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Attributes of the soil fertilized with sewage sludge and calcium and magnesium silicate

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A B S T R A C T

This study aimed to evaluate the chemical attributes of an Inceptisol cultivated with castor bean (*Ricinus communis* L.), variety 'BRS Energia', fertilized with sewage sludge compost and calcium (Ca) and magnesium (Mg) silicate. The experiment was conducted at the ICA/UFMG, in a randomized block design, using a 2 x 4 factorial scheme with three replicates, and the treatments consisted of two doses of Ca-Mg silicate (0 and 1 t ha^{-1}) and four doses of sewage sludge compost (0, 23.81, 47.62 and 71.43 t ha^{-1}, on dry basis). Soil organic matter (OM), pH, sum of bases (SB), effective cation exchange capacity ($CEC_{(t)}$), total cation exchange capacity ($CEC_{(T)}$), base saturation (V%) and potential acidity (H + Al) were evaluated. There were no significant interactions between doses of sewage sludge compost and doses of Ca-Mg silicate on soil attributes, and no effect of silicate fertilization on these attributes. However, fertilization with sewage sludge compost promoted reduction in pH and increase in H + Al, OM and CEC. The dose of 71.43 t ha^{-1} of sewage sludge compost promoted the best soil chemical conditions.

Palavras-chave:
adubação orgânica
biossólido
resíduos de siderurgia

Atributos do solo adubado com lodo de esgoto e silicato de cálcio e magnésio

R E S U M O

Objetivou-se, neste trabalho, avaliar os atributos químicos de um solo cultivado com mamona (*Ricinus communis* L.) variedade BRS Energia, adubada com composto de lodo de esgoto e silicato de cálcio e magnésio. O experimento foi conduzido no ICA/UFMG em Cambissolo Háplico, em esquema fatorial 2 x 4, no delineamento em blocos casualizados com três repetições. Este arranjo consistiu em duas doses de silicato de cálcio e magnésio (0 e 1 t ha^{-1}) e quatro doses de composto de lodo de esgoto (0; 23,81; 47,62 e 71,43 t ha^{-1}, em base seca). Foram avaliados o teor de matéria orgânica, pH, Soma de Bases (SB), CTC efetiva (t), CTC potencial (T), saturação por base (V%) e a acidez potencial (H + Al) do solo. Não foram constatadas interações significativas entre as doses de composto de lodo de esgoto e as de silicato de cálcio e magnésio sobre os atributos edáficos do solo e tampouco houve efeito da adubação com silicato sobre esses atributos; no entanto, a adubação com composto de lodo de esgoto promoveu a redução do pH e o aumento da acidez potencial, do teor de matéria orgânica e da capacidade de troca catiônica, sendo a dose de composto de lodo de esgoto de 71,43 t ha^{-1} a que promoveu melhores condições químicas para o solo.

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Introduction

The search for new sources of renewable energy for the production of biodiesel has stimulated the cultivation of oilseed plants, especially castor bean (*Ricinus communis* L.), which is demanding in soil fertility and intolerant to pH values below 6.0 (Gonçalves et al., 2005). As an alternative for the use of limestone to correct soil acidity, calcium (Ca) and magnesium (Mg) silicates have been used to neutralize soil acidity and provide Ca, Mg and silicon (Si) to plants (Chaves & Farias, 2008; Faria et al., 2008; Vidal & Prado, 2011).

The use of Mg silicates in agriculture promotes various agronomic benefits, among which the reduction of phosphorus (P), increasing its availability to plants (Korndörfer, 2002), and improvements on soil chemical properties, through the increase of pH, sum of bases (SB), cation exchange capacity (CEC), base saturation (V%) and potential acidity (H+Al) (Prates et al., 2011; Vidal & Prado, 2011). In addition, the deposition of silicon on cell walls can increase plant resistance to lodging and create physical barriers to the development of diseases and to the attack of chewing pests (Korndörfer, 2002; Marchezan et al., 2004).

The use of sewage sludge in soil fertilization stands out for allowing the recycling of organic matter and nutrients, promoting improvements on soil chemical and physical properties and having a lower cost; in addition, it is a solution for the destination of this residue (Galdos et al., 2004; Barbosa et al., 2007; Nascimento et al., 2009; Santos et al., 2011). Sewage sludge can be used in the cultivation of major crops, silviculture, floriculture, landscape gardening or in the recovery of degraded areas, besides complementing mineral fertilizers and reducing production costs (Lemainski & Silva, 2006). However, the agricultural use of sludge poses potential risks of soil and plant contamination by heavy metals, which can limit its use as a fertilizer (Nogueira et al., 2007).

The fertilization of agricultural soils through the application of sewage sludge, mainly as a source of organic matter and nitrogen (N) (Chiaradia et al., 2009), and Ca and Mg silicate, as a source of Ca and Mg (Korndörfer, 2002), can be an important alternative to reduce production costs and increase the profits of farmers. Therefore, this study aimed to evaluate the effect of sewage sludge and Ca-Mg silicate on the chemical attributes of a soil cultivated with castor bean.

Material and Methods

The experiment was carried out under field conditions from June to December 2010 at the Agricultural Sciences Institute (ICA) of the Federal University of Minas Gerais (UFMG) in Montes Claros-MG, Brazil (16° 51’ 38” S; 44° 55’ 00” W). Rainfalls (mm) along the experiment were distributed as follows: June = 2.75; July = 1.00; August = 0.00; September = 6.61; October = 85.70; November = 298.18 and December = 281.81, with a total of 676.05 mm.

The soil in the area was classified as Haplic Inceptisol, and the variety ‘BRS Energia’ of castor bean (*Ricinus communis* L.) was cultivated in the experimental plots. Soil chemical and physical characteristics (Table 1) were determined according to EMBRAPA (1997).

The experiment was set in randomized block design, in a 2 x 4 factorial scheme, which corresponded to two doses of Ca-Mg silicate (0 and 1 t ha^{-1}) and four doses of sewage sludge compost, on dry basis (0; 23.81; 47.62 and 71.43 t ha^{-1}), with three replicates.

For the application of Ca-Mg silicate, a commercial product was used, which showed the following composition: 36% of CaO, 9% of MgO and 23% of SiO_2, RNV of 85% and contents of Fe (27.20 mg kg^{-1}), Zn (19.00 mg kg^{-1}), Mn (43.00 mg kg^{-1}) and Cu (19.00 mg kg^{-1}). Considering the content of soluble Si in the soil around 8.7 mg dm^{-3}, the dose of 1 t ha^{-1} was applied, which was regarded as sufficient for plants to respond to Si application (Korndörfer et al., 2001).

The doses of sewage sludge compost were based on the N content in this product (1.68 kg t^{-1}), calculated according to the Resolution nº 375 of the National Environmental Council (CONAMA) of August 2006 (Brasil, 2006) and on the recommendation of fertilization for the state of Minas Gerais, 40 kg ha^{-1} (CFSEMG, 1999).

The dewatered sewage sludge was collected at the Sewage Treatment Station – STS of the municipality of Juramento-MG, 40 km distant from the experimental plots. The STS is administered by the Minas Gerais Sanitation Company (COPASA-MG) and has capacity to treat 217 m^3 d^{-1} of sewage. The treatment line is composed by a pre-treatment and an Upflow Anaerobic Sludge Blanket (UASB) reactor, connected to a facultative post-treatment pond, and the sludge is treated through sunlight exposure on a drying bed. The chemical characteristics of sewage sludge, bean straw and sewage sludge compost (Table 2) were obtained according to Tedesco et al. (1995).

Composting was performed by mixing sewage sludge to bean straw in pile systems with maximum height of 1.5 m, in order to obtain a C/N ratio of 30:1. Temperature and humidity were daily measured; these factors were controlled by turning the piles with a hoe, for three months.

Fertilization was performed in a single application of sewage sludge compost and Ca-Mg silicate in the planting furrows. Seeding was performed in furrows, by planting three seeds per hole, with spacing of 0.5 m between plants and 0.75 m between rows. At 15 days after seeding, thinning was performed, leaving only one plant per hole. Each experimental unit was formed by 28 plants, in rows of seven, and the 10

Table 1. Chemical and physical attributes of the soil used in the experiment

Soil layer cm	pH	P-rem. mg L^{-1}	P-Mehlich	K	Ca	Mg	Al	H + Al	SB	$CEC_{(t)}$	$CEC_{(T)}$	m	V	OM	Coarse sand	Fine sand	Silt	Clay
			mg dm^{-3}		cmol$_c$ dm^{-3}							%		g kg^{-1}				
0-20	6.2	33.8	3.2	140	6.2	2.9	0.0	2.59	9.46	9.46	12.05	00	78.0	55.8	120	480	180	220
20-40	6.2	30.8	2.2	70	5.6	2.2	0.0	2.45	7.98	7.98	10.43	0.0	76.0	47.9	93	487	180	240

*Methodology according to EMBRAPA (1997); P-rem – remaining phosphorus; H + Al – potential acidity; SB – sum of bases; $CEC_{(t)}$ – effective cation exchange capacity; $CEC_{(T)}$ – total cation exchange capacity; m – aluminum saturation; V – base saturation; OM – organic matter

Table 2. Chemical characteristics of sewage sludge (SS), bean straw (BS) and sewage sludge compost (SSC), and amounts of nutrients applied with the different doses of sewage sludge compost

Material	Chemical characteristics[1]											
	N	P	K	Ca	Mg	S	Zn	Cu	Cd	Cr	Ni	Pb
	g kg^{-1}						mg kg^{-1}					
SS	17.70	4.10	6.60	0.50	2.20	12.40	162.33	90.00	1.14	548.33	105.67	162.00
BS	9.10	1.20	20.00	12.00	4.00	0.40	16.00	2.50	0.00	0.00	1.00	40.00
SSC	16.30	4.20	6.80	4.00	2.20	12.60	304.33	81.67	1.84	740.67	116.00	151.33
ML[2]	-	-	-	-	-	-	2.800	1.500	39	1.000	420	300

SSC (t ha^{-1})	Applied amounts (kg ha^{-1})												
	N_{total}	N_{avail}	P	K	Ca	Mg	S	Zn	Cu	Cd	Cr	Ni	Pb
23.81	388.1	40.0	100.0	161.9	95.24	52.38	300.0	7.25	1.94	0.04	17.64	2.76	3.6
47.62	776.2	80.0	200.0	323.8	190.48	104.76	600.0	14.49	3.89	0.09	35.27	5.52	7.2
71.43	1.164.3	120.0	300.0	485.7	285.72	157.15	900.0	21.74	5.83	0.13	52.91	8.29	10.8

[1]Methodology according to Tedesco et al. (1995); [2]Maximum limit allowed in sewage sludge or derivative product according to the CONAMA Resolution nº 375, of August 2006 (Brasil, 2006); N_{avail} - content of available nitrogen calculated according to the CONAMA Resolution nº 375, of August 2006 (Brasil, 2006)

central plants of each plot were evaluated. Unwanted plants were controlled by manual weeding when necessary and the stubbles were left on the soil surface of the respective plots. During the crop cycle, micro-sprinkler irrigation was performed, with total water depth of 748 mm.

After castor bean plants were harvested, at 180 days after planting, four subsamples of soil were collected in each plot, between plants, in the layers of 0-10, 10-20, 20-40 and 40-60 cm, in order to form a composite soil sample for the analysis of organic matter (Tedesco et al., 1995), pH, sum of bases (SB), effective CEC (t), potential CEC (T), base saturation (V%) and potential acidity (H+Al) (EMBRAPA, 1997).

The obtained data were subjected to analysis of variance by F test at 0.05 probability level. The doses of sewage sludge were fitted to regression models, testing the coefficients until 0.1 probability level by t-test. For the analysis of variance and regression equation adjustments, the programs SAEG and Tablecurve were used, respectively.

Results and Discussion

The analysis of variance showed no significant interaction ($p > 0.05$) between doses of Ca-Mg silicate and doses of sewage sludge with respect to soil attributes.

There was no effect of Ca-Mg silicate doses on the contents of soil organic matter (Table 3). However, OM values decreased compared with the initial soil condition (Table 1). In spite of that, the values observed in the layers of 0-10 and 10-40 cm were agronomically classified as Good and Medium, respectively, according to Alvarez V. et al. (1999). As expected, there was a reduction in OM contents as soil depth increased. Caldeira Júnior et al. (2009), evaluating the chemical characteristics of a soil fertilized with Ca-Mg silicate, observed no influence of this input on the contents of organic matter in the soil.

Likewise, soil pH was not influenced by the application of Ca-Mg silicate (Table 3). However, there was an increase in pH compared with the initial soil condition (Table 1) and the results were agronomically classified as High, according to Alvarez V. et al. (1999). Although not observed in this study, increases in soil pH with the application of Ca-Mg silicates have been widely reported in the literature (Barbosa et al., 2008; Faria et al., 2008; Korndörfer et al., 2010; Prates et al., 2011; Vidal & Prado, 2011).

Table 3. Organic matter contents (OM) and pH in different soil layers, in response to the addition of sewage sludge compost and calcium and magnesium silicate

Variable	Dose of silicate (t ha^{-1})	Dose of sewage sludge compost (t ha^{-1})				Mean
		0	23.81	47.62	71.43	
OM (0-10 cm)	0	4.13	4.53	4.70	5.43	4.70 A
	1	4.53	4.60	4.90	4.83	4.72 A
	Mean	4.33	4.57	4.80	5.13	-
OM (10-20 cm)	0	3.63	3.57	3.60	4.17	3.74 A
	1	4.07	3.90	4.03	3.63	3.91 A
	Mean	3.85	3.74	3.82	3.90	-
OM (20-40 cm)	0	2.40	2.20	2.30	2.83	2.43 A
	1	2.47	2.33	2.33	2.23	2.34 A
	Mean	2.44	2.27	2.32	2.53	-
OM (40-60 cm)	0	1.80	1.63	1.93	2.17	1.88 A
	1	1.80	1.70	1.87	1.63	1.75 A
	Mean	1.80	1.67	1.90	1.90	-
pH (0-10 cm)	0	6.87	6.77	6.60	6.70	6.74 A
	1	6.97	7.03	6.93	6.67	6.90 A
	Mean	6.92	6.90	6.78	6.69	-
pH (10-20 cm)	0	6.70	6.53	6.40	6.70	6.58 A
	1	6.87	6.93	6.90	6.53	6.81 A
	Mean	6.79	6.73	6.65	6.62	-
pH (20-40 cm)	0	6.50	6.60	6.50	6.40	6.50 A
	1	6.80	6.20	6.50	5.80	6.33 A
	Mean	6.65	6.40	6.50	6.10	-
pH (40-60 cm)	0	5.97	6.43	6.53	6.07	6.25 A
	1	6.37	5.87	6.00	5.77	6.00 A
	Mean	6.17	6.15	6.27	5.92	-

For each variable, means followed by the same letter in the column do not differ at 0.05 probability level by F test

Potential acidity and sum of bases were not influenced by the application of Ca-Mg silicate (Table 4), respectively showing increasing and decreasing responses as depth increased. Unlike the results of this study, Prates et al. (2011) observed increase in sum of bases and reduction in potential acidity with the application of Ca-Mg silicate on the soil. Corroborating these results, Vidal & Prado (2011) also observed that the application of slag in a Latosol cultivated with rice promoted increase in sum of bases and reduction in potential acidity. The values of potential acidity in the layers of up to 10 and > 10 cm were agronomically classified as Low and Medium, respectively, and the values for sum of bases in the layers of up to 20 and > 20 cm were classified as Very good and Good, respectively, according to Alvarez V. et al. (1999).

Soil CEC and base saturation were also not influenced by the application of Ca-Mg silicate (Table 5), with a decreasing

Table 4. Potential acidity (H + Al) and sum of bases (SB) in different soil layers, in response to the addition of sewage sludge compost and calcium and magnesium silicate

Variable	Dose of silicate (t ha^{-1})	Dose of sewage sludge compost (t ha^{-1})				Mean
		0	23.81	47.62	71.43	
H + Al (0-10 cm)	0	2.09	1.85	2.86	3.03	2.46 A
	1	1.82	1.65	1.54	2.37	1.85 A
	Mean	1.96	1.75	2.20	2.70	-
H + Al (10-20 cm)	0	3.03	3.30	3.30	3.03	3.17 A
	1	2.59	2.31	2.20	3.25	2.59 A
	Mean	2.81	2.81	2.75	3.14	-
H + Al (20-40 cm)	0	3.69	3.47	3.91	3.74	3.70 A
	1	2.70	3.91	3.14	3.85	3.40 A
	Mean	1.85	1.74	1.96	1.87	-
H + Al (40-60 cm)	0	4.84	3.80	3.58	4.68	4.23 A
	1	3.25	4.79	4.51	402	4.14 A
	Mean	8.09	8.59	8.09	8.70	-
SB (0-10 cm)	0	9.59	10.88	9.68	10.44	10.15 A
	1	10.68	11.41	10.95	10.38	10.86 A
	Mean	10.14	11.15	10.32	10.41	-
SB (10-20 cm)	0	7.37	7.33	7.59	9.89	8.05 A
	1	9.17	9.41	10.14	7.62	9.09 A
	Mean	8.27	8.37	8.87	8.76	-
SB (20-40 cm)	0	4.95	4.53	4.45	6.22	5.04 A
	1	5.65	5.04	5.61	5.06	5.34 A
	Mean	5.30	4.79	5.03	5.64	-
SB (40-60 cm)	0	2.92	3.38	3.97	4.22	3.62 A
	1	4.19	3.04	3.46	3.92	3.65 A
	Mean	3.56	3.21	3.72	4.07	-

For each variable, means followed by the same letter in the column do not differ at 0.05 probability level by F test

response as depth increased. Different results were obtained by Vidal & Prado (2011), who observed that the application of slag promoted increase in CEC and reduction of soil potential acidity. $CEC_{(t)}$ values in the layers up to 20 and > 20 cm can be agronomically classified as Very good and Good, respectively, while $CEC_{(T)}$ values in the layer up to 40 cm are classified as Good. Base saturation values in the layers up to 20 and > 20 cm are classified as Good and Medium, respectively, according to Alvarez V. et al. (1999).

The absence of effect of Ca-Mg silicate application seems to be related to its low solubility, considering the conditions of low soil acidity, with initial pH of 6.2 (Table 1). In addition, the highest contents of Ca and Mg in the soil did not promote an effective sink effect for these elements, which would provide a substantial increase in the dissolution rate of silicates. Similar effect of Ca-sink in relation to the increase in the dissolution rate of calcium phosphates was reported by Novais & Smyth (1999).

The content of soil organic matter in the layer of 0-10 cm increased linearly with the increment in the doses of sewage sludge compost (Table 6), showing the highest value (5.10 dag kg^{-1}) at the dose of 71.43 t ha^{-1}. This increase is attributed to the organic nature of the residue, and its effects have been widely reported in the literature (Simonete et al., 2003; Galdos et al., 2004; Melo et al., 2004; Nascimento et al., 2004; Barbosa et al., 2007; Nascimento et al., 2009; Prates et al., 2011; Santos et al., 2011). It should be pointed out that the increase in organic matter in soils fertilized with sewage sludge is more effective in the incorporation layer, as observed by Galdos et al. (2004) in a eutroferric Red Latosol cultivated with corn and fertilized with

Table 5. Effective cation exchange capacity ($CEC_{(t)}$), total cation exchange capacity ($CEC_{(T)}$) and base saturation percentage (V%) in different soil layers, in response to the addition of sewage sludge compost and calcium and magnesium silicate

Variable	Dose of silicate (t ha^{-1})	Dose of sewage sludge compost (t ha^{-1})				Mean
		0	23.81	47.62	71.43	
$CEC_{(t)}$ (0-10 cm)	0	9.59	11.17	9.68	10.44	10.22 A
	1	10.67	11.40	10.95	10.38	10.85 A
	Mean	10.13	11.29	10.32	10.41	-
$CEC_{(t)}$ (10-20 cm)	0	7.37	7.33	7.59	9.89	8.05 A
	1	9.17	9.41	10.14	7.62	9.09 A
	Mean	8.27	8.37	8.87	8.76	-
$CEC_{(t)}$ (20-40 cm)	0	5.18	4.76	5.62	6.29	5.46 A
	1	5.65	5.34	5.61	5.40	5.50 A
	Mean	5.42	5.05	5.62	5.85	-
$CEC_{(t)}$ (40-60 cm)	0	4.18	4.31	4.89	5.15	4.63 A
	1	4.69	4.61	4.49	4.89	4.67 A
	Mean	4.44	4.46	4.69	5.02	-
$CEC_{(T)}$ (0-10 cm)	0	11.69	13.36	12.55	13.46	12.77 A
	1	12.50	13.06	12.49	12.75	12.70 A
	Mean	12.10	13.21	12.52	13.11	-
$CEC_{(T)}$ (10-20 cm)	0	10.40	10.64	10.89	12.92	11.21 A
	1	11.76	11.72	12.34	10.87	11.67 A
	Mean	11.08	11.18	11.62	11.90	-
$CEC_{(T)}$ (20-40 cm)	0	8.63	8.00	8.36	9.96	8.74 A
	1	8.35	8.95	8.75	8.91	8.74 A
	Mean	8.49	8.48	8.56	9.44	-
$CEC_{(T)}$ (40-60 cm)	0	7.76	7.17	7.53	8.90	7.84 A
	1	7.44	7.83	7.97	7.94	7.80 A
	Mean	7.60	7.50	7.75	8.42	-
V% (0-10 cm)	0	82.00	81.67	77.33	77.33	79.58 A
	1	86.00	87.00	88.00	81.67	85.67 A
	Mean	84.00	84.34	82.67	79.50	-
V% (10-20 cm)	0	70.67	68.00	68.67	76.67	71.00 A
	1	77.67	80.67	82.00	69.67	77.50 A
	Mean	74.17	74.34	75.34	73.17	-
V% (20-40 cm)	0	58.00	57.67	52.00	62.33	57.50 A
	1	67.33	56.33	64.33	56.67	61.17 A
	Mean	62.67	57.00	58.16	59.50	-
V% (40-60 cm)	0	38.00	49.00	55.00	46.67	47.17 A
	1	56.67	38.33	43.00	48.33	46.58 A
	Mean	47.34	43.67	49.00	47.50	-

For each variable, means followed by the same letter in the column do not differ at 0.05 probability level by F test

two sewage sludge applications in two crop years. The results showed that sewage sludge application influenced the increase in organic matter contents in the layer of 0-5 cm. Santos et al. (2011) also reported that sewage sludge fertilization in 'Ponkan' mandarin promoted significant increment in the values of soil organic matter only in the layer of 0-20 cm. However, Backes et al. (2009) observed no positive effect of the application of different sewage sludge doses in castor bean cultivation on the increase of soil organic matter contents. Melo et al. (2004) explain that the increase in soil organic matter with the application of sewage sludge depends on the amount of residue applied and on the type of soil, besides management and climatic conditions.

The increase in the applied doses of sewage sludge compost caused reduction of pH in the layer of 0-10 cm, with a quadratic response. Similar results were obtained by Simonete et al. (2003), who observed that fertilization with sewage sludge doses of up to 50 t ha^{-1} promoted reduction in

Table 6. Regression equations relating soil chemical attributes and the applied doses of sewage sludge compost

Variable	Unit	Equation	R^2	SSC (t ha^{-1})	MxMn	FC
OM (0-10)		Y = 4.31 + 0.011046**X	0.9925	71.43	5.10	G
OM (10-20)	dag kg^{-1}	Y = Ym = 3.80	-	-	3.80	M
OM (20-40)		Y = Ym = 2.39	-	-	2.39	M
OM (40-60)		Y = Ym = 1.83	-	-	1.83	L
pH (0-10)		Y = 6.91 - 0.00004842*X^2	0.9596	71.43	6.66	H
pH (10-20)		Y = Ym = 6.70	-	-	6.70	H
pH (20-40)		Y = Ym = 6.41	-	-	6.41	H
pH (40-60)		Y = Ym = 6.13	-	-	6.13	H
H + AL (0-10)		Y = 1.82 + 0.000170*X^2	0.9055	71.43	2.69	M
H + AL (10-20)	$cmol_c$ dm^{-3}	Y = Ym = 2.88	-	-	2.88	M
H + AL (20-40)		Y = Ym = 3.55	-	-	3.55	M
H + AL (40-60)		Y = Ym = 4.19	-	-	4.19	M
SB (0-10)		Y = Ym = 10.50	-	-	10.50	VG
SB (10-20)	$cmol_c$ dm^{-3}	Y = Ym = 8.57	-	-	8.57	VG
SB (20-40)		Y = Ym = 5.19	-	-	5.19	G
SB (40-60)		Y = Ym = 3.64	-	-	3.64	G
$CEC_{(t)}$ (0-10)		Y = Ym = 10.54	-	-	10.54	VG
$CEC_{(t)}$ (10-20)	$cmol_c$ dm^{-3}	Y = Ym = 8.57	-	-	8.57	VG
$CEC_{(t)}$ (20-40)		Y = Ym = 5.48	-	-	5.48	G
$CEC_{(t)}$ (40-60)		Y = 4.42 + 0.000117*X^2	0.9943	71.43	5.02	G
$CEC_{(T)}$ (0-10)		Y = Ym = 12.74	-	-	12.74	G
$CEC_{(T)}$ (10-20)	$cmol_c$ dm^{-3}	Y = Ym = 11.44	-	-	11.44	G
$CEC_{(T)}$ (20-40)		Y = 8.36 + 0.00019*X^2	0.8670	71.43	9.33	G
$CEC_{(T)}$ (40-60)		Y = 7.52 + 0.0000024*X^3	0.9798	71.43	8.39	M
V (0-10)		Y = Ym = 82.55	-	-	82.55	VG
V (10-20)	(%)	Y = Ym = 74.25	-	-	74.25	G
V (20-40)		Y = Ym = 59.35	-	-	59.35	M
V (40-60)		Y = Ym = 46.88	-	-	46.88	M

*,**, Significant at 0.05 and 0.1 probability levels, respectively by t-test; SSC – Dose of sewage sludge compost for the maximum value of the variable; MxMn – Maximum or minimum value of the variable; FC – Fertility class of the variable: L – Low, M – Medium, H – High, G – Good and VG – Very Good, according to Alvarez V. (1999)

soil pH, and by Galdos et al. (2004), who observed that sewage sludge fertilization promoted a significant reduction of pH in the layer of 0-5 cm, in second-crop corn. Nascimento et al. (2004) also observed a significant reduction in pH values with the application of increasing doses of sewage sludge until 60 t ha^{-1} in the cultivation of corn and bean. Oliveira et al. (2002) observed increase in soil pH with the increment of sewage sludge doses in successive applications, in a distrophic Yellow Latosol under sugarcane cultivation. On the other hand, Chiaradia et al. (2009) observed no significant effect of sewage sludge application on soil pH. According to Simonete et al. (2003), the reduction in soil pH with the application of non-limed sewage sludge can be attributed to nitrification reactions of ammoniacal N, probable oxidation of sulfites and the production of organic acids during the degradation of organic matter by soil microorganisms.

Potential acidity increased quadratically in the layer 0-10 cm with the increment in the applied doses of sewage sludge compost (Table 6), which reflected in pH behavior, as previously mentioned. Simonete et al. (2003) also observed increase in soil potential acidity when evaluated the effect of the application of sewage sludge doses of up to 50 t ha^{-1}, in Argisol, on corn growth and nutrition.

The application of sewage sludge compost promoted quadratic and cubic increases in $CEC_{(t)}$ and $CEC_{(T)}$, but only in deeper soil layers (Table 6), possibly associated with the leaching of organic compounds with higher solubility. However, the increase of this soil attribute has been more common in the layer of sludge incorporation, as described by Galdos et al. (2004). These authors, studying the effect of sewage sludge application on the chemical attributes of a clayey eutroferric Red Latosol, observed increase in CEC in the layer of 0-20 cm. According to Simonete et al. (2003), the increase in the contents of Ca, Mg and K caused by sewage sludge application contributes to the increase in soil CEC. However, Backes et al. (2009) did not observe positive effect of the application of increasing doses of sewage sludge, until 32 t ha^{-1}, on soil CEC in studies with castor bean. Corroborating these results, Chiaradia et al. (2009) did not observe significant effect of sewage sludge application until the dose of 20 t ha^{-1} on the CEC of a soil cultivated with castor bean.

As observed for sum of bases, base saturation percentage was not influenced by the application of doses of sewage sludge compost (Table 6). This means that the fertilization with this residue did not influence significantly the contents of Ca, Mg and K in the soil, which must have contributed to this lack of response. This reinforces the hypothesis that sewage sludge is richer in N; thus, other nutrients must be used to complement its application as a plant fertilizer. However, Ricci et al. (2010) observed increase in base saturation when evaluating the chemical attributes of a soil fertilized with increasing doses of up to 80 t ha^{-1} of sewage sludge compost. In addition, Simonete et al. (2003) observed that the application of sewage sludge doses of up to 50 t ha^{-1} contributed to the increase in sum of bases, due to the increment in the exchangeable contents of Ca, Mg and K in the soil. On the other hand, Prates et al. (2011) observed that the application of increasing doses of sewage sludge, until 19.2 t ha^{-1}, promoted reduction in the base saturation of a soil cultivated with jatropha, which was attributed to the increase of soil $CEC_{(T)}$.

Conclusions

1. Fertilization with calcium and magnesium silicate did not influence soil chemical attributes.

2. Fertilization with sewage sludge compost caused a slight reduction in soil pH and a moderate increase in potential acidity, organic matter and cation exchange capacity.

3. The dose of 71.43 t ha^{-1} of sewage sludge compost promoted the best soil chemical conditions.

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