Phosphorus management for pulses

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Phosphorus is an important plant nutrient for pulse crops. Phosphorus promotes the development of extensive root systems and vigorous seedlings. Encouraging vigorous root growth is an important step in promoting good nodule development. Phosphorus also plays an important role in the nitrogen fixing process and in promoting earlier, more uniform maturity.

However, many soils in Saskatchewan are lacking in phosphorus fertility. The International Plant Nutrition Institute (IPNI) collects a soil test data annually and reports once every five years to show long-term trends. The latest report, *Soil Test Levels in North America 2015*, indicates that 81 per cent of Saskatchewan soils are below critical phosphorus levels. The median soil test level in Saskatchewan was only 56 per cent of the critical phosphorus level. This low phosphorus fertility may contribute to reduced stand vigor, poor nodulation and growth, and ultimately lower yield.

Pulse Crops are Relatively Heavy Users of Phosphorus Fertilizer

Recent research at the University of Saskatchewan (U of S) led by Dr. Jeff Schoenau found amounts of phosphorus removed in grain harvest of lentils, peas, and soybeans to range from about 20 pounds of phosphate (P_2O_5) per acre (lbs/ac) to 40 lbs P_2O_5/ac with lower amounts in lentils and higher in soybeans and peas, depending on location and yield. High yielding pulses can export substantial phosphorus off the field in the grain harvest. If this exported phosphorus is not replaced, soil-phosphorus fertility will become depleted over time.

Table 1. Phosphorus up take and removal (lbs P_2O_5/ac) by pulse crops

Crop	Crop Yield in bushels per acre (bu/ac)	Uptake	Removal
Pea	50 bu/ac	38 - 46	31 - 38
Lentil	30 bu/ac	22 - 27	17 - 20
Faba bean	50 bu/ac	89 - 108	55 - 67
Chickpea	NA	NA	0.36 lbs P_2O_5/bu
Soybean	35 bu/ac	28 – 35	28 - 30
Dry bean	1,800 lbs/ac	NA	25

Sources: Nutrient Uptake and Removal. Fertilizer Canada 2001.
Soybean and dry bean data from Manitoba Ag.
Chickpea data from IPNI.

Pulses are good scavengers of soil phosphorus due to their ability to alter rhizosphere chemistry and solubilize certain phosphorus compounds. Pulses also establish beneficial relationships with soil organisms like *arbuscular mycorrhizal* fungi that act to extend the root system and further increase phosphorus uptake. This explains why pulses sometimes do not show a large yield response to phosphorus fertilizer, but can draw down soil-phosphorus reserves if the phosphorus is not replaced.

Safe Seed-Placed Phosphorus Fertilizer Rates

Pulse crops are sensitive to seed-placed phosphorous fertilizer. Too much phosphorus fertilizer placed with the seed can negatively affect germination and emergence, reducing the plant stand. The safe rates of seed-placed phosphorus fertilizer shown below are based on knife openers with a one-inch spread, nine-inch row spacing, and excellent soil moisture. The total pounds of P_2O_5 plus pounds of potassium (K_2O) should not exceed the maximum safe rate of seed-placed phosphate. Rates of seed-placed fertilizer should be reduced if the seedbed has less than ideal moisture.

Table 2. Maximum Safe Rates of Seed-Placed Monoammonium Phosphate Fertilizer

Crop	Pounds Actual P_2O_5 per Acre
Pea	15
Lentil	20
Chickpea	20
Faba bean	40
Soybean	20
Pinto bean	30

Source: Saskatchewan Ministry of Agriculture

**Divide by 0.51 to get pounds of 12-51-0 per acre.

Managing Phosphorus in the Rotation

Soil testing for available phosphorus is a valuable tool to assess the need for additional fertilizer phosphorus for a pulse crop in the upcoming year.

Phosphorus budgets that evaluate the amount of the input relative to removal in harvest over a number of years can be useful to determine what is happening to the soil phosphorus reserves over the longer term in a rotation.

Some growers employ a strategy of applying extra phosphorus with a cereal crop seeded the year before pulses to help maintain soil-phosphorus fertility, since cereals are more tolerant of seed-placed phosphorus than pulses.

Other phosphorus fertilizer strategies include applying a safe amount of seedrow starter phosphorus, and placing additional requirements separate from the seedrow, or rely on existing soil phosphorus that has been built up during the entire crop rotation.

A phosphate inoculant containing the naturally occurring soil fungus *Penicillium bilaii* can help release the bound mineral forms of soil and fertilizer phosphate to make phosphorus more available for the crop to use.

Peas

Research has found that peas are responsive to phosphorus fertilization. Research from the U of S by Henry et al. on low phosphorus fertility soils found that side-banding of mono-ammonium-phosphate (MAP) fertilizer from 0 to 90 lbs P_2O_5 /ac in Saskatchewan increased pea seed yields in a quadratic response curve. However, pea emergence and seed yields decreased as seed-placed phosphorus rates increased, and pea stand was decreased by 50 per cent at the highest phosphorus rate. Pea yields were higher with side-band phosphorus than seed-placed at all locations.

In Alberta research with 31 trials by McKenzie et al., a significant yield increase was observed on 52 per cent of pea plots due to the application of phosphate on soils with soil test phosphorus levels (modified Kelowna method) of less than 27 lbs/ac to six inches (13.5 parts per million), which is considered low in phosphorus fertility. Only one of 17 trials with soil test phosphorus levels of more than 27 lbs/ac had a significant yield increase.

Results from this Alberta research suggest that peas are most responsive to phosphorus fertilizer when soil phosphorus levels are less than 27 lbs/ac. Above this level, there is relatively little chance phosphorus fertilizer will have any effect on yield. When soil test phosphorus levels (modified Kelowna method) are medium (35 to 50 lbs/ac in the zero to six inch depth) and significant phosphorus fertilizer was applied in the past 10 to 20 years, an annual maintenance application of phosphate fertilizer is recommended to meet crop requirements and replenish soil phosphorus that is removed.

Lentils

Lentils grown on soils testing low in available phosphorus may respond to phosphate fertilizer. However, dramatic yield responses are not always achieved. In lentils grown in southwest Saskatchewan, research by Gan et al. found that starter phosphorus at a rate of 15 lbs P_2O_5 per acre increased lentil seed yield three-quarters of the time with an average yield increase of four per cent compared to the non-phosphorus check.

Chickpeas

Research at the U of S by Walley et al. on Desi and Kabuli chickpeas found that 36 lbs P_2O_5 per acre enhanced chickpea vegetative growth, although only Desi seed yield was significantly enhanced. These results suggested that although nitrogen and phosphorus application had no effect on Kabuli seed yield, Desi yields may increase with an application of low rates of starter nitrogen (i.e., 27 lbs/ac) and phosphorus (18 lbs/ac). Note that any starter nitrogen should be side-banded away from the seed.

In southwest Saskatchewan, research at Agriculture and Agri-Food Canada by Gan et al. found that Kabuli chickpea showed a substantial increase in lowest pod height with application of starter-phosphorus, which improved harvestability by five per cent, however like the U of S research, chickpea seed yield was not affected.

Additional research found that the use of a higher rate of phosphorus increased the seed size of Kabuli chickpeas. When Kabuli chickpea was seeded in the mid- to late-May in semiarid Saskatchewan, the application of phosphorus at the rate of 30 lbs P_2O_5 per acre compared to zero and 15 lbs P_2O_5 per acre increased the proportion of the nine millimetre diameter seeds from 54 to 59 percentage points in the harvested seedlot. However, such a response was not observed when Kabuli chickpea was seeded at an early-May seeding date.

Faba Beans

Faba bean removes 1.1 to 1.3 lbs P_2O_5 for every bushel produced. A 50-bushel crop can remove 60 lbs P_2O_5 per acre. Phosphate fertilizer should be used as a replacement strategy, with up to 40 lbs P_2O_5 per acre seed-placed under good moisture conditions.

Henry's U of S research found that faba beans were the most responsive pulse crop to phosphorus fertilizer when compared to peas and lentils. He also found that faba beans were the most tolerant to seed-placed phosphorus and that yield responses were similar with side-band and seed-placed methods over the range of the phosphorus rates tested (0 to 44 kg/ha).

In Alberta in the mid-2000s, faba beans did not respond to phosphorus fertilizer when averaged across six sites and three years. However, these trials were conducted on fields with top growers where the likeliness of a nutrient deficiency was low. On an individual site and year basis, at two separate locations there was a response to the first 20 lbs/ac of P_20_5 per acre, but adding an additional 20 lbs/ac increased the yield at one site and decreased it at another.

Soybeans

In Manitoba, research by the Manitoba Pulse and Soybean Growers with three years and 27 site-years of data, phosphorus fertilizer did not increase soybean yield regardless of rate, placement, soil type, or soil test phosphorus. This indicates that soybean is very good at extracting soil phosphorus. Manitoba recommendations are to plant soybeans on fields with a medium-high soil test phosphorus of 10 – 20 parts per million Olsen soil test (20 to 40 lbs/ac).

Limited phosphorus fertility research for soybean has been conducted in Saskatchewan. A three-year project funded by the Saskatchewan Pulse Growers in 2015 is looking at a combination of three phosphorus fertilizer rates (20, 40, and 80 lbs P_2O_5 per acre) and three placement options (seed-placed, side-banded, and pre-seed broadcast) at Indian Head, Outlook, Melfort, and Scott. In the first year of trials, regardless of residual soil phosphorus levels or placement method, there were no positive yield responses associated with phosphorus fertilization at any sites. There was some evidence of reduced plant stands and/or yield reduction with high rates of seed-placed phosphorus at two locations (Melfort and Scott). The slight reductions in plant density observed at Scott and Melfort did not translate into any yield penalties; however, at Outlook, the lowest yields were with 80 lbs P_2O_5 per acre placed in the seed-row.

Researcher Chris Holzapfel at Indian Head Agricultural Research Foundation says these results are still preliminary but are consistent with those from a study in Manitoba utilizing the same protocol, where yield increases with fertilizer have been rare and reductions in emergence have generally only been observed on coarse textured soils at the highest application rate.

A U of S study in 2014 at a site in the Brown soil zone in south-central Saskatchewan by Weiseth et al. revealed that in-soil placement (seed-placed, banded, or broadcast and incorporation) of 20 lbs P_2O_5/ac on a phosphorus deficient soil (nine parts per million soil test phosphorus) resulted in increased soybean grain yield in the lower slope position. Broadcasting of 11-52-0 without incorporation was not effective in increasing soybean yield.

Dry Beans

Information from the Saskatchewan Ministry of Agriculture reports that phosphorus is extremely important for optimum nodule, flower, and seed formation and advancing crop maturity of dry bean. If soil test phosphorus levels fall below 25 lbs/ac, an additional 30 lbs P_2O_5 per acre may be added.

Key Messages

- Pulse crops are heavy users of phosphorus
- Response to phosphorus fertilizer is variable depending on pulse crop and soil fertility
- There are limits for safe rates of seed-placed phosphorus fertilizer
- Fertilizer strategies should aim to replace phosphorus removal through separate-band, pre-seed band, or additional phosphorus fertilization in non-pulse years
- Balance input and removal over entire crop rotation cycle to maintain phosphorus fertility
- Regular soil testing is the key to managing soil phosphorus levels over time
- Adopt the 4R Nutrient Stewardship for optimum yield and quality while maintaining long-term sustainable production (the Right Product, applied at the Right Rate, Right Time, and Right Placement)