Kansas Research

Phosphorous Boosts Long-Term Corn and Sorghum Yields, Reduces Soil Nitrate Carryover

By Alan Schlegel and Kevin Dhuyvetter

A 30-year irrigated corn and grain sorghum study in western Kansas continues to emphasize the importance of phosphorus (P) for irrigated crop production. Phosphorus use has increased yield, increased crop response to nitrogen (N), and diminished nitrate-N accumulation in the soil.

FOR THE PAST 30 YEARS, a study at the Tribune Unit of the Southwest Kansas Research and Extension Center has demonstrated the importance of good fertilization practices in production of continuous irrigated corn and grain sorghum. The corn and grain sorghum plot areas in this study are adjacent (located on a Ulysses silt loam soil) and receive furrow irrigation. Fertilizer treatments include N rates ranging from 0 to 200 lb N/A in 40 lb increments, with and without P at a rate of 40 lb P_2O_5/A.

Over the years, crop responses to added P have continued to increase as soil test P levels have been drawn down by lack of P application. Corn has shown the largest responses to P because of higher average yields.

Phosphorus Differences Increase

Over the years, data from this study have indicated that maximum corn yields were achieved with N application rate of about 160 lb/A. At that optimum N rate, application of P has continued to increase its effect on corn yields (**Figure 1**). With N application rate of 160 lb/A, P produced an average yield increase of 38 bu/A from 1961 to 1991. From 1982 to 1991, P increased yields an average of 57 bu/A and in 1991 P increased yields 117 bu/A for a top yield of 206 bu/A.

Grain sorghum yields in this study have always been lower than corn. Similarly, P effects on yields have also been smaller but still highly significant (**Figure 1**). With N rate of 120 lb/A, 31 years of data indicated an average P yield increase of 15 bu/A. From 1982 to 1991, that effect increased to 24 bu/A and in 1991 P increased sorghum yields 38 bu/A.

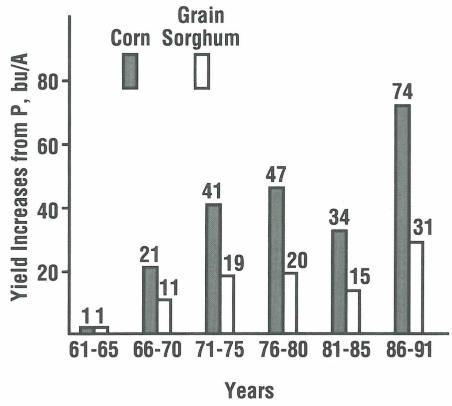

Figure 1. Irrigated corn and grain sorghum yield increases from fertilizer P have increased with time.

Nitrogen and Phosphorus Removal in Soil Test Levels

Amounts of N and P removed in the grain have increased with increasing N and P applications for both corn and grain sorghum. Grain N and P removal was about 50 percent higher for corn than

Dr. Alan Schlegel is with the Southwest Research-Extension Center, Route 1, Box 148, Tribune, KS 67879. Mr. Dhuyvetter is Extension Agricultural Economist-Southwest, 1501 E. Fulton Terrace, Garden City, KS 67846.

grain sorghum, reflecting the higher corn yields. At an optimum N rate of 160 lb/A without added P, corn grain removed about 67 lb N/A in 1990 compared to 104 lb N/A at the same N rate when P was supplied. With N rate of 120 lb N/A, grain sorghum without added P removed only 57 lb N/A; that amount increased to 77 lb N/A with 40 lb P_2O_5.

The effects of proper rates of N application with added P on nitrate accumulation in the soil over a 30-year period are indicated in **Figure 2**. Soil was sampled to a depth of 10 feet and showed a net accumulation of 224 lb nitrate-N/A at a rate of 160 lb N without added P. When P was supplied, the accumulated amount of nitrate-N was only 48 lb/A, emphasizing the improved N use efficiency from P fertilization.

Grain sorghum production resulted in similar soil nitrate-N accumulations with similar P effects. At a rate of 120 lb N/A without P, the 30-year accumulation of nitrate-N to a depth of 10 feet was 193 lb/A; it dropped to only 52 lbs when P was supplied at the same N rate. However,

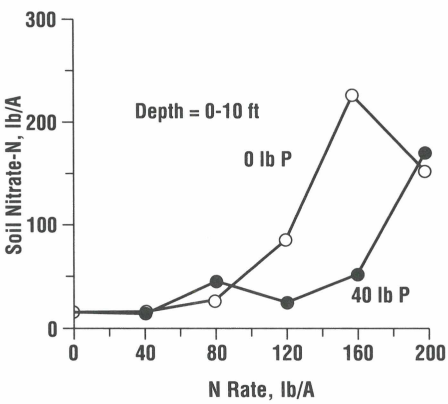

Figure 2. Nitrogen rate and P application effects on nitrate-N accumulation in the soil (corn, Kansas research).

when N was increased to 160 lb/A without P, residual nitrate-N jumped to 750 lb/A; it was only 195 lb/A when P was supplied. Those numbers emphasize the importance of N rate and P application for N use efficiency.

These same plots were sampled in 1973 and a comparison of the data from that

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date versus the 1990 sampling provides an interesting comparison (**Figure 3**). Phosphorus had the same dramatic effect on controlling nitrate-N accumulation and soil nitrate-N levels in the plots receiving 160 lb N plus 40 P_2O_5 actually declined slightly over that 17-year period. Without P, soil nitrate-N accumulations rose about 60 lb/A, which represents only about a 4 lb/A accumulation per year.

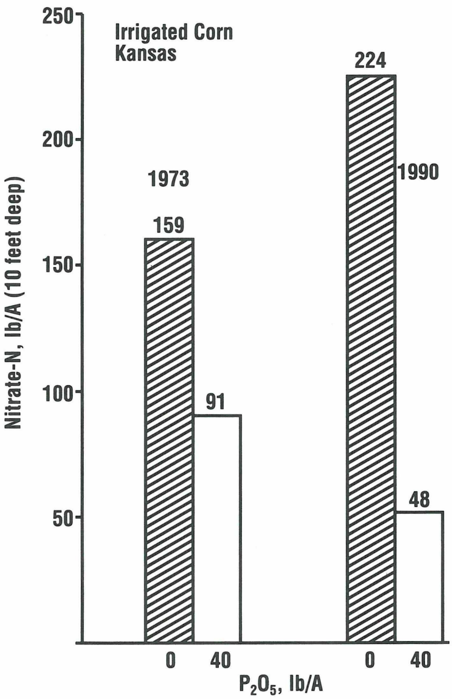


Figure 3. Soil nitrate accumulation to a depth of 10 feet has been dramatically controlled by the use of P fertilizer.

Phosphorus removal and soil test levels make an interesting comparison. In 1990, 160 lb of N without P and a yield of 118 bu of corn per acre removed about 22 lb P_2O_5/A. That constant removal over a 30-year period has caused soil test values to drop significantly from the original level (**Figure 4**). The optimum N rate of 160 lb N/A plus 40 lb P_2O_5 produced a yield of 212 bu/A in 1990 and removed about 51 lb P_2O_5/A in the grain. With an average application of 40 lb P_2O_5/A, P soil tests have been maintained at about an even level (**Figure 4**), slightly lower than the initial soil levels. This might indicate that a slightly higher rate of P application might have been beneficial for crop production even though an additional 40 lb of P_2O_5 early in the study showed no additional yield benefit.

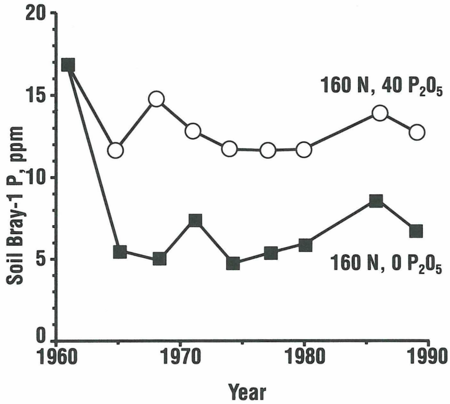


Figure 4. Corn production without application of P resulted in a decline in available soil P and yield losses.

Economic Analysis

This study provides some classic data that tie system profits with environmental protection. The data in **Figure 5** demonstrate clearly that net returns benefited from utilizing the optimum N rate with P.

Note that as yields increased, production costs per bushel dropped and net return (net revenue) increased to a maximum at about 160 lb N/A. To calculate these values, the price of corn was figured at $2.50/bu, N at $0.15/lb and other production costs at $200/A.

Analysis of the sorghum production system yielded essentially the same trends. The optimum N rate for sorghum was about 140 lb N/A with added P for medium and high yielding years and about 120 lb N/A for low yielding years. Applying N in excess of these values resulted in reduced net return and greater soil accumulation of nitrate-N.

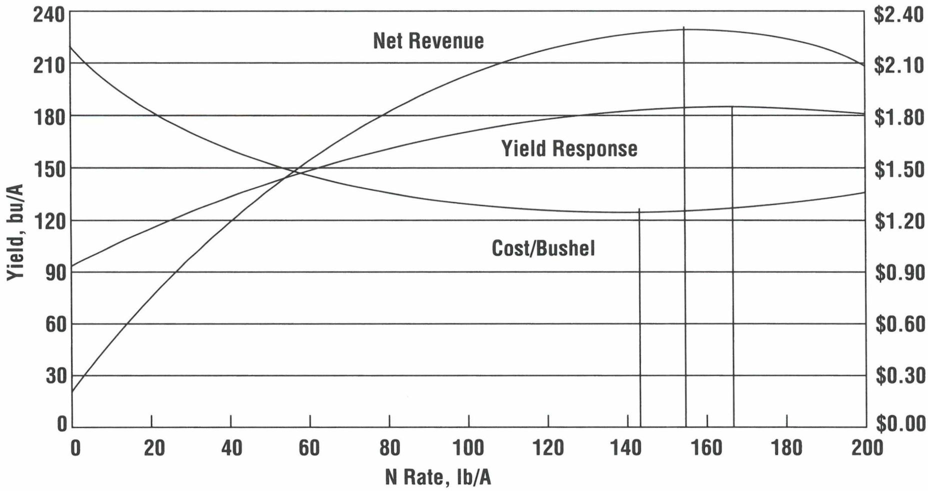
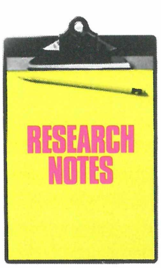


Figure 5. Yields increase, production costs per bushel decline and net returns (net revenue) increase when a production system includes adequate plant nutrients (irrigated corn, Kansas research).

Summary

This study demonstrates the benefits of long-term soil fertility investigations. Yields of irrigated corn in this system have been maintained and increased over the 31-year period of the study. Sorghum yields, however, have not kept pace and have slipped somewhat over the years. Clearly, use of a complete fertility program was able to maximize profit potential while minimizing soil-nitrate N accumulations and decreasing any hazards of potential nitrate leaching. ■



Utah

A Role for Potassium in the Use of Iron by Plants

STUDIES were conducted on iron (Fe) deficient tomato and soybean cultivars. Researchers found that neither species was able to respond to Fe stress in the absence of potassium (K) in growth solution.

The lack of Fe stress response resulted in reduced levels of leaf Fe and greater chlorosis in both species when K was omitted from the growth solution. Solution K was replaced with equal (equimolar) amounts of sodium (Na) and rubidium (Rb), but neither effectively substituted for K. It appears, from this research, that K is essential in evoking the Fe stress response which results in Fe uptake by the plant.

Researchers concluded that K seems to have a specific role in the plant for maximum utilization of Fe. ■

Source: V.D. Jolly, J.C. Brown, M.J. Blaylock and S.D. Camp, Brigham Young University, Provo, UT 84602. Published in Journ. of Plant Nutrition 11(6-11), 1159-1175 (1988).

Note: See *Potash Review,* Subject 4, 5th Suite, No. 5, p.1 (1989), for an abbreviated version of the above article.

Also for further reading: Jolly, V.D. and J.C. Brown, 1985. Iron stress in tomato affected by potassium and renewing nutrient solutions. *Journ. of Plant Nutrition,* 8(6), 527-541.