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Carbono orgânico do solo em uma topossequência no semiárido da Paraíba, Brasil

Soil organic carbon in a toposequence in the semiarid of Paraíba, Brazil

Carbono orgánico del suelo en un topossequence en semiáridas del Paraíba, Brasil

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Resumo

O carbono orgânico é um indicador sensível para avaliar a qualidade ambiental do solo. O objetivo deste estudo foi avaliar o teor de carbono orgânico do solo em uma topossequência na Serra do Teixeira, município de Teixeira, PB, região nordeste do Brasil. As amostras de solo foram coletadas no terço superior (TS), terço médio superior (TMS), terço médio inferior (TMI) e terço inferior (TI) em três profundidades (0-5, 5-10 e 10-20 cm) com cinco repetições para cada profundidade, resultando no total de 60 amostras. O carbono orgânico

foi avaliado utilizando a metodologia de Walkley-Black. Também foram realizadas análises físicas e químicas do solo. O maior teor médio de carbono foi encontrado nos primeiros 5 cm (19,83 g dm^{-3}), diferindo significativamente das demais profundidades. Observou-se também que a média do teor de carbono orgânico do solo no TMI foi significativamente superior os demais terços com 19,39 g dm^{-3}. Conclui-se que os maiores teores de carbono orgânico encontram-se na camada superficial do solo. As variações dos teores de carbono orgânico encontradas ao longo da topossequência indicam influência do relevo e da ação antrópica.
Palavras-chave: Declividade; Matéria orgânica; Camada superficial.

Abstract

Organic carbon is a sensible indicator to evaluate the environmental quality of the soil. The objective of this study was to evaluate the organic carbon content of the soil in a toposequence in Serra do Teixeira, municipality of Teixeira, PB. Soil samples were collected in the upper third (UT), upper middle third (UMT), lower middle third (LMT) and lower third (LT) on three depths (0-5, 5-10 and 10-20 cm), with five replicates for each depth, resulting in a total of 60 samples. The organic carbon was evaluated using the methodology of Walkey-Black. Physical and chemical soil analysis were also carried out. The highest mean of carbon content was found in the first 5 cm (19.83 g dm^{-3}), significantly differing from the other depths. It was also observed that the mean content of soil organic carbon on LMT was significantly higher than the other thirds, with 19.39 g dm^{-3}. It is concluded that the highest contents of organic carbon are found on the most superficial layer of the soil. The organic carbon content variations found along the toposequence indicates influence of the relief and the anthropic action.
Keywords: Declivity; Organic matter; Superficial layer.

Resumen

El carbono orgánico es un indicador sensible para evaluar la calidad ambiental del suelo. El objetivo de este estudio fue evaluar el contenido de carbono orgánico del suelo en un topossequence en Serra do Teixeira, municipio de Teixeira, PB, región noreste de Brasil. Las muestras de suelo se recogieron en el tercio superior (TS), el tercio medio superior (TMS), el tercio medio inferior (TMI) y el tercio inferior (TI) a tres profundidades (0-5, 5-10 y 10-20 cm) con cinco repeticiones para cada profundidad, lo que resulta en un total de 60 muestras. El carbono orgánico se evaluó utilizando la metodología Walkley-Black. También se realizaron análisis físicos y químicos del suelo. El contenido de carbono promedio más alto se encontró en los primeros 5 cm (19.83 g dm-3), difiriendo significativamente de las otras profundidades. También se observó que el contenido promedio de carbono orgánico del suelo en el TMI fue significativamente mayor que los otros tercios con 19.39 g dm-3. Se concluye que los niveles más altos de carbono orgánico se encuentran en la capa superior del suelo. Las variaciones en los niveles de carbono orgánico que se encuentran a lo largo de la secuencia de propósitos indican la influencia del relieve y la acción antrópica.

Palabras clave: Pendiente; Materia orgânica; Capa superficial.

1. Introduction

The soil organic matter is considerate one of the main sources of energy and nutrients that exists in the system, being able to maintain soils productivity in general. In this context, understanding the dynamics of the carbon existing in the organic matter and knowing the stock of this element in the ecosystems became a challenge to life maintenance on the conditions in which it is currently (Xavier et al., 2006; Congo et al., 2011).

Unlike fossil carbon reserves, the flux of soil carbon is a dynamic process and can, in short or long term, be transferred to the atmosphere, being unable, in this way, to fully compensate the emissions from fossil fuel combustion. Thus, although the soil is the largest carbon compartment of terrestrial ecosystems stocking carbon, depending on how used, it can slow or mitigate the negative impacts of global climate change, or increase the problem with its inadequate use, releasing CO^2 (Machado, 2005).

According to Souza (2012), forests plays an important role in the equilibrium of the carbon global cycle balance, because of their long term storage capacity of great quantities of carbon in their biomass and on other forest compartments, such as the underbrush, the litter and in the soil.

In the case of soil compartment, carbon addition occurs through the deposition and decomposition of organic matter, being the added amount dependent on edaphoclimatic conditions and species present in the area. The losses occurs basically by the release of CO^2 in the respiration of organisms, microbial decomposition of residuals and the soil organic matter and losses of its organic form by leaching and erosion (Giongo et al., 2011).

The losses of organic carbon in the soil through erosive processes are considered important, mainly in areas with steep declivity, where these processes are potentialized and constant. Souza et al. (2003) and Silva et al. (2007) report the influence of declivity on the superficial runoff, and consequent organic matter carriage, and the accentuation of erosive processes, being that in well-drained areas and with the other soil formation factors kept constant, the lower the declivity the higher will be the accumulation rate and organic matter.

The semi-arid region of the Brazilian northeast also faces problems due to the continuous use of the soil, by agricultural activity, and the phytomass removal for energy production, not adequately planned, reducing the soil carbon stock in general, as well as increasing the emission of CO^2 to the atmosphere. Added to these factors is the susceptibility of soils to erosion, which also have fundamental importance in the installation of the desertification process and the degradation of the semi-arid and the Caatinga, its main biome (Giongo et al., 2011). As consequence of these factors, the climate change can affect the magnitude of the processes, modifying the rates of addition and decomposition of carbon and, consequently, changing the amount of carbon stored in the soil.

According to Souza (2012), it is imperative that researches directed to determination of carbon content in the vegetation compartments and in the soil of the Caatinga biome are conducted, since there is a difficulty in estimating the total average of biomass produced by the vegetation, which has as a predominant characteristic a floristic composition formed by different vegetation typologies, due to the great variability of soils in the same area.

Therefore, studies that quantify carbon, considering the topography of the terrain also as a factor that determines its variation in the soil, are indispensable to fill the gaps on the behavior of this element in soils of the Caatinga biome. In this context, we hypothesized that the content of soil carbon content will be higher in areas with lower altitudes.

Thus, this work aims to evaluate the organic carbon content of the soil in a toposequence under a Caatinga vegetation in the municipality of Teixeira, PB.

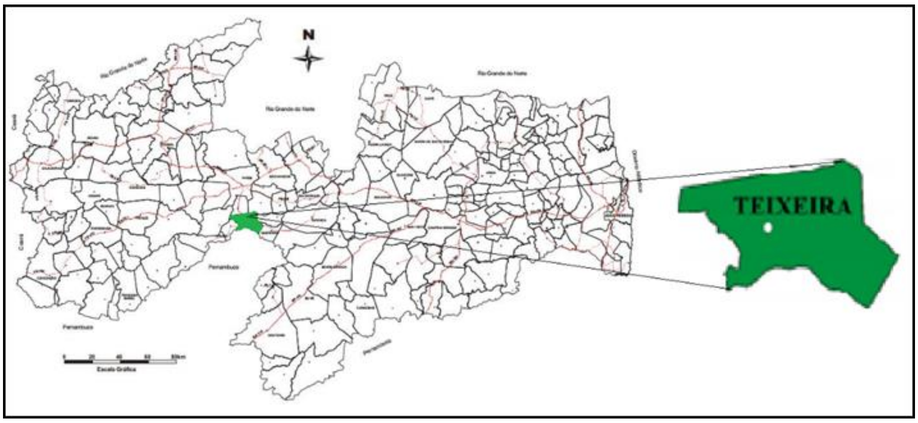
2. Methodology

For this research, field collections and laboratory analyzes were necessary, whose nature can be characterized as quali-quantitative (Pereira et al., 2018).

The study was carried out in a toposequence, located in the Serra do Teixeira, municipality of Teixeira, PB, in the central-west region of the State of Paraíba, with an area of 182 km² (Figure 1). The region's climate, according to the classification of Köppen, is BSh type, semiarid, marked by a dry season and a rainy one (Alvares et al., 2013).

The average annual rainfall stays around 800 mm. The relief varies from wavy to heavily wavy, with heights that vary from 630 m in the southeast portion, to higher than 750 m, reaching 960 m to the north, in the Serra of Teixeira (Mascarenhas et al., 2005).

Figure 1. Location of the municipality of Teixeira on the map of State of Paraíba.



Source: Santos et al. (2007).

The soils of the municipality have characteristic classes of the semi-arid region, as the Cambisols and the Lithic Neosols, with little depth and average texture (Cavalcante, 1989).

For the data collection, four areas were selected and georeferenced, following the ascendance of the terrain, whose information is showed in Table 1.

Table 1. General information of the toposequence.

Thirds of the slope	**Geographic Coordinates**	**Altitude (m)**
Higher (TS)	7° 12’ 43.5”S e 37° 15’12,4”W	776
Middle High (TMS)	7° 12’ 39.1”S 37° 16’ 15,2”W	630
Lower middle (TMI)	7° 11’ 49.1”S e 37° 16’23,5”W	404
Bottom (TI)	7° 11’ 30.4”S e 37° 17’00,8”W	347

Source: Ferreira et al. (2020).

The vegetation of the studied area is typical of the Caatinga, presenting different phytophysiognomies and preservation stages, in a way that the steeper it is, the more preserved the vegetation also is, because in the lower and lower middle thirds occurs agriculture and cattle raising practices with some predominant species of each studied third, as follows: upper third (UT): marmeleiro (*Croton sonderianus Muell.* Arg), jurema preta (*Mimosa tenuiflora* (Willd.) Poir.), catingueira (*Poincianella pyramidalis* (Tul.) L.P.Queiroz), feijão bravo (*Capparis flexuosa* (L.) L.) and aroeira (*Myracrodruon urundeuva* Allem); upper middle third (UMT): jurema preta (*Mimosa tenuiflora* (Willd.) Poir.); malva branca (*Sida cordifolia* L.) and catingueira (*Poincianella pyramidalis* (Tul.) L.P.Queiroz); lower middle third (LMT): jurema preta (*Mimosa tenuiflora* (Willd.) Poir.), umburana (*Commiphora* *leptophloeos* (*Mart.)* J.B. Gillett.), feijão bravo (*Capparis flexuosa* (L.) L.) and marmeleiro (*Croton sonderianus Muell*. Arg) and lower third (LT): jurema preta (*Mimosa tenuiflora* (Willd.) Poir.), marmeleiro (*Croton sonderianus Muell*. Arg), pinhão bravo (*Capparis flexuosa* (L.) L.) and mandacaru (*Cereus jamacaru* DC).

For the granulometric and chemical attributes analysis of the toposequence's soil, 20 simple samples were collected, four in each third (UT, UMT, LMT, LT), the mixed into four composite samples. The samples were collected in random points of the terrain, at the 0-20 cm depth, then homogenized (per third). The determined attributes were: pH, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), potential acidity (H+Al), cation-exchange capacity (CEC), base saturation (V%) and granulometric analysis by the densimeter method, following the methodology of Embrapa (2011).

On Table 2 is presented the data of the toposequence's soil granulometric analysis and it is verified that on the upper third (UT) the clay content was higher than the others, falling under the sandy-clay loam textural class; while on the upper middle third (UMT), lower middle (LMT) and lower (LT) the most predominant were sand particles, being included then in the sandy loam textural class.

Table 2. Physical analysis of the soil in a toposequence on Serra do Teixeira, PB.

Thirds of the slope	**Granulometry (g kg^{-1})**			**Textural Class**
	Sand	**Silte**	**Clay**	
Higher (TS)	582	202	216	Clay-sandy Franc
Middle High (TMS)	602	222	176	Sandy franc
Lower middle (TMI)	723	202	75	Sandy franc
Bottom (TI)	582	323	95	Sandy franc

Source: Ferreira et al. (2020).

Samples used to determine the soil organic carbon were collected following the completely randomized design, in a 4 x 3 factorial scheme (four areas: UT, UMT, LMT and LT and three depths: 0-5, 5-10 and 10-20 cm) with five replicates, totaling 60 samples.

The organic carbon was quantified by the Walkley-Black method, adapted from Cantarella et al. (2001), which adaptation was the non-use of Whatman 540 type filter paper, in which the soil was allowed to decant at the bottom of the erlenmeyer and the supernatant was collected without it.

The organic carbon contents had their significance evaluated by analysis of variance and the difference between the means obtained were compared by the Tukey test at 5%

probability, with the aid of the statistical program ASSISTAT Version 7.6 beta (Silva & Azevedo, 2013).

3. Results

The toposequence soil chemical analysis showed that the pH values tended from slightly acid in the upper thirds (UT and UMT) to acid in the lower middle and lower, fact in which higher values of P, Ca, Mg and K were identified on the upper thirds (Table 3).

Table 3. Chemical analysis of the soil in a toposequence on Serra do Teixeira, PB.

Thirds	pH	P	Ca	Mg	K	Na	H + Al	CTC	V
	Ca Cl_2	mg dm^{-3}	------------------------cmolc dm^{-3}--------------						%
S	6,2	109,3	11,5	2,5	0,26	1,13	2,0	17,4	88,5
TMS	6,2	21,9	3,6	1,4	0,43	1,52	1,8	8,8	79,4
TMI	4,8	1,7	6,1	1,9	0,18	0,87	3,1	12,1	74,5
TI	4,8	2,6	2,1	0,9	0,15	0,74	2,8	6,7	58,2

Source: Ferreira et al. (2020).

It can be observed in Table 4 with the analysis of variance that there were significantly differences at 5% of probability in the carbon content of the toposequence for the two studied variables (thirds and depths), as well as in the carbon evaluation through the interaction between the thirds and the depths at 5% of probability by the Tukey test, in a way that if there is an interaction, it is necessary to evaluate each factor individually, presenting the third and depths analysis separately.

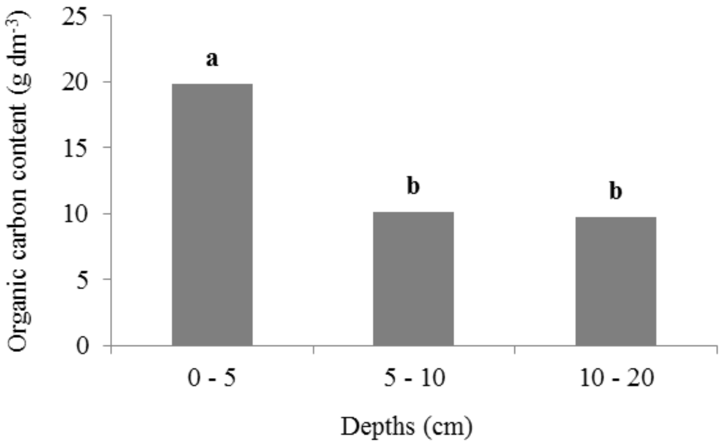
Table 4. Analysis of variance.

FV	GGL	SQ	QM	F
Thirds	3	780,21122	260,07041	15,895*
Depths	2	1305,42321	652,71161	39,892*
Thirds x Depths	6	480,26478	80,04413	4,892 *
Treatments	11	2565,89921	233,26356	14,256*
Residual	48	785,37452	16,36197	
Total	59	3351,27373		

* Significant at 5% probability level.
Source: Ferreira et al. (2020).

The highest mean of organic carbon content was found on the first 5.0 cm of the soil with 19.83 g dm^{-3}, significantly differing from the other depths, where it was registered lower values at the 5-10 cm depth with 10.15 g dm^{-3}, and 10-20 cm with 9.73 g dm^{-3}, both statistically equal (Figure 2).

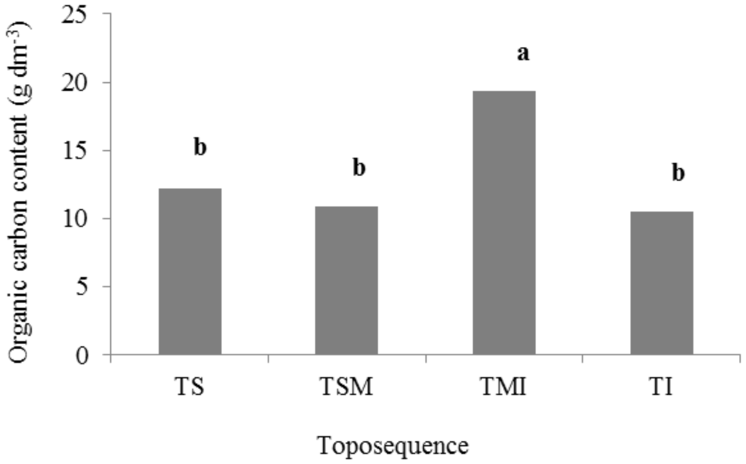
Figure 2. Organic carbon content (g dm^{-3}) in different soil depths in a toposequence on municipality of Teixeira, PB.



* Columns followed by the same letter did not show significant differences, different letter are significantly different at 5% probability by the Tukey test.
Source: Ferreira et al. (2020).

When the organic carbon content were quantified in four different thirds of the toposequence, it was observed that the mean of carbon content of LMT was significantly higher than the others with 19.39 g dm^{-3}, while the means of LT (10.50 g dm^{-3}), UMT (10.87 g dm^{-3}), and UT (12.19 g dm^{-3}) expressed different values among themselves, but, without significant differences, according the Tukey test at 5% (Figure 3).

Figure 3. Organic carbon content variation (g dm^{-3}) of the soil in a toposequence in municipality of Teixeira, PB.



* Columns followed by the same letter did not show significant differences, different letter are significantly different at 5% probability by the Tukey test.
Source: Ferreira et al. (2020).

4. Discussion

It was found that the content of nutrients P, Ca, Mg and K were lesser on the lower third (LT), with the reduction of P much more accentuated on the lower thirds, fact that can be explained by the increase of acidity and the significant presence of agricultural and livestock activities in these areas of lower declivity in the toposequence, suggesting that these practices reflect negatively on soil fertility, corroborating with this statement, Fraga & Salcedo (2004) and Sampaio et al. (1995) report that there is a reduction of nutrients, mainly P, as there is the substitution of native vegetation for agricultural activities.

Regarding the bases saturation (V%), it was verified that with the reduction of the toposequence declivity, the anthropic activity pressure on the vegetation of the Caatinga was increased, the Ca^{2+}, Mg^{2+} and K^{+} values were lowered, with consequent reduction of V%. On the other hand, the CEC had its values more elevated in the upper third (UT) and lower middle third (LMT), in the first case, probably because it had higher values of pH, P, Ca, Mg and K, as well as more preserved native vegetation.

Higher values of pH and P are found on the upper thirds (UT and UMT), corroborating with the results reported by Zos et al. (2009), who stated that the increase of the soil pH can reduce the P adsorption in the soil, increasing its availability for plant absorption. In this case, the reduction of P presence may be due the agricultural activities practiced on the lower thirds, as well as its availability reduction due to pH reduction.

According to Souza (2012), the acidity of the soil, quantified through pH, is one of the factors that directly affects the agricultural areas productivity, since acidic soils substantially compromise the cation-exchange capacity (CEC). Martinazzo (2006) affirms that, according the technical indications of Soil Chemical and Fertility Commission (CQFS, 2004), the soil pH should be higher than 5.5 and base saturation (V%) exceed 65% of the CEC, since this condition provides an adequate ambient suitable for the developing of crops. To Oliveira et al. (2005), the range from 5.8 to 6.2 in the soil pH is the one that presents greater essentials nutrients availability for vegetables.

The superficial soil layers receive the addition of organic residues coming from the established vegetation of the area, being degraded over the time by action of the edaphic fauna, which concentrates in greater number on the soil superficial layers, favoring the decomposition. Thus, the soil carbon content is regulated according to the amount of residue to be decomposed, their chemical composition, besides the edaphoclimatic conditions that could alter this process, resulting in an increase or decrease of the soil organic carbon stock.

Fracetto et al. (2012), while quantifying the carbon in a Caatinga area with native vegetation, verified a similar situation to the present work, where higher contents of C were found on the superficial layer (0-5 cm) and decreased as the depth increased. According with the same authors, this behavior is common in areas of native forest, due to the vegetable residues accumulation on the soil surface, promoting slow and gradual decomposition, ensuring one continuous incorporation of organic material into the soil, in a way that the concentrations are in the superficial layers. Other authors have also corroborate this idea, such as Passos et al. (2007), Potes et al. (2010) & Calonego et al. (2012).

Souza (2012), studying the soil organic carbon contents on the rainy and dry seasons in a vegetation of the Caatinga, observed that on the two studied seasons the of 0-5 cm layer had higher soil organic carbon content. The author salient that one possible justification for the presence of higher carbon contents on the superficial layer is the vegetable material decomposition that comes from herbaceous species, which have a short life cycle and die mostly in the dry period.

There was interaction between the thirds and soil depths in the soil organic carbon content, thus, as long there is absence of anthropic actions and maintenance of the vegetation cover due to the difficult use access of this area (LMT), there is greater accumulation of organic matter and consequently increase of organic carbon content on the superficial layer depth (0-5 cm).

This result may be related to the fact that in areas with accentuated declivity, like is the case of the UT and UMT, the organic carbon is more easily lost, resulting from the carriage of the particles from the most superficial layers of the soil to the lower parts of the relief, tending to an accumulation of this element in the lower areas of the landscape, such as occurred in the LMT. This result is similar to that observed by Silva et al. (2007) in a toposequence on the south of Minas Gerais, where they concluded that the soil organic carbon content decreased as the declivity increased.

In the LT, the lower values of carbon can be attributed to the more intense anthropic action, with inadequate management practices such as the cutting and burning the native vegetation, following the soil inversion to cultivate monoculture crops like maize or beans and livestock, resulting in the decrease of soil organic carbon content. Fraga & Salcedo (2004) identified a reduction in the carbon content when altering the vegetation cover and posterior soil use without conservationist precepts.

According to Barreto et al. (2006), when the natural vegetation is removed to install an agricultural system, there is an imbalance on the soil organic carbon content occurs, because the mineralization of the organic matter intensifies, initially causing the releasing of some nutrients, favoring the vegetal nutrition. When the organic matter addition process is inferior to that of decomposition, this system does not reach a new equilibrium, becoming exhausted and causing soil degradation. The authors also emphasizes that in tropical and subtropical soils, the organic matter has great contribution to fertility, increasing the cation-exchange capacity, improving their chemical, physical and biological characteristics, being then of fundamental importance in the maintenance of sustainability.

Calonego et al. (2012) compared different management systems with areas of native vegetation from Cerrado, and found that human intervention through farming practices reduced the carbon stock in the soil to levels much lower than what was found in native forest conditions. Fracetto et al. (2012), evaluating the alterations of C and N contents due to the change of soil use on a native vegetation in the Caatinga biome for castor bean cultivation, observed low organic carbon contents on the cultivated soils with this species, regardless of the implantation time of the crop. Just like Tiessen et al. (1998); Fraga & Salcedo (2004) observed that the removal of vegetation from Caatinga with subsequent agricultural use resulted in an expressive decrease of 40 to 50% in the soil C contents.

5. Conclusions

The highest organic carbon contents were found on the soil superficial layer of 0-5 cm. The organic carbon contents variations found along the toposequence indicates influence of the relief and anthropic action, such as deforestation, burnings, livestock and agriculture. There was interaction effect between studied factors, thus, the LMT presented higher organic carbon content on the superficial layer of 0-5 cm depth.

As the content of organic carbon in the soil was influenced according to the level of anthropization of the place, it is suggested that this parameter can be used as an indicator of degraded areas, and that they be taken into account in soil conservation studies.

References

Alvares, CA., Stape, JL., Sentelhas, PC., Gonçalves, JLM., & Sparovek, G. (2013). Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*, 22 (6), 711-728.

Barreto, AC., Lima, FHS., Freire, MBGS., & Freire, FJ. (2006). Características químicas e físicas de um solo sob floresta, sistema agroflorestal e pastagem no sul da Bahia. *Caatinga*, 19 (4), 415 -425.

Calonego, JC., Santos, CH., Tiritan, CS., & Cunha Júnior, JR. (2012). Estoques de carbono e propriedades físicas de solos submetidos a diferentes sistemas de manejo. *Caatinga*, 25 (2), 128 -135.

Cantarella, H., Quaggio, JA., & Raij, BV. (2001). Determinação da matéria orgânica. IN: Raij, BV., Andrade, JC., Cantarella, H., Quaggio, JA. Análise química para avaliação da fertilidade de solos tropicais. Campinas, 173 - 180.

Cavalcante, VLU. (1989). Transformação do Uso do Solo no Município de Teixeira. Monografia (Graduação em Geografia) João Pessoa - Universidade Federal da Paraíba, p. 48.

Comissão de Química e Fertiildade do Solo - CQFSRS/SC (2004). Manual de adubação e calagem para os Estados do Rio Grande do Sul e de Santa Catarina. 10.ed. Porto Alegre, SBCS - Núcleo Regional Sul/UFRGS, p. 400.

EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária (2013). Centro Nacional de Pesquisas de Solos. Manual de métodos de análises de solos. 2.ed. Rio de Janeiro: Embrapa Solos, p. 230.

Fraga, VS., & Salcedo, IH. (2004). Declines of organic nutrient pools in tropical semi-arid soils under subsistence farming. *Soil Science Society of America Journal*, 68 (1), 215-224.

Fracetto, FJC., Fracetto, GGM., Cerri, CC., Feigl, BJ., & Siqueira Neto, M. (2012). Estoques de carbono e nitrogênio no solo cultivado com mamona na caatinga. *Revista Brasileira de Ciência do Solo*, 36 (5), 1545-1552.

Giongo, V., Cunha, TJF., Mendes, ASM., & Gava, CAT. (2011). Carbono no Sistema Solo-Planta no Semiárido Brasileiro. *Revista Brasileira de Geografia Física*, 4 (6), 1233-1253.

Mascarenhas, JC., Beltrão, BA., Souza júnior, LC., Morais, F., Mendes, VA., & Miranda, JLF. (2005). Projeto Cadastro de fontes de abastecimento por água subterrânea. Diagnóstico do município de Teixeira, estado da Paraíba. Serviço Geológico do Brasil: CPRM. Recife, 1, p. 19.

Machado, PLOA. (2005). Carbono do solo e a mitigação da mudança climática global. *Química Nova*, 28 (2), 329 - 334.

Martinazzo, R. (2006). Diagnóstico da fertilidade de solos em áreas sob plantio direto consolidado. Dissertação (Mestrado em Ciências do Solo). Santa Maria, Universidade Federal de Santa Maria. 82 p.

Oliveira, IP., Costa, KAP., Santos, KJG., & Moreira, FP. (2005). Considerações sobre a acidez dos solos de Cerrado. *Revista Eletrônica Faculdade Montes Belos*, 1 (1), 01-12.

Passos, RR., Ruiz, HA., Cantarutti, RB., & Mendonça, ES. (2007). Carbono orgânico e nitrogênio em agregados de um Latossolo vermelho distrófico sob duas coberturas vegetais. *Revista Brasileira de Ciência do Solo*, 31 (5), 1109 -1118.

Pereira, A. S., Shitsuka, D. M., Parreira, D. J., & Shitsuka, R. (2018). *Metodologia do trabalho científico*. [*e-Book*]. Santa Maria. Ed. UAB / NTE / UFSM. Available at: https://repositorio.ufsm.br/bitstream/handle/1/15824/Lic_Computacao_Metodologia-Pesquisa-Cientifica.pdf?sequence=1. Accessed on: April 2nd, 2020.

Potes, ML., Dick, DP., Dalmolin, RSD., Knicker, H., & Rosa, AS. (2010). Matéria orgânica em Neossolo de altitude: Influência do manejo da pastagem na sua composição e teor. *Revista Brasileira de Ciência do Solo*, 34 (1), 23-32.

Sampaio, EVSB., Salcedo, IH., & Silva, FBR. (1995). Fertilidade de solos do semiárido do Nordeste. IN: PEREIRA, J.R.; FARIA, C.M.B. Fertilizantes: Insumos básicos para a agricultura e combate à fome. Petrolina, Embrapa, p. 51-71.

Santos, JYG., Cunha, TB., Vianna, PCG., & Travassos, IS. (2007). A incidência de casos de câncer no município de Teixeira - PB e a sua relação com a possível contaminação das águas do açude São Francisco II por agrotóxico. *In: IV SEMAGEO: Semana de Geografia da UFPB*, p. 1-21.

Silva, AC., Torrado, PV., Pérez, MG., Martin Neto, L., & Vasquez, FM. (2007). Relações entre matéria orgânica do solo e declividade de vertentes em topossequência de Latossolos do Sul de Minas Gerais. *Revista Brasileira de Ciência do Solo*, 31 (5), 1059-1068.

Silva, FAS & Azevedo, CAV (2013). Versão atualizada do software estatístico Assistat. Versão 7.6 beta.

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