Long-term Phosphorus and Potassium Fertilization Strategies for Corn-Soybean Rotations

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Introduction

A long-term study was established in 1979 to evaluate the effect of various combinations of phosphorus (P) and potassium (K) fertilizer rates on soil-test values and grain yields of corn and soybeans grown in rotation. Both crops are grown each year by alternating crops between two halves of the experimental area. The predominant soil is Kenyon loam, and soil pH is 6.7. Most treatments are applied annually and consist of combinations of 0, 46, or 92 lb P_2O_5/acre and 0, 72, or 144 lb K_2O/acre. Two additional treatments (92 lb P_2O_5/acre and 144 lb K_2O/acre) are applied every other year to corn or soybeans. Granulated fertilizers (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 disked or field cultivated in spring. Anhydrous ammonia is applied in spring only for corn at rates of 150 to 180 lb N/acre.

Results and Discussion

Results summarized in previous reports showed no yield response to any nutrient from 1979 until 1986, occasional very small responses until 1996, and consistent responses since 1997. Table 1 summarizes yield for the last two years (2002 and 2003) and for the last seven years (since 1997). Results for both periods of time show that plots that received both P and K yielded more than plots that received either P or K alone. Corn has been proportionally more responsive than soybeans for both nutrients. However, the highest yield of both crops was attained with the low P and K rates used (46 lb P_2O_5/acre and 72 lb K_2O/acre). A slightly higher corn response (4 to 5 bu/acre) to the highest rates during the last two years was not statistically significant.

Grain yield responses were expected because soil-test values of the check plots had decreased into the Low soil-test P and soil-test K interpretation classes a few years ago. In 1979, when the experiment began, soil-test values were High for P (28 ppm, Bray-1 test) and borderline between Optimum and High for K (170 ppm, ammonium acetate test), according to the recently updated Iowa interpretations. The soil-test decrease in the check plots is the result of the continuous removal of nutrients in grain and of reactions in the soil that reduce the availability of previously applied P and K.

By 2002, annual applications of the low P and K rates increased initial soil-test values into the Very High classes (Table 2). Application of the high annual rates increased soil tests to much higher values. Soil-test P was increased to values greater than three times the initial value. Soil-test K was increased to more than twice the initial value. The low P and K rates applied were estimated to maintain soil-test values, but obviously were excessive because they increased values of both nutrients. Maintenance P and K fertilization is currently recommended for the Optimum interpretation class (16 to 20 ppm of P by the Bray-1 or Mehlich-3 tests and 130 to 170 ppm for K by the ammonium acetate or Mehlich-3 tests).

Evaluation of fertilization benefits should be based on economic returns to fertilization rather than on yield responses. The annual net returns to investment in various P and K fertilizer combinations are shown in Table 3. Returns were calculated using the average responses for the last seven years shown in Table 1. Costs of fertilizer and application were subtracted from the value of the additional grain produced by fertilized plots compared with the check plots. The profitability of fertilization varied markedly with the nutrient rates used. For both crops, net returns were maximized by the low P and K rates (46 lb P_2O_5/acre and 72 lb K_2O/acre). The small additional yield increases with higher rates corresponded with much lower returns. No treatments had offset even the cost of materials until 1996.

Conclusions

The results showed that fertilization does not increase yield and is not profitable in high-testing soils. In this long-term study, which began with soil testing High in P and K, approximately 14 years were needed to see any yield response.

However, about 18 years were needed to see consistent economic returns from fertilization. Producers can increase the profitability of crop production by monitoring their fields with soil testing and applying fertilizers only when needed to maintain soil-test P and K values within the Optimum interpretation class.

Table 1. Effect of annual P and K fertilization on average corn and soybeans yields during the last two years and the last seven years.

Rate (lb/acre)		2002–2003		1997–2003	
P_2O_5	K_2O	Corn	Soybeans	Corn	Soybeans
		---------- bu/acre ----------			
0	0	139	47.3	152	49.3
0	72	155	50.7	165	53.8
0	144	152	47.5	165	51.3
46	0	128	46.7	151	50.3
46	72	162	52.1	176	56.5
46	144	169	52.4	178	55.3
92	0	153	46.8	166	52.3
92	72	171	53.1	179	56.3
92	144	175	52.6	179	56.0

Table 2. Effect of annual P and K fertilization on average soil-test values by 1997 (when consistent responses began to be observed) and 2002.

Rate (lb/acre)	Soil Test Values (ppm)		
P_2O_5	1979	1997	2002
0	28	13	10
46	28	42	45
92	28	93	101
K_2O	1979	1997	2002
0	170	104	99
72	170	207	209
144	170	347	378

Table 3. Economic net returns to various combinations of P and K fertilization during the last responsive seven-year period (1997–2003).[a]

Corn				Soybeans			
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		17.11	8.47	0		8.86	-8.78
46	-16.79	30.82	26.68	46	-8.54	20.02	4.18
92	5.92	26.53	17.89	92	-7.58	7.78	-2.66

[a] Average prices used were $2.25/bu of corn, $6.00/bu of soybeans, $0.24/lb of P_2O_5, $0.12/lb of K_2O, and $3.50/acre application cost for all treatment combinations.