FRST Lime Calibration Project

Rajveer Singh | SERA-6, MASTPAWG, and NRSP11 Joint Meeting | June 8, 2026

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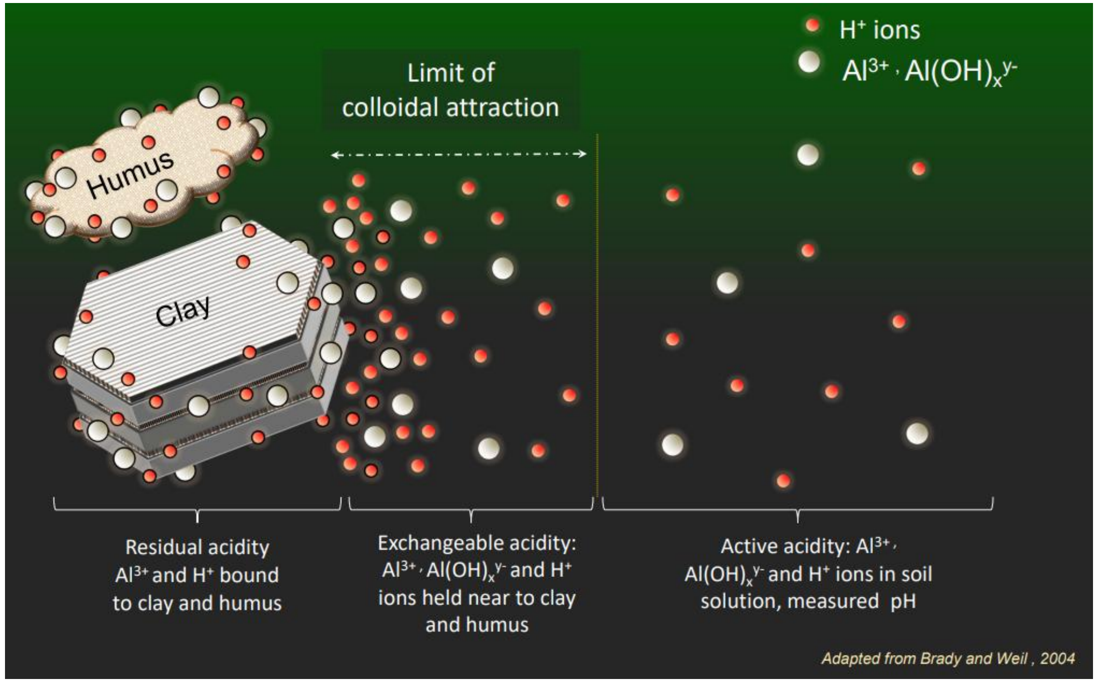
FERTILIZER RECOMMENDATION SUPPORT TEAM

Introduction

- **Soil acidity** is a major constraint to crop production.
- Liming is the primary practice used to increase soil pH.
- Effective liming neutralizes active, exchangeable, and reserve acidity.

How much lime should be applied?



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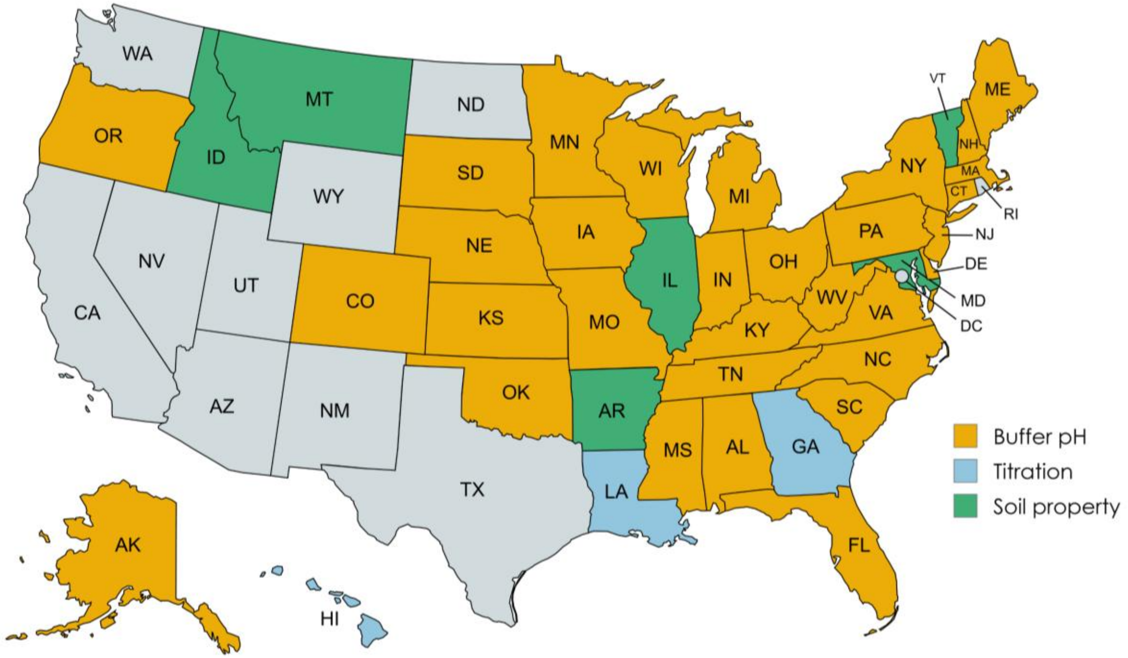


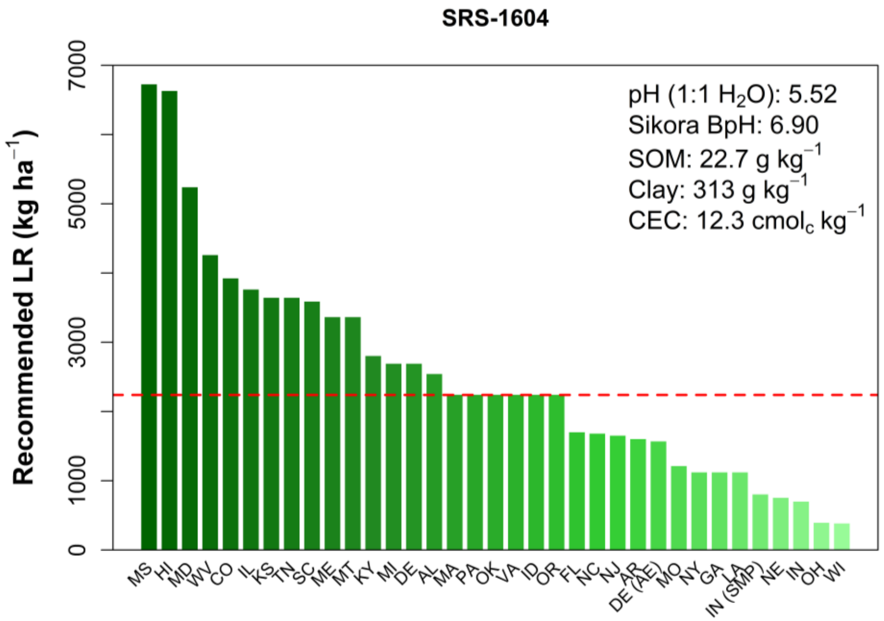
Buffer solutions: Woodruff, SMP, Adams–Evans, Mehlich, Mod. Woodruff, Mod. Adams–Evans, Sikora, Moore–Sikora, Sikora 2, and Mod. Mehlich

19 different methods are used by LGUs to make lime recommendations.

- **Buffer pH methods**: Most widely used approach
- **$Ca(OH)_2$ titration**
- **Soil property-based estimates**

These methods were developed and calibrated for specific states or regions.

Variation in lime recommendations across the United States



Assessment of soil pH and lime requirement methods and recommended lime rates for six reference soils across US land grant institutions

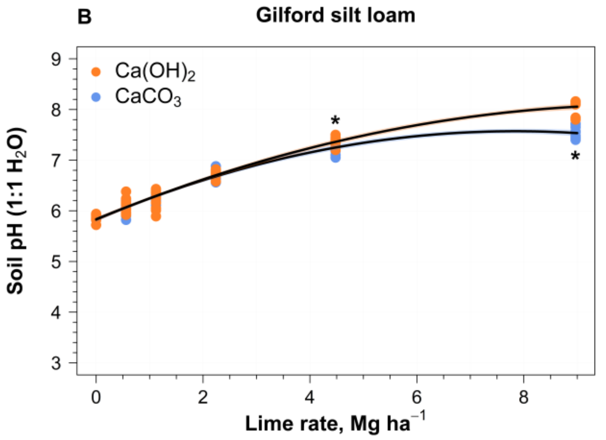
John D. Jones, Robert O. Miller, John T. Spargo, Frank J. Sikora, Manbir K. Rakkar, Nathan A. Slaton, Deanna L. Osmond

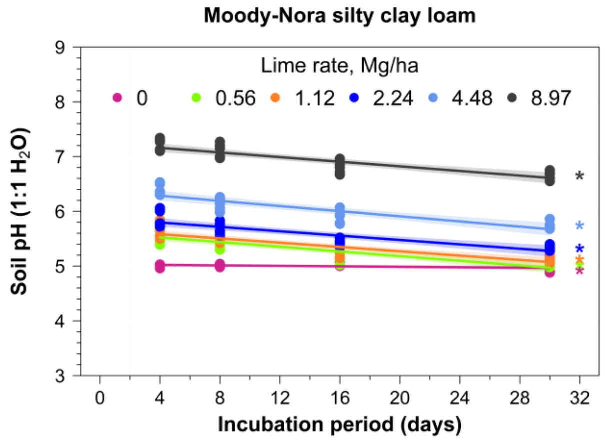
First published: 05 September 2025 | https://doi.org/10.1002/saj2.70116

- A 2022 survey evaluated lime recommendations from 34 land-grant universities using six reference soils.
- Recommended lime rates varied substantially among institutions.
- Results highlighted the need for **a national lime calibration effort**.

A National Lime Calibration Effort

The project aims to calibrate multiple LR methods using diverse U.S. soils

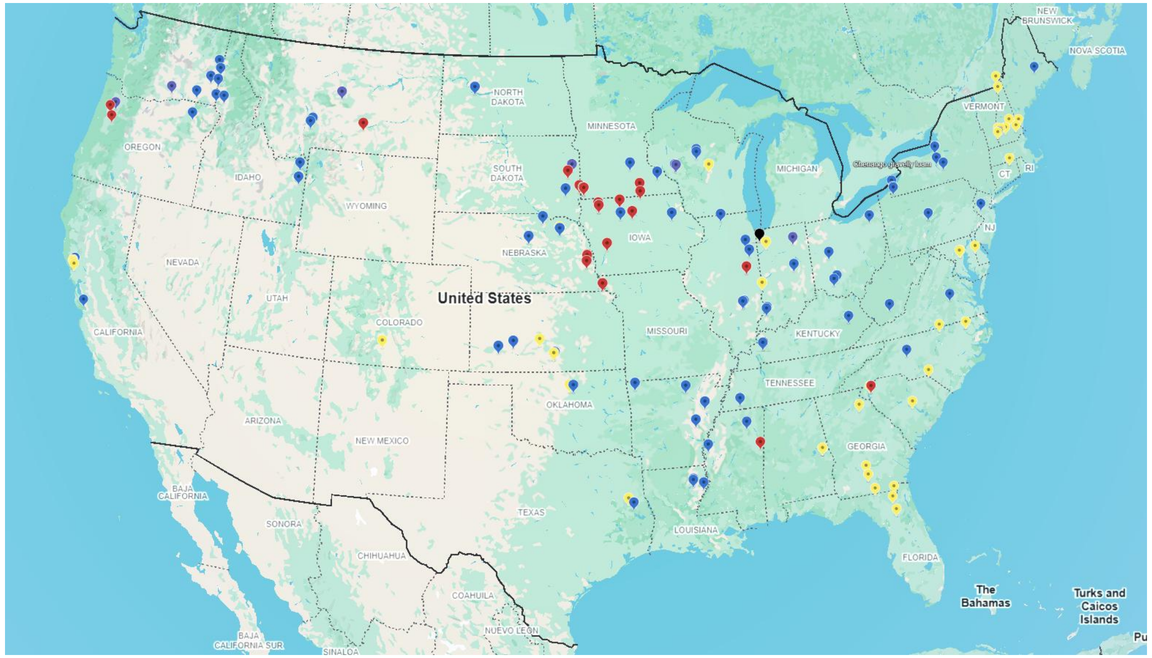




- A standardized protocol was needed for conducting soil incubations.
- A **pilot study** evaluated the effects of lime source [$CaCO_3$ and $Ca(OH)_2$] and incubation period (0–30 d).
- 4–8 d incubations with either $CaCO_3$ or $Ca(OH)_2$ were sufficient to characterize soil pH response to lime rate.

Materials & Methods

A total of **148 soils** were collected across the US



- pH (1:1 H_2O): 4.0–7.7
- Clay content (g kg^{-1}): 30–520
- Organic matter (g kg^{-1}): 2–190
- Mehlich-3 Ca (mg kg^{-1}): 100–5090

- **32 soils** with pH >6.2 were excluded

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Soils were characterized for different **buffer pH methods:**

- Adams-Evans: 5.71–7.82 (7.32, Median)
- Modified Adams-Evans: 6.84–7.96 (7.70)
- Moore-Sikora: 6.64–7.83 (7.58)
- Modified Mehlich: 4.93–6.34 (6.06)
- Modified Woodruff: 5.14–6.88 (6.52)
- SMP & Sikora: *Pending*
- Lime buffer capacity, mg kg^{-1} : 278–11498 (1316)

PennState

AUBURN UNIVERSITY

CLEMSON UNIVERSITY

UNIVERSITY OF GEORGIA

RUTGERS

Mizzou University of Missouri

LSU

ROCK RIVER LABORATORY, INC. AGRICULTURAL ANALYSIS

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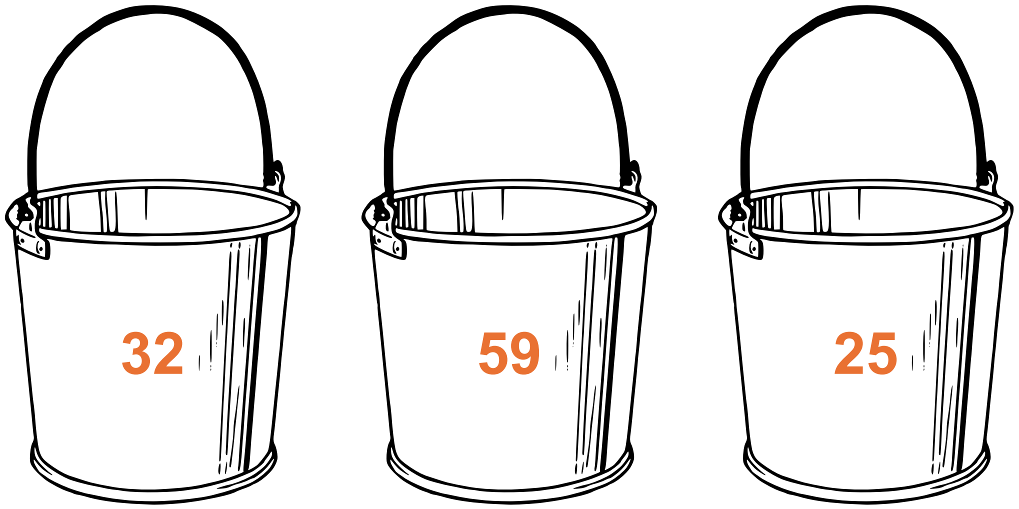
Soils grouped by lime requirement (target pH 6.5) using the Modified Mehlich BpH



<3.36 | 3.36–6.73 | >6.73

Mg ha^{-1}

Six lime rates (Mg ha^{-1}) applied:

- Group 1: 0, 1.12, 2.24, 3.36, 4.48, 6.73
- Group 2: 0, 1.12, 2.24, 4.48, 8.97, 13.45
- Group 3: 0, 2.24, 4.48, 8.97, 13.45, 17.93

Incubation setup

Sample size: 100 g per soil

Lime source: Reagent-grade $CaCO_3$

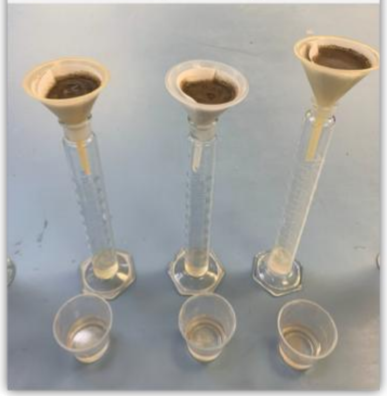
Soil moisture: 50–80% MWHC

Incubation period: 8–21 days

Temperature: 23 ± 2°C

Design: CRD (triplicate)

Soil water holding capacity



Lime application

Lime mixing

Soil–lime mixture

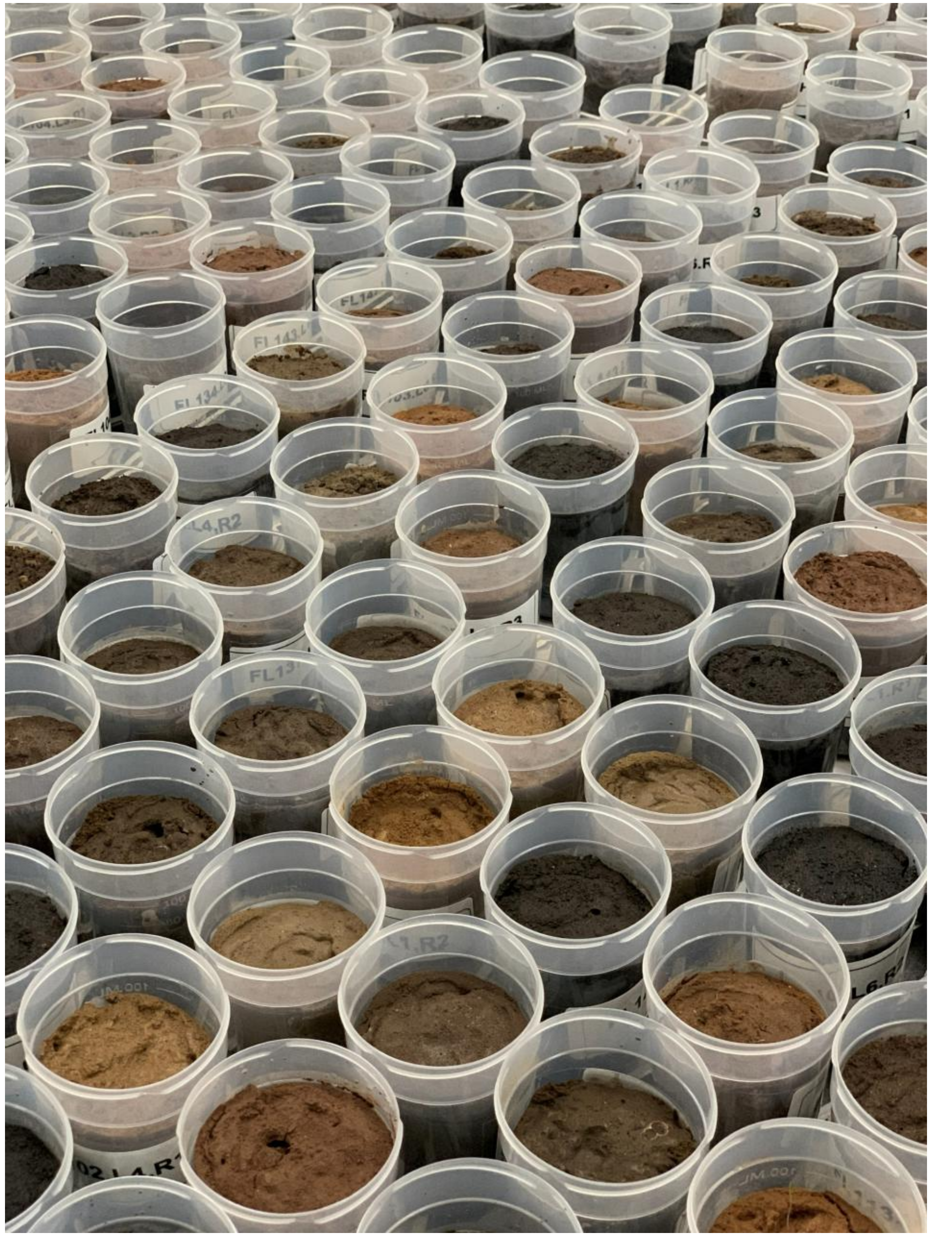
Moisture addition

Experimental setup

- **Post-incubation processing:**
  Oven-dried at 55°C for 48 h & ground to pass a 2-mm sieve.

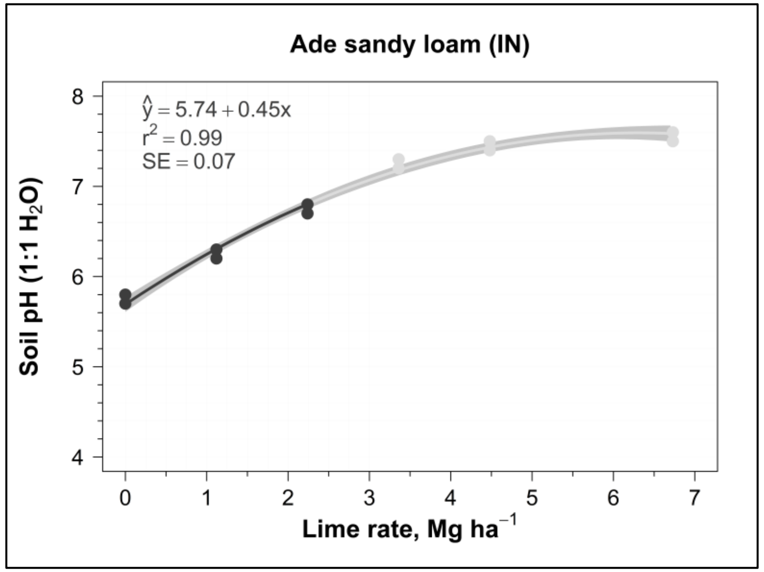
- **Post-incubation analyses:**
  - pH (1:1 & 1:2 H_2O)
  - pH (1:1 0.01 mol L^{-1} $CaCl_2$)
  - Mehlich-3 extraction

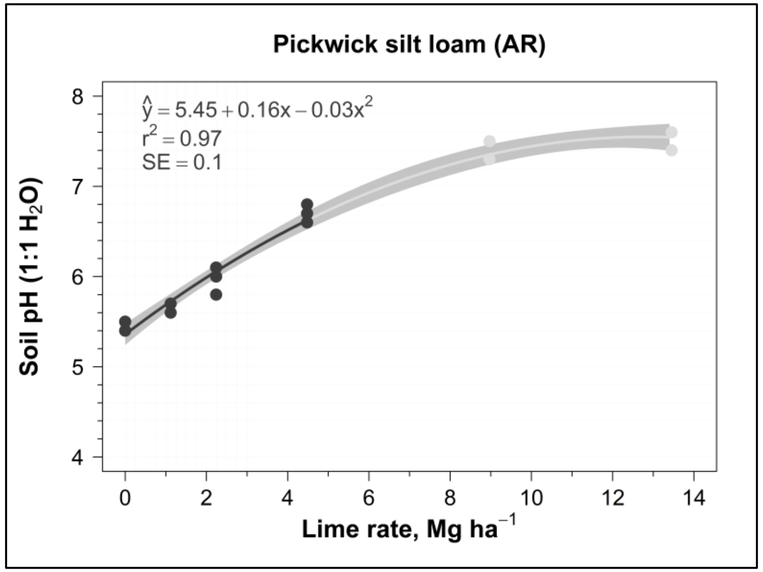
- **Data analyses:**
  - Soil pH response: Linear & quadratic regressions
  - Buffer pH methods evaluated against predicted LR
  - Forward stepwise regression

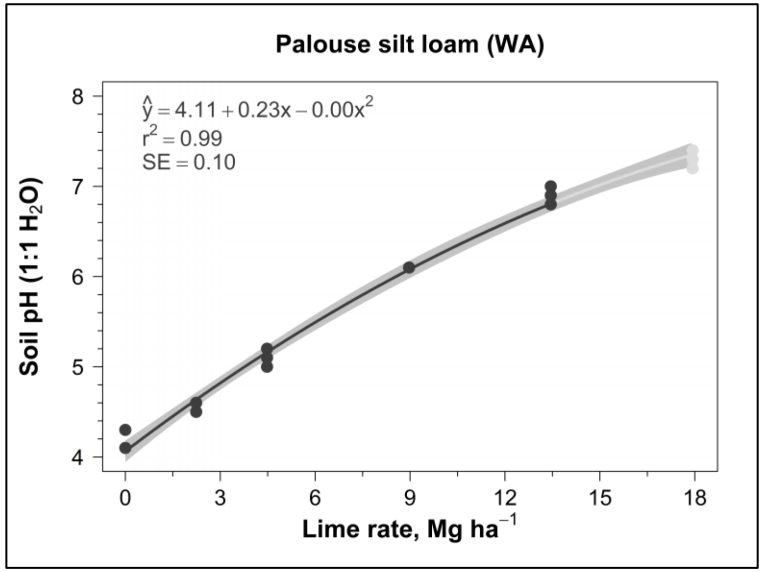


Results & Discussion

Soil pH response to increasing $CaCO_3$ application rate

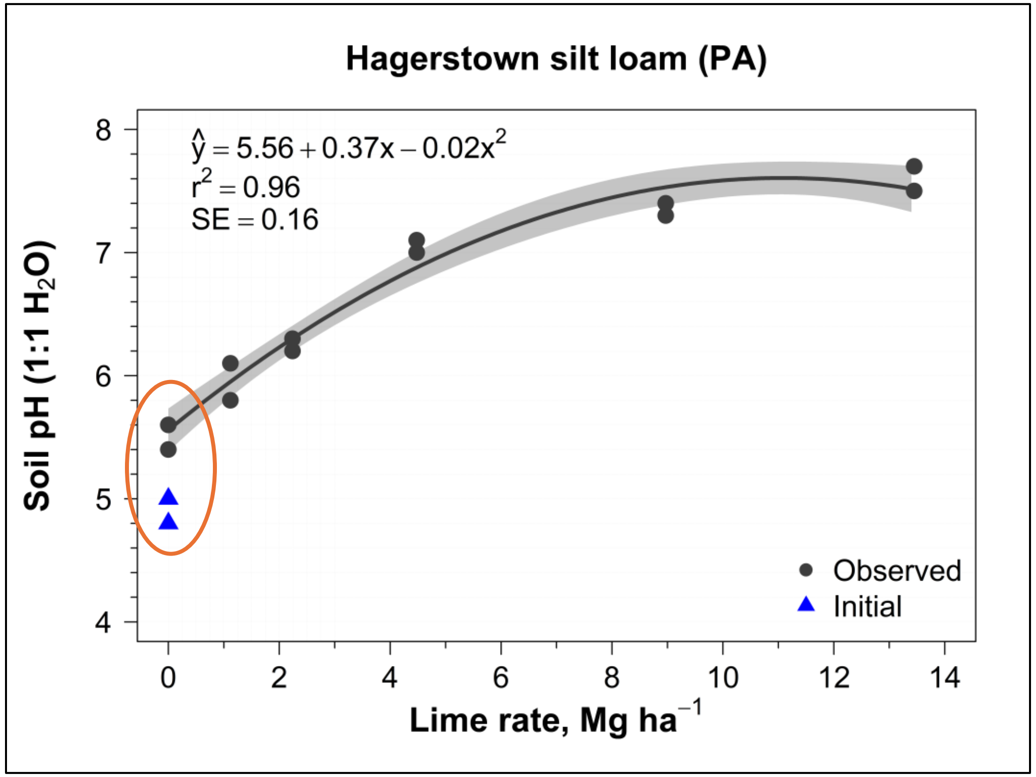


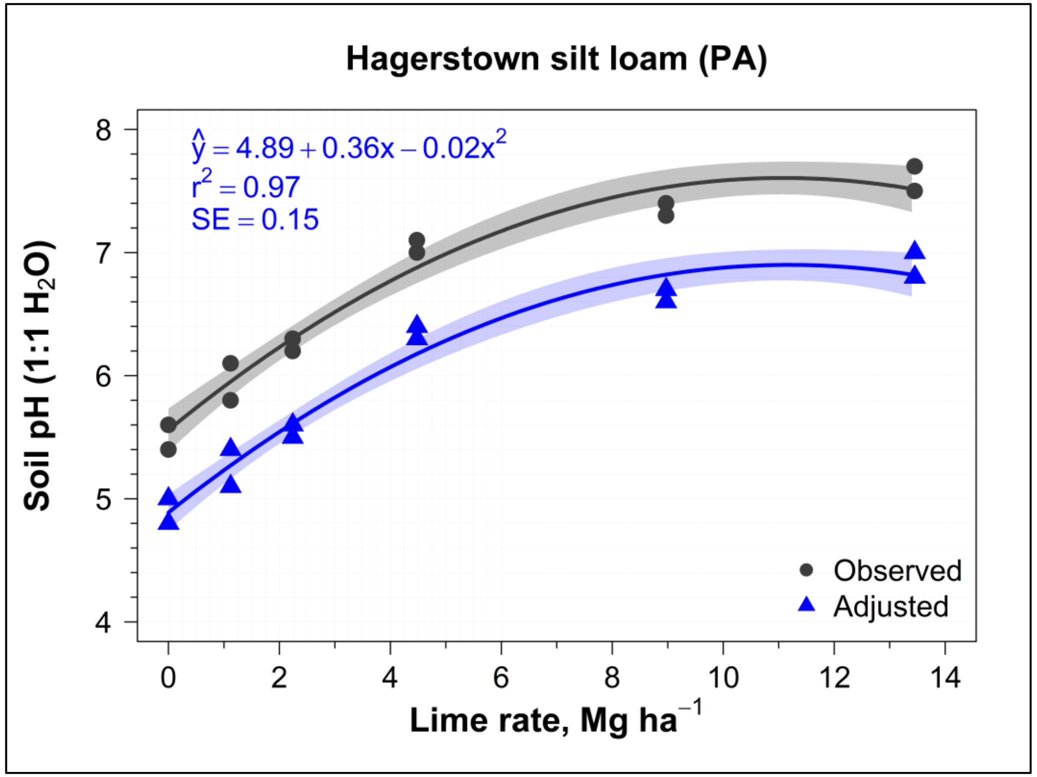




- Soil pH response modeled to a target pH of 6.8
- $r^2 = 0.87–1.00$

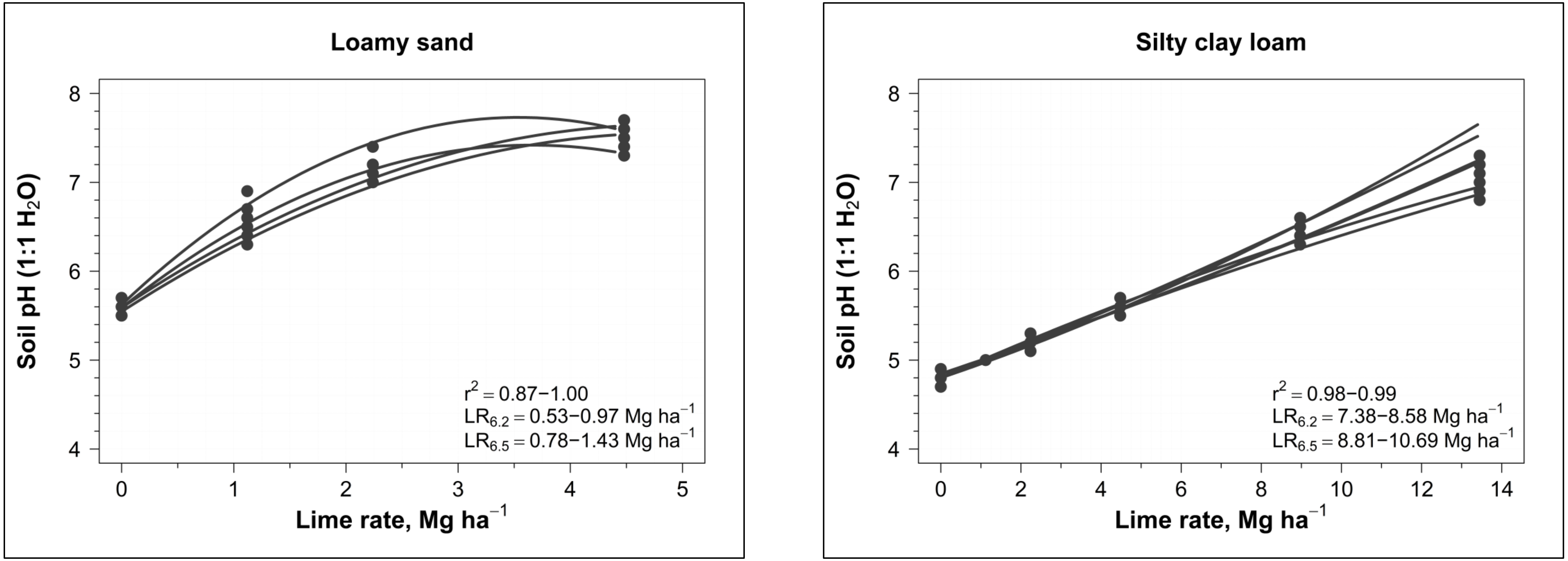
Control soil pH increased during incubation in 52 soils





Not unusual – ammonification and reducing conditions

Quality control: Two check soils

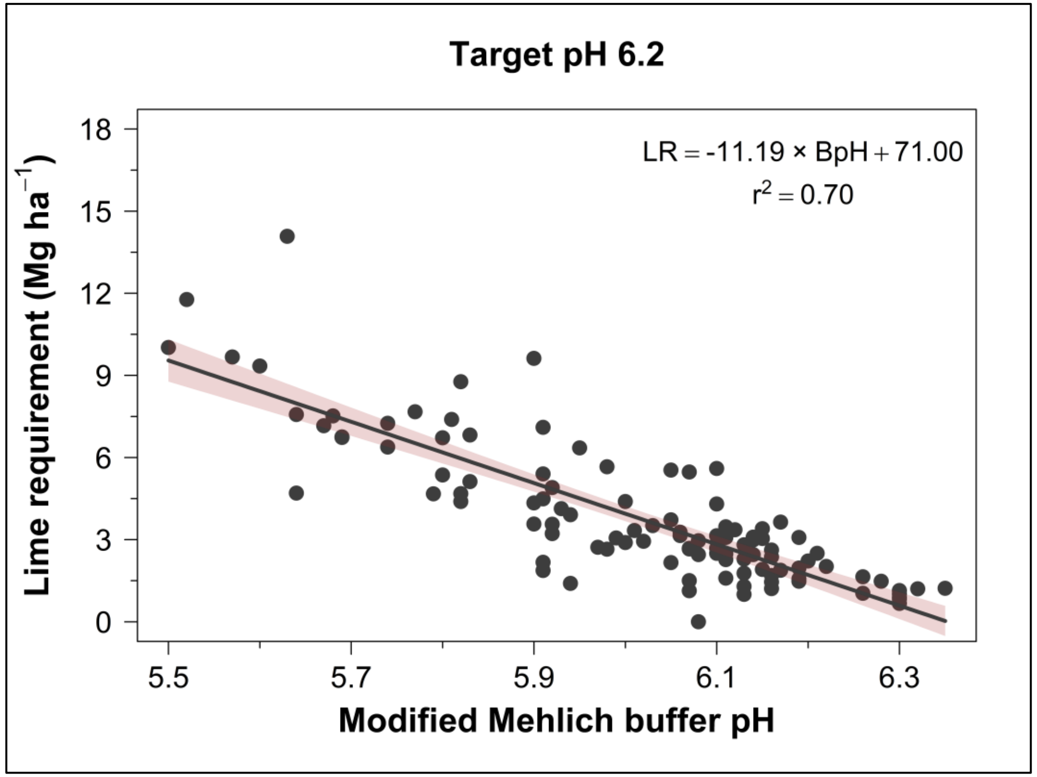


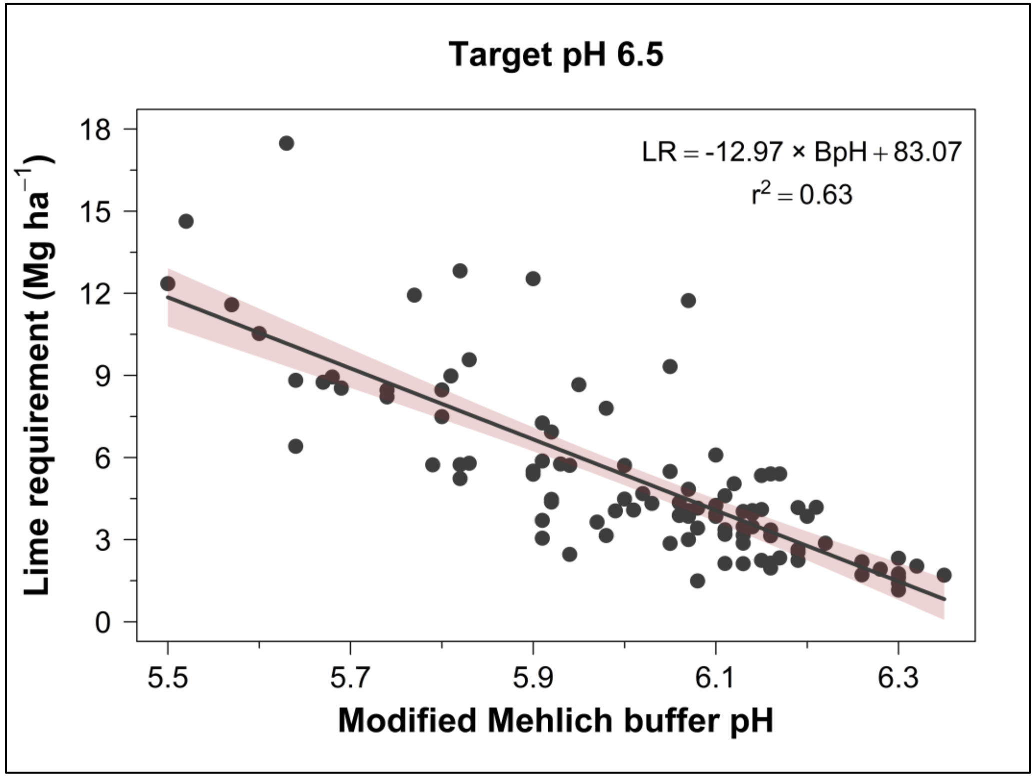
- CV = 25%
- CV (Marianna) = 10%

- CV = 10%
- CV (Marianna) = 0.1%

LR method evaluation

Modified Mehlich buffer pH





LR method evaluation

Modified Mehlich buffer pH

Communications in Soil Science and Plant Analysis, 39: 1848–1857, 2008

Comparison of Shoemaker–McLean–Pratt and Modified Mehlich Buffer Tests for Lime Requirement on Pennsylvania Soils

Ann M. Wolf,[1] Douglas B. Beegle,[2] and Bruce Hoskins[3]

Soil Science Society of America Journal

SSSA Soil Science Society of America

NUTRIENT MANAGEMENT & SOIL & PLANT ANALYSIS | Open Access

Evaluation of nonhazardous lime requirement estimation methods for Oregon soils

Carl Makepeace, Amber Moore, Dan M. Sullivan, David R. Huggins

First published: 15 July 2022 | https://doi.org/10.1002/saj2.20466 | VIEW METRICS

Communications in Soil Science and Plant Analysis, 39: 2270–2281, 2008

Modification of the Mehlich Lime Buffer Test

B. R. Hoskins and M. S. Erich

r^2 = 0.87–0.96

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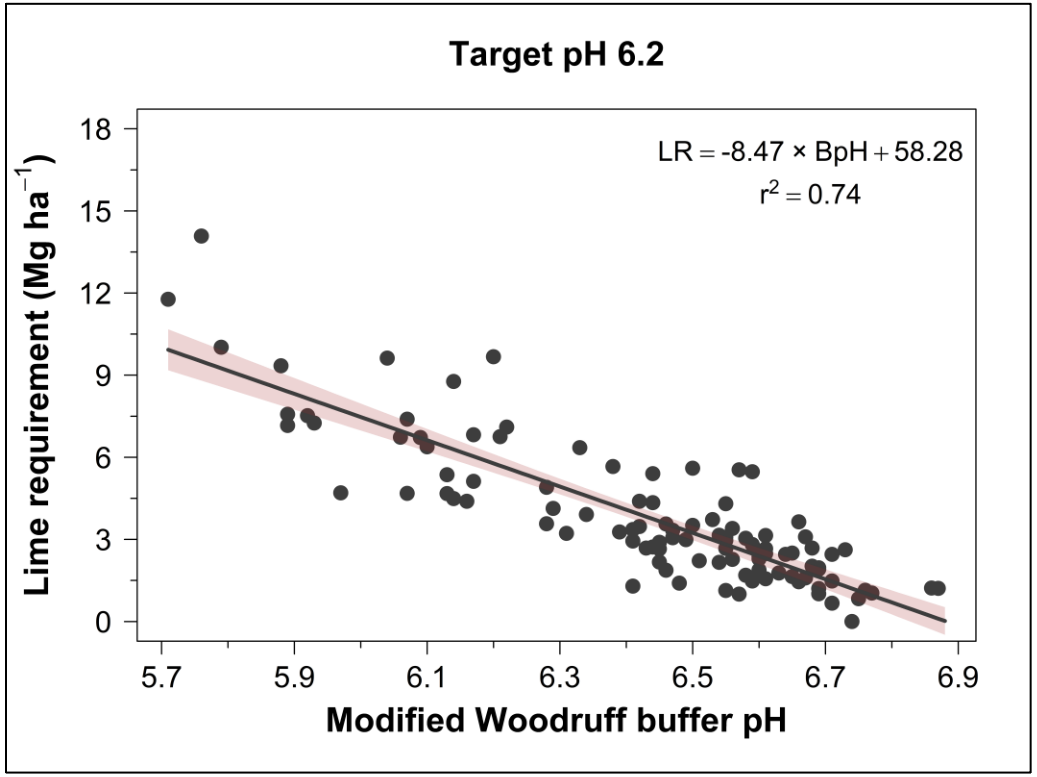
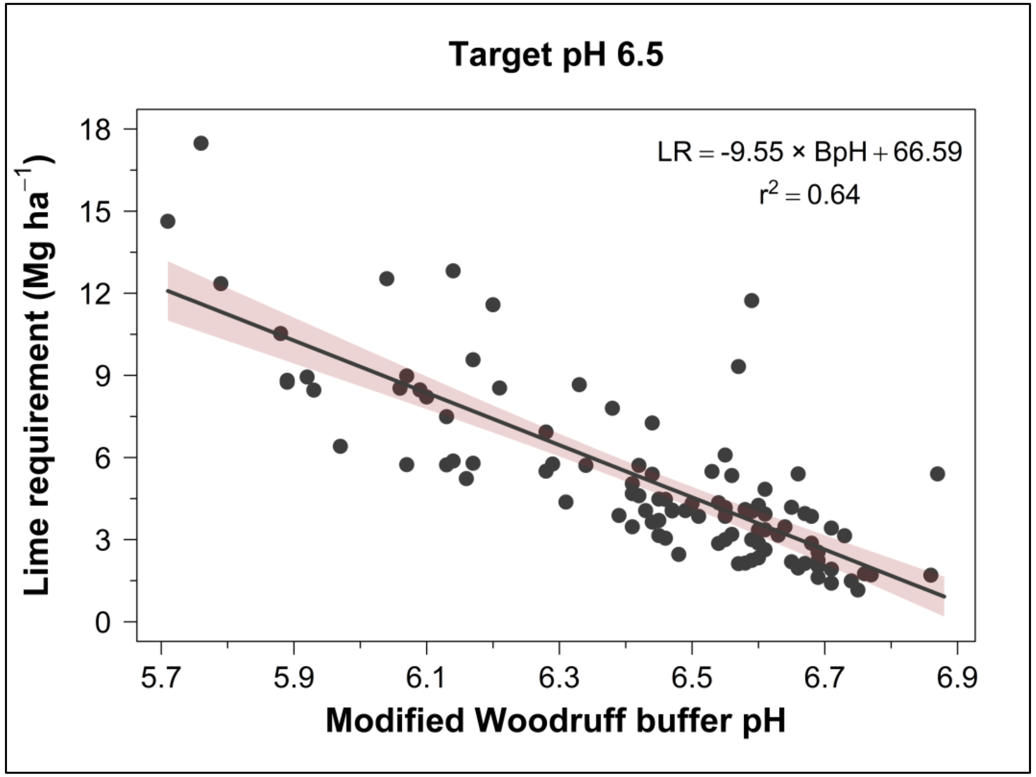
LR method evaluation

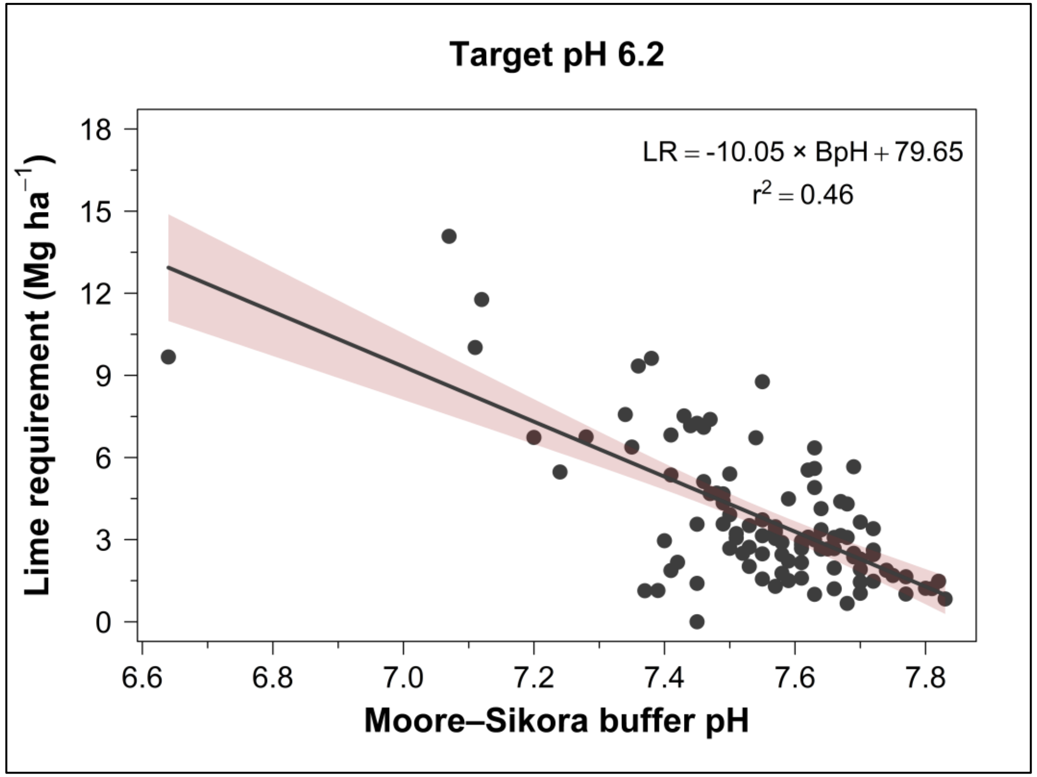
Modified Woodruff buffer pH

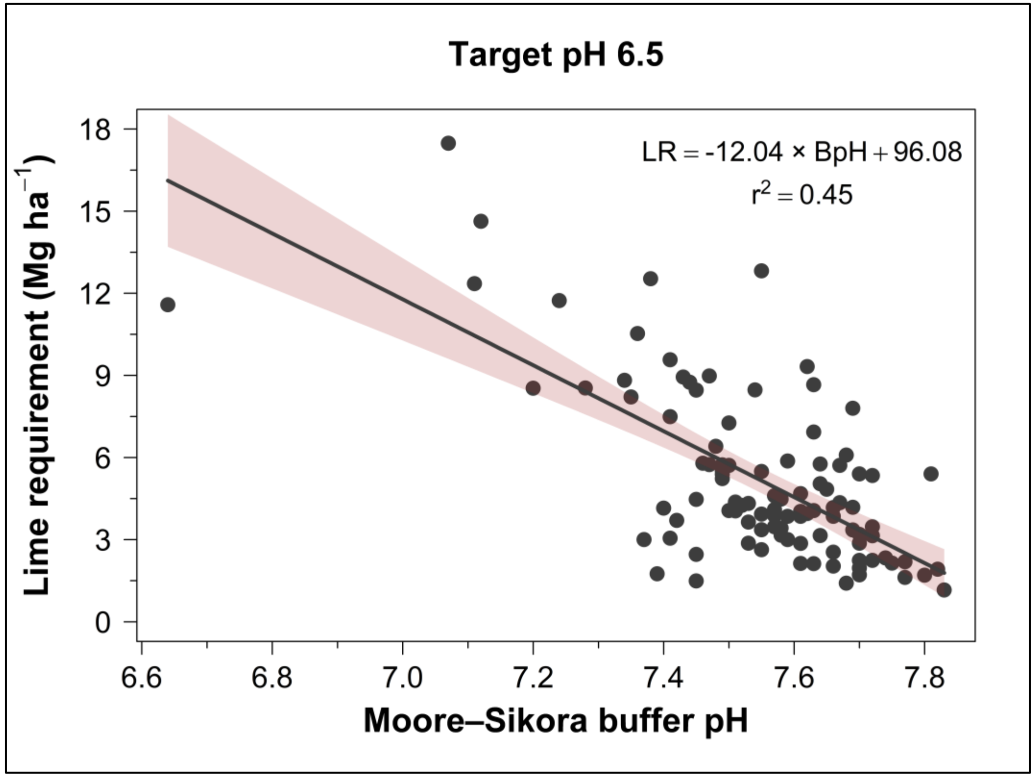




LR method evaluation

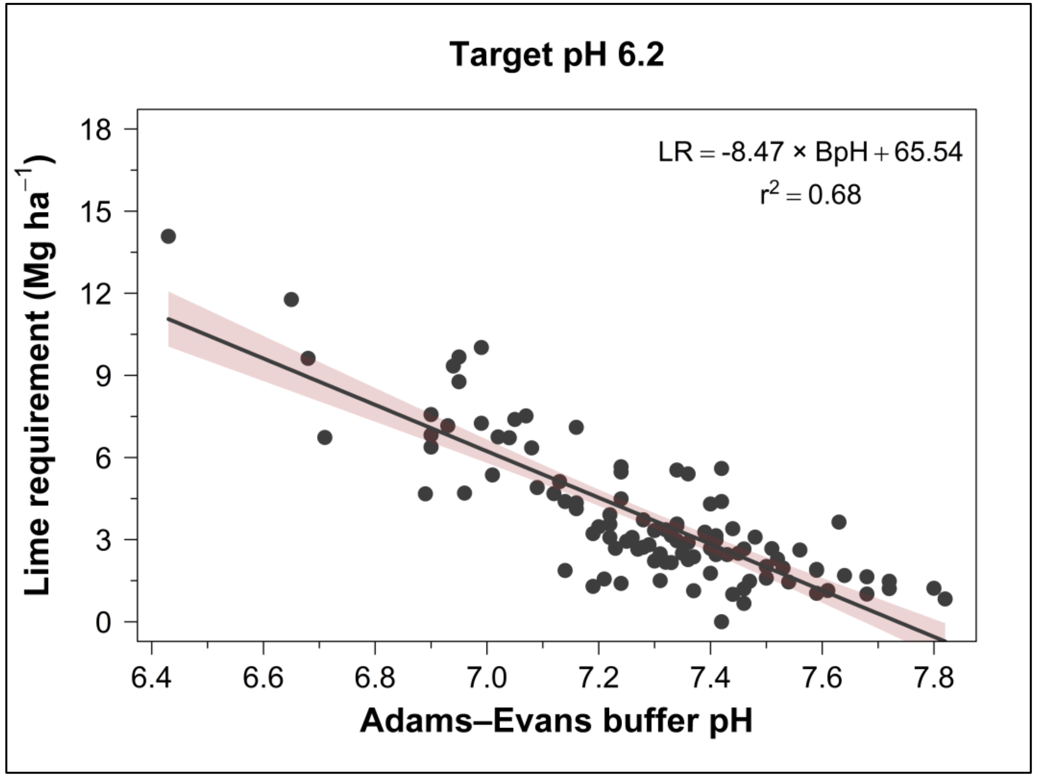
Moore–Sikora buffer pH

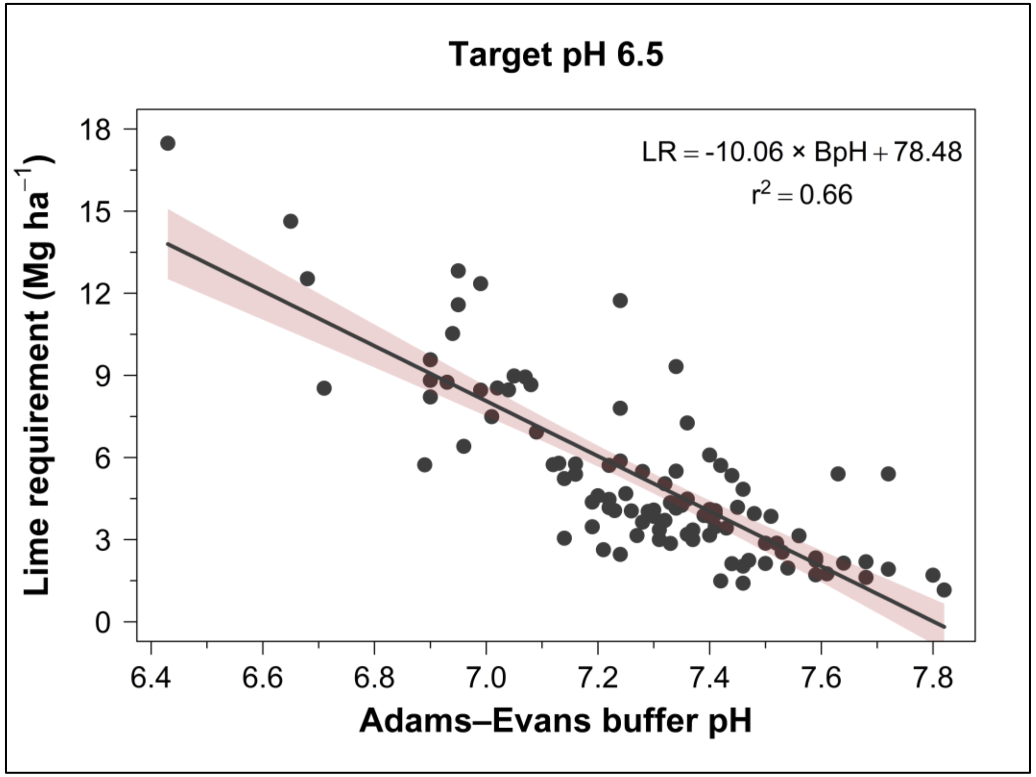




LR method evaluation

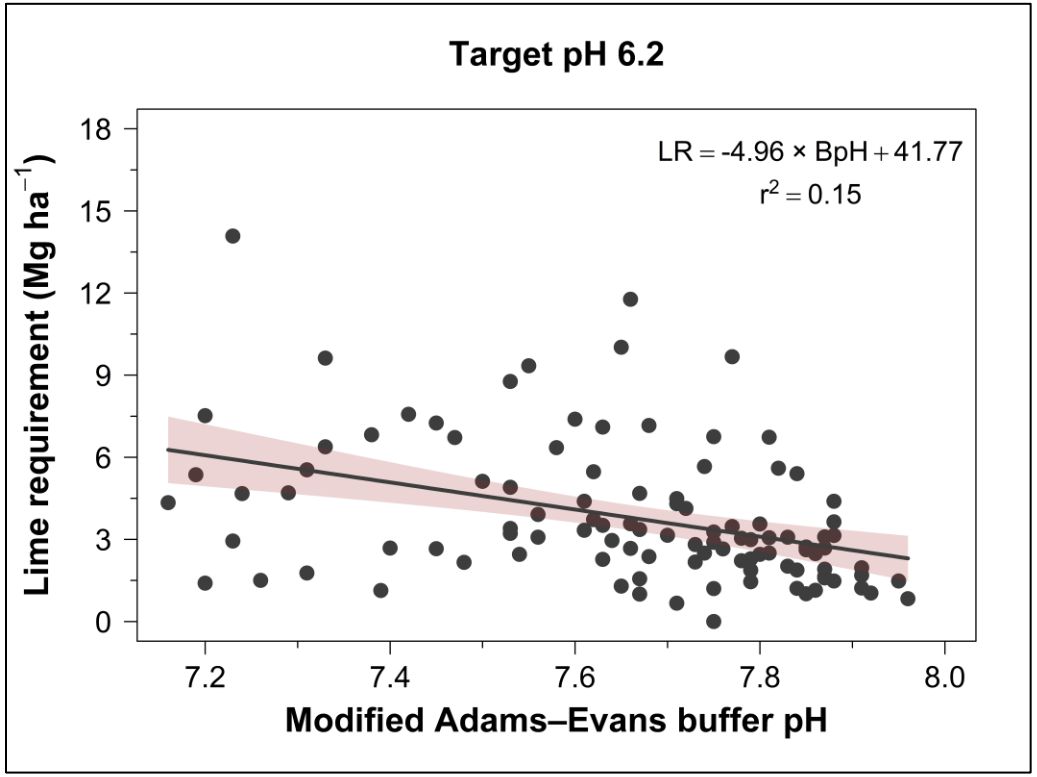
Adams–Evans buffer pH

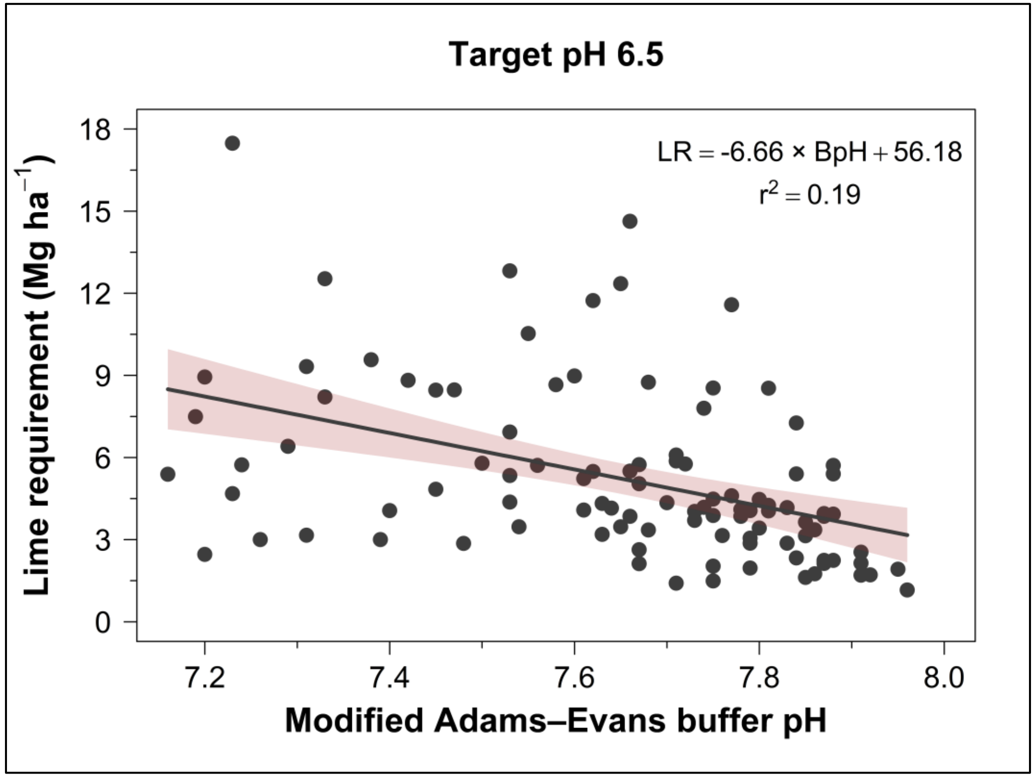




LR method evaluation

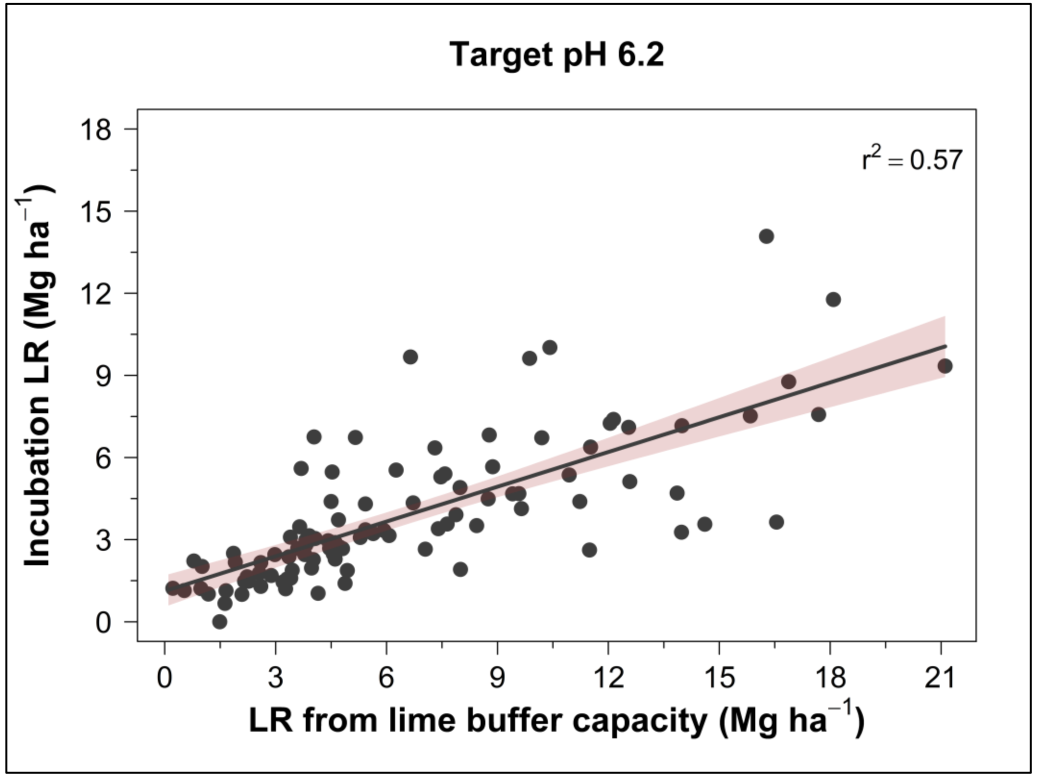
Modified Adams–Evans buffer pH

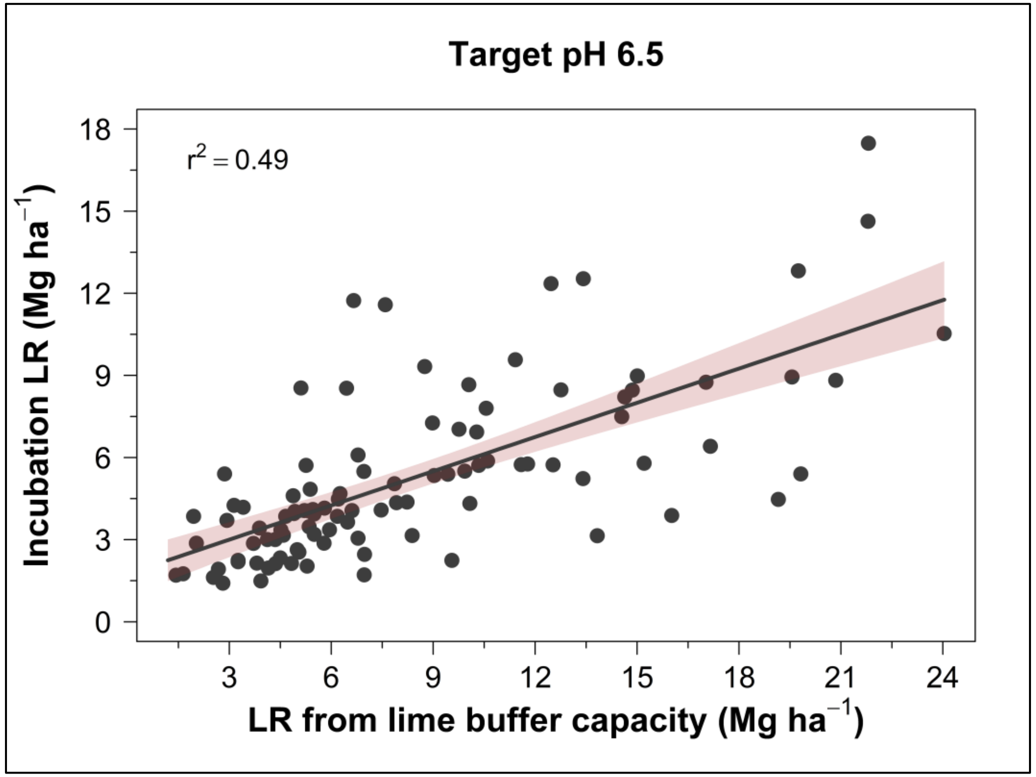




LR method evaluation

Lime buffer capacity





LR method evaluation

Routine soil test properties

Target pH	Multiparameter linear models for estimating LR (Mg ha^{-1})	r^2
6.2	LR = 21.29 – 3.41[**pH**] + 0.0003[**Ca**]	0.32
	LR = 15.89 – 3.12[**pH**] + 0.094[**OM**] + 0.016[**Al**] + 0.0036[**P**] + 0.0018[**Silt**] – 0.0013[**Mg**]	0.78
6.5	LR = 22.71 – 3.48[**pH**] + 0.0006[**Ca**]	0.22
	LR = 16.45 – 3.22[**pH**] + 0.126[**OM**] + 0.017[**Al**] + 0.0050[**P**] + 0.0023[**Silt**] – 0.0015[**Mg**]	0.75

Note: Soil test properties evaluated included pH (1:1 H_2O); Mehlich-3 extractable nutrients (mg kg^{-1}); EC (dS m^{-1}); KCl-extractable Al (mg kg^{-1}); organic matter by LOI (g kg^{-1}); and sand, silt and clay content (g kg^{-1}).

Wider adoption may be limited because **KCl-extractable Al** and **silt content** are not routinely measured.

Conclusions

- Modified Mehlich, Modified Woodruff, and Adams–Evans were the best-performing buffer methods (r^2 = 0.63–0.74).
- Modified Adams–Evans was the weakest predictor of LR (r^2 = 0.15–0.19).
- Soil test properties predicted LR with similar accuracy to the best buffer methods (r^2 = 0.75–0.78).
- Field validation is needed to confirm the laboratory-based LR relationships developed in this study.

Acknowledgement

FRST Lime Calibration Team

Amy Shober — University of Delaware
Robert Miller — ALP Program
Nathan Slaton — University of Arkansas
John Spargo — Penn State University
Luke Gatiboni — NC State University
David Kissel — University of Georgia (Retired)
Amber Moore — Oregon State University
Stephanie Murphy — Rutgers University
John Jones — University of Illinois
Deanna Osmond — NC State University
Shannon Alford — Clemson University
Manbir Rakkar — Ohio State University
Kurtis Schroeder — University of Idaho
Matt Yost — Utah State University
Daniel Kaiser — University of Minnesota

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Ted Gauthier — LSU AgCenter
Shannon Alford — Clemson University
Jason Thomas Lessl — University of Georgia
John Spargo — Penn State University
Rasel Parvej — University of Missouri
Caleb Stevens — Rock River Laboratory
Stephen Jones — Best-Test Analytical Services

UADA Soil Testing Program

Marianna Soil Testing Laboratory
Fayetteville Agricultural Diagnostic Laboratory

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Thank you!

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