Nitrogen fertilizer management to increase efficiency

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Lucas Haag

Overview

• Identifying nitrogen lost potential
• Management to increase N efficiency in corn
• The role of additives and other management tools
Economic optimum N vs maximum agronomic N?

\[ y = 78 + 0.89x - 0.0019x^2 \]

118 trials in Kansas

Should I cut back on N rates with current prices? How much?

[Graph showing net return to N ($/acre) vs N rate (lbs N/acre)]

[Legend: Max Return to N, < ~10%]
Managing nitrogen: key N processes affecting use efficiency

1. Volatilization
2. Denitrification
3. Leaching
4. Immobilization

Soil temperature and nitrogen processes (driven by microbial activity)

• Nitrification (NH4 → NO3): ~ 50 F
  – Also presence of oxygen in the soil

• Denitrification (NO3 → gas-N): ~ 75 F and higher
  – Also waterlogged conditions (no oxygen)
Soil temperature and duration of waterlogged conditions on denitrification

<table>
<thead>
<tr>
<th>Length of Saturation (days)</th>
<th>Soil Temperature (degrees F)</th>
<th>Nitrate-N Loss (% of NO3 present)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>55 - 60</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>55 - 60</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>75 - 80</td>
<td>60</td>
</tr>
</tbody>
</table>

Soil N during the growing season

![Graph showing N application rate 150 lbs as spring AA](image)
Use of nitrification inhibitor (N-serve) with NH3 (150 lbs/a)

Soils/environment prone to leaching or denitrification

Use of nitrification inhibitor with anhydrous ammonia (over 10 site years)

Grain Nitrogen uptake with yield

Nitrogen fertilizer efficiency
Use of nitrification inhibitor with anhydrous ammonia (over 10 site years)

Net return to N fertilizer

Com:N price ratio = 7.5

Urease inhibitors for side-dress urea

• Source: urea!
  Urea → NH3 → NH4
• Temperature
• Wind
• Moisture
• Soil pH
• Urease in the soil (residue)
N fertilizer efficiency with improved management in corn

\[ y = 140 + x - 0.0227x^2 \quad R^2 = 0.95 \]

**Compared to broadcast urea**

- Streamed UAN planting =
- Coulter UAN planting +
- 2x2 UAN planting +
- Broadcast ESN planting -
- Broadcast Urea+NBPT planting =
- Streamed UAN V6-V8 -
- Broadcast Super-U V6-V8 -

Nitrogen fertilizer source, time placement combinations to increase efficiency

- UAN Coulter
- Urea+NBPT
- Super-U @ V6
- UAN Streamed
- UAN Streamed @ V6
- ESN
- UAN Dribble

N agronomic efficiency (kg kg\(^{-1}\))

Irrigated, Rossville, 2021
Compared to broadcast urea

<table>
<thead>
<tr>
<th>Placement</th>
<th>Source</th>
<th>Time</th>
<th>“Efficiency”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streamed</td>
<td>UAN</td>
<td>planting</td>
<td>+</td>
</tr>
<tr>
<td>Coulter</td>
<td>Urea</td>
<td>planting</td>
<td>+</td>
</tr>
<tr>
<td>Broadcast</td>
<td>Super-U</td>
<td>planting</td>
<td>+</td>
</tr>
<tr>
<td>Broadcast</td>
<td>Urea+NBPT</td>
<td>planting</td>
<td>=</td>
</tr>
<tr>
<td>Broadcast</td>
<td>UAN+Agrotain</td>
<td>april/may</td>
<td>+</td>
</tr>
</tbody>
</table>

\[ y = 71 + 0.43x - 0.0015x^2 \]
\[ R^2 \approx 0.95 \]
Managing nitrogen in season: key processes affecting N use efficiency

<table>
<thead>
<tr>
<th>Loss process</th>
<th>N form</th>
<th>Management options</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Corn response to N applied with and without PivotBio-Proven

Plant N uptake

Grain yield
Grain sorghum response to N and PivotBio-Proven

Increasing nitrogen use/ minimize loses

- Combination of source, placement and time based on risk for N loss for specific condition
- Use of inhibitors can help during years/conditions of N loses (consider “average” multi-year)
- Biologicals/inoculants for N fixing show inconsistent results for N in field conditions
  - Basic research show potential, and ongoing developments
## Manure nutrients

<table>
<thead>
<tr>
<th>% Dry Matter</th>
<th>Total N</th>
<th>NH$_4$</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
<th>lbs/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy</td>
<td>21</td>
<td>9</td>
<td>5</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Beef</td>
<td>50</td>
<td>21</td>
<td>8</td>
<td>18</td>
<td>26</td>
</tr>
<tr>
<td>Swine</td>
<td>18</td>
<td>8</td>
<td>5</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Poultry</td>
<td>75</td>
<td>56</td>
<td>36</td>
<td>45</td>
<td>34</td>
</tr>
</tbody>
</table>

## Average animal manure micronutrient content of different sources

<table>
<thead>
<tr>
<th>Manure source</th>
<th>Iron</th>
<th>Manganese</th>
<th>Boron</th>
<th>Zinc</th>
<th>Copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy solid</td>
<td>0.5</td>
<td>0.06</td>
<td>0.01</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Swine solid</td>
<td>19.0</td>
<td>1.09</td>
<td>0.04</td>
<td>0.79</td>
<td>0.50</td>
</tr>
<tr>
<td>Poultry</td>
<td>3.0</td>
<td>0.61</td>
<td>0.08</td>
<td>0.48</td>
<td>0.66</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
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<th>Manganese</th>
<th>Boron</th>
<th>Zinc</th>
<th>Copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy liquid</td>
<td>0.9</td>
<td>0.11</td>
<td>0.03</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>Swine liquid</td>
<td>2.5</td>
<td>0.23</td>
<td>0.06</td>
<td>1.03</td>
<td>0.62</td>
</tr>
</tbody>
</table>
Manure nitrogen availability

- Inorganic N is all available.
- Organic N available the first year compared with fertilizer (MF-2562):
  - Liquid manure: 30%
  - Solid manure: 25%
  - Compost: 20%
- As for fertilizers, these numbers indicate potential availability.
- Assumes injection or incorporation and "best management practices".

Residual soil nitrate: effects on wheat yield
Soil sample handling: effects on NO3

Nitrogen volatilization loss from top-dress urea in wheat
Impact of sample handling practices on soil test results

Bryan Rutter
KSRE Soil Test Lab

Research Questions
Current recs are to get samples to the lab asap...

• Common sense, but Murphy’s Law...
• What happens if it takes a while to get samples into the lab?
• What if storage conditions aren’t ideal in the mean time?
Lab Study: Experiment Design

100 lbs bulk soil → Mix → Sieve → Bag subsamples → Randomize Bags

Lab Study: Site Description

- **Soil pH**: 7.6
- **SOM %**: 2.7
- **Sand %**: 18
- **Silt %**: 62
- **Clay %**: 20
- **CEC meq/100g**: 15

- Dryland, Strip-till
- Silt Loam
- Water content = 19 %
Box temperature

Soil Tests and Comparisons

Soil pH, Buffer pH, SOM, N, P, K, S, Cu, Fe, Mn, Zn

- Storage Environment
- Time
- Storage x Time

Soil tests grouped by effects

<table>
<thead>
<tr>
<th>No Changes</th>
<th>Change Over Time Only</th>
<th>Time x Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH</td>
<td>Cu</td>
<td>NO₃-N</td>
</tr>
<tr>
<td>Buffer pH</td>
<td>Fe</td>
<td>S</td>
</tr>
<tr>
<td>SOM</td>
<td>Mn</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Zn</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₄-N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Micronutrients
- Statistical significance
- Agronomic significance?

Closer look at Nitrogen
Effects on variability?

Conclusions

- Sample handling affects soil tests, especially N
- Warm storage temps corresponded to large increases in NO₃ over time
- Warm temps may increase NO₃ variability
Recommendations and Guidelines

- Get samples to the lab A.S.A.P
  - Let this be my problem, not yours...

If unable to get to the lab soon:

- Air-dry if you can
- Refrigerate < 40 F if you can’t air-dry

**Relationship between number of soil cores per composite sample and error for 0-24 inches**

Haag, Patel, Tomlinson, and Rajan, unpublished, data, 2021
Summary - Corn

pH decreased ~ 0.5 unit by N

SOM increased ~ 0.3% by N & P

Soil test P not maintained with 40 P
Long-term Corn Fertility

After 60 years

Soil pH

N Rate, lb/a

No effect from P fertilization

SOM after 60 years of N and P Fertilization
Irrigated Continuous Corn, Conventional Tillage
K-State SWREC, Tribune, KS, 1961-2020

Initial SOM in 1961 = 1.4%, LSD(0.05) = 0.1%
Prior to 1950, land was dryland farmed an unknown number of years,
assumed to be a wheat-fallow rotation

Schlegel, Bond, and Haag

Annual N application Rate, lbs/acre

0 P 40 P 80 P

Annual P₂O₅ Application Rate, lbs/acre
SWREC-Tribune, Long-Term Irrigated Corn Fertility Trial (2013-2022)

Relative Yield, % of Max

Nitrogen, lb/ac

Summary – Grain Sorghum
pH decreased ~ 1.2 unit by N
SOM increased ~ 0.5% by N & P
Soil test P increased with 40 P
Discussion on New Recommendations
Questions/ Discussion

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