Evaluation of the Efficiency of Aglime and Pelleted Aglime in Two Central Iowa Soils

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Antonio Mallarino, professor
Mazhar Haq, assistant scientist
Louis Thompson, ag specialist
Department of Agronomy

Introduction

Liming of acidic soils increases crop yield and farming profitability. 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 evaluated how ECCE evaluates the granulation effect on its acid neutralizing capacity compared with aglime. Therefore, a study was conducted at two Iowa State University (ISU) central Iowa farms to compare the effectiveness of calcium carbonate, calcitic aglime, and pelleted calcitic aglime at increasing soil pH and crop yield.

Treatments and Procedures

Two, 2-year trials were conducted during 2015 and 2016. One site had Nicollet loam soil with pH and organic matter, calcium (Ca), magnesium (Mg), and sodium (Na) concentrations 5.5, 3.2 percent, 2,165 ppm, 291 ppm, and 15 ppm, respectively. The other site had Clarion loam soil with pH and organic matter, calcium (Ca), magnesium (Mg), and sodium (Na) concentrations 4.9, 2.5 percent, 888 ppm, 179 ppm, and 21 ppm, respectively. Treatments replicated three times applied to plots 7.5 ft by 12 ft were 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 materials were analyzed as required by IDALS, and Table 1 shows the results. The application rates were 0, 1, 2, 4, and 8 ton CCE/acre. As lime sources analyses indicate, the CCE was similar for all three sources, but ECCE was lower for the aglime. The lime treatments were broadcast by hand in fall 2014 (October 23 at one site and October 27 at the other site). The materials were incorporated by light disking November 7, after rainfall produced no surface runoff. The plots were disked again before planting corn May 12 or 13, 2015 (Dekalb DKC 54-38 and Pioneer P0448). Non-limiting rates of N, P, K, S, and micronutrients fertilizers were applied. Soybean was no-till planted May 20, 2016 (Pioneer P22T69R and Asgrow AG2632). Soil samples (6-in. depth) were taken in March, June, October, and December 2015 and in March and September 2016. Grain was harvested by hand 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

The yield level and initial soil pH values were slightly different between the two sites, but the yield and soil pH responses to the lime treatments were similar. Therefore, in this brief report we show and refer to averages across both trials.

Crop yield response. Liming with any of the three sources did not result in statistically significant yield increases in any site or year. However, the average results across sites in

Table 2 shows a small responsive trend for corn. On average across the three sources, the 2-ton CCE rate increased corn yield by 6.2 bushels/acre over the control and the highest two rates increased yield by 9.2 bushels/acre. Soybean planted the second year showed no response trend. The small yield response to lime in these central Iowa soils is not surprising. Other research has shown the optimum pH for corn and soybean in this Iowa region is 6.0 and responses are small due to high-pH, calcareous subsoils (see ISU extension publication PM 1688).

Soil pH increases from liming. Figure 1 shows the largest pH increase was observed five months after liming (in late March, first sampling date). Further increases were smaller until a maximum pH was reached 12 months after application by all sources and rates. Later, there were decreases for the lower rates. It must be noted the unlimed plots also showed a pH decrease after 12 months. Therefore, the pH decreases for the last three sampling dates probably was a seasonal effect.

Figure 2 summarizes soil pH responses to lime application for the early 5-month and 12-month sampling date, when most sources and rates produced the largest pH response. For each period, graphs show the pH by expressing application rates as amounts of CCE/acre or ECCE/acre. Lime analyses in Table 1 and the graphs show the CCE and ECCE rates were similar for calcium carbonate and pelleted lime. For aglime, however, the ECCE rates were smaller than the CCE rates because its ECCE was lower.

Graphs A and B in Figure 2 have application rates expressed as CCE/acre and show little or no pH differences between calcium carbonate and pelleted lime for any sampling date. The pH increase was smaller for aglime but the difference became smaller over time. Graphs C and D, which have the application rates expressed as ECCE/acre, still show a difference, although smaller, between aglime and the other two sources for the early sampling date. By the 12-month sampling date, however, when all sources and rates had resulted in maximum pH, the pH for aglime was slightly lower than for the other sources, except for the lower application rates.

The results demonstrated a slower reaction of aglime compared with calcium carbonate and pelleted lime, and the ECCE measurement correctly assessed the neutralizing power of pelleted lime but slightly over-estimated it for aglime. It is important to note, in spite of the aglime slower reaction and early lower pH, there were no differences between liming sources for the first crop (corn).

Conclusions

Pelleted lime and pure powdered calcium carbonate increased soil pH similarly and faster than aglime. The effectiveness of aglime increased over time but even by the last sampling dates, the ECCE measurement slightly over-estimated the aglime neutralizing capacity. In spite of smaller early pH increases by aglime, the three lime sources were similar at increasing crop yield in the first and second 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 average crop yield across two sites.

	Application rate		Crop yield	
Source	**CCE**	**ECCE**	**Corn**	**Soybean**
	---- ton/ac ----		------- bu/ac -------	
Control	0	0	204	60.6
Aglime	1	0.61	204	63.0
	2	1.23	207	64.4
	4	2.46	213	62.6
	8	4.92	212	62.6
Calcium carbonate	1	0.99	208	64.3
	2	1.99	207	65.9
	4	3.98	212	62.2
	8	7.96	213	62.0
Pelleted lime	1	0.98	203	64.1
	2	1.97	206	62.1
	4	3.93	214	60.0
	8	7.87	213	63.3
Sources avg.	1	-	205	63.8
Sources avg.	2	-	207	64.2
Sources avg.	4	-	213	61.6
Sources avg.	8	-	213	62.6

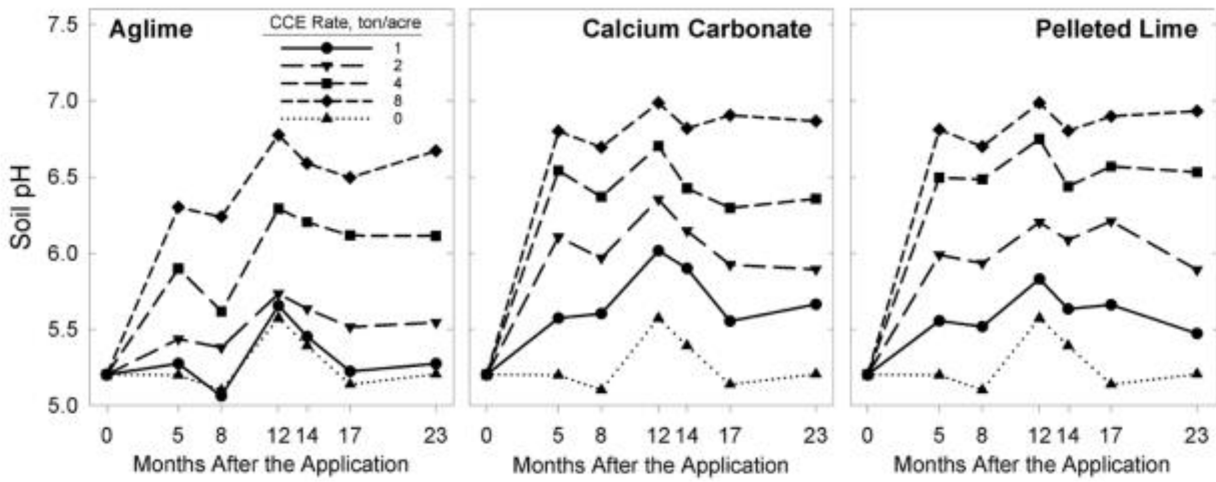

Figure 1. Effect of several calcium carbonate equivalent (CCE) application rates with three lime sources on soil pH over a 23-month period (averages across two sites).

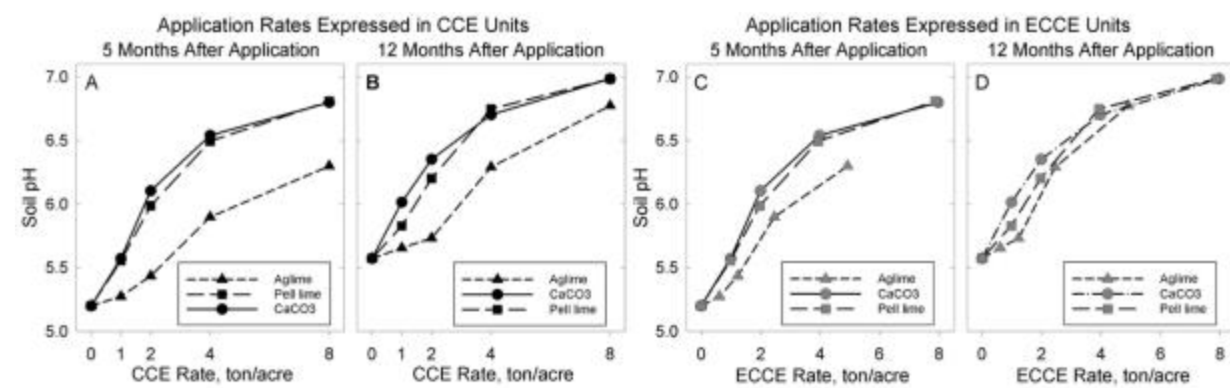

Figure 2. Soil pH 5 months after applying three lime sources and 12 months after the application when maximum pH was attained by all sources and rates with the rates expressed as CCE or ECCE (averages across two sites).