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

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Antonio Mallarino, professor
Mazhar Haq, assistant scientist
Department of Agronomy
Myron Rees, farm superintendent

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 evaluated 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 in 2015 and 2016 to evaluate the effectiveness of calcitic aglime and pelleted calcitic aglime at increasing soil pH and crop yield compared with finely ground pure calcium carbonate ($CaCO_3$).

Materials and Methods

A two-year trial was conducted on a Nira silty clay loam soil. Soil pH, organic matter, calcium (Ca), magnesium (Mg), and sodium (Na) were 5.6, 4.9 percent, 2,512 ppm, 429 ppm, and 19 ppm, respectively. Uniform and non-limiting rates of phosphorus, potassium, sulfur, and micronutrients fertilizers were applied. Treatments replicated three times were four rates of finely ground calcium carbonate and calcitic or pelleted calcitic aglime plus a non-limed control. The CCE and ECCE of the materials 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 6, 2014, and were incorporated by light disking October 22 after light rain had occurred. The plots were disked again the day before planting corn (Pioneer 1365AMX) May 19, 2015. The cornstalks were not tilled, and soybean (Pioneer P24T93R) 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 were large grain yield increases from liming, 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 25.3 bushels/acre over the unlimed control, and increased second-year soybean yield by 2.4 bushels/acre. The additional yield increase by applying the 2-ton CCE rate was much smaller for corn (8.1 bu/acre), but was larger for soybean (4.2 bu/acre). The higher application rates did not impact yield in a statistically significant trend. Therefore, a CCE rate of 2 ton/acre by all sources maximized yield of both crops. The 2 ton ECCE rate corresponded to 1.23, 1.99, and 1.97 ton ECCE/acre for aglime, calcium carbonate, and pelleted lime, respectively. Other research has shown the optimum pH for corn and soybean in this region of the state is pH 6.5. 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). The only exception to this was for the two lowest aglime application rates, when maximum pH was reached one year after application (third sampling date). Thereafter, pH remained approximately constant or decreased slightly until 14 to 17 months after application, but for most treatments, including the unlimed control, a sharper decrease was observed for the last sampling date (23 months after application). The pH increases from all application rates of aglime were smaller and more delayed than for the other sources.

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 after application. 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 difference for pelleted lime, because its ECCE was very high and similar to 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 Figure 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 maximum pH 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.

Conclusions

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.

						Passing through screen sizes		
Lime Source	**Moisture**	**CCE†**	**ECCE ‡**	**Ca**	**Mg**	**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/ac ----		------- bu/ac -------	
Control	0	0	189	67.3
Aglime	1	0.61	213	68.9
	2	1.23	220	74.8
	4	2.46	228	74.3
	8	4.92	228	70.7
Calcium carbonate	1	0.99	214	68.5
	2	1.99	224	74.0
	4	3.98	228	71.6
	8	7.96	230	70.3
Pelleted lime	1	0.98	216	71.7
	2	1.97	224	72.9
	4	3.93	227	72.9
	8	7.87	229	72.4

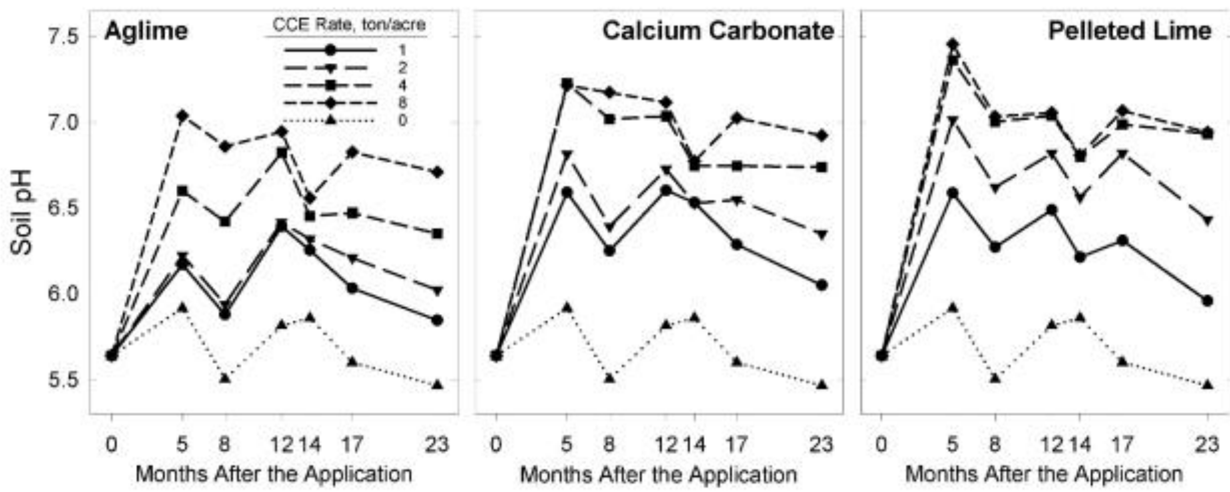

Figure 1. Effect of several calcium carbonate equivalent (CCE) application rates with three lime sources on soil pH over a 23-month period.

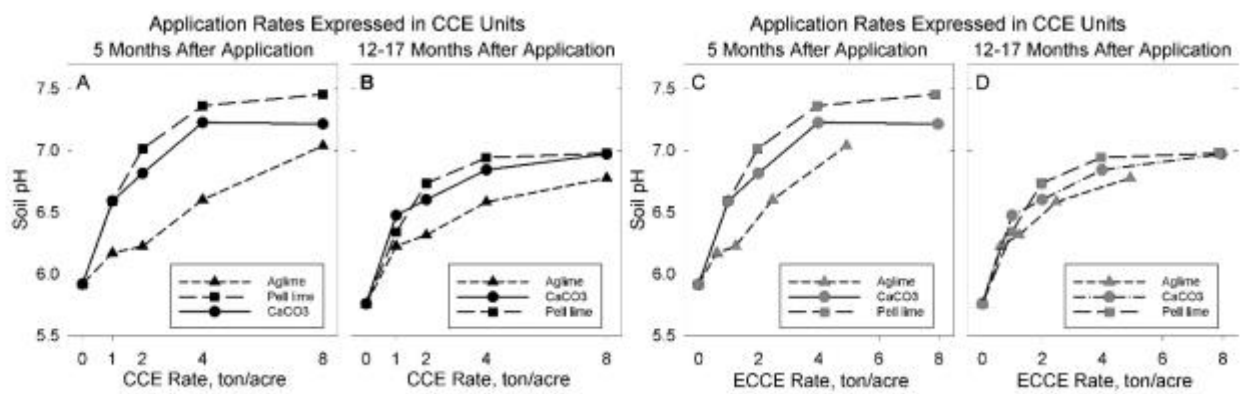

Figure 2. Soil pH at two times after applying three lime sources with the rates expressed as CCE or ECCE.