Field Calibration of Woodruff, Mehlich and Sikora Buffer Tests for Determining Lime Requirement for Missouri soils

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Objectives:

1. To determine whether the Modified Woodruff Buffer test is accurately predicting the lime requirement for Missouri soils.
2. To calibrate the Modified Woodruff Buffer, Sikora and Mehlich buffer tests for Missouri soils.
3. To determine lime recommendations Equations for Sikora and Mehlich Buffers on Missouri soils the pH rages of 5.5 to 6.0; 6.0 to 6.5 and 6.5 to7.0.
4. Compare field calibration results with incubation study results for the buffer tests.

Procedures:

- A Field calibration study was established at Bradford, Greenley, Southwest, Delta and Hundley Whaley University of Missouri Research and Extension Centers. The Bradford, Delta, Greenley, and Hundley-Whaley sites were planted with corn-soybean rotations. The Southwest Center site was planted with forages. The Delta and Hundley-Whaley sites were plowed and the Bradford and Greenley sites were under No-till systems.
- Each experimental field sites received seven lime treatments (0, 250, 500, 1000, 1500, 2000 and 2500 ENM/ac to cover a wide range from low, recommended, and double the recommended lime rates. The Southwest Center site was limed at 0, 250, 500, 750, 1000, 1500, and 2000 ENM/ac. The liming material used in the study had an ENM of 680. The experiment was laid out in a randomized complete block design with four replicates. All the plots received University of Missouri recommended levels of N, P and K based on soil test.
- Soil samples were collected at 0-6” and 6-12” depths to measure top soil and subsoil pHs at the beginning of the study. Results are presented in Tables 1-5. Soil samples were collected at 45, 90, and 120 days after lime applications at the 0-6” depth. Soil samples were analyzed for pHs, and buffer pH using Woodruff, Mehlich, and Sikora buffers.
- Crop yield data was collected at all five sites. The yield data was correlated with the response received from lime requirement estimated by the three different buffer tests and was compared with the incubation studies results.

Progress Report for 2010:

A field calibration study was established at University of Missouri at Bradford (BF), Delta (DE), Greenley (GR), Huntley-Whaley (HW) and South West (SW) Research and Extension Centers in 2009. The initial soil pH_s for the BR, DE, GR, HW and SW were 5.1, 5.2, 5.3, 5.8 and 5.6 respectively. The BR, DE, GR, HW sites were planted with corn-soybean rotations and SW site

with tall-fescue. The BR, GR, SW sites were under no-till and the DE and HW were under conventional tillage systems. . Each site received seven lime treatments to cover a wide range from low, recommended LR, and 2xLR rates. The experiment was a randomized complete block design with four replicates. Soil samples were collected (0 to 15-cm) at the beginning and at 45, 90, 120, and 365-d after lime applications and analyzed for pH_s, and for buffer pH using MWB, MMB, and SBs. The yield data was collected at all five sites.

Results:

a. Lab incubation study:

The incubation study conducted by Nathan and Sun (2009) comparing Sikora and Mehlich buffers to the Woodruff buffer test for Missouri soils had promising results. The Sikora and Mehlich buffers were found to be well correlated with the Woodruff buffer test suggesting these buffers could be used as an alternative to Woodruff buffer for Missouri soils.

Lime requirements(LR) for soils selected for the incubation study were estimated and the relationship between the buffer pH and lime requirement for Modified Woodruff Buffer (MWB), Modified Mehlich Buffer (MMB) and Sikora Buffer (SB)for soils to achieve target pHs of 5.8, 6.3 and 6.8 are presented in Fig 1.a, 1.b, and 1.c. There was a linear relationship between the buffer pH values for MWB, MMB and SB tests and the lime requirement to target pH_s 5.8, 6.3 and 6.8. The MMB and SB were found to be slightly better predictors of LR than MWB at target pH_s of 5.8, as demonstrated by the slightly higher R^2 values than MWB (Fig. 1.a). At target pH_s of 6.3 and 6.8 the MMB was found to be a better predictor of LR, followed by SB and MWB (Fig 1.b and 1.c). The findings from the lab incubation study led to the field calibration of these buffers with yield response to evaluate these buffer tests for Missouri soils.

b. Field Calibration Study:

Lime requirement based on the field calibration study was estimated and the relationship between the buffer pH and lime requirement for MWB, MMB and SB for soils to achieve target pHs of 5.8, 6.3 and 6.8 are presented in Fig 2.a, 2.b, and 2.c. There was a linear relationship between the buffer pH values for MWB, MMB and SB tests and the lime requirement to achieve target pH_s 5.8, 6.3 and 6.8. The LR estimated for different target pHs based on the three buffer pHs from the field study was not consistent. At the target pHs of 5.8, the MWB was a better predictor of LR than MMB and SBs (Fig. 2.a). At target pHs of 6.3 the MMB was a better predictor of LR than MWB and SBs. (Fig. 2.b). At target pH_s of 6.8 the SB was found to be a better predictor of LR, followed by MMB and MWB (Fig 2.c)

The LR predictions based on lab incubation and the field calibrations were different. In the lab study, the lime was thoroughly mixed with ground, sieved, homogenized soil, and temperature and moisture conditions were kept at constant levels. Conversely, in the field study lime was not as uniformly mixed with the soil and there were natural variations in soil temperature and moisture. These conditions likely explain the different LR estimations for each study.

The yield response for the lime treatments at the BR, DE, GR and HW locations are presented in Table 1.a (metric units) and 1.b (English units). The yield response to lime treatments was not consistent. However, the yield response for lime treatments was high enough to be economic in most cases.

The field calibration results were inconsistent in estimating LR for different target pHs due to the variability that existed in the field (tillage, surface application vs. mixing), the findings from the first two years of the field calibration study prompted the need for an in-situ field incubation study in the field sites. The findings from the lab and in-situ field incubation studies and the field calibration studies will help selecting the most suitable lime requirement method and in developing the most efficient lime recommendations for Missouri soils.

Brief summary of the proposed in-situ field incubation study in 2011:

Lime incubations have been conducted for Missouri soils with laboratory and field application. The lime requirement estimates from the field study and the lab incubation were remarkably different. The field study includes control plots without lime addition. These control plots provide an excellent opportunity to address questions on various methods of measuring soil pHs after lime incubation and to obtain a better understanding of the mechanisms involved with differences in lime requirement from field studies versus laboratory incubations.

Methodology

Soil from the control plots in the field study will be incubated with lime under four methods. Three of the methods will involve incubation of lime with soil in the control plots in six-inch diameter PVC pipes placed vertically in soil at six-inch depth. To simulate thorough mixing of lime and soil in conventional tillage, Method A will involve mixing lime with all the soil placed in the pipe. The bottom of the pipe will have a screen to contain the soil in the pipe when removed at the end of the incubation and to allow water to leach as normally occurs in the field. Method B will be the same as Method A but has a solid bottom to prevent water leaching. A comparison of Methods A and B will determine the importance of salt leaching on soil pH buffer capacity. Method C will simulate application of lime in no-till field management with surface application of lime and an open bottom with a screen to allow water to leach. This treatment will have another screen at the three inch depth in the PVC pipe so soil can be sampled at 0-3 inches and 3-6 inches at the end of incubation to evaluate the translocation of lime into the soil. Method D is a laboratory incubation where soil water is maintained at field capacity or slightly less.

Table 1. Description of treatments

	Location	Bottom of PVC pipe	Mixing of lime
Method A	Field incubation in PVC pipe	Open bottom	Thorough mixing
Method B	Field incubation in PVC pipe	Closed bottom	Thorough mixing
Method C	Field incubation in PVC pipe	Open bottom	Surface applied
Method D	Laboratory incubation		

Four rates of ag lime are recommended at 0, 0.5x, 1.0 x, and 2x where x is the amount of ag lime required to reach a target pH. Ag lime will be used to simulate actual lime application as occurs

in the field. An ag lime source will be chosen with a good quality (ENM greater than 700) and the amount of lime to add will be based on the ENM value of lime. The ag lime will be analyzed to verify the ENM value. The ag lime will be thoroughly mixed before use in the in-situ field incubation study treatments.

Soils for the incubations will be collected from a 0 to 6 inch depth in the control plots of the field lime studies. The soil will be air-dried. The soil will not be pulverized in order to maintain as much of the original soil structure as possible. After adding lime to the soils, the soil will be placed in the PVC pipe in Methods A, B, and C or in plastic bags with open top for Method D. The soils will be incubated in-situ with lime for a period of 6 months in the field. At the end of incubation, soil will be collected from each treatment, air-dried, and ground to pass a 2-mm screen. The samples will be analyzed for pHw, pHs, and 3 buffer tests (MWB, MMB, and SB).

Data Analysis: Lime response curves will be determined for the various measured of soil pH (water, 0.01 M $CaCl_2$, and 1 M CaCl2). Soil pH buffer capacity will be determined from each of the lime response curves as the inverse slope (delta pH/mg ENM/kg soil) and compared amongst the various method of lime incubation. Lime requirements curves will be developed based on the field in-situ incubation study. Results from this study will be used with the lab incubation and field calibration studies in developing appropriate lime recommendations equations for Missouri soils using the three lime requirement methods. This study is timely to develop the lime recommendations equations and use it fine tune University of Missouri lime recommendations. Additional funds are being requested to complete this study in year 2011.

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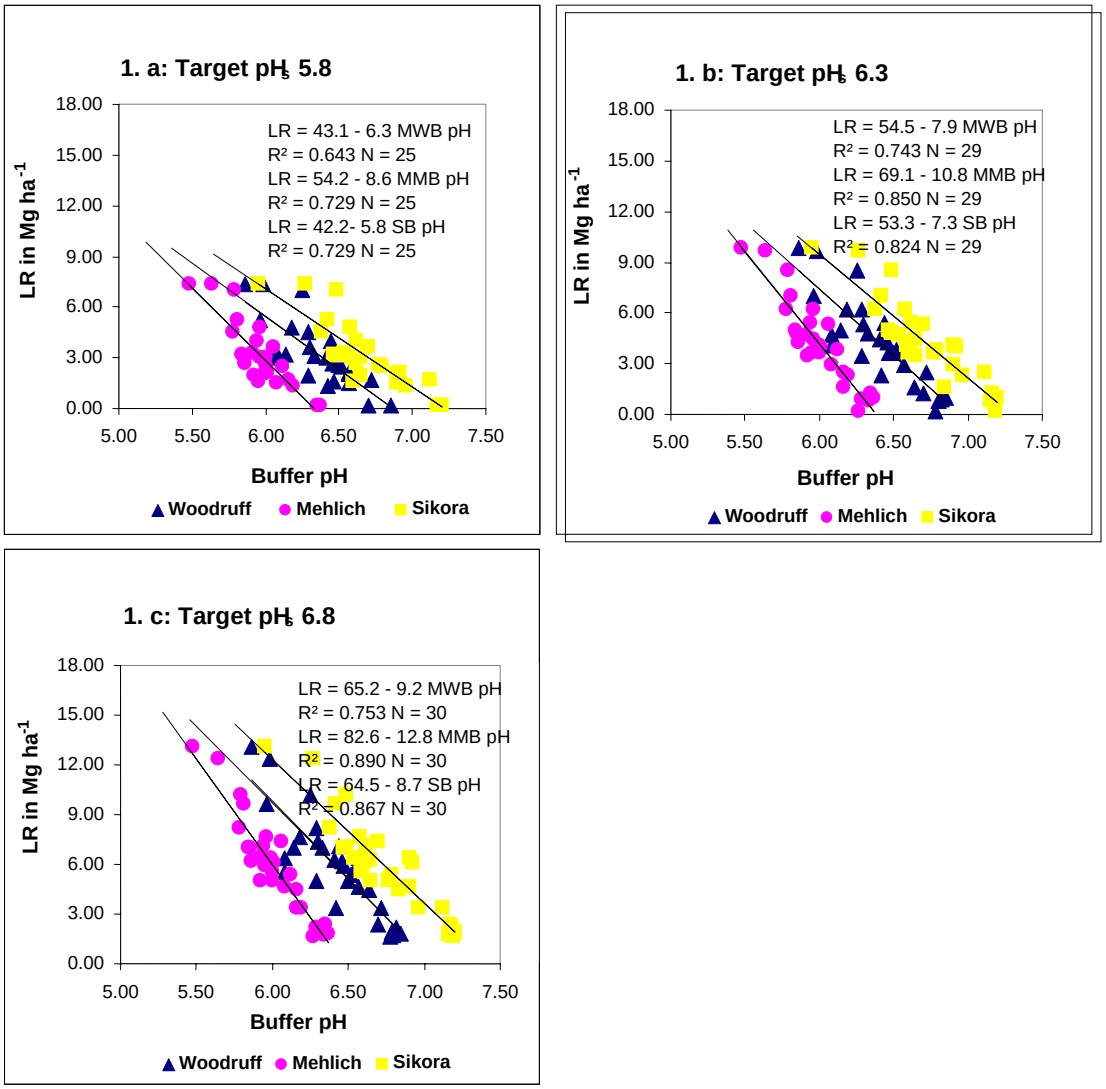

Fig. 1. Buffer pH vs lime requirement for (2a) target pHs 5.8, (2b) target pHs 6.3, and (2c) target pHs 6.8 based on lab incubation study.

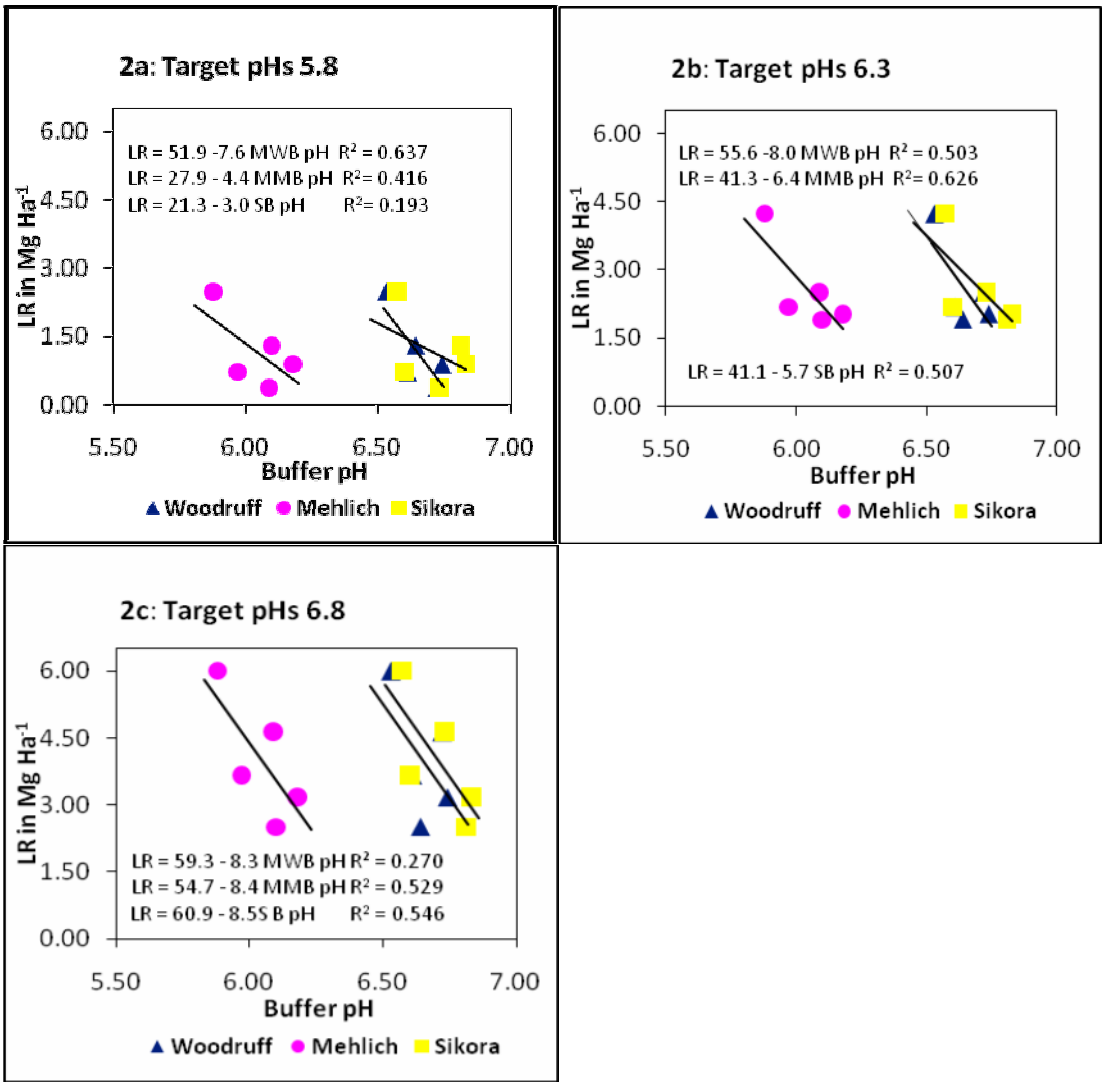

Fig. 2. Buffer pH vs lime requirement for (2a) target pHs 5.8, (2b) target pHs 6.3, and (2c) target pHs 6.8 based on field calibration study at 365 days after application.

Table 1.a: Yield response (Mg/ha) to lime treatments (ENM Mg/ha) at the field sites for 2009 and 2010

Lime Mg/ha ENM	BR corn Mg/ha 2009	BR beans Mg/ha 2010	DE corn Mg/ha 2009	DE beans Mg/ha 2010	HW corn Mg/ha 2009	HW beans Mg/ha 2010	GR corn Mg/ha 2009	GR beans Mg/ha 2010
0	5.66 ab	3.48 ab	9.16 b	1.464 d	12.83 b	3.45 ab	7.65 c	4.43 a
0.28	5.48 ab	3.86 a	9.93 ab	2.244 c	13.83 ab	3.31 b	8.53 bc	4.37 a
0.56	5.61 ab	3.08 b	10.13 a	2.342 c	14.26 ab	3.16 b	9.94 ab	4.63 a
1.12	5.41 ab	3.43 ab	10.43 a	3.220 a	14.34 ab	3.38 ab	10.54 a	4.43 a
1.68	6.30 a	3.40 ab	10.23 a	2.439 c	14.52 a	3.45 ab	10.69 a	4.36 a
2.24	4.84 ab	3.42 ab	10.13 a	3.090 ab	14.50 a	3.44 ab	9.37 abc	4.42 a
2.80	4.50 b	3.23 b	10.56 a	2.569 bc	14.61 a	3.61 a	8.59 bc	4.33 a

Table 1.b Yield response (bu/ac) to lime treatments (ENM lb/ac) at the field sites for 2009 and 2010

Lime	**BR- corn**	**BR-beans**	**DE -corn**	**DE-beans**	**HW -corn**	**HW -beans**	**GR –corn**	**GR-beans**
ENM lbs/ac	**bu/ac**	**bu/ac**	**bu/ac**	**bu/ac**	**bu/ac**	**bu/ac**	**bu/ac**	**bu/ac**
	2009	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**
0	**90.25**	**51.83**	**146.12**	**21.78**	**204.50**	**51.31**	**122.00**	**65.95**
250	**87.33**	**57.42**	**158.40**	**33.40**	**220.50**	**49.21**	**136.00**	**65.08**
500	**89.50**	**45.90**	**161.57**	**34.85**	**227.25**	**47.04**	**158.50**	**68.88**
1000	**86.33**	**51.10**	**166.32**	**47.92**	**229.25**	**50.31**	**168.00**	**65.98**
1500	**100.50**	**50.59**	**163.15**	**36.30**	**231.50**	**51.27**	**170.50**	**64.95**
2000	**77.25**	**50.92**	**161.57**	**45.98**	**231.25**	**51.20**	**149.50**	**65.78**
2500	**71.75**	**48.05**	**168.30**	**38.24**	**233.00**	**53.71**	**137.00**	**64.45**

Plan of work for 2011

March, 2011	Initial soil sampling of all 28 plots at 0-6” and 6-12” depths to measure surface and subsoil acidity.
April – May, 2011	Fertilizer applications, and planting of field calibration studies. Installing field incubation equipment in check plots and applying lime treatments and start the in-situ field incubation study.
July – September, 2011	Field observations, measurements and management of experimental plots. Collecting soil samples from the field incubation units and analyze them for pHs and buffer pH by the three methods (MWB, MMB, and SB).
October- November, 2011	Harvesting, yield measurements, end of season soil sampling, soil analysis.
December, 2011	Statistical analysis, data summary and report writing Final report and a manuscript will be submitted for Soil Science Society of America Journal.

This is the second year of the field calibration studies and study will be continued until 2011. Three years of field calibration data will be summarized with the lab and in-situ field incubation and a manuscript will be written for publication in Soil Science Society or Agronomy Journal.

Budget:

CATEGORIES	Year 2011
A. Salaries Senior Lab Technician (20%) General Labor for help with field work at the rate of $9:00 per hour 1600 man hours	 $5,842 $14,400
B. Fringe Benefits Fringe for Lab Technician (25%)	 $1,753
TOTAL SALARIES AND FRINGE BENEFITS	$21,995
C. Travel Travel to five field sites To present research findings at Field days & National Meetings	 $1,500 $600
TOTAL TRAVEL COSTS	$2,100
D. Equipment	
TOTAL EQUIPMENT use and maintenance COSTS	$2,000
E. Other Direct Costs Soil analysis Field and lab supplies Publication cost	 $6,100 $2,000 $800
TOTAL OTHER DIRECT COSTS	$8,900
TOTAL REQUEST	**$34,995**

Note: The above budget is for competing the third year of field calibration and for completing the in-situ field incubation study.

***J**ustification:*

Salaries and Fringe Benefits: Funds are requested support of a senior lab technician for 2.5 months based on an annual salary of $29,210, 30% fringe benefits.

Travel: Covers cost of travel to the five field sites located in through out the state of Missouri. For soil and plant samples collections, setting up of field incubation study, field measurements, and harvesting. Funds will be required to travel for field day presentations and to present the research work in the regional and national meetings.

Field and lab supplies: Seeds, fertilizer, lime, soil samplers, sample bags, making field incubation units, and other field and lab supplies.