Nitrogen Management for 1st- & 2nd-Year Corn after Alfalfa

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Managing the Rotation from Alfalfa to Corn

Matt A. Yost, Jeffrey A. Cooler, and Michael P. Rosselle
Alfalfa reduces corn N requirements, usually for at least 2 years

- Recovers soil nitrate
- Fixes atmospheric N
- Maintains high N concentration
- Adds N to soil organic matter pool
  (50 to 150 lb N/acre/year)
  - Harvest losses
  - Stand losses
  - Thin root turnover
  - Root exudation
## N credit from alfalfa to 1st-year corn (lb N/acre)

<table>
<thead>
<tr>
<th>State</th>
<th>Regrowth</th>
<th>Good (≥ 4 plants ft²)</th>
<th>Fair (2-3 plants ft²)</th>
<th>Poor (≤ 1 plant ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN</td>
<td>---</td>
<td>150</td>
<td>100</td>
<td>40</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>150</td>
<td>100</td>
<td>0</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>
<tr>
<td></td>
<td></td>
<td>Apply 0 - 30 lb N/acre for first-year corn</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A rotation with high N loading potential = 3 sources

1st-year corn

2nd-year corn

ScienceDaily.com

Extension.org

MN Dept. Ag.
Total N rate adds up fast!

Manure for 1st-year corn in MN

Example for 1st-year corn

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount (lb N/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa N credit</td>
<td>150</td>
</tr>
<tr>
<td>Manure N credit</td>
<td>50</td>
</tr>
<tr>
<td>N fertilizer</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>280</td>
</tr>
</tbody>
</table>
Improved N management is needed for corn following alfalfa

- Some of the most extreme cases of excess N fertilization in corn are when corn follows alfalfa

- Do past N credit recommendations still apply to today’s high-yielding corn crops?
42 on-farm alfalfa-corn N rate trials (2009-2012)

- **1st-year corn**: 31 trials
  - Predictors of N response
  - Stover removal, predictors
  - Manure
  - No-till
  - Regrowth, tillage time
  - K

- **2nd-year corn**: 11 trials
Farmer cooperators needed – 1 acre

- Alfalfa in 2015, corn in 2016
  - No manure since alfalfa seeding
  - Withhold manure & fertilizers (other than starter)
  - Otherwise, manage like rest of field

- We apply N & other fertilizers & measure corn yield

- Receive a small payment each year

- Receive yield information on corn response to N
Study #1 = 10 on-farm trials in 2009 & 2010

- Evaluated response to fertilizer N in 1\textsuperscript{st}-year corn
- No manure during alfalfa
- Alfalfa stands 3-5 years old; 4-10 plants/ft\textsuperscript{2}
- Tillage timing for stand termination varied with farm
- Loam to silty clay loam soils; 1 farm had loamy sand soil
Grain yield was not increased with fertilizer N on any of the 5 farms in 2009.
Grain yield was not increased with fertilizer N on any of the 5 farms in 2010.
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

Soil nitrate-N in the top 4 feet (lb/acre)

Fertilizer N rate (lb N/acre)
Study #2 = 6 on-farm trials in 2010

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

• Loam, silt loam, & clay loam soils
- Alfalfa fields 3-7 years old
- 4-8 plants/ft²
- 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>Height of regrowth -- inches --</th>
<th>Dry matter yield -------- lb/acre --------</th>
<th>N content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emmons</td>
<td></td>
<td>4</td>
<td>300</td>
<td>9</td>
</tr>
<tr>
<td>Brewster</td>
<td></td>
<td>6</td>
<td>400</td>
<td>17</td>
</tr>
<tr>
<td>Plainview</td>
<td></td>
<td>10</td>
<td>700</td>
<td>33</td>
</tr>
<tr>
<td>Chatfield</td>
<td></td>
<td>13</td>
<td>900</td>
<td>38</td>
</tr>
<tr>
<td>Lakefield</td>
<td></td>
<td>15</td>
<td>1,400</td>
<td>47</td>
</tr>
<tr>
<td>Montevideo</td>
<td></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 field had poorly-drained soil & abundant spring rainfall

64-77 lb N/ac – economic optimum

$0.37/lb N
$3.70/bu
No-till & reduced-till can work well for 1\textsuperscript{st}-year corn after alfalfa
No-till & reduced-till worked well in 2010 (averaged over 6 N rates, as no difference in response to N)
Study #3 = 7 on-farm trials in 2010 & 2011

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

- No manure during alfalfa

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

- Loam, silt loam, & clay loam soils

- Starter fertilizer (3-20 lb N/acre) used on all farms
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 (bu/ac)</th>
<th>Silage (tons/ac)</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

• No manure during alfalfa

• Alfalfa stands 2-5 years old; 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.
A sidedress rate of 40 lb N/ac was evaluated on these 8 farms in 2011.
2 farms that responded to fertilizer N in 2011

Equivalent yield with 40 lb N/acre sidedressed at V6 or 80 lb N/acre near planting
1st-year corn responded to N on 3 of 31 farms

$0.37/lb N  $3.70/bu
Review of past N fertilizer rate trials in 1\textsuperscript{st}-year corn after alfalfa

- N rates on first-year corn
- No manure
- At least 2 replications

31 recent MN sites + 228 from literature
### Review of past N rate trials – 1st-year corn

<table>
<thead>
<tr>
<th>Soil texture</th>
<th>Termination timing</th>
<th>Alfalfa age, years</th>
<th>Alfalfa seeding method</th>
<th>Sites responsive to fertilizer N</th>
<th>Total sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td></td>
<td></td>
<td></td>
<td>96%</td>
<td>11</td>
</tr>
<tr>
<td>Medium</td>
<td>Fall</td>
<td>1</td>
<td>Direct</td>
<td>56%</td>
<td>16</td>
</tr>
<tr>
<td>Medium</td>
<td>Fall</td>
<td>2</td>
<td>With oats</td>
<td>35%</td>
<td>54</td>
</tr>
<tr>
<td>Medium</td>
<td>Fall</td>
<td>2</td>
<td>Direct</td>
<td>8%</td>
<td>25</td>
</tr>
<tr>
<td>Medium</td>
<td>Fall</td>
<td>3+</td>
<td></td>
<td>5%</td>
<td>86</td>
</tr>
<tr>
<td>Medium</td>
<td>Spring</td>
<td>3+</td>
<td></td>
<td>17%</td>
<td>48</td>
</tr>
<tr>
<td>Fine</td>
<td></td>
<td></td>
<td></td>
<td>53%</td>
<td>19</td>
</tr>
</tbody>
</table>
Take home points for 1\textsuperscript{st}-year corn

- Harvest alfalfa regrowth in the fall before termination
- No-till and reduced-till can work well
- Response to N unlikely (5\% of time) on medium-textured soils following 3+ year-old alfalfa (including seeding year) if terminated in the fall
Likelihood of 1st-year corn requiring N is increased with:

- Coarse-textured soils (respond 96% of time)
- Fine-textured soils (respond 53% of time)
- Spring termination of alfalfa
- Significant rainfall between alfalfa termination & early-season corn growth on sandy or poorly-drained soils
- Warmer fall temperatures following alfalfa termination
Take home points for 1\textsuperscript{st}-year corn

• If one thinks N may be needed for 1\textsuperscript{st}-year corn on medium- or fine-textured soils...
  
  - Consider a small amount of N as a starter or pre-plant fertilizer
  
  - 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
Alfalfa N credits to 2\textsuperscript{nd}-year corn are real, but vary

<table>
<thead>
<tr>
<th>State</th>
<th>1\textsuperscript{st}-year N credit\textsuperscript{†}</th>
<th>2\textsuperscript{nd}-year N credit\textsuperscript{†}</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 Univ. guidelines:
  0-30 lb N/ac for 1\textsuperscript{st}-year corn
  0-60 lb N/ac for 2\textsuperscript{nd}-year corn

No university recommendation for 2\textsuperscript{nd}-year N credit

\textsuperscript{†} For good stands on medium- to fine-textured soils
40-60 lb N/ac optimized 2\textsuperscript{nd}-year corn yield on 3 farms in 2011

Average of 3 farms

Corn grain yield (bu/ac)

Fertilizer N rate (lb N/ac)

$0.37$/lb N
$3.70$/bu
8 trials in 2012 in 2nd-year corn after alfalfa

- No manure since alfalfa seeding
- 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
2nd-year corn grain yield was not increased with N on 4 of 8 farms in 2012.

- $0.37/lb N
- $3.70/bu

- 70-80 lb N/ac
- 191-207 lb N/ac
Enhanced efficiency when N was sidedressed at V6 in 2\textsuperscript{nd}-year corn

- At the 4 of 8 farms with response to N in 2012:

  - Sidedressed N was more efficient

  - 100 lb N/ac sidedressed = 118 lb N/ac near planting
No response to N in 45% of 67 trials of 2\textsuperscript{nd}-year corn

\begin{figure}
\centering
\includegraphics[width=\textwidth]{chart.png}
\caption{Economic optimum N rate (lb N/ac)}
\end{figure}

$0.37/lb$ N $3.70/bu$
Take home points for 2nd-year corn

- 2nd-year corn required no N 45% of time

- Grow 2 years of corn after alfalfa to capture N benefits

- Responsive sites needed 30-180 lb N/ac

- Use current N credits, but we hope to have field-specific recommendations in the future

- Applying N as a sidedress can enhance fertilizer N use efficiency
Thank you!

University of Minnesota Extension

USDA

Minnesota’s Agricultural Fertilizer Research & Education Council

Minnesota Corn Growers Association

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