Intelligent Inputs: Fertility Considerations

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Approaches to N Recs

• Maximum Return to Nitrogen (MRTN)
  – IA, MN, WI, IL, IN, MI, OH
  – State specific
  – No profile N credit, OM credit embedded

• NDSU MRTN
  – Does account for profile N
  – No explicit OM credit

• Mechanistic
  – KSU, CSU, UNL, OSU, ServiTech, AAL

Lets talk about the mechanistic approach to N recommendations

• The overall idea is to think about peak plant uptake needs, and then work backwards

\[ N_{rec} = YG \times \text{some factor} - \text{credits} \]

  Organic Matter, Profile NO_3, PCA

Common misconception is that it’s a removal based system.... NOT TRUE!
Let's talk about the mechanistic approach to N recommendations

- So why this approach vs. what other states of done?
  - Residual Nitrate. In Kansas production systems it's real, it's measurable, and it's valuable
  - Wide range of yield potentials and environmental factors
    - Irrigated vs. Dryland
    - East to West
    - Heavy silt loams vs. blow sand

Past K-State Recommendation

“Old” K-State Corn Nrec

\[ \text{Nrec} = \text{YG} \times 1.6 - \text{Profile N} - \text{Soil OM Credit} - \text{Other Credits} \]

But what about lbs/bu?

“You KSU guys are nuts!
It doesn’t take 1.6 lbs/bu, I can do it on 0.7!”

- The farm press as well as many producers and consultants want to think in terms of lbs/bu
  - A nice simple number for bragging rights
  - Probably not a bad approach in the corn belt
  - Maybe useful in less dynamic systems in Kansas (e.g. continuous irrigated corn)

- BUT:
  - If you don’t know NO₃ at the beginning and end of the season, it’s really not that useful of a number
### Corn

\[ N \frac{lbs}{a} = \left[ \frac{ie}{fe} EY - (se)NO3 - SOM - PCA \right] \times Price_{Adj} \]

Minimum N rate = 30 lbs/a

<table>
<thead>
<tr>
<th>ie (corn internal efficiency) lbs/bu</th>
<th>0.84</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Irrig</td>
<td>0.88</td>
</tr>
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<table>
<thead>
<tr>
<th>fe (fertilizer recovery efficiency)</th>
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<tbody>
<tr>
<td>High efficiency</td>
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<tr>
<td>Default</td>
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<tr>
<td>Low efficiency</td>
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<table>
<thead>
<tr>
<th>se (&quot;soil&quot; NO3 efficiency)</th>
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<tbody>
<tr>
<td>Low N loss</td>
</tr>
<tr>
<td>Medium texture or western KS</td>
</tr>
<tr>
<td>High N loss</td>
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<tr>
<td>Corse texture or eastern KS</td>
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</tbody>
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### Sorghum

\[ N \frac{lbs}{a} = \left[ \frac{ie}{fe} EY - (se)NO3 - SOM - PCA \right] \times Price_{Adj} \]

Minimum N rate = 30 lbs/a

<table>
<thead>
<tr>
<th>ie (sorghum internal efficiency), lbs/bu</th>
<th>1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum</td>
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<table>
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<th>fe (fertilizer recovery efficiency)</th>
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<tr>
<td>High efficiency</td>
</tr>
<tr>
<td>Injected + split applied</td>
</tr>
<tr>
<td>Default</td>
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<tr>
<td>Pre-plant</td>
</tr>
<tr>
<td>Low efficiency</td>
</tr>
<tr>
<td>Broadcast and applied in the fall</td>
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### Let's talk about the mechanistic approach to N recommendations

- **Limitations**
  - At the end of the day, its still a best guess (as is any N recommendation method)
  - Lots of moving pieces
    - Soil Efficiency
    - Fertilizer Efficiency
    - Organic Matter Mineralization
Economic Choices in N Management

OK, we said that applying whatever N it takes to meet the yield goal is essentially a “no-brainer”, even at today’s fertilizer prices (because it’s relative to crop prices)
Economic Choices
So where is there money to be made in Nitrogen management today?

1. Importance of using a proper yield goal
   1. For us in the west, this is heavily water driven

2. Knowing what we have. This is really important if we screwed up on step 1 last year (e.g. drought).

3. Economic benefits to implementing 4R
   i.e. reducing cost through improving fertilizer efficiency

Value of Knowing Soil Nitrate - Irrigated

- Nrec = 140 lb/ac, Ncost = $136/ac
- YG = 235 bu/ac, $5.25 Corn, $0.97 N, 2.5% OM
- Standard Preplant N Application (65% eff), 100% se

Value of Knowing Soil Nitrate - Dryland

- Nrec = 10
- Ncost = $9.70/ac

- Nrec = 95 lb/ac
- Ncost = $92.15/ac

- Nrec = 15 lb residual NO3
- Ncost = $9.70/ac

- Nrec = 80 lb residual NO3
- Ncost = $10.25/ac
Economics of Timing and Placement

- Nrec = 195
- Ncost = $68.25/ac
- Difference of $19.22/ac

YG=235 bu/ac, $3.80 Corn, $0.35 N, 10.9 price ratio
2.5% OM, 30 lb NO3

Economics of Timing and Placement

- Nrec = 195
- Ncost = $189/ac
- Difference of $53/ac

YG=235 bu/ac, $5.25 Corn, $0.97 N, 5.4 Price Ratio
2.5% OM, 30 lb NO3

Economics of Product Price, Timing, and Placement

- Nrec = 195
- Ncost = $68.25/ac
- Difference of $31.75/ac

Also ignores differences in volatilization risk
YG=235 bu/ac, $3.80 Corn, $0.35 UAN / $0.40 urea, 2.5% OM, 30 lb NO3

Results: N fertilizer efficiency with improved management in corn

- UAN coulter injected at planting

Compared to broadcast urea
Streamed UAN planting =
Coulter UAN planting +
3x2 UAN planting +
Broadcast ESN planting -
Broadcast Urea+NBPT planting =
Streamed UAN V6-V8 -
Broadcast Super-U V6-V8 -

Rossville, 2021

N fertilizer rate (lbs/acre)
Timing

• Some limitations in dryland, but still important
  – Moisture to move N into profile
  – Avoiding “tie-up”, minimizing volatilization potential
• Great opportunities with fertigation

Source

• Cost per lb. of nutrient
  – Always do the math!
• Equipment Considerations
  – VRT Equipment
• Source vs. Timing of Application

Phosphorus corn response study

• Wheat P study (completed): results show higher STP critical value than current 20 ppm
• Corn P Study (ongoing)
• Other crops: Soybean and sorghum?
  – Ongoing project with the KSC on soybean

The study was set up in 13 sites in 2021 and 20 sites in 2022. Total of 33 sites
Yield response to P

Across all sites

Responsive sites only

Different soil test phosphorus methods

Soils with a pH > 7.4 are indicated by red points.

Relationship between relative yield and tissue concentration

$ return to 60 lbs of P$_2$O$_5$ in the year of application in corn

2021 sites only

12 locations in 2021

Corn: $5.25/bu

P$_2$O$_5$: $0.86/lb

70 lbs Rec

30 lbs Rec

15 lbs Rec

12 locations in 2021

Soil test P M3, (ppm)
Phosphorus in wheat

- 24 locations in two years (2019 and 2020)
  - 18 Farmer’s field
  - 6 University

Early and late plant response

Treatments

- 4 P fertilizer rates as fall broadcast pre-plant
  - Nitrogen 50 lbs as pre-plant and 50 lbs at spring green up
- RCBD Design with four reps

<table>
<thead>
<tr>
<th>P rate (lbs P2O5/a)</th>
<th>N rate (lb N/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>120</td>
<td>100</td>
</tr>
</tbody>
</table>
Soil test critical values at 90 and 95% relative yield with 5 soil test methods and two regression models:

**M3 vs Olsen**

- **Mehlich3 P, mg kg⁻¹**
  - 0 1 2 3 4 5 6 7 8 0 5 10 15 20 25 30 35
- **Olsen P, mg kg⁻¹**
  - 0 5 10 15 20
- \(y = 1.93 + 0.43x\)
- \(R^2 = 0.93\)

**M3 vs Bray 1**

- **Mehlich3 P, mg kg⁻¹**
  - 0 1 2 3 4 5 6 7 8 0 10 20 30 40 50 60
- **Bray P, mg kg⁻¹**
  - 0 10 20 30 40 50 60
- \(y = 1.67 + 0.73x\)
- \(R^2 = 0.97\)

**pH:** > 7.6

**Calcium carbonate:** > 8%

**M3 vs H3A**

- **Mehlich3 P, mg kg⁻¹**
  - 0 1 2 3 4 5 6 7 8 0
- **H3A P, mg kg⁻¹**
  - 0 10 20 30 40 50 60 70
- \(y = -1.66 + 0.99x\)
- \(R^2 = 0.95\)

**Mehlich-3 : Bray 1 vs soil pH and carbonates**

- **Mehlich3 vs Bray 1**
  - Soil pH: 5.0 to 8.5
  - Soil Carbonates %: 0.0 to 15.0

**Mehlich-3 : H3A vs soil pH and carbonates**

- **Mehlich3 vs H3A**
  - Soil pH: 5.0 to 8.5
  - Soil Carbonates %: 0.0 to 15.0
Cation extraction methods vs soil pH

- Strong correlations between M3 and AA extractable cations
- Simple linear regression models fit K, Mg, and Na data
  - Influence of soil pH appears negligible
- Curvilinear relationship for Ca
  - Strongly influenced by soil pH

M3 vs AA: extractable cations

M3 vs AA: cation exchange capacity

Cation exchange capacity difference vs. soil pH

\[
\text{pH}_{\text{bp}} = 7.39
\]
Changes in soil pH with surface lime application in no-till

Yield response to surface lime application for wheat, corn and soybean

Crop rotation in this order: wheat, corn, soybean (2017-2019)

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

Lab Study: Site Description

<table>
<thead>
<tr>
<th>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>

- 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>
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<tr>
<td>NH₄-N</td>
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Micronutrients
• Statistical significance
• Agronomic significance?

Nitrogen and Sulfur
lbs/ac = ppm x 0.3 x 24 inches
• Variability, but trends are clear
• Differences in inorganic N are large
• Representative sample?

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

Questions and Discussion

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