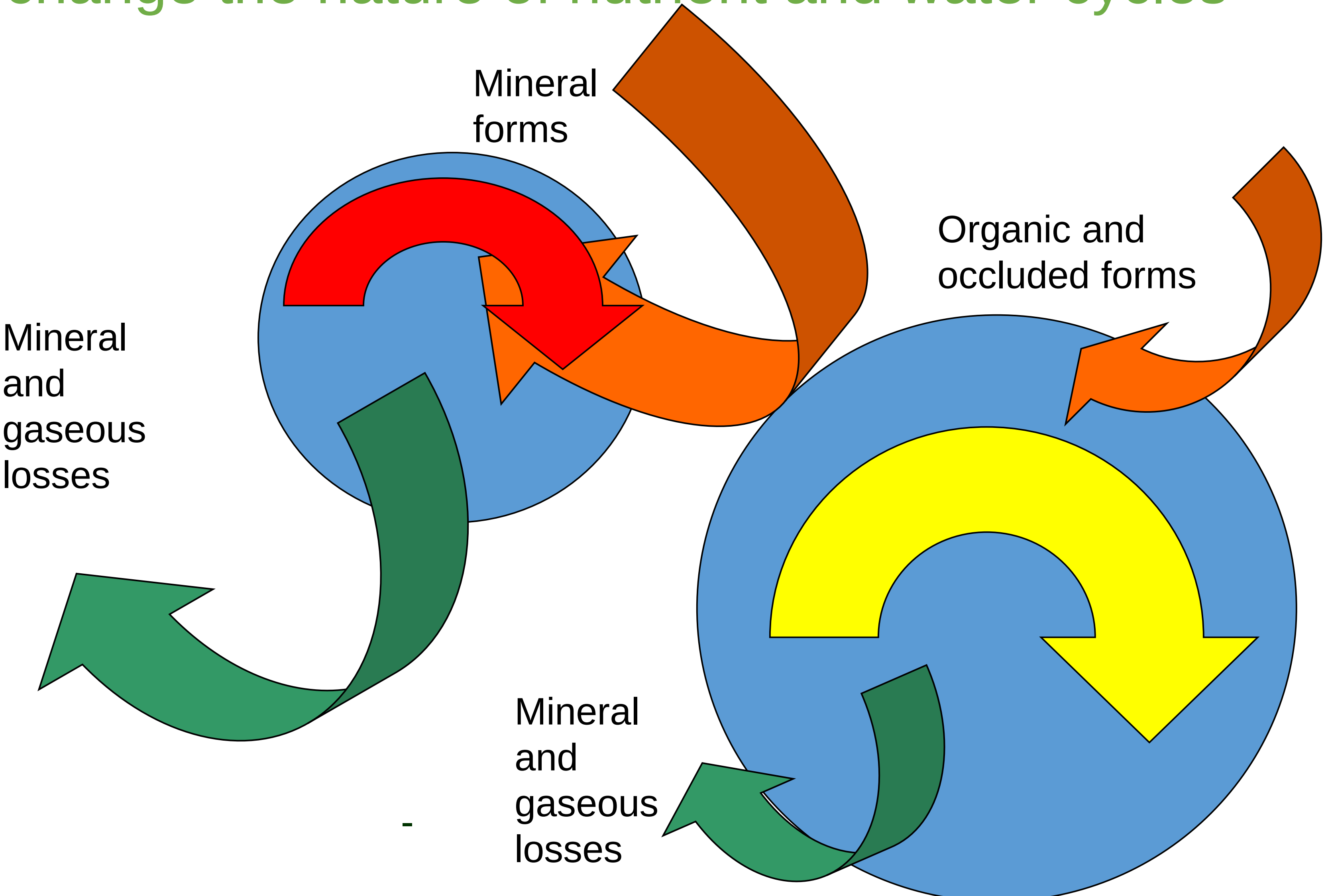
Phlogiston and humus theories

1661	Robert Boyle	Skeptical Chemist
1804	Nicolas de Sassure	Chemical Researches on Vegetation
1813	Sir Humphrey Davy	Elements of Agricultural Chemistry
1826	Carl Sprengel	About Plant Humus, Humic Acids and Salts of Humic Acids
1840	Justis von Leibig	Organic Chemistry in its Application to Agriculture and Physiology
1860	Louis Pasteur	Expériences Rrelatives aux Générations Dites Spontanées
1862	Louis Pasteur	Note Remise au Ministère de l'Instruction Publique et des Cultes, Sur sa Demande

Rational agriculture

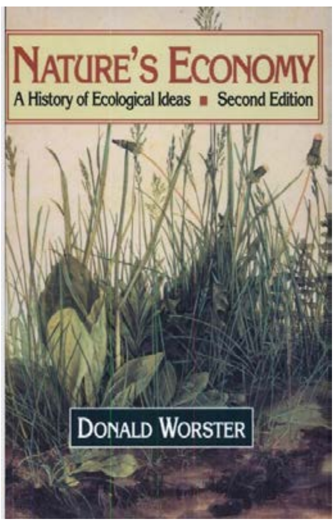
1809	Albrect Thaer	Principles of Rationale Agriculture
1881	Charles Darwin	The Formation of Vegetable Mould Through the Action of Worms
1910	Cyril Hopkins	Soil Fertility and Permanent Agriculture
1911	F.H. King	Farming of Forty Centuries in China, Korea, and Japan
1938	William Albrecht	Loss of Organic Matter and its Restoration" in 'Soils and Men'
1942	Lady Balfour	The Living Soil
1943	Albert Howard	An Agricultural Testament
1945	Jerome Irving Rodale	Pay Dirt: Farming and Gardening with Composts
1947	Ehrenfried Pfieffer,	Soil Fertility, Renewal and Preservation: Bio-Dynamic Farming and Gardening
1947	Ehrenfried Pfieffer	Soil Fertility, Renewal and Preservation: Bio-Dynamic Farming and Gardening
1975	William Albrect	The Albrecht Papers

Use rotation, crop, and management choices to change the nature of nutrient and water cycles



Change ‘open’ systems with rapid cycling and large fluxes to systems that simultaneously retain and supply more from internal reserves

Principles of organic soil stewardship



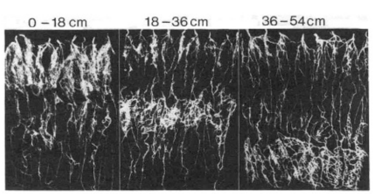


Fig. 14.4 Effect of nitrogen fertilizer placement in different soil depths on the root distribution of barley growing in a sandy soil. (From Gliemeroth, 1953.)

- **Biologically based fertility-** not organic by substitution
  - Emphasis on biologically sourced N through N fixation and judicious use of manures and composts- system dependent!
  - Use of plants to liberate nutrients from organic and inorganic sources
  - Facilitate plant-microbe associations (beneficial microbes)

- **Reduced reliance on external inputs**
  - This promotes self sufficiency
  - Local purchasing benefits community
  - Reduces cost of production

- **Create a healthy system**
  - Produce superior products
  - Promote disease and pest suppression through rotation and cultivar selection (management should be proactive rather than reactive)
  - Judicious use of inputs (what, when and where) can promote plant and animal health by maintaining balance and efficiency

Performance: Yield Stability, Resistance to Drought

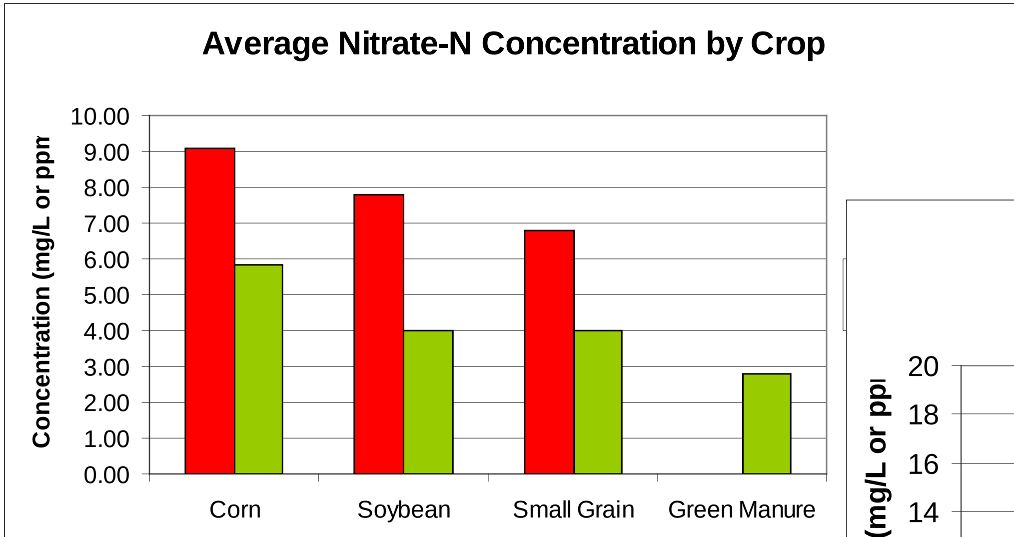
Rodale Research Center’s FST; Left is organic plots, right is a BMP, corn/soy rotation no cover crops, in drought year. Photo courtesy of Evian Bitan

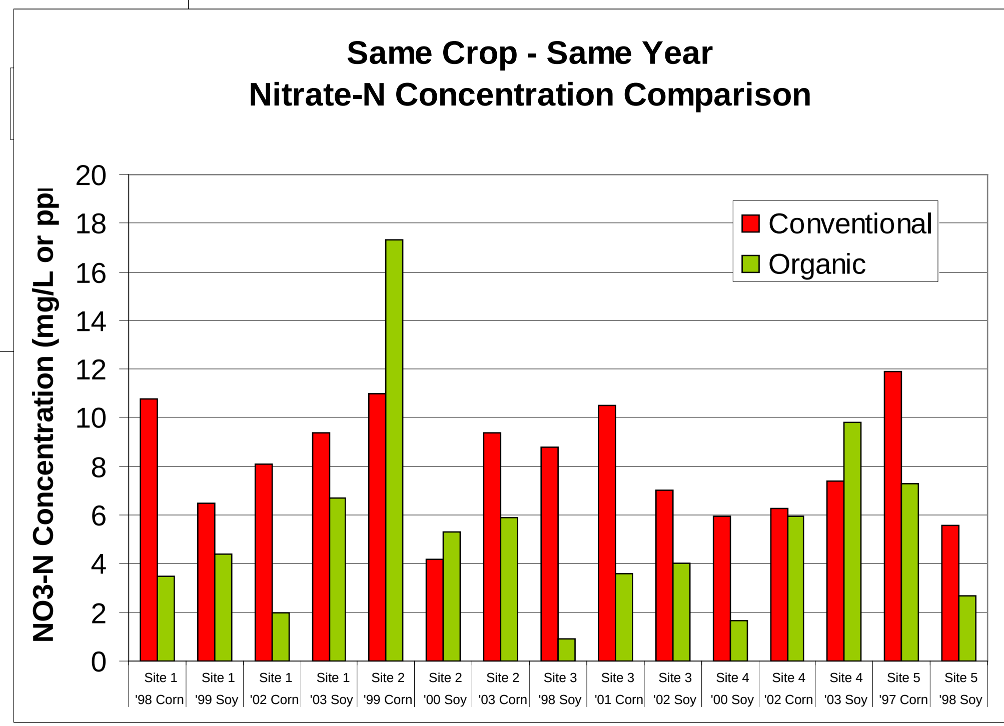
Resistance to erosion, improved drainage

DOK plots, organic compost v conventional

Photo courtesy of Evian Bitan

Reductions of Nutrient Export





Greg McIsaac, Organic Agronomy Day 2005

How to increase water and nutrient use efficiency

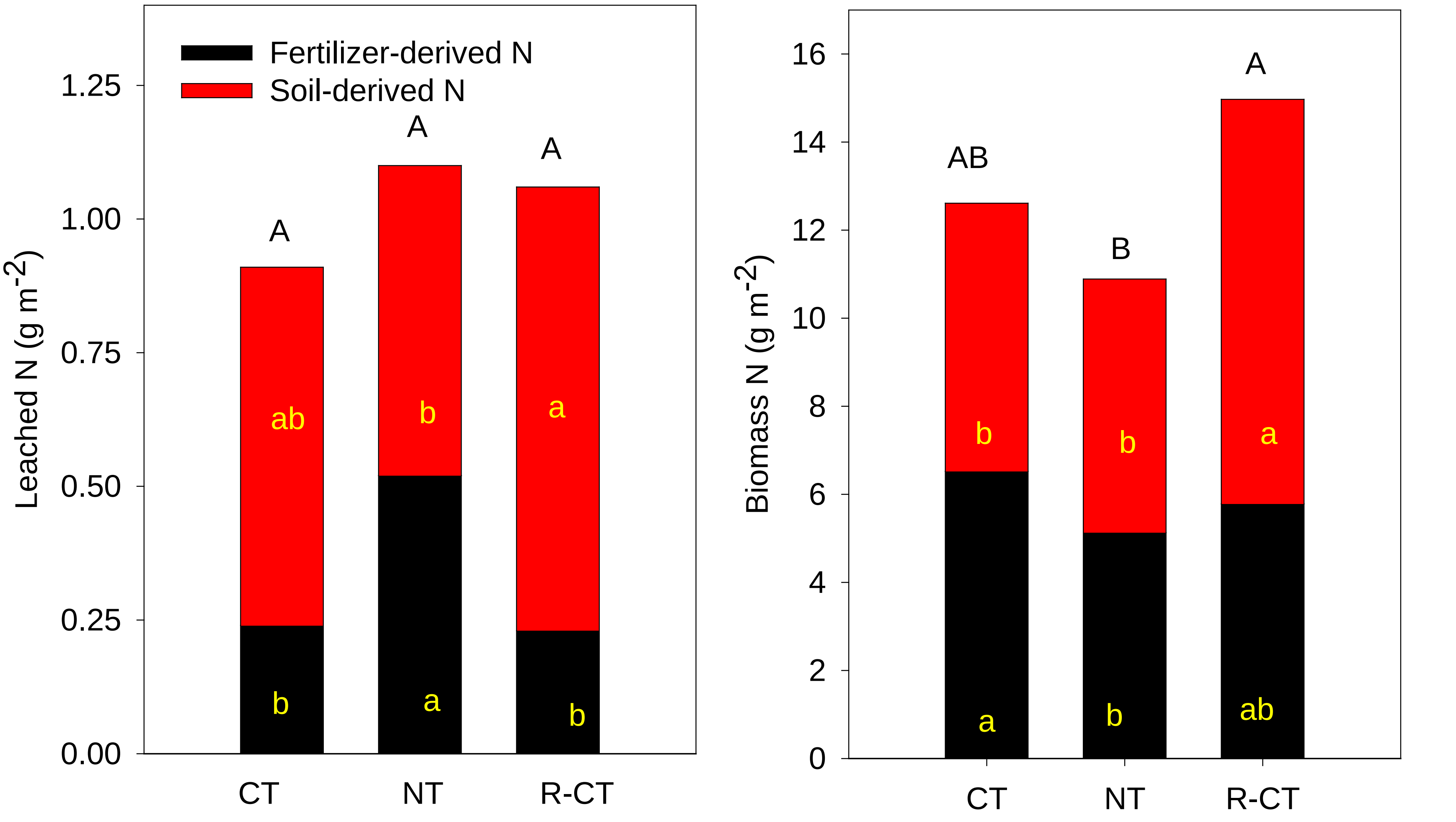
Samples collected from Illinois farm fields

CT; conventional corn soy

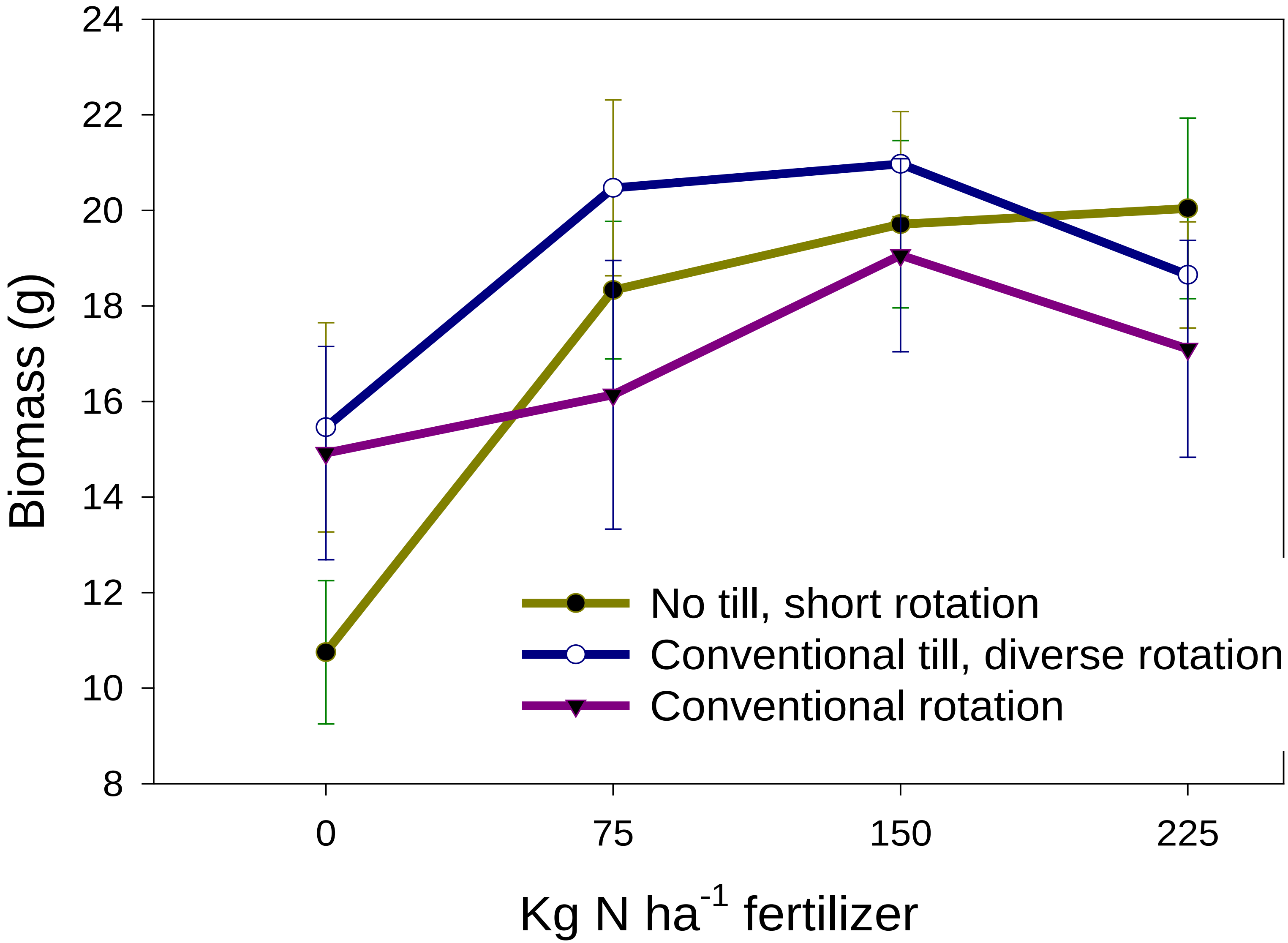
RT; conventional corn soy

R-CT; diversified, 3 of 4 were organic

Nissen and Wander, 2003

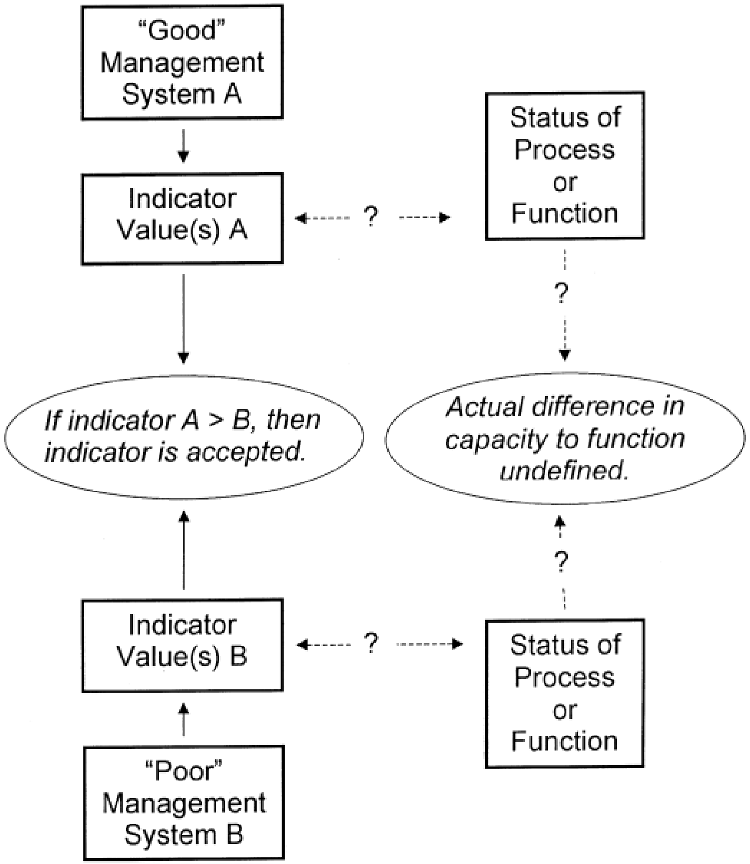


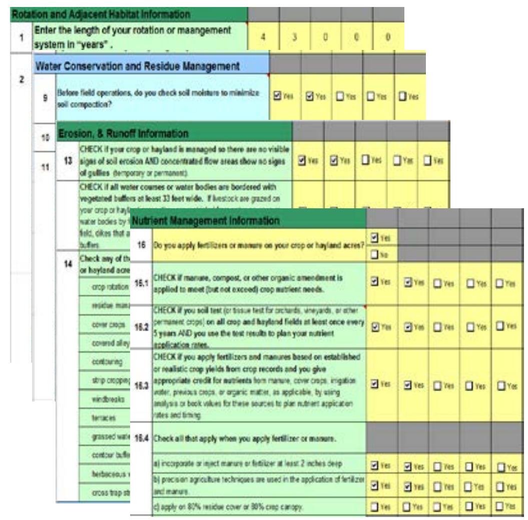
Fertilizer-derived N
Soil-derived N
Leached N (g m-2)
1.25
1.00
0.75
0.50
0.25
0.00
A
A
A
ab
b
a
b
a
b
CT
NT
R-CT
Biomass N (g m-2)
16
14
12
10
8
6
4
2
0
AB
B
A
b
b
a
a
b
ab
CT
NT
R-CT

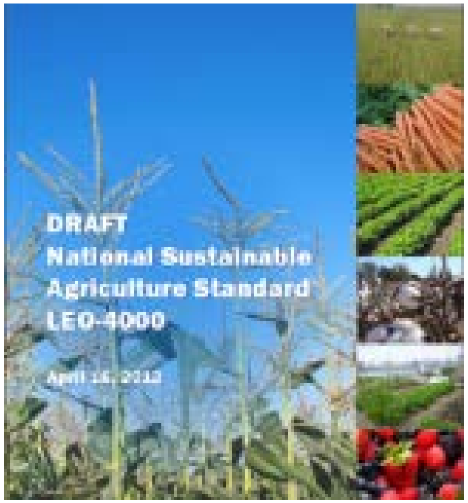


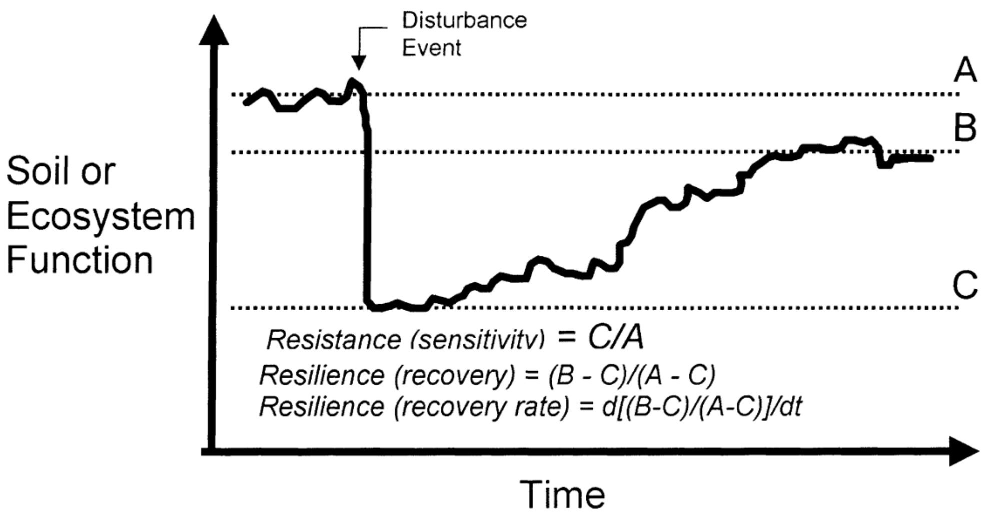
24
22
20
18
16
14
12
10
8
Biomass (g)
0
75
150
225
Kg N ha-1 fertilizer
No till, short rotation
Conventional till, diverse rotation
Conventional rotation

Part 2. Do organic farming systems measure up?









Q2. How do we best measure stewardship?

1. Based on practices used
2. Have to measure properties directly
3. Estimate services using process models
4. Some combination

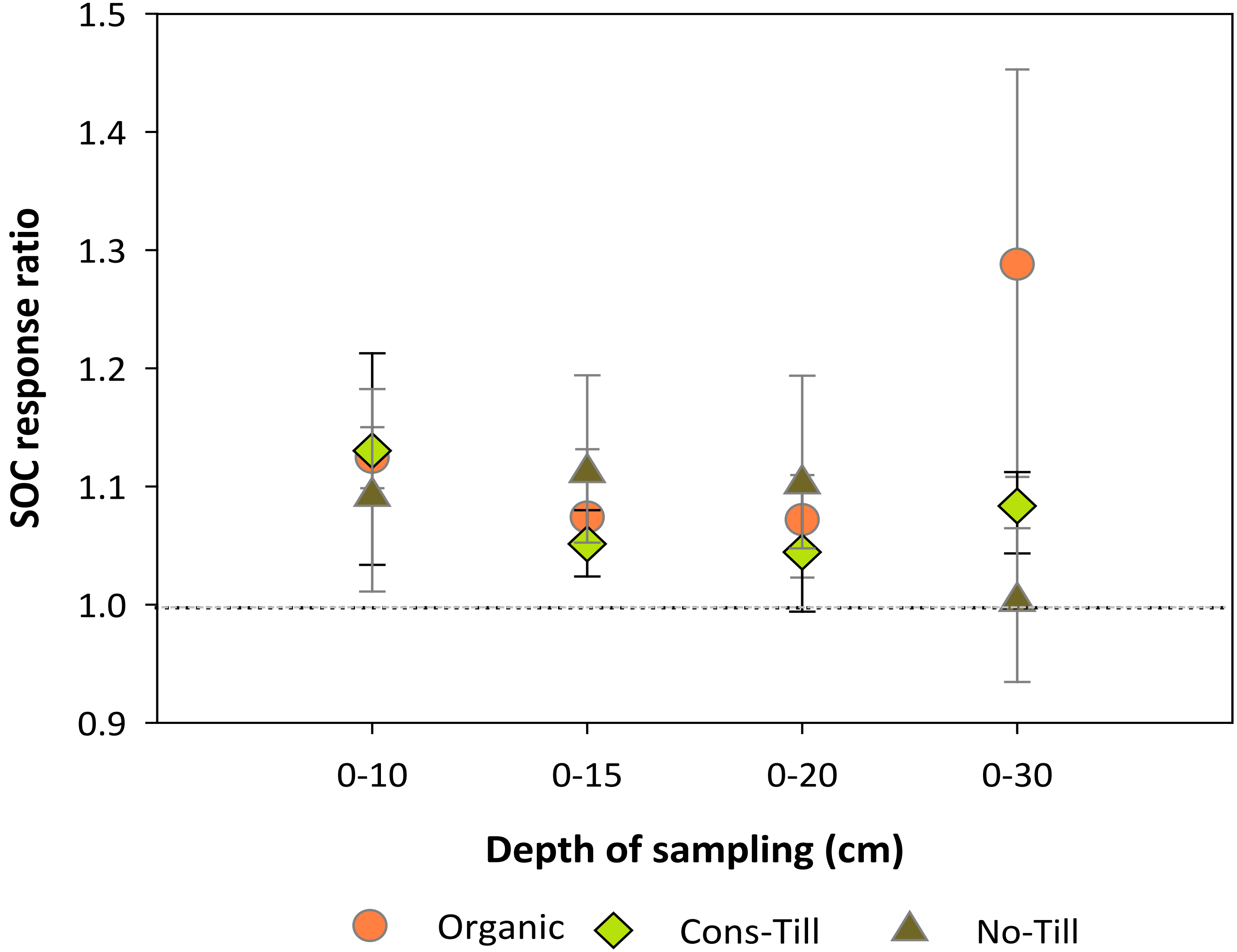
Treatment Pairs for Meta-Analysis

$$r = \frac{alternative\_practice}{conventional(control)}$$

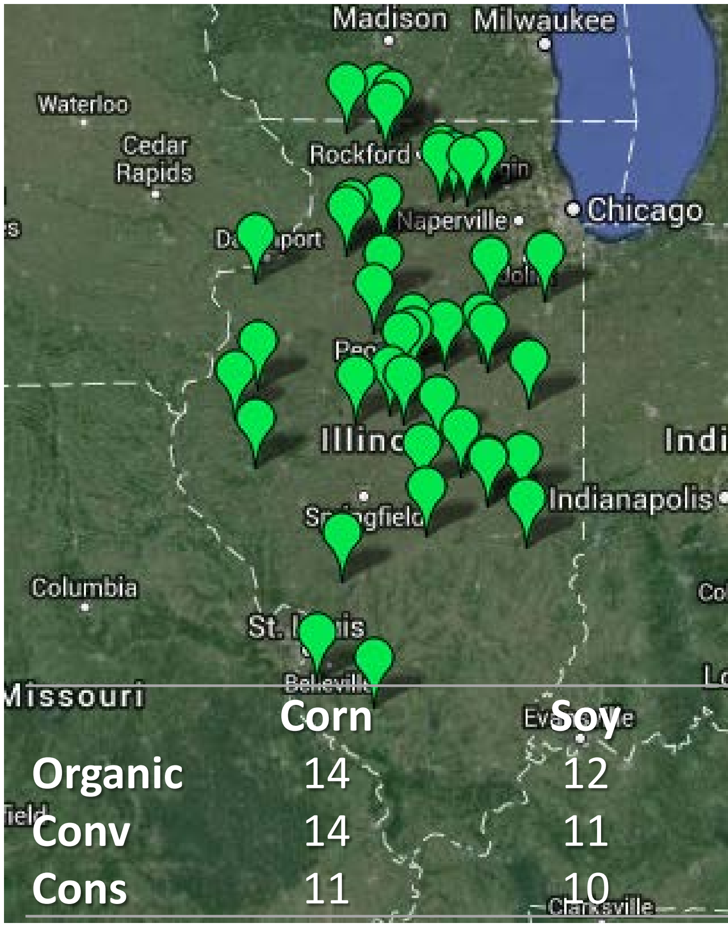
Ugarte et al 2014. Journal of Soil & Water Conservation

Management	Control	Treatment Practice
Cropping system	Conventional	-Organic -Conv. Cons-till -Conv. No-till
N source	Inorganic N	-Reduced inorganic fertilizer -Inorganic fertilizer+ cover crops -Manure -Manure + cover crops -Inorganic fertilizer + manure +cover crops -Cover crops only
Rotation length	1-yr	-2-yr -$\geq$3-yr

Soils Don't Lie



Comparison of Soil Stewardship 72 farms and 29 farmers



	Corn	Soy
Organic	14	12
Conv	14	11
Cons	11	10

Conventional	Conservation	Organic
Rotation length 1-yr or 2-yr rotation	2-yr rotation	>3-yr rotation
Sources of fertility Inorganic	Inorganic	Organic
Organic matter inputs Crop residues	Crop residues	Crop and cover crop residues and organic amendments
Tillage Heavy tillage alt yr	Reduced or non-tillage	Variable tillage followed by surface cultivation

Evaluation of Conservation Measurement Tool (CMT) and Century Model rankings for conventional, conservation till, and organic management through comparison of estimated (in italics) and measured properties (SOC is soil organic carbon, POM-C is particulate organic carbon, and SOC in active form is the percentage of SOC in POM).

		SOC (g kg-1 soil in top 6 inches)		Active SOM (g kg-1 in top 6 inches)		SOC in Active Form (% of total)	
Farming types	*CMT Soil Quality*	SOC	*Century Estimated*	POM-C	*Century Estimated*	POM/SOC (%)	*Century Estimated*
Organic	44.6	22.9b	22.6	2.48b	6.9	13.2	30.6
Conv	18.4	20.8a	20.7	2.06a	4.6	10.8	22.3
Cons	27.3	23.1b	23.0	2.32ab	6.9	12.3	30.1

Evaluation of Conservation Measurement Tool (CMT) and the DayCent Model rankings for conventional, conservation till, and organic management through comparison of estimated (in italics) and measured properties

	Air quality measures		Water quality measures	
Farming types	*CMT Air Quality*	*DayCent N_2O (g ha^{-1} yr^{-1})*	*CMT water Quality*	Bray P 6-12" (mg kg^{-1})
Organic	32.1	1021	49.6	13
Conventional	18.9	688	18.29	8
Conservation	28.7	675	36.02	10

Evaluation of Conservation Measurement Tool (CMT) plant productivity score and standard soil fertility measures for conventional, conservation till, and organic management through comparison of estimated (in italics) and measured properties.

	Soil fertility measures				
Farming types	*CMT Plant Productivity*	Plant avail N (mg kg^{-1})	Bray P top 6" (mg kg^{-1})	K (mg kg^{-1})	Ca/Mg ratio
Organic	51.86	53.8	27	191	5.76
Conv	28.17	68.9	33	202	5.85
Cons	32.24	69.8	30	259	5.50

Part 3. How do we get best practices into use?

Q3. What prevents farmers from being successful stewards?

1. Lack of information
2. Lack of motivation
3. Costs
4. Time
5. Lack of market

Business Orientation

Instrumental factors	Organic	Precision Conservation	Conventional
Certification	All	None	None
CRP	Many	Many	Some
CSP	Some	Many	Some
Crop insurance	Many	Many	All
Independent (anti gov program)	Several	Few	None
Carbon Sequestration Contracts	Some receptive	Many receptive	Some receptive
Sustainability Certification	Some receptive	Many receptive	Some receptive
Social/religious network	Critical	Important	Not central

Organic competes within the market it struggles

- Yield and price dynamics
- Land access, rental price and competition
- Shortened rotations
- Nitrogen supply- increasing use of N dense fertility sources
- Insufficient research support or investment in technology (improved cultivar development, decision support)

Acknowledgements

Farmers who are outstanding in their fields and…

- USDA-NIFA-ICGP-003218
  - Carmen Ugarte- co-PI
  - Eduardo Mendonca- Century modeling
  - Ed Zaborski- Farmer network
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  - eOrganic
  - Ellen Phillips, U of I Extension, Dave Miller, CEO of Iroquois Valley Farms, Jeff Schahczenski, NCAT Ag Policy and Funding Research Director, Sarah Brown, Oregon Tilth's Organic Conservation Program (OCP), Ryan Anderson Delta Institute, Dick Breckinridge, IL EPA

- Theory and practice underpinning soil management for organic and sustainable farming systems.
- Why and how soil health and its stewardship are the foundation of organic and sustainable production.
- Blended course draws on farmer and researcher strategies, data, and experiences and, uses farm case studies developed with support from Organic Valley and content developed for National eXtension's eOrganic.community of practice.

NRES 499 ESM for non-credit students
http://citl.illinois.edu/courses/section/120158/99972
•Cost: $500; Continuing education credits can be arranged upon request
NRES 499 XM1 for 3 credits degree or non-degree
http://citl.illinois.edu/courses/section/120158/65807
•Cost: undergraduate $1227 or graduate student $1356

8 Week online course

Oct 19-Dec 9, 2015

Tues 6:30 PM–8:30 PM

Staff Contacts
•Instructor: Michelle Wander| mwander@illinois.edu| (217) 333-9471
•CITL Program Director: Christine Martinez | cmartinz@illinois.edu | (217) 265-7595
•CITL Registration: Peggy Day | pcday@illinois.edu | (217) 244-2507

eOrganic Soil and Nutrient Management Resources at http://www.extension.org/organic_production

Publicly available, searchable collection of articles, videos, and webinars. All information is peer reviewed and checked for organic certification compliance.

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- Fertigation in Organic Vegetable Production Systems
- Legume Inoculation for Organic Farming Systems
- Making and Using Compost for Organic Farming
- Managing for Soil Organic Matter
- Managing Manure Fertilizers in Organic Systems
- Nutrient Budget Basics for Organic Farming Systems
- Nutrient Management Plans and Fit with Organic Systems Plan
- Organic Potting Mix Basics
- Organic Soil Fertility
- Soil Management for Better Fertility on Organic Livestock Farms
- Soil Microbial Nitrogen Cycling for Organic Farms

Soil and Nutrient Management Webinar Recordings

- Assessing Nitrogen Contribution and Rhizobia Diversity Associated with Winter Legume Cover Crops in Organic Systems
- The Evolution, Status, and Future of Organic No-Till in the Northeast US
- Estimating Plant-Available Nitrogen Contribution from Cover Crops
- Nutrient Management in Organic Systems
- Planning for Flexibility in Effective Crop Rotations
- Putting the Pieces Together: Lessons Learned from a Reduced-Tillage Organic Cropping Systems Project
- Researcher and Farmer Innovation to Increase Nitrogen Cycling on Organic Farms
- Root Media and Fertility Management for Organic Transplants
- Rotational No-till and Mulching Systems for Organic Vegetable Farms
- Soil Fertility Management in Organic Grain Cropping Systems
- Soil Fertility Management in Organic Wheat Production
- Undercover Nutrient Investigation: The Effects of Mulch on Nutrients for Blueberry

Available at http://www.extension.org/pages/25242 and
on YouTube at https://www.youtube.com/user/eOrganic

eXtension

eOrganic

Videos about Soil and Nutrient Management Research at http://www.extension.org/pages/18726 and on YouTube at https://www.youtube.com/user/eOrganic

- Vegetable Farmers and their Sustainable Tillage Practices Video Series
- Vegetable Farmers and their Innovative Cover Cropping Techniques Video Series
- Using Sheep to Terminate Cover Crops in Organic Farming
- Weed Em and Reap Part 2: Reduced Tillage Strategies for Vegetable Cropping Systems Video Series

Oregon Tilth

Resources

- Online library of publications, articles, FAQs, guides and more

Newsletter Sign-up

- Keep up-to-date on stories and resources

Events/Webinars

- Calendar for 2015

http://tilth.org/