AGRICULTURAL RESEARCH FOUNDATION
FINAL REPORT
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TITLE: Reevaluating the SMP buffer pH test for lime recommendations in the Pacific Northwest

RESEARCH LEADER:

Name: Amber Moore
Email address: amber.moore@oregonstate.edu
Phone number: 541 737-2870
Academic rank (delete non-applicable): Associate Professor
Appointment type (delete non-applicable): Tenured
Start date in current rank: June 16, 2017
Physical work location: Corvallis, Oregon
Immediate supervisor: Thomas Chastain
OSU academic home department: Crop and Soil Science Department

COOPERATORS:

Carl Evans, M.S. Graduate Student, OSU Crop and Soil Science Department
Dan Sullivan, Professor, Nutrient Management, OSU Crop and Soil Science Department
David Huggins, Professor and Soil Scientist, WSU and USDA ARS, Pullman, WA

EXECUTIVE SUMMARY:

Soil testing labs serving Oregon growers have been moving away from the traditional SMP buffer for estimating lime requirement, primarily due to concerns regarding hazardous materials associated with the method. The goal of our project was to evaluate the effectiveness of several non-hazardous lime requirement estimation methods on both Western and Eastern Oregon soils. Twenty-five Oregon soils from the 0-6 inch depth were incubated with lime at rates ranging from 0 to 10 ton/acre for 90 days. We determined how much lime was estimated for each soil to reach pH targets of 5.6, 6.0, and 6.4. The buffer tests of primary interest are the SMP, Sikora, Modified Mehlich, Moore-Sikora, and single addition $Ca(OH)_2$, along with a multivariate soil parameter approach. Buffer pH was well correlated to the incubation lime requirement for both SMP and Sikora for all soil categories, with r^2 values of 0.91 to 0.93 for both test across the three pH targets. The r^2 values were also similar between Sikora and SMP for each pH target, illustrating that the Sikora method is similarly accurate as the SMP buffer. Based on our findings, the Sikora buffer pH method appears to be a promising alternative to the SMP buffer method for Oregon mineral soils. Our findings will allow soil testing labs to move to Sikora buffer testing with confidence. Lime recommendations based on Sikora buffer pH will require adjustment, as the relationships between Sikora buffer pH and incubation lime response differed from current SMP buffer pH based recommendations from OSU. We anticipate fewer incidents of over- or under- application of lime once the Sikora test and the new recommendations are adopted.

OBJECTIVES:

The objective of this three-year study is to develop a more effective lime recommendation model for acidic soils in Oregon, by 1) determining which buffer pH tests and multivariate soil analyses approaches produce the strongest correlation with actual lime requirement for our highly varied Pacific Northwest soils, and 2) apply findings from this study to improving the accuracy of OSU lime recommendations through consideration of alternative testing methods, if improvement is needed.

PROCEDURES:

The study was conducted on acidic soils collected from the Pacific Northwest region of the United States, varying in in organic matter content, soil texture, clay minerology, extractable aluminum content, and other critical parameters. Acidic soils (soil pH < 5.5) were collected from 24 agricultural fields from Western and Eastern Oregon.

Soils were incubated with different rates of lime applications to determine how soil pH level increases with increasing rates of lime for each collected soil sample. Specifically, agricultural grade lime was combined with air-dried and sieved soil samples at rates equivalent to 0, 1, 2, 4, 6, 8, and 10 ton/acre, and incubated at room temperature and 75 – 105% field capacity for 90 days. Treated soils were incubated in plastic resealable bags. Lab incubated soils were analyzed for 1:2 water pH at the beginning and the conclusion of the incubation period. The amount of lime added to each treatment was correlated to lime amount added to increase in soil pH in order to accurately determine the actual lime requirement for each soil type. The collected air-dried soils were also treated and neutralized with various LRE test methods that are currently used by soil testing labs throughout the US. The buffer tests of primary interest are the SMP, Sikora, Modified Mehlich, Moore-Sikora, and single addition Ca(OH)2. We also evaluated an multivariate soil parameter approach, where combinations of parameters including organic matter content, KCl extractable Al, Mn, Cu, Mg, Ca, and clay content were used to predict LR. Lime requirements for each method were compared against the actual amount of lime needed to increase the pH level to a set point, with the r-square value used to determine the accuracy of a method for estimating LR.

The research efforts described above were conducted by Carl Evans, an OSU soil science Master's student, with technical support from Faculty Research Assistants in Amber Moore's and Nicole Anderson's programs.

SIGNIFICANT ACCOMPLISHMENTS:

Soil Characteristics

Overall, soil samples were collected from twenty-four Oregon agricultural sites. Soil samples were separated into five categories based on region and other relevant characteristics. 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. All soils were acidic (pH ≤ 5.5), and also

covered a range of relevant soil parameters (Table 1).

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 Extractable Al (mg kg^{-1})		Incubation LR* to reach pH 6.0 (ton/acre)	
	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range
Vertic Clay Loams (n=2)	46	46 - 46	6.9	6.8 – 7.0	16.9	7.8 – 26	7.4	7.0 – 7.8
Foothill Silty Clay Loams (n=4)	49	42 – 52	9.1	7.7 – 10.3	8.4	2.2 – 11	5.9	4.7 – 7.1
Valley Floor Loams (n=14)	25	18 – 39	4.1	3.3 – 6.7	5.8	0.6 – 11	2.7	1.7 – 4.0
Loess Silt Loams (n=3)	20	17 – 22	4.0	3.2 – 5.4	0.6	0.2 – 1.0	2.0	1.2 – 2.7
Volcanic Loamy Sand (n=1)	14	-	5.9	-	5.5	-	3.0	-

*Lime Requirement

Lime Incubation

In the lime incubation trial, soils showed an approximately linear pH response to lime addition up to pH 7.0, above which additional lime showed a reduced ability to raise pH (Figure 1). Soils with high pH buffering capacity, particularly Vertic Clay Loams and Foothill Silty Clay Loams, did not exceed pH 7.0, even at the highest lime rate of 10 ton/acre. For each soil, the incubation lime response data was fit with a 3rd-order polynomial. This polynomial was used to calculate real lime requirement for three pH targets: 5.6, 6.0, and 6.4 (pH target 6.0 summarized in Table 1).

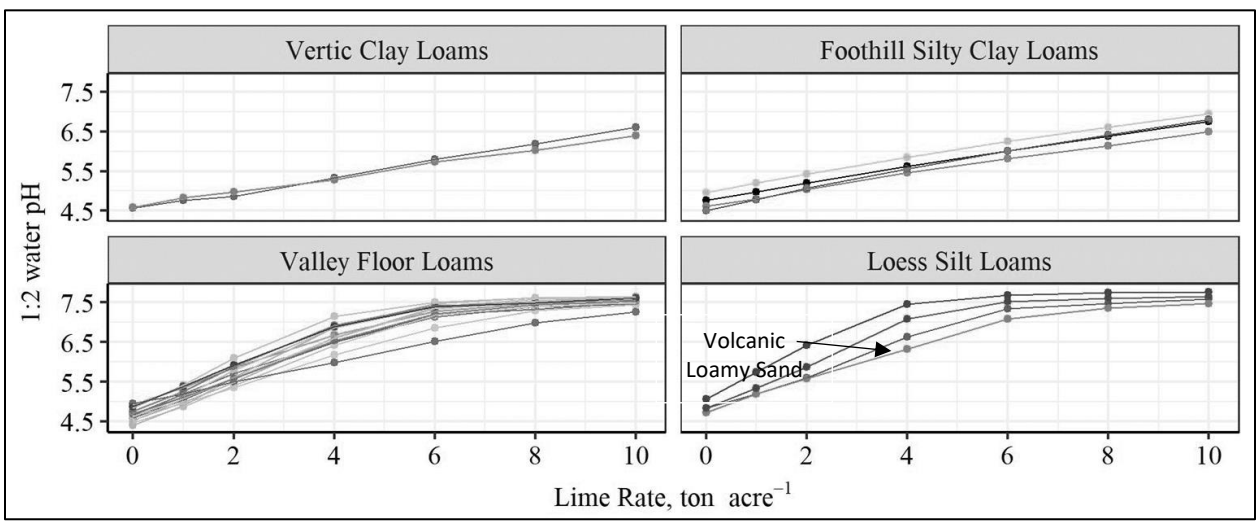

Figure 1. Soil pH response to increasing lime application rate for 24 Oregon soils following a 90-day lab incubation. Each line represents one soil, with each point representing the pH achieved at each lime rate.

Lime Requirement Estimation

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 2). 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. Modified Mehlich BpH (Figure 3) was also well correlated to incubation lime requirement, but not as strongly as SMP or Sikora. 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. Moore-Sikora BpH also correlated well to incubation lime requirement (Figure 4). Although this method shows accuracy comparable to SMP and Sikora, soils with low BpH showed higher levels of variability among replicated measurements (data not shown), making it less suitable than SMP and Sikora. 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).

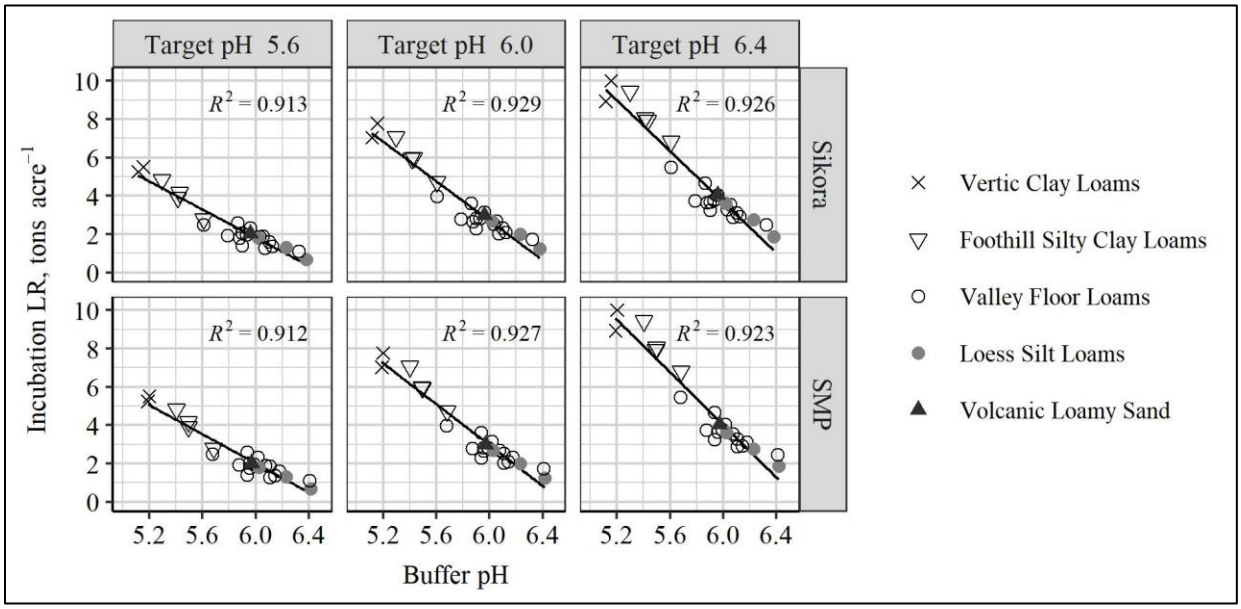

Figure 2. Correlation between incubation lime requirement and SMP and Sikora buffer pH. Sikora results are on the top row of graphs, with SMP below.

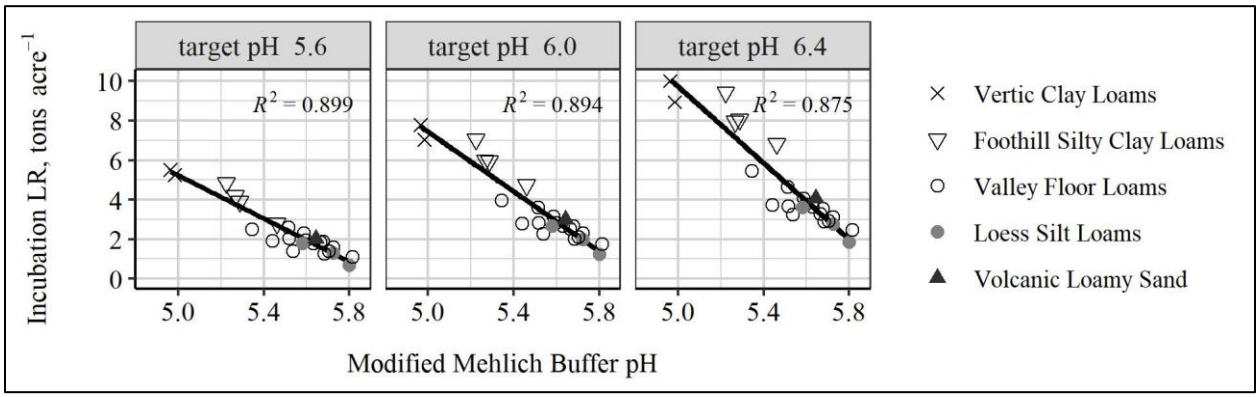

Figure 3. Correlation between incubation lime requirement and Modified Mehlich buffer pH

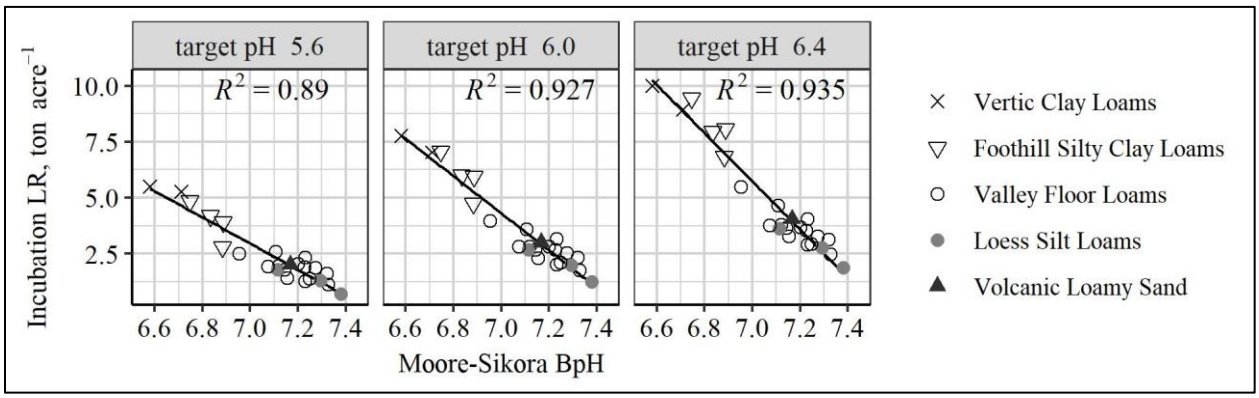

Figure 4. Correlation between incubation lime requirement and Moore-Sikora buffer pH

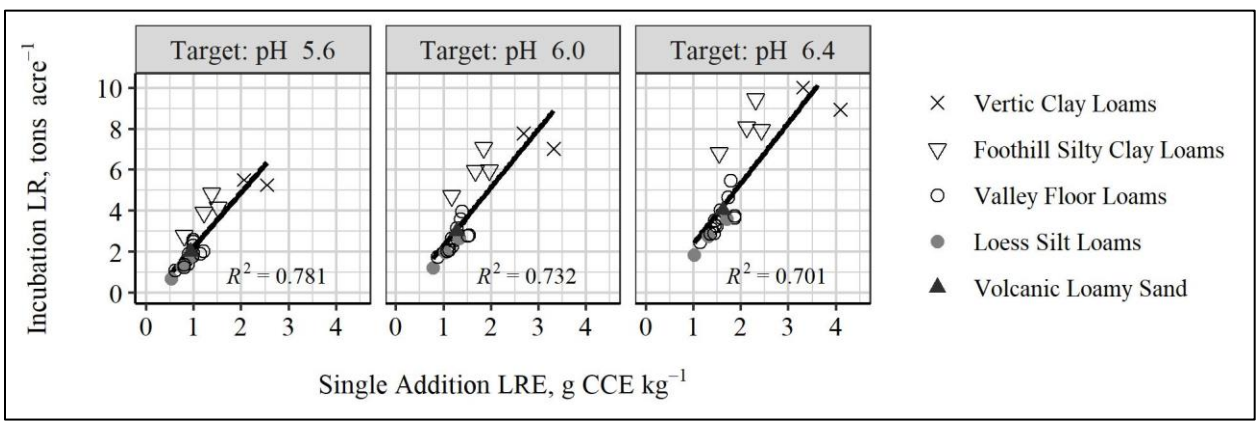

Figure 5. Correlation between incubation lime requirement and LRE determined by the Single Addition of $Ca(OH)_2$ method. CCE = Calcium Carbonate Equivalent.

Multiple parameters and combinations of parameters were evaluated on their ability to predict incubation lime requirement. A model combining KCl-extractable Al and OM was the best combination for predicting incubation lime requirement, with R^2 values of 0.82, 0.86, and 0.88 across pH targets (Figure 6). Other models that included pH, Mn, Cu, Mg, Ca, and clay content were less accurate (data not shown). Although this approach shows that multivariate models can be used to predict lime requirement with appreciable accuracy, it also has some notable disadvantages relative to buffer methods, such as increased cost, and the use of hazardous materials (potassium dichromate associated with Walkley-Black analysis).

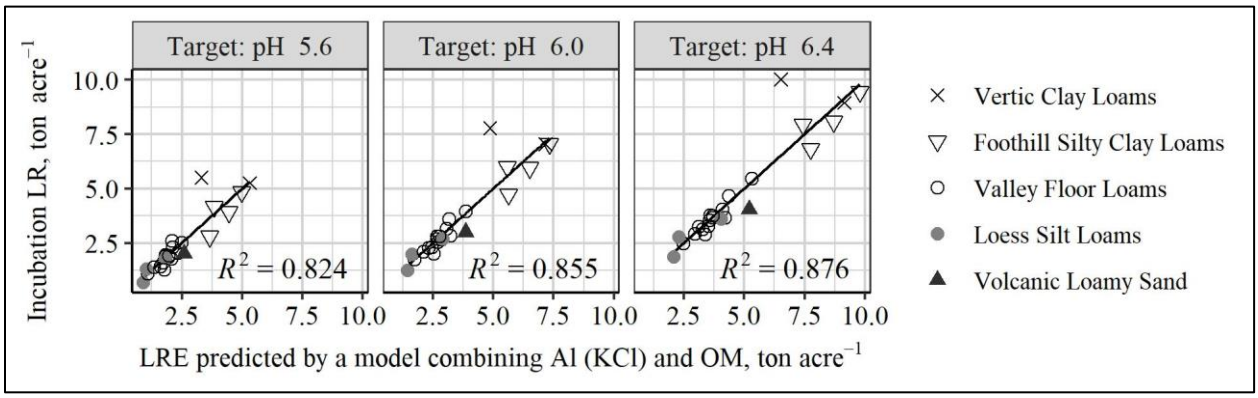

Figure 6. Correlation between incubation lime requirement and a model using measured Al (KCl-extractable) and Organic Matter ('OM', measured by Walkley-Black method).

Reshaping Lime Requirement Estimate Recommendations for Oregon

Based on our findings, the Sikora buffer pH method appears to be the most accurate alternative to the SMP buffer method for both Western and Eastern Oregon mineral soils. Fortunately, the Sikora buffer method also requires the use of non-hazardous materials and is relatively inexpensive to conduct, which will be of great interest to soil testing labs considering the change from the SMP to the Sikora buffer. Lime recommendations based on Sikora buffer pH will have to be adjusted, as the relationships between Sikora buffer pH and incubation lime response differed from the relationships between SMP and incubation lime response that were used to support the current SMP buffer pH based recommendations provided by OSU. We will work closely with Extension publishing services over the next several years to update lime and fertilizer guides to accommodate for Sikora buffer pH based lime recommendations. We are excited for this change, and look forward to improved accuracy in lime recommendations for Oregon soils based on low-hazard lab methodologies.

BENEFITS & IMPACT:

Soil testing labs in the PNW have been very supportive of this study, with several labs already planning to adjust their own buffer protocols and lime recommendations once we finish summarizing our findings. Our findings will have long-lasting impacts on growers working on acidic soils throughout the PNW, as they will be also used to support new soil test based LRE recommendations in OSU lime and fertilizer guides. Presentations on preliminary findings have been delivered at the local, regional, and national scale, with great interest from other regions that are

also evaluating various LRE methods for their soils. Journal articles reporting our findings and Extension articles providing recommendations are anticipated to be completed and published by the year 2022.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM:

We were fortunate to receive additional funding of $67,644 for this project. Oregon Tall Fescue Commission provided $57,644 and OSU Extension Services provided $10,000. Having these funds have allowed us to expand and improve upon the study to ensure that we would be able to develop solid buffer recommendations from this work.

FUTURE FUNDING POSSIBILITIES:

We are in the final stages of this project, therefore future funding is not of interest.