

Mapping Soil-Available Phosphorus: Considering Changes in Crop Yield and Fertilizer Sales

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In recent years, there has been increased interest in agricultural practices associated with the application and movement of soil P. The use of fertilizer has increased almost every year since 1945 in western Canada. Phosphorus is removed from the soil by plant uptake or lost by soil erosion and runoff. Crops remove varying amounts of P from the soil. With the changes in agricultural practices occurring across the Canadian prairies, it is timely to assess how the use of fertilizer is reflected in the amount of plant-available soil P measured by soil test.

A data set that included more than 150,000 soil test records collected between

1963 and 1967 was obtained from Alberta Agriculture Food and Rural Development (AAFRD). It was compared with a 1993 to 1997 data set provided by Norwest Labs and containing about 130,000 samples. Data recorded over the 1963 to 1967 time period

were obtained using the Miller and Axley extraction method ($0.03\text{N NH}_4\text{F} + 0.03\text{N H}_2\text{SO}_4$), while the data recorded during the 1993 to 1997 time period were obtained using the

Norwest Labs modified Kelowna method ($0.015\text{N NH}_4\text{F} + 0.5\text{N HOAc} + 1\text{N NH}_4\text{OAc}$). In order to reconcile the discrepancy in the measuring protocol, we performed a simple regression analysis using

In most areas of Alberta, soil phosphorus (P) has stayed the same or decreased by up to 40 percent over a 30-year period.

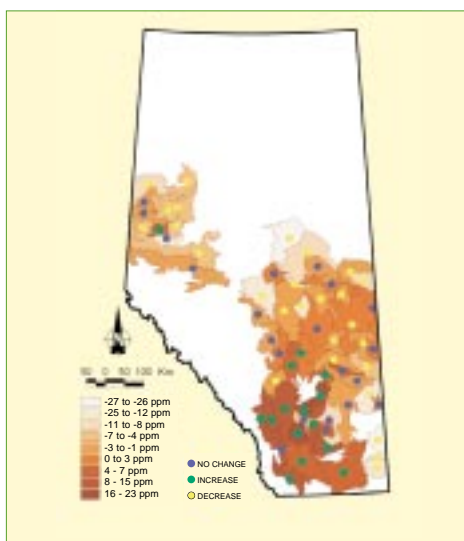


Figure 1. Changes in available P for rainfed annual crops, 1963-67 vs. 1993-97.

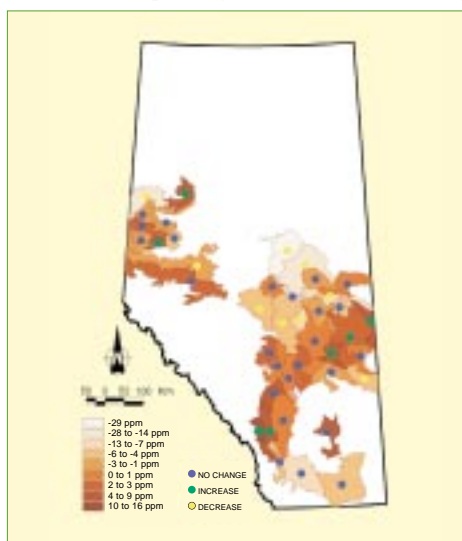


Figure 2. Changes in available P for rainfed perennial crops, 1963-67 vs. 1993-97.

data previously published elsewhere for Alberta. The data used for analysis were for the 0- to 6-in. soil depth, divided into two cropping classes, annuals and perennials. In this summary, data from only rainfed fields are included, with irrigated fields excluded. Crops such as wheat, barley and canola were grouped in the annual crop class, as was fallow. Grassland, alfalfa and clover are typical examples of the crops included as perennials.

Data were grouped on the basis of ecodistricts for analysis. Ecodistricts are part of a Canadian nationwide system of categorizing areas with similar land, climate and vegetation characteristics. There are 94 ecodistricts in Alberta, spanning over 50 million acres of land. Student's *t* test was used to identify statistically significant trends in soil available P that occurred over time in 62 ecodistricts for rainfed annual crops and 40 ecodistricts for rainfed perennials.

After 30 years of cropping, the comparison revealed that soil-available P for rainfed annual crops did not change in 20 ecodistricts, increased in 15, and decreased in 27 (**Figure 1**). For rainfed perennial crops, soil-available P from the 1960s compared to the 1990s remained unchanged in 24, increased in 7, and decreased in 9 ecodistricts (**Figure 2**). Although there are

some ecodistricts with a high proportion of fields with excess or optimum soil P for crop production, most soils in Alberta are deficient or marginal in soil P. For the recent 1993 to 1997 time period, 46 out of 62 (74 percent) ecodistricts for the rainfed annual crops (**Figure 3**) and 35 out of 40 (87 percent) for the rainfed perennial crops (**Figure 4**) had a soil P concentration equal to or lower than the 25 parts per million (ppm) level used to designate a crop response to P amendment.

The use of commercial fertilizer in both the U.S. and Canada has increased steadily since the 1950s, primarily as a result of higher application rates. An analysis of the fertilizer sales data for Canada reveals that the P sales in Alberta have increased at a slower rate than nitrogen (N) sales. In particular, while P sales doubled from 1968 to 1998, N sales increased five-fold over the same period. Although a number of concurrent factors should be considered, it is generally accepted that higher use of N fertilizer results in a higher biomass production. Therefore, if the amount of applied P fertilizer is not increased proportionally, the net uptake of P per volume of soil increases with the higher yields. This may result in a decrease in plant-available soil P.

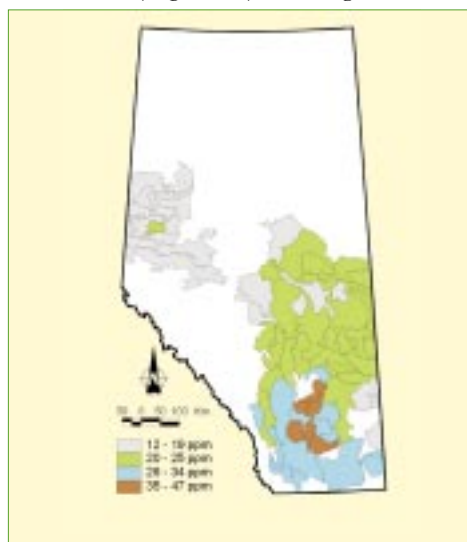


Figure 3. Available P for rainfed annual crops, 1993 to 1997.

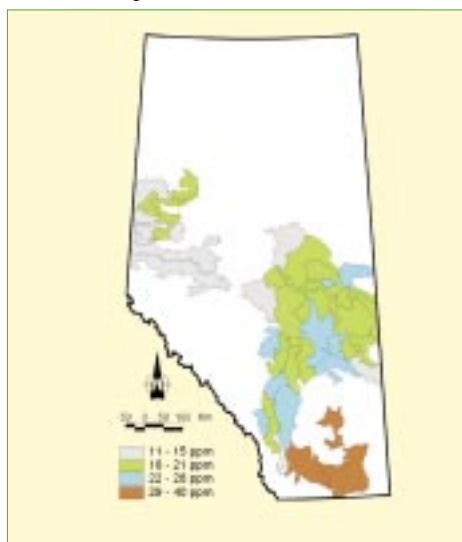


Figure 4. Available P for perennial annual crops, 1993 to 1997.

The progressive increase in yields for annual crops since the 1960s is illustrated in **Figure 5**. Annual crop values were obtained by averaging the yields across major crop types. An increase in perennial yields was also found between 1963 through to the early 1990s, after which perennial yields are characterized by a decreasing trend.

The changes in soil P recorded over the 30-year period were found to be more numerous on those soils cultivated with annual crops than those with perennials. A possible reason for soils with perennial crops being less affected by changes in soil P over time could be related to changes in management practices. Although a specific investigation is needed, we hypothesize that changes in the use of fertilizer have been more widely adopted in the production of annual than with perennial crops.

The practice of fertilizer band application with annual crops has resulted in more efficient and economical use of P by placing the fertilizer close to the plant roots. Traditionally, the P fertilizer has been seed-row applied for cereal crops and top-dressed for forage crops. During the 1980s, the widespread adoption of deep (3- to 4-inch) banding of N fertilizer, often in combination with P, was also effective in reducing immobilization of P on these dominantly alkaline soils. Good crop responses obtained with banded

or seed-row application of P fertilizer on annual crops have been the key factor in changing fertilizer practices toward a more efficient and economical use of P.

Major technological advancements in the way P fertilizer is applied to perennial crops, such as low disturbance banding or injection of P, have not been widely adopted. Therefore, we could speculate that the lack of major changes in technology could be another cause for the higher number of ecodistricts that show no changes in the soil P level over time on perennial crops.

In summary, available soil P did not increase consistently from the 1960s to the 1990s despite increased fertilizer application rates. Although there are some ecodistricts with a high proportion of fields with excess or optimum soil P for crop production, most soils in Alberta are deficient or marginal in soil P. Soil P levels and soil testing are required to develop a nutrient management plan to encourage optimum economic crop production. **BC**

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Acknowledgements

The authors thank the Alberta Environmentally Sustainable Agriculture (AESAs) program for providing funding and support, and also Mr. Tom Goddard for his valuable comments and discussion.

A copy of the full report on this research is available from the senior author at the e-mail address above.

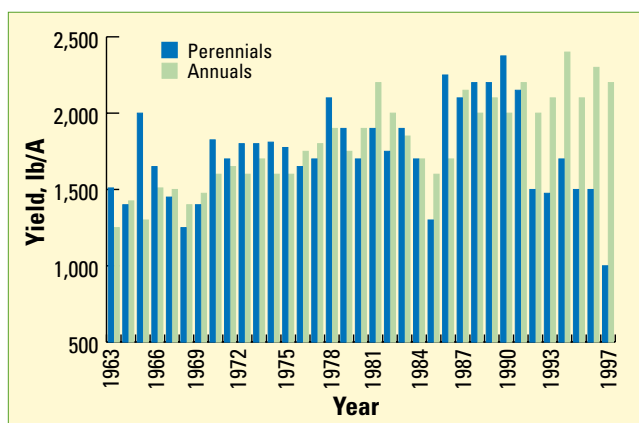


Figure 5. Provincial yield averages grouped by annual and perennial crop classes. Original source of data: Agriculture Division, Statistics Canada.