Nitrogen fertilizer management to increase efficiency

Dorivar Ruiz Diaz
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?

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 \(\rightarrow\) NO3): \(\sim\) 50 F
  – Also presence of oxygen in the soil

• Denitrification (NO3 \(\rightarrow\) gas-N): \(\sim\) 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

N application rate 150 lbs as spring AA

Average of 4 locations 2017-2018

Average of NO₃

Average of NH₄
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

Net return to N (\(¥ \text{a}^{-1}\))

Com:N price ratio = 7.5

Urease inhibitors for side-dress urea

Benefit under conditions with high risk for volatilization
- Source: urea!
  Urea \(\rightarrow\) NH3 \(\rightarrow\) NH4
- Temperature
- Wind
- Moisture
- Soil pH
- Urease in the soil (residue)
N fertilizer efficiency with improved management in corn

Irrigated, Rossville, 2021

Compared to broadcast urea

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fertilizer</th>
<th>Time Placement</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streamed</td>
<td>UAN</td>
<td>planting</td>
<td>=</td>
</tr>
<tr>
<td>Coulter</td>
<td>UAN</td>
<td>planting</td>
<td>+</td>
</tr>
<tr>
<td>2x2</td>
<td>UAN</td>
<td>planting</td>
<td>+</td>
</tr>
<tr>
<td>Broadcast</td>
<td>ESN</td>
<td>planting</td>
<td>-</td>
</tr>
<tr>
<td>Broadcast</td>
<td>Urea+NBPT</td>
<td>planting</td>
<td>=</td>
</tr>
<tr>
<td>Streamed</td>
<td>UAN</td>
<td>V6-V8</td>
<td>-</td>
</tr>
<tr>
<td>Broadcast</td>
<td>Super-U</td>
<td>V6-V8</td>
<td>-</td>
</tr>
</tbody>
</table>

Nitrogen fertilizer source, time placement combinations to increase efficiency

4 sites 2022
Sorghum and N fertilizer management

Compared to broadcast urea

<table>
<thead>
<tr>
<th>Placement</th>
<th>Source</th>
<th>Time</th>
<th>&quot;Efficiency&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streamed</td>
<td>UAN</td>
<td>April/May</td>
<td>+</td>
</tr>
<tr>
<td>Coulter</td>
<td>Urea</td>
<td>April/May</td>
<td>+</td>
</tr>
<tr>
<td>Broadcast</td>
<td>Super-U</td>
<td>April/May</td>
<td>=</td>
</tr>
<tr>
<td>Broadcast</td>
<td>Urea+NBPT</td>
<td>April/May</td>
<td>+</td>
</tr>
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Subsurface Urea before planting

~25 lbs

Sorghum, Hays 2021

Sorghum and N fertilizer management

Compared to broadcast urea

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<tr>
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<td>Urea</td>
<td>April/May</td>
<td>+</td>
</tr>
<tr>
<td>Broadcast</td>
<td>Super-U</td>
<td>April/May</td>
<td>=</td>
</tr>
<tr>
<td>Broadcast</td>
<td>Urea+NBPT</td>
<td>April/May</td>
<td>+</td>
</tr>
<tr>
<td>Streamed</td>
<td>UAN+Agrotain</td>
<td>April/May</td>
<td>+</td>
</tr>
</tbody>
</table>

Streamed UAN + NBPT

~28 lbs

Sorghum, Ashland 2022
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>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Corn response to N applied with and without PivotBio-Proven

Plant N uptake

Grain yield
Grain sorghum response to N and PivotBio-Proven

Roozeboom, Haag, Ruiz Diaz, and Rice

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>NH₄</th>
<th>P₂O₅</th>
<th>K₂O</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></td>
<td>lb/wet ton</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<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>
<tr>
<td></td>
<td>lb/1000 gal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<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

None Cold Storage Truck Bed Storage

Days:  0  2  4  6  8  10  12  14  2  4  6  8  10  12  14

Lab Study: Site Description

<table>
<thead>
<tr>
<th>Soil pH</th>
<th>SOM %</th>
<th>Sand %</th>
<th>Silt %</th>
<th>Clay %</th>
<th>CEC meq/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.6</td>
<td>2.7</td>
<td>18</td>
<td>62</td>
<td>20</td>
<td>15</td>
</tr>
</tbody>
</table>

- 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></th>
<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>
<td></td>
</tr>
<tr>
<td>Buffer pH</td>
<td>Fe</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>SOM</td>
<td>Mn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Zn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₄-N</td>
<td></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 NO$_3$ over time
• Warm temps may increase NO$_3$ 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
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

No effect from P fertilization

N Rate, lb/a

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)

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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