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Crop and Soil Responses to Rates of Lime

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Abstract
Grain producers in Iowa are interested in the effects of liming rates on crops and soils. It has been well known for many years that rotations including alfalfa must be limed to a pH of 6.9. This experiment was designed to determine the best pH for a corn-soybean rotation in this area and if there are any detrimental effects on crops when soils are underlimed or overlimed.

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Introduction

Grain producers in Iowa are interested in the effects of liming rates on crops and soils. It has been well known for many years that rotations including alfalfa must be limed to a pH of 6.9. This experiment was designed to determine the best pH for a corn-soybean rotation in this area and if there are any detrimental effects on crops when soils are underlimed or overlimed.

Materials and Methods

Corn and soybean crops are grown in alternate years on a Kenyon soil that had an initial soil pH of 5.5. Agricultural limestone from a local quarry was broadcast by hand and incorporated in May 1984 at rates of 0, 1,000, 2,000, 4,000, 8,000, 12,000 and 16,000 lb effective calcium carbonate equivalent (ECCE) per acre. In October 2003 after corn harvest, soil samples were collected to a depth of 6 in. in each plot and analyzed to determine soil acidity (pH), available phosphorus (P), and exchangeable cations (calcium–Ca, magnesium–Mg, potassium–K, and sodium–Na). Cation exchange capacity (CEC) was determined by summation of the calculated milliequivalent (meq) contents of Ca, Mg, K, Na, and hydrogen (H). The meqs of H were determined from lime requirement pHs using the following equation:

$$H_{meq} = 12 \times (7 - pH_{\text{lime requirement}})$$

Results and Discussion

Soils. Soil-test results from 2003 samples are shown in Table 1. The values are averages of four replications of each lime rate. Where no liming occurred, soil acidity declined to 5.1 from the initial 5.5 pH. As liming rates increased, soil acidity decline (pH increased) with the greatest increases occurring at the greatest rates. Available P and K values tended to be higher at soil pHs at or greater than 6.5. Mehlich 3 soil solution was used to determine available P and K as it is effective over the broad pH range encountered in this study. Neutral 1.0 normal ammonium acetate was used to extract exchangeable Ca, Mg, and Na contents. Both extractable Ca and Mg increased with lime rate. This is reflective of the dolomite lime applied in 1984. Soil cation exchange capacity of the soil increased with decreasing acidity. This is contrary to the result last reported, which was determined by summation of bases extracted with the acidic Mehlich 3 solution. By using neutral ammonium acetate, acidic dissolution of cations was avoided and CEC was more accurately measured.

Crops. Previous grain yield averages and 2003 corn and 2004 soybeans results are shown in Table 2. These data show that both crops have responded to liming. The long-term averages show that corn yields increased as liming rates increased. The long-term yield increase was surpassed in 2003 even though severe drought conditions prevailed. This suggests that managing soil acidity by liming maximizes a corn crop's yield under stress. Soybean grain moisture content and yields were generally greatest at 4,000 to 6,000-lb ECCE rates, which have yielded soil pHs of 5.7 to 6.3. Based on these data, row crop producers in northeast Iowa should test the soil and lime it to achieve a pH no greater than 6.5. Because maximum soybean yields were achieved at less than 6.5 pH, producers should lime after the soybean harvest. This will ensure that less acidity is present for the corn crop. A corn crop fertilized with nitrogen (N) fertilizer will consume 185 lb of ECCE per 100 lb of N applied. Thus, soil acidity will increase for the following soybean crop.

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Table 1. Soil test responses to lime application rates.

				Cation content						Cation saturation of CEC					
ECCE	pH	P	K	Ca	Mg	K	Na	H	CEC	Ca	Mg	K	Na	H	Ca:Mg
lb/ac		ppm		milliequivalents per 100 grams						percent					
0	5.25	19.1	112	7.6	1.6	0.2	0.8	5.4	15.5	48.9	10.1	1.0	5.1	34.8	4.83
1000	5.38	18.1	126	8.1	1.7	0.2	0.8	5.4	16.2	50.2	10.5	1.1	5.1	33.1	4.77
2000	5.48	15.7	119	8.5	1.8	0.2	0.8	3.3	14.6	58.3	12.5	1.1	5.6	22.5	4.66
4000	5.71	21.7	145	9.7	2.2	0.2	0.9	2.1	15.2	64.2	14.4	1.4	6.2	13.8	4.46
6000	6.28	16.2	114	10.3	2.4	0.2	0.9	0.0	13.8	74.5	17.7	1.2	6.7	0.0	4.21
8000	6.49	22.2	121	10.9	2.6	0.2	0.7	0.0	14.4	75.5	18.1	1.2	5.2	0.0	4.18
12000	6.84	29.2	126	11.5	2.8	0.2	0.8	0.0	15.3	75.1	18.3	1.2	5.4	0.0	4.10
16000	7.18	31.5	123	12.3	3.0	0.2	0.8	0.0	16.2	75.5	18.3	1.1	5.1	0.0	4.12

Table 2. Crop response to rate of limestone applications.

		2003 harvest						2004 harvest	
ECCE	95-01 avg	Yield	Moisture	Protein	Oil	Starch	94-02 Avg	Yield	Moisture
lb/ac	bushels/ac			percent			bushels/ac		percent
			Corn					Soybeans	
0	153	129	14.8	8.2	3.7	59.2	52.3	59.6	10.4
1,000	154	125	14.7	8.3	3.7	59.3	54.7	60.1	10.5
2,000	155	128	14.7	8.3	3.6	59.3	55.0	61.7	10.5
4,000	158	128	14.5	8.3	3.6	59.2	58.0	61.3	10.5
6,000	156	134	14.7	8.1	3.7	59.5	58.1	62.0	10.5
8,000	157	139	14.6	8.5	3.6	59.2	57.4	61.3	10.4
12,000	159	138	14.8	8.1	3.6	59.7	56.9	60.5	10.5