Phosphorus Management for Soybeans

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Background

- Soybeans remove large amounts of P ($\geq 0.85 \text{ lb } P_2O_5/\text{bu}$)
- Wide row spacings and narrow seed/fertilizer spread increase risk of fertilizer toxicity in seed row (current guidelines recommend a maximum of 10 lb $P_2O_5/\text{ac}$)
- Questions remaining about P fertilization and placement in soybeans

Source: Manitoba Pulse Growers Association
## P Uptake and Removal by Annual Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Seed Yield (bu/acre)</th>
<th>Uptake/Removal $^{*}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>lb P$_2$O$_5$/ac</td>
</tr>
<tr>
<td>Wheat</td>
<td>45</td>
<td>36 (26)</td>
</tr>
<tr>
<td>Canola</td>
<td>45</td>
<td>75 (46)</td>
</tr>
<tr>
<td>Soybeans</td>
<td>40</td>
<td>43 (34)</td>
</tr>
<tr>
<td>Barley</td>
<td>80</td>
<td>45 (34)</td>
</tr>
<tr>
<td>Peas</td>
<td>50</td>
<td>43 (34)</td>
</tr>
<tr>
<td>Oats</td>
<td>100</td>
<td>41 (26)</td>
</tr>
<tr>
<td>Corn</td>
<td>100</td>
<td>63 (44)</td>
</tr>
</tbody>
</table>

$^{*}$Removed in grain
60% of P is taken up during the reproductive phase.

In late stages, new P is taken up and old P translocates from veg. to seed at 1 lb $\text{P}_2\text{O}_5$/ac/day.

85% of P is removed in the seed.

Phosphorus uptake and removal by a 46 bu/ac soybean crop in Manitoba (Heard, 2005)
Soybeans are efficient feeders for soil P

(Kalra and Soper 1968)
Soybean response to P fertilizer and soil P fertility

Fertilizer P added 0 25 50 (lb P$_2$O$_5$/ac)

Soil P fertility

P fertilizer

Low P soil High P soil

Randall, U of Mn
Manitoba Soybean P Project: Effects of P Rate & Placement on Plant Stand and Seed Yield
Materials and Methods

- 8 sites established in 2013
- 10 sites established in 2014
Row spacing varied from 7 to 12”
Opener type: knife or disc ... low seed bed utilization

<table>
<thead>
<tr>
<th>Site</th>
<th>Olsen P (ppm)</th>
<th>Soil Texture</th>
<th>Row Spacing</th>
<th>Seeder Opener Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roseisle</td>
<td>N/A 4 (VL)</td>
<td>L Fine Sand</td>
<td>8</td>
<td>Knife</td>
</tr>
<tr>
<td>Melita</td>
<td>3 (VL) 5 (L)</td>
<td>Loamy Sand</td>
<td>9.5</td>
<td>Knife</td>
</tr>
<tr>
<td>Brandon</td>
<td>5 (L) 6 (L)</td>
<td>Clay Loam</td>
<td>8</td>
<td>Knife</td>
</tr>
<tr>
<td>Carman</td>
<td>N/A 15 (H)</td>
<td>Loamy Sand</td>
<td>8</td>
<td>Knife</td>
</tr>
<tr>
<td>Roblin</td>
<td>7 (L) 22 (VH)</td>
<td>Clay Loam</td>
<td>9</td>
<td>Knife</td>
</tr>
<tr>
<td>Beausejour</td>
<td>8 (L) 13 (M)</td>
<td>Clay</td>
<td>9</td>
<td>Disc</td>
</tr>
<tr>
<td>Arborg</td>
<td>14 (M) 22 (VH)</td>
<td>Clay</td>
<td>9</td>
<td>Disc</td>
</tr>
<tr>
<td>St Adolphe</td>
<td>23 (VH) 25 (VH)</td>
<td>Clay</td>
<td>7.3</td>
<td>Knife</td>
</tr>
<tr>
<td>Portage</td>
<td>34 (VH) 18 (H)</td>
<td>Clay Loam</td>
<td>12</td>
<td>Disc</td>
</tr>
<tr>
<td>Carberry</td>
<td>44 (VH) 11 (M)</td>
<td>Clay Loam</td>
<td>12</td>
<td>Disc</td>
</tr>
</tbody>
</table>
### Manitoba P Response Historical Data: Mainly Cereals

<table>
<thead>
<tr>
<th>Available P (ppm Olsen)</th>
<th>Number of Experiments</th>
<th>% Responding to Fertilizer P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 V. Low</td>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td>5-12 Low-Med</td>
<td>50</td>
<td>62</td>
</tr>
<tr>
<td>12-18 Med-High</td>
<td>16</td>
<td>56</td>
</tr>
<tr>
<td>&gt;18 High-VH</td>
<td>14</td>
<td>29</td>
</tr>
</tbody>
</table>

Hedlin, U of M, 1962
Westco Research: Percentage of Wheat Sites Responding to P Fertilizer as a Function of Olsen Soil Test P

Karamanos, Westco data for 33 site years in AB, SK, MB 1988-1995
Monoammonium phosphate (MAP, 11-52-0) was applied in spring, at the rates of 20, 40 and 80 lb/ac … in the seed row, side banded or broadcast.

Dekalb 24-10 RY was seeded for a target of 210,000 pl/ac

Seeded between May 22 and June 3 in 2013

Seeded between May 24 and June 9 in 2014

Treatments replicated 3 or 4 times

Plant stand assessed with 2, 3 and 4 weeks after planting

Midseason biomass collected at R3

Data analysed using SAS Proc Mixed
Results
Plant Stand:
Seedrow P reduced stand only at 80 lb P$_2$O$_5$/acre and only on coarse-textured soils

Melita 2013 – Loamy Sand, 3 ppm Olsen P

Beausejour 2013 – Clay, 8 ppm Olsen P
Seed Yield Response:
No yield increase due to P fertilizer at any sites;
Reduced only at 80 lb SRP/ac and < 100,000 plants/acre
Melita – 3 ppm Olsen P

Beausejour – 8 ppm Olsen P

Brandon – 5 ppm Olsen P

Arborg – 14 ppm Olsen P

2013
Carberry – 44 ppm Olsen P

St Adolphe – 23 ppm Olsen P

Portage – 34 ppm Olsen P

Roblin – 7 ppm Olsen P

2013
Beausejour – 13 ppm Olsen P

Arborg – 22 ppm Olsen P

Portage – 18 ppm Olsen P

Carman – 15 ppm Olsen P

2014

Stand (thousand plants/ac)

Yield (bu/ac)

P$_2$O$_5$ rate (lb/ac) and placement

P$_2$O$_5$ rate (lb/ac) and placement

P$_2$O$_5$ rate (lb/ac) and placement

P$_2$O$_5$ rate (lb/ac) and placement
2014

Roblin – 22 ppm Olsen P

St Adolphe – 25 ppm Olsen P
Summary and Conclusions for Soybean P Fertilization Project

• P fertilization regardless of soil test P, P rate and P placement did not increase seed yield for soybean

• The probability of reduced stand from typical agronomic rates of seed-placed P is small and the risk of reduced seed yields is even smaller ... but it’s still a risk ... with little reward

• Only two growing seasons, so far ... as the study goes into the third year, we look forward to learning more about P fertilization for soybeans in Manitoba
Soybeans may not “care” about P fertilizer, but what about the crop after soybeans?

The phosphorus deficit hangover ...
Applied = 6 lb N, 24 lb P$_2$O$_5$, 4 lb K$_2$O, 2 lb S/ac
Removed = 128 lb N, 28 lb P$_2$O$_5$, 46 lb K$_2$O, 4 lb S/ac
Majority of Manitoba Soils are Deficient in P According to % Less than Critical Level

Fixen et al. Better Crops 2010
Balancing P application with crop removal is essential to avoid excessive accumulation or depletion of P in soil.

- **P Removal**
  - eg. food & feed crops

- **P Application**
  - eg. fertilizer & manure
## Safe Rates of Seed-Placed P Will Not Replace P Removal for Many Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield (bu/ac)</th>
<th>P Removal</th>
<th>Seed Limit</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>40</td>
<td>29</td>
<td>50</td>
<td>+21</td>
</tr>
<tr>
<td>Canola</td>
<td>40</td>
<td>40</td>
<td>20</td>
<td>-20</td>
</tr>
<tr>
<td>Soybeans</td>
<td>40</td>
<td>32</td>
<td>10</td>
<td>-22</td>
</tr>
<tr>
<td>Barley</td>
<td>80</td>
<td>38</td>
<td>50</td>
<td>+12</td>
</tr>
<tr>
<td>Flax</td>
<td>32</td>
<td>20</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Peas</td>
<td>50</td>
<td>38</td>
<td>20</td>
<td>-18</td>
</tr>
<tr>
<td>Oats</td>
<td>100</td>
<td>29</td>
<td>50</td>
<td>+21</td>
</tr>
</tbody>
</table>

*Rates are based on solid seeding with disk or knife openers with a 1 in. spread, 6 to 7 in. row spacing and good to excellent soil moisture*
Soil Test P Trends in Manitoba: % Testing <10 ppm Olsen STP
Why be concerned about declining soil P fertility?
Crops respond to P fertilizer and soil P fertility, so depleted soil P can decrease crop yield potential.

Average Olsen soil test P for all rates of seed placed P after 5 years

Amount of P b'cast initially (lb P$_2$O$_5$/ac)

Wheat Grain Yields (bu/ac)

Optimum yield was higher with moderate rather than very low soil test P

Wagar *et al.* 1986

Crops respond to P fertilizer and soil P fertility, so depleted soil P can decrease crop yield potential.
Corn response to P fertilizer and soil P fertility

Fertilizer P added: 0, 25, 50 (lb P$_2$O$_5$/ac)

Yield bu/ac

Soil P fertility

P fertilizer

Randall, U of Mn
Phosphorus should be managed through the rotation ... not just on a single crop basis

- What is the current soil P level?
  - If excess, can draw down by using only starter P
  - If near optimum, can balance input and removal
  - If low, may want to build by applying fertilizer or manure P in excess of crop removal
A fertilization concept to move soil P levels into an optimum range over time

<table>
<thead>
<tr>
<th>Soil P Level</th>
<th>P Rate relative to Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td></td>
</tr>
<tr>
<td>MH</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td></td>
</tr>
<tr>
<td>H+</td>
<td></td>
</tr>
</tbody>
</table>

Buildup range

Maintenance range

- 10-20 ppm Olsen soil test P

Drawdown range with starter P

Adapted from OMAFRA Soil Fertility Handbook
So, why not simply broadcast fertilizer P ... eg. fall broadcast P?

An invitation to regulation ...
Excess P & Algae in Lake Erie Shuts Down Water Supply to Toledo, Ohio – August 2014

Algae’s lake effect reveals putrid, pea green disaster

Distribution centers offer free relief to community

Officials won’t give test results on 2nd day

Toledo Free Press
Excess P & Algae in Lake Erie Shuts Down Water Supply to Toledo, Ohio – August 2014

Toxic algal terror engulfs Toledo!

IT CAME FROM THE LAKE
“The control of phosphorus in agricultural operations must focus on changes in agricultural practices that have been implemented in recent decades, such as increased prevalence of fall application of nutrients, applying two years’ worth of fertilizer in a single application, and broadcast application.”
Ohio Regulators Aim to Help Water Problem With Fertilizer Licenses
Farmers in Ohio to Be Required to Get New Certification to Use Fertilizers

By MARK PETERS and MATTHEW DOLAN
Updated Aug. 5, 2014 7:47 p.m. ET

Algae floats in Lake Erie on Monday at Maumee Bay State Park in Oregon, Ohio. Getty Images
The drinking-water crisis in one of Ohio's largest cities is drawing attention to a new requirement for farmers in the state: a license to fertilize.
Recommended Strategies for Maintaining P Fertility in Soybean Fields

- Apply sufficient P in side- or midrow bands to match crop removal on annual basis
- Use a rotational fertilization strategy over several years:
  - Add extra P to crops in rotation that tolerate high rates of seed-placed P
  - Periodically band P into soil during fall tillage ... eg. MAP with AS prior to canola, which responds to fert. P & N
  - Build soil P to target level, but avoid excess accumulation, eg. manure applied at rate to meet crop N requirements will provide P benefit for several years
Soybean P Fertilization: Effects of Rates and Placement

• P fertilization appears to have a low probability of increasing yield

• The probability of reduced stand or yield from typical agronomic rates of seed-placed P is small

Worrying about P fertilization for soybeans may be a distraction ... instead, focus on maintaining soil P fertility

• Consider subsurface banding away from seed, rotational P fert’n

• Avoid fall broadcast P fertilizer
Acknowledgements

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Thank You!