Nitrogen Dynamics with a Rye Cover Crop

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Winter Cereal Rye Cover Crop

- Rye cover crop benefits
  - Conserve/recycle soil nitrate
  - Reduce tile flow nitrate-N
    - (31% -- Iowa Nutrient Reduction Strategy)
  - Soil surface protection (erosion)
  - Improve soil carbon content (OM)
  - Improve soil physical properties
Winter Cereal Rye Cover Crop System

- Corn N application
- Corn Soybean planting
- Corn/Soybean growth
- Rye seeding
- Corn/Soybean harvest
- Cover crop growth
- Residual nitrate uptake
- Rye termination

Timeline:
- Apr.
- May
- Jun.
- Jul.
- Aug.
- Sept.
- Oct.
- Nov.
- Dec.
- Jan.
- Feb.
- Mar.
- Apr.
Winter Cereal Rye Cover Crop

- Assume nitrate-N loss via tile drainage averages 30 lb N/acre per year
- 31% nitrate-N concentration reduction in tile flow with a rye cover crop
- Assume concentration reduction approximates load reduction
- Approximately 9 lb less nitrate-N/acre lost in tile drainage with a rye cover crop
Winter Cereal Rye Cover Crop Studies

- Corn N rate fertilization
  - Rye N uptake and degradation
  - Soil nitrate
  - Corn optimal N rate
  - Corn and soybean yield
- Rye plant root and shoot components
  - Biomass, carbon, N content
- Tillage and starter N influence on corn yield
Nitrogen Rate Fertilization

- Five locations, 2009-2013
- No-till corn-soybean rotation
- With and without ‘Wheeler’ winter cereal rye (1 bu/acre) drilled after crop harvest
- Rye termination at least 7 days before corn planting and at or within 7 days before soybean planting
- Aboveground rye biomass sampled at time of termination
Nitrogen Rate Fertilization

- Six N rates injected early sidedress as UAN
  - 0 to 200 lb N/acre in 40 lb increments
- Soil nitrate sampling spring preplant, late spring, and post-harvest
- Corn and soybean grain yield
- Economic optimum N rate (EONR) from corn N rate response
Nitrogen Rate Fertilization

Rye cover crop growth on October 20, 2008 (17 days of growth after planted into soybean stubble), Ames.
Nitrogen Rate Fertilization

Rye cover crop May 18, 2009 (rye termination May 4), Ames.
Nitrogen Rate Fertilization

March 29, 2012

April 17, 2012

April 17, 2012
Nitrogen Rate Fertilization

Rye cover crop following corn, before herbicide application on May 9, 2010, Crawfordsville.
Nitrogen Rate Fertilization

Soybean growth with the rye cover crop on June 1, 2010 (21 days after herbicide application and planting), Crawfordsville.
Nitrogen Rate Fertilization

Soybean growth with the rye cover crop (foreground) and without the rye cover crop (background) on June 24, 2010, Crawfordsville.
Nitrogen Rate Fertilization

No rye cover crop left – with rye cover crop right
Ames on June 8, 2012 (rye terminated May 2, corn planted May 10).
Rye Cover Crop Biomass and N Uptake (2009-2013)

Following Corn.

<table>
<thead>
<tr>
<th>N Rate</th>
<th>Rye Biomass</th>
<th>Rye N Uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb N/acre</td>
<td>lb DM/acre</td>
<td>lb N/acre</td>
</tr>
<tr>
<td>2009†</td>
<td>440</td>
<td>10</td>
</tr>
<tr>
<td>2010-2013‡</td>
<td>0</td>
<td>845c</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>985b</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>1220a</td>
</tr>
</tbody>
</table>

† No N rate treatments had been applied.
‡ Prior year N rate application to corn.

Following soybean.
580 lb DM/acre and 18 lb N/acre uptake.
Soil Nitrate in Corn Year

Spring sampling was to 2 foot depth only in the zero lb N/acre plots, and Fall sampling was to 3 foot depth before rye growth. Means with the same letter within each sampling time are not different, $P \leq 0.05$. 

Spring

- Pre-plant
  - No-RCC: a
  - RCC: c

- Late Spring
  - No-RCC: b
  - RCC: b

Fall

- 0 lb N/acre
  - No-RCC: c

- 120 lb N/acre
  - No-RCC: b

- 200 lb N/acre
  - No-RCC: a
### Soybean Grain Yield

Soybean grain yield with and without rye cover crop, 2009-2013.

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Ames</th>
<th>Crawfordsville</th>
<th>Lewis</th>
<th>Nashua</th>
<th>Sutherland</th>
</tr>
</thead>
<tbody>
<tr>
<td>With rye</td>
<td>54.4a†</td>
<td>58.5a</td>
<td>58.5a</td>
<td>61.2a</td>
<td>63.3a</td>
</tr>
<tr>
<td>Without rye</td>
<td>53.5a</td>
<td>59.0a</td>
<td>58.1a</td>
<td>62.4a</td>
<td>62.8a</td>
</tr>
</tbody>
</table>

† Yields at a site followed by the same letter are not different, \( p \leq 0.10 \).
Corn Nitrogen Response

Across Sites (2009-2013)

Corn Yield (bu/acre)

Fertilizer N Rate (lb N/acre)

No Rye

With Rye

<table>
<thead>
<tr>
<th>EONR</th>
<th>YEONR</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb N/acre</td>
<td>bu/acre</td>
</tr>
<tr>
<td>No Rye: 151</td>
<td>188</td>
</tr>
<tr>
<td>With Rye: 157</td>
<td>179</td>
</tr>
</tbody>
</table>
Corn Yield Response vs Rye Cover Crop Biomass Amount, 2009-2013

\[ y = 0.015x + 1.8 \]
\[ R^2 = 0.50 \]
Rye Biomass Degradation and N Cycling

- Four sites in 2010 and 2011
- Following corn
  - 0, 120, and 200 lb N/acre
- Following soybean
- At time of rye control
  - Rye biomass placed in mesh bags
  - Collected at 21, 63, 105 days (3, 9, 15 week)
  - Dry matter, carbon, and N remaining
Rye Biomass Degradation and N Cycling

Gone from rye:
After corn: 60%
10-14 lb N/acre
After soybean: 77%
20 lb N/acre
Rye Shoot and Root Composition

- Rye drilled after corn and soybean harvest (fall 2014) at Ames in three corn N rates
- Root ingrowth tubes installed between rye rows (1-2 foot)
- Tubes collected at time of rye termination (April 29 after soybean and May 8 after corn)
- Shoot and root biomass, carbon, and N determined
Rye Shoot and Root Composition

<table>
<thead>
<tr>
<th></th>
<th>Biomass</th>
<th>Nitrogen</th>
<th>C:N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb DM/acre</td>
<td>lb N/acre</td>
<td></td>
</tr>
<tr>
<td><strong>Following Corn</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoot</td>
<td>983a (2x)</td>
<td>18a (5x)</td>
<td>23b</td>
</tr>
<tr>
<td>Root</td>
<td>463b</td>
<td>4b</td>
<td>52a</td>
</tr>
<tr>
<td><strong>Following Soybean</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoot</td>
<td>1096a (2x)</td>
<td>26a (5x)</td>
<td>16b</td>
</tr>
<tr>
<td>Root</td>
<td>573b</td>
<td>5b</td>
<td>47a</td>
</tr>
</tbody>
</table>

Letters in a column and crop indicate significant difference (P ≤ 0.10).
Practices to Enhance Corn Yield

- Four sites in 2014 and 2015
  - Same sites as prior study
- Corn – soybean rotation
  - No-till and rye cover crop history since 2008
- Plus/minus rye cover crop
- Spring disk tillage and no-till
- Plus/minus 30 lb N/acre 2x2 starter
- Main N sidedress injected UAN (total 150 lb N/acre)
Practices to Enhance Corn Yield

- Rye broadcast in standing soybean (before leaf drop) at 1.5 to 2 bu seed/acre
- Planned rye termination at approximately 6-8 inch height
- Tillage after rye termination in spring
- Corn planting approximately 2 weeks after rye termination
Practices to Enhance Corn Yield

Rye cover crop following soybean, April 22, 2014 before rye termination, Lewis.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Till</td>
<td>6.2</td>
<td>137</td>
<td>5.3</td>
<td>7.7a</td>
<td>325a</td>
<td>13a</td>
</tr>
<tr>
<td>No-Till</td>
<td>7.3b</td>
<td>273b</td>
<td>10b</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Letters in a column indicate significant difference (P ≤ 0.10).
## Practices to Enhance Corn Yield

### Corn population, plant height, and grain yield, 2014-2015.

<table>
<thead>
<tr>
<th>Practice</th>
<th>V6 Population</th>
<th>V6 Height</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pl/acre</td>
<td>inch</td>
<td>bu/acre</td>
</tr>
<tr>
<td>Tillage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Till</td>
<td>31,900b</td>
<td>21a</td>
<td>203a</td>
</tr>
<tr>
<td>No-till</td>
<td>33,000a</td>
<td>20b</td>
<td>197b</td>
</tr>
<tr>
<td>Starter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starter</td>
<td>32,500a</td>
<td>21a</td>
<td>201a</td>
</tr>
<tr>
<td>No starter</td>
<td>32,400a</td>
<td>20b</td>
<td>198b</td>
</tr>
<tr>
<td>Cover Crop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No rye</td>
<td>32,500a</td>
<td>21a</td>
<td>202a</td>
</tr>
<tr>
<td>With rye</td>
<td>33,500a</td>
<td>21a</td>
<td>198b</td>
</tr>
</tbody>
</table>

Letters indicate significant difference (P ≤ 0.10).
No interaction between practices.
Cover Crop Studies Summary

- Rye cover crop biomass production related to fall seeding date (& prior crop), spring climatic conditions, and date of termination
- Rye nitrogen uptake low
  - By individual treatment and across all sites: Mean 20, min. 2, max. 62 lb N/acre
- A small rye effect on soil nitrate-N in spring preplant (14 lb N/acre lower)
  - Soil nitrate amount low each year
Cover Crop Studies Summary

- No effect of rye cover crop on soybean grain yield
- Corn grain yield reduced with the rye cover crop
  - Across sites and years 5% less
- Across sites and years 6 lb N/acre higher EONR with rye cover crop
Cover Crop Studies Summary

- Faster rye N recycling following soybean than following corn
- Degradation rate of rye biomass similar for prior-year corn N rates
- Nitrogen recycled after 105 days
  - 20 lb N/acre (77% of uptake) after soybean
  - 10-14 lb N/acre (60% of uptake) after corn
Cover Crop Studies Summary

- Rye cover crop shoot biomass 2 times the root biomass
- Rye cover crop shoot N content 5 times the root N content
- Root N content low (< 4-5 lb N/acre)
- Following corn:
  - Rye shoot C:N ratio 23:1 and root 52:1
- Following soybean:
  - Rye shoot C:N ratio 16:1 and root 47:1
Cover Crop Studies Summary

- Tillage following termination of rye cover crop increased corn yield (6 bu/acre) compared to no-till
- High N starter (30 lb N/acre, 2x2) increased corn yield (3 bu/acre), with main N sidedressed
- With these practices corn yield only 2% different (4 bu/acre) between with and without rye cover crop
Acknowledgements

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