Inoculants and Nutrient Management of Pulses
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Clearview Seed, Denton

Clain Jones, Extension Soil Fertility Specialist
clainj@montana.edu; 406-994-6076

MSU Soil Fertility Extension
Objectives

Provide you info on pulse fertility
- Requirements for N-fixation
- N fertilization and inoculation effects
- P, K, S needs
- Fertilizer rates, placement, timing
Uncontrollable factors negatively affecting nodulation & N fixation

- Extreme soil temps
- Waterlogged or dry soil
- Soil pH < 5.5, > 8 inoculant strains differ in tolerance
- Saline soils
- Maturing plants

Rice et al., 2003, greenhouse
Practices to improve nodulation & N fixation

- Use species-specific inoc
- Keep inoc cool, dark; granular more reliable than liquid
- Apply proper inoc rate
- Avoid fertilizer salts (mixing with fertilizer can kill bacteria)
- Adequate P, K, S
- Too much soil N inhibits
- No-till = retained soil moisture

Voison et al., 2003 greenhouse study
Pulses require N by either:

- Inoculation, especially on sites with no recent pulse history
- Fertilizer

“New” fields: Granular = more effective

Field with pulse history: Liquid or peat = less expensive

McConnell et al., 2002, stat letters (a, b) are w/in location-year

Fields had no recent pulse history
If legumes fix N, why add fertilizer N?

• Nodulation is carbon expensive, requires healthy plants
• Little N contributed by nodules until 3rd node, must come from top 12” of soil
• Rhizobial fed plants take 2-3 weeks longer to get going
• If insufficient N, plants get ‘stuck’ – can’t grow to feed nodules, nodules aren’t actively providing N for growth
• Insurance against nodule loss to pea leaf weevil
• N-fixation stops if soil nodule dries up, but growth optimized if there is soil N
How much seed row N?

- Too much N
  - inhibits nodulation
  - get excess vegetation
  - reduced yield
- Aim for 10-15 lb total available N/ac (soil + fertilizer) in top 12” in spring
- Place to side of seed row

Huang et al., 2017 in press, Moccasin
Does granular inoculant (GI) pay off?

Yields usually go up, but not always enough to offset the cost of inoculant. Considerations?

• Soils high in N (McKenzie et al., 2006)
• Fields with long or recent history of inoculation
• Dry soils – rhizobia die and water is limiting yield (McKenzie et al., 2006)
• Premium for protein? GI tends to consistently increase protein (data not shown). Protein may become a factor in price paid for pulse grains.
Rescue N

- If have yellow lower leaves (N deficiency) dig and look for rosy red nodules
- SK suggests 40-50 lb N/ac topdress
- Yield gain may not offset N cost
- Need water/rain to move N into soil
Questions on N?

On to S, P and K
Not Fertilized  Fertilized w/ P, K, and S

Winter Pea, Bozeman, 5/17/07

Image by T. Rick
Is this plant N deficient?

• Sulfur (S) deficiency is yellow upper (new) leaves
• S is necessary to take up N and make protein
• Soil tests are not reliable for S
• Base S on prior crop performance, S removal rate (0.15 lb S/bu) or tissue concentration (varies by crop; see *MT Cool Season Pulse Production Guide* or *The Soil Scoop: Soil Fertility for Pulse Crops*)
Sulfur fertilization

Preventive

- Bank elemental S. 71 lb S/acre before canola in canola, barley, pea system provided enough for the pea rotation 3 years later (Wen et al., 2003, SK)
- Sulfate S: 15-20 lb/acre at planting (<18 lb/acre in seed row)
- Liquid S: to the side of seed row at <18 lb/acre (Ahmed et al., 2017, SK)
- Save the seed row for P

Rescue

- 3-5 lb S/acre as granular or liquid
Montana phosphorus fertilizer guidelines for annual legumes vs winter wheat

<table>
<thead>
<tr>
<th>Olsen P (ppm) 0 to 6”</th>
<th>Annual legume application rate (lb P$_2$O$_5$/acre)</th>
<th>W wheat application rate (lb P$_2$O$_5$/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
<td>45</td>
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<tr>
<td>12</td>
<td>20</td>
<td>40</td>
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<tr>
<td>16</td>
<td>15</td>
<td>35</td>
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<tr>
<td>Above 16</td>
<td>0 up to crop removal*</td>
<td></td>
</tr>
</tbody>
</table>

* Assume 2/3 lb P$_2$O$_5$ per bushel of grain
Effect of P on spring pea yield (2004-2005)

Data from J. Waddell, Sidney, MT

Olsen P = 10-14 ppm
P response – depends on species and variety

• P response better when soil P < 9 ppm, add 30-40 lb P$_2$O$_5$/acre (Ffact No. 38; McKenzie et al., 2001; Karamanos et al., 2003)

• At soil P > 13 ppm, up to 15 lb P$_2$O$_5$/acre as maintenance amount ≈ max safe seed placed rate.

• P is more likely to pay off with pulse forage than grain when soil P is near adequate (Wen et al., 2008)

• P response loam >> than clay loam soils (Karamanos et al., 2003)

• Starter P may increase harvestability rather than pod production in lentil (Gan unpub. 2003).
Phosphorus source for seed row placement

- MAP < 5-20 lb P$_2$O$_5$/acre seed placed
- DAP use CAUTION = toxic to seedlings
- Liquids – equally potent as MAP, but close proximity of band to seed = higher risk to seed (Grenkow et al., 2013).

If more P required – sub-surface side band, broadcast incorporate before seeding, build with prior crop.
Take home messages on P

- Annual legumes need and remove similar amounts of P PER bu as wheat.
- P is necessary for N fixation.
- Legumes are better able to access soil and fertilizer P than small grains.
- Be cautious with seed placed, but don’t let that limit amount provided.
Potassium (K)

• K required for N-fixation

• K levels often moderate to high in Montana, generally not limiting

• Guidelines for MT pulse crops

<table>
<thead>
<tr>
<th>Soil K (ppm) 0 to 6 inches</th>
<th>Application rate (lb K₂O/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>45</td>
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<tr>
<td>50</td>
<td>40</td>
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<td>100</td>
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<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 (0.9 lb/bu)</td>
</tr>
</tbody>
</table>
Questions?

On to timing
Nutrient uptake

- Nutrient uptake precedes biomass
- Rapid demands once branching

Source: Malhi et al., 2007, Saskatchewan
Rescue N timing

- Up to 6 weeks after seeding
  - Pea: 9-12 node stage
  - Chickpea: 10-13 node
- If later
  - too much vegetative growth
  - poor pod set
  - delayed maturity

(McConnell et al., 2002, Moore, MT, 90 lb N/ac)
Take home messages on Timing

• **N:** at seeding, or as rescue

• **P:** build up with prior crop, in very small amount with seed, or side band at seeding

• **K:** build up with prior crop, side band below the seed, not seed-placed

• **S:** elemental with prior crop, sulfate at seeding or as liquid for rescue
Conclusions on fertilization of pulses

- Encourage N-fixation
- P response likely higher on low P soils, low amounts of seed-placed may pay off
- K needs are high for legumes, but little research on pea or lentil
- Elemental S can last for several years
- With high pulse prices, fertilization can pay for itself, if water isn’t limiting
For additional information

Soil Fertility Website:
http://landresources.montana.edu/soilfertility

Contains links to my presentations including this one, the bulletin *Montana Cool Season Pulse Production Guide*, and more.

SK Pulse Growers’ Nodulation and N-Fixation Field Assessment Guide

IPNI Seed Damage Calculator
http://seed-damage-calculator-herokuapp.com/
With good soil fertility you can grow big pods.

Remember Extension guides.