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PHOSPHORUS FERTILIZATION ECONOMICS[1/]

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INTRODUCTION

Fertilizer costs have become important factors in crop production in recent years because of (a) increased energy costs associated with fertilizer manufacturing and (b) material shortages. Since this trend will probably continue, it is important that fertilization practices maximize economic returns and fertilizer efficiencies. We have been evaluating the P fertilization needs of some of the major crops grown in southern Idaho since 1973. This report compares the increased net crop value resulting from P fertilization at different soil test P levels.

METHODS AND MATERIALS

The response of irrigated crops to P fertilization across a range of soil test P levels (STPL) were evaluated in 1973, 1974, 1975, and 1976 on a Portneuf silt loam soil at the Snake River Conservation Research Center. The cropping sequence, variety, and maximum crop yields are shown in Table 1.

Table 1. Cropping sequence, variety, maximum yields, and estimated crop value.

Year	Crop	Variety	Maximum yield/A	Estimated crop value
1973	Sugarbeets	(Amalgamated Sugar Co.)	30 T (9700# sugar)	$ 25/T
1974	Spring wheat	Twin	100 bu	$ 3/bu
1975	Potatoes	Russet Burbank	400 cwt	$ 3.50/cwt
1976*	Silage corn	NK, KE497	20 T @ 30% dm	$ 14/T

* Crop hail damaged, 8/2/76

Standard planting, harvesting, and other cultural practices were followed with all crops. Fertilization rates other than P were based on standard soil tests utilizing the University of Idaho fertilizer guides for each respective crop. Residual STPLs were established in the fall of 1972 by broadcasting different rates of 0-45-0 (CSP). Each plot was soil sampled in 12-inch

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increments to 24 inches in the spring of each year before any fertilization. The STPL was determined by the $NaHCO_3$ method (2). Where fresh P applications were desired, CSP was broadcast and disked in before planting. All experiments were furrow-irrigated on a schedule based on the evapotranspiration. All crop residues were returned to each individual plot after harvest.

The crop yields of each fertilizer treatment were used to calculate the total crop value in dollars. The crops' unit values used for these calculations are shown in Table 1. Phosphorus fertilizer costs have been assumed to be $0.40/lb P. Net dollar return per acre is the change in total crop value as a result of the P fertilization minus the P fertilizer cost (net dollar return = crop value with P — crop value without P — P fertilizer costs). No additional expense from extra harvesting and handling costs, P fertilizer application costs, nor other costs was considered.

RESULTS AND DISCUSSION

The P fertilizer rates applied in the fall of 1972 and the respective STPLs in the spring of 1973 are shown in Figure 1. Approximately 6.6 lb

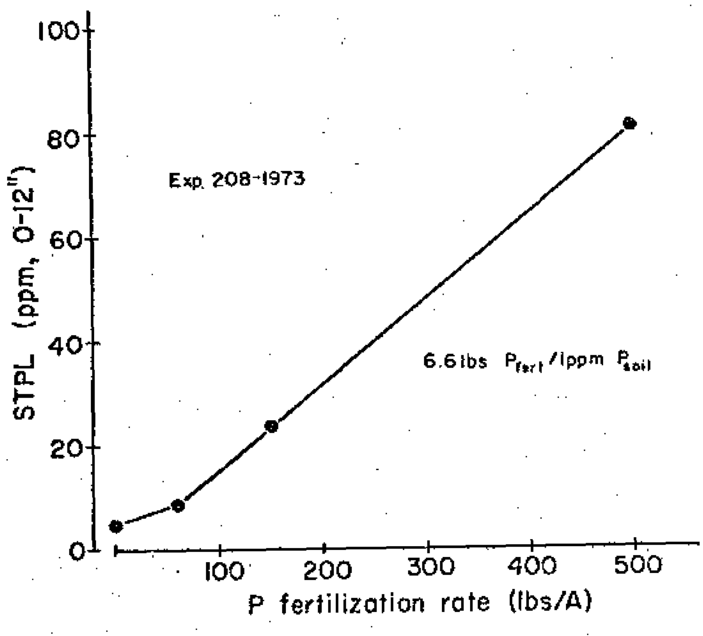

Fig. 1. Effect of P fertilization on the STPL of a Portneuf silt loam soil.

fertilizer P/A (15 lb P_2O_5/A) increased the STPL by 1 ppm P in surface 12-inch depth. After considering the soil's bulk density (1.3 g/cm^3), an average of 53% of the applied P fertilizer appeared as a change in the STPL. This is similar to that reported for other calcareous soils (1).

The relative yields of the four crops at different STPLs are shown in Figure 2. Yields of sugarbeets, spring wheat, and silage corn were not increased from P fertilization when the STPL was greater than 10 ppm P, whereas greater than 15 ppm P was required for potatoes. These levels were considered to be the critical STPLs for these crops.

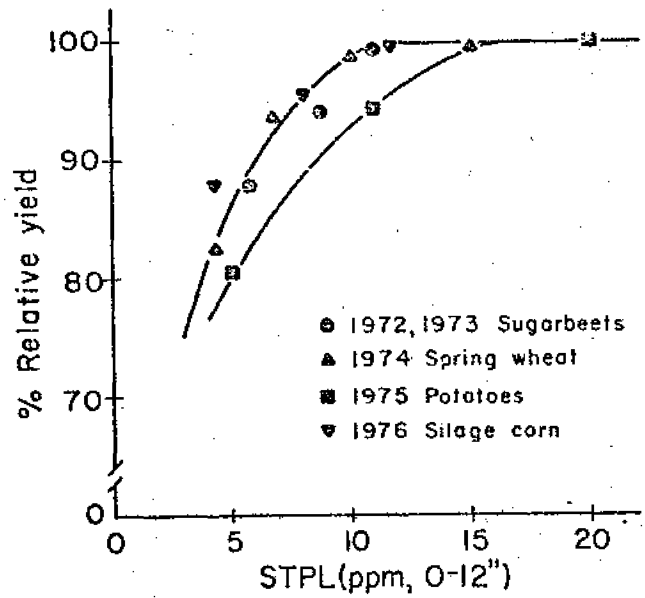

Fig. 2. Relationships between the STPL and relative crop yield for four selected crops grown on the Portneuf silt loam soil.

The STPLs, resulting from the initial 1972 P applications, decreased from 1973 to 1976, however the decreases were greater at the higher STPLs (Figure 3).

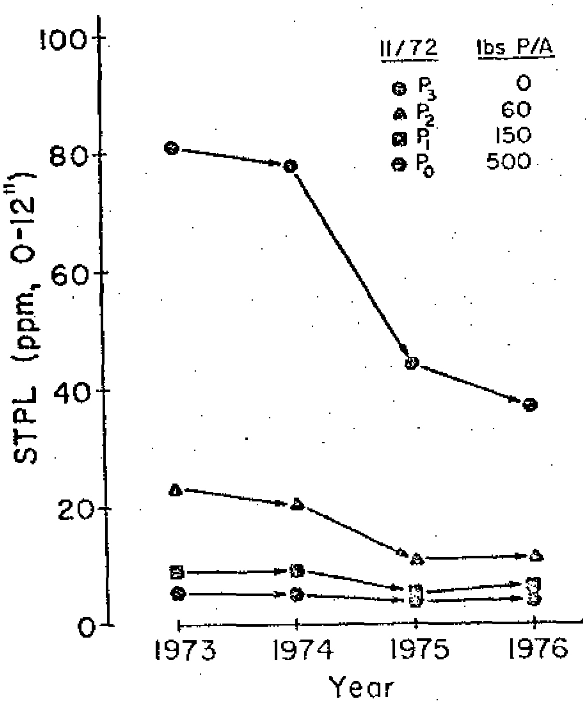

Fig. 3. Change in STPL with cropping at four different P treatments.

The STPL decreased from 81 to 38 ppm P for the P_3 treatment, whereas in the P_1 treatment the STPL decreased from 9.0 to 6.5 ppm P. These decreases with time probably resulted from a combination of crop uptake and reversion to less soluble soil-P forms. Small STPL changes at the lower STPLs (< 10 ppm P) illustrate this soil's ability to supply P for continued crop growth. The general decrease in all STPLs points out the need for a systematic soil-testing program. This was emphasized in the 1975 experiment, when the STPL of the P_2 treatment (Figure 3) had decreased below the critical STPL value for maximum potato yields (compare Figure 3 with Figure 2).

The value of the crops grown on the residual-P treatments over the 4-year cropping period are shown in Table 2. Gross crop values were near maximum on

Table 2. Crop values from phosphorus fertilization over a 4-year cropping period.

P applied * fall, 1972	1973 Sugar-beets	1974 Spring wheat	1975 Potatoes	1976 Silage corn	Total	P fert. costs	4-year net returns
	Gross crop value						
lbs/A	$/A						
P_0, 0	577	240	1214	232	2263	0	--
P_1, 60	661	267	1204	250	2382	24	95
P_2, 150	655	291	1277	239	2462	60	139
P_3, 500	660	306	1512	252	2730	200	267

* Initial STPL 5.6 ppm P (0-12")

the P_1 or P_2 treatments for sugarbeets, spring wheat, and silage corn; whereas it was maximum for potatoes on the P_3 treatment, primarily because the STPLs of the lower three residual-P treatments were below the critical level for potatoes. Summarizing the crop value across the 4-year period and then subtracting the P fertilizer costs for each residual P treatment to obtain the net dollar return showed that all the P treatments were profitable, however there was nearly a 4-fold return on money invested in the P_1 treatment compared with a 1.3-fold return in the P_3 treatment.

There is also an effect of the time at which a particular crop is grown in the rotation following P fertilization. For example, maximum potato yields require a STPL greater than 15 ppm compared with 10 ppm for the other three crops (Figure 2). Therefore, the net returns for the P_1 and P_2 treatments would have been much higher if potatoes had been grown in 1973 or 1974, instead of 1975, since the STPL of the P_2 treatment was above 15 ppm in 1974 (Figure 3). Thus, a crop with a relatively high P requirement should be grown as soon as possible after the P fertilizer application, if P is applied only once in a cropping rotation. These data do indicate the approximate values that can be placed on different P fertilization rates in a 4-year cropping sequence.

An additional factor to consider is the decrease of the high STPLs with time. For example, the STPL of the P_3 treatment, where 500 lb P/A were applied, decreased 43 ppm P from 1973 to 1976 (Figure 3). Assuming that half of this was due to reversion to unavailable forms and that 6.6 lb/A fertilizer P were required for each 1-ppm STPL change, then $57 of P fertilizer would be required to replace the precipitated P and should be subtracted from the net returns on treatment P_3 in Table 2.

Comparison of the net return from one initial fertilizer application with a similar amount applied in increments over the 4-year cropping period showed that the net dollar return increased $100/A for a total of 100 lb P/A applied in 3 of the 4 years when compared with a single initial 60 lb P/A application. Similarly, 140 lb P/A applied over the 4-year period increased net returns approximately $200 when compared with a single initial 150 lb P/A application. Thus, extremely high P fertilization rates may be profitable over several crops, but smaller yearly applications may be even more profitable. Maximum profits occurred in this study when the STPL was maintained at or slightly above each crop's critical STPL.

The net dollar returns from P fertilization at selected STPLs for individual crops are shown in Figure 4. Phosphorus fertilization was profitable

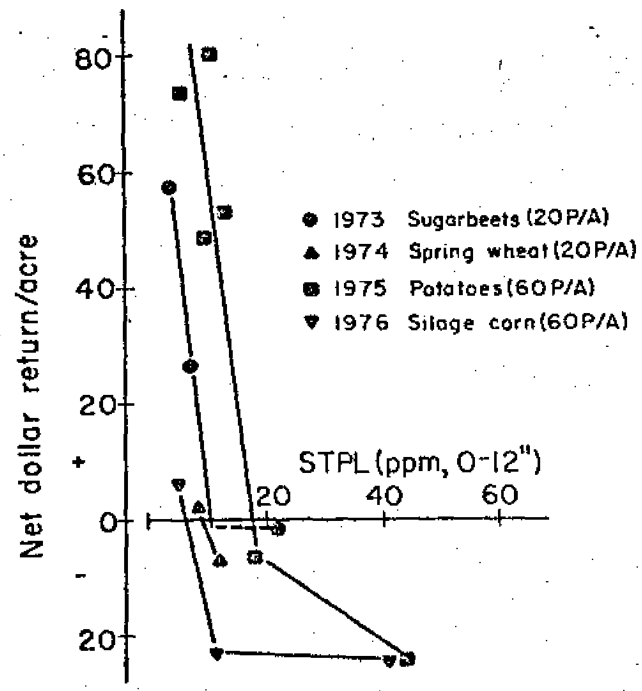

Fig. 4. The net dollar returns from P fertilization at selected STPLs and P fertilization rates for individual crops.

when the STPL was less than 10 ppm P for all crops, except potatoes where P fertilization remained profitable up to 15 ppm P. At STPLs greater than the critical STPLs, the P fertilizer costs were greater than the resulting increased crop value, causing a net dollar loss when only the single crop year is considered. Phosphorus fertilization under such conditions does increase the residual P level and its cost may be recovered in following crops. Phosphorus fertilization rates higher or lower than those indicated do not significantly change the conclusions shown in Figure 4. Phosphorus fertilization rates needed at the different STPLs for maximum crop production can be found in the Idaho Fertilizer Guides, published by the University of Idaho Extension Service.

SUMMARY

Economic evaluation of crop response to P fertilization across a range of soil test P levels (STPL) over a 4-year cropping period showed that P fertilization in a given crop year would not be profitable when the STPL was

greater than established critical levels. Maximum profits occurred when the P fertilization practice maintained the STPL at or slightly above each crop's critical STPL. Phosphorus fertilization when the STPL is above the crop's critical STPL increases the residual soil P level. The STPL decreases with cropping, with greater decreases occurring when the STPL has been increased by fertilization to greater than 12 ppm. About 6.6 lb fertilizer P/A were needed to increase the STPL 1 ppm in the top 12 inches of the Portneuf silt loam soil.

REFERENCES

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