The Effect of Phosphorus Fertilization on the Yield and Quality of Cereal Grains

E.H. Halstead

Department of Soil Science
University of Saskatchewan
Saskatoon

INTRODUCTION

The Saskatchewan Soil Testing Laboratory is currently compiling, and summarizing with the aid of the computer, all of the available fertilizer response data in Saskatchewan. The objectives of this project are to improve the current soil test benchmarks and to introduce the concept of expected returns from nutrient applications into the recommendations provided to farmers.

The 1970 Soil Fertility Workshop meetings dealt with a preliminary look at the response of wheat grown on summerfallow to phosphate fertilization. At the current (1971) Workshop meetings, J.W. Hamm, Director of the Saskatchewan Soil Testing Laboratory, reported on the results of the complete provincial summary of phosphate response on wheat. In his report Mr. Hamm introduced the concept of expected returns based on the results of the summarized data. He also indicated that the summary of phosphate response on other crops was progressing favorably and that this data would be used to predict expected returns on a soil test basis in the autumn of 1971.

The data reported in this paper, on the response of wheat and barley to phosphate fertilization, does not represent a complete picture of the computerized provincial summary. The data included herein is based largely on the results of trials carried out by the Department of Soil Science, University of Saskatchewan, over the past three decades. Since soil test levels for available phosphorus were not available for much of the early work, the data presented can only be viewed in terms of an average type of response situation. More detailed interpretation on a soil type and soil test level basis will have to await the completion of the province wide summary.

Yield Response of Wheat to Phosphate Fertilization

Yield increases of wheat grown on summerfallow to a given rate of 11-48-0 vary with both soil and climatic factors. For this reason, the average response data over a number of years for a particular soil is probably the most practical way of evaluating the response data. Figures 1 and 2 illustrate the average increase and the variations which can be expected from year to year for the Sceptre and Weyburn soils.

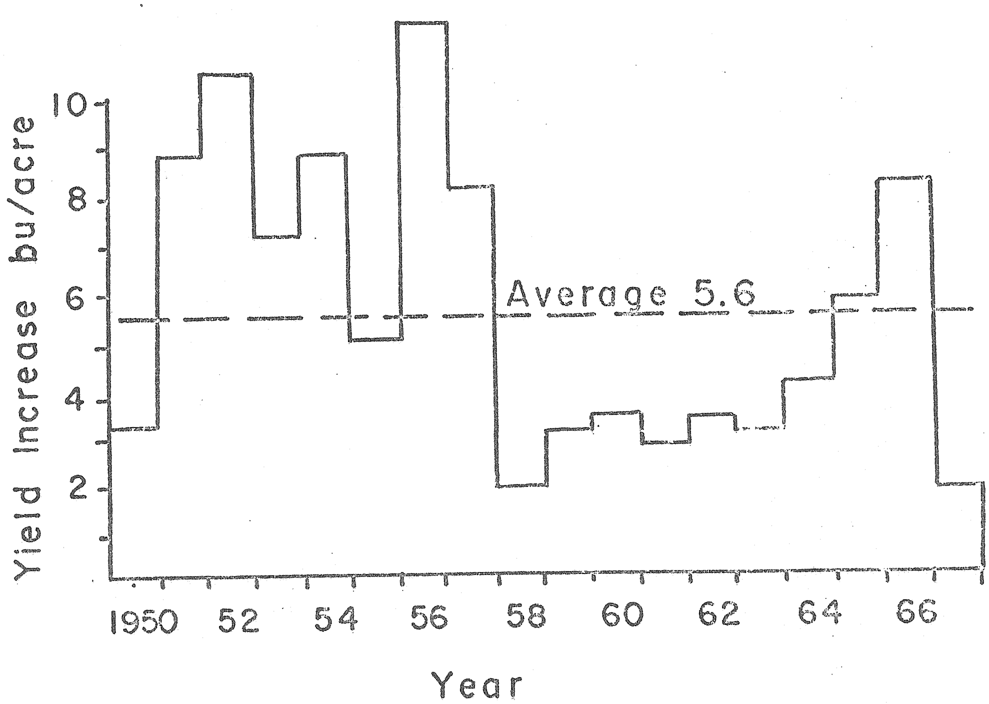

Figure 1. Average annual increase in wheat yield from 40 lb/acre 11-48-0 on Sceptre clay. F.G. Warder and W.S. Ferguson, 1968. Fertilizer Results South Western Saskatchewan 1950-1967.

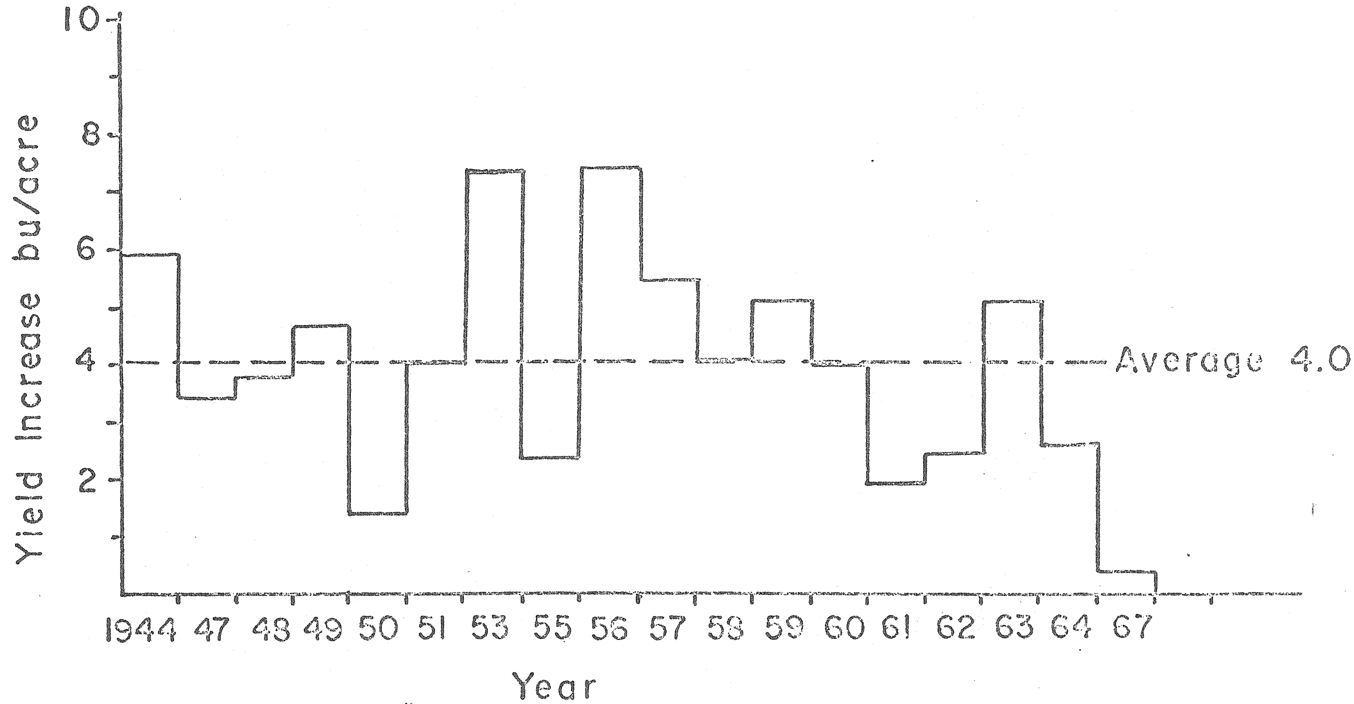

Figure 2. Average annual increase in wheat yield from 40 lb/acre 11-48-0 on Weyburn Loam. Department of Soil Science data.

Since the levels of extractable soil phosphorus are not available for these data a direct comparison between the soils is not possible. For the same reason the magnitude of response within one soil for any given year is likely influenced, at least to some extent, by the available P level of the site on which the trial was conducted.

The average response of wheat to phosphate fertilization on a soil zone basis in Saskatchewan is shown in Figure 3. It should be kept in mind that the curves shown are based only on Department of Soil Science data. It is quite possible that the relative positions of the curves shown may change when the results of the provincial summary are completed. The average data indicates the rate of P_2O_5 required to maximize net returns is about 15 pounds per acre in the

Brown soil zone and about 20 pounds per acre in the other soil zones. These calculations are based on wheat at \$1.25 per bushel and P_2O_5 at 10 cents per pound. At best, these data could be used only for making a general type of recommendation since they do not separate out soil type or soil test levels in relation to response. The data does, however, show an important concept in that it illustrates the magnitude of the average response, to a given rate of phosphate, appears to be dependent on both soil and climatic factors.

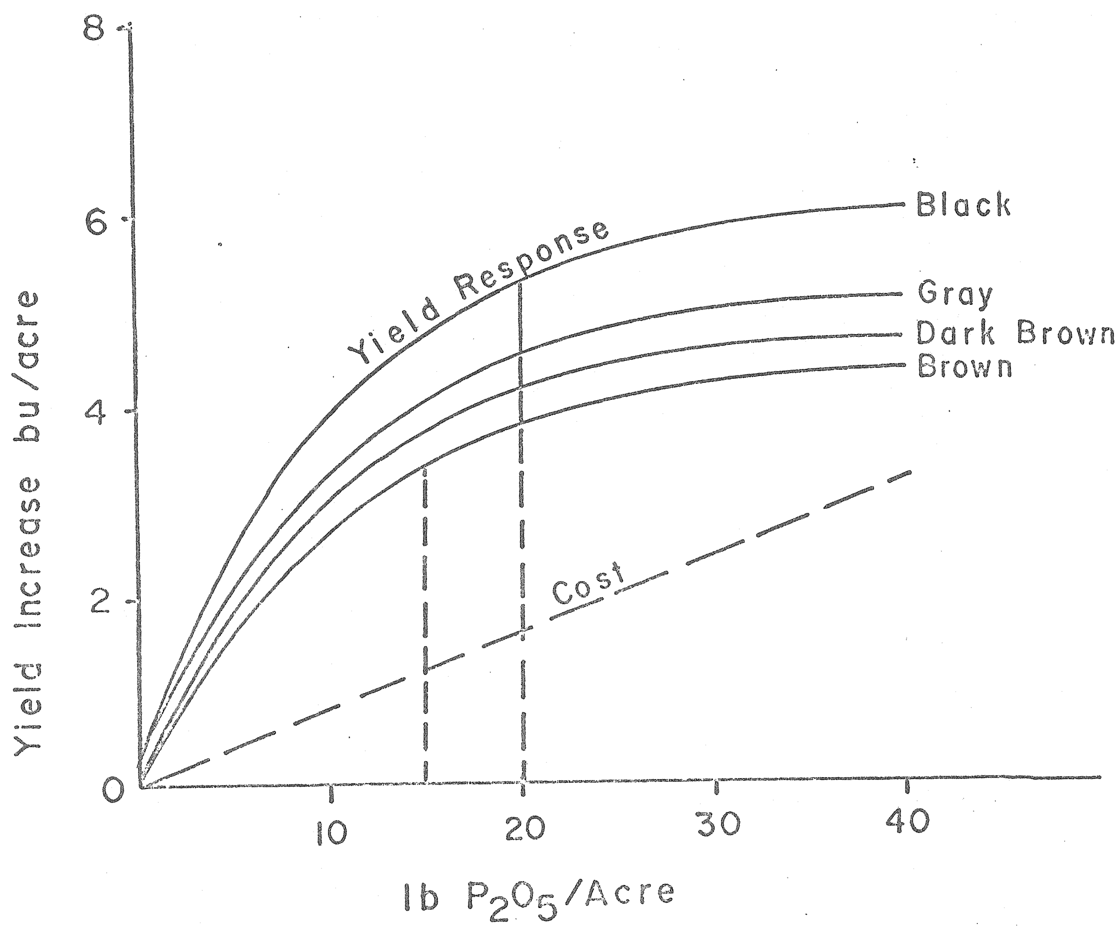

Figure 3. Average yield increase to phosphate for wheat on a soil zone basis.

Yield Response of Barley to Phosphate Fertilization

Much less data is available for the response of barley grown on summerfallow to phosphate fertilization than for wheat. However, the limited amount of data generally indicates relatively higher average responses on barley for a given rate of 11-48-0. In addition, the variation in response between years for a given rate of phosphate fluctuate more widely for barley than for summerfallow grown wheat. The Department of Soil Science data shows that yield increases for a specific rate of phosphate can be as low as one bushel/acre and as high as 20 or more bushels/acre. Figure 4 indicates that the average response increases as you move to higher rates of phosphate in a manner similar to that observed for wheat. However, the wide fluctuation between years suggests that the "fertilizer - climate" interaction is more pronounced for barley. This wide fluctuation is probably related to the advanced maturity observed in barley fields fertilized with phosphate.

The response of barley to phosphate fertilization on three selected Gray and Gray Black soils is shown in Figure 5. These data supplied by the Scott Experimental Farm indicate a variable response for the three soils shown. The highest yield increases were obtained on the Whitewood soil which had a very low level of available soil phosphorus. The rate of P_2O_5 required to maximize net returns on this soil appears to be in the range of 35 pounds of P_2O_5/acre. On the Waitville and Loon River soils the rate of P_2O_5 required to maximize net returns were in the range of 25 and 20 pounds of P_2O_5 respectively. These calculations are based on barley at 65 cents/bushel and P_2O_5 at 10 cents per pound. The average check yields on these plots were: Whitewood loam, 30 bushels/acre, Waitville loam, 38 bushels/acre and Loon River loam 43 bushels/acre.

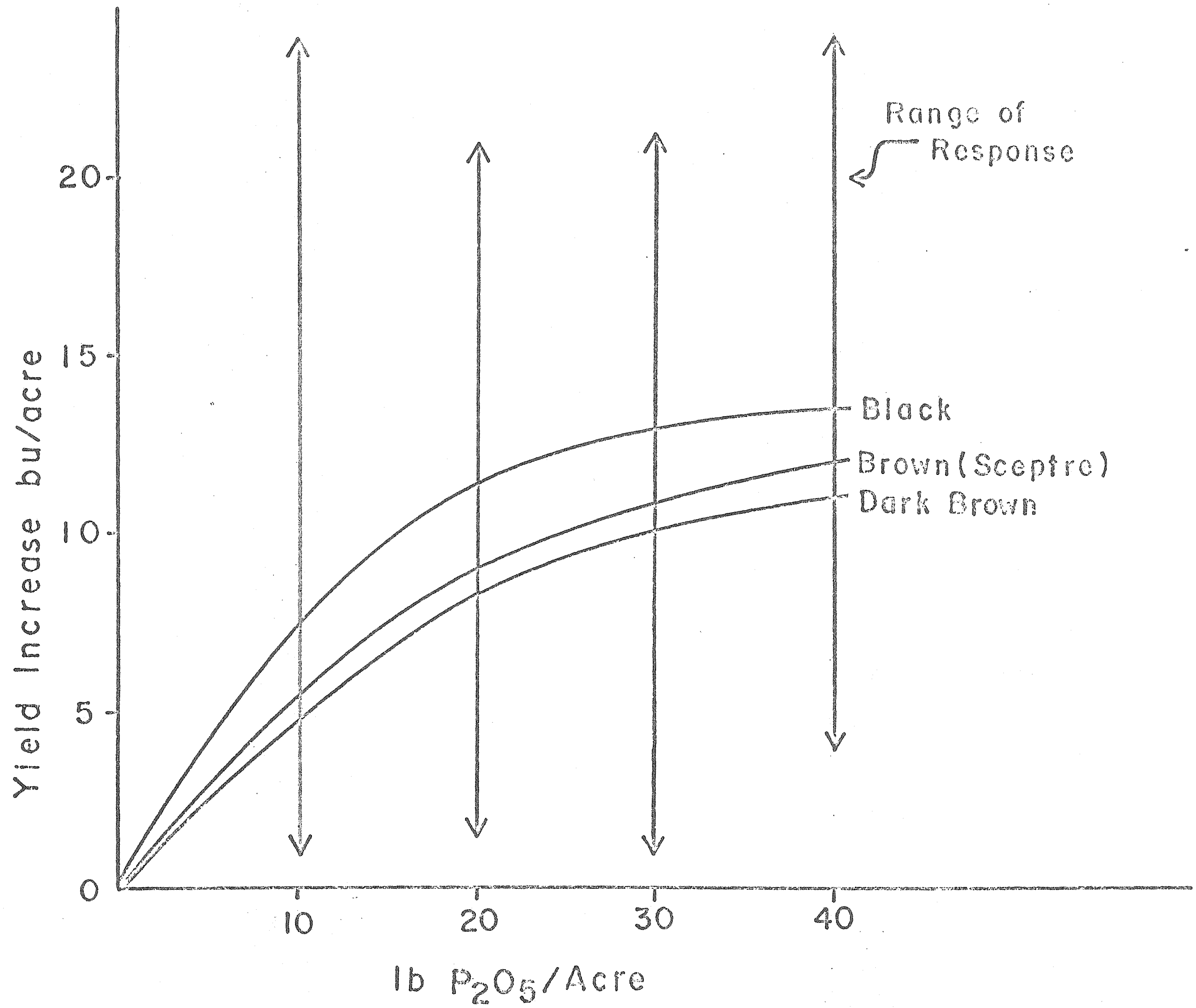

Figure 4. Average yield increase to phosphate for barley and range of response.

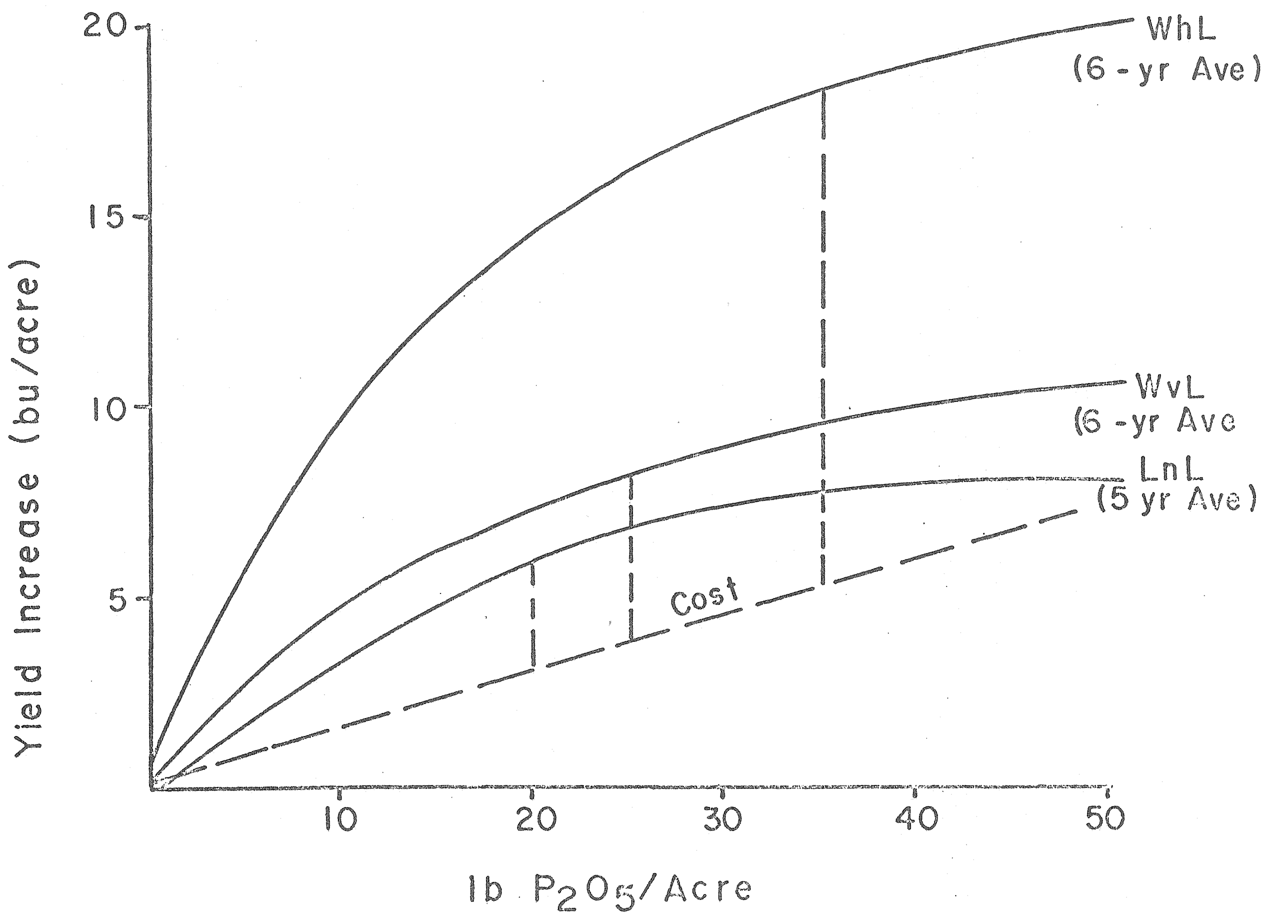

Figure 5. Response of barley to phosphate fertilization. Scott data.

The Effect of Phosphorus Fertilization on the Phosphorus and Protein Content of Wheat

Work reported by Rennie in 1956 indicated that phosphate fertilization had little effect on the percentage phosphorus in wheat grain. However, nitrogen applications were found to significantly reduce the percentage phosphorus in the grain. The results of this study, which are presented in Figures 6 and 7 show that grain grown on stubble land consistently contained higher percentages of phosphorus than on fallow. This is conceivably due to a deficiency of nitrogen on the stubble seeded crop.

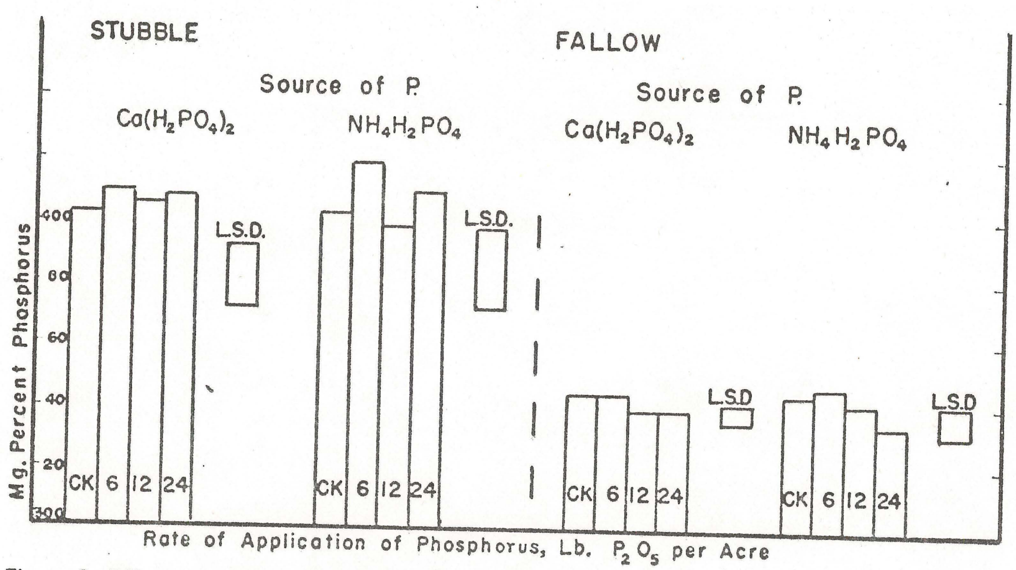

Figure 6 Effect of phosphate fertilization on the milligram percentage phosphorus in the grain for a fallow and stubble plot.

D.A. Rennie, 1956. Can. J. Agri. Sci. 36: 491-504

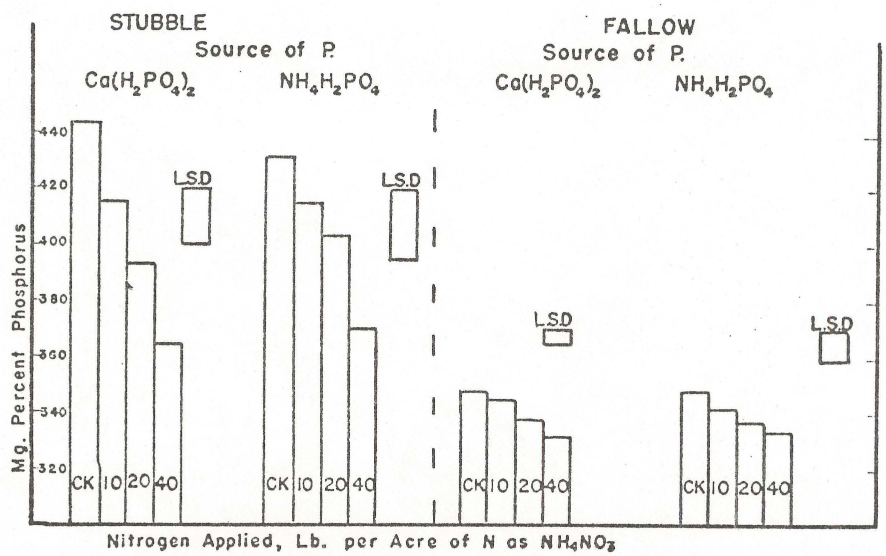

Figure 7. Effect of nitrogen fertilization on the milligram percentage phosphorus in the grain for a fallow and stubble plot.

D.A. Rennie, 1956. Can. J. Agri. Sci. 36: 491-504

Phosphorus fertilization generally results in an increase in the phosphorus content of the foliage. This effect is most evident in the early stages of growth and is usually not reflected in increased phosphorus content of the grain. However, the total yield of phosphorus per acre in the grain can be increased as a result of the yield increases that occur when phosphate fertilizers are used. The data shown in Tables 1 and 2 illustrate the above relationships.

Table 1. Phosphorus in the above ground portion of wheat for two sampling dates.

H.J.V. Schappert, 1968. B.S.A. Thesis Department of Soil Science, University of Saskatchewan

Sampling Date	Check	11-48-0 55 lb/acre	18-46-0 55 lb/acre	23-23-0 80 lb/acre	11-48-0 55 lb/acre + 34-0-0 75 lb/acre
July 12					
(% P)	0.096	0.114	0.112	0.098	0.112
(lb P/acre)	1.66	1.83	2.43	2.13	2.51
July 25					
(% P)	0.067	0.074	0.081	0.084	0.079
(lb P/acre)	1.42	1.94	2.46	2.45	2.15

Table 2. Percent phosphorus in the foliage, straw and grain of fallow and stubble seeded wheat.

(G.J. Racz, M.D. Webber, R.J. Soper and R.A. Hedlin, 1965 Agron. J. 57: 335-337)

N-P Treatment		21 days	Straw	Seed
Fallow	0- 0	0.33	0.12	0.50
	0-20	0.37	0.14	0.52
	60- 0	0.35	0.13	0.48
	60-20	0.41	0.14	0.50
Stubble	0- 0	0.30	0.09	0.45
	0-20	0.36	0.07	0.44
	60- 0	0.30	0.07	0.38
	60-20	0.41	0.09	0.42

The effect of soil type or climate cause greater variations in the percentage phosphorus in grain than phosphorus fertilizer treatments. This has been shown on many soil catena studies conducted by the Department of Soil Science at the University of Saskatchewan. An example of the variations which can result on a catena bases are shown in Table 3. These data show no significant differences in fertilizer treatments but significant differences in phosphorus content due to slope position.

Table 3. Percentage phosphorus in wheat grain on an Oxbow Catena.

(D.A. Rennie, 1958. Tracer Fertilizer Report. Department of Soil Science, University of Saskatchewan)

Soil Member	Check	11-48-0 at 20	11-48-0 at 40	23-23-0 at 20	LSD	Ave.
Calcareous	.382	.373	.380	.375	N.S	.378
Orthic	.372	.371	.359	.361	N.S	.367
Eluviated	.356	.381	.371	.367	N.S	.369
Gleysol	.451	.443	.433	.440	N.S	.442
LSD (P = .05)	.025	.023	.019	.023		.011

Fertilization with phosphorus has been shown to have little effect on the protein content of stubble seeded wheat in Saskatchewan. The data presented in Table 4 summarize the average results of 121 trials conducted by the Department of Soil Science during the 1965 to 1969 period. These data indicate very little difference between the average protein content of the check strip and the 40 lb/acre 11-48-0 treatment.

Table 4. The effect of phosphorus fertilization on the protein content of stubble seeded wheat.

Soil Zone	Check	11-48-0 40 lb/acre	No. of Trials
	% Protein at 13.5% Moisture		
Dark Brown	13.7	13.9	61
Black	13.4	13.3	48
Gray	12.4	12.6	12

Conclusions

1. The yield response of wheat and barley to phosphorus fertilization varies with soil and climatic factors. However, the optimum rate of phosphate is not necessarily different for each soil.

2. The response of barley to phosphorus fertilization is more variable than wheat. The very high responses which occur on barley in some years suggests a strong fertilizer-climate interaction.

3. Phosphorus fertilization appears to have little effect on the percentage phosphorus in the grain. However, nitrogen application can significantly reduce the phosphorus content of the grain. Similarily the phosphorus content of wheat is likely to be higher on stubble seeded land than on fallowed land which has higher available nitrogen levels.

4. The percentage phosphorus in grain is influenced more by soil and climate than by phosphorus fertilization. It appears that it would not be practical to apply phosphorus fertilizers with the expressed purpose of increasing the percentage phosphorus in the foliage or grain of cereal crops unless increases in yield can be expected.

5. On the average, the percentage protein in wheat grain is little affected by phosphorus fertilization.