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Phosphate Fertilizer Management for Irrigated Corn Production

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Continuous corn production usually is associated with a need for annual fertilizer applications. However, annual applications in excess of plant requirements may result in a buildup of some nutrients in the soil. Phosphorus is one of these nutrients. Although this is not always detrimental to the plant, it is an inefficient use of the fertilizer. On calcareous soils (pH 7.0), as found in much of Kansas and the Great Plains, phosphorus reacts chemically with calcium that is present in the soil. This reaction forms a calcium-phosphate compound that is very slowly soluble, thus reducing its availability to plants and its efficiency. Current research indicates that careful management of P_2O_5 fertilizers can improve their efficiency and reduce production costs.

AGRICULTURAL EXPERIMENT STATION
Kansas State University, Manhattan
John O. Dunbar, Director

Procedure

Research has been conducted on a Ulysses silt loam soil at the Tribune Branch Experiment Station and on a Richfield silty clay loam at the Garden City Experiment Station for 23 and 15 years, respectively, to evaluate responses to annual applications of P_2O_5 fertilizer. Experiments were designed to test the effects of different rates of P_2O_5 application on soil phosphorus levels, and on residual soil phosphorus after applications were discontinued. Irrigated corn was grown to evaluate the effects of phosphorus applications and residual phosphorus on grain yield.

Results: Soil Phosphorus

When the experiment was initiated on the Ulysses soil at Tribune in 1961, the soil phosphorus (P) was 34 lbs/A according to the Bray soil test method. This is in the medium soil P category according to the Kansas State University soil testing lab. Recommendations for fertilizer applications to soils in this category range from 20 to 40 lbs P_2O_5/A. Fertilizer was broadcast as 0-44-0 and incorporated with normal tillage operations at rates of 0 to 40 lbs/A annually.

The soil was sampled periodically, and analyzed for soil P over the next 20 years. Figure 1 shows that when no P_2O_5 was applied, soil P declined to 14 lbs/A within 4 years and remained at that level. The 40 lb P_2O_5 treatment, in contrast, has maintained soil P near the initial test level throughout the experimental period. This indicates that the recommended 40 lb application was neither excessive nor deficient for that soil.

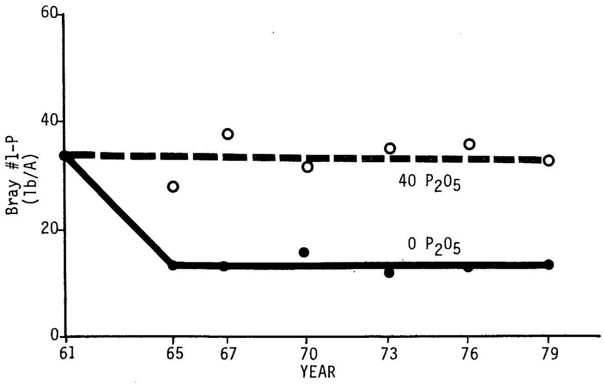

Figure 1. Effect of annual applications of 2 rates of P_2O_5 on concentrations of Bray #1-P in the surface 6 inches of a Ulysses silt loam.

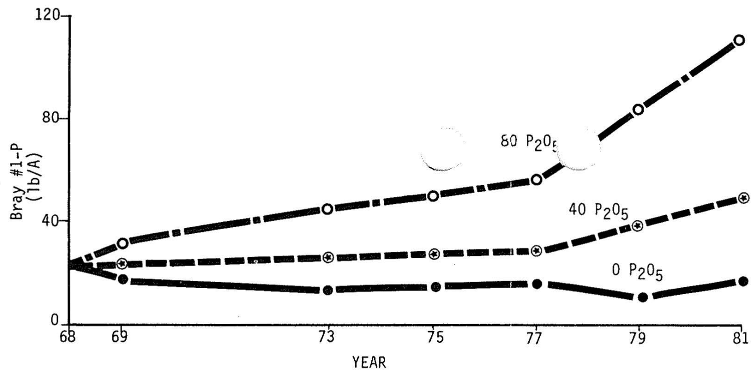

Figure 2. Effect of annual applications of 3 rates of P_2O_5 on concentrations of Bray #1-P in the surface 6 inches of a Richfield silty clay loam.

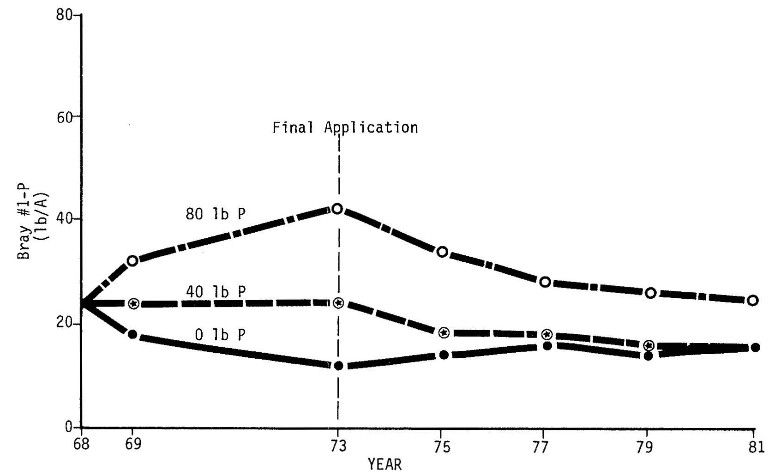

Figure 4. Effect of 6 years of application of 3 rates of P_2O_5 and 6 subsequent years of no application on residual Bray #1-P in Richfield silty clay loam.

At the Garden City location, on the Richfield soil, the initial soil P was 24 lbs/A. As with the Ulysses soil, the P_2O_5 fertilizer recommendation would be approximately 40 lbs/A. Fertilizer was applied as described above at rates of 0, 40 and 80 lbs/A annually. No P_2O_5 treatment resulted in a decline in soil P to 12 lbs/A by 1973, and it remained at that level (Figure 2). Annual applications of 40 lbs P_2O_5 maintained soil P constant through 1977, but increased it to 44 lbs/A by 1981. Eighty lbs P_2O_5 resulted in a constant buildup of soil P throughout the experiment, reaching more than 100 lbs by 1981.

The responses to applied P_2O_5 indicate that the 40 lb recommendation by the University soil testing service would be accurate for this location for a period of time, by not indefinitely. After 1977 recommended application rates would have been reduced, possibly as much as 20 lbs per acre, or alternate year applications might have been suggested. The 80 lb rate was in excess of plant needs, as seen by the continuous increase in soil P after initiation of the experiment. This further indicates the need and value of monitoring the soil through periodic soil testing.

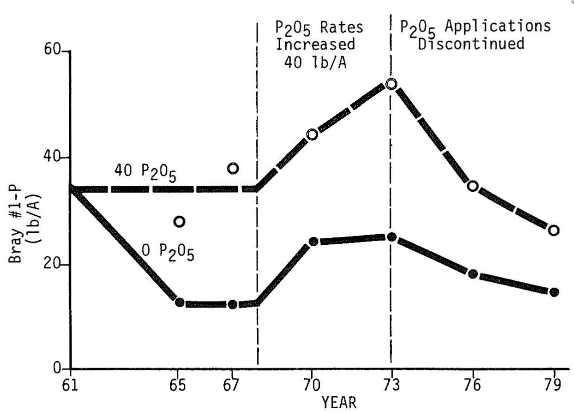

Figure 3. Effect of 13 annual applications of 2 rates of P_2O_5 and 6 subsequent years of no application on residual Bray #1-P in a Ulysses silt loam.

Results: Residual Soil Phosphorus

At the Tribune location, from 1968 through 1973, all P_2O_5 plots were split in half and fertilizer rates increased by 40 lbs/A. Thus, one-half of the O P_2O_5 plots began receiving 40 lbs/A and one-half of the 40 lb plots began receiving 80 lbs P_2O_5/A. Soil P increased on both treatments and by 1973 the 40 lb treatment had increased to 25 lbs/A and the 80 lb treatment to 52 lbs/A (Figure 3). This provides further evidence that the recommended 40 lb P_2O_5 rate was adequate on this soil. The University soil testing service recommends 40 lb P_2O_5 fertilizer to be applied to the former treatment and no more than 20 lbs to the latter.

After 1973, when P_2O_5 applications were discontinued on these two treatments, the soil P levels

declined steadily. The treatment receiving 40 lbs P_2O_5 from 1968-73 decreased to 15 lbs/A by 1979, and the 80 lb plots were below the initial soil test level, down to 26 lbs/A in 1979.

At Garden City in 1973, P_2O_5 applications were discontinued on a series of plots to monitor residual effects of P buildup. Figure 4 shows the changes in soil P over time. There was a general decline on both the 40 and 80 lbs/A P_2O_5 treatments. Within 4 years, the 40 lb treatments had declined to a soil P level essentially equal to that of the continuous O P_2O_5 plots. The 80 lb P_2O_5 treatment declined continually through the remainder of the experiment, and by 1979 it was nearly as low as the initial soil test level.

Based on this information, the evidence supporting the efficiency of applying high rates of P_2O_5 for the purpose of building up soil P was contradictory. At the Tribune location 6 years of annual 80 lb P_2O_5 applications built the soil P to 52 lbs, but within 3 years after P_2O_5 applications were halted, soil P was back to the level of annual 40 lb P_2O_5 applications. This resulted in a total P_2O_5 application of 480 lbs/A for the 80 lb rate but only 360 lbs for the 40 lb rate over the 9 year period. However, on the Richfield soil the residual P lasted much longer where 80 lbs had been applied. Soil P was built to 42 lbs/A in 6 years with this treatment. This residual soil P was able to supply crop needs for 6 additional years before it was depleted to the level of annual 40 lb P_2O_5 applications.

This resulted in equivalent P_2O_5 applications over the 12 year period for these treatments.

Results: Grain Yields

Grain yields from corn grown at the Tribune location, expressed as a percentage of the maximum yield, are shown in Figure 5. Maximum grain yields (averaging over 150 bushels for the 21 year period) were maintained consistently with annual applications of 40 lbs P_2O_5, which did not result in any buildup of P in the soil. However, where no P_2O_5 was applied yields have declined consistently since the initiation of the experiment, even though the soil P has not declined since 1965. This was a reflection of the trend toward higher actual yields (bushels per acre) that has occurred on the 40 P_2O_5 treatment plots over the period of the experiment, while actual yields on the O P_2O_5 plots remained relatively constant.

Where the P_2O_5 application was increased to 80 lbs from 1968-73, there was no increase in grain yield. When 40 lbs P_2O_5 was added to the O treatment, yields increased immediately, and within 2 years were equal to those from plots that received annual applications of 40 lbs P_2O_5. The soil P changes discussed earlier were reflected in the yield responses. When no yield response resulted (80 lb treatment) there was a buildup of soil P resulting from an over-application. But with the 40 lb P_2O_5 treatment there was only a moderate increase in soil P while the yields were increased to the maximum.

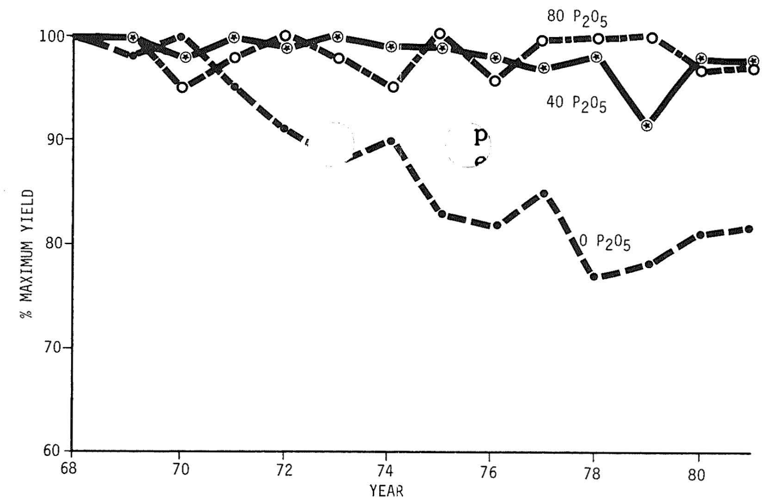

Figure 6. Irrigated corn yield response, expressed as a percent of maximum, to 3 rates of applied P_2O_5 on Richfield silty clay loam.

Corn grain yield response to the annual applications of P_2O_5 on the Richfield soil (Garden City) was similar to that at Tribune (Figure 6). Maximum production was achieved with 40 lbs P_2O_5 in most year, as would be expected from the soil analysis. At no time did the

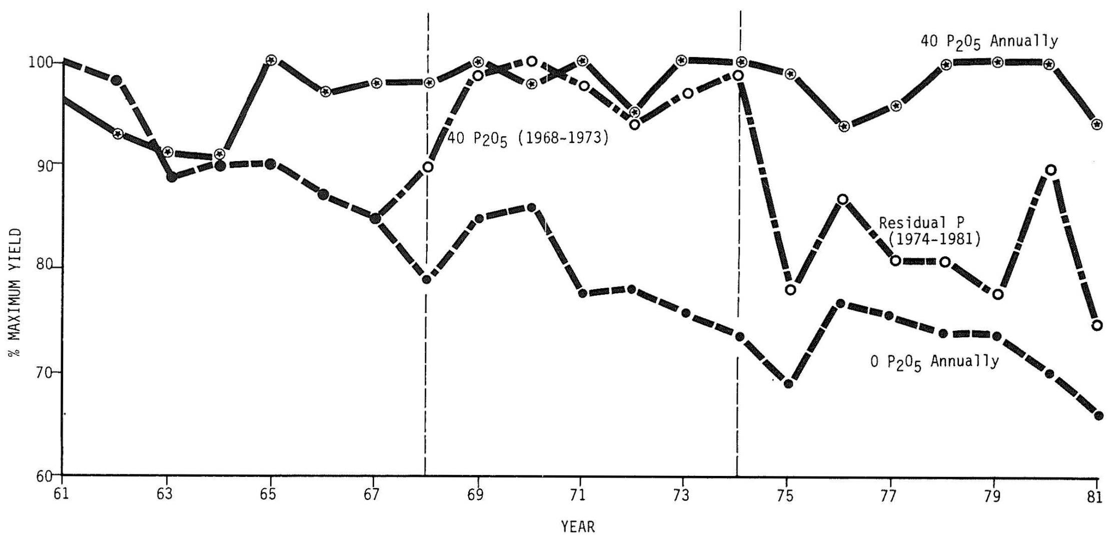

Figure 5. Irrigated corn grain yield response, expressed as a percent of maximum, to 2 rates of applied P_2O_5 on Ulysses silt loam.

80 lb P_2O_5 treatment produce significantly more grain than the 40 lb treatment. This is reflected in the buildup of soil P on the 80 lb plots. Yields of the O P_2O_5 plots continued to decline, relative to the maximum, in response to deficiencies in available soil P.

Conclusions

Phosphorus fertilizer is essential for optimum corn production. However, indiscriminate use of this nutrient may lead to an overly expensive fertilizer program. It pays to monitor the soil P status, so that a fertilizer program can be adjusted to meet plant needs but not allow inefficient soil buildup of the nutrient.

Contribution 83-100-S, Garden City and Tribune Branch
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