Nitrogen management on sandy soils

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Nitrogen rate response trials

- Purdue and farmer fields
- 4-6 N rates replicated 4-6 times
- Calibrated yield monitor
- Yield response fit with equation to determine opt. N rate and yield
Tracy loamy sand

\[ y = -0.0018x^2 + 0.8496x + 131.86 \]
\[ R^2 = 0.9946 \]

\[ y = -0.0014x^2 + 0.6954x + 151.23 \]
\[ R^2 = 0.9417 \]

Grain yield, bu/a

Total nitrogen, lb/a

Low – 132 bu/a
High – 236 bu/a
Delta – 104 bu/a
Table 3. Range of economic optimum N rate (EONR) values (lbs/ac applied N) for corn following soybean as influenced by nitrogen cost per lb. N (Table 8) and grain price per bushel based on yield response data summarized throughout Indiana on sandy, non-irrigated soils. The average agronomic optimum N rate for these sandy, non-irrigated soils is approximately 184 lbs N/ac.

<table>
<thead>
<tr>
<th>Sandy non-irrigated soils</th>
<th>Grain price</th>
</tr>
</thead>
<tbody>
<tr>
<td>N cost</td>
<td>$2.50</td>
</tr>
<tr>
<td>$0.30</td>
<td>166</td>
</tr>
<tr>
<td>$0.40</td>
<td>160</td>
</tr>
<tr>
<td>$0.50</td>
<td>154</td>
</tr>
<tr>
<td>$0.60</td>
<td>148</td>
</tr>
<tr>
<td>$0.70</td>
<td>142</td>
</tr>
<tr>
<td>$0.80</td>
<td>136</td>
</tr>
</tbody>
</table>

Based on 14 field-scale trials conducted 2006-2014. These rates assume N management practices that minimize the risk of N loss prior to plant uptake.
June and July rain is positive

y = 9.1688x + 78.876
R² = 0.8741

y = 9.5745x + 86.429
R² = 0.6081

Grain yield, bu/ac vs June + July rainfall, inches
Irrigated corn response to N
Optimum N rate varies
N uptake rates

|---------------------|------|-----|------|------|------|-----|------|------|-----|------|

Vegetative Growth Stages

<table>
<thead>
<tr>
<th>Age (Days)</th>
<th>4</th>
<th>7</th>
<th>8</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>N uptake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lb N/a/day</td>
<td>4.7</td>
<td>4.0</td>
<td>2.4</td>
<td></td>
<td></td>
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</table>

Reproductive Growth Stages

<table>
<thead>
<tr>
<th>Age (Days)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>N uptake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lb N/a/day</td>
<td>1.7</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Growing Degree Days

0 500 1000 1500 2000 2500 3000

Above-ground plant N, lb/acre

Miller, Nielsen, Camberato, 2010
Nitrogen fertilization to feed the crop

• Provide N early
  • N accumulated rapidly during vegetative growth, about 5 lb N/ac/day
  • Normally 2/3 of total

• Ensure N availability late
  • N accum. at similar rate per GDD as during veg. growth
  • Normally about 1/3 of total
  • Crop can accum. N faster if crop is N deficient
Nitrogen fertilizer forms

• Anhydrous ammonia
  • dissolves in water to form ammonium

• Urea ammonium nitrate
  • Urea (at application) and nitrate are leachable, but not ammonium
  • Urea is rapidly converted to ammonia/ammonium (1-3 d)
  • If left on surface ammonia loss can occur

• Ammonium is converted to nitrate in a few days to weeks
Nitrogen fertilizers

• Banding and urease inhibitors (NBPT, NPPT) reduce ammonia loss from surface-applied urea
• Banded fertilizers convert more slowly to nitrate (AA slower than UAN)
• Nitrification inhibitors (nitrapyrin, DCD) slow conversion of ammonium to nitrate
Irrigated corn N suggestions

• pH, P, K, S, and micronutrients and everything else provided at sufficient levels
• Minimize preplant N
• Use starter N – 25-40 lb N/ac, 10-15 lb P₂O₅/ac, plus S or Zn if needed (K?)
Irrigated corn N suggestions

• If 3 or more applications are planned
  • Sidedress V4-V7 to target N rate minus 30-50 lb N/ac
  • include strip at target +30 in several fields

• Apply remainder of N with irrigation by V12-V14
Potential tools for estimating N requirement

• Soil sampling for nitrate
• Sensors – SPAD, Greenseeker, OptRx, aerial photography
• Computer models – Climate Corp. N advisor, Pioneer Encirca, Agron. Tech. AdaptN
Soil N sampling and handling

- Soil N is quite variable, choose representative areas and take a lot of soil cores
- Keep samples cool until they can be dried by spreading thinly and air drying or dry in an oven at less than 250 °F
- Ship to laboratory
Soil N sampling suggestions

• 1-2’ in addition to 0-1’ when early-season rainfall may have moved some nitrate deeper in the soil (sandy soils)

• Ammonium-N (NH$_4^+$) in addition to nitrate (NO$_3^-$) if soil temperatures have been cooler than normal or recent N application
Assessing N loss with soil sampling

Expected level of NO$_3$-N or (NO$_3$-N + NH$_4$-N) in a 1 foot soil sample at different fertilizer application rates

<table>
<thead>
<tr>
<th>Fertilizer N applied prior to rains (lb/acre)</th>
<th>NO$_3$-N</th>
<th>NO$_3$-N + NH$_4$-N</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td>30</td>
<td>36</td>
</tr>
<tr>
<td>140</td>
<td>31</td>
<td>37</td>
</tr>
<tr>
<td>150</td>
<td>33</td>
<td>39</td>
</tr>
<tr>
<td>160</td>
<td>35</td>
<td>41</td>
</tr>
<tr>
<td>170</td>
<td>36</td>
<td>42</td>
</tr>
<tr>
<td>180</td>
<td>38</td>
<td>44</td>
</tr>
<tr>
<td>190</td>
<td>40</td>
<td>46</td>
</tr>
</tbody>
</table>

Apply 10 lb N/acre for every 2 ppm below expected level.
Adjustment for plant N uptake

Days after planting

Plant N content, lb/acre

V7 injection of UAN, 2010 PPAC
Adjustment for plant N uptake

• Plant N content / 4 = soil NO₃-N in ppm in upper 1’ of soil

• At V10 plant N content will be about 40-80 lb N/acre and will have reduced soil NO₃-N about 10-20 ppm
Sensing and imagery

• Requires a reference strip for each hybrid in each field
• Differences are not normally detectable early, if they are yield may be lost
• Best utilized for rescue or perhaps for variable rate application of supplemental N
The greater and later the stress the greater the decrease in yield.

Yield loss with N stress

<table>
<thead>
<tr>
<th>Sufficiency Index</th>
<th>Yield loss with delayed N application, bu/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.65</td>
<td>1.24</td>
</tr>
<tr>
<td>0.75</td>
<td>0.67</td>
</tr>
<tr>
<td>0.85</td>
<td>0.30</td>
</tr>
<tr>
<td>0.95</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Computer models

• Pioneer – Encirca Yield Nitrogen Management Service
• The Climate Corporation – Field Pro Nitrogen Advisor
• Agronomic Technology Corp. - AdaptN
Ammonia-N (NH₃)
- Volatilize
- If exposed on soil surface
  - Up to 20% loss over 5 days

Urea-N
- Urease enzymes
- Soil solution

Ammonium-N (NH₄⁺)
- Nitrification bacteria
- Nitrification (bacteria)

Ammonium-N (NH₄⁺)
- Soil solution
- Urease enzymes
- Urea

Liquid UAN
- Urease enzymes
- Urea
- Soil solution

Organic matter
- Immobilization (decomposers)

Nitrate-N (NO₃⁻)
- Microbial denitrification
- Excessive rains, Sandier soils
- Leach

N₂ gas
- Microbial denitrification

Bob Nielsen’s slide

Volatilize

Plant residues

Up to 5% loss per day
Computer models utilize some or all of these factors

- Anticipated yield and corn growth/N uptake models
  - Typically assume 1 lb N/bu yield

- Soil properties
  - Enhanced soil maps based on landscape parameters, sampling and analysis
Computer models utilize some or all of these factors:

- Estimate and predict soil N mineralization and loss of soil and fertilizer N
- Actual and historical weather
- N application amounts and dates, tillage, CRM, planting date, etc.
One model vs. std. rec. across 22 IN locations

Standard recommendation -$20/acre
Model recommendation -$95/acre

Model
Standard Rec.
Improving computer models

• All are yield based – Can we predict yield accurately? For different hybrids?

• N rec. is based on yield x N/bu factor of about 1.0
  – Research reveals N/bu factor can range from 0.8 to 1.6 lb N/bu
  – For 200 bu/acre corn the N demand would vary from 160 – 320 lb N/acre!!!!!!!!!!!!!!!

• Is variation in the lb N/bu factor a result of hybrid x env. x management interaction? How do we predict it?
Improving computer models

• The conversion of ammonium to nitrate determines the potential for N loss.............

• this process differs among soils and is dramatically slowed by banding

• How accurately can this be predicted for a given field area, N source, application timing?
Improving computer models

• Each model needs to be independently evaluated to determine its accuracy in making N recommendations
End-of-season cornstalk nitrate test

- Sample from ¼ milk line to 2 to 3 weeks after blacklayer
- Collect 8” segment from undamaged stalks 6” to 14” above the soil
- 15+ segments per sample, remove leaf sheaths
- mail to lab in paper bag (refrigerate, not freeze, samples if stored for more than a day)
Lower stalk NO$_3$-N accumulates often when N rate exceeds that needed for maximum yield.
Cornstalk nitrate relationship to yield
Sufficiency of N supply according to end-of-season cornstalk nitrate nitrate

<table>
<thead>
<tr>
<th>Corn stalk NO₃-N, ppm</th>
<th>Relative % yield</th>
<th>N deficit (-) or excess (+), pounds per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 250</td>
<td>81</td>
<td>-92</td>
</tr>
<tr>
<td>251 - 500</td>
<td>96</td>
<td>-27</td>
</tr>
<tr>
<td>501 - 1,000</td>
<td>96</td>
<td>-24</td>
</tr>
<tr>
<td>1,001 - 1,500</td>
<td>98</td>
<td>-9</td>
</tr>
<tr>
<td>1,501 - 2,000</td>
<td>99</td>
<td>5</td>
</tr>
<tr>
<td>2,001 - 4,000</td>
<td>100</td>
<td>33</td>
</tr>
<tr>
<td>4,001 - 8,000</td>
<td>99</td>
<td>53</td>
</tr>
<tr>
<td>&gt; 8,000</td>
<td>100</td>
<td>77</td>
</tr>
</tbody>
</table>
Cornstalk nitrate assessment

Much more than enough!
Cornstalk nitrate summary

• Multiple-season evaluations of cornstalk nitrate are suggested before modifying a N management plan
• Cornstalk nitrate is a good indicator of sufficient to more than enough N
• Low cornstalk nitrate levels do not necessarily indicate insufficient N supply
• Consider strip trials if <250 ppm or >4,000 ppm to determine adjustment to N rate
Questions?