Nitrogen Fertilizer Use Efficiency and Fertilizer Economics

Cabin Fever
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Goals today

• Discuss processes that happen to nitrogne (N) fertilizer once applied
• Discuss ways to increase N fertilizer use efficiency
• Show our economic tool that determines optimal N rate for small grains
Increasing Nitrogen Use Efficiency (NUE)

You will increase NUE by decreasing these losses.
How do I decrease N losses?

- Subsurface apply when possible
  - Prevents volatilization
  - Increases root growth and uptake
  - Decreases possible erosion losses
- Time application as close to peak N uptake as possible
Increasing N Fertilizer Use Efficiency

- Enhanced Efficiency Fertilizers
  Two major types:
  - slow release (ex: ESN, NSN)
  - urease inhibitors (ex: Agrotain)

- Should you consider using them?
  Yes: on warm season, irrigated crops
  Maybe: on cool season, dryland crops

Downside-N release often occurs too late to match N uptake

Upside-can apply ~2 – 4x as much slow release product as urea directly with the seed.
Effect of N source applied with the seed on spring wheat yield

Saskatchewan
Data from Mahli et al. 2003
Effect of an enhanced efficiency fertilizer (NSN) on spring wheat grain yield at Havre

Soil N to 3 ft = 42 lb/ac

Added N = 50 lb/ac

Spring wheat
Data from Carlson & Lamb 2008
Increasing N Fertilizer Use Efficiency

• Soil Test
  When??
  Spring is best
  Why??

~ 10 to 30 lb nitrate-N/acre more in spring than late summer depending on previous crop and location (Miller unpub. data)

Result: Fertilizing more than needed ($$)
April 2008 – August 2007 Nitrate-N Differences in Montana

Averaged over 8 sites

Jones et al. unpublished data
April 2008 – Nov 2007 Nitrate-N Differences

Averaged over 8 sites

Jones et al. unpublished data
Increasing Net Profit from N Fertilizer

- Use an economic N model developed by Griffith and Jones
Economic Model Development

• First, need yield and protein models
• Models based on N responses from plot studies, mostly on fallow.
• Spring Wheat: 25 site-years all in Golden Triangle, 1993-2006 (my focus today)
• Winter Wheat: 70 site-years from wide range of Montana. 1970-2006
• Barley: ~30 site-years from Golden Triangle and Mocassin. 1981-2006
Model Development

• “Quadratic Plateau” models appear to fit data the best

• Yield \( Y \) = \( b \times \text{TUN} - c \times \text{TUN}^2 \)

  \( \text{TUN} = \text{Total Useable Nitrogen} \)

  = Soil nitrate + Fertilizer N + N from O.M.

  \( c = \frac{b^2}{4Y_{\text{max}}} \)

• \( Y = \text{Yield Goal when TUN}>\text{optimum N} \)
Yield = b*(TN+c*OM) - (b^2)/(4Ymax)*(TN+c*OM)^2

b = 0.55, c = 27.4
$r^2 = 0.92$

Spring Wheat following Fallow
Effect of N and Yield Potential on SW Grain Yield

Spring Wheat Grain Yield (bu/ac)

Soil N to 3 ft + Fertilizer N (lb/ac)

Yield potential = 70 bu/ac

Yield potential = 50 bu/ac

Yield potential = 30 bu/ac

O.M. = 1.8% (study average)

Spring Wheat on Fallow
How much N was needed to obtain maximum yield?

- 30 bu/ac: \( \sim 2.0 \) lb N/bu
- 70 bu/ac: \( \sim 2.8 \) lb N/bu
- MSU guidelines? 3.3 lb N/bu
- Why different?
- Where did 3.3 come from?
Effect of N and Yield Potential on Grain Protein

Yield potential = 30 bu/ac
Yield potential = 50 bu/ac
Yield potential = 70 bu/ac

O.M. = 1.8% (study average)

Spring Wheat Grain Protein (%)

Soil N to 3 ft + Fertilizer N (lb/ac)
Effect of N and Yield on Marginal Return

**Spring Wheat**

- **Yield potential = 70 bu/ac**
- **Yield potential = 50 bu/ac**
- **Yield potential = 30 bu/ac**

**Marginal Return** = Grain Revenue - Fertilizer N ($/ac)

- Urea = $550/ton
- Wheat = $7/bu
- Discount = $0.16/0.25% protein

Soil N to 3 ft + Fertilizer N (lb/ac)
Effect of Organic Matter on Optimum N Rate

Spring Wheat

Marginal Return = Grain Revenue - Fertilizer N ($/ac)

Urea = $550/ton
Wheat = $7/bu
Discount = $0.16/0.25% protein
Yield Potential = 50 bu/ac

O.M. = 3.0%
O.M. = 2.0%
O.M. = 1.0%
Effect of Grain Price and Urea Cost on Marginal Return

Spring Wheat

Yield Potential = 50 bu/ac

$9/bu; $450/ton

$7/bu; $650/ton

$5/bu; $850/ton

Discount = $0.16/0.25% protein

Marginal Return = Grain Revenue - Fertilizer N ($/ac)
Effect of N and protein premium on marginal return

Marginal Return = Grain Revenue - Fertilizer N ($/ac)

$0.08/0.25%
$0.16/0.25%
$0.24/0.25%

Spring Wheat

$550/ton, $7/bu
Yield Potential = 50 bu/ac

Why do lines come together at 170 lb N/ac?
Total Available N for Maximum Return on SW following Fallow (lb N/bu)

<table>
<thead>
<tr>
<th>Protein Discount (¢/0.25%)</th>
<th>$450/ton</th>
<th>$650/ton</th>
<th>$850/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2.6</td>
<td>2.4</td>
<td>2.2</td>
</tr>
<tr>
<td>16</td>
<td>3.5</td>
<td>3.4</td>
<td>2.6</td>
</tr>
<tr>
<td>24</td>
<td>5.6</td>
<td>3.6</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Based on $7/bu, 50 bu/ac, 2% O.M.
Questions so far?
Winter wheat and barley models have also been developed

- For TODAY’s prices, discounts, and costs, and O.M. of 2%.

Economic optimum N rates:
Winter wheat ~ 2.5 to 2.7 lb N/bu for yields of 30 to 70 bu/ac.
Malt Barley ~ 0.9 to 1.1 lb N/bu for yields of 40 to 80 bu/ac.
• For 2008 RANGE of prices, discounts, and costs, and O.M. of 1.5 – 2.5%.
Economic optimum N rates:
Winter wheat ~ 2.0 to 3.0 lb N/bu for yields of 30 to 70 bu/ac.
Malt Barley ~ 0.6 to 1.2 lb N/bu for yields of 40 to 80 bu/ac.
Conclusions

• Nitrogen Use Efficiency can be increased by soil testing late Fall to early Spring.
• Despite recent high N prices, N fertilizer can still increase bottom line by up to about $200/acre.
• Economically optimum N rates depend on fertilizer N cost, grain price, protein premium, organic matter, and yield goal.
• Rates of N fertilizer should be backed off from the recommended rate (i.e. 3.3 lb N/bu SW) when fertilizer price is high and protein discount is low.
• Fertilizer N rates should be close to recommended rate when commodity and protein discounts are high, and N price is ‘low’.
For more information on soil testing and nutrient cycling: [http://landresources.montana.edu/soilfertility](http://landresources.montana.edu/soilfertility)

To access the models click on **Fertilizer Economics**.

QUESTIONS?