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

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Introduction

The capacity 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 studied 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 Marshall silty clay loam soil. Soil pH, organic matter, calcium (Ca), magnesium (Mg), and sodium (Na) were 5.1, 4,1 percent, 1,822 ppm, 337 ppm, and 19 ppm, respectively. Uniform and non-limiting rates of phosphorus, potassium, sulfur, and micronutrients 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 8, 2014, and were incorporated by light disking October 22 after light rain occurred. The plots were disked again the day before planting corn (Wyffels 5138RIB) May 1, 2015. The cornstalks were not tilled, and soybean (Pioneer P25T51R) 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 grain 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 application rate of 1 ton CCE/acre increased first-year corn yield by 6.9 bushels/acre over the unlimed control, and increased second-year soybean yield by 8.0 bushels/acre. The 2-ton application rate seemed to have increased corn yield more, but the small additional increase (5.8 bu/acre) was not statistically significant. Therefore, a CCE rate of 1 ton/acre by all sources maximized yield. This rate corresponded to 0.61, 0.99, and 0.98 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 variable with the characteristic fluctuation mainly due to rainfall. The maximum pH level was reached with most sources and rates between 12 and 17 months after application. The pH increases were smaller and more delayed for aglime than for the other two sources. Mostly pH decreases occurred between the sampling dates 17 and 23 months after the application, including for the unlimed control treatment.

Figure 2 summarizes soil pH responses to lime application for the earliest sampling date (5 months after lime application) and the average for the sampling dates 12 to 17 months of 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 that of calcium carbonate. However, the ECCE application rates for aglime were much smaller because, as is commonly the case, its ECCE was lower. Graphs A and B in Fig. 2 have application rates expressed as CCE/acre and show 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 much greater five months after the application (Fig. 2A) than 12 to 17 months later (Fig. 2B), which confirms a slower reaction. Graphs C and D in Figure 2 have application rates expressed as ECCE/acre and show a large difference between aglime and the other two sources five months after application (Graph C), but a small difference for the later sampling dates when a plateau was reached (Graph D). This result, and those in Figure 1, indicate the ECCE measurement considerably over-estimated the acid neutralizing capacity of aglime in the short term (5 to 8 months after the application), but not much after 12 months or later. On the other hand, the results clearly showed 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	56.2
Aglime	1	0.61	222	62.6
	2	1.23	225	62.6
	4	2.46	221	65.6
	8	4.92	230	62.2
Calcium carbonate	1	0.99	220	65.8
	2	1.99	225	63.3
	4	3.98	229	63.3
	8	7.96	229	64.4
Pelleted lime	1	0.98	221	64.0
	2	1.97	231	61.1
	4	3.93	226	61.8
	8	7.87	228	61.8

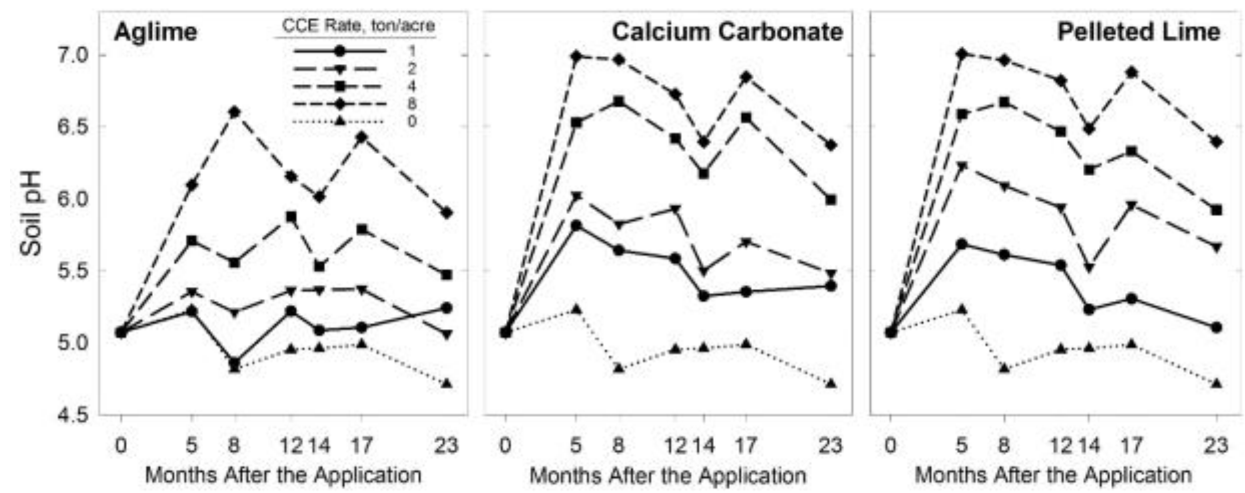

Figure 1. Effect of several calcium carbonate equivalent (CCE) application rates with three lime sources on soil pH over a 23-month period.

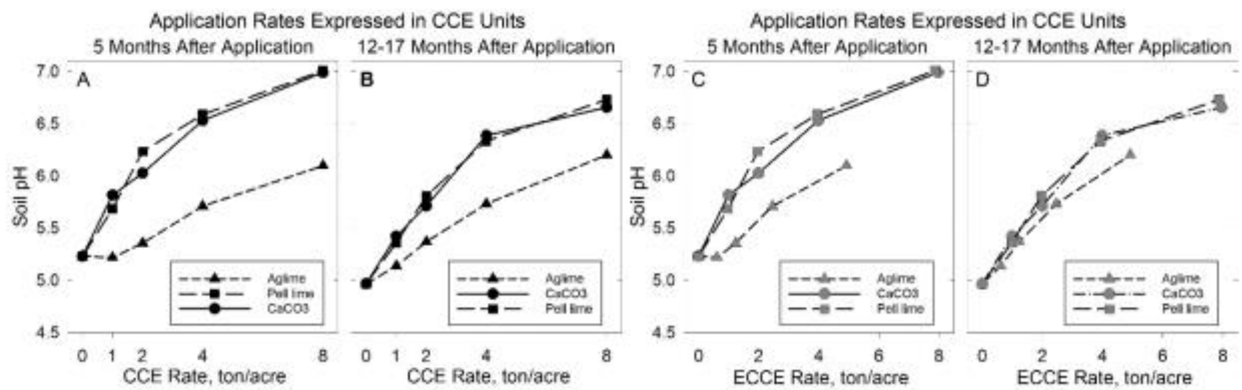

Figure 2. Soil pH at two times after applying three lime sources with the rates expressed as CCE or ECCE.