SOIL pH AND CROP RESPONSE TO LIME SOURCE AND TILLAGE

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Justification

Ag lime recommendations are based on soil pH, buffer pH, and neutralizing index or effective calcium carbonate equivalent (ECCE) of the lime to be used (Laboski and Peters, 2012). Determination of neutralizing index may vary by state and is often codified in state regulations related to the sale of ag lime. In Wisconsin, the neutralizing index of a lime is a function of purity (calcium carbonate equivalent) and fineness (particle size) (Schulte et al., 2005).

Pelletized lime is typically calcitic lime that has been finely ground and then pelletized. Measuring the neutralizing index of pelletized lime is problematic, since the physical size of the pellet does not allow it to pass though the finer sieves, and may result in a low neutralizing index. The ability to accurately assess the neutralizing index of pelletized lime is problematic for making appropriate liming recommendations.

Arguably the biggest advantage to using pelletized lime is the ability to spread it more evenly than traditional ag lime. Pelletized lime is often advertised as providing quicker, more consistent results than ag lime, thus requiring lower application rates. In some cases, the industry suggested application rate of pelletized lime is 20% of the application rate of ag lime with a neutralizing index of 91, which is the ECCE advertised for pelletized lime.

The discrepancy in application rates between liming products (ie. university recommended rates for ag lime and industry recommended rates for pelletized limes) causes confusion amongst producers and agronomists. The objective of this study was to evaluate the effectiveness of pelletized lime to change soil pH compared to ag lime (80-89 neutralizing index) in no-till and chisel tillage systems.

Methods and Materials

A study was conducted over four years on a Plano silt loam (fine-silty, mixed, superactive, mesic Typic Argiudolls) at the Arlington Ag Research Station. Prior to initiation of the study, the field was under no-till management for at least 10 years. The experimental design was a split-split plot with tillage (no-till or chisel) as the main plot, lime source (ag lime or pelletized lime) as the sub plot and lime rate (0, 1, 2.5, and 5 T/a) as the sub-sub plot with four replications. The ag lime used was dolomitic and had a neutralizing index of 70-79. The pelletized lime was calcitic. Lime was broadcast by hand to plots that were 10 feet wide and 40 feet long in spring 2009 before planting. Tillage, where required by treatment, occurred immediately following lime application. Soybeans were grown in 2009. Alfalfa was seeded in spring 2010 and was grown through 2012 using university recommended crop management practices. Soil samples were collected from each plot at 0 to 2, 2 to 4, 4 to 6, 6 to 8, and 0 to 8 inch depths in spring 2009 prior to lime application, fall 2009, spring and fall 2010 and 2011, and spring 2012. Soil pH was measured on a 1:1 soil:water slurry.

Data was analyzed in JMP Pro 10 using a mixed model for a split-split-plot design where rep was the random effect. All statistics were evaluated at the 0.10 probability level and Tukey was used for means separation.

Results

Changes in soil pH

Prior to lime application, soil pH average across all plots was 5.7, 5.8, 6.15, 6.3, and 6.0 in the 0 to 2, 2 to 4, 4 to 6, 6 to 8, and 0 to 8 inch depths, respectively. Initial soil pH varied by up to 0.3 units between replications within a treatment, but not all treatments had that much initial variability (Table 1). Therefore, the initial soil pH in spring 2009 in a given plot was subtracted from the soil pH on each sampling date. Evaluating the change in soil pH over time normalized for different starting pH. In general, as the rate of lime applied increased, soil pH increased. For either lime source, soil pH stopped increasing 18 to 24 months after application. This is about 12 months sooner than expected.

Three years after application, there was no significant difference in the increase in soil pH between lime sources regardless of the rate of lime applied (Table 1). These data suggest that pelletized lime does not react more quickly with soil than ag lime. There were some notable differences in the change in soil pH with lime application between tillage systems. At the 0 to 2-inch depth, there was no difference in the increase in soil pH between tillage systems for each rate of lime applied, regardless of lime source. However, chisel plowing resulted in a significantly larger increase in soil pH in the 2 to 4, 4 to 6, and 0 to 8 inch-depths at 5 T/a rate, and the 2 to 4 and 6 to 8 inch-depths at the 2.5 T/a rate; otherwise there was no difference. Pelletized lime was more effective at increasing soil pH in the 0 to 8 inch-depth compared to ag lime in the no-till system, but not in the chisel system.

Crop Yield

Soybean yield in 2009 was no affected by lime source or rate likely because the lime was applied shortly before planting and there was not adequate time for the lime to react with the soil. Chisel plowing resulted in significantly greater soybean yield than no-till (40 vs 34 bu/a). Seeding year alfalfa yield was significantly greater in chisel (3.02 T DM/a) compared to no-till (2.00 T DM/a). Any lime application significantly increased yield seeding year alfalfa yield compared to no application. There was no effect of lime source on seeding year alfalfa yield.

In 2011 and 2012, application of pelletized lime resulted in greater alfalfa yield compared to ag lime in a chisel system (pelletized lime: 5.12 and 4.42 T DM/a in 2011 and 2012, respectively; ag lime: 4.32 and 3.02 T DM/a in 2011 and 2012, respectively); while the reverse was true in the no-till system (pell lime: 4.62 and 4.20 T DM/a in 2011 and 2012, respectively; aglime: 5.01 and 4.27 T DM/a in 2011 and 2012, respectively). The yield data suggest that that incorporation of pelletized lime promoted breakdown of the pellet and the greater neutralizing index of the more finely ground lime reacted more quickly. However, the soil pH data does not corroborate this observation. Alfalfa yield averaged over tillage system and lime was 2.62, 4.79, and 3.64 T

DM/a for ag lime and 2.40, 4.87, and 4.31 T DM/a for pelletized lime in 2010, 2011, and 2012, respectively; though none of these annual yield differences was significant.

Alfalfa stand density was measured after the first cutting in 2011 and 2012 to assess the effects of liming and tillage on alfalfa survival. In 2011, there was no effect of tillage, lime source, or lime rate on alfalfa stand density. In 2012, chisel plow had a significantly greater stand density than no-till (4.8 vs 3.9 plant/ft^2) and ag lime had a significantly greater stand density than pelletized lime (4.7 vs 4.0 plant/ft^2).

Conclusions

- *In a chisel plow system*, there is no clear advantage to using pelletized lime instead of aglime with regard to increasing soil pH. The effectiveness of either lime source is related to the rate of lime applied. Chisel plowing provides adequate mixing of the lime with the soil.
- *In a no-till system*, there may be a slight advantage to using pelletized lime if a pH changed is desired through an 8 inch-depth, though individual depth increments did not show this advantage. If smaller pH changes are desired then, pelletized lime applied at a 1 to 2.5 T/a rate could be as effective as ag lime with a neutralizing index of 70-79 at 5 T/a.
- In spring 2013, ag lime with a neutralizing index of 80-89 cost approximately $33/T and pelletized lime cost approximately $194/T. Regardless of tillage system, traditional ag lime is a more cost effective liming source.

References

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Table 1. Initial soil pH in spring 2009 and the change in soil pH in spring 2012 by soil depth increment for each lime source, rate, and tillage

Depth	Lime rate	Ag lime, chisel		Ag lime, no-till		Pell lime, chisel		Pell lime, no-till	
		Spring 2009 soil pH	Spring 2012 Δ pH	Spring 2009 soil pH	Spring 2012 Δ pH	Spring 2009 soil pH	Spring 2012 Δ pH	Spring 2009 soil pH	Spring 2012 Δ pH
inches	T/a								
0 – 2	0	5.8	-0.15	5.5	0	5.7	-0.05	5.7	-0.25
	1.0	6.0	-0.10	5.6	0.23	5.7	0.25	5.9	0.25
	2.5	5.7	0.83	5.8	0.43	5.7	0.68	5.7	0.73
	5.0	5.7	1.03	5.5	0.68	5.5	1.18	5.8	0.95
2 – 4	0	5.9	-0.15	5.6	0.15	5.9	-0.10	5.8	-0.03
	1.0	6.0	-0.10	5.8	0.05	5.8	0.23	5.7	0.15
	2.5	5.7	0.98	5.8	-0.03	5.8	0.55	6.0	-0.08
	5.0	5.8	0.90	5.6	0.30	5.8	1.03	5.9	0.30
4 – 6	0	6.3	-0.28	6.0	0.10	6.2	-0.23	6.1	0
	1.0	6.3	-0.18	6.1	0.05	6.2	-0.08	6.2	0.03
	2.5	6.1	0.45	6.2	-0.05	6.2	0.18	6.1	0.15
	5.0	6.1	0.58	6.0	0.25	6.1	0.48	6.2	0.08
6 – 8	0	6.3	0	6.3	0.08	6.3	0.08	6.3	0.05
	1.0	6.3	-0.10	6.3	-0.03	6.4	-0.03	6.3	0.08
	2.5	6.2	0.33	6.3	-0.13	6.3	0.10	6.5	-0.10
	5.0	6.2	0.30	6.3	0.08	6.4	0.18	6.3	0.08
0 – 8	0	6.1	-0.10	5.9	-0.03	6.0	-0.08	6.0	-0.08
	1.0	6.1	0.33	6.0	0.18	6.0	0.05	6.0	0.33
	2.5	6.0	0.45	6.0	0.05	6.0	0.23	6.0	0.68
	5.0	6.0	0.68	5.9	0.15	6.0	0.70	5.9	0.95

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