Long-term Phosphorus and Potassium Fertilization Effects on Yields of Corn and Soybean Grown in Rotation

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Introduction

A long-term experiment has been conducted since 1979 at the ISU Northeast Research and Demonstration Farm to evaluate the effects of various combinations of phosphorus (P) and potassium (K) fertilizer rates on soil-test values and grain yield of corn and soybean grown in rotation. In 1979, the soil tested in the high soil-test P and K categories according to ISU interpretations at the time. The predominant soil is Kenyon loam, and soil pH has ranged from 6.2 to 6.8 with no clear trend over the years. Both crops are grown each year by alternating crops between two halves of the experimental area. Annually applied fertilizer treatments are combinations of 0, 46, or 92 lb P_2O_5/acre and 0, 72, or 144 lb K_2O/acre. Two other treatments are applied every other year to corn or soybean at rates of 92 lb P_2O_5/acre and 144 lb K_2O/acre. Fertilizers (granulated triple superphosphate and potassium chloride) are broadcast in the fall. Corn residues are chisel-plowed in the fall, and both corn and soybean residues are field cultivated in spring. Nitrogen rates of 150 to 180 lb N/acre are applied to all corn plots in the spring.

Results and Discussion

Results summarized in previous reports showed no yield increases to any nutrient from 1979 until 1986, occasional small increases until the mid 1990s, and consistent increases since 1997. Table 1 shows average yields for the period 1997–2012 and for the last two years (2013 and 2014). Results for both periods of time show plots that received both P and K fertilizers yielded more than plots that received either P or K alone. With both nutrients being applied, however, the yield of both crops was maximized by the lower annual rates applied (46 lb P_2O_5/acre and 72 lb K_2O/acre). An interesting result that has been observed in recent years is yield of soybean with the highest annual K rate (144 lb K_2O/acre) has often been less than with the low rate, which is reflected in the averages shown.

The data in Table 1 show that with no K, the high P rate was needed to maximize yield of both crops. With no P, however, the low and high K rate produced about the same maximum yield. Figure 1 shows this even more clearly for grain yield averages since 1997. When either K fertilizer rate was applied, however, the low and high rate of either nutrient maximized yield of both crops. These results indicate adequate K supply is needed to optimize P use by the crops, but a P deficiency does not necessarily affect K use efficiency.

Grain 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 with annual applications of one-half these amounts. These results confirm similar results from other experiments at this farm and at other farms.

Large grain yield increases in recent years were expected because the initially high (soil-test P) or optimum (soil-test K) plots that received no P or K decreased significantly over the years. On average for the last two years, soil-test P had decreased

to 10 ppm (low category) and soil-test K had decreased to 100 ppm (very low category). In contrast, the low and high fertilizer application rates increased soil P to about 40 and 100 ppm, respectively, and soil K to about 200 and 300 ppm, respectively.

The low P and K rates applied were planned to maintain the initial soil-test values, but results over the years showed they were higher than needed because they increased values of both nutrients over time. This means grain nutrient concentrations, or yields, or both, had been overestimated. In fall 2013, based on thousands of samples collected from many Iowa fields, Iowa State University reduced the estimates for P and K concentrations in harvested grain needed to estimate removal-based rates for the optimum soil-test category because they were too high (see Extension Publication PM-1688). Similar lower concentrations in grain have been observed in other states. In the fall 2013 update of this publication, boundary soil-test P values for the optimum category were not changed and are 16 to 20 ppm (Bray-1 or Mehlich-3 tests), but those for soil-test K were updated and for dried soil samples are 160 to 200 ppm (ammonium acetate or Mehlich-3 tests).

Average annual economic net returns to investment in various P and K fertilizer combinations are shown in Table 2. The net returns were calculated using the average grain yields observed in the last two years (Table 1). Costs of fertilization were subtracted from the value of additional grain produced in fertilized plots compared with the check plots. The profitability of fertilization varied greatly with the nutrient application rates used. For both crops, net returns were highest with the low annual P and K rates (42 lb P_2O_5/acre and 72 lb K_2O/acre) than with the high rates. Much lower or even negative net returns with the higher fertilizer rates were explained by increased costs for similar or even lower yield levels.

Conclusions

This study began with soil testing high in P and K. Previous reports showed 18 years were needed to see grain yield responses that resulted in consistent economic returns from P and K fertilization. Recent results confirmed 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. Effect of annual P and K fertilization on average corn and soybean yields since 1997 and during the last two years.

Rate (lb/acre)		1997-2012		2013-2014	
P_2O_5	K_2O	Corn	Soybean	Corn	Soybean
		---------- bu/acre ----------			
0	0	158	53	135	54
0	72	177	58	167	57
0	144	173	54	163	49
46	0	170	56	156	55
46	72	192	63	192	67
46	144	193	60	185	63
92	0	177	57	172	56
92	72	193	62	190	63
92	144	194	61	188	61

Table 2. Economic net returns to various combinations of P and K fertilizer rates for average crop yields during the last two years (2013 and 2014).[a]

Corn				Soybean			
P rate	K rate (lb K_2O/acre)			P rate	K rate (lb K_2O/acre)		
lb P_2O_5/acre	0	72	144	lb P_2O_5/acre	0	72	144
	-------- $/acre/year --------				--------- $/acre/year --------		
0	-	94	54	0	-	-7	-101
46	53	165	113	46	-23	73	4
92	91	134	103	92	-32	12	-33

[a]Assumed prices were \$3.80/bu of corn, \$9.50/bu of soybean, \$0.50/lb P_2O_5, \$0.35/lb K_2O, and \$5.00/acre application cost.

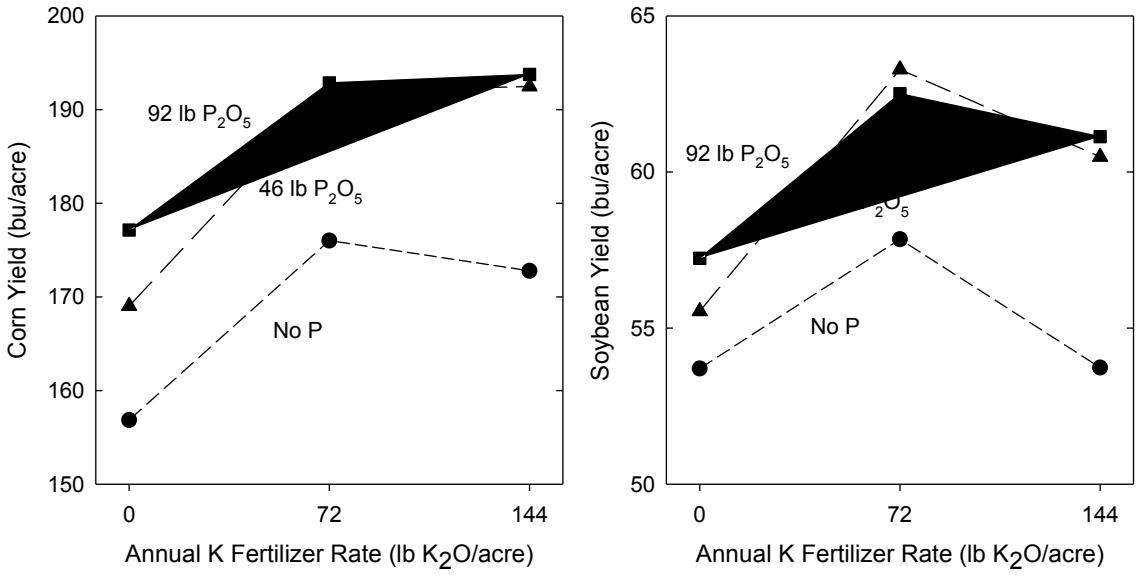

Figure 2. Effect of annual P and K fertilization on average crop yields from 1997 until 2014, Northeast Research Farm, Nashua, IA.