Evaluation of the Efficiency of Aglime and Pelleted Aglime in a Northwest Iowa Acid Soil

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Introduction

The effectiveness of a liming material for neutralizing soil acidity depends mainly on its calcium carbonate ($CaCO_3$) equivalent (CCE) and its fineness. The Iowa Department of Agriculture and Land Stewardship (IDALS) rules for agricultural lime (aglime) sales requires measuring Effective CCE (ECCE), which combines CCE and fineness efficiency estimates. Use of pelleted finely ground limestone has increased in recent years, but scarce field research has studies how ECCE evaluates the granulation effect on its acid-neutralizing capacity and its efficiency compared with aglime. Therefore, a study was conducted at this farm during 2015 and 2016 to compare the effectiveness of finely ground pure calcium carbonate ($CaCO_3$), calcitic aglime, and pelleted calcitic aglime at increasing soil pH and crop yield.

Materials and Methods

A two-year trial was conducted on a Galva silty clay loam soil. Soil pH, organic matter, calcium (Ca), magnesium (Mg), and sodium (Na) were 5.3, 5.0 percent, 2,684 ppm, 518 ppm, and 25 ppm, respectively. Uniform and non-limiting rates of phosphorus, potassium, sulfur, and micronutrient fertilizers were applied. Treatments replicated three times were commercial sources of finely ground calcium carbonate, calcitic aglime, and pelleted calcitic aglime applied at four rates plus a non-limed control. The CCE and ECCE of the lime sources were analyzed as required by IDALS, and Table 1 shows the results. The lime sources were applied at rates of 0, 1, 2, 4, and 8 ton CCE/acre to plots 7.5 ft by 12 ft. As lime sources analyses indicate, the CCE was similar for all three sources but ECCE was lower for the aglime. The treatments were broadcast October 16, 2014, and were incorporated by light disking October 22 after light rain occurred. The plots were disked again the day before planting corn (Dekalb 5792) April 29, 2015. The cornstalks were not tilled, and soybean (Asgrow 2136) was no-till planted in spring 2016. Soil samples (6-in. depth) to measure pH were taken in March, June, October, and December 2015, and in March and September 2016. Grain was harvested from a central area of each plot and yield was adjusted to 15.5 percent moisture for corn and 13 percent moisture for soybean.

Results and Discussion

Crop yield response. There was a yield increase from liming in both years of the study, but increases were statistically similar for the three sources (Table 2). On average across the three sources, the lowest rate increased yield only slightly (by 3.4 and 1.5 bu/acre of corn and soybean, respectively). The higher three application rates increased yield further, but there were no statistical differences between each other, and the increases were 11.3 bushels/acre for corn and 2.6 bushels/acre for soybean. Therefore, a CCE rate of 2 ton/acre by all sources maximized yield, which corresponded to 1.23, 1.99, and 1.97 ton ECCE/acre for aglime, calcium carbonate, and pelleted lime, respectively. The yield response to lime in this very acid soil is not surprising. Other research has shown the optimum pH for corn and soybean in this region of the state is pH 6.0.

The ISU liming guidelines are in extension publication PM 1688.

Soil pH increases from liming. Figure 1 shows soil pH for the different liming sources and application rates for several sampling dates during a period of 23 months. The largest pH increase was observed five months after the materials' application (the first sampling date). Further increases over time by the different rates of the three sources were highly variable. Differences between the three replicates did not always explain pH variables over time or variable differences between rates of a liming source. The maximum pH level was reached with most sources and rates between 12 and 17 months after application, and a levelling off or decrease was observed by the last sampling date 23 months after the application. The pH increases were smaller and more delayed for aglime than for the other two sources. The pH of the unlimed control plots showed an increasing trend until the 12-month sampling date, but then decreased, which probably was a seasonal effect.

Figure 2 summarizes soil pH responses to lime application for the earliest sampling date (5 months after lime application) and the average of the sampling dates 12 to 17 months after application, when most sources and rates reached maximum pH. For each of these two periods, graphs show the pH responses by expressing the application rates as amounts of CCE/acre or ECCE/acre. The lime sources analyses in Table 1 and the graphs in Figure 2 show the unit used to express the application rate did not make much of a difference for pelleted lime because its ECCE was very high and about the same as calcium carbonate. However, the ECCE application rates were much smaller for aglime because, as is commonly the case, its ECCE was lower.

Graphs A and B in Figure 2 have application rates expressed as CCE/acre and show little or no difference between calcium carbonate and pelleted lime for either time period. The pH increase for aglime was the smallest in both periods, but the difference was greater five months after the application (Fig. 2A) than 12 to 17 months later (Fig. 2B), confirming a slower reaction. Graphs C and D in Figure 2 have application rates expressed as ECCE/acre and show much smaller differences between aglime and the other two sources five months after application (graph C), but little or no difference for the later dates (graph D). This result indicates the ECCE measurement considerably over-estimated the acid-neutralizing capacity of aglime 5 to 8 months after application, but not much after 12 months or later. On the other hand, the ECCE measurement correctly assessed the high neutralizing value of pelleted lime.

Pelleted lime and pure calcium carbonate increased soil pH similarly, and faster than aglime. The effectiveness of aglime increased over time, and one year after the application or later, the difference with the other sources was very small. In spite of lower early pH increases by aglime, all three lime sources were similar at increasing crop yield in both years of the study.

Acknowledgements

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Table 1. Characteristics of three liming materials used in the study.

Lime source	Moisture	CCE†	ECCE‡	Ca	Mg	Passing through screen sizes 4	8	60
	-------	-------	%	-------	-------			
$CaCO_3$	0.07	92.5	92.0	37.1	0.1	100	100	100
Aglime	6.50	91.4	56.2	36.8	0.2	100	99	37
Pelleted lime	0.45	90.1	88.6	36.8	0.2	100	100	97

† CCE, $CaCO_3$ equivalent. ‡ ECCE, effective CCE calculated as required by IDALS.

Table 2. Effect of lime source and application rate on crop yield.

	Application rate		Crop yield	
Source	**CCE**	**ECCE**	**Corn**	**Soybean**
	---- ton/acre ----		------- bu/acre -------	
Control	0	0	214	57.2
Aglime	1	0.61	217	59.1
	2	1.23	226	61.4
	4	2.46	230	62.2
	8	4.92	226	61.5
Calcium carbonate	1	0.99	218	58.4
	2	1.99	230	60.1
	4	3.98	232	61.3
	8	7.96	229	59.7
Pelleted lime	1	0.98	218	58.6
	2	1.97	227	61.5
	4	3.93	231	62.6
	8	7.87	230	61.9

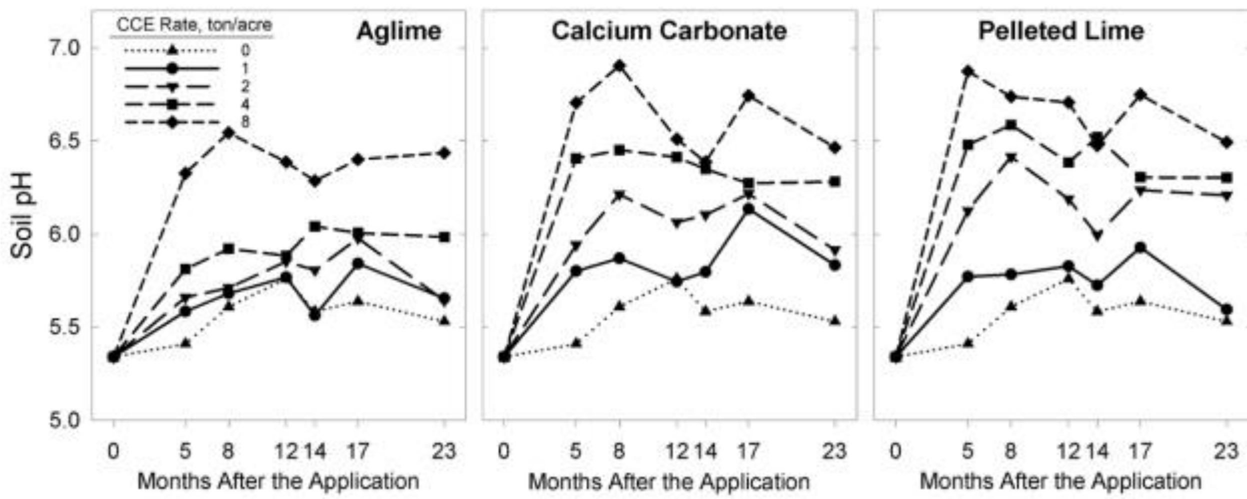

Figure 1. Effect of several calcium carbonate equivalent (CCE) application rates with three lime sources on soil pH over a 23-month period.

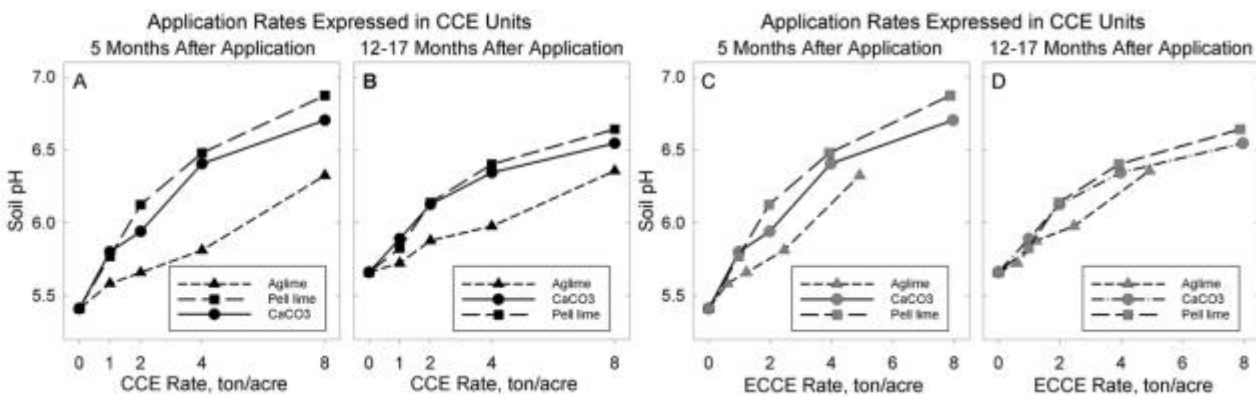

Figure 2. Soil pH at two times after applying three lime sources with the rates expressed as CCE or ECCE.