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SOIL SCIENCE

Accuracy of methods to estimate potential acidity and lime requirement in soils of west region of Santa Catarina

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ABSTRACT: *The objective of this study was to compare two methods of evaluation of potencial acidity (H+Al) and two methods to estimate liming requirement (LR) for soils from the west region of Santa Catarina State, Brazil. Fourteen soils were incubated with 7 lime rates for 120 days, obtaining the real values of H+Al at pH 7.0 and LR. These values were used as reference to evaluate the accuracy of two H+Al estimating methods: SMP buffer and calcium acetate at pH 7.0, and to evaluate the accuracy of two LR methods: base saturation (BS) and SMP index. On average, H+Al was underestimated in 6 and 40% by SMP and calcium acetate methods, respectively, especially in soils with high buffer capacity. The LR was underestimated in 20 and 30% by SMP index and BS, respectively. The SMP Index showed a better LR estimative than BS, especially in soils with high buffer capacity.*

Key words: *SMP, calcium acetate, base saturation, liming.*

Exatidão de métodos para estimativa da acidez potencial e necessidade de calcário em solos da região oeste de Santa Catarina

RESUMO: *O estudo objetivou comparar dois métodos de avaliação de acidez potencial (H+Al) e de estimativa da necessidade de calagem (NC) para solos da região Oeste de Santa Catarina (SC). Quatorze solos foram incubados com 7 doses de calcário durante 120 dias, obtendo-se ao final os valores reais de H+Al a pH 7,0 e a NC dos solos. Esses valores serviram de referência para avaliar a exatidão dos métodos de estimativa do H+Al: tampão SMP e acetato de cálcio a pH 7,0 e a exatidão dos métodos de estimativa da NC: índice SMP e saturação por bases (V%). Em média, o H+Al foi subestimado em 6 e 40% pelos métodos SMP e acetato de cálcio, respectivamente, sendo mais problemático nos solos de maior tamponamento. Já a NC foi subestimada em 20 e 30% pelo Índice SMP e V%, respectivamente. O índice SMP estimou melhor a NC que o método V%, principalmente em solos de maior tamponamento.*

Palavras-chave: *SMP, acetato de cálcio, saturação por bases, calagem.*

The SMP buffer has dual purpose, because it can be used both to estimate the potential acidity of the soil (H+Al), and can also be converted into an index to direct estimate the lime requirement (LR).The estimate of the LR for soils of the Rio Grande do Sul and Santa Catarina can be performed by SMP index or by the base saturation (BS) (CQFS-RS/SC, 2016). The SMP index (SHOEMAKER et al., 1961) uses the pH value of equilibrium solution between a buffered solution and the soil, using values from previous experiments of calibration to estimate the LR of soil (KAMINSKI et al., 2002). The SMP solution contains chemical components buffering in different pH ranges, being effective to extract acidity from different soil components and pKs, presenting high correlation with the H+Al of the soil (KAMINSKI et al., 2002). Conversely, the method of base saturation uses the relationship between pH in water and base saturation of the soil to estimate the LR, by calculating the amount of lime necessary to raise the base saturation to a value which corresponds to the desired pH (KOSTENKO,

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2015). Estimate of LR by the method of base saturation has as a limitation, the difficulty of estimating the potential acidity of the soil (H+Al), used in the determination of the CEC pH 7,0 (KAMINSKI et al., 2002), especially in soils of higher buffer capacity, being a more effective method in less buffered soils (LEBLANC et al., 2016). Besides the SMP buffer, the estimation of H+Al of the soil can be made with the traditional method, calcium acetate at pH 7.0, but it is time consuming and less effective in extracting soil acidity (KAMINSKI et al., 2002).

The hypothesis established is that calcium acetate and SMP buffer and base saturation and SMP index have deviations in relation to the real H+Al and LR to be used on soils from the west region of Santa Catarina (SC) State, Brazil. The objective of this study was to compare the accuracy of these methods to estimate H+Al and LR for a set of soils from the western region of SC.

Soil samples were collected in the top layer of 0.0-0.2m in areas under natural vegetation of 14 representative soils of the west region of SC (Table 1), all derived from basalt, originating from Serra Geral Formation. The soil samples were air dried, passed through a sieve (particles diameter <2mm) and subsequently, subjected to the characterization of chemical and granulometric attributes (Table 1). The experimental design was completely randomized in a factorial arrangement 14x7, with four replications. Each soil was incubated with 7 rates of lime, corresponding to 0, 50, 75, 100, 125, 150 and 200% of the amount of LR for each soil to reaches pH 6.0 in water, according to the SMP index (CQFS-RS/SC, 2016). The lime source used was $CaCO_3$ (analytic grade). The experimental unit was made up of a plastic bag with 5L capacity, containing 1000g of soil. The incubation was conducted in the laboratory of Chemistry and Soil Fertility of the Santa Catarina State University and the experimental units were maintained at 80% moisture of the field capacity, using distilled water as source. Every fifteen days the units were opened and the soil stirred to eliminate the CO_2 produced.

After 120 days of incubation the soil was air dried, ground, and passed through a sieve (particles diameter <2mm) and subjected to characterization of the chemical attributes related to soil acidity (TEDESCO et al., 1995). The real H+Al at pH 7.0 and the real LR to reach desired pH and BS% were determined by regression curves from the data of the incubation of each soil. Results obtained were correlated with the estimated values for H+Al by SMP buffer, using the equation: H+Al, $cmol_c$ dm^{-3} = $e^{(10.665-1.1483SMP)}/10$, suggested by CQFS-RS/SC (2016) and by the estimate done by the method of calcium acetate, described by VETTORI et

Table 1 - Chemical and granulometric characteristic of 14 soils collected in the west region of Santa Catarina State.

Soil	Clay	pH H_2O	pH SMP	TOC	Al	Ca	Mg	K	H+Al (1)	H+Al (2)	H+Al (3)	CEC pH 7	BS
	g kg^{-1}			%	----------cmol$_c$ dm^{-3}----------								%
1	260	4.1	4.3	5.8	4.5	0.4	0.5	0,2	31.7	18.4	31.7	19.5	5.6
2	349	4.5	4.7	2.9	2.7	2.9	1.2	0,2	16.7	6.0	19.1	10.3	42.1
3	425	4.7	4.8	5.5	1.1	3.1	2.3	0,5	22.2	15.2	16.6	21.1	27.9
4	360	4.1	4.1	8.3	5.3 -	0.7	0.6	0,2	44.4	28.4	37.9	29.9	4.9
5	325	5.3	5.4	6.4	0.1	6.2	2.7	0,8	17.3	10.8	8.8	20.6	47.6
6	468	4.9	5.6	1.9	0.2	9.6	2.9	0,4	9.4	7.0	6.8	19.9	65.1
7	293	5.0	5.3	3.8	0.3	3.9	2.5	0,7	13.5	8.6	9.7	15.8	45.3
8	231	4.8	5.2	3.5	0.2	4.5	2.1	1,6	15.5	10.6	11.0	18.8	43.9
9	532	5.5	5.8	3.6	0.1	6.4	2.7	1	10.5	6.7	5.4	16.8	60.4
10	501	5.4	5.5	8.2	0.1	12.8	3.3	1,9	19.4	11.1	7.4	29.1	61.9
11	254	4.8	5.3	2.4	1.2	3.2	2.5	0,5	12.8	8.8	9.7	15.0	41.4
12	428	4.3	4.6	5.4	3.0	1.2	1.6	0,2	25.4	15.9	22.9	18.9	16.0
13	230	4.5	4.7	2.5	2.8	1.3	1.5	0,4	12.9	11.1	18.9	14.2	22.2
14	258	5.5	5.8	3.8	0.0	6.7	3.1	0,6	10.0	7.6	5.3	18.0	58.0

Soils, classified by the WRB system (WRB, 2014): 1 – Haplic Cambisol (Água Doce); 2 – Haplic Cambisol (Xavantina); 3 – Rhodic Ferralsol (Faxinal dos Guedes); 4 – Ferritic Ferralsol (Palma Sola); 5 – Umbric Nitisol (Modelo); 6 – Haplic Cambisol (Barra Bonita); 7 – Umbric Nitisol (Concórdia); 8 – Ferritic Ferralsol (Chapecó); 9 – Haplic Cambisol (União do Oeste); 10 – Umbric Nitisol (São Miguel do Oeste); 11 – Haplic Cambisol (Novo Horizonte); 12 - Ferritic Ferralsol (Abelardo Luz); 13 – Umbric Nitisol (Maravilha); 14 – Umbric Nitisol (São Lourenço do Oeste). The values of total organic carbon (TOC), pH in water and SMP index and the contents of aluminum (Al), Calcium (Ca), magnesium (Mg) and potassium (K) were analyzed according to the method described by Tedesco et al. (1995). (1) Potential acidity of the soil at pH 7.0; (2) Potential acidity extracted by calcium acetate 0.5mol L^{-1} at pH 7.0; (3) Potential acidity determined by the SMP index (CQFS-RS/SC, 2016).

al. (1969). The real LR of the soils was compared with the estimated by the SMP index and BS described in CQFS-RS/SC (2016).

The real H+Al at pH 7.0 ranged from 9.4 to 44.4cmol$_c$ dm^{-3}, whereas the values estimated by calcium acetate ranged from 6.0 to 28.4cmol$_c$ dm^{-3} and by the SMP buffer ranged from 5.3 to 37.9cmol$_c$ dm^{-3}. The values estimated by calcium acetate and SMP buffer underestimated the values of real H+Al of the soil in 40% and 6% (Figure 1A), respectively, indicating that the SMP buffer has higher accuracy for the set of soils studied. The variation reported among the estimated and real values of H+Al is due to the similarity among the soils tested in terms of geologic formation and mineralogy, in contrast to the varied group of soils that were used to the main equation

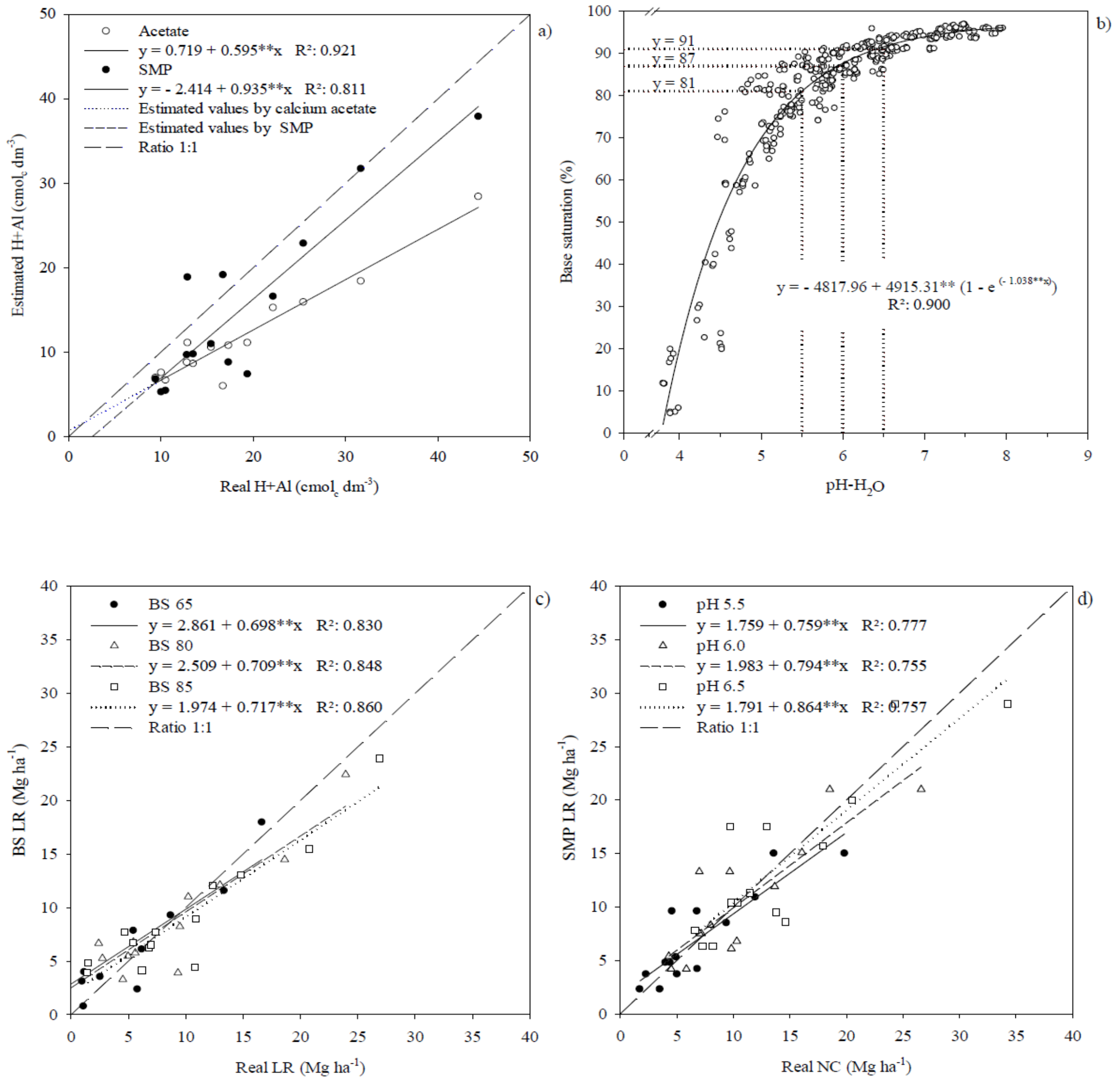

Figure 1 - The regression equation between the potential acidity (H+Al) of the soil at pH 7.0 and the potential acidity estimated by calcium acetate extractor and SMP equation of CQFS-RS/SC (2016), in 14 soils of west region of Santa Catarina (a); the relationship between base saturation (BS) and pH in water in 14 soils of the west region of Santa Catarina that received doses of limestone (b); The regression between the need for real limestone and estimated by the method of base saturation (BS) to achieve BS of 65, 80 and 85% (c), and by the SMP index to reach the ranges of pH in water of 5.5, 6.0 and 6,5 (D) in 14 soils of the west region of Santa Catarina that received doses of limestone.

used by CQFS-RS/SC (2016). Equations adjusted showed that for soils with values of H+Al higher than 9.2cmol$_c$ dm^{-3} the estimate of H+Al for SMP was always higher than the estimated by calcium acetate. However, the estimate of H+Al by SMP index showed higher dispersion, especially in acidity between 10 and 20cmol$_c$ dm^{-3} (Figure 1A) which may be related to the lowest buffering capacity of SMP solution at pH values near the pKa of some soil constituents within this pH range (TOLEDO et al., 2012).

There was a significant relationship between the pH in water and BS (Figure 1B); however, for values of pH in water of 5.5, 6.0 and 6.5, according to CQFS-RS/SC (2016), the values of BS should be close to 65, 75 and 85%, respectively. Nonetheless, in the study herein, the values of equivalence occurred in BS of 81, 87 and 91%, for the same pH ranges. The LR estimated by BS underestimated the real values necessary to raise the value of BS at approximately 30%, regardless of the desired value (Figure 1C). It is pointed out; however, that the underestimation occurred mainly in soils with high buffer capacity (LR>10Mg ha^{-1}), behavior attributed to the presence of high levels of organic matter in these Southern Brazilian soils, whose acidity buffer capacity is stronger, making it difficult the estimate of H+Al and CEC in these soils (KAMINSKI et al., 2002). However, for less buffered soils (LR<10Mg ha^{-1}) the method of BS can recommend quantities of lime close to the real LR (Figure 1C).

Evaluation of LR by the SMP index underestimated the real values in approximately 20% of the average of the three pH ranges desired (Figure 1D). However, the estimate was more appropriate than BS in soils of greater buffer capacity and maintained the accuracy in soils of lower buffer capacity, demonstrating to be thus more versatile than BS for a wide range of soils' buffer capacity. When the pH desired was 6.5, the accuracy of the method has increased by 10% compared to pH 5.5, showing that the SMP Index estimates better the LR when the pH desired is closer to the initial pH of the buffer (LEBLANC et al., 2016).

It is hypothesized however, the possibility of a better estimate of the LR by the SMP index with the reduction of soil: SMP buffer on soils with high buffer capacity. Reduction of relationship through the increase of the quantity of extractant may allow a better effectiveness in the neutralization of acids present in the soil (SILVA et al., 2008). This possibility; however, was not tested in the study herein, for this group of soils.

The SMP buffer estimates better the potential acidity than the calcium acetate and the LR than the base saturation, mainly in soils of high buffer capacity.

DECLARATION OF CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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