NOTA

POTENTIAL ACIDITY ESTIMATED BY SMP pH IN SOILS OF THE STATE OF PARÁ[1]

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SUMMARY

The use of SMP pH to estimate the potential acidity (H + Al) is more practical than the method of 0.5 mol L^{-1} calcium acetate for routine laboratory analyses. The objective was to fit an equation to estimate the H + Al from SMP pH values of soils of the State of Pará. From various regions of the state, 177 soil samples were collected, in which the SMP pH was determined in 0.01 mol L^{-1} $CaCl_2$ solution and H + Al in 0.5 mol L^{-1} calcium acetate and the results were related by regression analysis. The equation H + Al = 77.77 + 20.61 SMP pH - 1.435 SMP pH^2 (R^2 = 0.90) expressed the H + Al values (in $cmol_c$ dm^{-3}) best. When the SMP pH values were used in equations referring to other regions or states in Brazil, the H +Al values were over- or underestimated. The potential acidity in soils of Pará can be estimated by the method of SMP pH.

Index terms: H + Al, soil analysis, Amazon, soil fertility.

RESUMO: *ACIDEZ POTENCIAL ESTIMADA PELO MÉTODO DO pH SMP EM SOLOS DO ESTADO DO PARÁ*

O uso do pH SMP na estimativa da acidez potencial (H + Al) apresenta maior praticidade em relação ao método do acetato de cálcio 0,5 mol L^{-1} para laboratórios de rotina. Objetivou-se com este trabalho ajustar uma equação para estimar H + Al, a partir dos valores de pH SMP de solos do Estado do Pará. Foram utilizadas 177 amostras de solo das várias regiões do

(1) Received for publication on March 15, 2012 and approved on November 20, 2012.

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estado, em que se realizaram as determinações de pH SMP, em solução de $CaCl_2$ 0,01 mol L^{-1}, e H + Al, em acetato de cálcio 0,5 mol L^{-1}; os resultados foram relacionados por análise de regressão. A equação H + Al = 77.77 + 20.61 SMP pH - 1.435 SMP pH^2 (R^2 = 0,90) foi a que melhor expressou os valores H +Al em $cmol_c$ dm^{-3}. Quando se utilizaram os valores de pH SMP em equações de outras regiões ou estados brasileiros, ocorreu subestimativa ou superestimava dos valores de H + Al. A acidez potencial pode ser estimada pelo método do pH SMP em solos paraenses.

Termos para indexação: H + Al, análise de solo, Amazônia, fertilidade do solo.

INTRODUCTION

The lime requirement can be determined by the method of Al neutralization, with or without increasing Ca and Mg concentrations, or inferred from base saturation, based on the cation exchange capacity (CEC) at pH 7.0. This variable, in turn, must include the value of potential acidity (H + Al) plus the exchangeable bases (Kaminski et al., 2007).

In Brazil, the potential acidity is most commonly determined by the method of 0.5 mol L^{-1} calcium acetate at pH 7.0 in laboratories. However, the method has some drawbacks such as: the procedure is time-consuming for involving the two steps extraction and titration (Silva et al., 2006), the quality of most of the calcium acetate available for purchase is low (Pavan et al., 1996); the turning point of organic-matter-rich soils is hard to detect (Silva et al., 2000), and the H + Al levels in soils with a pH range of 6.5 - 7.0 are underestimated, due to the poor buffering of calcium acetate in soils with this acidity degree (Raij, 1997).

The potential acidity can be estimated by the SMP pH buffer method, which is strongly correlated with the H + Al values determined by the calcium acetate method (Quaggio & Raij, 2001; Moreira et al., 2004; Chaves et al., 2007). The SMP pH corresponds to the equilibrium pH obtained from the soil supernatant with the SMP buffer solution; the method was first developed by Shoemaker et al. (1961) to determine the lime requirement. In recent years, it has been widely tested and even used in routine analysis to estimate the potential acidity of soils in several Brazilian states (Sambatti et al., 2003; Pereira et al., 2006; Silva et al., 2006).

The SMP buffer solution contains *p*-nitrophenol and potassium chromate, classified as toxic and unhealthy substances, requiring special care with handling and waste disposal (Toledo et al., 2012). However, it is convincingly simple and convenient for routine analyses of H + Al of the CEC at pH 7.0 (Raij et al., 1997), as well as for recommendations of lime rates, and it is commonly used in the States of Santa Catarina and Rio Grande do Sul (Tedesco et al., 1995).

Despite the above advantages, the equations to estimate the potential acidity from the SMP pH should be regionally adjusted, since the results are influenced by the soil chemical, physical and mineralogical properties (Pereira et al., 2006). For the state of São Paulo, the fitted equation corresponded to ln (H + Al) = 7.76 - 1.053 SMP pH (R^2 = 0.99), for Mato Grosso do Sul to ln (H + Al) = 8.086 - 1.062 SMP pH (R^2 = 0.96), (R^2 = 0.96), for Santa Catarina to (H + Al) = 3.9014 - 0.391 SMP (R^2 = 0.90), for Pernambuco to (H + Al) = 38.448 + 8.4855 SMP pH - 0.4837 SMP pH (R^2 = 0.90) and for the Amazon region to ($CaCl_2$ pH): H + Al = 30.155 - 3.834 SMP pH (R^2 = 0.91), which shows the peculiarities of the soils in regions and states of Brazil (Silva et al., 2006).

The purpose was to fit a regression equation to estimate the potential acidity by the SMP pH value of representative soils of the State of Pará, with a view to introduce this method in routine analyses in regional laboratories.

MATERIAL AND METHODS

This study was developed in the laboratory of soil chemistry, Federal Rural University of Amazonia (UFRA) in Belém, Pará. From several municipalities, representing all mesoregions of Pará (Metropolitan Belém, Northeast, Southeast, Lower Amazon, and Southwest), 177 soil samples were taken from the 0-20 cm layer The samples were separated into the following texture classes (Embrapa, 2006): sandy (28), medium (50), clayey (68) and very clayey texture (31). The pH range in H_2O was 3.72 - 7.36, and the content of organic carbon was 2.27-38.59 g kg^{-1} and 100-800 g kg^{-1} of clay.

The analyses consisted of determining H + Al by the method of calcium acetate, SMP pH $CaCl_2$ and pH of each sample in triplicate. The potential acidity was determined by extraction with 0.5 mol L^{-1} calcium acetate at pH 7.0 and by titration with 0.025 mol L^{-1} NaOH. For this purpose, 10 cm^3 of air-dried fine earth was filled in a 250 mL Erlenmeyer flask with 100 mL of extraction solution. After stirring the earth-acetate suspension for 15 min and left to stand for 16 h, a 25 mL aliquot of liquid supernatant was taken, and three drops of phenolphthalein alcohol solution were added to determine H + Al by NaOH titration.

For the pH in 0.01 mol L^{-1} $CaCl_2$, a proportion of 1:2.5 for soil: solution was used, assessed in suspension (Embrapa, 1997). The SMP pH was determined according to Quaggio & Raij (2001), and to this end, after reading the $CaCl_2$ pH, 5.0 mL of SMP buffer solution was added at pH 7.5 and stirred for 15 min at 220 rpm. After standing for 60 min, the equilibrium pH was read in the soil- SMP solution.

The SMP pH and H + Al determined by the calcium acetate method were related and statistically adjusted by regression analysis, selecting the equation with the best coefficient of determination (R^2). In addition, a correlation analysis of the SMP pH and $CaCl_2$ pH was performed.

RESULTS AND DISCUSSION

The values of H + Al determined by the calcium acetate method varied between 3.10 and 14.9 $cmol_c$ dm^{-3}, while the SMP pH ranged from 4.58 to 7.56. The relationship between these variables was described by the following equation: H+ Al ($cmol_c$ dm^{-3}) = 77.77 + 20.61 SMP pH - 1.435 SMP pH^2 (R^2 = 0.90) (Figure 1). These results demonstrated that the SMP pH increase was accompanied by a decrease in the H + Al values in the soil samples from Pará. Similar inverse relationships were found for soils in the State of Pernambuco (Nascimento, 2000), in the North of Minas Gerais (Silva et al., 2002), in northeastern Pará (Gama et al., 2002) and in a microregion of homogeneous marsh in Paraiba (Chaves et al., 2007).

The adjustment equation between the data of potential acidity by the method of calcium acetate and the SMP pH added to the $CaCl_2$ pH solution after shaking obtained in this study and the equations of other states or regions of Brazil, can be compared based on six fixed values ranging from 4.5 to 7.5 (Table 1). In this SMP pH range, the Al + H estimated for the soils of the State of Pará were close to those found for northeastern Pará (Gama et al., 2002) and the

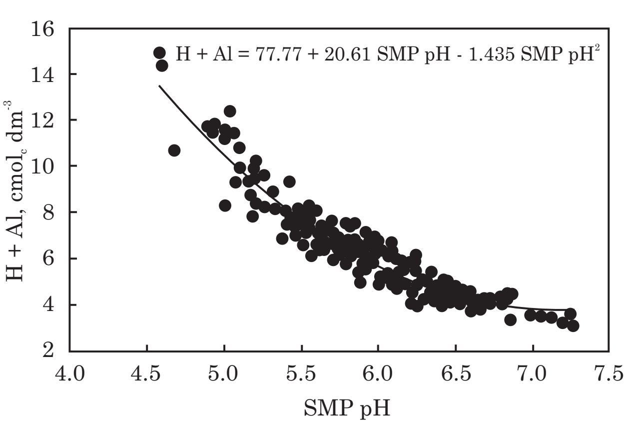

Figure 1. Relationship between the H + Al concentrations determined by the method of calcium acetate and SMP pH in representative soil samples of the State of Pará * Significant by regression analysis (p<0.05).

Table 1. Estimation of potential acidity (H + Al) *versus* SMP pH of soils of the State of Pará

SMP pH	H + Al	SMP pH	H + Al	SMP pH	H + Al
	$cmol_c$ dm^{-3}		$cmol_c$ dm^{-3}		$cmol_c$ dm^{-3}
4.50	14.08	5.45	8.07	6.40	4.64
4.55	13.70	5.50	7.82	6.45	4.54
4.60	13.33	5.55	7.59	6.50	4.43
4.65	12.96	5.60	7.36	6.55	4.34
4.70	12.60	5.65	7.13	6.60	4.25
4.75	12.25	5.70	6.92	6.65	4.17
4.80	11.90	5.75	6.71	6.70	4.10
4.85	11.57	5.80	6.51	6.75	4.03
4.90	11.24	5.85	6.31	6.80	3.98
4.95	10.91	5.90	6.12	6.85	3.93
5.00	10.60	5.95	5.94	6.90	3.88
5.05	10.29	6.00	5.77	6.95	3.84
5.10	9.98	6.05	5.60	7.00	3.82
5.15	9.69	6.10	5.45	7.05	3.79
5.20	9.40	6.15	5.29	7.10	3.78
5.25	9.12	6.20	5.15	7.15	3.77
5.30	8.85	6.25	5.01	7.20	3.77
5.35	8.58	6.30	4.88	7.25	3.77
5.40	8.32	6.35	4.76	7.30	3.79

Amazonas (Moreira et al, 2004). However, the equations for other states such as São Paulo (Quaggio et al., 1985), Minas Gerais (Corrêa et al., 1985), Mato Grosso do Sul (Maeda et al., 1997), Rio de Janeiro (Pereira et al., 1998), Northwestern Paraná (Sambatti et al., 2003), and for the Cerrado region (Sousa et al., 1989), compared with the one obtained in this study, mostly tended to overestimate the potential acidity for more acidic soil (pH<5.5) and to underestimate more alkaline soil (pH>6.0). These results show the similarity between the soils of the Amazon, and differences between them and soils of other regions (Table 2).

The difference between the equation in this study and equations from other regions and states confirmed the importance of a regional adjustment of the SMP pH method. This fact is related to the different chemical, physical and mineralogical properties of the soils that influenced the buffering (Escosteguy & Bissani, 1999; Silva et al., 2002).

Another important aspect of the use of SMP buffer is that an accurate estimation of the H + Al concentration is imperative, since these values underlie the calculation of CEC at pH 7.0 (T), which is used to calculate base saturation (V). Both variables are used to evaluate the lime requirement by the base saturation method, which should not be overestimated, to avoid additional costs with liming, or underestimated, which would reduce the rate and effect of neutralization by liming.

Table 2. Comparison of estimates of H + Al levels in soils in the State of Pará, with SMP pH between 4.5 and 7.3, based on equations adapted for different states and regions of Brazil

Region or state	Reference	SMP pH determined in $CaCl_2$						
		4.5	5.0	5.5	6.0	6.5	7.0	7.5
		H + Al, $cmol_c$ dm^{-3}						
São Paulo	Quaggio et al. (1985)	20.52	12.12	7.16	4.23	2.50	1.48	0.87
Minas Gerais	Corrêa et al. (1985)	21.43	12.3	7.06	4.06	2.33	1.33	0.77
Cerrados	Sousa et al. (1989)	18.41	10.79	6.33	3.71	2.17	1.27	0.75
Mato Grosso Sul	Maeda et al. (1997)	27.37	16.1	9.46	5.57	3.27	1.92	1.13
Rio de Janeiro	Pereira et al. (1998)	23.50	14.11	8.44	5.09	3.05	1.83	1.10
Northeastern Paraense	Gama et al. (2002)	14.05	10.11	6.82	4.17	2.17	0.82	0.12
Northwestern Paraná	Sambatti et al. (2003)	8.27	6.95	5.63	4.3	2.98	1.65	0.33
Amazonas	Moreira et al. (2004)	12.90	10.98	9.06	7.15	5.23	3.31	1.40
Pará	present study	14.08	10.60	7.82	5.77	4.43	3.82	3.84

The equations used to estimate H + Al concentrations based on SMP pH were: SP: ln (H + Al) = 7.76 - 1.053 SMP pH; MG: ln (H + Al) = 8.06 - 1.111 SMP pH; Cerrados: ln (H + Al) = 7.719 - 1.068 SMP pH; MS: ln (H + Al) = 8.086 - 1.062 SMP pH; RJ: ln (H + Al) = 7.75 - 1.02 SMP pH; Northeastern Pará: H + Al = 78.63 + 20.173 SMP pH - 1.3294 SMP pH^2; Northwestern Paraná: H + Al = 20.1925 - 2.6484 SMP pH; Amazonas ($CaCl_2$ pH): H + Al = 30.155 - 3.834 SMP pH.

CONCLUSION

The potential acidity (H + Al) (in $cmol_c$ dm^{-3}) of the soils of State of Pará can be estimated by the equation H + Al = 77.77 + 20.61 SMP pH - 1.435 SMP pH^2 ($R^2 = 0.90$).

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