FERTILIZER SOURCES
Extension Agent Agronomy College
September 24, 2014

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Goals for this section

• Source, placement and timing are interconnected, hard to treat individually
• Present pros and cons of various fertilizer sources
# Generalizations on different nutrient sources

<table>
<thead>
<tr>
<th>Source</th>
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<th>May increase availability &amp; reduce environmental losses</th>
<th>Used for in-season adjustments</th>
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Nutrient sources are not equally plant available

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>“Immediately” available</th>
<th>Growing season</th>
<th>Several Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Urea (46-0-0)</td>
<td>ESN, SuperU</td>
<td>Legume residue manure</td>
</tr>
<tr>
<td></td>
<td>UAN (28-0-0, 32-0-0, liquid)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CAN (27-0-0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AS (21-0-0-24)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>MAP (11-52-0)<em>, MAPS (16-20-0-13)</em></td>
<td></td>
<td>Phosphate rock Ca-phosphate</td>
</tr>
<tr>
<td></td>
<td>DAP (18-46-0)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>APP (10-34-0, liquid)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MESZ (12-40-0-10-Zn1)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Potash (KCl 0-0-60)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Ammonium Sulfate</td>
<td></td>
<td>Elemental sulfur Ca-sulfate</td>
</tr>
</tbody>
</table>

* Get tied up in mineral form making some unavailable to plants
Those more plant available are more easily lost
Plant availability affects timing and placement – discussed later
Basic N Cycle

\[
\text{NH}_4^+ + \text{NO}_3^- \rightarrow \text{Plant Uptake}
\]

Fixation

Mineralization

Organic material

Plant Uptake

Exchange

Clay or OM

\[
\text{NH}_4^+ \rightarrow \text{NO}_3^- \]

Fixation
How does N get ‘lost’ from the system?

- Volatilization
- NH$_3$
- Immobilization
- Mineralization
- Fixation
- Plant Uptake
- Denitrification
- N$_2$ Gas
- Leaching
- Exchange
- Clay or OM

- Organic material
- NH$_4^+$
- NO$_3^-$
Different N sources have different volatilization and leaching loss potential

<table>
<thead>
<tr>
<th>Source</th>
<th>Volatilization</th>
<th>Leaching</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conventional</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonium nitrate, CAN, ammonium sulfate</td>
<td>less</td>
<td>≈</td>
</tr>
<tr>
<td>UAN (solution 28 or 32)</td>
<td>less</td>
<td>≈</td>
</tr>
<tr>
<td><strong>Enhanced Efficiency Fertilizers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urease inhibitors (Agrotain)</td>
<td>less</td>
<td>≈</td>
</tr>
<tr>
<td>Nitrification inhibitors (DCD, N-Source, N-Serve, Instinct)</td>
<td>≈</td>
<td>less</td>
</tr>
<tr>
<td>Combinations (SuperU)</td>
<td>less</td>
<td>less</td>
</tr>
<tr>
<td>Controlled release polymer coated (ESN)</td>
<td>less</td>
<td>less</td>
</tr>
<tr>
<td>Slow release (Nitamin, N-Sure, N-Demand)</td>
<td>≈</td>
<td>less?</td>
</tr>
</tbody>
</table>
Does NBPT decrease volatilization losses in Montana (Engel et al)?

- Based on 17 studies:
  - Average N lost from urea: 18.1%
  - Average N lost from NBPT-urea: 6.5%
- Worst case-conditions for loss:
  - moist surface with only sprinkles for weeks (Fertilizer Fact #59)
NBPT (AgroTrain®) reduces N loss

NH₃ losses observed for late-fall and winter app > than spring, even though temperatures were colder; mitigation by NBPT ≈ 65%

Coffee Creek MT
Engel unpub. data

Urea
Urea with NBPT

N loss to vol. (% applied N)

Fall 2012
Winter 2012
Spring 2012
Fall 2013
Winter 2013
Spring 2013
NBPT with broadcast urea can increase WW grain protein

Coffee Creek, MT
Engel unpub data

NBPT sig increased protein by about 0.4 to 0.8% points for both years. NBPT only increased yield in Fall 2012.
Controlled release sources strive to supply N closer to plant uptake.

![Graph showing % Nitrogen Uptake or Release vs Days After Emergence](image)

- **Urea N Release**
- **Plant Uptake for Optimal Yield**
Urease inhibitor helps

% Nitrogen Uptake or Release

Days After Emergence

Urea N Release

Agrotain® N release

Plant Uptake for Optimal Yield
Ideal controlled N release curve

Adapted from Beres unpub ESN N release data
Slow- and controlled-release for the northern Great Plains

- No consistent benefit shown
- Fall broadcast may increase yield over broadcast urea, especially in a wet year when urea may leach overwinter
- If fall application to reduce spring work load (and save the marriage) is important, then extra cost might be worth it
- Release tends to be too slow with late winter early-spring application
- Allow for higher rate seed-placed
EEFs increase safe rate with seed

Grain Yield (bu/acre)

Application Rate (lb N/acre)

polymer coated
urease inhibitor
urea

Saskatchewan
Data from Mahli et al. 2003
Dry vs. liquid N: Foliar N as an in-season boost to yield and grain protein (timing to be discussed later)

How much foliar liquid urea is taken up via leaves at flowering?

1. <10% 13%
2. 10-20% 13%
3. 20-30% 13%
4. 30-40% 13%
5. 40-50% 13%
6. 50-75% 13%
7. >75% 13%
8. Depends on how hungry the plants are 13%

- 8-11% is taken up by leaves, vs. 37-67% of soil applied N taken up by plant in same study (Rawluk et al. 2000)
- ½ inch rain (have you been living right?) or irrigation needed to soak N into soil
- If scab risk, do not irrigate within 5 days of flower
Source and rate of N affect leaf burn

32% UAN causes more flag leaf burn and reduced grain yield than equal amount of N from foliar urea

• UAN max suggested rate 30 lb N/ac
• Foliar urea max suggested rate 45 lb N/ac

Brown & Long 1988, Parma, ID, irrigated winter wheat
Source and placement effect on irrigated spring wheat leaf burn and grain protein

Brown 1995, Idaho, Irrigated SW
All received 135 lb N/ac dry urea at tillering to produce 120 bu/ac, Yield was not sig different among...
Fertilizer leaf burn – added caution

- Reduce to 20 lb N/ac max if combined with herbicide
- Leaf damage increased with:
  - Surfactant + more than 20 lb N/ac of 28-0-0 UAN
  - Urea + Agrotain®
  - Sulfur
- Less leaf burn at beginning of stem elongation than at 2nd node visible, and with added S, but may not translate to increased yields (Phillips 2004)


http://www.msuweeds.com/assets/Annual-Results/2010-Results/Wheat/2010ResultsWT02-10.pdf
Questions?
Phosphorus

• Phosphate P is equally ‘available’ to the plant, whether in dry granular or liquid form
• Soil chemistry determines how much gets taken up by plant
  ▪ Alkaline soils with high Ca bind P to create mineral form unavailable to plants – liquids can produce higher yields on highly calcareous soils (> 20% CaCO$_3$)
  ▪ Limited independent replicated work done on specialty product Avail® for cereals in Montana and the western U.S.
Pre-plant plus foliar P offers most consistent yield benefit

Oklahoma, fine silty loam
Olsen P 6 ppm, TSP incorporated preplant
Mosali 2006
K and Micronutrients

Every article we found on foliar K was conducted on K sufficient soils w/ no to minimal benefits, as expected.

IF apply foliar K, should be by late tillering given very rapid uptake during stem elongation.

How about micronutrients?
Foliar application of micronutrients

Micronutrients should not be applied unless deficiency is identified through:

- soil analysis (see *Fertilizer Guidelines for MT Crops* for soil applied fertilizer guidelines)
- tissue sampling
- visual deficiency symptoms (see *Plant nutrient functions and deficiency and toxicity symptoms*)
So many choices

• Lack of independent replicated studies make it difficult to provide recommendations
• There are more new products coming out than resources to test them
• If it seems too good to be true, it probably is
• Use test strips to test a product for given production systems
• See Enhanced Efficiency Fertilizers for partial list of those available and mechanism
  (http://landresources.montana.edu/soilfertility/publications.html)
Questions?
How should a grower choose between 2 products with similar benefits? Determine cost per lb N.

ex. Ammonium sulfate (21-0-0-24) at 100 lb N/acre

\[
\frac{100 \text{ lb N/acre}}{0.21 \text{ lb N/lb AS}} = 476 \text{ lb AS/acre}
\]

- $385/\text{ton AS} = $0.19/\text{lb AS}$
- $0.19 \times 476 = $90.5/\text{acre for AS}$
Your turn. How much would 100 lb N/acre as urea cost, with $460/ton urea?

Urea (46-0-0) at 100 lb N/acre

- \[
\frac{100 \text{ lb N/acre}}{0.46 \text{ lb N/lb urea}} = 217 \text{ lb urea/acre}
\]

- $460/ton urea = $0.23/lb urea
- $0.23 \times 217 = $50/acre for urea

Other considerations, e.g.:
- Constraints on timing, placement, equipment
Rotations

A potentially very economical source, in the long run
Right rotation: Do legumes grown prior to winter wheat increase grain protein?

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**Graph Description:**

- **Y-axis:** Percent Protein (10% moist)
- **X-axis:** Fertilizer N Rate (lb/acre)
- **Legend:**
  - Winter pea
  - Spring pea
  - Chem fallow
  - Barley

**Data Source:** Miller unpub data
Legume green manure (LGM) study near Bozeman

- No-till pea forage/legume green manure-wheat vs. fallow-wheat
- Spring or winter wheat planted in even years. 2010 was wettest of wheat years.
- 2 N rates: Full (3 lb available N/bu) and ½
- No wheat yield or protein differences between after fallow and pea forage/pea manure in first 6 years of study (3 pea cycles)
Pea green manure after 4 LGM-wheat rotations saved **124 lb N/ac** compared to fallow.
Take home messages

• After 4 two-year cycles, wheat grain yield and protein were higher after LGM than after fallow.
• Over 100 lb N/ac was saved in the fourth cycle of LGM-wheat compared to fallow-wheat.
Economics of integrating pulse crops into wheat systems

Bozeman
Miller et al. in press
Summary

- NBPT (Agrotain®) helps reduce urea loss to volatilization and can increase grain protein.
- Slow and controlled release fertilizers:
  - Tend to be more beneficial in wet than dry conditions.
  - Release too slow when spring applied.
  - Are safer than urea to seed placement.
- Foliar applications are useful for in-season adjustments, but best followed by rain or irrigation.
Summary (cont.)

• All else being equal, select source based on cost per unit of nutrient (e.g. lb N)
• In the long run, legumes in rotation are an excellent economical source of N
Questions?

For more information on MT research on volatilization:
Fertilizer Facts 59 & 60
http://landresources.montana.edu/fertilizerfacts

Factors Affecting Nitrogen Fertilizer Volatilization
(EB0208)

Management to Minimize Nitrogen Fertilizer Volatilization
(EB0209)
http://landresources.montana.edu/soilfertility/

Urea volatilization research website
http://landresources.montana.edu/ureavolatilization