2-1-1989

TB134: A Laboratory Study to Assess Methods for Predicting pH Change of Ash Amended Forest Soils

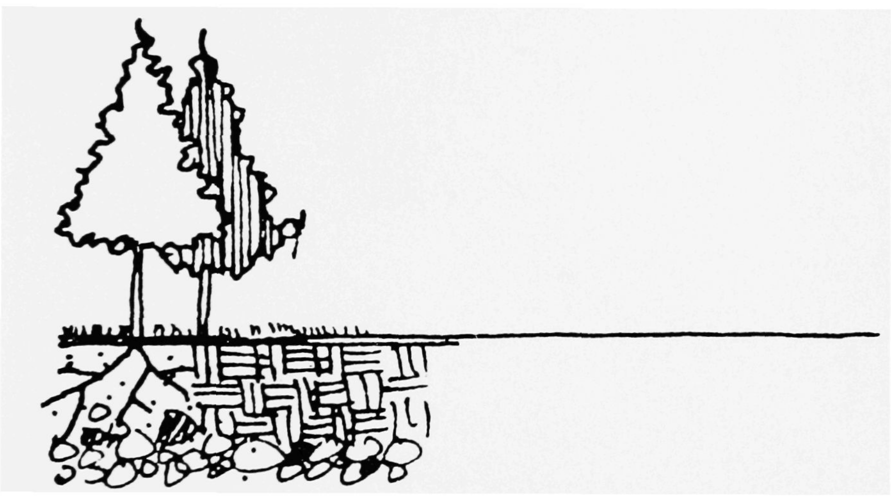
Yvonne L. Unger

Ivan J. Fernandez

ISSN 0734-9556

A LABORATORY STUDY TO ASSESS METHODS FOR PREDICTING pH CHANGE OF ASH AMENDED FOREST SOILS

Yvonne L. Unger
and
Ivan J. Fernandez



MAINE AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF MAINE
ORONO, MAINE 04469

Technical Bulletin 134

February 1989

A LABORATORY STUDY TO ASSESS METHODS FOR PREDICTING pH CHANGE OF ASH AMENDED FOREST SOILS

By

Yvonne L. Unger

Graduate Assistant

and

Ivan J. Fernandez

Associate Professor

Department of Plant and Soil Sciences

University of Maine

Orono, Maine 04469

Technical Bulletin 134

February 1989

INTRODUCTION

Site characterization and monitoring procedures for soils have been outlined by Maine's Department of Environmental Protection due to increased land spreading of wood-ash. Required procedures include determination of lime requirement. Several methods for determining lime requirement exist. However, available lime requirement tests were developed for use in traditional agriculture, and the accuracy of these methods when used to predict the response of forest soils has not been investigated. Lime requirement testing is important for land spreading of wood-ash because it describes the amount of lime required to raise soil pH a given amount. Knowing the liming potential of wood-ash, the lime requirement test can be used to prescribe wood-ash loading rates to soils and to predict the resultant change in soil pH. The objective of this study was to compare several commonly used lime requirement tests and soil capacity factors for their ability to predict pH change following wood-ash amendment. The ability to predict pH change is important because it is one of the criteria used to prescribe rates of ash amendment to forest soils.

MATERIALS AND METHODS

Soils

The six forest soils used in this experiment were the O and B horizons from a Marlow (coarse-loamy, mixed, frigid Typic Haplorthod) and Telos (coarse-loamy, mixed, frigid Aquic Haplorthod) soil, and the B horizon from both a Hermon (sandy, mixed, frigid Typic Haplorthod) and Buxton (fine-silty, mixed, mesic Dystric Eutrochrept) soil. Marlow, Telos, and Hermon soils are all derived from basal till, whereas Buxton soils are derived from marine sediments. The soils, once collected, were air-dried on paper-covered benches in the greenhouse and thoroughly homogenized.

Lime Requirement Tests

Soil lime requirement (LR) was determined by five different methods on each of the six soil horizon materials. All five methods were assessed for their ability to predict pH change following ash amendment and were therefore considered potential "lime requirement" (LR) methods. Methods used to measure LR included the Schoemaker, McLean, and Pratt single buffer (SMP-SB) and double buffer (SMP-DB) (McLean 1982), and the Mehlich pH method (Reference Methods for Soil Testing 1980). The SMP-SB method is based on a relationship generalized for all soils and developed by calibrating the calculated LR from the buffer pH against actual changes in soil pH measured following $CaCO_3$ amendments. SMP-DB is similar to the SMP-SB, but takes into consideration the buffering capacity of the soil (McLean 1982). In both the SMP-SB and SMP-DB methods the desired pH level can be selected. The Mehlich method is calibrated against salt-exchangeable acidity, and the target pH is not preselected. Instead, lime is applied at a rate that neutralizes all or a portion of the salt-exchangeable acidity that has been experimentally determined to be optimum for plant growth.

The soil capacity factors measured were Aluminum (Al-P) and Lime (L-P) potential (Arberg 1986), both theoretically based soil properties governed by soil-solution chemical equilibria. Both Al-P and L-P were calculated using solution concentrations of Al and Ca after the soil was equilibrated with dilute 0.002 M $CaCl_2$. Al-P is defined as (3pH - pAl) and L-P as (pH - 1/2 pCa).

Experimental Design

Twelve 50 g samples of each soil horizon were placed in 400 ml beakers. Of the 12 samples, six were treated with the equivalent of 8 Mg ha^{-1} wood-ash (on a mass equivalent basis). The remaining untreated samples served as controls. After thoroughly mixing the soil and ash, all of the samples were gravimetrically brought to 75% of the predetermined field capacity with distilled-deionized water (DDI). The beakers were loosely covered with Parafilm and allowed to incubate at room temperature. Incubation times were 1, 7, and 30 days. At the end of each incubation period, the pH of 2 treated samples and 2 control samples was determined. Soil pH was measured in DDI water using a 1:2 soil solution ratio and in 0.01 M $CaCl_2$ (pH_s) using a 1:2.5 dilution for mineral soil. For organic horizon materials, dilutions were 1:5 (soil:solution) with DDI water and 1:7.5 with 0.01 M $CaCl_2$. Soil pH was determined using a glass electrode and a Corning Model 145 pH meter.

RESULTS AND DISCUSSION

Results from the lime requirement tests were regressed against changes in the pH of the soils following ash amendment and are shown in Table 1. The highest coefficient of determination existed between the pH change over one day of incubation (pH_w) and the Mehlich method. When the analysis was performed on all soils the r^2 value of 0.43 increases to 0.90 when the regression is performed using results from mineral soils only. Although a low sample size indicates a need for caution in drawing conclusions from this data, the results call into question the use of traditional, agricultural methods on forest soils and identify the Mehlich method as worthy of further evaluation.

Errors in LR values can occur with the SMP-SB method as a result of decreased reactivity of H^+ in high organic matter soils and an increased reactivity of H^+ in acid-leached soils (McLean 1982). Using SMP-SB to determine the LR of organic forest floor and acid-leached subsurface mineral horizons does not appear to be a suitable method given these results and indications from the literature.

The SMP-DB method was designed to improve the accuracy of LR predictions for soils having low LR. Results from the regression analysis (Table 1) indicated that SMP-DB was better correlated with change in pH than the SMP-SB method, but both methods appeared highly ineffective for forest soils. Tran and van Lierop (1982) also found, after recalibration, that the SMP-DB was not substantially more accurate than SMP-SB. In either case the correlations were poor and indicated little practical utility for these methods for forest soil testing.

The weak relationship between Al-P results and pH change from ash amendment indicates that it, also, is not a suitable soil parameter for predicting forest soil pH change from ash amendment. Extractable Al is sometimes used as an index for LR in agriculture; however, the extracting solution typically used (1 N KCl) has a much higher ionic strength (McLean 1982) and probably extracts much more Al, than does the 0.002 M $CaCl_2$ used for Al-P. A similarly poor correlation existed using L-P indicating it also is not a potentially useful forest soil measurement for predicting LR.

Table 1. Coefficients of Determination (i.e. r^2) for regressions between results of lime requirement tests and pH change from ash amendment (n=6).

Days	pH	Mehlich		SMP-SB		SMP-DB		Al-P*		L-P	
		r^2	prob>F	r^2	prob>F	r^2	prob>F	r^2	prob>F	r^2	prob>F
						Mineral soils (n=4)					
1	pHw	0.90	0.05	0.10	0.78	0.14	0.62	0.85	0.25	0.07	0.73
	pHs	0.81	0.10	0.18	0.58	0.23	0.52	0.94	0.88	0.03	0.89
7	pHw	0.68	0.17	0.05	0.77	0.02	0.84	0.98	0.76	0.56	0.23
	pHs	0.71	0.16	0.04	0.81	0.07	0.74	0.99	0.04	0.20	0.55
30	pHw	0.96	0.02	0.03	0.84	0.01	0.90	0.30	0.63	0.63	0.38
	pHs	0.99	0.003	0.001	0.97	0.01	0.91	0.46	0.52	0.21	0.92
						All soils (n = 6)					
1	pHw	0.43	0.16	0.02	0.78	0.05	0.67	0.03	0.78	0.01	0.97
	pHs	0.24	0.32	0.06	0.63	0.11	0.51	0.05	0.71	0.01	0.85
7	pHw	0.26	0.31	0.002	0.94	0.02	0.77	0.004	0.92	0.01	0.82
	pHs	0.18	0.40	0.01	0.82	0.05	0.68	0.004	0.91	0.002	0.94
30	pHw	0.35	0.22	0.0001	0.98	0.01	0.83	0.001	0.96	0.01	0.84
	pHs	0.17	0.42	0.02	0.79	0.06	0.64	0.008	0.89	0.005	0.89

*For Al potential n = 3 for mineral soils and n = 5 for all soils.

Only the LR results from the Mehlich method were significantly correlated with pH change from ash amendment. The Mehlich method differs from the other methods in that it was designed to react preferentially with salt-extractable acidity (primarily H and Al), while other methods also react with weaker forms of soil acidity. Tran and van Lierop (1981) reported that this buffer seemed more sensitive to KCl exchangeable acidity in their study, but concluded that it also reacted with other forms of soil acidity as well. Exchangeable acidity is of less consequence in limed, fertilized agricultural soils; however, in forest soils there is often a substantial amount of potential acidity (Pritchett and Fisher 1987). Thus, the Mehlich method may be superior for use with forest soils. In the study reported by Tran and van Lierop (1982), the Mehlich method was also determined to be the most accurate for determining LR (pH 5.5) when the unmodified SMP-SB, SMP-DB, Yuan, Woodruff, and Mehlich methods were compared using coarse textured soils.

This study indicates the Mehlich method yields LR values most closely correlated to pH change following wood-ash amendment; the practical disadvantage of this method, however, is that a target pH can not be selected and empirical data need to be collected to define expected pH changes for different forest soils. This method was designed to provide LR values that would neutralize all or a large proportion of the effective exchangeable acidity; modifications to the method may be called for when it is used to prescribe wood-ash amendment rates on forested sites.

CONCLUSIONS

The traditional LR tests used in agriculture may not be suitable for use on forest soils; the Mehlich method, however, appears to have potential for use in predicting forest soil pH change following ash amendment. Further research should be conducted under controlled laboratory and field conditions to evaluate the Mehlich method. Other lime requirement tests not studied here should also be considered. Investigations are also needed that incorporate a wider range of soil types across a gradient of organic matter content, drainage, and textural characteristics. Consideration should be given to developing different protocols for mineral versus organic soil materials.

ACKNOWLEDGEMENTS

This study was supported by McIntire-Stennis funds. The authors wish to thank Rachael Beemer for her technical assistance and Mary Thibodeau for her help in preparing the manuscript.

LITERATURE CITED

Arberg, P.A. 1986. Lime and aluminum potential. Statement of work National Acid Deposition Soil Survey. pp. A9-1 - A9-6.

Council on Soil Testing and Plant Analysis. 1980. *Reference methods for soil testing*. Revised ed. Athens, GA.

McLean, E.O. 1982. In A.L. Page et al. (ed.) Methods of soil analysis, part 2. No. 9: 199-223. Madison, WI: American Society of Agronomy.

Tran, T.S., and W. van Lierop. 1982. Lime requirement determination for attaining pH 5.5 and 6.0 of coarse-textured soils using buffer-pH methods. *Soil Sci. Soc. Am. J.* 46:1008-1014.

Tran, T.S., and W. van Lierop. 1981. Evaluation and improvement of buffer-pH lime requirement methods. *Soil Sci.* 131:178-188.

Pritchett, W.L., and R.F. Fisher. 1987. *Properties and management of forest soils*. 2d ed. New York: John Wiley & Sons.