The effect of N management and cover crops on tile nitrate loads

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Midwest Cover Crop Council
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By using cover crops, …

- can we use immobilization of N as a tactic against tile N loss?
- can we tighten the N cycle and decrease loss of mineralized N during the non-growing season?
- can we turn inorganic N fertilizer into a slow release organic form?
Soil Mineralization vs. Immobilization

We are really talking about “net mineralization”, which is mineralization minus immobilization.

C:N ratio of residue impacts met mineralization

C:N < 15:1 = net mineralization
C:N > 30:1 = net immobilization
(Embarras River Watershed)

- USGS gauge at Camargo, IL
- 119,000 acres
- 90% row crop
- Few animals
- Little sewage effluent
Upper Embarras River Nitrate Concentration

25 Year Baseline of River Nitrate Load = 27 lbs/A/yr
U.S. Science Advisory Board

IL Science Assessment

IL NLRS

Calls for 45% reduction of N and P export

Suite of BMP for agricultural production
IL Nutrient Science Advisory Committee

Recommendations for numeric nutrient criteria and eutrophication standards for Illinois wadeable streams and rivers

<table>
<thead>
<tr>
<th></th>
<th><strong>Total Phosphorus (µg/L)</strong></th>
<th></th>
<th><strong>Total Nitrogen (µg/L)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>North Ecoregion</td>
<td>South Ecoregion</td>
<td>North Ecoregion</td>
</tr>
<tr>
<td>Numeric Criteria</td>
<td>113</td>
<td>110</td>
<td>3979</td>
</tr>
<tr>
<td>Lower 95 % CL</td>
<td>33</td>
<td>18</td>
<td>-78†</td>
</tr>
<tr>
<td>Upper 95 % CL</td>
<td>193</td>
<td>202</td>
<td>8036</td>
</tr>
</tbody>
</table>

† the negative concentration is a statistical artefact and can be interpreted as zero.
Flow-Weighted Mean of Nitrate Conc.
(Upper Embarras R. for past 25 years)
(Average FWM of nitrate = 8.96 ppm)
Flow-Weighted Mean of TP Conc.
(Upper Embarras R. for past 19 years)
(Average FWM of total phosphorus = 0.25 ppm)
Replicated tile drainage study
Tile Map

Cropping Pattern

Soy-Corn-Soy

Corn-Soy-Corn

Corn-Soy-Corn
Large replicated plots

Pattern drainage in Lacustrine soil
Cereal rye after corn (before soybean)

Biomass = 1.25 Tons/A
Biomass N = 32 lbs/A

Photo by John M. Green
Oat and radish after soybean (before corn)
Not enough biomass to decrease tile nitrate load
We switched to annual ryegrass and radish in 2018

Photo by John M. Green
3 year Cumulative Tile Nitrate Load

Cumulative Nitrate Loss (lb ac\(^{-1}\))

- 160F
- 80/40/40
- 160S
- 120S
- 0/80/80
- 0/80/80C

41% ↓
Cereal Rye Termination Study

3 termination dates in the spring
(approximately 2 weeks apart)

3 fertilizer N treatments
50 plant + 150 SD
100 F + 50 plant +50 SD
200 spring preplant
Cereal rye planted Oct. 18, 2016 following soybean

3 termination dates:

T1 = March 19
T2 = April 2
T3 = April 13

3 N systems:

50 plant + 150 SD
100 F + 50 plant +50 SD
200 spring preplant

Corn planted on April 14, 2017
2017

N application

Fall N/strip = Nov. 1, 2016 as AA

Spring N = Mar. 9, 2017 as AA

Side-dress = May 16 as AA
Cereal rye biomass

(Mild winter with warmest Feb. on record)

Cover Crop Termination Date and Growing Degree Days

Mar. 19 (807)  Apr. 2 (933)  Apr 13 (1083)

Tons/A

- 0/50/150
- 100/50/50
- 200 S
Cereal rye N concentration

Cover Crop Termination Date and Growing Degree Days

Mar. 19 (807)  Apr. 2 (933)  Apr 13 (1083)
Cereal rye N content

Cover Crop Termination Date and Growing Degree Days

- Mar. 19 (807)
- Apr. 2 (933)
- Apr 13 (1083)

N Content (lbs/A)

- 0/50/150
- 100/50/50
- 200 S
2017 Corn biomass at V7 (52 DAP)

- **NC**: 0.20 Tons/A
- **T1**: 0.21 Tons/A
- **T2**: 0.19 Tons/A
- **T3**: 0.18 Tons/A

Averaged over N treatments
Soil inorganic N at V7

Averaged over N treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nitrate + Ammonium (lbs/A) (0-2 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Cover</td>
<td>a</td>
</tr>
<tr>
<td>T1</td>
<td>a</td>
</tr>
<tr>
<td>T2</td>
<td>ab</td>
</tr>
<tr>
<td>T3</td>
<td>b</td>
</tr>
</tbody>
</table>
On-Farm Cover Crop Crop x N Trial

Nitrogen treatments

- No cover
- T1 Mar 19
- T2 Apr 2
- T3 Apr 13

Corn yield (bu/acre)

- 50 Plant + 150 SD
- 100 Fa+50 Pl+50 SD
- 200 E. Spring pre
On-Farm Cover Crop x N Trial

Yield (bu/acre)

<table>
<thead>
<tr>
<th>Cereal rye termination date</th>
<th>a</th>
<th>ab</th>
<th>ab</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>No cover</td>
<td>235</td>
<td>228</td>
<td>226</td>
<td>222</td>
</tr>
<tr>
<td>T1 Mar 19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2 Apr 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T3 Apr 13</td>
<td></td>
<td></td>
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Averaged over N management treatments
On-Farm Cover Crop x N Trial

Averaged over cover crop treatments

Yield (bu/acre)

50 Plant + 150 SD
100 Fa+50 Pl+50 SD
200 E. Spring pre

Nitrogen treatments

50
100
150
200
250

225
227
230
Biomass was much less in 2018
**Cereal Rye Biomass**

**Cover Crop Termination Date and Growing Degree Days**

- **Apr. 10 (429)**
- **Apr. 24 (627)**
- **May 1 (718)**

- 0/50/150
- 100/50/50
- 200 S

**Tons/A**
GDD vs. Cereal Rye Biomass 2017 and 2018

\[ y = 0.0108e^{0.0045x} \]

\[ R^2 = 0.9938 \]
On-Farm Cover Crop Crop x N Trial

Yield (bu/acre) averaged over N management treatments

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<thead>
<tr>
<th>Cereal rye termination date</th>
<th>Yield (bu/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No cover</td>
<td>226</td>
</tr>
<tr>
<td>T1 Apr 10</td>
<td>228</td>
</tr>
<tr>
<td>T2 Apr 24</td>
<td>230</td>
</tr>
<tr>
<td>T3 May 1</td>
<td>227</td>
</tr>
</tbody>
</table>
On-Farm Cover Crop x N Trial

Averaged over cover crop treatments

<table>
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<th>Yield (bu/acre)</th>
<th>N Treatments</th>
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<tbody>
<tr>
<td>227</td>
<td>50 Pl + 150 SD</td>
</tr>
<tr>
<td>223</td>
<td>100 Fa + 50 Pl + 50 SD</td>
</tr>
<tr>
<td>232</td>
<td>200 E. Spring pre</td>
</tr>
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Conclusions

• Both years spring N produced the greatest corn yield.

• There is a balance between cover crop biomass production and the potential for the cover crop residue to immobilize soil N, which can lead to delays in early crop growth and lower yield.

• Cereal rye ahead of soybean, let it grow/cereal rye ahead of corn, kill it early (unless it was a cold spring with little growth of the cover crop).
Warm winters are draining our ecological capital from the prairie.

Warm winters enhanced mineralization outside of the row crop growing season.

Over-wintering cover crops will capture mineralized N and release it during the growing season.

End of pipe techniques are not the best strategy for preventing this type of loss.
Tile Nitrate Concentration from C-S-W

- Corn (253 bu/A)
- Cereal - Rye (75 bu/A)
- Soybean (98/55 bu/A)
- Wheat/DC Soy (265 bu/A)
- Corn (265 bu/A)

Tile Nitrate-N (ppm)

8/1/2014 - 8/1/2018
### FWM of Tile Nitrate Conc. from C-S-W

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Nitrate Conc. (ppm)</th>
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<tbody>
<tr>
<td>Corn</td>
<td>(7.7 ppm)</td>
</tr>
<tr>
<td>Cereal (Rye)</td>
<td>(2.1 ppm)</td>
</tr>
<tr>
<td>Soybean</td>
<td>(2.2 ppm)</td>
</tr>
<tr>
<td>Wheat/DC Soy</td>
<td>(4.7 ppm)</td>
</tr>
</tbody>
</table>

- **AVG of 2016-2018**: 2.6 ppm
- **AVG of 2015-2018**: 3.7 ppm
Summary

• In warm winters, cover crops can take up mineralized N and keep it from reaching the tiles.

• If cover crop growth is restricted by a cold winter, cold winters lose less nitrate anyway.

• Cover crops protect the soil, especially following soybean.