Optimizing N Fertilizer Use

Swank Tour
July 21, 2011

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Evening presentations are best because:

1. I get an early start on my beauty rest
2. I get out of doing dishes
3. The coffee has worn off and I can concentrate
N fertilization costs are approximately what percent of your input costs (seed, chemical, fuel, fertilizer)?

1. < 10%
2. 10 - 20%
3. 20 - 30%
4. > 30%
Management practices to optimize N fertilizer use and boost grain protein

1. Base fertilizer N rate on reasonable yield potential and accurate soil nitrate
2. Split/in season N applications
3. Minimize N losses
4. Consider an enhanced efficiency fertilizer
5. Consider legumes, perennials and deep rooted crops in rotation
Determining fertilizer N rate

Increase accuracy of soil nitrate-N levels (affects N rate)

- Collect sufficient number of sub-samples
  Ideally more than 8 sub-samples per composite should be collected; more on a large field.

- Timing of sampling
  Soil sample in late winter/early spring if possible b/c soil nitrate levels can change overwinter.
Timing of soil sampling

- Nitrogen fertilizer guidelines are based on spring soil samples for nitrate in Montana
- BUT, most sampling in MT occurs from late summer to late fall

Based on 35 ‘clicker’ responses at MABA 2010 Convention, when asked when crop advisers do most of their soil sampling:

Why is this a potential problem?
November to April nitrate changes
Montana data based on 180 samples (Jones et al. 2011)

![Bar chart showing nitrate changes overwinter.](chart.png)

- Nitrate increased overwinter
- Nitrate decreased overwinter

<table>
<thead>
<tr>
<th>April - Previous November Nitrate Change (lb N/ac)</th>
<th>Percentage of soil samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; -60</td>
<td>4</td>
</tr>
<tr>
<td>-60 to -40</td>
<td>2</td>
</tr>
<tr>
<td>-40 to -20</td>
<td>8</td>
</tr>
<tr>
<td>-20 to 0</td>
<td>21</td>
</tr>
<tr>
<td>0 to 20</td>
<td>39</td>
</tr>
<tr>
<td>20 to 40</td>
<td>19</td>
</tr>
<tr>
<td>40 to 60</td>
<td>4</td>
</tr>
<tr>
<td>60 to 80</td>
<td>1</td>
</tr>
<tr>
<td>80 to 100</td>
<td>1</td>
</tr>
</tbody>
</table>
Soil sampling summary

• Nitrate levels change from late summer/fall to spring and are highly variable
• High nitrate levels on shallow coarse soils can be lost overwinter, resulting in under-fertilization
• Nitrate levels can increase overwinter, resulting in over-fertilization
• Sampling later will better represent growing season nitrate levels
Determining fertilizer N rate (cont’d)

Select fertilizer N rate based on soil N+ fertilizer N per bushel of yield goal OR use economic N rate calculator.

<table>
<thead>
<tr>
<th>Crop</th>
<th>MSU Fertilizer Guidelines</th>
<th>MT producers (based on survey)</th>
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<tbody>
<tr>
<td>Winter wheat</td>
<td>2.6 lb N/bu</td>
<td>Guesses? (n = 64)</td>
</tr>
<tr>
<td>Spring wheat</td>
<td>3.3 lb N/bu</td>
<td>Guesses? (n = 54)</td>
</tr>
</tbody>
</table>

Do you think MT producers fertilizer wheat:

1. Less
2. About these amounts
3. More
Determining fertilizer N rate (cont’d)

Select fertilizer N rate based on soil N+ fertilizer N per bushel of yield goal OR use economic N rate calculator.

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</table>

What is this under-fertilization costing MT spring wheat producers?
• in protein?
• in dollars?
Economic Analysis of Fertilizer Application Rates for Spring Wheat After Fallow in Montana.

Funding for the development of this program was provided by the Montana Fertilizer Advisory Committee.

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Duane Griffith, Montana State University, 406-994-2580, griffith@montana.edu

This program was developed to aid the agriculture industry in optimizing nitrogen fertilizer application on Spring Wheat after fallow. The model used to estimate the economic optimal allocation of nitrogen fertilizer requires the user specify a minimal set of input values for their location. The model was developed as a statewide application, but the user must keep in mind that many variables will affect their final results and this model can not incorporate all of those individual variables. Because the model allows the user to set their expected yield goal, it allows the individual user to determine a cap on the estimated yield response from the application of nitrogen fertilizer, considering ALL of the user specific knowledge and conditions for an individual producer’s site. The yield and protein models are based on a best fit regression analysis of plot research performed in Montana from 1993 to 2006 on 24 research plots, (24 site years) for spring wheat. Actual N needed to optimize yield on your farm/site may vary from that predicted due to differences in soil depth, texture, and climate.

This model is not valid for recrop spring wheat.

Please read the information on the other tabs on this page (Introduction Tab) before using the tabs across the top of this page.

The F11 key will toggle (switch on and off) the screen viewable area between normal and maximum viewable area.
Determining fertilizer N rate (cont’d)

What is this under-fertilization costing MT spring wheat producers?

~$25/acre compared to fertilizer guidelines
~$60/acre compared to economic calculator prediction

Tens of millions of revenue dollars statewide?
Danger of aggressive N fertilization?

Hot dry season, low protein discounts, lower net returns, and higher leaching/volatilization N losses.

Strategy to avoid this possibility?
Use a conservative pre-plant N rate
Apply a 2nd application if needed
QUESTIONS ON DETERMINING FERTILIZER N RATE?
Split/In-season N Applications

1. By splitting N application, can better estimate yield potential based on precip to date
   - Don’t apply 2\textsuperscript{nd} application if dry
   - Apply large 2\textsuperscript{nd} application if wet

2. Later applications have less chance of causing lodging

3. Later applications have a better chance of making protein rather than yield
Top-dress amount and timing based on wheat growth stage

Cumulative N uptake (% maximum)

- Tillering
- Stem elongation
- Heading
- Ripening

50% required N used up by mid tillering
For yield should top-dress more N by early- to mid-tillering
When should late-season N be applied to maximize grain protein?

![Graph showing the effect of top-dress timing on winter wheat grain protein.](image-url)

- Control
- 2 d after flowering

Source: Finney et al. 1957
How should you decide whether to apply late-season N?

Ask:

1. Do you have a way to apply N without severely damaging crop? (e.g. fertigation, high clearance weed sprayer, fly it on, etc.)

2. Are protein discounts sufficiently high to justify cost? (calculation will depend on expected % protein boost)

3. What is the flag leaf N concentration?
Effect of top-dressing 40 lb N/acre at heading on spring wheat grain protein increase as affected by flag leaf N

Relationship between protein response to N top-dressed and flag leaf N in irrigated sw. Fertilizer Fact 12
How much N should be top-dressed at flowering?

- Will depend on flag leaf N (if measured), protein discounts, and cost of application. About 20 to 30 lb N/ac is typical.
- No more than 30 lb N/ac of 28-0-0 and no more than 45 lb N/ac of liquid urea to minimize burn and yield loss (Brown and Long, 1988). Dilute 1:1 to reduce risk.
- If you make your own liquid urea (~15% N), beware that urea + water will lower temp to near freezing and thus not dissolve as much urea. Be patient.
QUESTIONS ON SPLIT APPLICATIONS OR TOP-DRESSING?

See *Nutrient Uptake Timing by Crops: to assist with fertilizing decisions* (EB 0191)
Minimizing N losses

• Potential losses:
  
  Volatilization
  Leaching (See MontGuide)
  Denitrification (nitrate \rightarrow nitrogen gas)
  Erosion
  Immobilization (tie up by microbes-not a true loss)
  Weed N uptake

• Largest loss in Montana?
  Likely volatilization
In your opinion, urea volatilization losses are highest when applied:

1. On warm dry soil prior to extended dry period
2. On moist soil prior to extended dry period
3. On warm dry soil right before heavy precipitation
4. On snow covered or frozen ground

0 of 5
<table>
<thead>
<tr>
<th>Campaign</th>
<th>Fertilization date</th>
<th>Urea</th>
<th>Agrotain®</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>April 3, 2008</td>
<td>8.4</td>
<td>4.4</td>
</tr>
<tr>
<td>2</td>
<td>Oct 8, 2008</td>
<td>3.1</td>
<td>1.4</td>
</tr>
<tr>
<td>3</td>
<td>Nov 14, 2008</td>
<td>31.5</td>
<td>4.0</td>
</tr>
<tr>
<td>4</td>
<td>March 25, 2009</td>
<td>35.6</td>
<td>18.0</td>
</tr>
<tr>
<td>5</td>
<td>March 26, 2009</td>
<td>39.9</td>
<td>18.1</td>
</tr>
<tr>
<td>6</td>
<td>Oct 6, 2009</td>
<td>10.7</td>
<td>3.3</td>
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<td>7</td>
<td>Oct 13, 2009</td>
<td>10.4</td>
<td>4.8</td>
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<tr>
<td>8</td>
<td>Oct 19, 2009</td>
<td>15.7</td>
<td>3.4</td>
</tr>
<tr>
<td>9</td>
<td>Jan 27, 2010</td>
<td>24.3</td>
<td>9.3</td>
</tr>
<tr>
<td>10</td>
<td>Feb 26, 2010</td>
<td>44.1</td>
<td>11.9</td>
</tr>
<tr>
<td>11</td>
<td>March 29, 2010</td>
<td>6.3</td>
<td>1.7</td>
</tr>
<tr>
<td>12</td>
<td>April 20, 2010</td>
<td>14.7</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td><strong>20.4</strong></td>
<td><strong>6.8</strong></td>
</tr>
</tbody>
</table>

*wide range in N loss amounts*
Volatilization from grass
Hermiston, Oregon (150 lb N/a)

N loss as NH3 (% of N applied)

Days after application

Urea
UAN
CAN
Agrotain

pH 6.5 and 7.1

Horneck unpub data
What about applying urea in front of air-drills?

**Fall Campaigns**

- **pre-plant urea**
- **post-plant urea ‘control’**
What about applying urea in front of air-drills?

### Three Campaigns last Fall

<table>
<thead>
<tr>
<th>Fertilization date</th>
<th>Cooperator</th>
<th>Pre-seeding</th>
<th>Post-seeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 15</td>
<td>McIntosh- north Havre</td>
<td>18.7%</td>
<td>13.8%</td>
</tr>
<tr>
<td>September 27</td>
<td>McCormick - Kremlin</td>
<td>20.4%</td>
<td>24.4%</td>
</tr>
<tr>
<td>October 7</td>
<td>Peterson – Cottonwood</td>
<td>4.1%</td>
<td>5.2%</td>
</tr>
</tbody>
</table>
What about applying urea on snow?
Denton – March 2 – fertilizer spread
Campaign 16 - Denton site

% of applied N lost

Weeks post-fertilization

Urea (total 20.7%)
Agrotain (total 10.1%)
Denton-2 wk post-fertilization

snow-cover gone
What should you do to minimize volatilization?

1. Do not apply urea on moist ground UNLESS a snow or rainstorm is forecast to drop at least ½ inch of moisture in a day, preferably more (unlikely unfortunately!)
2. If irrigate, apply at least ½ inch of irrigation water after urea application
3. Apply urea below the surface – either in a midrow band, 2 inches from the seed or with the seed with a ‘protected’ product
4. Consider using Agrotain®, UAN, or ammonium nitrate (if available) if can’t apply during a low risk time
Has this information increased your understanding of volatilization?

1. Yes
2. No
Will you make a management change to reduce volatilization loss based on this information?

1. Yes
2. No
QUESTIONS ON UREA VOLATILIZATION?
Enhanced Efficiency Fertilizers
EEFs

• Any fertilizer designed to:
  – Increase fertilizer availability
  – Decrease fertilizer losses

• 3 major methods of action
  – Stabilized - alter soil microbial or enzymatic reactions (e.g. Agrotain®= NBPT, NServe®)
  – Slow release - have additives which require chemical or biological decomposition to release nutrients (e.g. GP’s Nitamin Nfusion® and foliar Nitamin®)
  – Controlled release - a semipermeable coating, usually a polymer, regulates release (e.g. Agrium’s polymer coated ESN®)
NBPT uses

- Can minimize urea volatilization for several weeks
- ‘Buys’ time for rainfall, irrigation or mechanical incorporation to protect urea
- Warm weather top-dressing
- Cool weather broadcast
Effects of over-winter moisture conditions on effectiveness of PCU

Yield change with spring-banded PCU over conventional urea (%)

- Barley
- Canola
- Wheat

Grant & Dowbenko 2008
Spring banded PCU
Saskatchewan

Low moisture
High moisture

WHY?
What type of crops would you expect slow release to work better?

- Irrigated
- Warm season

What about dryland cool season crops?
Timing of N uptake by wheat and ESN® N release

Options for wheat?

Approx % N released by typical ESN seed placed in mid May
How does PCU work for small grains?

- Fall/winter pre-plant works well. PCU is in soil long enough to dissolve in time for plant need.
- Late winter/spring broadcast PCU does not - may dry out, release is too slow.
- Incorporation is important, especially late winter/spring.
- Blending is recommended with late winter/spring surface applied PCU.
- Controlled and slow release should have best chance of boosting protein – results are variable
Under what growing conditions would you expect EEFs to work better?

• High potential volatilization loss
  coarse soils
  moist surface
  warm temps
  long time between application and incorporation

• High potential leaching
  coarse soils
  high moisture content/irrigation/rainfall
QUESTIONS ON N ENHANCED EFFICIENCY FERTILIZERS?

See *Enhanced Efficiency Fertilizers* (EB0188) and/or request a copy of Dave Franzen’s summary on N EEFs from me (has more data than EB0188)
Do you include legumes in your rotation?

1. Yes
2. No
Inclusion of legumes

• Legumes are excellent N scavengers – will use much of what is in soil before ‘fix’ N
• Since legumes don’t need N fertilizer, this leaves less nitrate in soil, especially in dry year when crops don’t remove much
• Legume residues are similar to ‘slow release N fertilizers’ which can lower N fertilizer needs in long run
• Beware of herbicides with high persistence
Legumes in rotation w/ winter wheat to increase protein?

Legumes grown instead of a small grain or fallow can result in a protein increase similar to about 25 lb N/ac of fertilizer.
Management practices to optimize N fertilizer use

- Use a conservative pre-plant N rate
- Add in-season N applications by mid tillering for yield, at flowering for protein
- Consider enhanced efficiency fertilizers
- Minimize N volatilization by incorporation or irrigation/rain
- Minimize N leaching with legumes, perennials and deep rooted crops in rotation
Additional info in:

http://landresources.montana.edu/soilfertility

Fertilizer Facts and economic model: go to “Fertilizer Information”

Other soil fertility publications: go to “Extension Publications”

Ammonia volatilization taped presentation: go to “Ammonia Volatilization”

This presentation: go to “Presentations”.
Questions?

Watrous, SK, 1920's