REEVALUATING THE SMP BUFFER PH TEST FOR LIME RECOMMENDATIONS IN OREGON

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ABSTRACT

Soil testing labs in the Pacific Northwest are considering non-hazardous alternatives to the Shoemaker-McLean-Pratt (SMP) buffer method for lime requirement estimation (LRE). While alternative LRE methods have been adopted in other parts of the U.S., they have not been evaluated for Oregon soils. The goal of this study was to evaluate several LRE methods for Oregon agricultural soils, using the lime incubation method for actual lime requirement. Twenty-four acidic soils (pH ≤ 5.5) from Oregon agricultural fields were mixed with lime at rates equivalent to 0, 1, 2, 4, 6, 8, and 10 ton acre^{-1}, and were incubated for 90 days at 72° F. Lime requirement estimation methods evaluated included SMP buffer, Sikora buffer, Modified Mehlich buffer, and Single Addition of $Ca(OH)_2$. Incubation lime requirement and LRE methods were evaluated for the pH targets of 5.6, 6.0, and 6.4.

The mean amount of lime required to meet the target pH of 6.0 was 2.0 ton acre^{-1} for E. Oregon loess silt loams (n=3), 2.7 ton acre^{-1} for W. Oregon valley floor loams (n=14), 3.0 ton acre^{-1} for C. Oregon volcanic loamy sand (n=1), 5.9 ton acre^{-1} for W. Oregon foothill silty clay loams (n=4), and 7.4 ton acre^{-1} for W. Oregon vertic clays (n=2). The SMP, Sikora, Modified Mehlich, and $Ca(OH)_2$ methods were each correlated against incubation lime requirement, respectively producing mean R^2 values of 0.92, 0.92, 0.89, and 0.74 across pH targets. While these preliminary findings suggest that the Sikora buffer method could be a suitable replacement for SMP in Oregon, other buffer methods and calculation approaches will be evaluated before a new LRE method for Oregon can be adopted.

INTRODUCTION

The buffer pH test currently recommended for making lime requirement estimates (LRE) in Oregon is the Shoemaker, McLean, and Pratt (SMP) method (Anderson et al. 2013). This recommendation is based on a 1971 evaluation of the SMP method for Oregon soils by laboratory lime incubation (Peterson 1971). The SMP test requires the use of regulated hazardous materials, namely para-nitrophenol and potassium chromate. Because of this, commercial soil test labs serving Oregon have recently expressed interest in transitioning to a non-hazardous alternative test.

Since the development of the SMP method in 1961, several non-hazardous LRE methods have been developed. Some methods involve replacing the hazardous components in existing methods in a way that maintains the original method characteristics as much as possible. Examples of this include the Sikora modification of the SMP method (2006), the Sikora-Moore modification of the Adams-Evans method (2008), and the Modified Mehlich method (Hoskins and Erich 2008). Other non-hazardous methods estimate lime requirement without the use of buffers. The Single Addition of $Ca(OH)_2$ method calculates LRE based on the pH response of a soil slurry to the addition of a strong base (Liu et al. 2005). Other methods calculate LRE using multivariate models that combine multiple soil test parameters, such as organic matter content and KCl extractable Al (LeMire et al. 2005; McFarland 2016).

In order to replace the SMP method in Oregon, candidate LRE methods must be evaluated. The objective of this project was to conduct a lime addition lab incubation study to compare the effectiveness of SMP, Sikora, Modified Mehlich (MM), and Single Addition of $Ca(OH)_2$ methods for estimating LRE on western and eastern Oregon agricultural soils.

METHODS AND MATERIALS

Twenty-four acidic soils (pH<5.5) were collected from various agricultural regions in Oregon, with an emphasis on tall fescue fields in the Willamette Valley. Soil samples were separated into five categories based on region and relevant characteristics (Table 1). Vertic clay loams originate from the Willamette Valley, and have higher clay content compared to other soils in the area. Foothill silty clay loams are also from the Willamette valley, specifically the foothills on the western side of the Cascade mountain range. Valley floor loams are all other soils collected from the Willamette Valley. Loess silt loams were collected from the Palouse region of eastern Oregon. The volcanic loamy sand was collected from Deschutes County in central Oregon.

Lab-grade calcium carbonate was mixed with 200 g aliquots of soil at rates of 0, 0.231, 0.461, 0.922, 1.384, 1.845, 2.306 g, which is equivalent to 0, 1, 2, 4, 6, 8, 10 tons acre^{-1} (assuming a bulk density of 1.3 g cm^{-3} and 15 cm depth, or 81.2 lb ft^{-3} and 5.91 in. respectively). Treatments were replicated four times in a complete randomized design. Soil-lime mixtures were incubated in resealable bags for 90 days at room temperature (~73° F). Soils were maintained at 75 – 105% of field capacity (as determined by pressure plate analysis) during incubation. The combination of 24 soil types, seven lime treatments, and four replications resulted in 672 experimental units for the incubation study. At the end of the 90 day incubation, soils were air-dried and analyzed for 1:2 water pH using a pH electrode to determine actual lime requirement ("incubation LR"). A third-order polynomial was fit for each soil to estimate the amount of lime needed to meet the target pH values of 5.6, 6.0, and 6.4. These LR estimates at each target pH level were used to evaluate the effectiveness of candidate LRE methods to predict the amount of lime needed to reach each pH target.

Table 1. Summary of soil parameters and lime requirement for 24 Oregon agricultural soils collected from the 0-6 inch soil depth. $\bar{x}$ is the mean measurement for each category. Clay was measured using the hydrometer method, and organic matter was measured using the Walkley-Black method (Gavlak et al. 2005).

Regional Soil Class	Clay (%)		Organic Matter (%)		KCl Ext. Al mg kg^{-1}		Incubation LR ton acre^{-1} to reach pH 6.0	
	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range
Vertic Clay Loams (n=2)	45	43 - 47	6.9	6.8 – 7.0	16.9	7.8 – 26	7.4	7.0 – 7.8
Foothill Silty Clay Loams (n=4)	50	44 – 53	9.1	7.7 – 10.3	8.4	2.2 – 11	5.9	4.7 – 7.1
Valley Floor Loams (n=14)	23	15 – 40	4.1	3.3 – 6.7	5.8	0.6 – 11	2.7	1.7 – 4.0
Loess Silt Loams (n=3)	17	14 – 20	4.0	3.2 – 5.4	0.6	0.2 – 1.0	2.0	1.2 – 2.7
Volcanic Loamy Sand (n=1)	10	-	5.9	-	5.5	-	3.0	-

The same 24 soils used in the incubation study were also used to evaluate the SMP buffer (Gavlak et al. 2005), the Sikora buffer (2006), the Modified Mehlich buffer (Sikora and Moore 2014), and the Single Addition of $Ca(OH)_2$ method (Sikora and Moore 2014). Unincubated soils were used for the evaluation. Each soil analysis was replicated three times. Soils were also analyzed for clay content, organic matter, extractable aluminum, manganese concentration, and other variables that may be used to further improve estimation of lime requirement for these soils.

RESULTS

Lime Incubation

Soil pH response to lime applications varied widely among the five Oregon agricultural regions (Figure 2). The soil pH for the foothill silty clay loams and the vertic clays increased linearly from 0 to 10 ton lime/acre, while soil pH for the valley floor loams and the loess silt loams appeared to stop increasing between 7 to 8 ton acre^{-1}.

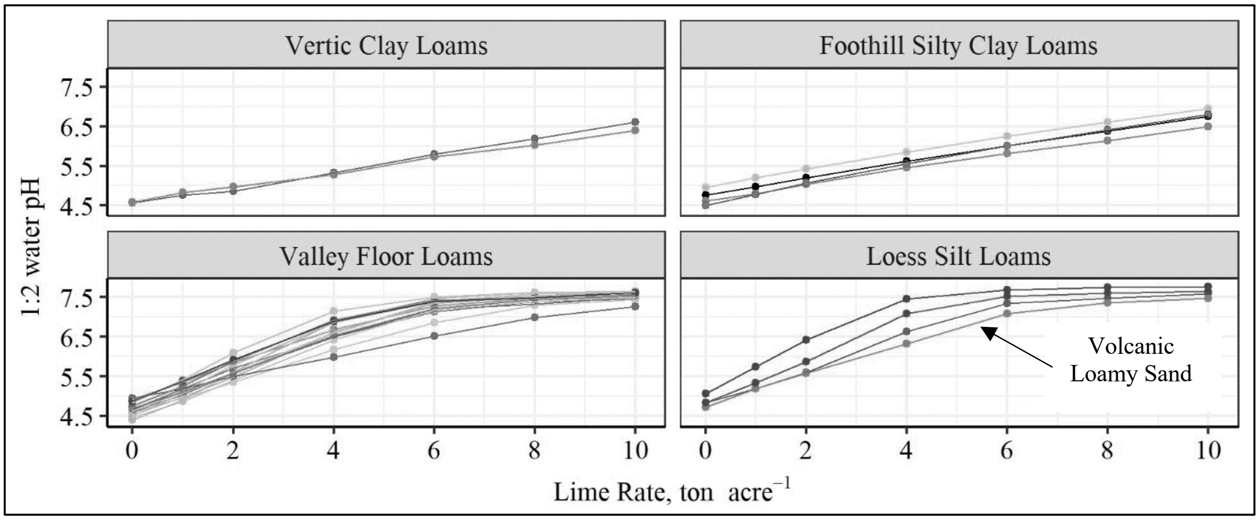

Figure 2. Soil pH response to increasing lime application rate for 24 Oregon soils following a 90 day lab incubation. Each line represents one soil, with each point representing the pH achieved at each lime rate.

Candidate LRE Methods

Buffer pH was well correlated to the incubation lime requirement for both SMP and Sikora for all soil categories evaluated at the pH targets of 5.6, 6.0, and 6.4, (Figure 3). The R^2 values were also similar between Sikora and SMP for each pH target, illustrating that the Sikora method would produce results with similar accuracy to the SMP buffer.

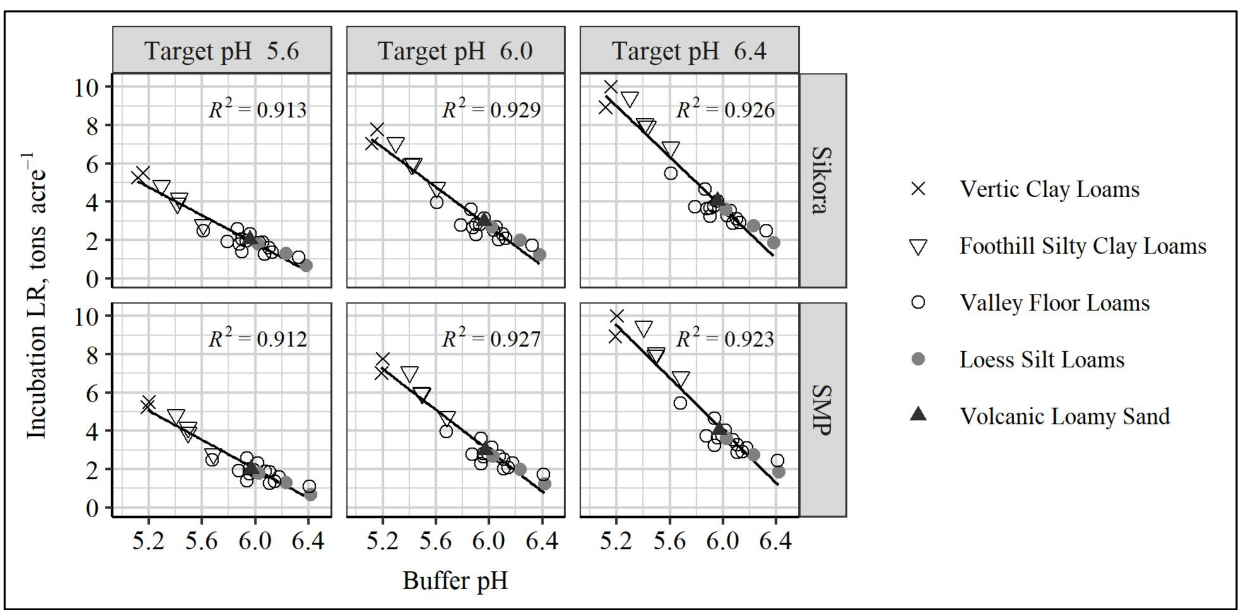

Figure 3. Correlation between incubation lime requirement and SMP and Sikora buffer pH. Sikora results are on the top row of graphs, with SMP below.

Modified Mehlich BpH was also well correlated to incubation lime requirement, but not as strongly as SMP or Sikora (Figure 4). Lime requirement estimates were also calculated from BpH values according to equations from Mehlich 1976. These LRE values correlated to incubation lime requirement with R^2 values of 0.90, 0.89, and 0.87 for pH targets of 5.6, 6.0, and 6.4 (Figure 4).

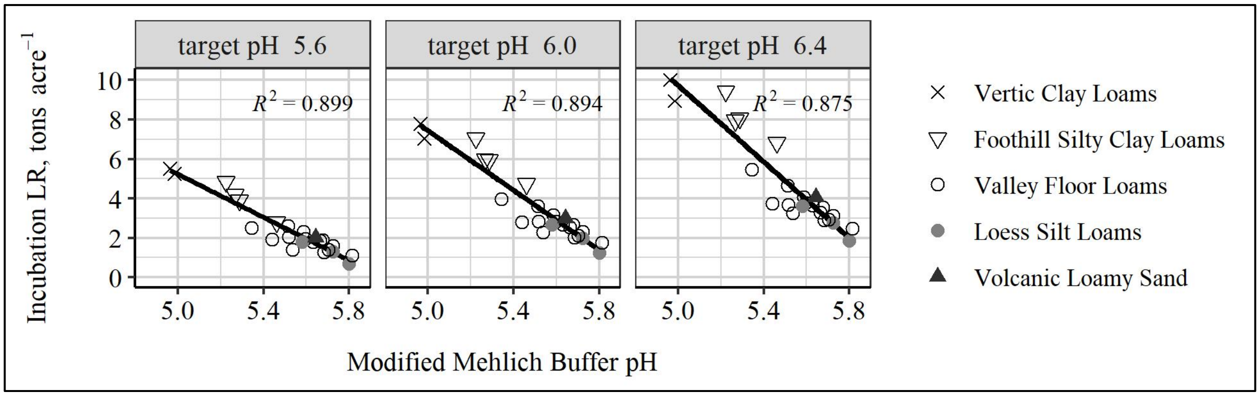

Figure 4. Correlation between incubation lime requirement and Modified Mehlich buffer pH

The calculated LRE values produced by the Single Addition of $Ca(OH)_2$ method correlated with incubation lime requirement with R^2 values of 0.78, 0.73, and 0.70 across pH targets (Figure 5).

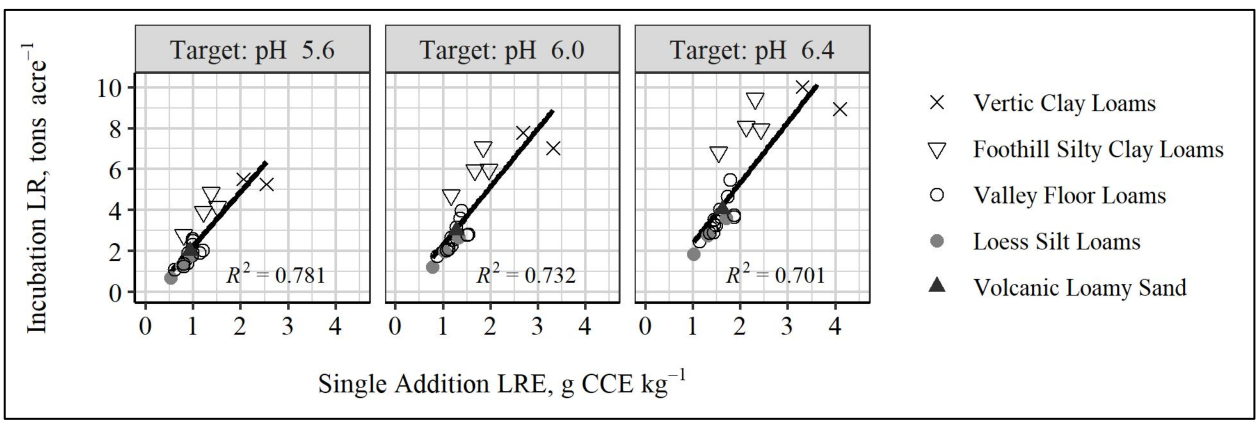

Figure 5. Correlation between incubation lime requirement and LRE determined by the Single Addition of $Ca(OH)_2$ method. CCE = Calcium Carbonate Equivalent.

A model incorporating 1:2 water pH and Sikora BpH was also evaluated. This model took the following form: $LRE = Ax + Bxy + Cy + D$, where x and y are 1:2 water pH and Sikora BpH respectively, and A, B, C and D are fitting constants. Three models corresponding to pH targets of 5.6, 6.0, and 6.4 correlated to incubation lime requirement with R^2 values of 0.93, 0.94, and 0.94 respectively (data not shown).

DISCUSSION

Lime Incubation

Soils from the vertic and foothill categories had significantly higher incubation LR, and had more linear incubation response to lime rate, compared to soils from the other three categories.

This is likely due to the higher amount of clay and organic matter present in these soils. These soil components are known to contribute to CEC and soil pH buffering.

Clay mineralogy may also be an important factor for lime requirement. Both of the vertic clay soils, as well as five of the 14 valley floor soils are classified as having predominantly smectitic clay mineralogy. All the other soils collected are classified as having mixed mineralogy (Soil Survey Staff). This difference in mineralogy may partially explain why the vertic clay category had higher incubation LR compared to the foothill group, despite higher average clay and organic matter content in the foothill group.

Candidate LRE Methods

The critical criteria for recommending a replacement for the SMP method is that the new method must be as or more accurate than SMP. Of the alternative methods evaluated, only the Sikora method had an R^2 equivalent to SMP. This suggests that Sikora is a viable non-hazardous alternative to the currently recommended SMP buffer.

Other promising approaches to lime requirement estimation remain unevaluated in Oregon. Namely, the Sikora-2 method, and soil parameter-based multivariate models. Prior work suggests that soil test parameters such as soil pH, organic matter, and KCl extractable Al can be used to predict lime requirement (LeMire et al. 2005; McFarland 2016).

CONCLUSIONS

There is currently a desire to replace the SMP method with a non-hazardous alternative in Oregon. Three alternative methods were evaluated for their ability to predict incubation lime requirement for 24 Oregon soils. Of these, only the Sikora method had accuracy equivalent to the SMP method. Additional approaches to LRE determination will also be evaluated before LRE test recommendations are updated in Oregon.

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