Winter Cover Crop Impacts on Erosion and Nitrate Losses in Tile Drainage

Cover Crops and Soil Health: Harvesting the Potential Environmental Impacts of Cover Crops Session
Tuesday Feb. 18, 2014

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

Tom Kaspar
Ben Knutson
Keith Kohler
Kent Heikens
Dan Jaynes
Tim Parkin
Tom Moorman
Rob Malone
Rye after Corn Silage
Corn and Soybeans have a 7 Month “BROWN” Gap

Corn or Soybean Crop at Maturity approx. Oct. 1

Phosphorus

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

Soil OM

Topsoil

Nitrogen

Corn or Soybean Crop at Emergence approx. May 1

Winter Cover Crops “Catch” Losses

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

Soil productivity is lost during the “BROWN” gap because there are no “GREEN” plants to protect soil and recycle nutrients.
Erosion Measurements with Simulated Rainfall

NO COVER CROP  OAT COVER  RYE COVER
Relative Erosion Rate in No-till Soybean as Affected by Cover Crops

Nitrate Loss in Tile Drainage
Nitrate Loss in Tile Drainage Measurements
Flow Meters & Sample Collectors

Cumulative Annual Drainage

Tile flow (mm)

Rain (mm)

- No Cover Crop
- Rye Cover Crop


Rainfall (mm):
- 2002: 700
- 2003: 800
- 2004: 900
- 2005: 1000
- 2006: 1100
- 2007: 1200
- 2008: 1300
- 2009: 1400
- 2010: 1500
- 2011: 1600
- 2012: 1700
- 2013: 1800
- Avg: 1400

Tile flow (mm):
- No Cover Crop: 200, 400, 600, 800, 1000, 1200, 1400
- Rye Cover Crop: 700, 900, 1100, 1300, 1500, 1700, 1900

Average:
- Tile flow: 400 mm
- Rainfall: 1200 mm

Legend:
- Blue: No Cover Crop
- Red: Rye Cover Crop

Graph showing cumulative annual drainage with comparison between no cover crop and rye cover crop for the years 2002 to 2013.
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**
Cumulative Nitrate-N Load

Annual N Loss in Tile Drainage for a Corn-Soybean Rotation With and Without a Rye Cover Crop

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

<table>
<thead>
<tr>
<th>Year</th>
<th>No Cover Crop</th>
<th>Rye Cover Crop</th>
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</thead>
<tbody>
<tr>
<td>2002</td>
<td>40.4</td>
<td>11.2</td>
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<tr>
<td>2003</td>
<td>81.1</td>
<td>33.9</td>
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<tr>
<td>2004</td>
<td>47.2</td>
<td>23.0</td>
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<tr>
<td>2005</td>
<td>34.4</td>
<td>11.1</td>
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<tr>
<td>2006</td>
<td>36.0</td>
<td>9.0</td>
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<td>2007</td>
<td>66.9</td>
<td>37.1</td>
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<tr>
<td>2008</td>
<td>62.7</td>
<td>36.6</td>
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<td>2009</td>
<td>28.9</td>
<td>19.0</td>
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<tr>
<td>2010</td>
<td>34.8</td>
<td>21.9</td>
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<tr>
<td>2011</td>
<td>14.9</td>
<td>2.8</td>
</tr>
<tr>
<td>2012</td>
<td>6.4</td>
<td>0.8</td>
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<tr>
<td>2013</td>
<td>25.9</td>
<td>7.8</td>
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<tr>
<td>Avg. 02-13</td>
<td>40.0</td>
<td>17.8</td>
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<tr>
<td>Treatment</td>
<td>Nitrate-N Lost (kg/ha)</td>
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</tr>
<tr>
<td>----------------------------</td>
<td>------------------------</td>
<td></td>
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<tr>
<td></td>
<td>12-yr sum</td>
<td>12-yr avg.</td>
</tr>
<tr>
<td>Corn-soybean</td>
<td>480</td>
<td>40</td>
</tr>
<tr>
<td>Corn-soybean with rye</td>
<td>214</td>
<td>18</td>
</tr>
<tr>
<td>Total Reduction</td>
<td>266</td>
<td>22</td>
</tr>
<tr>
<td>% Reduction</td>
<td>55%</td>
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</tr>
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<td></td>
<td>Cover Crop Shoot Biomass</td>
<td>Cover Crop Shoot N Concentration</td>
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<td>-----------------------</td>
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<td>----------------------------------</td>
</tr>
<tr>
<td></td>
<td>Mg/ha</td>
<td>%</td>
</tr>
<tr>
<td>Avg 02-13</td>
<td>1.71</td>
<td>2.86</td>
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<tr>
<td>Sum 02-13</td>
<td>20.52</td>
<td></td>
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</table>
Estimated Change in Soil Total N Balance over 4 years (2002-2005)

Fertilizer N added
Estimated N Fixation by Soybean - estimate relative to yield
N in Rainwater
N Removed in Grain
N Lost in Drainage Water
Change in Inorganic Soil N
Gaseous losses of N - ?????? – assume not different

Corn-Soybean with rye cover crop increased 82 kg N/ha
Corn-Soybean without cover crop decreased -18 kg N/ha

Change in total soil N - ??????
So where is the nitrogen the cover crops took up?

Can N fertilizer rates be decreased at some point in the future?

Will losses of N in drainage increase after cover crops have been used for many years?

Do soybeans fix more or less N when following rye or oat cover crops?

Good questions without good answers.
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
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
Nitrogen Summary

• Winter cover crops reduce N losses in tile drainage by taking up N and reducing nitrate concentrations in soil and drainage water. There is some lag between cover crop N uptake and reduced nitrate concentrations.

• Winter cover crops don’t seem to have a large impact on the total annual amount of drainage, but could have seasonal effects.

• Impact of cover crops on nitrate losses depends on cover crop growth, soil type, weather, and when drainage occurs.
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
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
2006 Nitrate Concentration of Tile Drainage Water Over Time

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

Nitrate Concentration (ppm)

2006 Nitrate Concentration of Tile Drainage Water Over Time

- No Cover Crop
- Rye Cover Crop
Impacts of Cover Crops – Nashua

29% reduction in corn
22% reduction in soybean
Impacts of Cover Crops – Gilmore City

~15-20% Reduction in Nitrate-N Concentration With Annual Rye Cover Crop

Matt Helmers Iowa State University
## Impacts of Cover Crops – COBS site Ames

<table>
<thead>
<tr>
<th>Treatment</th>
<th>3-Year Avg. Nitrate-N Lost</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Conc</td>
<td>Load</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>kg/ha</td>
<td></td>
</tr>
<tr>
<td>Continuous corn</td>
<td>8.3</td>
<td>12.4</td>
<td></td>
</tr>
<tr>
<td>Continuous corn with winter wheat crop</td>
<td>5.3</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td><strong>Total Reduction</strong></td>
<td><strong>3.0</strong></td>
<td><strong>8.4</strong></td>
<td></td>
</tr>
<tr>
<td>% Reduction</td>
<td>36%</td>
<td>68%</td>
<td></td>
</tr>
</tbody>
</table>
Multiple Scale Monitoring

Nitrate-N, mg L$^{-1}$

- LEC In (CC after 2011)
- Boone River
- Eagle Creek Downstream
- Eagle Creek Upstream

Slide from Eileen Bader with The Nature Conservancy
Relative Erosion

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