Wheat Fertility Management for Yield and Protein
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K-State Northwest Research-Extension Center, Colby, Kansas
K-State Southwest Research-Extension Center, Tribune, Kansas

2022 WheatRX - Phillipsburg

Grain : Nutrient Price Ratios

<table>
<thead>
<tr>
<th></th>
<th>Historical</th>
<th>Jun-22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn:Nitrogen</td>
<td>3.42</td>
<td>4.87</td>
</tr>
<tr>
<td>Wheat:Nitrogen</td>
<td>2.75</td>
<td>4.51</td>
</tr>
<tr>
<td>Corn:Phosphorus</td>
<td>5.05</td>
<td>5.53</td>
</tr>
<tr>
<td>Wheat:Phosphorus</td>
<td>4.07</td>
<td>5.12</td>
</tr>
</tbody>
</table>

4R nutrient stewardship?
- Right Source
- Right Rate
- Right Time
- Right Place
Phosphorus

- We’re going to talk mostly about N this morning
- Anything said about maximizing response to N assumes that we have taken care of P
- Are we aware of our removal rates (e.g. increase of soybeans in NCKS rotations)
- Wheat responds to starter P, especially when late planted or low STP soils
- Recent KSU research would suggest threshold STP may be closer to 25 ppm (Bray1/Mehlich3)

**Phosphorus removal values**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Unit</th>
<th>P₂O₅ (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>bushel</td>
<td>0.33</td>
</tr>
<tr>
<td>Grain Sorghum</td>
<td>bushel</td>
<td>0.40</td>
</tr>
<tr>
<td>Wheat</td>
<td>bushel</td>
<td>0.50</td>
</tr>
<tr>
<td>Sunflowers</td>
<td>pound</td>
<td>0.02</td>
</tr>
<tr>
<td>Oats</td>
<td>bushel</td>
<td>0.25</td>
</tr>
<tr>
<td>Soybeans</td>
<td>bushel</td>
<td>0.80</td>
</tr>
<tr>
<td>Dry Beans</td>
<td>cwt</td>
<td>1.32</td>
</tr>
<tr>
<td>Proso Millet</td>
<td>cwt</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Wheat Response to Soil Test P Level

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

```
Nrec = YG x some factor – credits
Organic Matter, Profile NO₃, PCA
```

Common misconception is that it’s a removal based system.... NOT TRUE!
But what about lbs/bu?

“You KSU guys are nuts! 2.4 lb/bu is a ridiculous amount of N!”

- The farm press as well as many producers and consultants want to think in terms of lbs/bu of yield
  - A nice simple number for bragging rights
  - 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

N_{rec} = YG \times 2.4 \ - \ \text{Profile N} - \ \text{Soil OM Credit} - \ \text{Other Credits}

(65 \times 2.4) - 40 \ \text{lb/ac} - (2.5 \times 10)

156 - 40 - 25 = 91 \ \text{lb/ac}
N Removal

Lbs of Nitrogen Removed in Wheat Grain, per Bushel

<table>
<thead>
<tr>
<th>Protein Content, %</th>
<th>Moisture Content 9.00</th>
<th>9.50</th>
<th>10.00</th>
<th>10.50</th>
<th>11.00</th>
<th>11.50</th>
<th>12.00</th>
<th>12.50</th>
<th>13.00</th>
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<tbody>
<tr>
<td>10.0</td>
<td>0.83</td>
<td>0.88</td>
<td>0.93</td>
<td>0.97</td>
<td>1.02</td>
<td>1.07</td>
<td>1.11</td>
<td>1.16</td>
<td>1.20</td>
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<td>10.5</td>
<td>0.83</td>
<td>0.88</td>
<td>0.92</td>
<td>0.97</td>
<td>1.01</td>
<td>1.06</td>
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<td>1.15</td>
<td>1.20</td>
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<td>1.29</td>
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<td>0.87</td>
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<td>1.01</td>
<td>1.05</td>
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<td>1.14</td>
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<td>0.91</td>
<td>0.96</td>
<td>1.00</td>
<td>1.05</td>
<td>1.10</td>
<td>1.14</td>
<td>1.18</td>
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<td>1.28</td>
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<td>0.86</td>
<td>0.91</td>
<td>0.95</td>
<td>1.00</td>
<td>1.04</td>
<td>1.09</td>
<td>1.13</td>
<td>1.18</td>
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<td>0.86</td>
<td>0.90</td>
<td>0.95</td>
<td>0.99</td>
<td>1.04</td>
<td>1.08</td>
<td>1.13</td>
<td>1.17</td>
<td>1.22</td>
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<td>0.85</td>
<td>0.90</td>
<td>0.94</td>
<td>0.98</td>
<td>1.03</td>
<td>1.07</td>
<td>1.12</td>
<td>1.16</td>
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<td>1.25</td>
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<td>0.93</td>
<td>0.98</td>
<td>1.02</td>
<td>1.07</td>
<td>1.11</td>
<td>1.16</td>
<td>1.20</td>
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Prepared by L. Haag, K-State Northwest Research-Extension Center, Colby

Determining your potential for N loss

- Identify potential N loss mechanisms
  - Runoff or runaround
  - Leaching
  - Denitrification
  - Volatilization
  - Immobilization

Most mechanisms involve water and are impacted by soil properties and temperature

How can I get the most from my nitrogen?

- Try to estimate how much N you really need.
- Figure out how much N is available in the soil.
- Sort out your potential for N loss and determine the likely N loss mechanism due to:
  - Local rainfall and climate
  - Soils, especially drainage, texture and pH
  - Management/cropping system
- Assess what tools are available to you.

Nitrogen – management factors

- How do we best utilize our N?
  - Timing – as close to utilization as possible
  - Rate – determine accurate application rates
  - Placement – apply below the soil surface if possible
  - Fertilizer source – AA, UAN, Urea
  - Specialty fertilizers – ESN
  - Fertilizer additives
    - Agrotain – urease inhibitor
    - N-Serve – nitrification inhibitor
    - Super U – urease and nitrification inhibitor
Application method of topdress N

<table>
<thead>
<tr>
<th>N rate (lbs/acre)</th>
<th>Nitrogen Source</th>
<th>Application Method</th>
<th>Yield (bu/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>46</td>
</tr>
<tr>
<td>60</td>
<td>Dry urea</td>
<td>Broadcast</td>
<td>51</td>
</tr>
<tr>
<td>60</td>
<td>UAN</td>
<td>Sprayed</td>
<td>47</td>
</tr>
<tr>
<td>60</td>
<td>UAN</td>
<td>Streamer bars</td>
<td>56</td>
</tr>
</tbody>
</table>

LSD (0.1) 3

Tucker and Mengel, 2008

Higher probability of significant profile N

- Medium-fine textured soils
- Recent history of excessive N rates
- Previous crop
  - Lower than expected yield
  - Drought affected
  - Previously destroyed stands of alfalfa/clovers
- Manure application
- Warm, late falls and/or early, warm springs

Perin, Santos, Lollato, Ruiz-Diaz, and Kluitenberg, 2020

Surface Applied Urea
Dates shown are dates of application
Losses ranged from 0.3 to 29.6% of total N applied

Tucker and Mengel, 2008
### Average soil nitrate levels

<table>
<thead>
<tr>
<th>Previous crop</th>
<th>Number of samples</th>
<th>Average Profile NO3 lb/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>1</td>
<td>103</td>
</tr>
<tr>
<td>Corn</td>
<td>11</td>
<td>65</td>
</tr>
<tr>
<td>Fallow</td>
<td>12</td>
<td>154</td>
</tr>
<tr>
<td>Sorghum</td>
<td>9</td>
<td>70</td>
</tr>
<tr>
<td>Soybean</td>
<td>4</td>
<td>84</td>
</tr>
<tr>
<td>Wheat</td>
<td>38</td>
<td>65</td>
</tr>
</tbody>
</table>

Fall sampling before wheat, range: 4-313

From a set of 75 samples. Soil testing lab. K-State, 2008

### Other Topdressing Thoughts

- Need to be aware of timing of application. Are we getting it on early enough?
- Pricing of UAN vs. Urea has been very tight at times, UAN has ½ the volatilization potential
- Streaming UAN as opposed to broadcast spray will minimize tie-up and reduce volatilization risk

### Rationale

- Current KSU recommendations allow for 20 - 30 lbs ac⁻¹ nitrogen with the seed when in 7.5 – 10” spacing
- However we recommend no seed placed urea
- Research in the Northern Great Plains and Prairie Provinces indicates the use of urea and urea products may be possible
A moment for clarification...

- This study was not designed to evaluate wheat response to N timing, source or placement
- Our objective was to evaluate potential stand reduction and its effect on yield
- A full nitrogen program was performed in-addition to our use of in-furrow urea

In-Furrow Urea Materials and Methods

- Western Sites: No-till into chem-fallow, Certified CSU-Byrd, target 1.05 million seeds/ac
- Hunter 2017: No-till into wheat stubble, Certified KSU-Larry
- Treatments were in addition to grower practice
  - Factorial (4 rates x 3 products, plus two controls)
    - 10, 20, 30, 60 lbs/ac N as ESN, NBPT+NPPT (Limus), or Urea
    - MAP to get 10 lbs/ac N (91 lbs/ac of MAP)
    - Control (no in-furrow product)
- Row spacing was 7.5” in 2016 and 2017, 10” in 2018
Summary

- In general our data would suggest we could place up to 10 lb ac\(^{-1}\) of urea in-furrow
  - However, at 2 of 9 site-years (Tribune 2016, Colby 2016) yields were reduced by 7 bu ac\(^{-1}\). This was at 95-105 bu/ac yield levels

Across site-years NBPT+NPPT did not reduce yields up to rates of 30 lb ac\(^{-1}\)
  - Some individual site-years did see reductions, 3 of 9

- Across site-years, ESN at 60 lb ac\(^{-1}\) did not reduce yield relative to the control
- ESN was never detrimental at the 30 lb ac\(^{-1}\) rate

Conclusions

- ESN and NBPT+NPPT coated urea provides some safety over untreated urea when used in-furrow in western Kansas
- Not enough site-years yet to truly evaluate the risk of various levels
- Rates of 10, 20, and 30 lb ac\(^{-1}\) for urea, NBPT+NPPT, and ESN appear to be safe in most instances

Wheat Protein

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Colby, Kansas
Importance of Protein

- Bread rises because of yeast and gluten
- Gluten – is a “sticky” protein complex
- Proteins are made up of amino acids
- Amino acids are stored in the seed as they are the foundation of plant growth (seedlings)

Amino acid arginine ($C_6H_{12}N_4O_2$)

- Amino nitrogen N
- 32% by weight is N

Making Protein

- Nitrogen is a basic component of amino acids
- Amino acids are the building blocks of plant growth and are stored for seedling development
- The protein in the kernel is generally considered to be laid down first before most of the carbohydrates

Nitrogen Uptake

- Most of the N used by wheat is taken up before flowering and later moved to the kernel during grain fill
- Photosynthesis occurring during grain fill largely determines kernel starch contents
Plant Use of N

Adding N: Increases number of tillers and kernels per head; Affects weight per kernel; Grain protein made from mineralized N; N arts to protein

Growth Stage: Early leaf, Tillering, Stem Elongation ends, Boot, Heading, Flowering, Ripening

FIGURE 2. Approximate cereal growth stages and N application timing effects on yield and protein. This figure was modified from its original (4).

Jones et al., Montana State Univ. EB0206

N supply effects on Grain Yield and Protein

Yield and Protein

N Supply

Deficient | Sufficient | Excessive

Protein

FIGURE 1. The response of wheat yield and grain protein to increasing N (7).

Jones et al., Montana State Univ. EB0206

Wheat grain yield, bushels/acre

30 40 50 60 70 80


Wet and Cool

Dry and Hot

N rate, lbs/acre

0 20 40 60 80 100

11.3 P 11.6 P 12.5 P 13.2 P 13.6 P 16.5 P 14.8 P

“The dilution effect”

Wheat grain yield, bushels/acre

30 40 50 60 70 80


USDA-ARS Central Great Plains Research Station, Akron, Colorado

N rate, lbs/acre

0 20 40 60 80 100

11.3 P 13.2 P 16.5 P 17.2 P
Increasing Grain Protein

- UNL (NebGuide EC143) recommends an additional 20 lbs of spring applied N to increase protein 1% (up to 40 lbs Max)

- CSU (Bulletin 544) recommends an additional 20-30 lbs of N to increase protein 1%

- The additional applications will not increase protein if you’re short of N to maximize yield
What Role Does Variety Play?

• Anyone who wants to have a conversation about varieties and protein without talking yield isn’t really having a conversation

• Varietal differences have been difficult to identify, takes large datasets

• Work by CSU and others has looked at Grain Protein Deviation as a potential indicator
Closing Thoughts on Protein

• Selecting a variety with a good protein score doesn’t mean you can get by with less N
• Varieties with a good protein score will still be affected by dilution at high yields
• Protein can be used as a valuable post-hoc evaluation of your N program
  – If protein is consistently less than 11.5% then you are leaving yield on the table!

Challenges to Protein Management

• Semi-arid environment
  – Highly variable yield potential, remember N has to make yield FIRST
  – Timing of N is key to maximizing protein response
  – Need moisture to move the N
    • Use of slow release N?
• Are you going to get paid for exporting your nitrogen as protein? The opportunities finally seem to be surfacing...