Nutrient Management of Forages and Legumes

Crop Pest Management School
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by Clain Jones, Extension Soil Fertility Specialist
and Kathrin Olson-Rutz research associate

clainj@montana.edu; 994-6076
http://landresources.montana.edu/soilfertility
Goals

1. To review use of Fertilizer Guidelines to determine fertilizer N rates on forages
2. To present yield and economic responses of pasture and hay to fertilizer
3. To provide an update on new fertilizer products that could benefit forage producers
4. To illustrate some benefits of phosphorus, potassium and sulfur on legumes and forages
Do you or your clients grow forages?

1. Annual forages
2. Perennial forages
3. Both
4. None
How much N should be applied to alfalfa-grass stands?

Can use Fertilizer Guidelines for Montana Crops (EB 161)

<table>
<thead>
<tr>
<th>Yield Potential (t/a)*</th>
<th>ALFALFA/GRASS</th>
<th>80/20</th>
<th>60/40</th>
<th>40/60</th>
<th>20/80</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N fertilizer (lbs/a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>15</td>
<td>30</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>25</td>
<td>50</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>30</td>
<td>60</td>
<td>90</td>
<td>120</td>
</tr>
</tbody>
</table>

Need to divide by fraction of N in fertilizer to find total fertilizer need.
How much N should be applied to grass?

Fertilizer Guidelines for Montana Crops (EB 161):

<table>
<thead>
<tr>
<th>Yield Potential (t/a) *</th>
<th>Available N (lbs/a) **</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>125</td>
</tr>
</tbody>
</table>

http://www.montana.edu/wwwpb/pubs/eb161.html
Single N application on dryland grass pasture

- near Willow Creek, MT
- 0, 50, 100 lb N/acre spring broadcast
- harvested once
- dryland grasses
  - **Natl Bnch**: Basin wldrye
  - **Natl Rhizom**: Western whtgrs
  - **Hybrid Bnch**: whtgrs (2), wldrye (4)
  - **Intro Rhizom**: whtgrs (3)
Single N application on dryland grass pasture

Willow Creek, MT, 1 year
lb N/ac applied once in spring
Carlstrom, Cash, and Ditterline 2003

0    50  100
Natv bnch
(Basin Wldrye)

0    50  100
Natv rhiz
(Wstrn Whtgrs)

0    50  100
Hybrid bnch
(6)

0    50  100
Hybrid rhiz
(3)
Willow Creek, MT, 1 yr harvest
lb N/ac applied once in spring
$375/ton urea, $80/ton hay
Carlstrom, Cash and Ditterline 2003

First year marginal return as hay

Marginal Return as Hay ($/acre)

Natl bnch (Basin Wldrve)
Natl rhiz (Wstrn Whtgrs)
Hybrid bnch (6)
Hybrid rhiz (3)
First year marginal return as forage

Willow Creek, MT

lb N/ac applied once in spring

$375/ton urea, $15.75/AUM, 750 lb DM/AUM, 50% utilization

Carlstrom, Cash and Ditterline 2003
Why would anyone fertilize pasture?

Potential long term effect
Single N application to dryland grass pasture

- near Havre, MT
- 0, 50 and 100 lb N/acre fall broadcast once
- harvested for 6 years
- dryland grasses
  - **Natl Bnch**: Basin wldrye, Beardless whtgrs, Green needlegrs, Slender whtgrs
  - **Natl Rhizom**: Thickspike whtgrs, Western whtgrs
  - **Intro Bnch**: Crested whtgrs, Russian wldrye, Tall whtgrs
  - **Intro Rhizom**: Pubescent whtgrs, Intermed whtgrs (2)
Single 50 lb N application increases yields over control on some grasses for several years.

Havre, dryland grasses
single fall broadcast 50 N lb/acre
Lorbeer et al. 1994
Single N application increases dryland grass yields

Havre, dryland grasses
single fall broadcast N lb/acre

Lorbeer et al. 1994
First year marginal return on dryland grass fertilization

Havre, dryland grasses
single fall broadcast N lb/acre
$375/ton urea, $80/ton hay

Lorbeer et al. 1994
6-yr average annual marginal return as hay

Havre, dryland grasses
$375/ton urea, $80/ton hay
single fall broadcast N lb/acre
Lorbeer et al. 1994
6-yr average annual marginal return on forage

Havre, dryland grasses
$375/ton urea, $15.75/AUM
750 lb DM/AUM, 50% utilization
single fall broadcast N lb/acre
Lorbeer et al. 1994
Under what situation would you advise N fertilization?

1. Only if there is a local hay market
2. On any grass if individual is also buying hay
3. Only with introduced rhizomatous species

1. 0% of 5
Effect of N Rate on Irrigated Western Wheatgrass, Blaine County

Christiansen, unpub. data

Effect of N Rate on Irrigated Western Wheatgrass, Blaine County

Yield (t/ac)

N rate (lb/ac)

Economics?
QUESTIONS?
Placement

- Granular: On established forage, surface broadcast is essentially only option. Others?
- Liquid (UAN; 32-0-0 or 28-0-0): Surface broadcast including fertigation, surface band, or knifed.

<table>
<thead>
<tr>
<th>Method</th>
<th>Forage Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast</td>
<td>2.9 t/ac</td>
</tr>
<tr>
<td>Knife</td>
<td>2.8 t/ac</td>
</tr>
<tr>
<td>Surface Band</td>
<td>3.4 t/ac</td>
</tr>
</tbody>
</table>

N. Central Regional Extension Pub #326, KSU
Some N can be absorbed through leaves
However, most foliar applied N ends up being washed off and taken up by roots:
Only 8-11% of foliar applied liquid urea was taken up by leaves, whereas 37-67% of soil-applied N was taken up by plant in same study (Rawluk et al., 2000).
Risk of burn? Likely not an issue due to low rates applied (~25 lb N/t). Has anyone seen grass ‘burn’?
Timing

- Yield and quality are affected by timing
- Because urea may take days to weeks to become available, urea should be applied earlier than AN historically was for fast green-up (AN simply dissolves, UR requires a chemical reaction to become available).
Enhanced Efficiency Fertilizers and forage production

• Forage production lacks incorporation, and plant residue intercepts fertilizer, increasing chance for volatilization

• EEFs retain N on site by reducing losses through:
  • Stabilizing or inhibiting soil processes to extend N availability (NSN®) or reduce urea conversion to ammonia (Agrotain®: urease inhibitor – 14 days max) or ammonium to nitrate (DCD)
  • Slow release of urea through a coating (polymer coated – PCU such as ESN®, sulfur coated - SCU)
What is your experience with EEFs?

1. Never heard of them
2. Heard of them but never used
3. Have used once
4. Have used more than once
5. Have recommended their use

1. 0 of 5
Nitrogen EEF and forage production

- Can increase mid to late season cuttings and protein, and encourage uniform growth through season
- Can be blended with urea to meet goal
  - Large early crop? PCU too slow, but urease inhibitor can help reduce urea loss
  - Season-long forage or a late cutting? Delayed release of PCU desirable
EEFs

- Allow application flexibility - e.g. fall broadcast on coarse soil
- Are environmentally responsible but more $
- Are a Conservation Stewardship Program enhancement

*Enhanced Efficiency Fertilizers (EB0188)*

[http://landresources.montana.edu/soilfertility](http://landresources.montana.edu/soilfertility)

Go to Fertilizer Information
General considerations for dryland grass N fertilization

- Species response to fertilization varies greatly
- Introduced and hybrid grasses tend to respond more than native grasses
- A single moderate fertilization (50-100 lbs) may increase production for several years
- Equal amounts of total N applied once or annually over several years can yield the same total production
Other considerations for dryland grass N fertilization

- Dryland grass pasture tends to hold N on site and respond during wet years
- Protein and digestibility may improve with N added
- Net economic gain as hay, but most likely not as forage. What does this tell you?
QUESTIONS?
Phosphorus (P)

Why often deficient in Montana soils?

Binds with calcium to form poorly soluble calcium phosphate minerals
Advantages of phosphorus (and potassium, sulfur) fertilization on alfalfa-grass stand?

- Helps with N fixation in nodules
- Favors alfalfa over grass
Single P application increases alfalfa yield for several years

Location (Olsen P)

Geyser (6.2 ppm) Moore (5.2 ppm)

Total 4-yr Alfalfa Yield (ton/acre)

- 0-0-0-0
- 50-0-50-25
- 50-100-50-25

One single application

Economics?

Wichman unpubl. data
P fertilization strategy

- At $80/ton hay and $0.40/lb P, net revenue of P fertilization = $22/acre/year

- At $80/ton hay and $1.20/lb P, net revenue of P fertilization = $2/acre/year
Koenig et al. 2009 - Iron County, UT, 2 site-years
P rate = lb P₂O₅/acre
spring broadcast/sprayed

Olsen P = 7.8 ppm (0-12 in.)

2002

0 P MAP - 68 MAP - 138 APP - 68 APP - 138

2003

Olsen P = 4.0 ppm (0-12 in.)

0 P MAP - 95 MAP - 188 APP - 95 APP - 188
Marginal return on P by rate and source

Koenig et al. 2009 - Iron County, UT, 2 site-years
P rate = lb P\textsubscript{2}O\textsubscript{5}/acre, spring broadcast/sprayed
$400/ton MAP and APP, $100/ton hay

2002
Olsen P = 7.8 ppm (0-12 in.)

2003
Olsen P = 4.0 ppm (0-12 in.)
<table>
<thead>
<tr>
<th>Year</th>
<th>yes</th>
<th>no</th>
<th>1/2P</th>
<th>yes</th>
<th>no</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>P &gt; no P</td>
<td>MAP &gt; APP</td>
<td>full P &gt; $1/2P$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
What to recommend to producers when $400/ton MAP and $100/ton hay on a site with Olsen P < 8 ppm?

1. No application
2. Single large application
3. Smaller annual applications
How might your recommendation be different when MAP is $1050/ton?
Marginal return on P by rate and source at high $ P

Koenig et al. 2009 - Iron County, UT, 2 site-years
P rate = lb P\textsubscript{2}O\textsubscript{5}/acre, spring broadcast/sprayed
$1050/ton MAP and APP, $100/ton hay

Olsen P = 7.8 ppm (0-12 in.)

2002
MAP - 68
MAP - 138
APP - 68
APP - 138

2003
MAP - 95
MAP - 188
APP - 95
APP - 188

Olsen P = 4.0 ppm (0-12 in.)
Phosphorus fertilization considerations

- Low P soil should yield higher return on P investment
- Yield response to P varies with growing conditions
- On average, MAP is more economical than APP, but not in every case
QUESTIONS ON NITROGEN OR PHOSPHORUS?
Potassium (K)

Needed in Montana?

Useful on many soils, even some having high K values (especially in spring due to cool temperatures)
Which forages have largest K needs?

<table>
<thead>
<tr>
<th>Crop</th>
<th>Assumed Yield per Acre</th>
<th>K$_2$O removal (lb/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>2.5 t</td>
<td>150</td>
</tr>
<tr>
<td>Brome grass</td>
<td>1.5 t</td>
<td>95</td>
</tr>
<tr>
<td>Orchard grass</td>
<td>1.5 t</td>
<td>75</td>
</tr>
<tr>
<td>Timothy</td>
<td>1.5 t</td>
<td>94</td>
</tr>
<tr>
<td>Corn silage</td>
<td>20 t</td>
<td>167</td>
</tr>
</tbody>
</table>
How might K, or lack of K, affect an alfalfa-hay field?
Factors decreasing S availability

1. Irrigated with low S in irrigation water
2. Sandy, acidic, or low organic matter soils
3. Cold soils
4. Soils formed from minerals low in S or far from industrial sources
Sulfur (S)

Responses seen in alfalfa-grass fields?

Note: Yield increased 30% at Moccasin (See Fert. Fact 27)
QUESTIONS ON SULFUR?
Special considerations for grass fertilization

- If sub-irrigated fertilize for high yield potential but apply P in fall
- On irrigated/wet meadows apply nutrients in spring
- Split N generally does not increase total yield
- If seeding on fallow, OM >3% provides adequate N for 2-3 years
- If N is banded or seed placed do not exceed 10-15 lb N/acre, also for P as ammonium-phosphate
Special considerations for forage fertilization

- Broadcast most effective on perennial stands – deep banding OK on old alfalfa stands
- Late fall/early spring for cool season mix (except on sandy soil), mid-May for warm season mix
- In dryland consider ‘build up’ of P and K prior to seeding
Fertilization of annual legumes
Do you grow or advise on annual legumes for:

1. Forage/hay
2. Seed crop
3. Green manure
4. A mix of the above
5. Do not grow or advise on annual legumes

1. 0 of 5
Phosphorus and potassium uptake

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Peas, Lentils, Chickpeas</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus (lb/bu)</td>
<td>0.67</td>
<td>0.62</td>
</tr>
<tr>
<td>Potassium (lb/bu)</td>
<td>0.87</td>
<td>0.38</td>
</tr>
</tbody>
</table>

P levels are often low in Montana (due to calcareous soils).

K levels are often moderate to high in Montana. No research located on K and legumes in region.

BOTH P and K needed for N fixation!
Effect of P on spring pea yield (2004-2005) Sidney

Data from J. Waddell

Olsen P = 10-14 ppm

P rate (lb P$_2$O$_5$/acre)  

Grain Yield (bu/ac)
### Montana phosphorus fertilizer guidelines for annual legumes

<table>
<thead>
<tr>
<th>Olsen P (ppm) 0 to 6 inches</th>
<th>Application rate (lb P$_2$O$_5$/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Above 16</td>
<td>0 up to crop removal*</td>
</tr>
</tbody>
</table>

* - Assume 2/3 lb P$_2$O$_5$ per bushel of grain
Why are P fertilizer needs of annual legumes somewhat less than for small grains and oilseeds?

- Lower yields
- Annual legume roots are shallower-better able to take advantage of higher P levels in upper 6 inches
- Legumes lower soil pH, mobilizing P
Montana potassium fertilizer guidelines for annual legumes

<table>
<thead>
<tr>
<th>Soil Test K (ppm) 0 to 6 inches</th>
<th>Application rate (lb K$_2$O/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>35</td>
</tr>
<tr>
<td>150</td>
<td>30</td>
</tr>
<tr>
<td>200</td>
<td>25</td>
</tr>
<tr>
<td>250</td>
<td>20</td>
</tr>
<tr>
<td><strong>Above 250</strong></td>
<td><strong>0 up to crop removal</strong>*</td>
</tr>
</tbody>
</table>

* - Assume 0.87 lb K$_2$O per bushel of grain
Fertilizer placement for legumes

- No nitrogen (N) or potassium (K) fertilizer with the seed
- Small amounts of phosphorus (<10 lb P₂O₅/ac) with the seed
- Ideal placement is below the seed
Rooting patterns and starter and deep band fertilizer placements

Wheat

Legumes

Secondary root system

Primary root systems
Conclusions

- Nitrogen, phosphorus, potassium, and sulfur can all produce growth responses in Montana forage.
- Economic benefits often aren’t realized in the first year (so don’t trust 1 year studies!).
- Soil testing is critical for determining fertilizer needs.
Questions?

Additional info at
http://landresources.montana.edu/soilfertility