SOIL FERTILITY 101

Basic Principles

Essential Plant Nutrients

No nutrient is more important than another nor can another nutrient substitute.

However – nitrogen, a key component in photosynthesis, is the nutrient where response is most often seen.
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Many factors influence soil nutrient availability

Chemical form (gas/solid)

Soil CEC and nutrient charge (+ or -)

Nutrient biology and chemistry (nutrient cycling)

Soil pH (alkaline, neutral, acidic)
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![Diagram of soil fertility pH levels for various nutrients including Nitrogen, Phosphorus, Potassium, Sulfur, Calcium, Magnesium, Iron, Manganese, Boron, Copper and Zinc, and Molybdenum.](image)
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Mobility in plant relates to where symptoms initially occur

Mobile – disease symptoms seen in older parts of plants (N, P, K, S)

Immobile – disease symptoms often seen in newer growth (Most of the micros, with exceptions)
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Our goal is to deliver the right amount of nutrients to the plant at the right time!

Important to understand each nutrients behavior as well as how it can get “lost”

Let’s focus on the big one – Nitrogen
MALT BARLEY
What is the plant nitrogen uptake pattern?

Data from 2015/2016 N uptake pattern (Aberdeen, ID) – (Rogers and Hu)

Average of 5 varieties – behavior is “relatively” similar among varieties
PLANT UPTAKE

What’s going on here?

Rogers and Hu, Unpublished
PLANT UPTAKE

Rogers and Hu, Unpublished
FERTILIZER NITROGEN MANAGEMENT

Recommendation Components

\[
N \text{ needed} = \left( \frac{N \text{ needed based on potential yield}}{N \text{ needed for residue breakdown}} \right) - \left( \frac{\text{Mineral-izable } N}{\text{Soil test } N} \right)
\]
MALT BARLEY

A) What is your yield goal?
   A) 150 bu/ac - (~1.1. to 2.0 lb N/ac)

B) How much residue did you return to soil (grain straw)?
   A) 1 ton wheat straw - (15 lb N/ac for each ton up to 50 lb N/ac, no extra N for potato, sugarbeet)

C) What is your mineralizable N?
   A) ??? 45 lb N/ac estimate - LOI is sometimes used but correlation data is limited

D) Inorganic N from soil test
   A) Ammonium and nitrate from soil test - ppm x 4 = lb N/ac
DO THE MATH!
FERTILIZER NITROGEN MANAGEMENT

Nitrogen X Variety Response 2015

*Aberdeen R&E Center*

Yield maximized at **130 lb/ac** of applied + inorganic N

- Except AB Voyager

However! At higher rates lodging can be a major issue – even with growth regulators

- Proteins remained within maximum malt limits even at highest N rates

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Rogers et al., Unpublished
Figure 1. Yield response of six malt barley varieties to supplemental nitrogen application on a grower field in Idaho Falls, ID in the 2016 growing season.
Figure 1. Yield response of six malt barley varieties to supplemental nitrogen application on a grower field in Idaho Falls, ID in the 2016 growing season.

The graph shows the yield response of six malt barley varieties to applied nitrogen. The equation $f(x) = ax^2 + bx + c$ is used to model the yield response. The varieties included in the study are ARS-219-46, Harrington, Klages, Moravian-69, Merem, and Voyager. The data was collected by Rogers et al., Unpublished.
Figure 1. Yield response of six malt barley varieties to supplemental nitrogen application on a grower field in Idaho Falls, ID in the 2016 growing season.

We are working on trials using multiple N rates and varieties to reassess recommendations.

A) Curve fitting to revise optimal rates
B) Use of RGY may improve recommendations
C) We are working on improved N mineralization tests
D) We are working on FNUE – $^{15}$N Isotope tracer

Rogers et al., Unpublished
Figure 1. Protein response of six malt barley varieties to supplemental nitrogen application on a grower field in Idaho Falls, ID in the 2016 growing season.
How much of the fertilizer nitrogen you apply makes it into the plant?

Well it depends on how you manage your fertilizer

Let’s talk about an optimal situation and a suboptimal
FERTILIZER NITROGEN USE EFFICIENCY

- Feekes 4/5 Soft Dough Harvest
  - Incorporated
  - Unincorporated

  A  A  B  B  C  C
FERTILIZER NUTRIENT USE EFFICIENCY

Soil Retention

- 16% of fertilizer N: 0 to 1 ft
- 3% of fertilizer N: 1 to 2 ft
- 1% of fertilizer N: 2-3 ft

An average recovery in the soil-plant system of 80% was measured
WHERE DID WE “LOSE” THE REST?

Where did we “lose” the rest of the applied fertilizer nitrogen?

1) Leached through soil

3) Surface runoff

4) **Ammonia volatilization**

5) Denitrification (limited oxygen)

\[
\text{NO}_3^- \rightarrow \text{NO}_2^- \rightarrow \text{NO} + \text{N}_2\text{O} \rightarrow \text{N}_2
\]
FALL CEREALS

1) Largest N loss when urea applied to wet or damp soil – even if soil temperatures are cold (e.g. 26 to 35 N loss can exceed 30%, but temps below 40-50F are recommend

2) Application onto snow can exceed 20% loss

3) Apply to dry soil – irrigation/ or rain of at least 0.5” is optimal to incorporate urea

4) Some loss is likely unavoidable

5) NBPT has consistently been shown to reduce losses (longer regulation in alkaline soils)

6) Seeding after broadcasting urea was not sufficient to reduce volatilization

Research results of Dr. Rick Engel, Montana State
AMMONIA VOLATILIZATION

Time after fertilizer application (days)

NH₃ volatilization (% of applied N)

AS-SURFACE
Urea+NBPT-SURFACE
Urea-SURFACE
FALL CEREALS

Winter wheat is most of the winter acreage, though 2016/2017 acreage plantings are lowest in over a decade

Understanding how to manage fall applications is key

Preplant applications have increased time and opportunity for loss, particularly with winter moisture (leaching, gaseous loss)

Split applications may improve fertilizer use efficiency
FALL CEREALS

N uptake pattern is different as winter and cold temperatures slow/stop growth

Issue is avoiding loss mechanisms over winter (gaseous loss, leaching etc.)

- What do you think we may see in terms of nitrogen this spring as a result of the heavy snow and rain?
- Ammonia volatilization and leaching are of concern

NITROGEN (NO₃⁻)
Plant yellowing
**FALL CEREALS**

<table>
<thead>
<tr>
<th>Wheat class</th>
<th>Protein goal (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard red winter (HRW)</td>
<td>12.5</td>
</tr>
<tr>
<td>Hard white winter (HWW)</td>
<td>12.5</td>
</tr>
<tr>
<td>Hard red spring (HRS)</td>
<td>14</td>
</tr>
<tr>
<td>Hard white spring (HWS)</td>
<td>12.5</td>
</tr>
</tbody>
</table>

**Table 2. — Nitrogen (N) required (per bushel of wheat) to reach a specific grain protein goal.**

<table>
<thead>
<tr>
<th>Grain protein goal %</th>
<th>N requirement Average (lb N/bu)</th>
<th>Range (lb N/bu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>2.4</td>
<td>2.2–2.6</td>
</tr>
<tr>
<td>11</td>
<td>2.7</td>
<td>2.4–2.9</td>
</tr>
<tr>
<td>12</td>
<td>3.0</td>
<td>2.6–3.2</td>
</tr>
<tr>
<td>13</td>
<td>3.3</td>
<td>2.8–3.5</td>
</tr>
<tr>
<td>14</td>
<td>3.5</td>
<td>3.0–3.7</td>
</tr>
<tr>
<td>15</td>
<td>3.7</td>
<td>3.3–4.0</td>
</tr>
</tbody>
</table>

Flowers et al. 2007 – PNW
FALL CEREALS

N needed for yield should be applied during vegetative growth by about the end of tillering (Feekes 5)

Additional N between boot and flowering can increase grain protein

Remember late in the season more N is not taken up, rather it moves from the stem to the straw!

Sulfur applications may be important as the sulfur requirement is approximately 1/10 of the N requirement – up to 25 lb S/ac

Dryland growers should apply the majority of N during seeding

Flag leaf testing where N concentration are below 4.2% indicate a late-season N application may increase grain protein
FALL CEREALS

Winter malt barley recommendations are similar to spring; however, we are currently investigating rates and timing of applications. 

½ in internode elongation is recommended timing of split application in the eastern US, which occurs near greenup in spring. 

We are investigating tissue N rates and tissue levels to determine if split applications are beneficial in Idaho.

Figure 2. Winter barley at Zadocks 30/Feekes 5 (Alley et al., 2009)
FURTHER RESOURCES

**Wireworms in Idaho Cereals: Monitoring and Identification**

*Aziz Rahet, Frank Ester, Christopher W. Rogers, and Javier M. Martinez*

**Introduction**

FOR THE PAST SEVERAL YEARS, growers in central and eastern Idaho, Washington, Oregon, and Montana have been suffering from increasing crop damage due to the emergence of a key pest known as the wireworms. Wireworms are the larval stage of a beetle group known as click beetles (Coleoptera: Elateridae). Historically, wireworm damage was managed using environmentally persistent conventional insecticides; these products were removed from the market due to environmental and human health concerns. While new treatments are becoming available, developing effective control strategies remains a challenge.

**Southern Idaho, 2019**

*Spring Barley Quick Facts*

<table>
<thead>
<tr>
<th>Rotation and seeding</th>
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<tbody>
<tr>
<td>Seeds given will not rotate, but not recommended after small grains or sure when alternative treatments are readily available due to disease pressures.</td>
</tr>
<tr>
<td>Good soil will contact and moisture availability are key.</td>
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<tr>
<td>Seed depth, 1.0 to 1.5 inches.</td>
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<tr>
<td>Sow on at least 4 Fehr stages.</td>
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<tr>
<td>Seed rate: approximately 800,000 seeds per acre (final). Actual seeding rate depends on seed size, purity, and potential, and soil moisture.</td>
</tr>
<tr>
<td>Spring barley growth and development</td>
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<tr>
<td>Stage</td>
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<tr>
<td>-------</td>
</tr>
<tr>
<td>1.0</td>
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**Scheduling the Final Irrigation for Wheat and Barley**

*H. Nebeling, C. W. Rogers and Z. Qureshi*

**Introduction**

CROP PRODUCTION IN IRRIGATED AREAS IS becoming more water constrained. In many areas, municipal water use is increasing with urban expansion, whereas periodic drought episodes occur. Water right adjustments will potentially reduce the amount of available irrigation water, particularly where sourced from ground water. At the same time, increased irrigation (i.e., water, energy, and labor) costs as well as other production inputs have reduced the economic return for grain crops. As a result, it is important to know when and how much water is needed for optimal crop performance.

**Fertilization**

- **Sampling:** To minimize in-crop nutrient management, it is important to monitor the soil nutrient content. Depth to rooting zone is a critical factor for efficient use of fertilizers.
THANK YOU
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