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SOIL PH AND CORN GRAIN YIELD RESPONSE TO LOW RATES OF PELLETIZED LIME AND TYPICAL AGLIME

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ABSTRACT

Maintaining the optimal soil pH for crop production is an important consideration for most producers across the Corn Belt. Lime is usually the most expensive single input in the year of application because of the relatively high application rates and material cost. These high input prices may cause producers to identify other application materials and techniques to neutralize soil to the desired pH level including the use of pelletized lime. The objective of the research was to determine the ability of low rates of pelletized lime to neutralize soil acidity and to determine the impact on subsequent corn (Zea mays L.) crop productivity. A field experiment was established at the OARDC West Badger Farm near Wooster, OH. Two lime sources (aglime and pelletized) were compared at three rates (1.3, 2.5, and 5 ton per acre). Soil samples were collected throughout the growing season to monitor changes in soil pH. Application of lime rates below the lime requirement did not neutralize soil to the desired pH level regardless of the lime source. Aglime neutralized soil pH faster than the pelletized lime at most sampling dates. Pelletized lime applied at the low rate had grain yields similar to the untreated control, but higher rates of pelletized lime and all aglime rates had significantly higher yields. Based upon this dataset, application of pelletized lime does not neutralize acidity any faster than aglime, nor does application of low rates achieve the desired neutralization of soil acidity.

INTRODUCTION

Maintaining the optimum soil pH for the crop species being grown is an important aspect of nutrient management. Unfortunately, lime is a relatively large investment for most agronomic producers, and thus they are more likely to seek alternative methods to typical aglime. Typical aglime is a quarried material that contains a combination of relatively fine materials and coarse materials. Since lime is relatively insoluble, the finer the product the less is necessary to achieve the desired neutralization of soil acidity.

Most state departments of agriculture provide guidelines or liming laws that dictate how liming materials are marketed based upon effective neutralizing power (ENP), relative neutralizing value (RNV), or effective calcium carbonate efficiency (ECCE). These standards typically account for calcitic or dolomitic content, purity, fineness of material, and moisture level of the liming material.

Land-grant universities determine lime requirements based upon lab incubations using reagent-grade calcium carbonate (1, 4, 9). The lime requirement (LR) is a measure of the amount of lime required to neutralize a fraction of total acidity and thus attain a desired soil pH (4, 11). Of the various methods developed to determine the lime requirement of a soil, buffer pH methods are typically used due to their simplicity and rapidity. A buffer solution (mixture of a weak acid and its conjugate base) will resist marked pH changes in the solution, but will give a linear decrease in pH when the soil's potential acidity reacts with the buffer (9). This decrease in buffer pH estimates the lime required to neutralize the total acidity of the soil to a desired pH (3).

Pelletized lime is a product made of finely-ground lime with aid of a binding agent is made into a pellet. The relatively pulverous nature of pelletized lime should increase its solubility and reactivity compared to typical aglimes that contain coarser material sizes, assuming that the pellet binding material is readily soluble in water. The binding agent commonly used is a lignosulfonate compound (6, 13). Lignosulfonate is a lignin-based compound that is derived from the pulping process used in the manufacture of paper (12). Additional binding agents such as brewex (an organic product derived from beer production) or molasses can also be used (10, 12).

The binding agent is critical when considering the reactivity rate of pelletized liming materials. In an experiment testing lime in a horticultural media, pelletized limestone neutralized acidity as fast as ground limestone, but pelletized dolomite did not react as fast as ground dolomite. The authors did not hypothesize why the pelletized dolomite material did not neutralize acidity as quickly. Another study reported that in a laboratory study, pelletized lime did not react as fast as typical aglime due to the insolubility of the binding agent (13). Despite the small particle size of the liming material that is pelleted, the binding agent may negatively affect the solubility of the pellet, thus slowing its reaction rate.

The objective of this study was to determine the ability of low rates of pelletized lime to neutralize soil pH and its impact on corn grain yield compared to aglime.

SITE DESCRIPTION AND SAMPLING PROCEDURES

A single field experiment was established in the spring of 2004 at the OARDC West Badger Farm near Wooster, OH. The soil at the experimental location was Canfield silt loam (fine-loamy, mixed, mesic Aquic Fragiudalf). Initial soil test information for the experimental site can be found in Table 1.

Table 1. Initial soil test information for the experimental site measured on April 24, 2004.

Soil pH†	Buffer pH‡	Available P	Exchangeable K	Exchangeable Ca	Exchangeable Mg
		------------------------------ppm-------------------------------------			
5.1	6.2	171	270	503	67

†-soil pH measured with 1:1 soil:water; ‡-buffer pH measured with SMP buffer; available P – measured with Bray-Kurtz P-1; Exchangeable K, Ca, and Mg – measured with 1 N ammonium acetate.

Using Ohio State University recommendations for lime applications (5), the lime requirement necessary to raise the soil pH to 6.8 was 5 ton per acre. Ohio State University liming recommendations assume the effective neutralizing power (ENP) of the lime selected to be 2000 lb per ton. A pure calcium carbonate material where all particles pass a 60 mesh screen that is completely dry would have an ENP value of 2000 lb per ton. Two lime sources (pelletized and aglime) were compared at three lime rates (1.3, 2.5, and 5 ton per acre). The actual rate of material applied was adjusted based upon the ENP of the respective materials to compare equivalent rates. The actual ENP of the materials and the respective material application rates used in this study are presented in Tables 2 & 3.

Table 2. Properties of the liming materials used within this study.

Lime source	TNP†, %	Fineness index	Moisture, %	ENP‡, lb ton^{-1}
Aglime	80.0	93.8	39.0	916
Pelletized lime	93.0	100.0	0.0	1860

† - TNP – total neutralizing power; ‡ - ENP – effective neutralizing power

Table 3. Effective neutralizing power (ENP) of the two liming materials used and their equivalent application rates.

Lime source	ENP, lb per ton	Lime requirement	Liming material application rate
		---------------------ton per acre--------------------	
Aglime	916	1.3	2.7
		2.5	5.5
		5.0	10.9
Pelletized lime	1860	1.3	1.3
		2.5	2.7
		5.0	5.4

The lime materials were surface applied by hand on May 6, 2004 to plots that were 10 ft wide by 30 ft long. Each treatment was replicated three times in a randomized complete block design. The two low rates were applied in a single application event, but the 5 ton per acre high rate was split into two application events. Following the first application all plots were tilled with an offset disk to a depth of 4 in. After the second application event, all plots were again tilled with an offset disk to a depth of 4 in. A field cultivator was used on the entire study area prior to planting. Corn was planted on May 11 at 32 000 seeds per acre (30 in rows). Urea-ammonium nitrate (UAN) was coulter injected at a rate of 160 lb N per acre after corn emergence near growth stage V3 (7). Soil samples were collected at various intervals throughout the growing season. Samples were collected on May 24, June 16, July 7, July 23, August 31, October 4, November 3, and in the subsequent spring (April 2005) and fall (October 2005). Soil samples were collected to a depth of 6 in. A total of eight soil cores were collected between mid-row and the corn row to constitute a composite sample per plot. Samples were collected away from mid-row to ensure that as the ammonium was nitrified that the acid soil around the UAN band did not affect soil pH measures. At corn maturity, the two center rows of each plot were harvested by hand. Lime source and rate main effects and simple effects were tested using PROC GLM in SAS (8). Analysis was done for soil pH at each sampling time and corn grain yield.

Results and Discussion

Neutralization of Soil Acidity

For all of the soil pH measurements, no interactions were noted, thus only main effects will be discussed (Table 4). With the exception of the fourth sampling date (July 23, 2004) and the final sampling date (October 2005), aglime significantly increased soil pH more than pelletized lime (Table 4). Additionally, with the exception of the fourth sampling date, as the rate of lime increased and approached the actual recommended rate, soil pH increased linearly. These results reveal that within this study, typical aglime reacted faster than pelletized lime at neutralizing soil acidity. The aglime source used in this study was a relatively fine material, but it had a considerable moisture content (Table 2). Thus differences in the relative speed of reaction may have been more similar between the aglime utilized and the pelletized lime. Soil pH measurements collected over a year and a half after the lime application revealed that no significant differences existed between the lime sources.

Table 4. Effect of lime source and rate on soil pH measured 9 times after lime application.

Lime Source	Lime rate (ton acre-1)†	May 24	June 16	July 7	July 23	Aug 31	Oct 4	Nov 3	Apr 2005	Oct 2005
None	0	4.9	4.3	4.3	5.2	5.0	5.1	5.0	5.1	4.9
Aglime	1.3	5.7	5.3	5.8	6.1	5.8	6.0	5.6	5.7	5.5
	2.5	6.1	5.9	5.8	6.6	5.9	6.5	6.3	6.2	6.1
	5.0	6.5	6.5	6.3	6.4	6.6	6.8	6.6	6.6	6.8
Pelletized	1.3	5.2	4.9	5.2	5.8	5.7	5.6	5.5	5.6	5.5
	2.5	5.2	5.4	5.4	6.1	5.7	6.2	6.0	5.9	6.0
	5.0	5.9	5.7	6.1	5.9	6.1	6.4	6.2	6.3	6.3
	0	4.9	4.3	4.3	5.2	5.0	5.1	5.0	5.1	4.9
Interaction		NS	NS	NS	NS	NS	NS	NS	NS	NS
Lime source main effect		***	**	**	NS	**	**	**	***	NS
Lime rate linear trend		***	***	***	NS	***	***	***	***	***

† - lime rates shown are based upon equivalent application rates not absolute application rate; ***,**, NS – statistically significant at the 0.01, 0.05, or non-significant.

These results reveal that despite the relative fineness of the pelletized lime used, it did not increase the speed of neutralization significantly over the aglime. Additionally, supplying a low amount well below the lime requirement based upon buffer pH, did not achieve neutralization to the desired level. Thus application of such low rates is not warranted.

Impact on Corn Grain Yield

Unlike the soil pH information, there was a significant interaction noted between lime source and rate on grain yield, thus only simple effects will be discussed. Application of pelletized lime at the low rate (1.3 ton per acre) resulted in yield levels similar to the untreated control (Figure 1). This is the only significant yield difference noted for this study. Pelletized lime is often marketed for its increased speed of reaction and neutralization compared to aglime because of its fine particle size. The corn yield data collected within this study does not substantiate that claim, nor does it support application of significantly lower rates of pelletized lime that are well below the lime requirement. Interestingly, application of aglime at the lowest rate performed as well as the higher rates with regard to corn grain yield. The most likely difference between the aglime and pelletized lime was the speed of reactivity. Soil pH measurements collected throughout the growing season revealed that aglime at the low rate consistently had higher pH readings than the corresponding pelletized lime (Table 4). In fact, soil pH for the low rate of pelletized lime never rose above 6.0. This likely accounted for the yield differences noted at the end of the growing season.

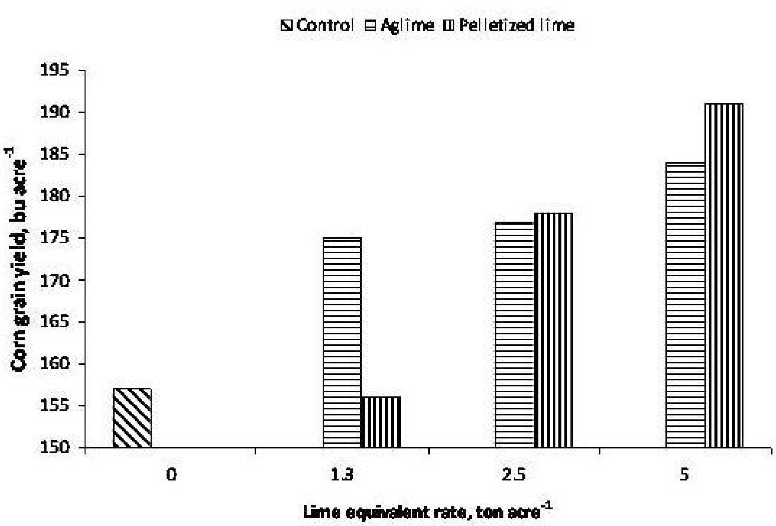

Figure 1. Effect of lime source and rate on corn grain yield in 2004.

CONCLUSIONS

This study confirms what we suspect to be true based upon chemistry. Land-grant universities determine lime requirements based upon incubations using fine reagent-grade calcium carbonate. Lime requirements are completely independent from the liming material being used. State departments of agriculture and the land-grant universities then devise an approach to allow for comparison of different liming materials based upon liming material, its purity, fineness, and moisture percent. In terms of chemistry, application of any material (pelletized or not) well below the lime requirement based upon incubation is very unlikely to deliver the desired change in soil pH. The difficulty from the research perspective is to show yield impacts when conducting lime experiments. This study is an example of the risk a producer takes when applying lime at a rate considerably lower than the land-grant university recommends. These data illustrate that it is especially risky when using a pelletized lime that may not react as fast as a typical aglime. Additionally, pelletized lime can cost 5 to 6 times as much as aglime making larger application rates cost prohibitive.

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