Nitrogen Calibration for Corn

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NDSU Extension Soil Specialist
More Nitrogen is used in regional crops than any other nutrient
N recommendations-

1.2 X Yield Goal

is our current published recommendation
Our old N recs were developed for lower yield potential than today.

Most of the yield came from the linear portion of a curvilinear graph.

At N prices around 8-12 cents/lb N, these recommendations were acceptable.
Our data show that “yield goal” is not a good predictor of optimal economic N rate.

Optimal N rates tend to be similar over a wide range of environmental conditions.

Poor to normal growing years require similar N rates to above-normal growing condition years.
Economic optimum N rates in high, medium and low yielding years.

Schlegel et al., 1996, KS
This suggests that-

In poor years, efficiency of N uptake is reduced, requiring more N/yield unit.

In good growing years, efficiency of N, and N released from OM by microorganisms is increased, requiring less supplemental N per yield unit.

The net result is that supplemental N requirements tend to be similar between years.
There are often problems within a field from varying soil texture, risk of erosion, leaching and denitrification depending on years.
Corn N timeline

Application

Period of greatest uptake

Day 1  Day 45  Day 80  Day 120
20 sites in 2010-19 dryland and 1 irrigated.
One additional site lost to deer.

2 sites west-river
2 sites Carrington
1 site Sargent Co.
2 sites Barnes Co.
7 sites Richland Co.
6 sites Cass Co.
16 sites in 2011- all dryland, all in the east.
2 sites lost west river due to wet fields
1 site lost near Carrington to hail
1 site lost near Gardner due to wet fields, 1 site to poor stand, 1 site to high winds

1 site Carrington
3 sites Sargent Co.
1 sites Barnes Co.
5 sites Richland Co.
6 sites Cass Co.
Relationship of total known available N to corn yield, all sites, 2010-11

\[ y = -6 \times 10^{-5} x^2 + 0.2774x + 101.66 \]

\[ R^2 = 0.1924 \]
2 sites, one year, both long-term no-till

West-River Corn N Data, 2010

\[ y = -0.0003x^2 + 0.1703x + 75.562 \]

\[ R^2 = 0.6725 \]
Steps to implementation of Return to N-

- Generate yield response data
- Use regression model from data to predict yield at N rates from 0 to maximum reasonable rate.
- Generate gross return from each N rate
- Generate cost of N from N rate
- Subtract Cost of N from Gross return from N
West-River Sites, Return to N, 2010

Return to N, $/acre

Total Known Available N, lb/acre

<table>
<thead>
<tr>
<th></th>
<th>40c</th>
<th>50c</th>
<th>60c</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3</td>
<td>63</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>118</td>
<td>75</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>153</td>
<td>118</td>
<td>83</td>
</tr>
<tr>
<td>6</td>
<td>174</td>
<td>145</td>
<td>117</td>
</tr>
</tbody>
</table>
Relationship total available N to Yield, Eastern Conventional Sites
2010-2011

\[ y = -0.0004x^2 + 0.4292x + 109.86 \]

\[ R^2 = 0.3031 \]
No-Till Sites, Eastern, ND

Yield vs Total Known Available N, No-till sites, 2010-2011

\[ y = -0.0008x^2 + 0.5899x + 63.269 \]

\[ R^2 = 0.5237 \]
Yield vs Total Known Available N
Eastern Conventional Medium Texture Sites Not S Affected

\[ y = -0.0006x^2 + 0.4961x + 110.02 \]
\[ R^2 = 0.3547 \]
Return to N for Eastern conventional non-clay sites, S problem plots excluded 2010-11
Yield vs Total Known Available N
2011-12, clay sites only

\[ y = -1\times 10^{-5}x^2 + 0.3272x + 53.126 \]

\[ R^2 = 0.4561 \]
Return to N, clay sites, 2010 - 2011
$3-6 corn, 40cent-60cent N
Eastern North Dakota, medium-textured sites, S deficient site excluded, high-clay soils excluded

Return to N, $/acre vs. Total Known Available N, lb/acre
### Rutland site (long-term no-till, cover crop grazed) 2010

<table>
<thead>
<tr>
<th>N rate, lb/acre</th>
<th>Corn Yield, bu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>172</td>
</tr>
<tr>
<td>40</td>
<td>187* Most productive N rate LSD 10%</td>
</tr>
<tr>
<td>80</td>
<td>189</td>
</tr>
<tr>
<td>120</td>
<td>189</td>
</tr>
<tr>
<td>160</td>
<td>188</td>
</tr>
<tr>
<td>200</td>
<td>198</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>NS</td>
</tr>
</tbody>
</table>

### Most efficient use of N

68 + 50 + 50 -30 +40 = 178 lb N for 190 bu corn
Rutland fall cover crop grazed, spring 2010
Rutland site (long-term no-till, cover crop grazed) 2011

<table>
<thead>
<tr>
<th>N rate, lb/acre</th>
<th>Corn Yield, bu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>86</td>
</tr>
<tr>
<td>40</td>
<td>109</td>
</tr>
<tr>
<td>80</td>
<td>129</td>
</tr>
<tr>
<td>120</td>
<td>150</td>
</tr>
<tr>
<td>160</td>
<td>173 *</td>
</tr>
<tr>
<td>200</td>
<td>176</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>23</td>
</tr>
</tbody>
</table>

43 + 50 -30 +160 = 223 lb N for 173 bu corn
About 1.29 lb N/bu corn
Prosper site 2011
(high clay soil, wet conditions, after bean stubble residual N 43 lb/a; starter N 4 lb/acre)

<table>
<thead>
<tr>
<th>N rate, lb/acre</th>
<th>Corn Yield, bu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>49</td>
</tr>
<tr>
<td>40</td>
<td>66</td>
</tr>
<tr>
<td>80</td>
<td>76</td>
</tr>
<tr>
<td>120</td>
<td>99</td>
</tr>
<tr>
<td>160</td>
<td>95</td>
</tr>
<tr>
<td>200</td>
<td>106 *</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>28</td>
</tr>
</tbody>
</table>

Least efficient use of N
Top yield took $43 + 4 + 40 + 200 = 283$ lb N/acre
2.50 lb N/bu
Differences in efficiency were differences in soil conditions and tillage. Most of the differences were soil conditions—wetness
Microbial transformations of ammonia fertilizers set us up for loss
Ammonia volatility through urease

Nitrate loss after nitrification through leaching

Nitrous oxide loss after nitrification and denitrification
Nitrogen use efficiency-

Worldwide about 33% NUE
(Raun and Johnson, 1999)
- Nitrification inhibitors
- Urease inhibitor additives
- Nitrification and urease inhibitor
- Urease inhibition through chemical binding with urea as applied with slow-release properties
- Urease inhibition through physical separation of urea from soil
Nitrification inhibitors-

N-Serve® /Instinct®
nitrpyrin (2-chloro-6-[trichloromethyl] pyridine)

DCD, dicyandiamide
Fall N, Touchton et al., 1978

\[ y = 0.0013x^2 - 1.2107x + 269.82 \]
\[ R^2 = 0.64 \]

Spring N, Touchton et al., 1978

\[ y = -0.0183x^2 - 0.017x + 238.8 \]
\[ R^2 = 0.9175 \]
Some studies showed a yield increase with N-Serve, while others showed no yield increase. Yield increases were more a result of weather between application and N uptake rather than performance of the product.

Yield increases over the seven years in Minnesota were 15 bushels per acre more for fall anhydrous ammonia + N-Serve over fall anhydrous ammonia alone, and 27 bushels per acre more for spring anhydrous ammonia compared to fall anhydrous ammonia (Randall et al., 2008).
Instinct® is a new formulation of Nitrapyrin that can be mixed with ammonium fertilizers and can stay on the soil surface without incorporation.

Research so far at Minnesota, Illinois, Iowa and Nebraska have shown no yield benefit to the use of Instinct over N fertilizer alone, although the product inhibits nitrification (Kentucky, Schwab, unpublished data)
Wisconsin-

Corn yield increase with Instinct in 2008, but not 2009.
DCD- a nitrification inhibitor

Found in
- AgrotainPlus (Agrotain, Int.)
- SuperU (Agrotain, Int.)
- Guardian DF (Conklin)
- Guardian DL (Conklin)
<table>
<thead>
<tr>
<th></th>
<th>No. of comparisons</th>
<th></th>
<th>Average response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>With significant advantage</td>
<td>%</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>4</td>
<td>1</td>
<td>+1.6</td>
</tr>
<tr>
<td>Spring</td>
<td>15</td>
<td>3</td>
<td>+3.4</td>
</tr>
<tr>
<td>Sidedress</td>
<td>3</td>
<td>1</td>
<td>+1.4</td>
</tr>
<tr>
<td><strong>N Source</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonium sulfate</td>
<td>2</td>
<td>0</td>
<td>-1.0</td>
</tr>
<tr>
<td>Anhydrous ammonia</td>
<td>6</td>
<td>1</td>
<td>+3.6</td>
</tr>
<tr>
<td>Urea</td>
<td>4</td>
<td>4</td>
<td>+2.2</td>
</tr>
</tbody>
</table>

From Malzer et al., 1989
**NBPT** (N-(n-butyl) thiophosphoric acid triamide)

Agrotain

Competes for active sites on the urease enzyme and ties up activity for about 10 days, depending on weather conditions.
Yield for side-dressed no-till corn in Hardin County, KY.
(From Schwab and Murdock, 2009)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield, bushels per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check (50 lb N/acre preplant N only)</td>
<td>117d*</td>
</tr>
<tr>
<td>Urea</td>
<td>158c</td>
</tr>
<tr>
<td>Urea + Agrotain</td>
<td>201b</td>
</tr>
<tr>
<td>SuperU</td>
<td>201b</td>
</tr>
<tr>
<td>UAN</td>
<td>150c</td>
</tr>
<tr>
<td>UAN + Agrotain</td>
<td>179bc</td>
</tr>
<tr>
<td>UAN + Agrotain Plus</td>
<td>175bc</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>239a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Corn Yield bu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea surface applied</td>
<td>130</td>
</tr>
<tr>
<td>Urea surface applied + Agrotain</td>
<td>143</td>
</tr>
</tbody>
</table>
Illinois, average of four southern Illinois locations, Varsa et al., 1999.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Corn Yield (bu/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea surface applied</td>
<td>106</td>
</tr>
<tr>
<td>Urea surface applied + Agrotain</td>
<td>125</td>
</tr>
</tbody>
</table>
Economics of preplant N vs split-applied N

On high-clay soils, it took about 2 X the N rate to achieve similar (?) yields as medium textured soils with better drainage.

$120 \text{ lb N} \times $0.50/\text{lb N} = $60/\text{acre}.$

Cost in yield and return if you ignore a wet spring-
$50 \text{ bu/acre} @ $6/\text{bu} = $300/\text{acre}.$
Cost of a 12-row coulter unit for 28% side-dress = $50,000.

Cost of 2\textsuperscript{nd} application $8/acre.

Extra cost of 80 lb N as 28% vs urea- $8

Total cost per acre of side-dress over 1,500 acres corn- paying for coulter unit in year 1- $74,000
1,500 acres X 120 lb N X $0.50 = $90,000
1,500 acres X $300 lost revenue = $450,000
Total cost of not side-dressing = $540,000

Return for side-dressing =

$540,000 - $74,000 = $466,000
If you knew what the yield was going to be beforehand, the yield-based formula for nearly every conventional site on medium-lighter textured soils in the east would be

1.1 \times \text{YP} \text{ less credits} = \text{N rate}

Subtracting 50 lb N credit for long-term no-till placed these sites within this same formula.
Clay sites needed about 120 lb N more than the 1.1 formula to achieve maximum yield.

Probably 120+ lb N/acre were lost from these sites in 2011 due to May/June wetness.
Where to go from here?

Will repeat these experiments in different fields in 2012 and 2013.

Some of the cooperators will provide sites in 2012, but some won’t.

If you would like to have 100 ft X 120 ft experiment on your land in 2012, contact me.