Nitrogen and Tillage Options for Improving Returns to Corn after Alfalfa

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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 microbes?)
  – Can reduce corn yield in dry years (excess water removal)
How does alfalfa provide N to corn?

- Recovers excess soil nitrate
- Fixes atmospheric N
  (100 to 500 lb N/acre/year)
- Maintains high N concentration
  (>2% N in roots and residue)
- 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 for 1st Year Corn after Alfalfa (lb N/acre)

<table>
<thead>
<tr>
<th>State</th>
<th>Regrowth</th>
<th>Alfalfa stand at termination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Good</td>
</tr>
<tr>
<td>MN</td>
<td></td>
<td>150</td>
</tr>
<tr>
<td>WI</td>
<td>&lt; 8”</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>&gt; 8”</td>
<td>190</td>
</tr>
<tr>
<td>IA</td>
<td></td>
<td>120 - 200</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>150</td>
</tr>
<tr>
<td>MI, IN, OH</td>
<td></td>
<td>140</td>
</tr>
<tr>
<td>MO</td>
<td></td>
<td>120 - 140</td>
</tr>
<tr>
<td>NE</td>
<td></td>
<td>150</td>
</tr>
</tbody>
</table>
Can we rely on alfalfa N credit estimates?

- In 91% of 140 site-years in northern U.S., 1st-year corn 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.
  - Rainfall between the time of alfalfa termination & early-season corn growth.
  - Regrowth at termination adds available N.
Study #1 = 10 On-Farm Trials in 2009 & 2010

• On dairy farms with no manure during alfalfa; stand termination varied with farm

• Evaluated response to fertilizer N in 1st-year corn after alfalfa

• Good alfalfa stands at termination: 4-10 plants/ft²

• Loam to clay loam soils; 1 farm was loamy sand
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.
Silage yield was not increased with fertilizer N on any of the 5 farms in 2009.
Silage yield was not increased with fertilizer N on the 4 farms where it was measured in 2010.
Apparent fertilizer N uptake across 10 farms

Only 14% of fertilizer N was recovered by corn.
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

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

Fertilizer N rate (lb N/acre)
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.

• 1\textsuperscript{st}-year corn only recovered 14% of the applied N.

• Soil nitrate-N after harvest increased greatly when the N rate exceeded 40 lb N/acre.
Study #2 = 6 On-Farm Trials in 2010

- On cash grain farms.
- Loam to clay loam soils.
- Evaluated 1st-year corn response to fertilizer N based on alfalfa regrowth in the fall & tillage timing for alfalfa termination.
- Alfalfa fields 3-7 years old
- 4-8 plants/ft² at termination
- 4 replications per farm

6 rows wide x 35 feet
Brewster, MN

Chatfield, MN
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 in plots where it was not harvested</th>
<th>Height of regrowth -- inches --</th>
<th>Dry matter yield ------ lb/acre ------</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brewster</td>
<td></td>
<td>6</td>
<td>400</td>
<td>17</td>
</tr>
<tr>
<td>Chatfield</td>
<td></td>
<td>13</td>
<td>900</td>
<td>38</td>
</tr>
<tr>
<td>Emmons</td>
<td></td>
<td>4</td>
<td>300</td>
<td>9</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>
<tr>
<td>Plainview</td>
<td></td>
<td>10</td>
<td>700</td>
<td>33</td>
</tr>
</tbody>
</table>
5 of 6 farms had no grain response to N in 2010.

- 31 bu/ac (+16%) with 69-80 lb N/ac.
Economics of grain yield response at Brewster, MN

(4 year old stand, 6 plants/ft$^2$, no manure history, poorly-drained soil, abundant rainfall)

$5.75$/bu; $0.45$/lb N

69-80 lb N/ac
Silage response to N across 6 farms in 2010

0.8 tons/ac (+3%) with 42-64 lb N/ac
Economics of silage response to N across 6 farms in 2010

- Gross Return to N
- Net Return to N
- Fertilizer N Cost

$61/ton; $0.45/lb N

42-64 lb N/ac
Apparent fertilizer N uptake across 6 farms in 2010

At best, only 22% of fertilizer N was recovered by corn.
Basal stalk nitrate test
(indicator of late-season N fertility)
Basal stalk nitrate test at 6 farms in 2010

- 84 lb N/acre needed at Brewster to reach the optimum range.
- Test not likely needed for corn after alfalfa.
No-Till & Reduced-Till Can Work for 1st-Year Corn After Alfalfa
No-Till & Reduced-Till Worked Well in 2010 (averaged across 6 N rates)

<table>
<thead>
<tr>
<th>Location</th>
<th>Treatment</th>
<th>Corn Grain Yield (bu/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakefield (clay loam)</td>
<td>No regrowth + no-till</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>Grower's normal practice</td>
<td>208</td>
</tr>
<tr>
<td>Brewster (clay loam)</td>
<td>No regrowth + spring field cultivate (x 2)</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>Grower's normal practice</td>
<td>217</td>
</tr>
<tr>
<td>Plainview (silt loam)</td>
<td>10&quot; regrowth + spring field cultivate (x 2)</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>Grower's normal practice</td>
<td>210</td>
</tr>
</tbody>
</table>
Study #2 - Summary

• Yield of 1st-year corn & its response to N was 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 1 of 6 farms, even with average yields of 180 to 231 bu/acre.

• Silage corn may need a small amount of N (42-64 lb N/acre).
  – *Save on fertilizer N for 1st-year corn.*
  – *Research is needed to better predict when 1st-year corn will respond to fertilizer N.*

• No-till & reduced-till worked well in 2010.
Study #3 = 17 On-Farm Trials in 2011

- On dairy farms with no manure during alfalfa.
- Loam to clay loam soils; good alfalfa stands at termination.
- Evaluated response to fertilizer N rates & side-dressed N in 1st-year corn after alfalfa.
  - 7 farms with no-till & no manure before corn.
  - 10 farms with fall tillage (both with & without dairy manure in the fall before corn).
    - 7 farms = dry manure (provided 5-23 lb N/acre for corn).
    - 3 farms = liquid manure (provided 36-120 lb N/acre for corn).
  - Plots without manure were fertilized for P, K, & S.
5 of 7 no-till farms had no response to N in 2011.

- 38 bu/ac (+20%) with 87-100 lb N/ac
- 76 bu/ac (+64%) with 160 lb N/ac
No effect of dairy manure on grain yield or its response to fertilizer N on 10 farms in 2011.
8 of 10 farms with tillage had no response to N in 2011 (averaged across manure treatments)

- 24 bu/ac (+18%) with 104-128 lb N/acre
- 30 bu/ac (+18%) with 160 lb N/acre
On 3 of 4 farms that responded to fertilizer N in 2011, side-dressing 40 lb N/ac at V6 optimized yield (less expensive than optimal preplant rates of 87-160 lb N/ac)
Study #3 - Summary

- On 6 of 7 no-till farms, average yield of 1\textsuperscript{st}-year corn after alfalfa was 198 to 212 bu/acre.
- Dairy manure did not affect 1\textsuperscript{st}-year corn grain yield or its response to fertilizer N on 10 farms with conventional tillage (compared to commercial fertilizer at recommended rates).
- 1\textsuperscript{st}-year corn grain yield responded to fertilizer N at 4 of 17 farms in 2011.
- On 3 of the 4 farms where corn grain yield responded to fertilizer N, side-dressing 40 lb N/acre was as good as optimal preplant rates of 87 to 167 lb N/acre.
Take full advantage of N credits with 2 years of corn

Alfalfa N credit guidelines for good stands (at least 4 plants/ft$^2$) on medium & fine textured soils.

<table>
<thead>
<tr>
<th>State</th>
<th>1st year N credit</th>
<th>2nd year N credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>120 - 180</td>
<td>90 - 150</td>
</tr>
<tr>
<td>Illinois</td>
<td>150 - 180</td>
<td>20 - 50</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>150</td>
<td>50</td>
</tr>
<tr>
<td>Minnesota</td>
<td>150</td>
<td>75</td>
</tr>
</tbody>
</table>
Take Home Points

• Yield boost for corn after alfalfa.

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

• No-till & reduced-till systems can work well for 1st-year corn.

• On medium to heavy soils with good alfalfa stands at termination, 1st-year corn grain yield was increased with fertilizer N on just 5 of 33 farms.

• It may be more common for silage corn to respond to a small amount of N than grain corn.
Soil nitrate after harvest can increase greatly if rates above 40 lb N/acre are applied to 1st-year corn & if it is not needed to optimize yield.

If you think you need N for 1st-year corn…
- Consider a small amount of N in a starter fertilizer, or
- Side-dress a small amount (~40 lb N/acre) based on early-season soil/crop conditions rather than applying a high rate before planting.

The chance of 1st-year corn responding to N can increase if there is significant rainfall between alfalfa termination & early-season corn growth on poorly-drained or sandy soils.

Don’t forget about N credits for 2nd-year corn.
Thanks!

www.extension.umn.edu/corn