Fertility Recommendations for Irrigated Wheat, Corn, Malt Barley, and Dry Bean

Prepared for 2011 Montana/Wyoming Sugarbeet and Barley Symposium by Clain Jones, Extension Soil Fertility Specialist clainj@montana.edu; 406 994-6076
Goals today

1. Present the effects of
   - fertilizer source
   - rate
   - placement and
   - timing
   on irrigated crop yield and quality

2. Discuss interactions between these four factors
Source

- Conventional vs ‘enhanced efficiency fertilizer’
- MAP (11 52 0) vs DAP (18 46 0); Urea vs Ammonium Sulfate
- Solid vs liquid
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
  – Slow release - have additives which require chemical or biological decomposition to release nutrients
  – Controlled release - a semi-permeable coating, usually a polymer, regulates release

• Most of these products are N fertilizers
Stabilized Urease Inhibitors

Volatilization

NH$_3$

Plant Uptake

N$_2$ and N$_2$O

N$_2$ and N$_2$O

Denitrification

Leaching

Nitrification

NO$_2^-$

NH$_4^+$

Plant Uptake

Urea slow urea hydrolysis here, most common is NBPT

UAN
Stabilized Nitrification Inhibitors

NH$_4^+$

Volatilization

Plant Uptake

NO$_2^-$

Nitrification

NO$_3^-$

Plant Uptake

N$_2$ and N$_2$O

Dentirification

Leaching

NH$_3$

N$_2$ and N$_2$O

Denitrification

Leaching

Urea

UAN

slow conversion to nitrate here
Slow and Controlled Release

- Volatilization
  - \( \text{NH}_3 \)

- Urea
- UAN

- Plant Uptake
- Nitrification
  - \( \text{NO}_2^- \)

- Denitrification
  - \( \text{N}_2 \text{ and N}_2\text{O} \)

- Leaching

- \( \text{NH}_4^+ \)
- \( \text{NO}_3^- \)

- \( \text{NH}_4^+ + \text{NO}_3^- \to \text{NH}_3 + \text{NO}_2^- \)
- \( \text{NH}_3 + \text{NO}_3^- \to \text{NH}_2\text{NO}_3 + \text{N}_2 \text{ and N}_2\text{O} \)

Control release here

Slow release here
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 (with tillage or irrigation)

- High potential leaching
  - coarse soils
  - high moisture content/irrigation/rainfall
NBPT (Agrotain®) 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
Effect of irrigation and NBPT on volatilization

0.8 inch irrigation on days 2 and 8 on irrigated treatments

Manitoba (Rawluk 2000)
N release by polymer-coated fertilizers

water moves in through coating

urea dissolves in prill

N moves out through coating into soil solution

collapsed prill biodegrades

Schematic adaptation and photo courtesy of Agrium, U.S. All rights reserved.
Effect of pre-plant ESN® and urea on furrow irrigated spring wheat grain yield and protein

Effect of pre-plant and top dress ESN® and urea on furrow irrigated winter wheat yield


furrow irrigated averaged over 3 years and 120, 180 and 240 lb N/acre

Winter Wheat Grain Yield (bu/acre)

Pre-plant

Top dress

Effect of top-dress ESN® and urea on sprinkler irrigated winter wheat grain yield

Conventional N fertilizer sources

• urea vs ammonium sulfate vs UAN
  - Generally “a pound of N is a pound of N” so use price and convenience to select.

Some exceptions:
  - In cool soils, urea can take up to 5 weeks to become available. Nitrate and ammonium are instantly available.
  - Nitrate is more mobile (good for plants, bad for leaching) than ammonium. Ammonium converts to nitrate within a few days to 2 weeks.
Nitrogen Liquids
(Foliar Application/Fertigation)

• Some N can be absorbed through leaves
• However, most foliar applied N ends up being washed off and taken up by roots (Rawluk et al., 2000).
• Risk of burn if $> \sim 20$ lb N/ac (crop dependent). Yield losses at higher rates (40-60 lb N/ac).
• Liquid urea causes about $\frac{1}{2}$ the burn of UAN (Brown and Long, 1988)
Conventional P fertilizer sources

• MAP vs DAP vs liquid ammonium polyphosphates “a pound of P$_2$O$_5$ is a pound of P$_2$O$_5$”

One exception: in highly calcareous soils (>20% CaCO$_3$), liquid P is more available
Questions on Fertilizer Source?
# Fertilizer Rates – Nitrogen based on yield goal

<table>
<thead>
<tr>
<th>Crop</th>
<th>N rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>3.3 lb N/bu (sw); 2.6 lb N/bu (ww)</td>
</tr>
<tr>
<td>Corn</td>
<td>9 lb/ton (silage); 1.2 lb/bu (grain)</td>
</tr>
<tr>
<td>Malt Barley</td>
<td>1.2 lb N/bu</td>
</tr>
<tr>
<td>Dry Bean</td>
<td>5 lb N/100 lb</td>
</tr>
</tbody>
</table>

Other crops? See Fertilizer Guidelines for MT Crops (EB0161) at [http://landresources.montana.edu/soilfertility](http://landresources.montana.edu/soilfertility)
Click on Fertilizer Information or Extension Publications
<table>
<thead>
<tr>
<th>Crop</th>
<th>Olsen P 4 ppm</th>
<th>Olsen P 8 ppm</th>
<th>Olsen P 12 ppm</th>
<th>Olsen P 16 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat (spring)</td>
<td>45</td>
<td>35</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Corn (silage)</td>
<td>65</td>
<td>50</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>Malt Barley</td>
<td>40</td>
<td>30</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Dry Bean</td>
<td>25</td>
<td>20</td>
<td>15</td>
<td>5</td>
</tr>
</tbody>
</table>

*Note: To maintain P levels, could use P removal rates: Wheat (0.62 lb P$_2$O$_5$/bu); Corn silage (~4.5 lb P$_2$O$_5$/ton); Barley (0.36 lb P$_2$O$_5$/bu); Dry Bean (0.79 lb P$_2$O$_5$/bu)
Questions on Fertilizer Rates?

• Note: K and micronutrients also contained in MSU Fertilizer Guidelines
Fertilizer Placement

Surface broadcast urea

• Recent research in MT has found ~20% of broadcast urea volatilizes on no-till fields (go to: http://landresources.montana.edu/ureavolatilization for more information)

• To avoid this risk, incorporate with tillage or irrigation within 2 days of application

• How much irrigation??
Effect of irrigation rate on broadcast urea volatilization (Horneck, unpub. data)

\[ y = 62.655e^{-3.9586x} \]

\[ R^2 = 0.9193 \]
Does $\frac{1}{2}$ inch of rain also stop volatilization? (Horneck unpub data)

Not if spread out over 3 days
Effect of pre-plant N Rate and topdressing on Corn Yield - SARC

0 lb N topdress: Yield = 95.4 + 0.84*nrate – 0.0021*nrate^2
R^2 = 0.99

60 lb N topdress: Yield = 131.2 + 0.59*nrate – 0.0016*nrate^2
R^2 = 0.98

N rate at maximum yield:
Preplant = 180/175 ~1 lb N/bu
Preplant+TD = 240/180 ~1.3 lb N/bu

Kephart, unpub data
Increased corn value due to topdressing (60 lb N/acre)

SARC

Cost of TD Application $40

SPAD reading prior to topdressing

Kephart, unpub data

* Value of yield increase based on $3.30/bushel price for corn.
Effect of Placement on Spring Wheat Yield – Weed Free

Spring wheat grain yield (bu/ac)

1998 1999

Lethbridge, AB
Blackshaw et al. (2004)

4 in. deep, every other row
Effect of N Placement on Spring Wheat Yield—With Wild Oats

Spring wheat grain yield (bu/ac)

Why the difference from weed-free?

Lethbridge, AB
Blackshaw et al. (2004)
Banding vs Unincorporated Broadcast Phosphorus

Banding P is much more effective than banding N, because P is much more immobile in the soil.

Figure 7. The advantages of P banding are greatest when STP levels are very low (VL) to low (L). From Randall and Hoeft (1988).
QUESTIONS on Placement?
Fertilizer Application Timing

• Phosphorus and potassium are best applied somewhat before or at seeding
• Nitrogen can be applied later, especially on wheat to maximize protein
N application timing effects on yield and protein

**Nitrogen early**
- Number of tillers and kernels/head

**Grain protein from remobilized N**

**Nitrogen late**
- Weight/kernel
- Higher grain protein

Diagram showing growth stages in cereals with stages labeled:
- Stage 1: One shoot
- Stage 2: Tillering begins
- Stage 3: Tiller sheaths formed
- Stage 4: Leaf sheaths strongly erected
- Stage 5: Leaf sheaths strongly visible
- Stage 6: First node of stem visible
- Stage 7: Second node visible
- Stage 8: Last leaf just visible
- Stage 9: Ligule of last leaf just visible
- Stage 10: Boot
- Stage 10.1: Flowering (wheat)
- Stage 10.5: Flowering
- Stage 11: Ripening
Cumulative N uptake by wheat

Nutrient Uptake Timing by Crops: to assist with fertilizing decisions
http://landresources.montana.edu/soilfertility/publications.html
How can you better match N release to reduce potential losses and increase yield?

- Use split application (pre-plant and topdress or just topdress)
- Use a slow release fertilizer
Use Nutrient Uptake figure to time top-dress

Example on per acre basis:
- 200 lb N total need, 40 lb N in soil, 60 lb preplant N
- soil and preplant supply 100 lb N = 50% total N required
- \((200 - 100) = 100\) lb N top-dress
Top-dress amount and timing based on plant growth stage

- 50% required N used up by mid tillering
- Must topdress 100 lb N by early- to mid-tillering
Conclusions

• Controlled release urea has produced higher wheat yields when applied early enough
• Controlled release urea has produced lower wheat yields when applied too late if furrow-irrigated
• Surface broadcast urea should either be immediately incorporated to prevent volatilization or treated with NBPT. Use at least 0.5 inches of irrigation to incorporate.
• Placing N near the seed should maximize yield and decrease weed density
• Use split applications, based on N uptake curves, to maximize grain protein in wheat.
• Phosphorus should be banded near the seed or incorporated to optimize yields.
For additional information

• Soil Fertility Website:
  
  [http://landresources.montana.edu/soilfertility](http://landresources.montana.edu/soilfertility)

  Contains links to my presentations including this one, economic N rate calculator, fertilizer facts, press releases, Extension publications, this presentation, etc.

QUESTIONS?