Nitrogen Studies in Corn and Wheat

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Background

• Nitrogen fertilizer most costly input in wheat production
• Nitrogen losses can be significant (only ~1/3 of N applied is used by the crop)
• New sources of N are available that may offer advantages in efficiency and in application timing (e.g. can be safely applied in the fall)
Wet cycle increases likelihood of N losses
• Nitrogen availability not only impacts yield, but in the case of wheat, quality
• More higher yielding varieties have lower protein content
Recent research that will be reviewed

• Enhancing protein quality with late season N applications
• Predicting protein content in-season to determine if N additions are needed
• Field studies on nitrogen “stabilizers” and split applications in both wheat and corn
Effect of N treatment on yield, five environments, 2011 and 2012

LSD 0.05= n.s.
Effect of N treatment on Yield, Crookston, 2011

Yield (bu/acre)

- 120
- 90
- Plus PA UAN
- Plus PA Urea
- Plus Boot UAN
- Plus Boot Urea
- Plus RR
- Plus UAN Agro
- Plus PA Urea
Effect of N treatment on % leaf burn, Crookston, 2011

[Bar chart showing the effect of different nitrogen treatments on percent of leaves burn.]
Effect of N treatment on protein, five environments, 2011 and 2012

Protein %

LSD 0.05=0.24
Effect of N treatment on grain protein, average three varieties and three environments, 2011 and 2012

![Bar chart showing the effect of N treatment on grain protein with average values for three varieties and three environments in 2011 and 2012. The x-axis represents different N treatments (80, 80+30, 110, 110+Gly) and the y-axis represents the percentage of grain protein. The bars are colored to represent 2011 Ave, 2012 Ave, and 2013 Ave.]
Effect of N treatment on loaf volume

![Bar chart showing the effect of N treatment on loaf volume in cubic cm for 2011 and 2012 averages. The chart compares treatments 80, 80+30, 110, and 110+Gly. The 2011 Ave shows a significantly higher loaf volume compared to the 2012 Ave, especially for the 80+30 treatment.]
Relationship between protein and loaf volume.

\[ y = 0.0051x + 10.499 \]

\[ R^2 = 0.3126 \]
Lessons learned

• Of late in-season treatments, UAN after flowering the best most years for protein
• Foliar N more effective than soil applied N for protein
• Significant plant injury can occur
• Additional protein is of equal quality as that formed with earlier applications
• Cost effective in years with high premiums only and does not increase protein sufficiently to “save” a really low protein crop
• Recent data from OSU suggest finer droplet and adjuvant improves performance of UAN
Predicting grain protein in-season

• Provides insight into “need” for post-flowering applications
Remote Sensing (Greenseeker)
Tissue Sample (Leaf and Stalk)
Leaf Color Chart
Relationship between NDVI and protein, 2011-12.

\[ y = -29.36 + 182.92x \]
\[ R^2 = 0.73 \]

Relationship between N in stem and protein, 2011-12.

\[ y = 105.72 + 51.44x \]
\[ R^2 = 0.71 \]
Relationship between chlorophyll content and grain protein, 2011-12.

\[ y = 3.93 + 148.25x \]
\[ R^2 = 0.47 \]

Relationship between N concentration in flag leaf and grain protein, 2011-12.

\[ y = -36.94 + 189.38x \]
\[ R^2 = 0.62 \]
Can we predict protein content in a wide range of cultivars treated similarly?

Relationship between NDVI and protein, 25 varieties, Cando, ND, 2013.

\[ y = -4.6423x + 18.715 \]
\[ R^2 = 0.0419 \]
Relationship between SPAD and protein, Cando variety trial

\[ y = 0.0427x + 12.941 \]

\[ R^2 = 0.0485 \]
Relationship between NDVI and Protein, three varieties and four Langdon, 2013

\[ y = 4.33x + 9.7255 \]
\[ R^2 = 0.0295 \]

Protein %

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Glenn \( r = 0.47 \)
Faller \( r = 0.07 \)
Elgin \( r = 0.41 \)
Relationship between NDVI and Protein, Prosper, 2013 (%)

\[ y = 21.205x - 3.1357 \]

\[ R^2 = 0.4157 \]
Relationship of NDVI and protein for cultivar separate, Prosper, 2013

1. \[ y = -0.015x^2 + 0.4119x - 1.9936 \]
   \[ R^2 = 0.8068 \]

2. \[ y = -0.0062x^2 + 0.2075x - 0.894 \]
   \[ R^2 = 0.4983 \]

3. \[ y = -0.0094x^2 + 0.289x - 1.3814 \]
   \[ R^2 = 0.7557 \]
Relationship between NDVI and protein within a fertilizer trial with a single cultivar (Prosper), Prosper, ND 2013

\[ y = 15.127x + 1.2586 \]

\[ R^2 = 0.3558 \]
Relationship between protein and flag leaf N content, three cultivars, Prosper, 2013.

\[ y = 0.1543x + 2.3355 \]

\[ R^2 = 0.2909 \]
Relationship between flag leaf N content and grain protein, Glenn, 2013

\[ y = 0.1837x + 2.2221 \]
\[ R^2 = 0.6562 \]
Lessons learned

• Predicting protein with mid-season measurements promising
• Several techniques gave positive results
• “Sensed” data available sooner than lab data
• Grouping of “sensed” values when protein ≥13% makes predicting difficult within these ranges (establishing a precise threshold value for 14% not possible)
• Predicting is variety specific both sensed and N content
• Less grouping with lab-based data?
Research directed towards improving N efficiency
Treatments included in the research

• Standard treatment – urea pre-plant incorporated
• Agrotain – urease inhibitor which slows the conversion of urea to ammonium
• Instinct – new formulation of nitrapyrin that inhibits nitrification (ammonium to nitrate). Not yet labeled for use on wheat but soon?
• SuperU – both urease and nitrification inhibitors
• Split application – UAN applied at the 4If (wheat) or 6 If (corn)
  • Streamer bars in wheat, dribbled in corn
Treatments included in the research

- Polymer coated urea – (ESN) coated so that it will not release the urea until temperatures exceed 50 degrees
- Split with UAN + Agrotain Plus – urease inhibitor plus nitrification inhibitor in powder form for ease of mixing with UAN
- Three rates of N
Experimental locations

• Wheat 3 locations in 2012 and 2013
• Corn 5 locations in 2012 and 2013
  – 2012 dry but productive year
  – 2013 excess moisture early
Effect of additives on yield, all treatments and all locations, 2012.
Effect of additive on protein, all treatments and all location, 2012.
Effect of additive on yield, averaged over rates and locations

Yield (bu/acre)

2013

Urea, Agrotain, Instinct, SuperU, Split, Split plus, ESN, Urea+ESN
Effect of additives on yield, average of locations, lowest N rate, 2013

<table>
<thead>
<tr>
<th>Additive</th>
<th>Yield (bu/acre)</th>
</tr>
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<tbody>
<tr>
<td>Urea</td>
<td>62</td>
</tr>
<tr>
<td>Agrotain</td>
<td>66</td>
</tr>
<tr>
<td>Instinct</td>
<td>66</td>
</tr>
<tr>
<td>SuperU</td>
<td>66</td>
</tr>
<tr>
<td>Split</td>
<td>68</td>
</tr>
<tr>
<td>Split plus</td>
<td>66</td>
</tr>
<tr>
<td>ESN</td>
<td>62</td>
</tr>
<tr>
<td>Urea+ESN</td>
<td>58</td>
</tr>
</tbody>
</table>
Effective additive, Roseau, lowest rate, 2013
Effect of additive on protein, average of rates and locations

![Bar chart showing the effect of different additives on protein percentage. The chart compares Urea, Agrotain, Instinct, SuperU, Split, Split plus, ESN, and Urea+ESN. The chart indicates that ESN has the highest protein percentage, followed by Split plus, Split, SuperU, Instinct, Agrotain, Urea, and Urea+ESN.](chart.png)
Effect of additive on protein, lowest rate average of locations

Protein %

<table>
<thead>
<tr>
<th>Additive</th>
<th>Protein %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>11.2</td>
</tr>
<tr>
<td>Agrotain</td>
<td>11.4</td>
</tr>
<tr>
<td>Instinct</td>
<td>11.6</td>
</tr>
<tr>
<td>SuperU</td>
<td>11.8</td>
</tr>
<tr>
<td>Split</td>
<td>12.0</td>
</tr>
<tr>
<td>Split plus</td>
<td>12.2</td>
</tr>
<tr>
<td>ESN</td>
<td>12.4</td>
</tr>
<tr>
<td>Urea+ESN</td>
<td>12.6</td>
</tr>
</tbody>
</table>
Effect of additive on protein, Roseau, low N and average of rates.
Lessons learned

• Management interacts with environment. In seasons of little N loss, little response to management
• Splits can be positive or negative depending on rainfall after application
• “Additives” tended to impact protein more than yield
• ESN may release too slowly for use as a spring fertilizer when used exclusively (for yield)?
• ESN is safe to mix with seed at fairly high levels
Effect of additive yield of corn, Fargo and Prosper, 2011.
Effect of nitrogen management practices on yield of corn in five environments, 2012.
Effect of nitrogen management practices on yield of corn in five environments, 2013.

- Urea alone
- Urea plus nitrapyrin
- Poly coated urea
- Urea @ planting & UAN 6 If stage
- Urea @ planting & UAN+DCD+NBPT 6 If stage

Yield (bu/acre)
Summary

• In corn experiments, only treatments that differed significantly were splits
• Splits were slightly beneficial in 2012 and slightly lower yielding in 2013
• Instinct and ESN had higher yield than check in 6 of 10 environments, splits 3 of 10 environments