Lessons Learned from the Reduced-tillage Organic Systems Experiment

W.S. Curran, J.M. Wallace, R. Hoover
Pennsylvania State University

Reduced-tillage Organic Systems Experiment (ROSE)

Penn State
Mary Barbercheck, Alan Cook, Bill Curran, Mark Dempsey, Scott Harkcom, Jay Harper, Ron Hoover, Clair Keene, Christy Mullen, Ariel Rivers, Dave Sandy, John Wallace
USDA-Beltsville, Maryland
Steven Mirsky, Lauren Young, Don Weber, Ruth Mangum, Betty Morose
University of Delaware
Mark VanGessel, Barb Scott, Quintin Johnson
Cornell University
Matt Ryan
North Carolina State University
Chris Reberg-Horton
Organic Farmers
Elvin Ranck & Kirby Reichert (PA)
Aaron Cooper & Eddie Taylor (MD)
Rob Foscue, Ben & Kenny Haines (NC)
Oregon State University
Alex Stone, John McQueen
PSU Cooperative Extension
Greg Hostetter, Del Voight
Funding Agency
USDA OREI Award No. 2009-51300-05656

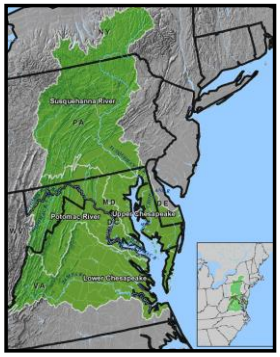
Outline

- Rationale
- Objectives & Methods
- Expectations & Results On-Station
- Expectations & Results On-Farm
- Summary & Recommendations

Reducing Tillage in Mid-Atlantic Region

Regional perspective

- Important watershed with historical problems
- Diverse agriculture
- High density animal agriculture
- No-till enthusiasm
- Lots of interest in cover crops and some adoption
- Incentive programs for no-till and cover crops
- Interest in sustainable and organic agriculture



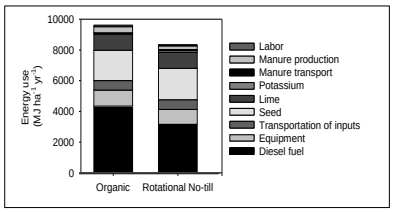
The role of tillage in organic grain production

- Backbone of weed control
  - Primary tillage for perennials
  - Mechanical control of annuals
- Incorporate fertility sources
- Control insects and diseases
- Terminate perennials and green manure cover crops

Reducing tillage in organic grain crops

Potential Benefits

- Protect soil against erosion/loss in quality
- Reduce labor and energy use; reduced costs

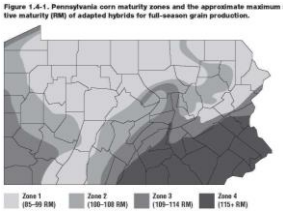


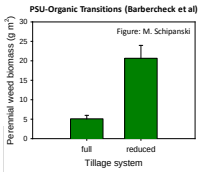
Mirsky, SB, MR Ryan, WS Curran, JR Teasdale, J Maul, JT Spargo, J Moyer, AM Grantham, D Weber, T Way, and G Camargo. 2012. Tillage issues: Cover crop-based organic rotational no-till grain production in the Mid-Atlantic region. *Renewable Agriculture and Food Systems.* 27(1): 31-40.

Reducing tillage in organic grain crops

Potential Barriers

- Growing season length
- Maintaining good weed control
- Insect and invertebrate pests





Approaches to reducing tillage in organic systems

- Continuous no-till not realistic at this time
- Rotational tillage or reduced tillage
  - Use perennial crops in the rotation (ex. Alfalfa)
  - Reduce tillage intensity (chisel vs. moldboard plow)
  - ***Reduce tillage frequency (cover crops & cultural practices)***

Roller Crimper Technology

Cover crop termination & No-till Cash Crop Planting

Mirsky, S., W.S. Curran, M. Ryan (2005) Effects of Planting and Termination Date on Cover Crop Biomass and Subsequent Weed Suppression Using Roller-Crimper Technology. The Pennsylvania State University

PENNSTATE
Department of Crop and Soil Sciences
Weed and Agroecology Lab

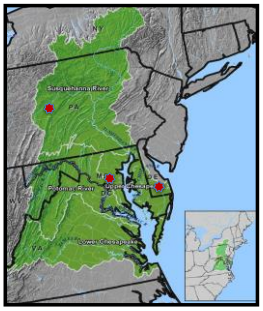
Reduced-tillage Organic Systems Experiment (ROSE)
Objectives

- Test feasibility of organic rotational no-till management in **systems experiment**
- Determine if manipulating the timing of cover crop termination/ cash crop planting is a viable weed and insect pest management tool
- Evaluate suitability of the ROSE rotation across the Mid-Atlantic region

Research funding: USDA OREI Award No. 2009-51300-05656 USDA-NIFA-ICGP-002796

Reduced-tillage Organic Systems Experiment (ROSE)
Methods

- **Design:** Full entry cropping systems experiment from 2010 to 2013.
- **Replicated at 3 sites**:
  State College, PA (3050 GDD)
  Beltsville, MD (3650 GDD)
  Georgetown, DE (4350 GDD)
- **On farm trials**:
  Pennsylvania
  Maryland
  North Carolina



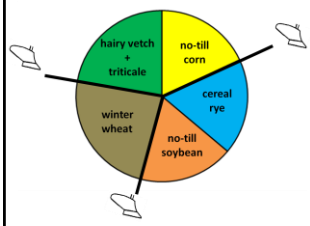
ROSE System: 3-Year Rotation
corn-soybean-wheat

No-till corn into rolled hairy vetch + triticale

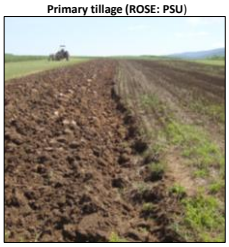
No-till soybean into rolled cereal rye

ROSE System: Primary tillage

moldboard plow (3 events within 3 year rotation)

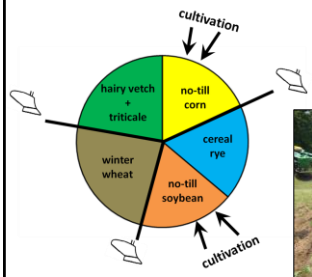


Primary tillage (ROSE: PSU)



ROSE System: Supplemental tillage

high-residue cultivation (4 events within 3 year rotation)



Inter-row high residue cultivation in corn

ROSE: Experimental Treatments

Cover crop termination & cash crop planting date (3 planting dates)

- **Treatment**: Planting date (early, middle, late); corn & soybean only
- Cover crops terminated at (corn) or prior to (soybean) cash crop planting
- Planting dates spaced about 1 wk apart

(L) late planting date; (R) early planting date at PSU (2011)

ROSE: Experimental Treatments

Supplemental Weed Control with High Residue Cultivator

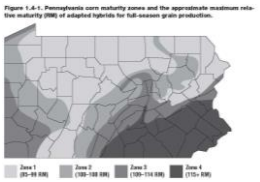
- **Treatment**: high residue cultivation vs. none
- High residue cultivation conducted twice per crop season in corn and soybeans
- Corn and soybeans planted in 30" rows (non cultivated soybean in 15" rows)


ROSE: Experimental Treatments

Standard variety vs. variety varied with planting date

- **Treatment**: Variety Type (standard vs. variable)
- Variable variety matches maturity group with variable season length for planting date treatments.

Crop	Site	Planting Date	Maturity (day /group)
Corn	DE MD	Early	104
		Middle	96
		Late	85
	PA	Early	100
		Middle	95
		Late	85
Soybean	DE MD	Early	3.8
		Middle	3.4
		Late	2.7
	PA	Early	2.9
		Middle	2.7
		Late	1.1



Things don't always go as planned

EXPECTATIONS & RESULTS

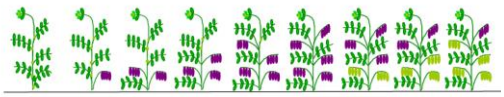
Expectation #1

Cover crop termination timing

Expectation: The window for effective cover crop termination using the roller crimper is sufficiently wide to enable delayed cash crop planting.

Hairy vetch termination

Optimal termination timing at flowering (Mischler et al. 2010)



Vegetative 1	20% Flower 2	40% Flower 3	60% Flower 4	80% Flower 5	100% Flower 6	Early Pod Set 7	Mid Pod Set 8	Late Pod Set 9

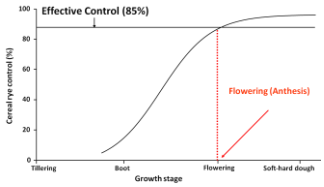
- Vegetative (1): no flower buds
- Early pod set (7): when 1-2 pods
- Late pod set (9): when 4+ pods

Consistent control with roller-crimper

Mischler, R., Duiker, S. W., Curran, W. S., and Wilson, D. 2010. Hairy Vetch Management for No-Till Organic Corn Production. Agronomy Journal 102: 355-362.

Cereal rye termination

Optimal termination timing post-anthesis (Mirsky et al. 2009)



Mirsky, S.B., W.S. Curran, D.A. Mortensen, M.R. Ryan, and D.L. Shumway. 2009. Control of cereal rye with a roller-crimper as influenced by cover crop phenology. Agron. J. 101:1589-1596.

Expectation #1

Results

- 2011: one pass was not enough
- 2012 & 2013: two passes improved control
- We have a narrow window in which to control with a roller-crimper without producing volunteer cover crop
- You may have to be able to live with a few volunteers

Cover crop termination

Hairy vetch (PSU 2011)

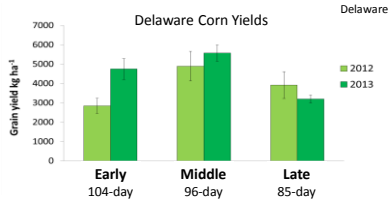
Cover crop termination

Cereal Rye (PSU 2011)

Cover crop termination

Hairy vetch effect on corn yield

Delaware Early Corn (2012)



Expectation #2

No-till planting into high-residue

Expectation: Standard no-till equipment is sufficient for establishing cash crops.

Expectation #2

Results

- Specialized no-till equipment can be necessary for this much residue
- Difficult to slice through residue – too dry
- Lack of seed furrow closure - too wet
- Poor seed to soil contact reduced corn and soybean populations

Crop Populations

Effect of cover crop biomass

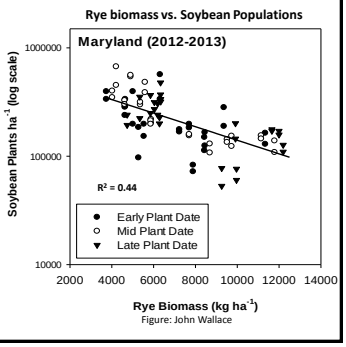
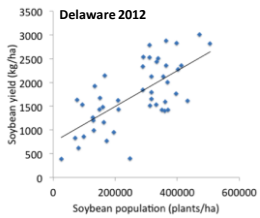


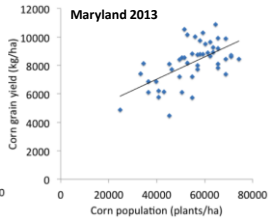
Figure: John Wallace

Crop Populations

Effect of poor population stands on crop yield

Crop Yields: Consistent crop yields were limited by factors related to poor crop establishment in high cover crop residue environments.





No-till planting into high residue

Equipment adjustments

Weight needed for seed placement

Coulter Type

Wave **Ripple**

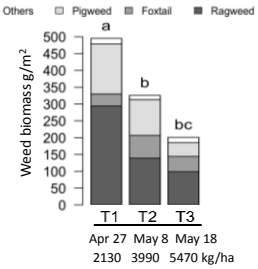
Closing wheel adjustments

Full-till VS. **No-till**

Expectation #3

Physical suppression of summer annuals by cover crops

Expectation: Weed suppression will increase with delayed planting date



Nord et al. (2012) Effects of management type and timing on weed suppression in soybean no-till planted into rolled-crimped cereal rye. Weed Sci. 60:624-633.

Expectation #3

Results

- Cover crop biomass accumulation did not increase linearly with delay in planting date – already near the peak at termination 1
- No consistent trend between cover crop biomass and weed abundance or biomass
- Weed biomass was also influenced by cover crop regrowth, cover crop volunteers, and cash crop populations

Expectation #4

Supplemental weed control with high residue cultivation

Expectation: Supplemental weed control will be necessary to maintain high levels of weed control

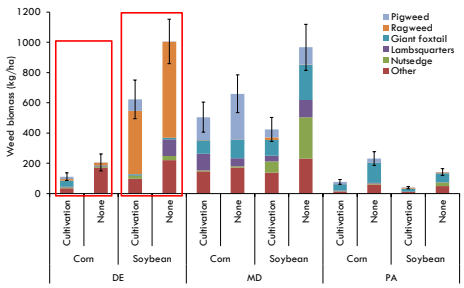
Expectation #4

Results

- Shallow high-residue cultivator very effective at reducing weed biomass
- Improved yields where weed competition high (Delaware)
- Was not necessary where weed competition low (Pennsylvania) and can hurt soybean yield

High Residue Cultivation

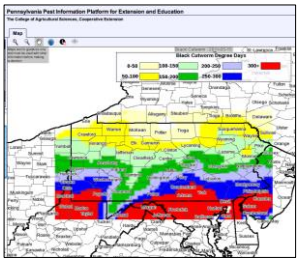
Treatment effect on weed biomass



Expectation #5

Pest avoidance

Expectation: Delaying planting date will decrease crop injury related to early season insect pests (ex: black cutworm)



Expectation #4
Results

- Bio-control services increased as planting was delayed
- Pests never reached damaging levels (PA)
- Predation increased each year of organic management

True Armyworm

Variegated Cutworm

Pitfall trap

Emergence trap

Predators & Herbivores
PSU (2011-2012)

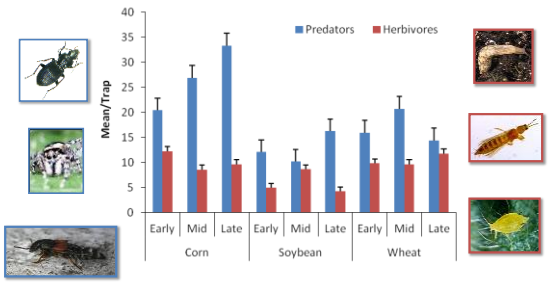


Figure: Mary Barbercheck

Predators in wheat
Predation levels over time (PSU: 2011-2013)

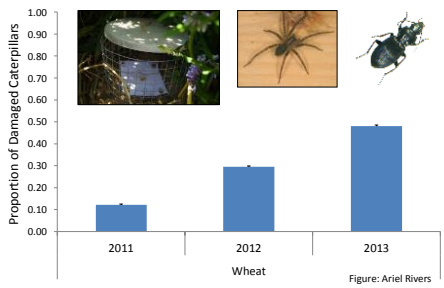
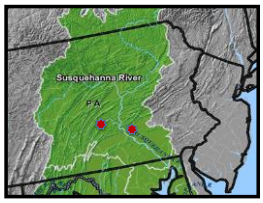


Figure: Ariel Rivers

On-Farm Projects in PA in Support of ROSE concepts

overview

- **Implement ideas from ROSE with appeal to farmers on larger plots (0.1-0.2 ac/plot)**
- **Design:** Randomized Complete Block
  1) Conventional organic (full tillage)
  2) Roll cover crop, no-till plant soy or corn
  - 4 replicates
- **Replicated at 3 sites**:
  Ranck farm (Mifflin, SC PA)
  Reichert farm (Hershey, SE PA)
- **3 years at each farm (2010-2013)**:



Expectations for On-Farm Research

Expectation # 2: No-till planting into high-residue

Expectation: Standard no-till equipment is sufficient for establishing cash crops.
On-Farm: Planters were good for no-till if conditions were NOT challenging:
- Excessive amounts of rolled cover crop to slice through
- Cover crop "blown down" and not rolled in an organized fashion

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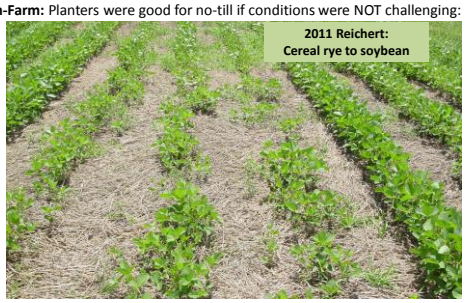

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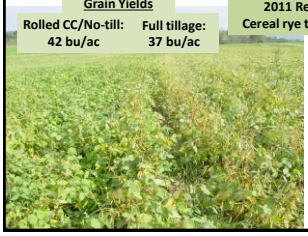
- Excessive amounts of rolled cover crop to slice through
- Cover crop "blown down" and not rolled in an organized fashion

Grain Yields
Rolled CC/No-till: 42 bu/ac **Full tillage: 37 bu/ac**



2011 Reichert: Cereal rye to soybean

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2012-2013 Ranck: Hairy vetch, crimson clover, triticale to corn

3 October 2012

4 May 2013

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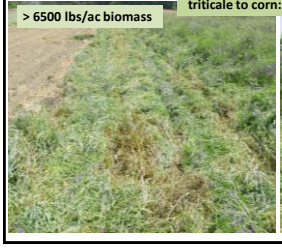
2013 Ranck: Hairy vetch, crimson clover, triticale to corn: 5 June 2013

> 6500 lbs/ac biomass



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Grain Yields
Rolled CC/No-till: 119 bu/ac **Full Tillage: 137 bu/ac**

2013 Ranck: Hairy vetch, crimson clover, triticale to corn: 31 July 2013

Expectations for On-Farm Research

Expectation # 3: Weed suppression with rolled cover crops

Expectation: Heavy cover crops, to provide season-long mulch, are possible.
On-Farm: Planting cover crop early enough, WITH enough fertility to result in adequate biomass, can be a challenge.

2013 Reichert: Cereal rye to soybean

Rye drilled mid-November N fertility insufficient

Planted into standing rye followed by rolling/crimping

Expectations for On-Farm Research

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Expectation: Heavy cover crops, to provide season-long mulch, are possible.
On-Farm: Planting cover crop early enough, WITH enough fertility to result in adequate biomass, can be a challenge.

2013 Reichert: Cereal rye to soybean

Rye cover crop too light (3-4000 lbs/ac)

Expectations for On-Farm Research

Expectation # 6: No-till drills capability similar to that of planters

Expectation: Today's heavy drills can get seed where we want it.

On-Farm: Not enough weight per opener to penetrate; without specially modified closing wheels, closing furrow under residue mat extremely challenging.

2012 Reichert:
Cereal rye to soybean

Moderate rye cover (4-5000 lbs/ac) no-till drill not able to cut residue AND close furrow

Summary of Results

ROSE (2010-2013)

- **Crop Yields**: Crop yield was variable across years and sites, but acceptable yields can be achieved:
  - **Soybean**: 70 bu/ac (MD 2011)
  - **Corn Grain**: 140 bu/ac (MD 2011)
  - **Corn Silage**: 18 ton/ac (PA 2013)
- **Insect pest management**: Beneficial insects respond positively to organic management and increase pest-suppression services
- **Weed management**: 1) perennials did not become a problem in 3 years but supplemental control necessary where annual weed density is high; 2) starting with a clean field will maximize the probability of being able to maintain good annual weed control

Recommendations for the Northeastern US

ROSE (2010-2013)

- **Hairy vetch-triticale and cereal rye cover crops**
  - Can effectively control weeds in corn and soybean, but have great potential to become a weed if timing of termination relative to crop maturity is not aligned
  - Double rolling cover crops improved kill and decreased volunteers
- **No-till planting corn and soybean**
  - Adjust equipment to ensure planter is slicing through residue, penetrating the soil, and achieving good seed-to-soil contact
- **High-residue cultivation**
  - Effective back-up if weeds break though mulch and canopy, but also has potential to reduce crop population and yield, especially in soybean
- **Other management lessons**
  - Corn silage rather than grain necessary in PA for rye establishment, whereas fewer concerns about timing in MD and DE
  - Large difference in organic corn varieties, pays to have good genetics and crop maturity appropriate for the timing of planting
  - Planting corn late = less yield (go figure!)

THANK YOU

QUESTIONS?

For more information, visit our webpage:
http://agsci.psu.edu/organic/research-and-extension/rotational-no-till

Or contact:
Bill Curran (wcurran@psu.edu)

Question 1

- What region of the US do you work in?
  - Northeast
  - Southeast
  - Northern corn belt
  - Southern corn belt
  - High plains
  - Pacific Northwest
  - California (West Coast)
  - Other _____

Question 2

- What experience do you have with organic no-till?
  - I have never tried it
  - I have a small amount of experience with it (3 times or less)
  - I have a moderate amount of experience with it (more than 3 times)
  - I have a lot of experience with this technique