Crop and Soil Responses to Rates of Lime

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Introduction

Soil pH is one of the most important soil characteristics of crop production. The pH is the negative logarithm of the hydrogen ion activity of a soil. For each unit increase in pH, there is a 10 times change in acidity. A pH of 5 is 10 times more acid than a pH of 6, and 100 times more acid than a pH of 7. A soil pH greater than 7 is called alkaline or basic. A soil pH less than 7 is called acidic.

Limestone applications are recommended to raise soil pH when soil test results show that the pH is too acidic for optimum crop production. Iowa State University (ISU) Extension provides limestone recommendations for Iowa soils in publication PM-1688, A General Guide for Crop Nutrient and Limestone Recommendations in Iowa. Limestone recommendations are given for corn, soybean, alfalfa and pasture when soil pH falls below 6.5, 6.5, 6.9, and 6.0, respectively.

Certain soils in Iowa are naturally acidic while others acidify over time from environmental and crop production influences. Other soils in Iowa are naturally alkaline and may never require lime. The availability and uptake of essential plant elements is influenced by soil pH. Acid soils can reduce the availability of calcium (Ca), magnesium (Mg), and potassium (K), and with further acidity reduce the availability of other elements (Figure 1). Alkaline soils can reduce the availability of phosphorous (P), boron (B), iron (Fe), manganese (Mn), and other elements. For example, Fe chlorosis is a notable problem in soybean production on the highly alkaline (calcareous) soils of central Iowa.

This long-term trial was designed to determine the effects of limestone applications on soil pH for a corn-soybean rotation that was either under-limed, adequately, or over-limed according to ISU recommendations.

Materials and Methods

A corn-soybean rotation was grown on a Kenyon loam soil at the ISU Northeast Research Farm, Nashua, Iowa. The soil pH was 5.5 at the start of the trial. At that time, a one-time application of limestone from a local quarry was applied at rates of 0, 1,000, 2,000, 4,000, 8,000, 12,000, and 16,000 pounds of effective calcium carbonate equivalent (ECCE) per acre. Tillage followed the lime applications. The trial was designed as a randomized complete block with four replications. Individual plots were 1,000 square ft.

At pollination, six corn leaves were collected in each plot. These were dried, ground, and analyzed for concentrations of nitrogen (N), P, K, Ca, Mg, and zinc (Zn). After corn harvest in early November, soil samples were collected to a depth of six in. in each plot and analyzed to determine soil pH, available P, and exchangeable K, Ca, Mg, and Zn. Phosphorous was analyzed by both the Bray P1 and Olsen tests. These plant and soil test results were through 2009.

Results and Discussion

Soils. Soil test results and corn leaf analysis from the 2009 samples are provided in Table 1. Where no limestone applications were made, the soil acidity declined only slightly from an initial 5.5 pH. As limestone rates were increased, soil pH increased. Soil available P increased with increases in soil pH for both P soil test methods. Soil Ca and Mg increased and H ion concentration decreased with increased limestone application rates. Soil test K and Zn remained constant at all soil pH levels. Corn leaf concentrations of P, Ca, and Mg increased with increased soil test levels affected by increased limestone applications. Corn leaf concentration of N, K, and Zn did not change with increased limestone rates.

Crops. The average corn and soybean yield responses for the last 20 years are provided in Table 2. Increased soil pH improved grain yields for both crops. Increased soil pH also shortened time to corn pollination by as much as two days and lowered corn grain moisture at harvest by nearly 1 percent. Achieving the lowest possible grain moisture content at harvest reduces drying costs. Soybean grain moisture is generally unaffected by soil acidity, but grain yields improved as pH levels rose to recommended levels. Based on these results, soil testing should be a standard practice by producers to determine soil pH and make appropriate adjustments, if needed, through limestone applications. This also will increase fertilizer use efficiency by improving nutrient availability to the plants, thus maximizing yield.

Figure 1. General relationship between soil pH and availability of plant nutrients. The wider the bar, the more available the nutrient (Foth, Henry D., *Fundamentals of Soil Science*, 6th edition).

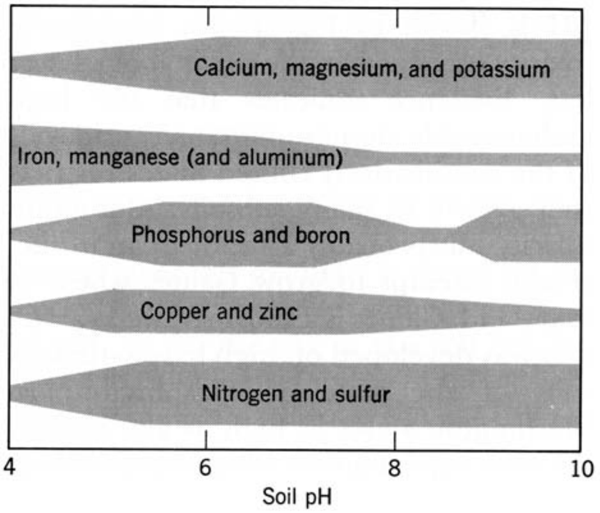

Table 1. Post-harvest soil test results and percent elements in corn leaves at R1 stage from lime applications in 2009.

ECCE	pH	Bray1 P	Olsen P	Ca	Mg	P	Ca	K	Mg
lbs/ac		---------------------- soil, ppm ----------------------				-------------------- leaf, % ---------------------			
0	5.18	33.2	7.0	1,165	187	0.26	0.30	1.41	0.20
1,000	5.34	35.1	7.3	1,233	204	0.27	0.31	1.45	0.20
2,000	5.37	32.9	6.9	1,423	232	0.27	0.31	1.47	0.21
4,000	5.57	29.7	6.6	1,543	253	0.27	0.33	1.44	0.22
6,000	5.93	28.6	6.3	1,633	281	0.28	0.33	1.48	0.24
8,000	6.15	27.9	7.6	1,743	307	0.27	0.32	1.48	0.23
12,000	6.38	35.6	9.5	1,870	342	0.28	0.34	1.46	0.25
16,000	6.93	37.0	11.0	1,988	368	0.29	0.34	1.45	0.25

Table 2. Average 20-year response of corn and soybean to rates of lime after initial lime applications in 1984.*

ECCE	Corn pollination date	Corn harvest moisture, %	Corn yield, bu/ac	Soybean yield, bu/ac
lb/ac	-- 1995 to 2014 ---			
0	7/20	21.4 a	179.1 a	56.2 a
1,000	7/20	21.4 a	179.8 a	57.5 ab
2,000	7/19	21.3 ab	180.9 a	58.0 b
4,000	7/19	21.1 abc	184.4 ab	60.2 c
6,000	7/19	20.9 bcd	187.0 bc	60.1 c
8,000	7/18	20.8 cd	189.8 bc	60.3 c
12,000	7/18	20.7 cd	190.3 c	60.1 c
16,000	7/18	20.6 d	191.7 c	59.5 bc
LSD $_{0.05}$		0.5	5.8	1.7

*Means within a column followed by the same letter do not differ ($P \leq 0.05$).