Yield Benefit of Phosphorus Fertilizer for Wheat, Barley, and Canola in Alberta

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Phosphorus fertilizers are applied annually to almost all cereal and oilseed crops grown on the Canadian Prairies. Their benefit to crop yield was first demonstrated in studies conducted from 1928 to 1930 and their use expanded rapidly from the early 1940s until the late 1960s. Since 1975, the import of P in fertilizers to the three Prairie Provinces has been approximately equal to the export of P in grain.

The widespread use of P fertilizers has likely contributed to a reduced yield response of P fertilizer. A recent review of fertilizer trials in Saskatchewan found that prior to 1970, P fertilizer increased wheat yield by an average of 26% (874 trials). After 1970, P fertilizer increased wheat yield by an average of only 11% (252 trials).

To evaluate the current P responses in Alberta, small plot fertilizer trials were conducted from 1991 through 1993 at 154 locations across the province. About 28% of locations were on Brown (Aridic Boroll) or Dark Brown (Typic Boroll) soils, 45% were on Black (Udic Boroll) soils, and 27% were on Gray (Boralfic Boroll) soils.

About 80% of the locations were on stubble (recrop) land and 20% were on fallow land. At each location, fertilizer responses were determined for barley, spring wheat, and canola (at some locations, only one or two crops were tested).

The replicated field trials included the treatments 0, 13, 26, and 39 lb P_2O_5/A applied as monoammonium phosphate (MAP). Treatments were applied with the seed except at the highest application rate for canola. To avoid germination damage in canola, application was split with 13 lb P_2O_5/A seed placed and 26 lb P_2O_5/A banded prior to seeding. Nitrogen (N) and any other required fertilizer nutrients were banded prior to seeding. The best-rated crop varieties were used in each region.

Soil samples were obtained during the previous

The average yield response to phosphorus (P) fertilizer across the 154 locations included in this study was 10%. Net returns in the year of application were maximized by application of 20 to 35 lb P_2O_5/A.

TABLE 1. Effect of soil type, crop, and year on response to fertilizer P additions.

Crop	Soil type	Frequency of grain yield response[1]	Grain yield increase over check, %	Yield increase, bu/A
Barley	Brown	57	8	5.7
	Black	78	8	6.4
	Gray	63	18	7.8
	All	68	10	6.5
Wheat	Brown	57	7	2.8
	Black	72	8	3.7
	Gray	59	12	3.9
	All	64	9	3.5
Canola	Brown	39	8	2.6
	Black	40	9	3.2
	Gray	68	20	4.3
	All	45	11	3.1

[1]% of sites where check < fertilized.

fall at locations in southern Alberta or just prior to trial establishment at locations in central or northern Alberta. Available soil P was determined using the modified Kelowna method (0.15 M NH_4F, 1.0 M CH_3COONH_4, 0.5 M CH_3COOH). At maturity, crop yields were collected and expressed on a dry weight basis. Yield data from each experimental site was subject to an analysis of variance and only those experimental sites that had a coefficient of variation of less than 20% were used in the analysis.

In total, fertilizer responses were recorded at 143 barley sites, 141 wheat sites, and 108 canola sites. Two thirds of the cereal sites and just under half of the canola sites had a significant ($p < 0.05$, LSD) yield increase due to P application (**Table 1**). The average increase in yield due to application of P fertilizer was 10%. This is similar to the 11% yield response reported for 252 trials conducted across Saskatchewan between 1970 and 1991.

Differences in average P fertilizer response were small among crop types (**Table 1**). The only significant difference was a slightly smaller percentage yield gain for wheat than for barley or canola.

Soil type significantly affected P fertilizer response, depending on crop type (**Table 1**). The grain yield increase due to P fertilizer, expressed as percent of unfertilized check, was significantly greater for barley and canola on Gray soils relative to Black or Brown soils, but was similar for wheat.

One factor that contributes to differences in P fertilizer response among crop types is P acquisition strategy. Canola roots lower the pH within the rhizosphere more effectively than cereal roots, allowing canola to deplete acid-soluble P fractions more effectively than cereals. This strategy is likely to be most effective in calcareous soils and may partially account for the less frequent and smaller response of canola in Brown and Black soils than in the more acidic Gray soils. A second factor that may contribute to differences in crop response to P fertilizer is the "starter" effect of P fertilizer. The importance of starter fertilizer in cool soils may account for the greater P fertilizer response in Gray soils, which are found in regions characterized by cooler spring (May-June) air temperatures.

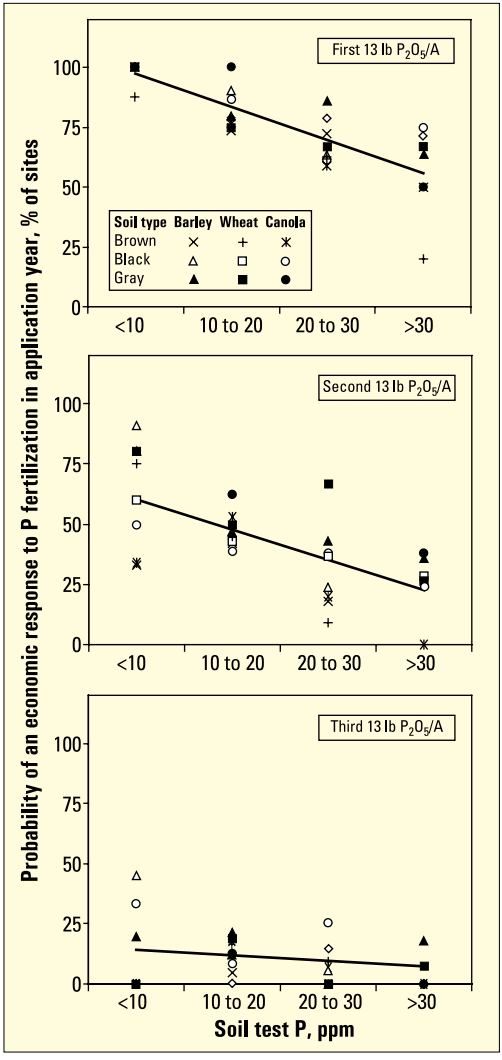

Figure 1. Probability of an economic increase in yield due to application of three increments of P fertilizer for barley, wheat, and canola on various soil types.

An alternative method of presenting fertilizer recommendations that is useful when factors other than fertility greatly influence crop response is based on

Grain yield increase due to P fertilizer was significantly greater for barley and canola on Gray soils relative to Black or Brown soils in Alberta.

probability diagrams. Using the response functions determined for each site and fertilizer-to-grain cost ratios, the probability (% of sites) of an economic increase in yield as a function of soil test and fertilizer rate can be determined (**Figure 1**). It is important to remember that this applies to the application year only, and does not take into consideration any residual P from the applied fertilizer that will be available in future years. The probability of an economic increase in yield due to application of the first 13 lb P_2O_5/A was high for all crops and soil test levels, declining from close to 100% when soil test P was less than 10 parts per million (ppm) to about 60% when soil test P was more than 30 ppm. Crop type and soil zone had little influence on the probability of an economic increase with the first increment of fertilizer addition.

With the second increment of 13 lb P_2O_5/A, a wider variation in the probability was observed. The probability of an economic P fertilizer response at the lowest soil test level was least for barley and canola in Brown soils. The probability of an economic increase in yield with the third increment of 13 lb P_2O_5/A was low for all soil test levels and crops. Maximum profits for fertilizer P applied in that year were achieved if sites were fertilized at rates that provided an approximate 40% probability of an economic increase. At this level, rates of required P fertilizer ranged from about 20 lb P_2O_5/A at high soil test P levels to about 35 lb P_2O_5/A at low soil test P levels.

Since this work was completed in 1993, soil test summaries indicate that about 60% of Alberta soils test medium or below in soil P, and would likely respond to fertilizer P application. An evaluation of crop production and fertilizer use in 2001 found that fertilizer additions accounted for 87% of crop removal in the province. These results indicate that any change in soil P since this study was carried out have been minor.

The average yield response to P fertilizer at the 154 locations included in this study was 10%. This increase was much smaller than reported in early studies on the Canadian Prairies, likely due to a gradual increase in residual soil P fertility caused by the regular application of P fertilizer. Despite this weak response, the application of 20 to 35 lb P_2O_5/A generally provided optimum returns in the application year. The probability of a profitable yield benefit declined with increasing fertilizer rate or soil test P level.

The results of this study support the use of soil testing to establish the availability of soil P and develop suitable fertilizer management practices. BC

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