Fertilizer Management in a Down Market, Barley Focus

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MSU Soil Fertility Extension
Primary objective today: Assist you in maximizing profit from fertilizer management in era of low commodity prices

Specifically, I will discuss:

- Steps towards calculating an optimum N rate
- The law of diminishing returns
- Fertilization for optimal N use
  - Timing
  - Source & legume rotations
  - Placement
- P, K, S, and micronut. management
Driving forces behind fertilizer rates

• Soil nitrate-N: can vary greatly by year due to e.g. plant residue decomposition, leaching. Fertilization is influenced by yield goal, soil test ideally 2-3 ft. in the spring or late fall.

• P and K: are more stable in soil. Losses to erosion, and harvest and ‘fixation’, fertilization determined by 6” soil test level independent of yield goal.

• Soil S: can also vary greatly by year, but soil tests not best tool. Use field history, crop performance and tissue tests.

• Micronutrients: can vary seasonally and annually. Availability is influenced by organic matter and pH, which are relatively stable over time, and soil temperature and moisture, which vary greatly. Very little research.
N: Realistic yield goal for rate calculations

- Use variety selection tools (AMBA, MSU-SARC, MSU Dept Plant Sciences and Plant Pathology)
- Past yields indication of future performance
- Having ability for in-season N application allows conservative yield estimate for pre-plant rate
Law of diminishing returns

Yield increases with increasing N

Additional N does not produce any additional YIELD

Optimal N for 80 bu/ac yield

Soil N = 10 lb/acre, SOM = 2%
Inputs
- N fertilizer cost, malt/feed grain price, plump and protein cutoff
- Yield goal
- Residual soil N
- SOM
- These help calculate **TOTAL** available N for max net return

Calculators online for barley, SW, and WW after fallow

http://www.msueextension.org/econtools/nitrogen/index.html
N considerations unique to barley

• Malting barley 1.2 lb N/bu, feed barley 1.6 lb N/bu starting levels.

• Lower N for malting barley to decrease risk of low plump and high protein.

• Test spring soil N to avoid high protein.
Optimal N for 70 bu/ac barley

With 40 lb residual N, add 40 lb N/ac for optimal NR

Economic optimal N

N for max yield (70 bu/acre)

Protein penalty

Barley yield (bu/ac)

Net revenue ($/ac)

Applied N (lb/ac)

Urea $460/ton, grain $6/bu
If fertilize for 70 bu/ac but get 40 bu/ac

Optimal total N for 40 bu/ac is 35 lb N/ac. Any additional N or soil residue N will not increase yield, which was water limited. Will produce feed grade barley.

NR if fertilized for 40 bu/ac, with ‘room’ for topdress

Plump < 22%

Urea $460/ton, grain $6/bu
MSU N rate calculation tool takes into account fertilizer costs, grain prices, soil organic matter, residual soil N, and protein discounts/premiums (for wheat)

http://www.msuextension.org/econtools/nitrogen/index.html
Total available N (lb N/bu) for maximum return:
Malt barley following fallow

<table>
<thead>
<tr>
<th>Barley ($/bu)</th>
<th>$/ton urea</th>
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<tbody>
<tr>
<td></td>
<td>$275</td>
</tr>
<tr>
<td></td>
<td>Total lb N/bu</td>
</tr>
<tr>
<td>4</td>
<td>1.16</td>
</tr>
<tr>
<td>6</td>
<td>1.16</td>
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</tbody>
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Based on 60 bu/ac, 2% O.M.

Best way to maximize profit is to adjust rates based on costs, prices, and discounts, on the MSU calculator.
N rate adjustments

• Fall vs. spring soil test

• Stubble: small grains stubble high carbon to N (C:N). Adjust fertilizer N up or down? 10 lb N/1000 lb stubble up to 40 lb N

• Fallow: assume ½ of stubble has decomposed over previous year when adjusting

• After legume rotation: Adjust fert up or down? Legumes credit (add) N

<table>
<thead>
<tr>
<th>Crop</th>
<th>N credit (lb N/acre)</th>
</tr>
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<tbody>
<tr>
<td>Alfalfa</td>
<td>40</td>
</tr>
<tr>
<td>Annual legume 1 x</td>
<td>~10</td>
</tr>
<tr>
<td>Annual legume &gt;3 x</td>
<td>~20</td>
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</tbody>
</table>
Soil test: Fall soil tests can lead to over or under-fertilized fields

High N crop residue and/or high O.M.

Mineralization

Over winter

High Precip

High N on shallow or coarse soil

Over fertilized

N leaching (or N$_2$ gas losses?)

Under fertilized

Compare fall with spring a few times to see patterns of loss or gain for given pastures/rotation
Variable rate N application (Zone or site specific farming)

- At this time economic advantage is inconsistent (and hard to study)
- At simplest, divide field into zones of low, med, high productivity
- NDSU has bulletin series on Zone farming SF1176 series at www.ag.ndsu.edu/publications
Critical barley stem tissue nitrate-N concentrations may help decide whether to topdress N

- 3-leaf
- Feekes 3
- Feekes 7
- Feekes 10

Feekes 3 = main shoot and 6 tillers, F7 = 2\textsuperscript{nd} node visible, F10 = boot swelling

Stark and Brown, 1987, ID, irrigated, 3-leaf and Feekes 3
Thompson 2004, AZ, irrigated, Feekes 3, 7 and 10
Questions?

On to *Timing, Source, Placement*
Timing depends on source

- Readily available [urea (46–0–0), urea ammonium nitrate (28–0–0)]
  - shortly before seeding up to mid-tillering
- Slowly available (manure, slow-release N)
  - take time to become available
  - apply well before needed – e.g., fall
- Legumes, the ultimate slow release, will be discussed under ‘rotations’
Different N sources have different volatilization and leaching loss potential

<table>
<thead>
<tr>
<th>Source</th>
<th>POTENTIAL loss compared to urea</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Volatilization</td>
</tr>
<tr>
<td><strong>Conventional</strong></td>
<td></td>
</tr>
<tr>
<td>Ammonium nitrate, CAN, ammonium sulfate</td>
<td>less</td>
</tr>
<tr>
<td>UAN (solution 28 or 32)</td>
<td>less</td>
</tr>
<tr>
<td><strong>Enhanced Efficiency Fertilizers</strong></td>
<td></td>
</tr>
<tr>
<td>Urease inhibitors (Agrotain, N-Fixx, Arborite® AG)</td>
<td>less</td>
</tr>
<tr>
<td>Nitrification inhibitors (DCD, N-Source, N-Serve, Instinct)</td>
<td>≈</td>
</tr>
<tr>
<td>Combinations (SuperU)</td>
<td>less</td>
</tr>
<tr>
<td>Controlled release polymer coated (ESN)</td>
<td>less</td>
</tr>
<tr>
<td>Slow release (Nitamin, N-Sure, N-Demand)</td>
<td>≈</td>
</tr>
</tbody>
</table>
Slow- and controlled-release for the northern Great Plains

- No consistent benefit shown
- Fall broadcast may increase yield over spring broadcast urea, especially in a wet year when urea may leach overwinter
- If fall application to reduce spring workload is important, then extra cost might be worth it
- Release tends to be too slow with late winter/early-spring application
- Consider blending with urea
Placement and N source on barley grain yield

PCU = polymer coated urea
Edmonton, AB, Nyborg et al. 1999
Nitrification inhibitors

- Potential benefit with fall-banded urea where:
  - high precip with leaching in sandy soils
  - denitrification (nitrate $\rightarrow$ $N_2$ gas) in water logged/clay soils

- Benefits less likely in dry or well drained soils
Instinct II® (nitrification inhibitor) increased winter wheat grain yield under irrigation but not dryland

Scherder et al., 2015, inland Pacific NW
UAN sidedress dribble stream bar, urea preplant incorporated
Placement – uniform application, where it’s needed

- Urea and ammonium-based fertilizers – best subsurface placed (due to volatilization)
- Banding is more efficient use of N, use less N but different equipment and takes more time
- Safe rates for seed placed
  - On-line resources to calculate
  - 2-3 x higher with polymer coated
- Foliar application
  - Use practices to minimize leaf burn
  - < 30 lb N/ac of UAN
  - < 45 lb N/ac of liquid urea
  - Use less with herbicide, surfactant, sulfur, NBPT
Questions?

On to *Rotations*
Crop rotations

- Barley shows little yield response from previous crop. However there are other benefits:
  - Reduce pest levels of weeds, diseases and insects
  - Increase soil organic matter for increased water storage and nutrient supply
  - Increase economic and environmental resiliency

<table>
<thead>
<tr>
<th>Residue</th>
<th>Relative Barley Yield</th>
</tr>
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<tbody>
<tr>
<td>SW, Barley</td>
<td>1.00</td>
</tr>
<tr>
<td>Pea, Lentil</td>
<td>1.02</td>
</tr>
<tr>
<td>Canola</td>
<td>0.99</td>
</tr>
<tr>
<td>Sunflower, Safflower</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Based on research at Mandan, ND, average over 4 rotations. Adapted from Tanaka et al., 2005 and 2007, by K. McVay
Crop rotation and tillage system effects

4 dryland crop cycles of wheat-fallow or wheat-pea grain, then all fallow before barley
N from legumes

- Legume cover crops release more N more quickly than legume grain (pulse).
- Benefit to yield with less or no fertilizer N, compared to fallow, takes 3 to 4 cycles (several MSU studies with wheat; e.g., Miller et al., 2015).
- A pulse rotation can still increase barley yields planted three years after the pulse crop.
- Legume N credit is highly variable among species and agronomic conditions.

<table>
<thead>
<tr>
<th>Legume crop</th>
<th>N Credit lb N/acre</th>
</tr>
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<tbody>
<tr>
<td>Grain 1-2x</td>
<td>~10</td>
</tr>
<tr>
<td>Grain ≥ 3x</td>
<td>~20</td>
</tr>
<tr>
<td>Cover crop 1-2x</td>
<td>20-30</td>
</tr>
<tr>
<td>Cover crop ≥ 3x</td>
<td>30-50</td>
</tr>
</tbody>
</table>
Prior Crop Effect on Irrigated Barley Yield and Protein

Huntley, MT, Welty et al. 1988, McGuire et al. 1989
Varieties for low protein

- Variety trials are regionally available
- MSU Post Farm in Gallatin Valley
  - irrigated: Champion, Haxby, Hockett, Metcalfe
  - dryland: MT090190, MT124112, MT124128
- Dillon irrigated: Champion, Haxby, Odyssey, Synergy
- Moccasin dryland: MT090190, MT124112, MT124128
3-year net return of x-canola-barley rotation

**Swift Current, SK**

**Scott, SK**

Khakbazan et al., 2014, SK, only 1 time 3-crop rotation
Questions?

*On to S, P, K, and micronutrients*
S fertilization

- Use crop and field history (sandy, acidic, or low OM soils are more likely low in S), crop appearance, and soil and tissue sampling
- If the prior crop showed S deficiency, then 10-15 lb S/acre before or at seeding could be a wise investment (MSU Ffacts # 41)
- Apply sulfate S sources in spring to avoid overwinter leaching loss
- Elemental S slow to supply plant available S. Apply in fall to become available before peak demand. Will supply crop for > 2 years
With low soil S, balance S with N, select variety, for yield without high protein

Sherman et al., 2017, unpub data, dryland, Moccasin
P and K rates for feed/malt barley based on soil test levels to 6” depth

<table>
<thead>
<tr>
<th>Olsen P soil test (ppm)</th>
<th>lb P$_2$O$_5$/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>&gt;16</td>
<td>&gt;16 use removal rates, 0.36 lb P$_2$O$_5$/bu grain and 4.1 lb P$_2$O$_5$/ton straw</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K soil test (ppm)</th>
<th>lb K$_2$O/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feed</td>
</tr>
<tr>
<td>0</td>
<td>75</td>
</tr>
<tr>
<td>50</td>
<td>65</td>
</tr>
<tr>
<td>100</td>
<td>55</td>
</tr>
<tr>
<td>150</td>
<td>45</td>
</tr>
<tr>
<td>200</td>
<td>30</td>
</tr>
<tr>
<td>250</td>
<td>20</td>
</tr>
<tr>
<td>&gt;250</td>
<td>&gt;250 use 0.25 lb K$_2$O/bu grain and 30 lb K$_2$O/ton straw</td>
</tr>
</tbody>
</table>

Source: MT Fertilizer Guidelines EB0161
Impact of starter P in a cool spring on spring wheat emergence

P is immobile and gets tied up in soil, consider “pop-up”

Both sides received fall-banded 70-30-10-10

10 lb of starter P$_2$O$_5$ with seed       No starter P
P band better than broadcast in:
- Low soil P
- Dry soils
- Reduced tillage

Barley tolerant to high P rates in seed row

Nyborg & Hennig 1969, AB

Randall & Hoeft 1988
P source options

• Generally no yield differences between sources

• Exception: Liquids can produce higher yields on highly calcareous soils (> 20% CaCO$_3$), but may not be economical

• Limited research on specialized P fertilizers for cereals in Montana and surrounding region
Can 0-0-60 be ignored? Definitely not.

20 lb KCl (0-0-60)/acre at seeding would supply both K and Cl

Data suggest of the micros, zinc and Cl should be given most attention

Avise unpub. data, N=210 samples
Cl on small grains

- Cl is very mobile - may need more if leaching or yield potential is high. 20 lb KCl/acre annually should provide enough.
- Over 210 trials in KS, MN, MT, ND, SD, MB and SK have evaluated Cl-response in wheat and barley*
- Significant yield response in 48% of trials*
- Average response of 5 bu/acre*
- Especially consider KCl for barley varieties with low disease tolerance

*Source: Cindy Grant, Agriculture and Agri-Food Canada
Micronutrients

• A combination of deficiency symptoms, soil testing, and tissue testing may be best approach at identifying deficiencies. This is NOT an exact science.
• Micronutrient deficiencies are the exception, not rule
• Cool wet conditions cause deficiency – will generally disappear when weather warms
• Too much micronutrient may hurt yield more than not enough
Micronutrients, cont.

• The main challenge is even distribution of a very small quantity – consider foliar options
• Read product label: look for ‘available’ micronutrients and watch for heavy metal contamination
• “Micronutrients should be used when there is an economic benefit to the farmer ....” – R. Karamanos, Ph.D. soil scientist
• Most conclusive test is growth responses from field strip trials
Summary

• Use realistic yield goals and soil test N to calculate pre-plant N rate
• Adjust in-season for given year
• Select the source appropriate for conditions
• Use on-line tools for variety selection, optimal N rate, safe seed-placed rates
• Diversify and recrop, consider legumes
• Build P & K in good times to rely on during lean times
• Watch for insufficient S, limiting N uptake
Resources - online

• Variety selection tool [www.sarc.montana.edu](http://www.sarc.montana.edu) > research results > reports to MWBC > reports by year > spring barley variety performance


• SARC Fertilizer Calculator [http://www.sarc.montana.edu/php/soiltest/](http://www.sarc.montana.edu/php/soiltest/)

• Safe Rate Seed Placed Calculator [http://seed-damage-calculator.herokuapp.com/](http://seed-damage-calculator.herokuapp.com/)
Resources - publications

On soil fertility website under "Extension Publications"
http://landresources.montana.edu/soilfertility/

- MT Barley Production Guide (EB0186)
- Interpretation of Soil Test Reports for Agriculture (MT200702AG)
- Developing Fertilizer Recommendation for Agriculture (MT200703AG)
- Nutrient Uptake and Timing by Crops (EB0191)
- Nutrient Management in No-Till (EB0182)
- Enhanced Efficiency Fertilizers (EB0188)
- Soil Scoops - under “Soil Scoop”

Under “Presentations” Micronutrient Testing and Mgt in Barley, Corn, Pulses. Jan 2017, and more
QUESTIONS?

This presentation and additional information on soil fertility topics is available at http://landresources.montana.edu/soilfertility

Photo by Andrew John