Canadian Agronomist

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4R management of phosphorus fertilizer

CATEGORY **soils and fertility** | ***September 16, 2019***

To achieve 4R principles, placing ammonium phosphate fertilizer in a band, in or near the seed-row, at the time of seeding and at a rate that matches P removal by the crop generally provides the greatest P efficiency, long-term sustainability, and environmental protection for small grain, oilseed, and pulse crop production in the northern Great Plains.

A 1993 review, *Impact of Macronutrients on Crop Responses and Environmental Sustainability on the Canadian Prairies*, commonly called the 'Red Book', reviewed macronutrient research dating back to the early 1900s. The Red Book included a chapter on phosphorus fertility and fertilizer strategies.

In a new, 2019 review of P fertility research, *4R Management of Phosphorus Fertilizer in the Northern Great Plains: A review of the Scientific Literature*, the authors built upon the Red Book's Chapter 2 on Phosphorus by incorporating research conducted since 1993, and aligning the research review with 4R principles. The full 255-page review is posted on Fertilizer Canada's website, while the authors summarized the review in a peer-reviewed article published in the Journal of Environmental Quality.

The basic strategy of 4R fertilizer stewardship is to apply the right fertilizer source at the right rate, right time, and right place to achieve the economic, social, and environmental goals for each situation.

Phosphorus fertilizer rate
The rate of P fertilizer applied should be selected to meet crop requirements based on an effective soil test. The Olsen test is effective across a wide range of neutral to high pH soils, including high pH calcareous soils. Kelowna and modified Kelowna tests are also effective on many of the soils in the northern Great Plains. The Bray test is effective only in neutral to lower pH, noncalcareous soils.

Several strategies for P fertilizer application rates were identified. The goal of a short-term sufficiency approach is to apply a rate that will optimize net returns in the year of application. This rate is based on regionally calibrated soil test results and the probability of response to P in the year of application.

A long-term sustainability approach seeks to balance P fertility over the longer term. Its goal is to ensure soil P is maintained at a level that does not limit crop production with low fertility or pose an environmental risk with excess fertility. This approach will mean P fertilizer rates are applied to build, replace or draw down soil P based on the critical level of soil test P where a yield response is likely to occur, which is identified as about 10-20 ppm using the Olsen (bicarbonate) extraction or 15-30 ppm using the Kelowna extraction.

Phosphorus fertilizer source
Monoammonium phosphate (MAP, 11-52-0) is the most common form of P fertilizer used on the northern Great Plains. It is highly water soluble and provides both ammonium and orthophosphate ions for plant uptake.

The most common liquid phosphate fertilizer on the northern Great Plains is ammonium polyphosphate (APP, 10-34-0), which provides both polyphosphate and orthophosphate forms of P. As with MAP, the ammonium in the fertilizer increases P availability. Plants take up P as orthophosphate, but because the polyphosphates rapidly convert in the soil to orthophosphate, the P in APP is readily available to our crops.

Additives and coatings have been evaluated to improve P fertilizer efficiency. Blending monoammonium phosphate, ammonium sulfate, and elemental sulfur into a single granule has not shown an increase in P uptake compared to MAP and AS applied separately. A maleic-itaconic copolymer applied as an additive to either granular or liquid P fertilizer did not show a benefit in most field studies. In field trials, polymer-coated P compounds yielded similarly to uncoated products, but with the benefit of producing significantly lower seedling damage.

Fungal inoculation with *Penicillium bilaiae* has occasionally provided a benefit under field conditions but has been erratic and unreliable as a method of improving P nutritional status of crops on the northern Great Plains. Similarly, although mycorrhizae aid in P uptake in crops, the populations provided in currently available mycorrhizal inoculants may not be an improvement over a well-established native populations. And neither of these inputs add any P to replace the P exported when crops are harvested.

Phosphorus fertilization timing

Cold soils during early spring can slow root growth and reduce the solubility and mobility of soil P, limiting the plant's ability to take up P from the soil. As a result, early-season P supply from fertilizer is often important for optimum crop yield.

Early-season P availability is improved by placing the fertilizer where the roots will contact it soon after germination. Placement near the seedrow at planting is most important in low P soils where the plant cannot access enough P from the soil to meet its growth requirements. On high P soils, yield responses to starter applications may still occur with early seeding into cold soils.

Phosphorus fertilizer placement

Selecting the best fertilizer placement depends on soil P fertility, P application rate, and environmental conditions. To build soil P in a long-term sufficiency approach, broadcasting with incorporation is effective, especially prior to establishing perennial forage crops. Periodically banding P under the soil surface, ahead of planting a crop is another way of improving P fertility in situations where it's difficult to maintain P fertility with annual applications.

In a short-term sufficiency approach, band applications near the seed are generally preferred because plant uptake of P is more efficient from banded than broadcast applications of P when applying low rates of P fertilizer, particularly on low P soils. P fertilizer banded in or near the seed-row can also provide crop response early in the growing season when cold soil temperatures occur even on soils that are moderate to high in available P.

Small seeded crops like flax, canola, and legumes are sensitive to seed-placed fertilizer. Side banding or midrow banding can produce higher yields by avoiding seedling damage and allowing higher rates of P to optimize crop yield.

Using 4R stewardship practices to apply the right source at the right rate, time, and place will help to optimize crop yield and agronomic efficiency while minimizing negative environmental impacts and excessive depletion of this precious resource.

This review was funded by Fertilizer Canada with the support of the North American 4R Research Fund.

Grant, C. A., and D. N. Flaten. 2019. 4R Management of Phosphorus Fertilizer in the Northern Great Plains. J. Environ. Qual. 0. doi:10.2134/jeq2019.02.0061 https://dl.sciencesocieties.org/publications/jeq/articles/0/0/jeq2019.02.0061

4R Management of Phosphorus Fertilizer in the Northern Great Plains: A Review of the Scientific Literature – link to the complete 255-page research review: https://fertilizercanada.ca/4r-management-of-phosphorus-fertilizer-in-the-northern-great-plains-a-review-of-the-scientific-literature/

The Red Book: ***Impact of Macronutrients on Crop Responses and Environmental Sustainability on the Canadian Prairies*** https://canadianagronomist.ca/resource/the-red-book/

