Using Cover Crops to Reduce Leaching Losses of Nitrate

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

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Thanks to:
Lowell Gentry, Univ. IL
Adam Kiel, ISA
Eileen Kladivko, Purdue
Matt Helmers and Mike Castellano, Iowa State
What’s the Problem?

Nitrates in rivers hit record levels
Des Moines Register Friday May 10, 2013

Finding Fixes for Nitrates
Des Moines Register Sunday Sept. 13, 2015

Chesapeake Bay cleanup: Is Iowa next?
Des Moines Register Nov. 17, 2015

And of course the nitrates in rivers in Iowa end up in the Mississippi River and the Gulf of Mexico
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen
Most recent instantaneous value: 2.94 11-27-2017  16:00 CST

USGS 05484500 Raccoon River at Van Meter, IA

Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen

- Blue line: Nitrate plus nitrite
- Green line: Period of approved data
- Red line: Estimated nitrate plus nitrite
- Pink line: Period of provisional data
NO3-N Concentration in the Raccoon River at Des Moines

Data provided by Chris Jones
Des Moines Water Works
## What Causes the Problem?

It’s the Golf Courses and Lawns!

<table>
<thead>
<tr>
<th></th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn &amp; Soybean</td>
<td>24,507,219</td>
</tr>
<tr>
<td>Golf Courses</td>
<td>49,172</td>
</tr>
<tr>
<td>Lawns</td>
<td>154,064</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>24,710,455</strong></td>
</tr>
</tbody>
</table>

There are 120X more corn & soybean acres than golf courses and lawns in Iowa.
It’s the Sewage Treatment Plants!

…. Nonpoint (farmland) sources comprise 89.6% of the total nitrate load in the watershed.

….. So it’s mostly farmland again.

Statewide Tile Nitrate Results

Statewide Tile Nitrate Results 2014

Tile Nitrate mg/L

1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec

Funded in part by the soybean checkoff
So why is this such a difficult problem?

We just need to manage N fertilizer and manure better.

Right?
Water and Nitrate Flow Pathways

- Precipitation
- Surface Runoff
- Subsurface Drainage
- Lateral Flow
- Deep Percolation
- Ground Water

Nitrate Moves Easily with Water

Adapted from Castellano and Helmers, Iowa State
Large Pools of N in Soil Organic Matter

It’s not just N fertilizer!

Native Soil Organic Matter Nitrogen ~ **10,000 lb N/acre**

Organic Matter is the 10,000 lb Gorilla in the room!

**Corn Nitrogen Cycling & Budget**

- Corn Grain Harvest (~100 lbs N/acre/year)
- Corn Nitrate Use (~165 lb N/acre)
- Corn Residue Return (~65 lbs N/acre/year)
- Gaseous Loss (~10 lbs N/acre/year)
- Fertilizer to Corn (~150 lbs N/acre/year)

NITRATE

- Microbial production of nitrate from native soil (100-400 lbs N/acre/year)
- Microbial re-uptake of nitrate (150-350 lbs N/acre/year)
- Nitrate leaching to water (~30 lbs N/acre/year)
Poor Timing Between Uptake and Availability

Soil Nitrate Production vs Crop Nitrate Uptake

Rate of Soil Nitrate Production

Rate of Crop Nitrate Uptake

Brown Gap

Modified from Castellano and Helmers
Our Cropping Systems Have Changed

From 1949 to 2002: % of Iowa Raccoon River Basin cropland in Small Grains and Hay decreased from over 45% to less than 3%.

Hatfield et al. 2009
Annual Flow-wt NO3 Concentration of Tile Drainage for Four Rotations near Lamberton, MN

- **Cont. Corn**
- **Corn in Corn-Soyb**
- **Soybean in Corn-Soyb**
- **Alfalfa**

Randall et al. 1997
Corn and Soybeans have a 7 Month “BROWN” Gap

Winter Cover Crops “Catch” Losses

Cover Crops Fill the “BROWN” Gap with “GREEN” Plants
The more “GREEN” the more benefits and protection
15 years of Measurements of Nitrate Loss in Tile Drainage with and without Cover Crops
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**

59% Reduction
2014 Drainage Water Nitrate Concentration

- **Low N**: 7.9 mg N/L, Load = 31.7 kg N/ha
- **No Cover Crop**: 10.8 mg N/L, Load = 33.9 kg N/ha
- **Winter Rye Cover Crop**: 4.2 mg N/L, Load = 9.8 kg N/ha
Annual Flow Weighted Nitrate Concentration in Tile Drainage for a No-till Corn-Soybean Rotation near Ames, IA with either Rye or Oat Cover Crop or without Cover Crops

<table>
<thead>
<tr>
<th>Year</th>
<th>NoTill No CC</th>
<th>NoTill Rye CC</th>
<th>No-Till Oat CC</th>
<th>5-yr Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>16.4</td>
<td>13.2</td>
<td>12.1</td>
<td>12.1</td>
</tr>
<tr>
<td>2007</td>
<td>14.9</td>
<td>10.5</td>
<td>10.5</td>
<td>10.5</td>
</tr>
<tr>
<td>2008</td>
<td>14.5</td>
<td>8.1</td>
<td>9.1</td>
<td>9.1</td>
</tr>
<tr>
<td>2009</td>
<td>7.1</td>
<td>7.6</td>
<td>6.7</td>
<td>6.7</td>
</tr>
<tr>
<td>2010</td>
<td>5.5</td>
<td>5.4</td>
<td>4.8</td>
<td>4.8</td>
</tr>
</tbody>
</table>

NoTill No CC: 48%
NoTill Rye CC: 25%
No-Till Oat CC: 25%
# Total Nitrate-N Lost 2002-2016 in Tile Drainage

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nitrate-N Lost in Drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15-yr total</td>
</tr>
<tr>
<td>Corn-soybean no-till</td>
<td>503</td>
</tr>
<tr>
<td>Corn-soybean no-till w. rye cover crop</td>
<td>214</td>
</tr>
<tr>
<td>Reduction</td>
<td>289</td>
</tr>
<tr>
<td>% Reduction</td>
<td>57</td>
</tr>
<tr>
<td>Treatment</td>
<td>Nitrate-N Lost in Drainage</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>Corn-soybean no-till</td>
<td></td>
</tr>
<tr>
<td>Corn-soybean no-till w. rye cover crop</td>
<td></td>
</tr>
<tr>
<td>Corn-soybean fall chisel plow</td>
<td></td>
</tr>
</tbody>
</table>
Reduction of Nitrate Leaching with Rye Cover Crop – 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
Tile monitoring research in large farmer fields in Illinois. Each tile is 2000 ft long, 100 ft apart, and covers over 4 acres. Courtesy of Lowell Gentry, Univ. of Illinois.
Tile Nitrate Concentrations Averaged across Treatments
(from 12/12/14 to 08/01/16)
Lowell Gentry – University of Illinois at Urbana-Champaign

- Spring N
- Side-dress N

- 160S
- 0/80/80
- 0/80/80C

Nitrate (mg N L⁻¹)

Corn planted
Rye planted
Soy planted
Cover crop fields had 40% lower nitrate load 2016

Nitrate Load (pounds per acre per day)

Month

4 5 6 7 8 9

No 116 fields
Yes 62 fields
Why Does Cover Crops Effectiveness Vary from Site-to-Site?

- Would expect it to vary
- Different amounts of cover crop growth
- Different weather/rainfall at the sites
- Different soil types – OM, texture
- Tile spacing, tile depth, effectiveness
- Different crop management
- Different field history
How much impact could widespread adoption of cover crops have in Midwest?

- In OH, IN, IL, IA, MN we estimated that 21% of the harvested acres could adopt cover crops “relatively easily”
- Used Root Zone Water Quality Model to predict reduction in nitrate-N losses
- Cover crop predicted growth and benefit greatest in southern IL and IN
- Estimated 19% reduction in nitrate-N load to Mississippi River

Cover Crop Summary

- Cover crops reduce N losses in tile drainage by taking up N during the “Brown Gap” between maturity and planting of corn and soybean.

- Unlike other practices used to reduce N losses to water, cover crops will provide other benefits.
Midwest Cover Crops Council
Working to Keep Fields Green All Year Long
http://www.mccc.msu.edu/