Long-Term Phosphorus and Potassium Fertilization of Corn and Soybean Grown in Rotation

Antonio P. Mallarino, professor
Department of Agronomy
Ken Pecinovsky, farm superintendent

Materials and Methods

A long-term study has been conducted since 1979 to evaluate effects of various combinations of phosphorus (P) and potassium (K) fertilizer rates on soil-test values and grain yield of corn and soybeans grown in rotation. In 1979, the soil tested High for P (28 ppm, Bray-1 test) and borderline between Optimum and High for K (170 ppm, ammonium acetate test). The predominant soil is Kenyon loam and pH has been 6.2 to 6.8. Both crops are grown each year by alternating crops between two halves of the experimental area. Annual treatments consist of combinations of 0, 46, or 92 lb P_2O_5/acre and 0, 72, or 144 lb K_2O/acre. Two other treatments (92 lb P_2O_5/acre and 144 lb K_2O/acre) are applied every other year to corn or soybean. Granulated fertilizers (triple superphosphate and potassium chloride) are broadcast in the fall. Corn residue is chisel plowed in the fall, and both corn and soybean residues are disked or field cultivated in spring. Nitrogen rates of 150 to 180 lb N/acre are applied to all corn plots.

Results and Discussion

Results summarized in previous reports showed no yield response to any nutrient fertilization from 1979 until 1986, occasional small responses until the early 1990s, and more consistent responses since 1997. Table 1 shows average yields for the last two years (2005 and 2006) and for the last 10 years (since 1997). Results for both periods of time show plots that received both P and K fertilizer yielded more than plots that received either P or K alone. However, the highest yield of both crops was attained with the lower annual rates applied (46 lb P_2O_5/acre and 72 lb K_2O/acre). The rate of each nutrient that produced maximum yield did not affect the rate of the other nutrient. An interesting recent result is that the yield of soybeans with the highest annual K rate (144 lb K_2O/acre) has been less than with the low K rate for all P rates. Yields for treatments of 92 lb P_2O_5/acre and 144 lb K_2O/acre every other year to corn or soybean were similar to equivalent annual rates and are not shown.

Grain yield responses were expected because the initially high soil-test values of plots receiving no P or K have decreased markedly over the years (Table 2). Soil-test P decreased into the Low interpretation class by 1997 and to a value intermediate between the Low and Very Low classes by 2005. Soil-test K decreased to the lower part of the Low class by 1997 and since then has remained approximately constant. The soil-test values decrease in the check plots is the result of grain nutrient removal over many years.

Application of the low P and K rates had increased soil-test values into the Very High interpretation classes by 1997 and increased them more since then (Table 2). Application of the high fertilizer rates increased soil-test values to much higher values. The low P and K rates applied were those estimated to maintain the initial soil-test values, but over the years were excessive because they increased values of both nutrients. Iowa State University recommends maintenance P and K rates based on crop removal for the Optimum class (see Extension Publication PM-1688). Boundary values for this class are 16 to 20 ppm P for the Bray-1 test and 130 to 170 ppm K for ammonium acetate test.

Average annual net returns to investment for various P and K fertilizer combinations are shown in Table 3. Returns were calculated using

the average yield responses for the last 10 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 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 are explained by increased costs for similar or even lower yield levels.

Conclusions

The results show that fertilization in high-testing soils does not increase yield and is not profitable. In this study, which began with soil testing High in P and K, approximately 14 years were needed to see any yield response. About 18 years were needed to see consistent economic returns from fertilization. Corn and soybean growers can increase the profitability of crop production by using soil tests and applying fertilizers only in low-testing soils or 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 soybean yield during the last 10 years and the last two years.

Rate (lb/acre)		1997-2006		2005-2006	
P_2O_5	K_2O	Corn	Soybean	Corn	Soybean
		---------- bu/acre ----------			
0	0	153	50.7	154	55.6
0	72	168	54.8	173	58.7
0	144	167	51.7	172	53.1
46	0	155	52.4	169	59.7
46	72	181	59.2	193	67.3
46	144	183	56.6	195	61.0
92	0	169	53.7	173	59.7
92	72	183	58.9	194	66.9
92	144	183	57.4	193	62.3

Table 2. Effect of annual P and K fertilization on average soil-test values by 1997 (when consistent responses began to be observed) and 2005.

Rate (lb/acre)	1979	1997	2005
	Soil-test values (ppm)		
P_2O_5			
0	28	13	8
46	-	42	49
92	-	93	106
K_2O			
0	170	104	119
72	-	207	242
144	-	347	400

Table 3. Economic net returns to various combinations of P and K fertilizer rates for average crop yields during the last 10-year responsive period (1997 to 2006).[a]

Corn				Soybean			
P rate	K rate (K_2O lb/acre)			P rate	K rate (K_2O lb/acre)		
P_2O_5 lb/acre	0	72	144	P_2O_5 lb/acre	0	72	144
	--------- $/acre/year ----------				-------- $/acre/year ----------		
0		25.88	7.76	0		-5.20	-28.44
46	-13.18	49.70	40.58	46	-9.32	15.00	-15.20
92	13.64	40.52	25.40	92	-16.96	-1.92	-25.74

[a]Assumed prices were $3.00/bushel of corn, $5.80/bushel of soybean, $0.33/lb P_2O_5, $0.21/lb K_2O, and $4.00 application cost.