Nutrient Demands of Pulse Crops

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Primary Nutrients: N,P,K,S

IT ALL STARTS HERE!

Nodules that form on legume roots containing superior strains of N fixing bacteria fix N for legume crop and contribute to N nutrition of following crop.
**Amount of N fixed in Western Canada**

<table>
<thead>
<tr>
<th>Crop</th>
<th>lbs N / acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>100 – 250</td>
</tr>
<tr>
<td>Faba Bean</td>
<td>80 - 160</td>
</tr>
<tr>
<td>Pea</td>
<td>50 – 150</td>
</tr>
<tr>
<td>Soybean</td>
<td>40 - 140</td>
</tr>
<tr>
<td>Lentil</td>
<td>30 - 120</td>
</tr>
<tr>
<td>Chickpea</td>
<td>20 - 100</td>
</tr>
<tr>
<td>Dry Bean</td>
<td>5 – 70</td>
</tr>
</tbody>
</table>

- Actual amount depends on inoculation/nodulation, environmental conditions, soil available N and other nutrients like P.
Pulse Grain, Nitrogen Yield and N Fixation at Four Sites in Saskatchewan in 2014

Grain yield (kg/ha) of lentil, pea and soybean at the four sites.
Above-ground Nitrogen Yield: Peas $\geq$ Soybean $\geq$ Lentil

Nitrogen yield (grain+straw) kg/ha of lentil, pea and soybean.
% ndf& at Rosthern: soybean > pea = lentil

% of N in plant derived from N₂ fixation (%ndfa)
What about Faba beans?
Average **grain yield** (kg ha\(^{-1}\)) of four **faba bean** varieties averaged across four sites in 2016 (Klippenstein et al., 2017).
Average grain and straw total N uptake (kg ha$^{-1}$) for four P, K, S fertilized faba bean varieties across four sites in 2016.
• For pulses, we have observed typically ~ 3.5 to 4.5 lbs plant N uptake per bushel of grain yield.

• ~ 50% to 70% comes from N fixation.

• ~ 50% to 70% of above - ground plant N removed in grain.
Phosphorus requirement: soy = pea > lentil

Above ground (grain + straw) P uptake (kg P/ha).

Note: Multiply by 2.3 to get kg P$_2$O$_5$/ha
Average grain and straw **total P uptake** (kg P ha\(^{-1}\)) for four fertilized *faba bean* varieties across four sites (Klippenstein et al. 2017).
• ~ 0.5 lbs of P (~ 1.2 lbs P$_2$O$_5$) plant P uptake per bushel of grain yield.

• ~ 60% to 80% of above-ground P is contained in grain (lowest for lentil, greatest for faba)

• Compared to other crops, pulses are good P scavengers.
20 kg $P_{2}O_{5}$/ha Soil Applied, Foliar Applied, or Split

2016 Soil vs Foliar P @ Pilger Site (S. Froese et al.)

Grain Yield

Wheat

Canola

Pea

Foliar P Treatment (kg/ha)

Cntrl 0 5 10 20 Cntrl 0 5 10 20 Cntrl 0 5 10 20

Cntrl 0 5 10 20
Crop Biomass Response to 20 kg P2O5/ha Soil vs Foliar applied in Pilger soil (7 ppm STP) Controlled environment S. Froese, 2017

- Control
- Seed-Placed
- Split Foliar
- High Foliar

Crop types: Canola, Pea, Wheat
K uptake (kg K/ha) in grain and straw in 2014

Multiply by 1.2 to get $\text{K}_2\text{O}$. Soybeans are high K users & removers.
So are faba beans

Average straw and grain K uptake (kg ha\(^{-1}\)) of four faba bean varieties across four sites (Klippenstein et al)

Multiply by 1.2 to get K\(_2\)O

Note: Compared to N and P, higher proportion of K in straw
Sulfur uptake (kg S/ha) in grain and straw in 2014 (Xie, 2017)
Average straw and grain S uptake (kg ha\(^{-1}\)) of four faba bean varieties at four sites in 2016 (Klippenstein, 2017)
Micronutrients
Soil Conditions Contributing to Micronutrient Deficiencies

• Sandy:
  - low content of minerals capable of releasing micronutrients by weathering.

• Calcareous (high lime content), high pH:
  - will fix micros like Cu and Zn into insoluble forms.

• Very low or very high O.M. content.
  - low O.M. can contribute to low B availability. Peat soils can suffer from deficiency in Cu and Mn.

• Nutrient imbalances.
  - high soil P can interfere with Zn and Cu uptake.
  - addition of Cu and Zn can reduce plant growth on P deficient soils

Sandy, gray, peaty soils have greatest frequency of micro deficiencies
Higher Cu and Zn uptake by pea explained by high yield of pea at this site in 2014.
## Lentil Response to Zn Fertilization in Field

**Anderson et al. 2013**

<table>
<thead>
<tr>
<th>Site</th>
<th>Yield $^\dagger$ (kg ha$^{-1}$)</th>
<th>Zn Rate</th>
<th>SEM$^\ddagger$</th>
<th>P values</th>
<th>Rate (R)</th>
<th>Cultivar (C)</th>
<th>R*C Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>2.5</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central Butte</td>
<td>Grain</td>
<td>2919</td>
<td>2880</td>
<td>2913</td>
<td>359</td>
<td>0.9944</td>
<td>0.5542</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
<td>2597</td>
<td>2502</td>
<td>2508</td>
<td>194</td>
<td>0.9285</td>
<td>0.1982</td>
</tr>
<tr>
<td>Saskatoon</td>
<td>Grain</td>
<td>4104</td>
<td>4355</td>
<td>4172</td>
<td>183</td>
<td>0.6089</td>
<td>0.8774</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
<td>3743</td>
<td>3946</td>
<td>3872</td>
<td>168</td>
<td>0.6907</td>
<td>0.6904</td>
</tr>
</tbody>
</table>

DTPA Zn: 0.9 kg/ha

DTPA Zn: 3.7 kg/ha
2015 Polyhouse Study (N. Rahman)

**SCEPTRE Soil O.V (Sceptre, SK)**
DTPA Cu=1.6; Zn=0.7; B=1.7 mg kg\(^{-1}\)
Zn fortification of pea grain from Zn fertilization of Sceptre Association soil (Rahman, 2017).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain Zn (mg Zn per kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>16.7b</td>
</tr>
<tr>
<td>Soil Zn sulfate</td>
<td>19.0ab</td>
</tr>
<tr>
<td>Soil Zn chelate</td>
<td>23.0a</td>
</tr>
<tr>
<td>Foliar Zn chelate</td>
<td>20.4ab</td>
</tr>
</tbody>
</table>

$p$-values = 0.023
• For crop micronutrient responses to fertilization we have evaluated:
  
  *Cu on wheat, Zn on pulse, B on canola*

Yield response of wheat to Cu was most frequently observed.

Yield response of pulse to Zn was variable and often not statistically significant.
Some interesting rotational and interaction effects with pulses and micronutrients
Field Pea (CDC Sage)

Dr. R. Hangs polyhouse research with Cu, Zn and B in wheat-pea-canola rotation
Wheat Grain Yield Yr 1 2015
(12 mineral soils; n = 48)

*Bars with the same letters are not significantly different (P >0.05) using LSD.*
Pea Grain Yield Yr 2 2016
(12 mineral soils; n = 48)

*Bars with the same letters are not significantly different (P > 0.05) using LSD.*
• Peas did not respond positively to Zn fertilization, but responded positively to soil applied Cu fertilizer applied the year before to wheat.
  – Fungicidal or nutritional effect?

• A negative interaction effect is observed when Zn + Cu applied on P deficient soil.
  – Effect observed on wheat (N. Rahman), also on peas grown the year after (R. Hangs).
Iron Deficiency in Soybean
“IDC”

Photo: Ryan Hangs
Response of Soybean to Iron (Hangs and Schoenau, 2017)

• Field trial conducted in southern SK near Central Butte in 2015 and 2016 on slightly saline, high pH, high nitrate lower slope.

• Two soybean varieties: one IDC sensitive, one IDC tolerant.

Findings:
• 2015 very dry May, June, July. No response to Fe fertilization.
• 2016 was wetter, environment more conducive to IDC. 
  *IDC sensitive variety (Moosomin) responded significantly to foliar Fe sulfate while IDC tolerant variety (McLeod) did not.*

Genetics best defense when IDC is concern, Foliar Fe may be suitable rescue treatment.
Final Points

- For this year’s crop, diagnostic tools (soil, tissue, imagery) are a good approach for determining nutrient needs.
- Over several years, several cycles of rotation containing pulses need to think about nutrient removal, replenishment to maintain fertility.
- N fixation input $\sim = N$ in pulse grain removal so N kept in balance for pulse phase.
• Pulses are good scavengers of P, K, S but will deplete soil reserves over time, especially if grain yields are high.

• Deficiencies of micronutrients do not seem to be a major limitation, but merit attention when soil, environmental and crop rotation are conducive to reduced supply.

• Because of uncertainty in response, removals not a good basis for micronutrient recommendations.
Thanks for opportunity to participate!

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