Managing for Yield and Protein in Spring Wheat

Joel Ransom, Extension Agronomist for Cereal Crops
Nitrogen management impacts both yield and protein

- Yield is a function of variety, management and environment
- Protein is a function of variety, management, environment and yield

Why the need for protein?
- Hard spring wheat market demands high levels
- 14% is standard but many of our customers purchase 15%
- Used in applications that require high levels of functionality,
- Relatively small production of high protein wheat in the world when compared to wheat production in general
Why the yield and protein balancing act

- Protein is expensive to produce, both for the plant and the producer
- Therefore is a negative relationship between the yield potential of a variety and protein content
- Environment plays such a large role in yield, it is hard to predict yield at time of planting and therefore difficult to plan nitrogen amounts that would be adequate for needed protein levels.
The relationship between yield and protein across varieties is strong and negative, (data from Langdon 2013 as example).

\[ y = -0.067x + 20.312 \]

\[ R^2 = 0.6108 \]
Environment impact can be significant for both yield and protein.
Spring Wheat Yield vs N Rate, North Dakota 1970-2006

$y = 0.1453x + 22.084$

$R^2 = 0.3435$

Slide prepared by D. Franzen
Spring Wheat Protein vs N Rate, North Dakota 1970-2006

\[ y = -8 \times 10^{-5} x^2 + 0.0321 x + 11.88 \]

\[ R^2 = 0.2283 \]

- Protein
- Protein vs N Rate

Slide prepared by D. Franzen
Protein premiums and discounts can be substantial and not easy to predict

- Factors that impact premiums and discounts
  - Protein levels in winter wheat regions
  - Average protein levels from the spring wheat region
- High yielding crops usually have lower protein, so years with high yields usually result in lower protein levels and higher discounts for low protein
Protein premiums and discounts can be substantial and hard to predict.

Daily Protein Spreads for Hard Red Spring Wheat - Minneapolis, MN

June 1, 1999 - Jan. 28, 2016

Data from USDA-AMS
Graph prepared by Frayne Olson - NDSU
Strategies for balancing yield and protein

1. Select an appropriate variety
   • Options
     • High yield lower protein
     • Lower yield, higher protein
     • Balanced for yield and protein
Varieties with yields > mean, western North Dakota, 2015
Varieties with protein > mean, western North Dakota, 2015
Varieties with yield and protein > means, western North Dakota, 2015
Varieties with yields > mean, northern Minnesota, 2015
Varieties with protein > mean, Minnesota, 2015
Impact of variety on gross revenue using $4.69/bu and $0.475 discount and $0.30 premium per point protein, 2015 yield trial data.

<table>
<thead>
<tr>
<th>Eastern ND</th>
<th>NW Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linkert (2, 6)</td>
<td>HRS3530 (16, 2)</td>
</tr>
<tr>
<td>Rollag (5, 2)</td>
<td>Bolles (1, 27)</td>
</tr>
<tr>
<td>Prevail (17, 1)</td>
<td>Linkert (3, 28)</td>
</tr>
<tr>
<td>Bolles (1, 22)</td>
<td>SY Valda (21, 5)</td>
</tr>
<tr>
<td>Vantage (3, 11)</td>
<td>Samson (22, 6)</td>
</tr>
</tbody>
</table>

(Rank [protein], [yield])
Out of 29
Yield 70.8-53.2
(Rank [protein], [yield])
Out of 35
Yield 81-103
Impact of variety on gross revenue using $4.69/bu and $0.475 discount and $0.30 premium per point protein, 2015 yield trial data.

<table>
<thead>
<tr>
<th>Bottom five for gross revenue</th>
<th>Eastern ND</th>
<th>NW Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faller (25, 25)</td>
<td>LCS Nitro (33, 12)</td>
<td></td>
</tr>
<tr>
<td>LCS Nitro (26, 23)</td>
<td>Knudson (29, 30)</td>
<td></td>
</tr>
<tr>
<td>LCS Iguacu (28, 13)</td>
<td>MS Stingray (35, 1)</td>
<td></td>
</tr>
<tr>
<td>WB9507 (27, 29)</td>
<td>Chevelle (32, 26)</td>
<td></td>
</tr>
<tr>
<td>MS Stingray (29, 28)</td>
<td>Marshall (26, 34)</td>
<td></td>
</tr>
</tbody>
</table>

(Rank [protein], [yield])

Out of 29

Protein 12.0-16.1

(Rank [protein], [yield])

Out of 35

Protein 12.2-15.9
Impact of variety on gross revenue using $5.77/bu and $1.125 discount and $1.625 premium per point protein, 2014 yield trial data.

<table>
<thead>
<tr>
<th>Top Five</th>
<th>Bottom Five</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vantage (1, 26)</td>
<td>MS Chevelle (26, 8)</td>
</tr>
<tr>
<td>Rollag (2, 14)</td>
<td>Samson (23, 28)</td>
</tr>
<tr>
<td>Linkert (3, 21)</td>
<td>LCS Albany (28, 4)</td>
</tr>
<tr>
<td>SY Ingmar (5, 15)</td>
<td>LCS Iguacu (29, 5)</td>
</tr>
<tr>
<td>Glenn (4, 29)</td>
<td>MS Stingray (30, 2)</td>
</tr>
<tr>
<td>(Rank [protein], [yield])</td>
<td>(Rank [protein], [yield])</td>
</tr>
<tr>
<td>Out of 30</td>
<td>Out of 30</td>
</tr>
<tr>
<td>Protein 11.7-15.4</td>
<td>Yield 79.2-99.9</td>
</tr>
</tbody>
</table>
Strategies for balancing yield and protein

1. Select an appropriate variety
2. Ensure that sufficient N is applied to meet the extra requirement for both yield and protein
3. Target availability of N when need is critical
   • Post anthesis applications?
   • N application timing strategies
Conceptual model of grain yield and grain protein relationship

Part A: Protein changes very little
Part B: Protein change begins to increase, yield begins to slow
Part C: Protein changes rapidly, grain yield very little

Adapted from Mason, 2007
Effect of N rate on yield of four spring wheat varieties, Crookston, MN 2011-2013 (adapted from Farmaha, Sims and Wiersma, 2015).
Effect of N rate on protein content of four spring wheat varieties, Crookston, MN 2011-2013 (adapted from Farmaha, Sims and Wiersma, 2016).
Rate recommendation

• In a high yield potential environment, perhaps 60 lbs additional N would be required to achieve protein levels of high protein varieties

• Adjust according to recently grown varieties and protein level desired

• For yields less than 50 bu, meeting your protein goal probably does not require a change in management?
Strategies for balancing yield and protein

1. Select an appropriate variety
2. Ensure that sufficient N is applied to meet the extra requirement for both yield and protein
3. Target availability of N when need is critical
   - Post anthesis applications?
   - N application timing strategies
   - Fertilizer types/additives
Fertilizer timing – ensuring N is available when needed for protein formation

- Application
- Period of greatest uptake

Day 1  Day 30  Day 60  Day 90

30 days exposure to losses from leaching/denitrification

80% of N used in protein formation translocated from vegetative tissue

Spring Wheat N timeline
• Split applications
  • Thought to be more efficient, especially in full season crops
    • More N near the time of greatest need
    • Negative is getting the fertilizer into the soil and enabling uptake by the plant
  • Urea or UAN are options for application to soil
  • Since they are applied to the soil’s surface, consider adding a urease inhibitor if rain is not likely within a few days (UAN is 50% urea)
Applying UAN to leaves post anthesis N

• Rainfall not needed to activate the fertilizer
• Apply after flowering is complete
  • Don’t mix with fungicide
• 30 lbs N optimum (10 gals UAN plus 10 gals water)
• Use regular flat fan nozzles
• Spray in the cool of the day
• Data suggest that more efficient for protein than 30 lbs extra at planting
• Leaf burning is possible so don’t create protein at the expense of yield!
Effect of nitrogen fertilizer rate/timing on yield of spring wheat, two locations in Minnesota, 2015.
Impact to fertilizer nitrogen rate and timing on protein content, two locations in Minnesota, 2015

Protein content (%)
Improving N efficiency should improve protein levels

• Reduce the time between fertilizer application and plant update (with wheat we have a much smaller window than in full season crops)

• Keep applied fertilizer in ammonium form as long as possible
  • Slow release and nitrification inhibitors may play a role
Effect of additives and split applications on yield, all treatments and all location, 2012.
Effect of additive on protein, all treatments and all location, 2012.
Effect of additive on yield, averaged over rates and locations, 2013

![Bar chart showing yield (bu/acre) for different additives: Urea, Agrotain, Instinct, SuperU, Split, Split plus, ESN, Urea+ESN. The yield ranges from 60 to 75 bu/acre.]
Effect of additive on protein, average of rates and locations, 2013
Effect of N type and timing on yield, combined locations, 2015.
N source and timing on protein, combined, 2015

![Bar chart showing protein percentage for different N source and timing treatments.](chart)
Thoughts on fertilizer types/timing

- Response from strategies that strive to put N at time that it will be most needed depends on the environment
  - Splits can be stranded or partially lost through volatilization
  - Delayed release may occur when conditions are dry and plant cannot access

- Benefit of these strategies occur as N losses increase (protecting applied N, not creating additional N)
Did post anthesis N pay?

- Comparison of returns
  - Protein from 13.56 to 14.5
  - Cost per acre $33.35 (application and material $24.71 plus lost of wheat to wheel tracks)
  - Premium/discount $.05 per fifth ($.25 per %)
  - Price/bu @13.5 protein (71.1 bu/a x $4.55=$323.51)
  - Price/bu @14.5 protein (71.1 bu/a x $4.80=$341.28)
  - Added value to crop = $17.77 per acre
  - Net return -$15.58
What are the costs of N strategies

- UAN $295/ton = $0.52/lb N
- Urea $375/ton = $0.41/lb N
- ESN $540/ton = $0.61/lb N
- SuperU $505/ton = $0.54/lb N
Conclusions

• Variety selection is a key starting point
• Adjusting rate based on the variety grown and yield of the season
• Post anthesis UAN provides an option for responding to the season, providing 0.5 to 1.0 percent additional protein
• N management strategies can help with protein in some environments but profitability will depend on value of the protein and the yield of the crop.