Agronomic and Environmental Assessment of Cover Crops in Illinois

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Outline

Why to include cover crops?

What we hear and what we know

Objectives

Materials & Methods

Activities to date at RCs and farm sites

Challenges

Preliminary results

Next steps
Cover crops?

A crop planted between periods of regular cash crop
Why include CC?

- Soil erosion control
- Nutrient cycling
  - Water quality
  - Air quality
- Improvement of soil properties
Why include CC?

Dry season
Nitrate-N build up

Wet season
Nitrate-N flushed
Why include CC?

- Dry season: Nitrate-N build up
- Wet season: Nitrate-N uptake by cover crop
- Planting: Residue decomposition provides N to following crop
Why include CC?

- Improvement of Soil Properties
  - KEY to SUSTAINABILITY
Residues added to soil

Primary effects
- Protect soil surface
- Loosen soil: macropores, channels
- Food source for microbes and fauna

Secondary effects
- Enhances microbial functions
- Production of humic substances
- Production of polysaccharides and other compounds

Subsequent effects on soil system
- > Nutrient retention and availability
- > Water holding capacity
- Production of macropores and burrows
- > Aggregate stability
- > Buffering capacity
- Less fertilizer needed
- Better aeration, $O_2$ supply to roots
- > Water infiltration
- Less surface runoff
- > Water availability
- Less soil erosion
- Greater plant production
Why include CC?

Residues + root activities → Soil organic matter → Soil structure → Nutrients → Crop production → Environmental benefits

Great variability due to environment & management
Importance

- Issues such as increasing population and gulf hypoxia make the intelligent management of farms increasingly more important, and cover cropping may be a way of maximizing fertilizer efficiency and increasing yields…
Newest addition to CP

Cover Crops have been adopted as a cost-share conservation program with USDA-NRCS

- Reimbursement to cover seed and seeding
Governor Quinn Launches Statewide Cover Crop Demonstration Project
Initiative Aims to Improve Water Quality, Control Erosion and Increase Yields

SPRINGFIELD – Governor Pat Quinn today announced the start of a three-year demonstration project by the Illinois Department of Agriculture to encourage the planting of environmentally-beneficial cover crops. The initiative’s goal is to improve water quality in Illinois lakes and streams by reducing soil erosion and nutrient run-off from farm fields. Today’s action is part of Governor Quinn’s agenda to protect the state’s natural resources and ensure a clean and healthy environment for future generations, while boosting Illinois agriculture.

“Helping is a leading agricultural state because of its ability to adopt sustainable farming practices that protect our valuable soil and water resources without sacrificing productivity,” Governor Quinn said. “This project is a good example of the industry’s commitment to our environment.”

“The time is right for this initiative,” Steve Chad, the Department of Agriculture’s bureau chief of Land and Water Resources, added. “New plant varieties and new production techniques have been discovered that eliminate many of the problems that farmers who planted cover crops in the 1990s and 90s experienced.”

Cover crops are plants seeded into agricultural fields, either within or outside of the regular growing season, with the primary purpose of improving or maintaining ecosystem quality. Cover crops, typically certain grasses or legumes, can enhance biodiversity; lead to less flooding, washing, and runoff; create wildlife habitat; attract honey bees and other beneficial insects; improve soil quality; combat weeds; and break disease cycles. Cover crops appear to have a significant competitive advantage compared to the more traditional management practices that have been used to control soil erosion and nutrient run-off.

“Recent studies have shown that growing cover crops during the dormant season between annual row crops can provide the same environmental benefits on more acres for significantly less cost than practices like grassed waterways and terraces can,” Chad said.

Cover crops also may offer production benefits. A survey of Midwestern farmers last winter by USDA’s Sustainable Agriculture Research and Education (SARE) Program revealed higher corn and bean yields in fields where cover crops had been planted. The differences were significant: 10 percent for corn and 12 percent for beans.

Farmers are planting more cover crops across, according to the survey. The total has increased each of the past five years, from an average of 116 acres in 2008 to 421 in 2011.

The department’s demonstration project will attempt to capitalize on this renewed interest in cover crops and increase their adoption. Beginning this fall, 14 plots throughout the state will be planted in such crops either by aerial seeding into a standing crop of corn or soybeans or by drilling a cover crop seed mix into the soil after harvest. All of the plots are located adjacent to an interstate or state highway and were specifically chosen because of their high visibility.

Signs at each of the plots will direct passers-by to covercrops.illinois.gov, a website established as a “one-stop shop” for information about cover crops. The site will include a link to the Midwest Cover Crops Decision Tool, an interactive resource that provides specific information on which varieties of cover crops are best suited to meet a grower’s objectives as well as the best dates for planting and management advice.

“The department encourages farmers to use the latest, best management practices in their operations,” the Department of Agriculture’s Laura Sessa, division manager of Natural Resources for the department, said. “Best management practices are farming methods that assure optimum plant growth and minimize adverse environmental effects. Improving overall nutrient utilization is a key element in improving yields and profitability for farmers.”

Partners in the project include local Soil and Water Conservation Districts and the USDA Natural Resources Conservation Service.

www.illinois.edu
There’s a selection tool...

- [http://mcccdev.anr.msu.edu/VertIndex.php](http://mcccdev.anr.msu.edu/VertIndex.php)
A survey of Midwestern farmers last winter by USDA's Sustainable Agriculture Research and Education (SARE) Program revealed higher corn and bean yields in fields where cover crops had been planted. The differences were significant, too, 10% for corn and 12% for beans.

Farmers are planting more cover crop acres, according to the survey. The total has increased each of the past five years, from an average of 116 acres in 2008 to 421 in 2013.
But...

THIS WE KNOW FROM RESEARCH...
CC effects on corn yield (Miguez & Bollero 2005)

Fig. 3. Mean response ratio [yield of corn following winter cover crops/yield of corn following no cover (RR)] and 95% confidence interval (horizontal bars) for the three levels of winter cover crop (WCC).
CC effects on Yield  (Miguez & Bollero 2005)

Observations
ECAN (24)
NCE (11)
SE (83)
NE (39)
NW (5)
CC effects on soils (Villamil et al. 2006; 2008)

- No till systems including CC of hairy vetch or mixtures vetch and rye have more soil organic matter (SOM), water aggregate stability (WAS), plant available water, and less available P and N

✓ After 7 years of treatments
CC effects on soils and yield  
(Acuna & Villamil, 2014)

Daikon Radish    Buckwheat    Triticale    Hairy vetch    Rye
CC effects on soils and yield  (Acuna & Villamil, 2014)

- Conventional system, soybean crop
- Short term effects evaluated
  - After 1 cover crop season - 2 fields 2 years
    - Soil properties – no change except for available N
    - Yields – not different from controls
In Illinois?

- Marginal area for CC
  - Shorter growing season
  - Narrow window for plant growth in the fall
    - Less biomass accumulation & associated benefits
  - Spring growth generally suppressed
    - Less biomass accumulation & associated benefits

- Use of tillage could negate the benefits from cover crops
  - Or not...
Importance

- Adoption remains low:
  - Cover Cropping practices have not picked up by most (~90%) local corn-soybean rotation farmers (Singer et al 2007)
Objectives

- Develop a comprehensive set of trials to look at effects of cover crops in both on-farm and on-station sites
- Measure the effect of cover crops in scavenging N
- Evaluate the effect of cover crops on commercial crop yields and on economic returns
- Evaluate the effect of tillage on crop and soil responses to cover crops
**Cover Crops**

**Daikon radish (Raphanus sativus)**
- Improved soil aeration
- Overall pest control
- Nutrient capture

**Hairy Vetch (Vicia villosa)**
- Soil improvement
- Nitrogen fixation
- Weed suppression

**Cereal Rye (Secale cereale)**
- Nutrient capture
- Erosion control
- Good in mixtures

**Annual Ryegrass (Lolium multiflorum)**
- Nutrient capture
- Erosion control
- Weed/nematode control

**Rapeseed (Brassica napus)**
- Subsoil improvement
- Deep nutrient capture
- *Weed/Nematode control

**Red Clover (Trifolium pratense)**
- *Improving soil stability and WHC
- *Nitrogen fixation
- *Weed suppression

**Spring Oats (Avena sativa)**
- *Nutrient capture
- *Weed suppression
# Materials & Methods

## Experimental Design

### Cover Crop After Corn Harvest (Before Soybean Planting)

- **Rep 1**: None<br>  - 20-ft alley, planted<br>  - 40-foot cross-alley, planted
- **Rep 2**: Spring oats<br>  - 20-ft alley, planted<br>  - 40-foot cross-alley, planted
- **Rep 3**: None<br>  - 20-ft alley, planted
- **Rep 4**: Radish<br>  - 20-ft alley, planted

### Cover Crop After Soybean Harvest (Before Corn Planting)

- **Rep 1**: None<br>  - 20-ft alley, planted<br>  - 40-foot cross-alley, planted
- **Rep 2**: Radish<br>  - 20-ft alley, planted<br>  - 40-foot cross-alley, planted
- **Rep 3**: Spring tillage done before planting.<br>  - 20-ft alley, planted<br>  - 40-foot cross-alley, planted
- **Rep 4**: None<br>  - 20-ft alley, planted<br>  - 40-foot cross-alley, planted

### Crop that follows CC

- **Corn**: Canola, Clover, Hairy vetch, None, Radish, Ryegrass
- **Soybean**: Canola, Clover, Hairy vetch, None, Radish, Ryegrass

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↑Should cross-plant 10 ft of crop here (in each block) to divide tillage treatments.

↓Good to cross-plant 10 ft on outside ends of each block.
Materials & Methods

- **Experimental Design**
  - Split block design of factors tillage and cover crops with 4 reps
  - Nested within crops and locations
    - Established at 4 research centers in fall 2012
    - Established at 2 sites in Southern Illinois in 2013
      - Dixon Springs UI and SIU Carbondale

- **Statistical Analysis**
  - Mixed procedure in SAS 9.3
    - When several depths, repeated measures approach with an autoregressive model for the variance-covariance matrix of the residuals
Materials & Methods

- At farm sites:
  - One cover crop of choice compared with no cover; 4 reps on either corn or soybean fields
  - 10 sites established in fall 2013

Possible layout for on-farm (farmer fields) cover crop trials

PLOT

Strip of cover crop 40 ft or so wide at the edge of field

1. 30 ft x 400 ft
   - Cover crop
   - Rep 1

2. 30 ft x 400 ft
   - Control

3. 30 ft x 400 ft
   - Control
   - Rep 2

4. 43 ft x 400 ft
   - Cover crop

5. 43 ft x 400 ft
   - Cover crop
   - Rep 3

6. 34 ft x 400 ft
   - Control

7. 34 ft x 400 ft
   - Control
   - Rep 4

8. 30 ft x 400 ft
   - Cover crop

Rest of field planted to cover crop.

At farm sites:

- One cover crop of choice compared with no cover; 4 reps on either corn or soybean fields
- 10 sites established in fall 2013
Materials & Methods

- At Research sites

  ✓ Fall 2012
  - 4 sites established
  - Cover crop hand seeded following harvest of cash crops
    - Between 9/9 – 10/15 at all sites
    - Seeding rates followed MCCC recommendations
  - Soils sampled up to 3ft for full characterization of research sites

<table>
<thead>
<tr>
<th>Cover crop</th>
<th>Seeding rate (lbs/acre)</th>
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<tbody>
<tr>
<td>Cereal rye</td>
<td>90</td>
</tr>
<tr>
<td>Spring oats</td>
<td>60</td>
</tr>
<tr>
<td>Clovers and hairy vetch</td>
<td>20</td>
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<tr>
<td>Ryegrass</td>
<td>15</td>
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<td>Radish</td>
<td>8</td>
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<tr>
<td>Canola (rape)</td>
<td>5</td>
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</tbody>
</table>
Materials & Methods

- At Research sites
  - Spring 2013
    - Biomass sampling of overwintering cover crops and weeds
    - Soil sampling and determination of available N up to 3ft
    - Cash crop planting
  - Challenges:
    - Spring operations were all delayed by frequent rain in Apr and May 2013 preventing deep soil sampling at one of the RCs and all soil sampling at another
    - Late planting
Materials & Methods

- At Research sites

  ✓ Summer - fall 2013
    - 2 additional sites established in southern IL
    - Cover crop hand seeded on standing crops
      - Seeding rates and dates followed MCCC recommendations
      - 2\textsuperscript{nd} - 3\textsuperscript{rd} week of Sept at all sites
    - Soils sampled up to 3ft for
      - Full characterization at new sites
      - Available N at established sites
    - Cash crop harvested
      - Yields recorded

  ✓ More challenges
Materials & Methods

At farm sites

- 10 sites established in fall 2013
  - Cover crop aerially seeded following MCCC recommendations
  - Detailed agronomic information collected for each site
  - GPS coordinates for revisiting and sampling
  - Soils sampled up to 3ft for full characterization of farm sites

- Recruitment of collaborating farmers continues
## Results

### Fall 2012 Characterization of sites

<table>
<thead>
<tr>
<th>Soil property</th>
<th>Depth</th>
<th>Crop 2012</th>
<th>SE</th>
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<td></td>
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<td>soybean</td>
<td>corn</td>
</tr>
<tr>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>3</td>
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<tr>
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<td>2</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>1.6</td>
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<tr>
<td>CEC</td>
<td>meq/100gr</td>
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<tr>
<td></td>
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Results

Tillage effect on SOM

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<td>475</td>
<td>0.6</td>
<td>0.6649</td>
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Fall 2012 Characterization of sites
Results

Fall 2012 Characterization of sites

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Fall 2012 Soil Nitrate-N

Soil Nitrate-N (ppm)

Depth (ft)

Soil Nitrate-N (ppm)

0 2 4 6 8 10

0

1

2

3 corn

soybean

www.illinois.edu
## Results

<table>
<thead>
<tr>
<th>Crop 2012</th>
<th>Cover crop</th>
<th>n</th>
<th>Biomass (gr/m²)</th>
<th>Mean</th>
<th>SE</th>
<th>CV</th>
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<td>0</td>
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<td></td>
<td>hvetch</td>
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<td>87</td>
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<td>77</td>
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<td>60</td>
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<tr>
<td>corn</td>
<td>rape</td>
<td>6</td>
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<tr>
<td></td>
<td>rye</td>
<td>23</td>
<td></td>
<td>145</td>
<td>31</td>
<td>102</td>
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<tr>
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<td>ryegrass</td>
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<td>59</td>
<td>12</td>
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Results

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<td>262</td>
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</tr>
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<td>262</td>
<td>4.76</td>
<td>&lt;.0001</td>
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<tr>
<td>till*cover(crop)</td>
<td>10</td>
<td>262</td>
<td>0.91</td>
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<td>481</td>
<td>0.52</td>
<td>0.9583</td>
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</table>

Spring 2013 Characterization of sites

Spring Soil Nitrate-N

Cover crop
- hvetch
- cclover
- spoats
- ryegass
- rye
- rape
- radish
- Control

Soil Nitrate-N (ppm)

Corn
Soybean
Results

Tillage effect on soil nitrate-N

<table>
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Spring 2013 Characterization of sites
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<td>10</td>
<td>149</td>
<td>0.83</td>
<td>0.5983</td>
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Crop yields 2013

![Crop yields 2013 chart](chart.png)
Summary

- Preliminary findings
- Challenging seasons 2012 – 2013
  - cover crop establishment and growth
  - measure soil available N
- Experiments are in place at 6 RCs and 10 farm sites
  - more years and locations will allow a realistic assessment of the potential of cover crops to affect yields and scavenge N
Next steps

- Spring 2014: 6 RCs and 10 farm sites
  - Biomass sampling
  - Soil sampling
    - available N
  - Corn and soybean planting
  - Recruitment of farm collaborators to start late summer/early fall
Acknowledgements

- Angie, Bob, Russ & Dennis
- Gevan Behnke, Brian Mansfield, and Jeff Warren
- Brookside lab team and Mr. Tim Smith (www.cropsmith.com)
- Participant farmers
- Ivan Alex Dozier, MS student
Thanks!

QUESTIONS?