Development of 4R Phosphorus Fertilization Options for Manitoba Farmers and Agronomists

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Background

Manitoba's phosphorus (P) guidelines have not been updated since the early 1990's, so the following options are offered:

- **RATE**: retain traditional short-term sufficiency rate approach and offer a long term sustainability strategy to build, maintain or drawdown soil test P (STP) levels into a medium-high range.
- **TIMING**: Options to fertilize annually, or where dictated by crops and seeding practices, to meet P needs on a rotational basis.

The above approaches are often used outside the Prairie region and our rationale for these options are provided. The research to support development of these approaches is reported in **"4R Management of Phosphorus Fertilizer in the Northern Great Plains: A Review of the Scientific Literature"** by C. Grant and D. Flaten.[1]

Rationale:

1. **P fertility is declining in many Prairie soils**. Current fertilization strategies based on traditional soil test rate recommendations have not kept pace with crop removals – due to higher yields of all crops, increased acres of crops less tolerant of seedplaced P (canola, soybeans and corn) and decreased acres of crops with opportunity to place high P rates with seed (wheat and barley).
2. **Crop yield potential is limited on low P soils.** Prairie studies have shown that crop yields did not attain full yield potential on soils that were low or very low in P, even with high rates of seedplaced fertilizer.
3. **A desirable target STP range is 10-20 ppm.** The probability of crop response to P fertilizer is 50% in the range of 10-20 ppm Olsen P, a medium to high soil test range generally considered desirable for economical crop production.
4. **The amount of P fertilizer required to build soil test P is referred to as buffering capacity (BC).** BC varies from soil to soil. Prairie studies found the rate of surplus P (applied P less crop removal P) required to raise Olsen P by 1 ppm varied from 20 lb P_2O_5/ac on a neutral pH, coarse textured soil to 37 lb P_2O_5/ac on a calcareous, clay loam soil.
5. **Band placement of P is well recognized to optimize use efficiency and yield in the Prairies**, since soils are cool at seeding and generally calcareous. Manitoba farmers apply 90% of P fertilizer in the spring for wheat and canola often placed with the seed (Table 1). Seeders with narrow openers and wider row spacings have low seedbed utilization (SBU) which limits the safe rates of seed row applied fertilizer, especially with sensitive crops such as canola and soybeans. For such crops, meeting full P fertilizer needs elsewhere in the rotation may be required.

Table 1. P fertilizer placement and timing in Manitoba for wheat, canola, soybeans and corn.

Practice	Wheat	Canola	Soybeans	Corn
	% of acres or volume applied			
PLACEMENT				
Broadcast , no incorporation	0	1	2	5
Broadcast incorporated	3	9	14	35
Preplant banded	7	3	6	21
Sidebanded	23	13	13	19
Mid row banded	14	11	6	3
Seed placed	54	62	11	32
TIMING				
Fall	6	2	17	23
Spring, preplant	3	5	6	34
At seeding	91	92	34	55

Data for wheat, canola, soybean and corn from Stratus Ag Research surveys in 2015, 2015, 2016 and 2018, respectively.

Options provided:

A) Phosphorus Rate:

Short-term Sufficiency

- Rate is based on economic yield response in year of application, often a seed-place a low rate of P.
- Sustainable for short-term land tenure and when P costs are high relative to crop prices.

Long-term Sustainability

- Target applications to reach and maintain a STP target range.
- Long term economics considers the residual P value.
- Suitable for long-term land tenure and when P costs are low relative to crop prices.
- Ongoing soil testing is important to track changes in STP

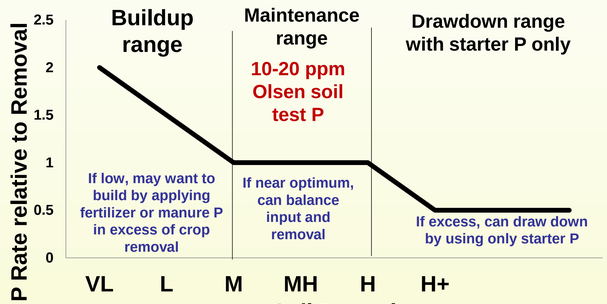

Figure 1. Long term sustainability strategy: a fertilization concept to move soil P levels into an optimum range over time (adapted from OMAFRA Soil Fertility Handbook).

Table 3. Proposed Manitoba guidelines for P fertilization.

Soil test Olsen P ppm	Short-term Sufficiency	Long-term Sustainability			
	Wheat, Canola Oats, Soybeans	Wheat	Canola	Oats	Soybeans
	lb P_2O_5/ac				
0	40	110	110	110	105
5	40	85	85	85	80
10	30	60	60	60	55
15	15	35	35	35	30
20	10	10	10	10	0
20+	10	10	10	10	0

Rates in Table 3 are derived as follows:

$$\text{Application rate} = \frac{(\text{Target STP} - \text{Current STP}) \times \text{BC}}{\text{Years to Build}} + \text{CR}$$

Example for 60 bu/ac wheat, current STP = 5 ppm and 5 years to build:

- Target STP is 15 ppm
- Crop removal (CR) = yield x P concentration = 60 x 0.57 lb P_2O_5 /bu = 34 P_2O_5 /ac
- Typical P buffering capacity (BC) by soil characteristics (assuming 25 lb P_2O_5 /ac to increase 1 ppm STP)
- Time frame to build, assuming 5 years:

$$= \frac{(15-5) \times 25}{5} + 34 = \frac{(250)}{5} + 34 = 84 \text{ lb } P_2O_5 \text{ ac}$$

B) Phosphorus Timing: Annual vs Rotational Fertilization

Where annual P rates cannot be safely applied with the seed and other placement options are not available (Table 1), consider balancing the crop removal of P over the length of a 4-5 year crop rotation with targeted applications:

1. Seed place safe rates for starter effect and placing additional P with other crops in the rotation that do tolerate high seed placed rates
2. Periodic batch P applications as manure or other low cost sources.

Extension

To assess the understanding of these approaches an exercise was directed to 250 agronomists at the 2019 Crop Diagnostic School with:

- Field plots of various P rates and placement on wheat and canola on low P soil
- A brief explanation of the P management concepts
- Participants were asked to select "an appropriate P fertilization approach" for various scenarios

Fertilization approach	Scenarios
1. No P	• Young farmer, limited capital
2. Starter P only	• Rented land
3. Balance P annually	• Newly purchased land
4. Balance P over the rotation	• High P costs • High crop prices
5. Build P in one batch	• Cash strapped • Low SBU seeders
6. Build P over the rotation	• Retiring farmer • Livestock farmer with manure • Organic farmer • High priced land • High crop process • Other factors limiting yield

Figure 2. Participants selecting appropriate P fertilization approaches based on the scenarios listed.

Figure 3. Contrasting P fertilization approaches in 3 scenarios: newly purchased land, rented land, and a retiring farmer.

According to responses above, there was no "single approach" to P fertilization with these 3 scenarios. The farmer's situation can greatly influence the selected approach, but many factors work into the decision to build, maintain or draw down STP.

The comprehensive review of scientific literature[1] by C. Grant and D. Flaten should assist agronomists and growers in their "phosphorus conversation" to formulate appropriate 4R strategies.

Reference:

[1]https://fertilizercanada.ca/4r-management-of-phosphorus-fertilizer-in-the-northern-great-plains-a-review-of-the-scientific-literature/