The Effect of Phosphate Applications on Soil Tests and on Subsequent Yield of Field Beans and Wheat[1]

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The differential response of various crops to residual fertilizers and the effect of applied fertilizers on soil tests is of considerable interest. These effects have been studied for the past three years in conjunction with an experiment established near Bay City, Michigan, on a calcareous Kawkawlin-Wisner loam soil complex, pH 7.5.

Materials and Methods

A rotation of beets, beans, and wheat with a companion crop of sweet clover in the wheat was established at the above location in 1959. Each crop in the rotation appeared each year. For the sugar beet crop, four rates of P_2O_5 were broadcast and plowed under ahead of planting, 0, 200, 400, and 800 pounds per acre. A basic application of 200 pounds of 60 percent muriate of potash was plowed under. At planting time a starter fertilizer of either 5-20-10 or 6-24-12 was used on the beets.

The wheat and bean crops were fertilized with 150 pounds of either 5-20-10 or 6-24-12 per acre.

Soil samples were taken (20 cores per plot) and were analyzed for phosphorus using .025 normal HCl plus .003 normal NH_4F extractant with a one to eight soil to extractant ratio. The area was divided into three sections—Section A, where the first application of phosphate was made in the spring of 1959. Soil samples were taken on July 30, 1959, and again on August 16, 1961. The phosphate fertilizer was plowed down on Section B in the fall of 1959, and the soils were sampled on July 8, 1960, and August 16, 1961. The phosphate was applied on Section C in the fall of 1960 and the soils were sampled on August 16, 1961.

Sanilac variety of field beans was planted following the sugar beet crop. The sequence of crops was beets, beans, and wheat. Phosphate treatments were replicated three times and four subplots (28′ × 66′) out of each main plot were sampled.

Results and Discussion

The data in Table 1 show that the amount of phosphate applied was reflected by the soil tests. The greater the amount of phosphate applied the higher the soil test. The relationships

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Table 1.—The effect of phosphate applications on phosphorus soil tests (Monitor Sugar Co., 1961).

Lbs P_2O_5/acre	Pounds P per acre[1]				
	Section A P_2O_5 applied spring, 1959		Section B P_2O_5 applied fall, 1959		Section C P_2O_5 applied fall, 1960
	7-30-59[2]	8-16-61[2]	7-8-60[2]	8-16-61[2]	8-16-61[2]
0	24	27	23	29	26
200	40	40	50	41	48
400	70	63	89	63	79
800	119	122	130	98	117
L.S.D. (5% level) (1% level)	16	9	18	8	13

[1] P determined by extracting the soil sample with Brays P. extracting solution (.025 NHCl + .003 N NH_4F) 1:8 soil to solution ratio.

[2] Dates of sampling.

in general appear to be linear. The variability in the data is indicated by the pounds of P required for significance between treatments. This difference amounted to 16 pounds per acre for the sampling date of July 30, 1959, where one plowing had intervened between the time of application of phosphate and the time the samples were taken. The difference was significant (1% level) for all treatments. However, when the soils were sampled on August 16, 1961, the least significant difference required between means had decreased to 9. Similar results were obtained for the samples taken from Section B. There is no consistent decrease between the two sampling dates in soil tests over the three-year period in Section A or the two-year period in Section B. There was a great similarity between the soil test values on the various sections indicating that the soil was fairly uniform as far as phosphorus content was concerned.

One of the objectives of soil testing is to set up a threshold value above which small increases in yield would be expected other than those obtained from the use of planting time or starter fertilizer. Now as these data might suggest, as far as the sugar beet crop is concerned, this value has not been attained, because yields of sugar beets in 1961 were substantially higher where 800 pounds of phosphate was plowed under than where 400 was applied (Table 2). Bean yields were significantly reduced (1% level) in 1961 where additional phosphate was applied, that is, 400 and 800 pounds per acre. However, there was no significant increase in yields of wheat due to the phosphate that was plowed under for the sugar beet crop. This indicates that crops differ with respect to their nutritional needs for phosphorus.

Table 2.—The effect of phosphate applications for the sugar beet crop on the yields of subsequent crops of beans and wheat (Monitor Sugar Co., 1961).

	Section A			Section B		Section C
Lbs P_2O_5/acre Plowed under for sugar beets	Sugar beets 1959 Tons/acre	Beans 1960 Bu/acre	Wheat 1961 Bu/acre	Sugar beets 1960 Tons/acre	Beans 1961 Bu/acre	1961 Sugar beets Tons/acre
0	14.7	25.0	55.5	9.5	26.3	15.2
200	16.8	27.2	58.9	10.7	26.8	15.8
400	18.9	29.8	59.6	11.3	21.4	16.5
800	18.8	24.0	58.7	12.5	15.0	19.2
L.S.D. (5% level)	1.9	N.S.	N.S.	1.5	3.9[1]	2.0

[1] Significant at the 1% level.

While the difference in yield of beans due to phosphate applications was not significant in 1960, nevertheless, the lowest yield was obtained where 800 pounds of phosphate had been plowed under. In 1961, a very striking situation developed. Just prior to blossoming time, about six weeks after planting the beans, browning symptoms on the leaves developed. This was progressively worse as the amount of phosphate plowed under increased and significant reductions in yields resulted. The beans from the plots that had received the two higher rates of phosphate application were small and apparently did not develop normally. When this condition was noted, several minor elements, including zinc, were applied on the plot, but no noticeable result was indicated in the appearance of the plant or in the final yield. Judging from past experiences with corn, possibly zinc should be applied in the starter fertilizer to correct zinc deficiency. There are several instances reported by farmers and others who state that beans in some cases do not do well after sugar beets. It is suggested that this condition may have been due to a zinc deficiency caused by the tie-up of zinc by the phosphate, in that zinc phosphate is one of the most insoluble phosphate compounds. The observation concerning beans following sugar beets has also been made in USDA Leaflet No. 495 entitled "Zinc Deficiency of Field and Vegetable Crops in the West."

Summary

The amount of phosphate applied was reflected in soil tests. The greater the amount applied the higher the soil test.

Less variability between the data was found after the soil had been plowed three times after an application of phosphate fertilizer than one time after plowing. Apparently the subsequent mixing in the soil of the phosphate permitted more precise sampling.

Crops vary in their response to phosphate. Wheat apparently will produce well at relatively low phosphate levels between 40 and 50 pounds per acre, whereas sugar beets produce the highest yield where the soil tests were above 100 pounds per acre, approximately 125 pounds per acre.

The appearance and behavior of a bean crop, particularly in 1961, suggests that a possible zinc deficiency is being induced where high rates of phosphate fertilizer are used. Bean yields were 11.3 bushels of beans lower where 800 pounds of phosphate had been applied as compared to where no phosphate had been plowed under.