Research on Winter Rye Cover Crops in Corn-Soybean Rotations in Iowa

2014 CPM Short Course and MCPR Trade Show
Minneapolis, MN

USDA-ARS
National Laboratory for Agriculture and the Environment
Ames, Iowa

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Corn and Soybeans have a 5 to 7 Month “BROWN” Gap

Corn or Soybean Crop at Maturity approx. Oct. 1

Soil OM

Winter Cover Crops “Catch” Losses

Cover Crops Fill the “BROWN” Gap with “GREEN” Plants

Corn or Soybean Crop at Emergence approx. May 1

Phosphorus

Nitrogen

Soil productivity is lost during the “BROWN” gap because there are no “GREEN” plants to protect soil and recycle nutrients.
Principles of Cover Crops

- Continuous living cover – at least when the ground is not frozen – more like natural systems – adds plant diversity
- Recycling nutrients – all of them
- Continuous inputs of carbon – Soil C is an inputs and outputs game
- Continuous water use – transpiration versus evaporation/leaching
- Competition with weeds
- Support and maintain soil organisms
- Soil surface protection and insulation
- Cover crops are a long-term investment
Why Focus on Cover Crops for Corn-Soybean Rotations

- Illinois 95% of harvested cropland
- Indiana 92%
- Iowa 94%
- Minnesota 77%
- Ohio 81%
- Because most of the harvested cropland in 2012 was in these two crops in the Upper Midwest.
How Many Acres of Corn and Soybean have Cover Crops Now and How Many Acres Could have Cover Crops

- In Iowa the 2012 NASS Census of Agriculture reported 379,614 acres of cover crops in Iowa = 1.6% harvested cropland
- Kladivko et al 2014 estimated that cover crops could be planted on 70 to 80% of the agricultural land in two Iowa counties
- We have a long way to go! Especially since cover crops are a big part of Iowa’s “voluntary” Nutrient Reduction Plan
Corn and Soybeans in Iowa and Minnesota Leave a Relatively Cold and Short Growing Season for Cover Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Iowa</th>
<th>Minnesota</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20% Planting Completed</td>
<td>22-Apr</td>
<td>23-Apr</td>
</tr>
<tr>
<td>80% Harvest Completed</td>
<td>10-Nov</td>
<td>9-Nov</td>
</tr>
<tr>
<td>Soybean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20% Planting Completed</td>
<td>8-May</td>
<td>9-May</td>
</tr>
<tr>
<td>80% Harvest Completed</td>
<td>19-Oct</td>
<td>18-Oct</td>
</tr>
</tbody>
</table>
Rye Winter Cover Crop Spring Shoot Dry wt vs Fall GDD with a 4ºC Base

\[ y = -8E-06x^2 + 0.011x - 0.0092 \]

\[ R^2 = 0.7655 \]
Growing Degree Days 0°C base

Aug 1 = DOY 213 = 1221 GDD
Sept 1 = DOY 244 = 660 GDD
Oct 1 = DOY 274 = 237 GDD
Nov 1 = DOY 305 = 15 GDD

50% 28°F = DOY 287 (Oct 14) = 118 GDD
<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Species</th>
<th>4-yr. Avg.</th>
<th>4-yr Rank</th>
</tr>
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<tbody>
<tr>
<td>Elbon</td>
<td>rye</td>
<td>2.16 a</td>
<td>1</td>
</tr>
<tr>
<td>Aroostook</td>
<td>rye</td>
<td>2.13 a</td>
<td>2</td>
</tr>
<tr>
<td>Maton</td>
<td>rye</td>
<td>2.11 a</td>
<td>3</td>
</tr>
<tr>
<td>Dacold</td>
<td>rye</td>
<td>1.83 b</td>
<td>4</td>
</tr>
<tr>
<td>Rymin</td>
<td>rye</td>
<td>1.73 bc</td>
<td>5</td>
</tr>
<tr>
<td>Oklon</td>
<td>rye</td>
<td>1.69 bcd</td>
<td>6</td>
</tr>
<tr>
<td>Wheeler</td>
<td>rye</td>
<td>1.66 bcd</td>
<td>7</td>
</tr>
<tr>
<td>Pronghorn</td>
<td>winter wheat</td>
<td>1.57 bcd</td>
<td>8</td>
</tr>
<tr>
<td>Nekota</td>
<td>winter wheat</td>
<td>1.49 cd</td>
<td>9</td>
</tr>
<tr>
<td>Wesley</td>
<td>winter wheat</td>
<td>1.46 d</td>
<td>10</td>
</tr>
<tr>
<td>NE-422t</td>
<td>triticale</td>
<td>1.15 e</td>
<td>11</td>
</tr>
<tr>
<td>Boreal</td>
<td>triticale</td>
<td>0.94 e</td>
<td>12</td>
</tr>
<tr>
<td>Avg.</td>
<td></td>
<td>1.66</td>
<td></td>
</tr>
<tr>
<td>LSD (0.10)</td>
<td></td>
<td>0.27</td>
<td></td>
</tr>
</tbody>
</table>
What Do We Know About Cover Crops Mixtures for Corn Soybean Rotations in Iowa?

Not Much!
Or at least I don’t know much.
Advantages of Cover Crop Mixtures

• More plant diversity - more like natural systems
• Balanced C/N ratio
• Different plant architecture - roots/shoots
• Better Pest Management
• Better support for soil organisms
• Better responsiveness to soil and weather variability
• Potential for more growth stability
Disadvantages of Cover Crop Mixtures

- Can be more expensive
- Can be difficult to seed/plant
- Termination may be more complicated
- Residual herbicides can more of a problem
- We don’t know much
Cover Crop Variety Trial 2013-2014

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- Chad Ingels – Fayette
- Clarke McGrath – Crawford, Pottowattamie, Ringold, Union
- Steve McGrew – Mills
- Mark Peterson – Montgomery
- Myron Rees – Washington
- Dave & Meg Schmidt – Audubon

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NCR-SARE

Web Link:

In a Nutshell
Cover crop entries were hand seeded at locations into standing corn and soybeans and evaluated for fall ground cover, spring ground cover, and spring biomass production.

Key findings
- Cereal rye and mustard tended to produce the most amount of fall ground cover.
- Sufficient rainfall following cover crop seeding is necessary for fall cover crop growth and overwintering potential.
- Cereal rye was the only entry to successfully overwinter and produce spring growth and remains a strong cover crop candidate even in the face of a challenging winter.

Project Timeline:
Fall 2013 - Spring 2014

Mustard grows in cover crop test plots on Jeremy Gustafson's farm in Boone County near Boone, Iowa.
Erosion and Cover Crops

Steve Berger
Which side has 30% cover?
Erosion Measurements with Simulated Rainfall

NO COVER CROP  OAT COVER  RYE COVER
Relative Erosion Rate (%)

Relative Rill and Interrill Erosion Rate in No-till Soybean as Affected by Cover Crops

RUSLE2 Erosion Estimates Using Beta Version of Cover Crop Vegetation Files

- Corn–Soybean rotation, NT, spring anhydrous, 5% slope, 150 ft slope length, Ames, IA
  - without rye cover crop = 2.1 t/ac/yr
  - with rye cover crop = 1.2 t/ac/yr

- Continuous Corn Silage, NT, spring anhydrous, 5% slope, 150 ft slope length, Ames, IA
  - without rye cover crop = 4.8 t/ac/yr
  - with rye cover crop = 1.9 t/ac/yr
Why do Cover Crops Reduce Erosion in No-till

- Increased surface residue cover and infiltration only a little bit
- Cover crops anchored surface residue and prevented it from moving
- Added some height and layers to surface residue cover
- Slowed water movement across the surface
- Roots in near surface soil seemed to help prevent detachment
- More intensive rainfall events
Nitrate Loss in Tile Drainage
Flow Meters & Sample Collectors

Cumulative Annual Drainage

- No Cover Crop
- Rye Cover Crop

Tile flow (mm) vs Rain (mm) over years 2002 to 2013. The average tile flow and rain are indicated by dashed lines.
Nitrate-N Concentration

Annual Flow-wt NO3 Concentration of Tile Drainage for Corn-Soybean Rotation near Ames, IA with or without a Cover Crop

- **No Cover Crop**
- **Rye Cover Crop**

<table>
<thead>
<tr>
<th>Year</th>
<th>No Cover Crop</th>
<th>Rye Cover Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>19.1</td>
<td>5.8</td>
</tr>
<tr>
<td>2003</td>
<td>24.7</td>
<td>11.8</td>
</tr>
<tr>
<td>2004</td>
<td>19.8</td>
<td>9.3</td>
</tr>
<tr>
<td>2005</td>
<td>21.6</td>
<td>8.0</td>
</tr>
<tr>
<td>2006</td>
<td>15.9</td>
<td>4.9</td>
</tr>
<tr>
<td>2007</td>
<td>14.9</td>
<td>7.8</td>
</tr>
<tr>
<td>2008</td>
<td>14.5</td>
<td>8.1</td>
</tr>
<tr>
<td>2009</td>
<td>7.1</td>
<td>5.4</td>
</tr>
<tr>
<td>2010</td>
<td>7.6</td>
<td>4.8</td>
</tr>
<tr>
<td>2011</td>
<td>7.2</td>
<td>1.8</td>
</tr>
<tr>
<td>2012</td>
<td>10.4</td>
<td>2.3</td>
</tr>
<tr>
<td>2013</td>
<td>12.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Avg. 02-13</td>
<td>14.6</td>
<td>6.1</td>
</tr>
</tbody>
</table>
2014 Drainage Water Nitrate Concentration

Nitrate (mg-N L⁻¹)

2-Mar 21-Apr 10-Jun 30-Jul 18-Sep

Flow Weighted N Concentration

- Low N = 10.6 mg N/L
- No Cover Crop = 13.2
- Winter Rye Cover Crop = 5.3
## Total Nitrate-N Lost 2002-2013 in Tile Drainage

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nitrate-N lost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12-yr total</td>
</tr>
<tr>
<td></td>
<td>lbs/acre</td>
</tr>
<tr>
<td>Corn-soybean</td>
<td>428</td>
</tr>
<tr>
<td>Corn-Soyb w. Rye</td>
<td>191</td>
</tr>
<tr>
<td>Reduction</td>
<td>237</td>
</tr>
<tr>
<td>% Reduction</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Cover Crop Shoot Biomass</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td></td>
<td>lbs/acre</td>
</tr>
<tr>
<td>Avg 02-13</td>
<td>1526</td>
</tr>
<tr>
<td>Sum 02-13</td>
<td>18307</td>
</tr>
</tbody>
</table>
Reduction of Nitrate Leaching with Rye – Four Other Iowa Sites

• Nashua, Iowa 22 – 29%
• Gilmore City, Iowa 15 - 20%
• COBS Experiment, Kelly, Iowa 36%
• Tim Smith farm, Eagle Grove, Iowa 48%

Data from Matt Helmers, Eileen Bader, Tim Smith, and A.L. Daigh
Slide from Eileen Bader with The Nature Conservancy
Why Does Cover Crops Effectiveness Vary from Site-to Site?

• Would expect it to vary
• Different amounts of cover crop growth
• Different weather at the sites
• Different soil types – OM, texture
• Tile spacing, tile depth, effectiveness
• Different crop management
• Different field history
Cover Crops and SOM
Rye Cover Crop Effect on Soil Quality in a Corn Silage System after 10 years

• A rye cover crop “increased” total soil organic matter (SOM) in the top 4 inches from 4.8% to 5.3% or ½% change in SOM

• Very rough estimates would say a ½% change in SOM would result in an additional ½ inch of water and 11 kg/ha of mineralized soil N.

• 48% greater Potential N mineralization

• Rough estimates would say this would be 9-11 kg/ha of mineralized soil N.

• These are really hard measurements to make
Soil biology/Earthworms

- Plant growth during normally "fallow" period (Sept-Nov, March-April) provides continuous and stable food source for soil organisms.
- Plant cover moderates temperature and water content.
- Diversity of plant materials may also increase diversity of soil biological community.
- Soil organic matter maintained and cycled from coarse residue to humic acids.
**Lumbricus terrestris** middens per 0.38 m² on three farms in Iowa 2014 - data from Iowa Learning Farms

<table>
<thead>
<tr>
<th>Location</th>
<th>Rye Cover Crop</th>
<th>No Cover Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ames</td>
<td>10.06</td>
<td>7.25</td>
</tr>
<tr>
<td>Sindt</td>
<td>13.69</td>
<td>9.94</td>
</tr>
<tr>
<td>Tobin</td>
<td>5.44</td>
<td>4.19</td>
</tr>
<tr>
<td>Average</td>
<td>9.73 A</td>
<td>7.13 B</td>
</tr>
</tbody>
</table>
Roots are important

• When building soil quality, esp. with NT, the cover crop ROOTS are probably more significant than the shoot growth

• Still need good shoot growth for erosion control, mulch effects for moisture conservation, weed suppression, etc.
# Cereal Rye Cover Crop Root Weight and Rooting Depth in the Spring

<table>
<thead>
<tr>
<th>Year</th>
<th>Root Dry Weight (kg/ha)</th>
<th>Shoot Dry Weight (kg/ha)</th>
<th>Rooting Depth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>330.0</td>
<td>1480</td>
<td>96.5</td>
</tr>
<tr>
<td>2005</td>
<td>720.0</td>
<td>2740</td>
<td>83.1</td>
</tr>
<tr>
<td>2006</td>
<td>680.1</td>
<td>2440</td>
<td>116.3</td>
</tr>
<tr>
<td>2007</td>
<td>513.7</td>
<td>610</td>
<td>92.5</td>
</tr>
<tr>
<td>2008</td>
<td>435.0</td>
<td>1260</td>
<td>98.6</td>
</tr>
<tr>
<td>Avg.</td>
<td>535.8</td>
<td>1706</td>
<td>97.0</td>
</tr>
</tbody>
</table>
Future of Cover Crops

• Great untapped potential
• Cover crop cultivars/species that are better adapted, grow faster, winter hardy, and easy to terminate. Need public breeding programs
• Cover crop mixtures – could be even better
• More experiment station research on long-term benefits of cover crops and on-farm studies for improving management
• More seed, products, machinery, services, and consulting from agribusiness.
WELCOME TO THE MIDWEST COVER CROPS COUNCIL WEBSITE

The goal of the Midwest Cover Crops Council (MCCC) is to facilitate widespread adoption of cover crops throughout the Midwest to improve ecological, economic, and social sustainability.

WHO WE ARE?

The MCCC is a diverse group from academia, production agriculture, non-governmental organizations, commodity interests, private sector, and representatives from federal and state agencies collaborating to address soil, water, air, and agricultural quality concerns in the Great Lakes and Mississippi river basins (including Indiana, Michigan, Ohio, Manitoba, Ontario, Illinois, Wisconsin, Minnesota, Iowa, and North Dakota).

WHY COVER CROPS?

Cover crops are an effective tool to reduce soil erosion and increase nutrient recycling on farmlands, thereby also decreasing the soil and nutrient loads entering lakes and waterways. Cover crops can have numerous other benefits including improvement of soil quality, pest management, fertility management, water availability, landscape diversification, and wildlife habitat.

NEWS

Mark your calendars for the next MCCC meeting in Windsor, Ontario February 10-11, 2009.

Reflect on 2008 and get ready for 2009 by viewing the newly added 2008 MCCC Meeting reports!

View the MCCC plans for the Cover Crop Selector Tool from the 2008 ASA Posters.
Questions?

Tom.Kaspar@ars.usda.gov