Optimizing Fertilizer Applications on Big Horn Basin Crops

Westi Ag Days, Worland, Wyoming
February 4, 2009

Jay Norton, Soil Fertility Specialist
Renewable Resources Department
University of Wyoming
307-766-5082
jnorton4@uwyo.edu  http://uwyo.edu/SOILFERT/
Overview

- Challenges of farming Wyoming soils;
- Components of reliable fertilizer recommendations;
- Optimizing fertilizer application on:
  - Sugar beet
  - Dry bean
  - Small grains
  - Corn
Legacy of the desert

- High nutrient content:
  - Leaching losses are minimal;
- Evaporation far exceeds precipitation:
  - Elements released through weathering of soil parent materials accumulate as salts;
  - Soluble components move UP, not down;
- Alkaline pH (>7.0) from abundance of base cations, including CaCO₃
  - Ties up P and some micronutrients;
- Low productivity of the desert:
  - Low soil organic matter content
  - Low water and nutrient holding capacity;
  - Low nutrient content;
Fertilizer requirements

- Wyoming soil tests usually indicate needs for supplemental nitrogen, phosphorus, and often sulfur;

- N is most limiting to growth and yield:
  - Most common, plant available form is nitrate (NO₃⁻), which is very soluble and volatile;
  - Test soil for N content every year;

- P is second most limiting:
  - Applied as phosphate (P₂O₅); less soluble but is rapidly tied up in soil minerals because of abundant CaCO₃;
  - Test soil for P every year, but apply every year;

- S is often applied as ammonium sulfate:
  - Sufficient S in most Wyoming soil or from water, but often get a yield response from added S;
  - Test for S every 2-3 years at least;

- Micronutrients: High pH soils can limit availability of Zn, Fe and others: test soils every 2-3 years.
Components of reliable fertilizer recommendations

1. Analysis of representative soil samples at a reliable lab;
2. Realistic yield goals;
3. Residual soil nutrients;
4. Soil organic matter;
5. Irrigation water management;
6. Cropping history;
Representative soil sample

- Bulk by one-foot depth increments down to three feet or deeper:
  - Mix samples from 15-20 points with like soils and management and subsample;
  - More is better, especially where fertilizers have been banded.
  - Dry samples thoroughly ASAP, but don’t oven dry.
  - Each year for N and P, every 3-4 years for other nutrients, pH, and organic matter.
- At minimum: five 0-12” bulk samples per crop/soil type combination.

- [http://ces.uwyo.edu/PUBS/MP6.3.pdf](http://ces.uwyo.edu/PUBS/MP6.3.pdf)
Realistic yield goals

- Use average yields for particular fields, not maximum or record yield:
  - Set goal at 105% of five-year average;
- Yield goals set too high result in excess fertilizer that wastes money and can reduce yields.
Residual soil nutrients

- Available nutrients left in the soil after the previous crop;
- Impacted by:
  - Yield & management of previous crop;
  - Weather: SOM mineralization, leaching;
- N and P can be lost:
  - Measure as close to planting as possible;
  - Don’t apply excess;
- Should be measured by a lab for best recommendations.
Organic matter

- Crop residues & humus;
- Store of time-release nutrients;
- UWyo soil lab assumes 20 lbs of N per year for each 1% SOM;
- Many other attributes:
  - Increases water- and nutrient-holding capacity;
  - Improves tilth;
  - Dark color;
- Can be increased or decreased by management.
Increasing SOM

- Whole cropping system soil management:
- Manure applications to crops where high protein is desired, but not malting barley;
- Green manure crops: Planted after barley, for instance, and then plowed down in fall before wheat, corn, oats, or feed barley;
- Legumes in rotation can supply all N needs;
- Reduced tillage.
Tillage

- Tillage speeds loss of SOM;
- Reduced- or no-till reduces fuel and labor costs;
- Builds SOM but may increase N needs early on because of immobilization;
- Later N from SOM mineralization can increase protein;
- Conserves water;
- Residues can cause problems for furrow irrigation;
- Fertilizer should be banded to be away from residue.
Irrigation water management

- Irrigation enables precise nutrient management because dissolved fertilizers move where the water moves;
- Early on, shallow irrigation prevents losses through leaching: Most fertilizer used up before roots, and irrigation, extend deeper into soil;
- Recommend irrigation water management plan based on soil intake and water holding capacity:
  - Sprinklers provide most control over nutrient movement;
  - Surge irrigation, at least in early-season applications, much better than standard furrow.
N credit from irrigation water

- Have NO3 content of irrigation water tested at lab;
- Each ppm NO3 = 2.72 lbs N per acft of water;
- \(2.72 \times \text{ppm NO3 in water} \times \text{acft of water use} = \text{Lbs N/ac};\)
- This can change through the season, so having several samples tested can support better estimates.
## Nitrogen from legumes and manure

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;80% stand</td>
<td>100-140</td>
<td>50-70</td>
<td>0</td>
</tr>
<tr>
<td>60-80% stand</td>
<td>60-100</td>
<td>30-50</td>
<td>0</td>
</tr>
<tr>
<td>0-60% stand</td>
<td>0-60</td>
<td>0-30</td>
<td>0</td>
</tr>
<tr>
<td>Dry beans</td>
<td>30</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Manure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Dry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lbs N / ac credit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lbs N / ton (dry wght)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>50%</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Dairy</td>
<td>20%</td>
<td>15</td>
<td>7.5</td>
</tr>
<tr>
<td>Poultry litter</td>
<td>75%</td>
<td>25</td>
<td>12.5</td>
</tr>
</tbody>
</table>

The N and moisture content of manure is variable: have it tested in a lab for accurate credit.
Sugar Beets

- Highest value crop grown in Wyoming and is regionally economically important;
- Most resource-intensive crop, requiring large amounts of water, fertilizers, and pesticides;
- Until recently high value dwarfed input costs, but high fertilizer prices have changed that;
Sugar beet nutrition

- Sugar beets convert energy from the sun into sugar so need to close their canopy rapidly to intercept maximum sunlight;
- This requires abundant fertility, especially nitrogen, early in the season;
- But N uptake later in the season forms impurities and promotes vegetative growth at the expense of root growth.
Sugar beet nutrition

- Challenge is to provide abundant nutrition early but limit access later;
  - Beets have limited lateral root development;
  - Growth starts slow in cool spring temperatures;

- Irrigation can provide excellent control for nutrient management because NO3 is soluble and moves with water;

- Over-irrigation with over-fertilization carries excess N below the early season roots
  - Might be lost or
  - Become available as roots extend downward later in the season.
Sugar beet nutrition

- Application at soil-test-based rates combined with careful water management would limit access to deep, late season N;
  - Sprinkler or surge irrigation improves control;
- May reduce early season growth but would increase quality and reduce fertilizer costs;
- So far confirmed by current trials at Powell.
Sugar beet nutrient requirements

Required for growth:

- Nitrogen: 9 lbs per ton;
- Phosphorus: 3 lbs per ton;
- Potassium: 9 lbs per ton;
- So 20 tons per acre requires TOTAL:
  - 180 tons of N per acre
  - 60 tons of P per acre
  - 180 tons of K per acre

- Recommendations use total required minus RSN, nutrients from decomposing organic matter, and other credits from legumes, manure applications, and nitrate in irrigation water.
Fertilizer placement

- Important for early access with limited lateral root development;
- Options include broadcast, knife banded, and point injected;
- Broadcast & incorporation of urea is common, but losses can be large because of poor early season access;
- Banding liquid provides better placement and can save an operation;
- Knife banding liquid UAN known to reduce losses and increase availability, but takes more horsepower;
- In research at PREC point injection performed better than knife banding with less disturbance and fuel.
N source, rate, and placement study

- **Urea**: standard dry N form (46% N);
- **UAN**: standard liquid N form (32% N);
- **Agrium ESN**: coated, slow release urea;
- **Simplot NSN**: coated, slow release urea;
- **Agro-Culture NRG**: liquid slow release;
- **Georgia Pacific Nfusion**: slow release, mix 80/20 with UAN.
Treatments

- **PRODUCTS:**
- **RATES:**
  - UW N recommendation: 150 lb/ac in 2007, 118 in 2008;
  - Standard application at PREC: 220 lb/ac;
- **TIMING:**
  - All preplant;
  - Split: half preplant/half with UAN sidedress;
Products

Root Yield (tons per acre)

Percent Sucrose

Sucrose Yield (tons per acre)

Products
- Subtle differences in yield;
- Suggest no advantage to higher rates, expensive products, or split application;
- Except for UAN and UAN+Nfusion.
Dry beans

- Beans are legumes and fix nitrogen from the atmosphere if inoculated with appropriate rhizobium bacteria;
- In dryland bean production, N fixation can provide all the N needs of the crop;
- But N is most often limiting nutrient in irrigated dry beans;
- Beans require adequate N, but excess can delay maturity and damage quality;
- Split applications can improve uptake, especially on sandy soils.
Dry bean nutrient requirements

- Requirements per cwt. yield goal:
  - Nitrogen: 3.3 lbs
  - Phosphorus: depends on soil texture and lime content;
    - 1.5 (coarse soils) to 3 lbs (fine or high lime soils) per cwt to compensate for P fixation;
    - Cut in half for banded application;
- Potassium: adequate in Wyoming soils;
- Micronutrients: High pH can cause problems with some micronutrients, especially Zn and Fe. Apply as per soil lab recommendation.
Dry bean fertilizer recommendations

- Based on representative soil sample to at least 12 inches;
- Recommendation = YG – RSN – other credits + straw adjustment.
- YG = Realistic, field-specific yield goals: long-term Wyoming average = 2300 lbs/.ac;
- RSN = Residual soil nutrients determined from soil tests;
- Other credits: previous legumes and manure applications;
- Straw adjustment: decomposition of non-legume crop residue ties up N. Recommendation is increased by 15 lbs N per ton of straw:
  - 30-50 lbs of straw per bushel of grain; 50-70 for wheat.
Optimizing fertilizer on dry beans

- Innoculate if beans haven’t been grown for 2-3 years or if previous crop wasn’t well nodulated;
- Banding 2 inches to the side and 2 inches below of P and up to 40 lbs N improves emergence on fine soils, but harms it on sandy soils;
- For high application rates (80 lbs/ac or more) split applications reduce loss, improve uptake, and decrease seedling damage;
- Test for micronutrients: N and P are wasted if the crop is stunted from Zn or Fe deficiency;
- Increase SOM and N fixation (more later)
- Careful irrigation water management.
Spring-planted small grains

- Include spring wheat, oats, feed barley, and malting barley;
- Short season means ample nutrient supplies needed early;
- N is most often limiting nutrient;
- Split applications for high rates of N can reduce loss, but not for malting barley. But short season means usually all preplant;
- Late season N availability increases protein, which is good for wheat, oats, & feed barley, but degrades malting quality.
Small grain nutrient requirements

- Wheat: 1.72 lbs N, 1.0 lb P$_2$O$_5$ per bu;
  - Average yield in NW = ~75 bu;
- Oats: 1.15 lbs N, 0.5 lb P$_2$O$_5$ per bu;
  - Average yield in NW = ~95 bu;
- Feed barley: 1.55 lbs N, 0.7 lb P$_2$O$_5$ per bu;
- Malting barley: 1.35 lbs N, 0.7 lb P$_2$O$_5$;
  - Average all barley yield in NW = ~100 bu;
- Multiply by YG (105 % of 5y average) and subtract credits;
- K, S, and micronutrients usually sufficient, but test occasionally.
Optimizing fertilizer on irrigated small grains

- Soil sample to two feet in 1-foot increments and as close as possible to planting time;
- N from manure and legumes in rotation is an excellent source for wheat, oats, and feed barley;
- Manure should not be applied to malting barley;
- Malting barley shouldn’t follow legume;
- Increase OM through reduced tillage;
- Careful irrigation water management.
Irrigated corn

- Very high value and very resource intensive;
- Very high N requirements;
- Split applications and late spring soil testing are recommended; just before rapid growth phase;
- Deep roots can capture deep-leached N from previous crops like sugar beet but late-season N doesn’t hurt the quality of corn;
- Responds well to late-season N from manure, previous legumes, or green manure crops.
Nutrient requirements of corn

- About 1.6 lbs of N per bushel;
- About 6 lbs of P2O5 per bushel;
- About 1.2 lbs of K2O per bushel.
- Grain yield: NW = ~130 bu;
- Silage yield: about 23 tons/ac.

- Soils tests usually recommend supplemental N and P but Wyoming soils usually have adequate K.
Optimizing fertilizer on irrigated corn

- Soil sample to at least three feet;
- Test for and apply micronutrients if needed;
- Band fertilizers and split applications;
- Late spring soil test;
- Increase OM;
- Rotate with legumes;
- Apply manure;
- Careful irrigation water management.
Summary

- Optimizing returns from fertilizer requires
  - Knowledge from soil testing;
  - Realistic yield goals;
  - Building soil organic matter;
  - Tillage and fertilizer placement advances;
  - Careful water management;
  - Remembering what happened last year.

Soil Resources Web Page:

uwyo.edu/soilfert