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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 to study the effects of phosphorus (P) and potassium (K) fertilization on soil-test values and grain yield of corn and soybean grown in rotation. The soil is Kenyon loam, and initially tested High for P (28 ppm, Bray-1 test) and borderline between Optimum and High for K (170 ppm, ammonium-acetate test). Boundary values for the Optimum class are 16 and 20 ppm P and 130 to 170 ppm K (ISU Extension publication PM-1688). Both crops are 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 P2 O5/acre and 0, 72, or 144 lb K2 O/acre. One other treatment applies 92 lb P2 O5/acre and 144 lb K2 O/acre every other year before corn, and another treatment applies similar rates every other year before soybean. Granulated fertilizers (triple superphosphate and potassium chloride) are broadcast in the fall. Corn residues are chisel plowed in the fall, and all plots are disked or field cultivated in spring. Nitrogen rates of 150 to 180 lb N/acre are applied in spring to all corn plots.

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RFR-A9126

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Introduction

A long-term experiment has been conducted since 1979 to study the effects of phosphorus (P) and potassium (K) fertilization on soil-test values and grain yield of corn and soybean grown in rotation. The soil is Kenyon loam, and initially tested High for P (28 ppm, Bray-1 test) and borderline between Optimum and High for K (170 ppm, ammonium-acetate test). Boundary values for the Optimum class are 16 and 20 ppm P and 130 to 170 ppm K (ISU Extension publication PM-1688). Both crops are 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. One other treatment applies 92 lb P_2O_5/acre and 144 lb K_2O/acre every other year before corn, and another treatment applies similar rates every other year before soybean. Granulated fertilizers (triple superphosphate and potassium chloride) are broadcast in the fall. Corn residues are chisel plowed in the fall, and all plots are disked or field cultivated in spring. Nitrogen rates of 150 to 180 lb N/acre are applied in spring to all corn plots.

Results and Discussion

The treatments have affected soil-test values significantly (Table 1). By 2008, soil-test P in plots receiving no P had decreased to a value between the Very Low and Low interpretation classes for the three K application rates. Soil-test K in plots receiving no K decreased to the upper range of the Low class for the three P application rates. However, the effects of the low P or K application rates on soil-test values varied with the rate of the other nutrient. The low P rate increased soil-test P into the Very High class but the increase was less as the K rate increased. The low K rate increased soil-test K by about 40 ppm when no P was applied but did not maintain soil-test K when P was applied (was 10 to 15 ppm lower). Application of the highest P and K rates always increased soil-test values, but increases were higher when the other nutrient was not applied. These trends reflect the nutrient application rates and also nutrient removal with harvest, which is affected by the effect of the fertilizer application on yield.

Summaries in previous reports showed no grain yield response to P and K from 1979 until 1986, occasional small responses until the early 1990s, and consistent economic responses since 1997. Average crop yield results since 1997 (Table 1) show that plots that received both P and K yielded more than plots that received either P or K alone. However, the rates that resulted in the maximum yield have not been affected by the rate of the other nutrient, and were attained by the lower amounts applied. This has been the case even recently, as Figure 2 shows, for averages of the last two years, although overall yields levels have increased significantly. A result shown by Figure 2, which began to be observed recently, is that for soybean the highest annual K rate of 144 lb K_2O/acre has become excessive when P fertilizer has not been applied.

Crop yields for the treatments that have applied 92 lb P_2O_5/acre and 144 lb K_2O/acre every other year before corn or soybean are not shown because they have been similar to

yields for treatments that have applied annually one-half these amounts. These results confirm similar results from other P and K experiments at this farm and at other farms.

Average annual net returns to investment in P and K fertilizer rates are shown in Table 3. Returns were calculated using the average grain yield responses since 1997, when consistent crop responses began to be observed. Prevailing 2009 prices for crops and fertilizers were used. The cost of fertilization was subtracted from the value of additional grain produced in fertilized plots compared with plots receiving no P or K fertilizer. 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 higher fertilizer rates were explained by increased costs for similar or lower yield levels.

Conclusions

This study began with soil testing High in P and borderline between Optimum and High in K. Previous reports showed that 18 years were needed to see grain yield responses that resulted in consistent economic returns from P and K fertilization. Recent results show that producers can increase the profitability of crop production by using soil testing and applying P and K fertilizers only in low-testing soils and to maintain soil-test values within the Optimum interpretation class over time.

Table 1. Effects of P and K fertilization on soil-test values by 2008 and average grain yield since 1997.

P or K Rate		Soil tests		Crop yield	
P_2O_5	K_2O	P	K	Corn	Soybean
lb/acre/year		----- ppm -----		---- bu/acre ----	
0	0	9	83	159	51.0
0	72	9	207	174	56.1
0	144	7	355	173	52.0
46	0	43	80	162	52.8
46	72	36	155	190	61.0
46	144	34	290	191	58.5
92	0	105	85	173	55.2
92	72	81	160	191	60.7
92	144	87	329	191	59.2

Table 2. 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	-	-23.26	-11.36
	46	37.30	65.80	36.92
	92	15.85	51.17	21.80
Soybean	0	-	-17.06	-24.07
	46	28.96	47.22	13.26
	92	-29.57	4.15	-19.12

Assumed prices: $3.80/bu corn, $10.00/bu soybean, $0.38/lb P_2O_5, $0.43/lb K_2O, $4.20/acre application.

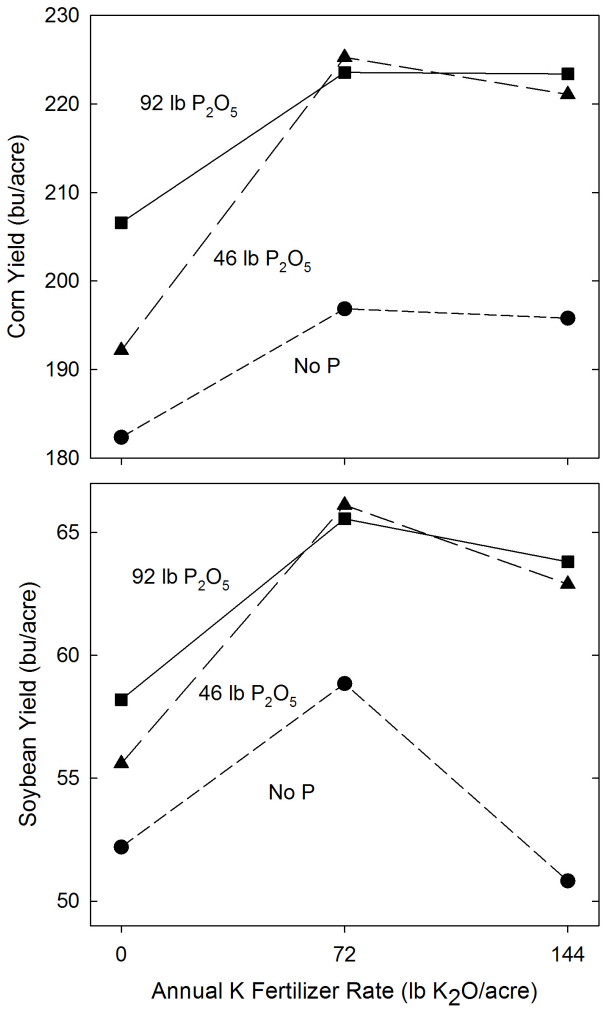

Fig. 2. Effect of annual P and K fertilization on average crop yields for the last two years.