Nitrogen and Tillage Management for Corn following Alfalfa

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http://z.umn.edu/corn
Benefits of rotating alfalfa with corn

• Provides N to corn
  – About 100% of the N needed for 1\textsuperscript{st}-year corn
  – About 50% of the N needed for 2\textsuperscript{nd}-year corn

• Non-N rotation effects are \textit{usually} positive
  – Improved soil physical properties (water infiltration, root extension)
  – Lower disease & pest pressure (corn rootworm)
  – Altered rhizosphere community (beneficial soil microbes)
  – But it can reduce corn yield in dry years (excess water removal)
1) Rotation increased yield (7 to 19% at high N rate)

2) Alfalfa reduced corn’s fertilizer N needs for 2 years

Lancaster, WI (1990-2004); silt loam soil

Stanger et al. (Agronomy Journal, 2008)
1) Crop rotation increased yield

2) Alfalfa reduced corn’s fertilizer N needs for 2 years

Nashua, IA (2003-2006); loam soil

Non-N rotation effects

Mallarino & Pecinovsky (2006)
How does alfalfa provide N to corn?

• Recovers excess soil nitrate
• Fixes atmospheric N
  \(100 \text{ to } 500 \text{ lb N/acre/year}\)
• Maintains high N concentration
  (>2% N in roots and residue)
• Adds N to soil organic matter pool
  \(50 \text{ to } 150 \text{ lb N/acre/year}\)
  – Harvest losses
  – Stand losses
  – Thin root turnover
  – Root exudation
## N credit from alfalfa to 1<sup>st</sup>-year corn (lb N/acre)

<table>
<thead>
<tr>
<th>State</th>
<th>Regrowth</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN</td>
<td>---</td>
<td>≥ 4 plants ft&lt;sup&gt;2&lt;/sup&gt;</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>WI</td>
<td>&lt; 8”</td>
<td>150</td>
<td>120</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>&gt; 8”</td>
<td>190</td>
<td>160</td>
<td>130</td>
</tr>
<tr>
<td>IA</td>
<td>---</td>
<td>Apply 0 - 30 lb N/acre for first-year corn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>---</td>
<td>150</td>
<td>50 - 100</td>
<td>0</td>
</tr>
<tr>
<td>MI,IN,OH</td>
<td>---</td>
<td>140</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>MO</td>
<td>---</td>
<td>120 - 140</td>
<td>40 - 60</td>
<td>0 - 20</td>
</tr>
<tr>
<td>NE</td>
<td>---</td>
<td>150</td>
<td>120</td>
<td>90</td>
</tr>
</tbody>
</table>
N recommendations vary among states
(for good stands on medium- to fine-textured soils)

$7.25/bu $0.50/lb N

<table>
<thead>
<tr>
<th>State</th>
<th>Corn after corn</th>
<th>First-year corn after alfalfa</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>IL</td>
<td>175</td>
<td>100</td>
</tr>
<tr>
<td>IN, MI, OH</td>
<td>225</td>
<td>150</td>
</tr>
<tr>
<td>MN</td>
<td>175</td>
<td>100</td>
</tr>
<tr>
<td>NE</td>
<td>225</td>
<td>150</td>
</tr>
<tr>
<td>SD</td>
<td>300</td>
<td>200</td>
</tr>
<tr>
<td>WI</td>
<td>150</td>
<td>20</td>
</tr>
</tbody>
</table>
Improved N management is needed for corn following alfalfa

• Surveys by the MN Dep. of Ag. = The most extreme cases of excess N fertilization in corn are when corn follows alfalfa

• Do N credit recommendations still apply with contemporary, high-yielding corn crops?
Can we rely on alfalfa N credit estimates?

• In 91% of 140 site-years in northern U.S., 1st-year corn after alfalfa had no response to fertilizer N
  – At least 1 full year of alfalfa; good stands at termination
  – Alfalfa typically terminated in the fall with tillage
  – Deep, medium- to fine-textured soils

• Considerations:
  – Poorly-drained clay loam soils & sandy soils had the most frequent N response
  – Excessive rainfall between the time of alfalfa termination & early-season corn growth can lower the N credit
  – Regrowth at termination adds available N
Our on-farm research uses grower participation

- Creates opportunities for interaction, education, & innovation
- Accelerates adoption of best practices
Study #1 = 10 on-farm trials in 2009 & 2010

- Central and southern MN
- Evaluated response to fertilizer N in 1st-year corn after alfalfa
- No manure during alfalfa
- Alfalfa stands 3-5 years old with 4-10 plants/ft²
- Tillage timing for stand termination varied with farm
- Loam to clay loam soils; 1 farm was loamy sand

Yost et al. (Agronomy Journal, 2012)
Grain yield was not increased with fertilizer N on any of the 5 farms in 2009

Yost et al. (Agronomy Journal, 2012)
Grain yield was not increased with fertilizer N on any of the 5 farms in 2010

Yost et al. (Agronomy Journal, 2012)
Silage yield was not increased with fertilizer N on any of the 5 farms in 2009

Yost et al. (Agronomy Journal, 2012)
Silage yield was not increased with fertilizer N on the 4 farms where it was measured in 2010

Yost et al. (Agronomy Journal, 2012)
Sampling to 4 feet for residual soil nitrate-N
Soil nitrate-N after harvest in the top 4 feet at 7 farms in 2009-2010

Risk when N rate exceeds 40 lb N/acre

Yost et al. (Agronomy Journal, 2012)
Study #1 - Summary

• 1\textsuperscript{st}-year corn grain & silage yields were not increased with fertilizer N on 10 farms, even with yields over 195 bu/acre on 7 of the 10 farms

• Soil nitrate-N after harvest increased greatly when the fertilizer N rate exceeded 40 lb N/acre

Yost et al. (Agronomy Journal, 2012)
Study #2 = 6 on-farm trials in 2010

• Evaluated 1st-year corn response to fertilizer N based on alfalfa regrowth in the fall & tillage timing for alfalfa termination

• 6 farms in southern & central MN; loam to clay loam soils
- Alfalfa fields 3-7 years old
- 4-8 plants/ft² at termination
- 4 replications per farm
No effect of fall alfalfa regrowth or tillage timing on grain or silage yield, or their response to fertilizer N

<table>
<thead>
<tr>
<th>Location in Minnesota</th>
<th>Fall alfalfa regrowth where it was not harvested</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height of regrowth -- inches --</td>
<td>Dry matter yield -- lb/acre</td>
<td>N content</td>
</tr>
<tr>
<td>Emmons</td>
<td>4</td>
<td>300</td>
<td>9</td>
</tr>
<tr>
<td>Brewster</td>
<td>6</td>
<td>400</td>
<td>17</td>
</tr>
<tr>
<td>Plainview</td>
<td>10</td>
<td>700</td>
<td>33</td>
</tr>
<tr>
<td>Chatfield</td>
<td>13</td>
<td>900</td>
<td>38</td>
</tr>
<tr>
<td>Lakefield</td>
<td>15</td>
<td>1,400</td>
<td>47</td>
</tr>
<tr>
<td>Montevideo</td>
<td>18</td>
<td>1,500</td>
<td>52</td>
</tr>
</tbody>
</table>
5 of 6 farms had no grain response to N in 2010

Responsive farm had poorly-drained soil & abundant rainfall

Yost et al. (Agronomy Journal, 2012)
Silage yield responded to N across 6 farms in 2010

0.8 tons/ac (+3%) with 42-64 lb N/ac

$68/ton; $0.50/lb N

Corn silage yield at 65% moisture (ton/ac)

Fertilizer N rate (lb N/ac)

Yost et al. (Agronomy Journal, 2012)
No-till & reduced-till can work well for 1st-year corn after alfalfa
No-till & reduced-till worked well in 2010
(averaged over 6 N rates, as no differences in response to N)
Yield of 1ˢᵗ-year corn & its response to N were not affected by alfalfa regrowth or tillage timing

- *Harvest regrowth in last year on medium- to fine-textured soils*
- *Potential flexibility in tillage timing when terminating alfalfa*

1ˢᵗ-year corn grain yield responded to fertilizer N at only 1 of 6 farms, even with average yields of 180 to 231 bu/acre

Silage corn needed a small amount of N (42-64 lb N/acre)

No-till & reduced-till worked well in 2010 & did not affect corn response to fertilizer N
Study #3 = 7 on-farm trials in 2010 & 2011

• Evaluated response to fertilizer N in 1st-year no-till corn after alfalfa

• 7 farms in southern Minnesota & western Wisconsin

• No manure during alfalfa

• Alfalfa stands 2-7 years old with 4-8 plants/ft²

• Loam, silt loam, & clay loam soils

• Starter fertilizer (3-20 lb N/acre) used on all farms

Yost et al. (Agronomy Journal, 2013)
Grain and silage yields were not increased with fertilizer N on any of these 7 no-till farms.

<table>
<thead>
<tr>
<th>Location</th>
<th>Soil type</th>
<th>Grain</th>
<th>Silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cashton</td>
<td>Silt loam</td>
<td>199</td>
<td>27.9</td>
</tr>
<tr>
<td>Goodhue</td>
<td>Silt loam</td>
<td>203</td>
<td>21.1</td>
</tr>
<tr>
<td>Lake City</td>
<td>Silt loam</td>
<td>220</td>
<td>---</td>
</tr>
<tr>
<td>Lakefield</td>
<td>Loam</td>
<td>212</td>
<td>24.5</td>
</tr>
<tr>
<td>Norwalk</td>
<td>Silt loam</td>
<td>211</td>
<td>30.3</td>
</tr>
<tr>
<td>Okabena</td>
<td>Clay loam</td>
<td>209</td>
<td>---</td>
</tr>
<tr>
<td>Plainview</td>
<td>Silt loam</td>
<td>211</td>
<td>---</td>
</tr>
</tbody>
</table>
Study #4 = 8 on-farm trials in 2011

• Evaluated response to fertilizer N in 1st-year corn after alfalfa; used fall tillage to terminate alfalfa

• No manure during alfalfa

• Alfalfa stands 2-5 years old with 3-7 plants/ft²

• Loam, silt loam, silty clay loam, & clay loam soils

• Starter fertilizer (2-15 lb N/acre) used on 6 of 8 farms
6 of 8 farms with tillage had no response to N in 2011

Yost et al. (Agronomy Journal, In Review)
On the 2 farms that responded to fertilizer N in 2011, sidedressing 40 lb N/ac at V6 optimized yield

Yield equal to the higher optimal N rate applied near planting

Yost et al. (Agronomy Journal, In Review)
Study #4 - Summary

- On farms that used fall tillage to terminate alfalfa, fertilizer N increased 1\textsuperscript{st}-year corn grain yield on 2 of 8 farms in 2011.

- On the 2 farms where corn grain yield responded to fertilizer N, sidedressing 40 lb N/acre was as good as the optimal rate of 80 lb N/acre applied near planting.
Fertilizer N increased 1st-year corn grain yield in just 3 of 31 trials, but what if it’s my farm?

$7.25/bu $0.50/lb N
Can one predict which fields need fertilizer N?

1) **Fall soil nitrate test** – dry regions such as western MN
   - 0- to 2-foot soil sample collected in **fall** when residual nitrate is suspected
   - *Not recommended for 1st-year corn after alfalfa*

2) **Preplant soil nitrate test (PPNT)**
   - 0- to 2-foot soil sample collected in **spring** before planting when residual nitrate suspected
   - *Not recommended for 1st-year corn after alfalfa*

3) **Presidedress soil nitrate test (PSNT)**
   - 0- to 1-foot soil sample collected at V4 to V6 corn stage
   - *Not currently recommended in MN, but other states (IA, WI, etc.) use the test*

4) **Early-season plant tissue nitrate test**
   - Nitrate concentration in whole plant sample at V4 to V6 corn stage
   - *Calibrations have not been developed in many states*

5) **Basal stalk nitrate test**
   - Nitrate concentration in 8” section (6 to 14” above ground) of basal corn stalk collected 1 to 3 weeks after black layer
   - *Does not tell you how much N to apply in the future*
• Yield boost when corn follows alfalfa

• Harvest alfalfa regrowth in the fall before stand termination if possible, especially if stand density is good

• No-till and reduced-till can work well for 1st-year corn after alfalfa

• On medium- to fine-textured soils with good alfalfa stands at termination, 1st-year corn grain yield was increased with fertilizer N on only 3 of 31 farms (10% of time)

• It may be more common for silage corn to respond to a small amount of N than grain corn
Take home points for 1\textsuperscript{st}-year corn

• Soil residual nitrate-N after harvest can increase greatly if rates above 40 lb N/acre are applied to 1\textsuperscript{st}-year corn & if N is not needed to optimize yield

• If a grower thinks they might need N for 1\textsuperscript{st}-year corn...
  - Consider a small amount of N in a starter fertilizer, or
  - Sidedress a small amount of N (about 40 lb N/acre) based on early-season soil/crop conditions rather than applying a higher rate before planting

• The chance of 1\textsuperscript{st}-year corn responding to N increases if there is \textit{significant rainfall} between alfalfa termination & early-season corn growth on poorly-drained or sandy soils
9 on-farm field days educated growers & farm advisors managing over 1 million acres
On-farm field day results

• Most attendees were surprised by:
  – Widespread lack of N fertilizer response for 1\textsuperscript{st}-year corn grain yield
  – 2\textsuperscript{nd}-year N credit – larger than expected, but variable

• Evaluations indicate:
  – Baseline N mgt. for 1\textsuperscript{st}- & 2\textsuperscript{nd}-year corn varied widely
  – 52% of respondents would modify future N fertilizer mgt. for corn following alfalfa by \textit{much} or \textit{very much}
  – Field day attendees would \textit{annually} reduce N input to 1\textsuperscript{st}-year corn by over \textit{1.1 million lb N}, equivalent to $562,000 & an energy savings of \textit{24.6 million MJ}
Alfalfa N credits to 2nd-year corn are real, but vary

<table>
<thead>
<tr>
<th>State</th>
<th>1st-year N credit†</th>
<th>2nd-year N credit†</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>IL</td>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td>IN</td>
<td>140</td>
<td>---</td>
</tr>
<tr>
<td>KS</td>
<td>120</td>
<td>---</td>
</tr>
<tr>
<td>MI</td>
<td>140</td>
<td>---</td>
</tr>
<tr>
<td>MN</td>
<td>150</td>
<td>75</td>
</tr>
<tr>
<td>MO</td>
<td>100</td>
<td>---</td>
</tr>
<tr>
<td>ND</td>
<td>150</td>
<td>75</td>
</tr>
<tr>
<td>NE</td>
<td>150</td>
<td>---</td>
</tr>
<tr>
<td>OH</td>
<td>140</td>
<td>---</td>
</tr>
<tr>
<td>SD</td>
<td>150</td>
<td>75</td>
</tr>
<tr>
<td>WI</td>
<td>150</td>
<td>50</td>
</tr>
</tbody>
</table>

* Iowa State guidelines:
0-30 lb N/ac for 1st-year corn
0-60 lb N/ac for 2nd-year corn

No university recommendation for 2nd-year N credit

† For good stands on medium- to fine-textured soils
Study #5 = 8 on-farm trials in 2012

- Evaluated response to fertilizer N in 2nd-year corn after alfalfa as affected by residue management in 1st-year corn

- No manure during alfalfa

- Alfalfa stands 2-7 years old with at least 4 plants/ft²

- Stand termination method varied with farm

- 0-6 lb N/ac in starter fertilizer

- Loam, silt loam, & clay loam soils
(2010-Alfalfa; 2011-Corn; 2012-Corn)

Corn residue mgt. treatments imposed in fall 2011

4 replications per farm

<table>
<thead>
<tr>
<th>Corn residue removed (baled)</th>
<th>Corn residue retained in field</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>70</td>
<td>95</td>
</tr>
<tr>
<td>120</td>
<td>240</td>
</tr>
<tr>
<td>0 + 40</td>
<td>0 + 70</td>
</tr>
<tr>
<td>15 + 40</td>
<td>30 + 40</td>
</tr>
</tbody>
</table>

0, 15, 30 lb N/ac at planting + additional 40 or 70 lb N/ac as sidedress N
Residue mgt. treatments had little effect on yields & no effect on response to N in 2\textsuperscript{nd}-year corn

- Across farms, 2\textsuperscript{nd}-year corn grain & silage yields were not consistently increased or decreased when residue was removed

- Residue management did not affect the response to N for 2\textsuperscript{nd}-year corn grain yield or silage yield
2nd-year corn grain yield was not increased with N on 4 of 8 farms in 2012.

- Costs:
  - $7.25/bu for corn
  - $0.50/lb N for fertilizer

- Nitrogen Rates:
  - 70-80 lb N/ac for initial application
  - 191-207 lb N/ac for later applications
2nd-year corn silage yield was not increased with N on 4 of 8 farms in 2012.

- 194-206 lb N/ac
- 240 lb N/ac
- $68/ton
- $0.50/lb N
Enhanced efficiency when N was sidedressed in 2nd-year corn

- At the 2 locations where the optimum N rate for grain yield was 70-80 lb N/acre when applied near planting, equivalent grain yields were obtained with just 40 lb N/acre sidedressed at V6.

- At the 2 locations where the optimum N rate for grain yield was 191-207 lb N/acre when applied near planting, grain yields were 87% of the optimum with just 70 lb N/acre sidedressed at V6.
The PSNT correctly predicted response to N at 5 of 8 locations with 2\textsuperscript{nd}-year corn.

<table>
<thead>
<tr>
<th>Location</th>
<th>PSNT value (ppm)</th>
<th>Should the location respond to N?</th>
<th>Did the location respond to N?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brewster</td>
<td>4</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dennison</td>
<td>8</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fountain</td>
<td>10</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Jeffers</td>
<td>4</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Le Center</td>
<td>11</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Medford</td>
<td>7</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Randolph</td>
<td>21</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Russell</td>
<td>6</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Take home points for 2\textsuperscript{nd}-year corn

- 2\textsuperscript{nd}-year corn only responded to N at 4 of 8 locations
- In the future, we hope to be able to better predict 2\textsuperscript{nd}-year N credits. Until then, use current N credit guidelines
- Grow 2 years of corn after alfalfa to capture N benefits
- More N was needed for 2\textsuperscript{nd}-year corn when grown for silage rather than grain
- Applying N as a sidedress can enhance N use efficiency
- The PSNT was a little more successful in 2\textsuperscript{nd}-year corn than 1\textsuperscript{st}-year corn (63% success vs. 55% success)
Thanks!

http://z.umn.edu/corn