Soil Fertility of Annual Legumes

Prepared for 2007 Crop Pest Management School

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Questions for you

- How many of you have clients who grow annual legumes?
- How many of you grow annual legumes?
- Small grain replacement or fallow replacement?

Your experiences?
Both good and bad?
U.S. Lentil Acres
(USDA – NASS)

Eric Bartsch, Northern Pulse Growers
Lentil Production Area
US Dry Pea Acres
(USDA-NASS)

US Dry Pea Acres

<table>
<thead>
<tr>
<th>Year</th>
<th>ND</th>
<th>MT</th>
<th>ID</th>
<th>WA</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>100,000</td>
<td>200,000</td>
<td>300,000</td>
<td>400,000</td>
<td>500,000</td>
</tr>
<tr>
<td>2001</td>
<td>110,000</td>
<td>210,000</td>
<td>310,000</td>
<td>410,000</td>
<td>510,000</td>
</tr>
<tr>
<td>2002</td>
<td>120,000</td>
<td>220,000</td>
<td>320,000</td>
<td>420,000</td>
<td>520,000</td>
</tr>
<tr>
<td>2003</td>
<td>130,000</td>
<td>230,000</td>
<td>330,000</td>
<td>430,000</td>
<td>530,000</td>
</tr>
<tr>
<td>2004</td>
<td>140,000</td>
<td>240,000</td>
<td>340,000</td>
<td>440,000</td>
<td>540,000</td>
</tr>
<tr>
<td>2005</td>
<td>150,000</td>
<td>250,000</td>
<td>350,000</td>
<td>450,000</td>
<td>550,000</td>
</tr>
<tr>
<td>2006</td>
<td>160,000</td>
<td>260,000</td>
<td>360,000</td>
<td>460,000</td>
<td>560,000</td>
</tr>
</tbody>
</table>

Acres

0 100,000 200,000 300,000 400,000 500,000 600,000 700,000 800,000 900,000 1,000,000

Year
U.S Dry Pea Production

US Dry Pea Production

Year

CWT

2000 2001 2002 2003 2004 2005 2006

ND
MT
ID
WA
US
New Organization: Northern Pulse Growers

• Formed last year: Combined ND Pea and Lentil Association with Montana annual legume growers
• Checkoff: For marketing and research
• Information: www.ndpealentil.org
Goals Today

• Show small grain yields following legumes compared to:
  - Following Fallow
  - Following Small grains

• Discuss N credit from legumes

• Point out phosphorus and potassium fertilizer needs of legumes vs small grains

Pea field in north central MT
July 4, 2004

Photo: P. Miller
Moccasin Cropping System/Tillage Study

Previous crop: Winter Pea (forage)   Spring Wheat   Spring Pea (grain)

Winter Wheat

Photo by C. Chen
Effect of Previous Crop and N on 2006 Winter Wheat Grain Yield (NT)
Moccasin, MT

Data from C. Chen
Effect of Previous Crop and N on 2006 Winter Wheat Grain Yield (NT)

Moccasin, MT

Note: There was good moisture in 2006

Data from C. Chen
Effect of Previous Crop on Residual Nitrate-N

Why different?

C. Chen
Wheat needs up to 45 lb/ac less N when grown on fallow or winter pea than on barley, but the same amount of N when grown on spring pea.
Effect of Previous Crop on WW Yield
Bozeman Rotation Study

Winter wheat yield - Bozeman

bu/ac (12% moist)

2001 2002 2003 2004

Pea
Canola

P. Miller
Winter wheat yield - Bozeman

Same trend with spring wheat?

Spring wheat yield - Bozeman
What about wheat yield following other annual legumes?

Spring Wheat Saskatchewan

P Miller
Take home messages on yield

- Small grain yield after pea is generally greater than after small grains and oil seed crops.
- Small grain yield after pea can be competitive with after fallow.
- Caution needed in dry areas and dry years.
QUESTIONS SO FAR?
Nitrogen Benefits

• Peas and lentils CAN ‘fix’ about 2-4 lb N/bu. Ex: 50-100 lb N/acre for 25 bu crop.
• Over 1/2 of this is removed at harvest.
• Credit TO NEXT CROP is between 0 and 20 lb N/acre. Where did rest go?
• If replacing a small grain or oilseed with a legume, bigger N savings will be in legume year.
• If replacing fallow with legume, bigger N savings will be in long-term.
Effect of Lentil on Spring Soil Nitrate-N Levels

Swift Current, SK
Zentner et al. 2004
How do I maximize N benefit?

• Seed legume into soil with low available N
• Inoculate, especially if field never had legumes
• Provide sufficient phosphorus (P) and potassium (K)
Effect of Inoculation on Dry Pea Yield
Carrington, ND

![Bar chart showing the effect of inoculation on dry pea yield. The x-axis represents different treatments: No Inoc, 0 N, Inoc, Inoc, 45 N, Inoc, 90N. The y-axis represents yield in pounds per acre (lb/acre) ranging from 0 to 4500. The graph shows a significant increase in yield for the inoculated treatments compared to the non-inoculated treatment.](chart.png)
QUESTIONS SO FAR?
# 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 Fertilizer on Amount of N Fixed: Soybeans

Figure 5. Phosphorus application may enhance N₂ fixation in soybean growing in low P soils. Biological N₂ fixation can only be effective if all necessary nutrients are available in the soil. If phosphorus is limiting, N₂ fixation can be enhanced by P fertiliser application, as illustrated in the above example (data of J. Dombovari presented by Zapata and Baert, 1989)
Effect of P on Spring Pea Yield (2004-2005)

Sidney

Grain Yield (bu/ac)

0 17.5 35 70

Olsen P = 10-14 ppm

P rate (lb P2O5/acre)

Data from J. Waddell
Effects of P and Previous Crop on Soil Nitrate (to 3 ft.)

Spring 2005

P rate (lb P2O5/ac)

Soil Nitrate (lb N/ac)

After Pea

After Wheat

J. Wadell, Sidney
Effect of Pea on Spring Lentil Yield
Moccasin (CARC) and Cutbank

![Graph showing yield vs. P-application](http://landresources.montana.edu/fertilizerfacts)

Data from C. Chen and G. Jackson

http://landresources.montana.edu/fertilizerfacts (# 38)
Montana Phosphorus Fertilizer Guidelines for Annual Legumes

<table>
<thead>
<tr>
<th>Olsen P (ppm) 0 to 6 inches</th>
<th>Application rate (lb P₂O₅/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 P₂O₅ per bushel of grain
Why are P needs of annual legumes somewhat less than for small grains and oilseeds?

- Lower yields
- Annual legumes root shallower:
  Better able to take advantage of higher P levels in upper 6 inches
- Legumes lower soil pH, mobilizing P
Why does rooting depth matter?

P accumulates near surface

Chen and Jones

Shallow rooted crops can better utilize P from near surface
# Maximum Rooting Depths
(Mandan, North Dakota)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Maximum rooting depth (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Pea</td>
<td>3.0</td>
</tr>
<tr>
<td>Canola</td>
<td>3.5</td>
</tr>
<tr>
<td>Spring Wheat</td>
<td>4.0</td>
</tr>
<tr>
<td>Sunflower</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Merrill et al. 2002
What is More Important than Max. Root Length for Nutrient Uptake?

Dry pea will use more nutrients from surface; canola will use more from depth.
Legumes can also acidify root zone
Take home messages on P

- Annual legumes need similar amounts of P PER bu.
- P is necessary for N fixation.
- Legumes are better able to access soil and fertilizer P than small grains.
QUESTIONS SO FAR?
## 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>Above 250</td>
<td>0 up to crop removal*</td>
</tr>
</tbody>
</table>

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

• No nitrogen or potassium 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

- Small grain yields are generally higher following legumes than following small grains or oilseeds.
- Small grain yields can be similar following legumes than following fallow, esp. in moist year.
- N benefits from legumes will be higher when soil N is low, seed is inoculated, and P and K are adequate.
- Phosphorus has been shown to have both positive and neutral results on pea and lentil yields, but response should be higher on low P soils.
- Potassium needs are high for legumes, partly b/c needed for N fixation, but little research has been conducted on pea or lentil responses.
For more information

- Soil Fertility Website: http://landresources.montana.edu/soilfertility
- Cropping Systems Website: http://scarab.msu.montana.edu/CropSystems