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Phosphorus and Potassium Fertilization for Corn and Soybean Grown in Rotation for 30 Years

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Abstract
A long-term experiment has been conducted since 1979 at the ISU Northeast Research and Demonstration Farm, Nashua, Iowa, to study the effects of phosphorus (P) and potassium (K) fertilization on soil-test values and grain yield of corn and soybeans grown in rotation.

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Phosphorus and Potassium Fertilization for Corn and Soybean Grown in Rotation for 30 Years

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Introduction

A long-term experiment has been conducted since 1979 at the ISU Northeast Research and Demonstration Farm, Nashua, Iowa, to study the effects of phosphorus (P) and potassium (K) fertilization on soil-test values and grain yield of corn and soybeans grown in rotation.

Materials and Methods

The soil is Kenyon loam, and before applying treatments for the first time in 1979 it tested 28 ppm in P (Bray-1 test) and 170 ppm in K (ammonium-acetate test). Current boundary values for the Optimum class are 16 and 20 ppm P and 161 to 200 ppm K (ISU Extension publication PM-1688). Both crops have been grown each year by alternating them between adjacent trials with identical design and management. Nine annual treatments are the combinations of 0, 46, or 92 lb P_2O_5/acre and 0, 72, or 144 lb K_2O/acre. Two other treatments apply a mixture of 92 lb P_2O_5/acre and 144 lb K_2O/acre once every other year before corn or before soybean. Granulated fertilizers (triple superphosphate and potassium chloride) are broadcast in the fall before tillage. Cornstalks are chisel plowed in the fall, and all plots are disked or field cultivated in spring. Nitrogen rates of 150 to 200 lb N/acre have been applied in the spring to all corn plots.

Results and Discussion

Soil-test results. The P and K treatments have affected soil-test values significantly. During the last two years, soil-test P of plots receiving no P had decreased to 8 ppm (Very Low) from initial 28 ppm on average across the three K application rates. Soil-test K in plots receiving no K decreased to 97 ppm (Very Low class) from initial 170 ppm on average across the three P application rates. In contrast, P fertilization with 46 and 92 lb P_2O_5/acre/year increased soil-test P to 40 and 109 ppm, respectively, and K rates of 72 and 144 lb K_2O/acre/year increased soil-test K to 207 and 382 ppm, respectively. These soil-test changes reflect the nutrient application rates and also nutrient removal with harvest, which is affected by the effect of the fertilizer application on yield and the overall yield levels.

Crop grain yield results. Figure 1 shows corn and soybean grain yield trends over the 35 years of the study for plots that received no K and for plots that received both P and K. The data for fertilized corn are averages for the low and high P or K rates because there were no large or consistent differences between the rates. However, the fertilized data for soybean are for the low P and K rates because the highest rates sometimes decreased soybean yield. The graphs show the large yield variation due to weather. There were very small or no yield increases from P and K fertilization for either crop until about 1996, 17 years after the experiment began. It took all those years for initial soil-test values of the non-fertilized plots to decrease to levels between Low and Optimum, when small, consistent yield increases began to be observed. The grain yield increases became larger over time as soil-test values of non-fertilized plots continued decreasing, and in recent years increases have been 40 to 60 bushels/acre for corn and 10 to 20 bushels/acre for soybean.

Yield averages for 2011 and 2013 (excluding the drought-affected yields in 2012) in Figure 2 show plots that received both P and K yielded more than plots that received either P or K alone. In recent years, the highest P rate (92 lb P_2O_5/acre) has increased corn yield slightly more than the low P rate, but decreased soybean yield compared with the low P rate (46 lb P_2O_5/acre). The highest K rate (144 lb K_2O/acre) has not affected corn yield compared with the low rate (72 lb K_2O/acre), but sometimes has decreased soybean yield compared with the low rate (72 lb K_2O/acre), mainly when no P or the low P rate were applied.

Table 1 shows average annual net returns to investment for P and K fertilizers using current prevailing grain and fertilizer prices. Returns were calculated using the average grain yield responses since 1997, when consistent responses began to be observed for both corn and soybean. The cost of fertilizer was subtracted from the value of additional grain produced in fertilized plots compared with non-fertilized plots. The profitability of fertilization varied greatly with the nutrient rates used. For both crops, the net returns were highest with the low annual P and K rates used. Much lower and even negative returns with the highest fertilizer rates resulted from increased costs for approximately similar corn yields or lower soybean yields.

Another interesting result from this study (not shown) has been that grain yield for treatments that apply a mixture of 92 lb P_2O_5/acre and 144 lb K_2O/acre every other year either before corn or soybean have been similar to yields for treatments that have applied one-half these amounts annually. These results confirm similar results from other experiments at this farm and at other farms, in that the needed P or K rate for two years of a corn-soybean rotation can be applied only once, either before corn or soybean.

Conclusions

This study began with soil testing High in P and Optimum in K. About 17 years were needed to see consistent grain yield responses that would have resulted in economic returns from P and K fertilization. Increasing yield increases since 1996 were explained by decreasing soil-test values of non-fertilized plots into the Low P and K soil-test interpretation classes. Results showed producers may increase the profitability of crop production by using soil testing and applying P and K to low-testing soils. Maintaining soil-test values within the Optimum class does not always result in short-term economic benefits. Definitely, there is no economic justification for applying P or K to high-testing soils.

Table 1. Annualized net returns to P and K fertilizers for average crop yield since 1997.

		K rate (lb K_2O/acre)		
Crop	**P rate**	**0**	**72**	**144**
	lb P_2O_5/a	------- $/acre/year -------		
Corn	0	-	51.66	16.03
	46	20.66	97.49	72.28
	92	24.85	74.51	49.57
Soybean	0	-	34.09	-43.98
	46	-1.19	65.48	7.10
	92	-4.99	31.07	-11.66

Assumed prices: \$4.50/bu corn, \$12.00/bu soybean, \$0.57/lb P_2O_5 (18-46-0) \$0.38/lb K_2O (0-60-0). No application costs were included.

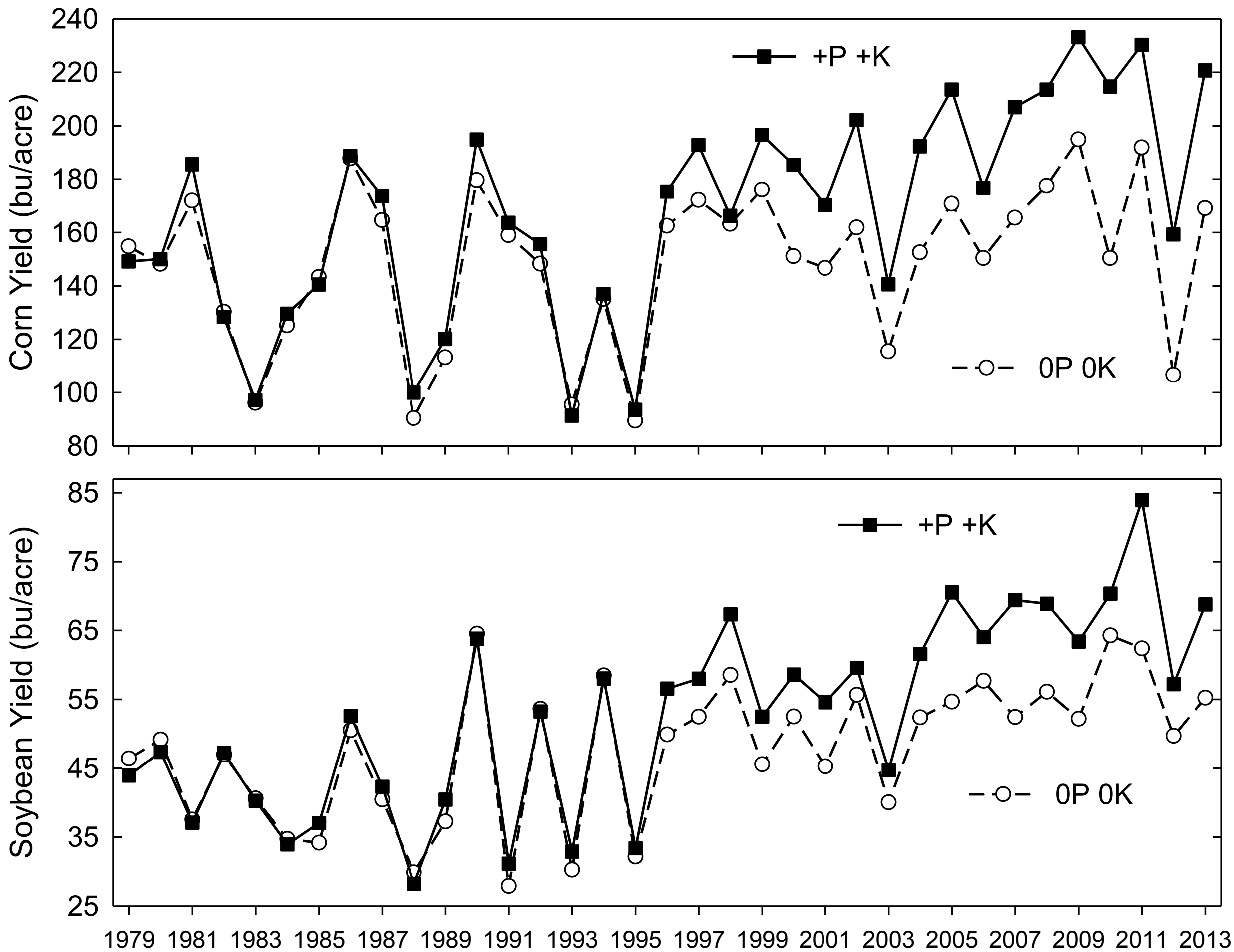

Figure 1. Corn and soybean grain yields and response to P and K across all 35 years of the study. 0P 0K=no P or K applied; +P +K=average all P and K rates for corn and of only the low rates for soybean (the two highest rates sometimes decreased soybean yield).

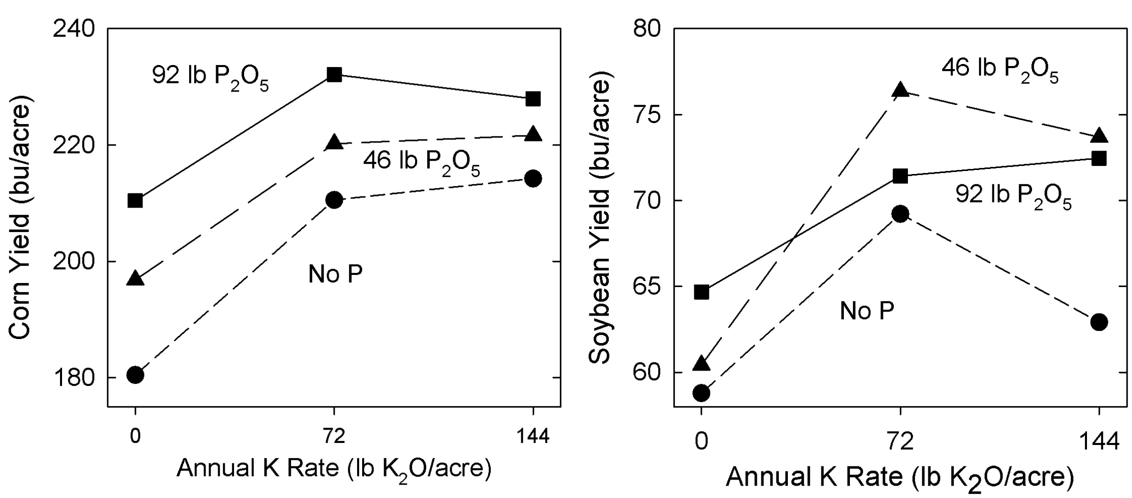

Figure 2. Effect of annual P and K fertilization on average crop yields for 2011 and 2013 (excluded drought-affected 2012).