Evaluation of Superphosphate and Rock Phosphate for a Corn-Oat-Forage Rotation

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Introduction

The most commonly used sources of phosphorus (P) fertilizer in Iowa are the water-soluble calcium or ammonium phosphates found in superphosphate, diammonium phosphate (DAP), and dry mixtures. These fertilizers are manufactured by acidifying rock phosphates with sulfuric or phosphoric acid. The characteristics of the rock phosphates vary greatly although the P-containing compounds are calcium or calcium-fluor phosphates of low water solubility. When ground rock phosphate is applied to soils, however, some of the P becomes available for plants because of the acidity of the soil solution and because of various chemical reactions with soil constituents. The solubilization process is slow, but is faster for soils with acid or slightly acid pH. Some rock phosphates of sedimentary origin are more suitable for direct use because the solubilization process is faster. It has been suggested that rock phosphates could be valuable sources of P for maintaining desirable soil-test values for cropping systems that include forage legumes. Furthermore, it could be valuable for producers of specialty crops that may not be fertilized with chemically treated materials.

This study compared the long-term effectiveness of rock phosphate and superphosphate as sources of P for a crop rotation that includes corn, oats, and forage legumes. The experiment was established in 1957 on and the treatments described below were applied until 1994. In 1995, the treatments were changed. This report summarizes information for the first 38-year period of the study.

Methods

The experiment was established in 1957 on a Webster soil. Soil pH of the experimental area varied from 5.8 to 6.6, and soil-test P was very low. Corn, oats, and a forage legume mixture were grown every year by switching areas of the experimental field as needed for the rotation. The legume mixture consisted of alfalfa and red clover, always undersown with oats. Uniform, high rates of potassium were applied to all plots. No nitrogen fertilizer was applied for corn or oats other than a small amount of starter N for corn with some treatments. The treatments were preplant P rates applied as rock phosphate or triple superphosphate, and starter or no starter applied with the planter. All P treatments were applied only for corn. Superphosphate rates equivalent to 0, 46, 92, and 138 lb P_2O_5/acre were plowed in the fall ahead of corn (once every three years for each phase of the rotation).

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Rock phosphate rates equivalent to 276 and 552 lb P_2O_5/acre were plowed in the fall ahead of alternate corn crops (once every six years for each phase of the rotation). The highest superphosphate rate and the lowest rock phosphate rate applied similar amounts of P over a 6-year period. A starter rate of 115 lb/acre of a 5-20-20 dry fertilizer was applied to one-half of every plot where corn was planted. The plot half receiving the starter was switched every time corn was grown (once every three years for each phase of the rotation).

Results

Average crop yields for the 38-year period are shown in Table 1. Use of superphosphate holds a clear advantage over rock phosphate for all crops. Yields for Treatment 2 always were lower than yields for Treatment 6. These treatments apply similar amounts of P over a 6-year period. Even doubling the amount of P applied (Treatment 3 compared with Treatment 6) has not been enough to compensate for the lower efficiency of the rock phosphate. This result could be explained by the only slightly acid soil pH. The efficiency of the rock phosphate usually is higher in acid soils than for neutral, calcareous, or alkaline soils.

Table 1. Effect of rock phosphate, superphosphate, and starter fertilizer on yields of corn, oats, and forage over a 38-year period.†

Treatments applied over a 6-year period‡			Crop yield			
			Corn			
Treatment code	Rock phosphate	Super-phosphate	No starter	Starter	Oats	Hay
	------ lb P_2O_5/acre ------		---------- bu/acre ----------			ton/acre
1	0	0	102	115	52	1.5
2	276	0	117	126	58	2.7
3	552	0	124	131	62	3.2
4	0	92	128	136	64	2.5
5	0	184	134	138	69	3.3
6	0	276	134	140	70	3.8

† The starter was applied and evaluated only for corn.
‡ The rock phosphate treatments were applied once every six years, and superphosphate treatments were applied once every three years for corn only.

Corn responded significantly to the application of starter. The higher responses corresponded to plots that received either low preplant P rates or no preplant P. This result suggests that the P in the mixture accounted for most of the response, although some effects of the N and K cannot be discounted. Over the 38-year period there is a small advantage for the starter plots even at the high P rates. It is noteworthy that this soil was in the very low range for many years before soil P of plots that received the highest rates of preplant P reached soil P levels borderline between the Low and Optimum soil test classes.

It is of interest to consider the responses of corn to preplant and starter fertilizer during recent years, when the yield potential of the hybrids was highest. Table 2 shows average yields of corn

for the period 1989 to 1994.

Table 2. Effect of rock phosphate, superphosphate, and starter fertilizer on average yields of corn during the last years of the study.

Treatments applied over a 6-year period			Period 1989-1994		Years 1990, 1992, and 1994	
Treatment	Rock	Super	No starter	Starter	No starter	Starter
	------ lb P_2O_5/acre ------		---------- bu/acre --------		---------- bu/acre --------	
1	0	0	118	123	159	167
2	276	0	124	123	169	171
3	552	0	133	135	184	183
4	0	92	133	138	181	187
5	0	184	137	137	181	188
6	0	276	138	138	185	186

Table 2 also shows corn yields for the 1990, 1992, and 1994 growing seasons, when yield levels were high. Deficient moisture limited yields in 1989, and both cold spring weather and excess moisture limited yields markedly in the 1991 and 1993 growing seasons. The corn responses to the treatments during recent years followed similar trends in high-yielding years or low-yielding years. In contrast to results for the 38-year period, the starter had essentially no effect on corn yields at the highest rates of preplant P. This result is reasonable because soil P of plots receiving the high rates of preplant P had reached soil P levels near the Optimum soil-test class.

Conclusions

Rock phosphate could be used to maintain optimum soil P levels in these soils, but it would not be suitable in low testing soils. Starter fertilization is quite effective when soil P is low and additional P is needed but is not cost effective when soil P is high or when high preplant P rates are applied.