Lessons Learned from the Reduced-tillage Organic Systems Experiment
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Reduced-tillage Organic Systems Experiment (ROSE)

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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

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
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. 2009-51300-05266 USDA-NIFA-ICGP-002796

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)**

**ROSE System: Supplemental tillage**

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

**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**
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)

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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.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Site</th>
<th>Planting Date</th>
<th>Maturity (day/group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>DE</td>
<td>Early</td>
<td>104</td>
</tr>
<tr>
<td></td>
<td>MD</td>
<td>Middle</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Late</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>MA</td>
<td>Early</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Late</td>
<td>85</td>
</tr>
<tr>
<td>Soybean</td>
<td>DE</td>
<td>Early</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>MD</td>
<td>Middle</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Late</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>MA</td>
<td>Middle</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Late</td>
<td>1.1</td>
</tr>
</tbody>
</table>

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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)

Cereal rye termination
Optimal termination timing post-anthesis (Minsky et al. 2009)
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 Corn Yields

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early 104-day</td>
<td>5000</td>
<td>5500</td>
</tr>
<tr>
<td>Middle 96-day</td>
<td>4500</td>
<td>5000</td>
</tr>
<tr>
<td>Late 85-day</td>
<td>4000</td>
<td>4500</td>
</tr>
</tbody>
</table>

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

Rye biomass vs. Soybean Populations
Maryland (2012-2013)

\[ R^2 = 0.44 \]

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

![Graph showing weed biomass with different planting dates](image)


• Cover crop biomass accumulation did not increase linearly with delay in planting date – already near the peak at termination 3

• 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

![Image of supplemental weed control equipment](image)
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

Predators & Herbivores
PSU (2011-2012)

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

2011 Reichert:
Cereal rye to soybean

6000 lbs/ac biomass
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

Rolling CC/No-till:
- **2011 Reichert:** Cereal rye to soybean

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

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

- 3 October 2012
- 4 May 2013

Grain Yields:
- Greater than 6500 lbs/ac biomass

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

<table>
<thead>
<tr>
<th>Grain Yields</th>
<th>2013 Ranck: Hairy vetch, crimson clover, triticale to corn: 31 July 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolled CC/No-till:</td>
<td>119 bu/ac</td>
</tr>
<tr>
<td>Full Tillage:</td>
<td>137 bu/ac</td>
</tr>
</tbody>
</table>

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

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

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

- 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 |

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**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

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**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