Journal of Agricultural Science; Vol. 10, No. 6; 2018
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Soil Physical Attributes and Organic Carbon in a Cohesive Yellow Latosol (Oxisol) Under Different Soil Management Systems in the Coastal Plains of Bahia, Brazil

Fagner Taiano dos Santos Silva[1], Fabiane Pereira Machado Dias[2], Polianna dos Santos de Farias[3], Flávia Melo Moreira[3], Ludimila de Oliveira de Amorim[3], Juan Manuel Anda Rocabado[3], Felipe Torres Sampaio[3] & Júlio César Azevedo Nóbrega[3]

[1] State University of Santa Catarina, Santa Catarina, Brazil

[2] Federal University of Goiás, Goiás, Brazil

[3] Federal University of Recôncavo da Bahia, Bahia, Brazil

Correspondence: Júlio César Azevedo Nóbrega, Federal University of Recôncavo da Bahia, Rui Barbosa Avenue, 710, Downtown, CEP 44380-000, Cruz das Almas, Bahia, Brazil. E-mail: jcanobrega@gmail.com

Received: February 28, 2018 Accepted: April 7, 2018 Online Published: May 15, 2018

doi:10.5539/jas.v10n6p272 URL: https://doi.org/10.5539/jas.v10n6p272

Abstract

Although soil physical attributes are determining factors of soil quality and for root development of crops, they are often neglected when dealing with soil management, which refers only to fertility. The objective of this work was to evaluate soil physical characteristics, organic carbon content and carbon stock levels in yellow Latosol cohesive distrophic coastal plains of Bahia, Brazil, where different soil management systems were implemented. Soil texture, water dispersible clay, flocculation index, soil density and porosity, liquid limit, plastic limit, plasticity index, stability of aggregates, organic carbon content and resistance to penetration were evaluated from soil samples collected in the 40 cm-top soil. The different soil plot covers consisted of (i) *Eucalyptus* with grasses (EGR), (ii) *Eucalyptus* with spontaneous vegetation (EVE), (iii) fallow (POU), (iv) pasture (PAS), and (v) native forest (MN). It was found that EVE and MN contributed to greater stability of larger aggregates in the 20-40 cm-soil layer compared to EGR, PAS and POU. The high organic matter contents of soils of the cultivated plots (EVE and EGR) increased the limits of consistency. Soil management systems with *Eucalyptus* and pasture contributed to accelerate the oxidation process and the loss of C.

Keywords: stable aggregates, soil structure, plasticity index

1. Introduction

Inadequate management and intensive soil utilization promote degradation of soil physical properties, mainly due to modifications of its original structure, which impairs the formation of stable aggregates in the soil (Melo et al., 2008), thus limiting crop productivity. The intensity with which these modifications occur depends on soil class, soil use and management systems employed (Centurion et al., 2001), which when are inadequate may reduce crop productivity (Lourente et al., 2011). In addition, they enhance a fast reduction of the organic matter contents in the soil (Xavier et al., 2006), the main factor for aggregate's development and stabilization (Wendling et al., 2005).

Soil aggregates are basic units of construction for soil structure, resulting from the interaction between minerals, polyvalent cations, organic matter, microorganisms, fragments and plant roots and clay minerals (Schjonning et al., 2007). Soil aggregation controls internal water as well as air and heat movement, for this reason its distribution in size classes and its quantity and stability are important (i) to determine the quantity and distribution of porous spaces in the soil, (ii) in the evaluation of soil susceptibility to wind and water erosion, (iii) in monitoring soil management and conservation practices and (iv) in the evaluation of soil water storage capacity, among other factors (Conte et al., 2011).

Organic matter is directly related to various soil attributes, including soil degradation (Prevedello et al., 2014), soil density (Luciano et al., 2014), total porosity and distribution of pore size (Gomes et al., 2015), soil consistency and water availability. Therefore, in order to preserve an adequate structure for the radicular system, it is essential to promote a continuous input of organic residues to the soil (Queiroz et al., 2011), which depends of many factors, among those are the soil use and management practices. Vasconcelos et al. (2010) found that the stabilization process of aggregates was intimately associated with the organic matter content. They concluded that the higher the content of organic matter in the soil, the higher was the stability of aggregates in the soil. With that in mind, it is expected that soil use and management systems which promote an increase of organic matter in the soil would also increase the stability of aggregates.

Coastal tablelands represent a vast food production area in the Brazilian Northeastern region. Unfortunately, the occurrence of cohesive horizons constitutes a problem for agricultural production in these areas. Inadequate management practices potentially modify soil structure; hence, the importance to study the impact of previous vegetation or soil use on its physical properties.

Thus, the present work had the objective to evaluate the physical attributes of a dystrophic cohesive yellow Latosol (Oxisol) and their correlations with the organic carbon (C) contents and C stock in areas under different management systems in the coastal tablelands' region of Bahia, Brazil.

2. Material and Methods

The study was performed at the Federal University of Recôncavo da Bahia (UFRB), Campus of Cruz das Almas, in the coastal tablelands, in the state of Bahia, Brazil. It was located in the latitude 39°06′26″S and longitude 12°40′39″W, at an altitude of 226 m. According to Köppen's classification the climate is hot and tropical humid. The soil is predominantly a yellow Latosol (Oxisol). Annual precipitation and mean annual temperature are 1200 mm and 24.5 °C, respectively.

The management systems evaluated were (i) native forest (MN), (ii) *Eucalyptus* with grasses (EGR), (iii) *Eucalyptus* with spontaneous vegetation (EVE), (iv) pasture with grazing (PAS) and (v) fallow area (previously under planted pasture, POU). For each system, soil samples were collected at each of 0.0-10; 10-20 and 20-40 cm-depths, with four replicates. Samples were collected in August 2014 from transects established in each selected area, which were equidistantly distributed. For each transect four sampling points were defined. Samples were conditioned in plastic bags and then transported to the laboratory where they were air-dried, sieved through a 2.0 mm-mesh and air-dried fine soils (TFSA) obtained.

Soil texture, water dispersible clay, flocculation index, soil density were determined by volumetric ring method, particle density by volumetric method. Total volume of pores was the ratio of soil density over particle density (EMBRAPA, 2011).

To determine the stability of aggregates, 50 g of soil samples sieved through a 7.93 mm mesh and retained in 2 mm mesh were weighted in triplicate. One sample was used to determine the humidity in an oven. The humidity was the difference between the sample weight before drying minus the weight of the dried sample. Initially, samples were saturated for 4 minutes in filter paper over moistened sponges. Then, they were transferred to a sieve set with 2.0, 1.0, 0.50, and 0.25 mm mesh and agitated in a vertical oscillation machine with 32 oscillations per minute and amplitude of 4.0 cm height for four minutes. Samples retained in each sieve were transferred into appropriate containers, put to dry in an oven at 105 °C for 12 hours, and weighted (Donagema et al., 2011).

The liquid limit (LL) was determined according EMBRAPA (2011), as a function of the content of humidity of a soil in the changing limit between the stages of liquid to plastic state, using the energy of shearing resistance given by the equation:

$$LL = WN \times (N/25)^{0.12} \quad (1)$$

Where,

LL = liquid limit; WN = percentage of humidity corresponding to N drops; N = number of drops.

The plastic limit (LP), which evaluates the content of humidity in the soil in the changing limit between the stages of plastic to semi-solid state, was determined according EMBRAPA (2011). From the values of LL and LP, the index of plasticity (IP) was calculated according to EMBRAPA (2011) by a simple arithmetic:

$$\text{Plasticity index} = \text{Liquid limit} - \text{Plastic limit} \quad (2)$$

The soil mechanical resistance to root penetration (RP) was determined in transects system, with 10 random replicates. Simultaneously, soil disturbed samples were collected to determine humidity at a depth of 0-10, 10-20 and 20-40 cm in the transect. RP was determined using an impact penetrometer-model IAA/Planalsucar, Embrapa Agropecuária Oeste, Brasil; the impact mass of 4 kg had a free fall of 0.40 m, with a total of 10 replicates. The data obtained from the penetration of the rod of the apparatus in the soil (cm/impact) were transformed to dynamic resistance to penetration (MPa) using the formula developed by Stolf (1991):

$$R\ (\text{kgf cm}^{-2}) = \frac{(Mg + mg) + \left(\frac{M}{M+m}\right) \cdot Mg \cdot h/x}{A} \quad (3)$$

Where,

R is the penetration resistance in kgf cm^{-2} (kgf cm^{-2} × 0.0981 = MPa); M is the mass of the plunger (4.0 kg), Pa corresponds to 4.0 kgf; m is the mass of the apparatus without the plunger (3.2 kg); h is the fall height of the plunger (040 cm); x is the penetration of the apparatus rod (cm/impact); A is the area of the cone (1.29 cm^2); and g is the acceleration of gravity. For each area and soil depth, disturbed samples were collected to determine the humidity.

Conversion of RP ìn kgf cm^{-2} to Mpa was made using Stolf's (1991) equation:

$$RP = 5.6 + 6.89\ (N) \quad (4)$$

Obtaining results in kgf cm^{-2} and then multiplying them by a constant 0.0981.

The total organic carbon content of the soil (COT) was obtained by humid oxidation, using a solution of potassium dichromate in acidic medium, with an external source of heat (Yeomans & Bremner, 1988). From the values of soil density and COT, the carbon stock values were calculated for each depth and for each soil management system, using the following formula: $EstC$ = C or N content (g kg^{-1}) × ds × e, where, ds = soil density (kg dm^{-3}) and e = soil layer thickness (cm) (Freixo et al., 2002). Was calculated Pearson correlation coefficient (r) between the liquid limit, plastic limit and plasticity index with the organic matter content.

3. Results and Discussion

Table 1 shows the granulometric characterization of the yellow Latosol according to the soil depth. The management systems EGR, EVE and POU, in the the 0-10 cm-soil layer, showed lower values of water dispersible clay (12 g kg^{-1} each) (Table 2), which consequently contributed to increase the flocculation index (94 against 90 for PAS and MN). At 10-20 cm depth, a higher value of water dispersible clay is observed for POU, followed by EVE and the lowest values for EGR, PAS and MN. In the case of these three last treatments, higher values of flocculation index are observed, followed by EVE and POU, respectively. At a 20-40 cm depth, it was verified that MN showed the highest water dispersible clay value and the lowest flocculation index. Treatments EGR, EVE, POU and PAS did not show differences. These values illustrate the structural quality of the soil, showing its resistance to water erosion, where the higher the water dispersible clay value, the more susceptible the soil to erosion and the inverse occurring in the case of the flocculation index (Souza et al., 2004).

Table 1. Granulometric composition of the topsoil of the coastal tableland region

Depth	Total Sand	Silt	Clay
	-----------	g kg^{-1}	-----------
0-10 cm	444	352	203
10-20 cm	612	273	144
20-40 cm	565	292	142

Regarding soil density, lower values were verified in areas planted with (EGR and EVE) and native forest (MN) (indicate the range of the values) (Table 2), independently of the soil depth. In these management systems higher values of total pore volume were also observed, which resulted in better structural quality of the soils, probably due to a higher content of organic matter derived from fallen leaves and branches. They have contributed to improving soils physical, chemical and/or biological attributes. An analysis of variance (ANOVA) done for each of the parameters measured and their mean values compared by Tukey test at 5% probability using Assistat 7.7 Beta software (Silva, 2008).

Table 2. Water dispersible clay (ADA), flocculation index (IF). Soil density (Ds), total volume of pores (VTP), aggregate classes and *mean weight-diameter* aggregates (DMP) in a yellow Latosol under different soil management systems

Management systems[1]	ADA	IF	Ds	VTP	Classes of aggregates (mm)					DMP
					7.93-2	2.0-1.0	1.0-0.5	0.5-0.25	< 0.25	
	$g\ kg^{-1}$	%			------------------	------------------	$g\ kg^{-1}$	------------------	------------------	mm
0-10 cm										
EGR	12 b	94 a	1.35 b	45.65 a	744.4 a	65.8 cd	55.9 b	43.9 b	90.0 b	5.69 ab
EVE	12 b	94 a	1.38 b	43.42 a	768.9 a	56.8 d	46.5 c	38.4 b	89.4 b	6.04 a
POU	12 b	94 a	1.57 a	35.47 b	532.1 b	97.2 a	124.5 a	75.5 a	170.6 a	3.37 c
PAS	20 a	90 b	1.59 a	33.48 b	676.2 a	82.9 ab	52.1 c	44.6 b	144.2 a	4.87 b
MN	20 a	90 b	1.39 b	42.96 a	767.5 a	54.8 d	55.4 b	71.5 a	50.8 c	5.97 a
10-20 cm										
EGR	20 c	86 a	1.35 b	46.10 a	515.0 b	43.7 c	86.7 bc	148.9 a	205.7 a	3.39 b
EVE	40 b	72 b	1.37 b	44.18 a	755.6 a	67.6 bc	51.7 d	40.7 b	84.4 c	5.85 a
POU	50 a	65 c	1.55 a	37.00 b	506.8 b	102.6 a	134.2 a	90.5 b	165.9 ab	3.12 b
PAS	20 c	86 a	1.57 a	35.46 b	712.0 a	97.7 b	60.1 c	42.3 b	87.9 b	5.27 a
MN	20 c	86 a	1.39 b	43.65 a	706.8 a	57.3 c	90.2 b	72.9 b	72.8 d	5.16 a
20-40 cm										
EGR	40 b	71 a	1.30 b	47.66 a	523.6 b	131.2 ab	139.2 ab	185.7 a	20.3 c	3.45 b
EVE	40 b	71 a	1.41 b	43.74 ab	759.4 a	80.2 b	52.7 b	35.7 b	72.0 b	5.92 a
POU	40 b	71 a	1.54 a	38.16 bc	311.6 c	143.4 a	204.0 a	146.6 a	194.4 a	2.18 c
PAS	40 b	71 a	1.56 a	36.39 c	576.6 b	156.9 a	100.6 b	62.0 b	103.9 ab	3.81 b
MN	50 a	64 b	1.35b	45.62 a	723.6 a	50.4 a	96.3 b	67.7 b	62.0 a	5.43 a

Note. EGR: *Eucalyptus* with grasses; EVE: *Eucalyptus* with spontaneous vegetation; POU: fallow area; PAS: pasture with animal grazing; MN: native forest.

(1) Means followed by the same letter do not significantly differ.

An improvement of the soil structure in areas with *Eucalyptus* was also assessed when analyzing data on aggregates' sizes distribution by class and mean weight-diameter of Soil Aggregates among management systems. Results showed a higher quantity of aggregates of high dimensions (7.93-2.0 mm) in EGR, EVE and MN areas, especially in the 0-10 cm-layer. In this layer, a higher value for aggregates and higher mean weight-diameter were also observed in PAS areas, preserving the same behavior in the 10-20 cm layer, with the exception of EGR and POU. These results demonstrated that although areas planted with Eucalyptus were superior when compared to areas under pastures, such effect is more prominent when spontaneous vegetation is preserved in the areas, when compared to areas planted with grasses. The 0-10 cm-layer concentrated more organic matter, which according to Kiehl (1979), promotes an intense activity of microorganisms, which act as aggregation agents of particles, due to mycelia or viscose substances produced, forming aggregates with higher stability to erosion.

A reduction of values for aggregates of 2.0-1.0, 1.0-0.5, 0.5-0.25, and < 0.25 mm for all management systems was searched. POU obtained the highest mean value for 7.93-2.0 mm aggregates. EGR, EVE, PAS and MN recorded significant reduction of values for smaller size aggregates, which was expected due to the higher value of aggregates bigger than 2 mm diameter.

Values of mean weight-diameter (Table 2) were statistically higher for management systems with Eucalyptus (EGR and EVE) and MN at 0-10 cm depth; EVE, PAS and MN at 10-20 cm and EVE and MN at 20-40 cm depth, due to the higher value of aggregates of bigger size (7.93-2.0 mm). PAS showed an intermediary value, not differing form EGR, while POU showed the lowest valued for mean weight-diameter, due to the lower value of aggregates bigger than 2.0 mm and a high proportion of aggregates of < 0.25-2 mm, resulting from a lower organic matter content.

In the 10-20 cm-soil layer, management systems EVE, PAS and MN showed highest values of aggregates of more than 2.0 mm diameter, followed by EGR and POU (Table 2), which is related to the organic matter content. In POU there was a reduction of aggregates values, majority being of sizes 2.0-1.0, 1.0-0.5, and < 0.25 mm, which also occurred in EGR, where a significant concentration of aggregates of 0.5-0.25 and > 0.25 mm, was observed. In EVE, PAS and MN there were higher organic matter contents, which provided higher quantities of aggregates bigger than 2 mm and reduced values for aggregates of 2-1, 1-0.5, 0.5-0.25 and < 0.25 mm, supporting results observed by Vasconcelos et al. (2010), who concluded that the process of aggregate stabilization was associated with the organic matter content.

Mean weight-diameter were high in EVE, PAS and MN due to the concentration of higher values of bigger size aggregates (7.93-2.0 mm but did not differ statistically). Reductions of values of mean weight diameter were observed in treatments EGR and POU, being statistically identical, due to the reduction of bigger sized aggregates' values. These results evidence that treatments EVE, PAS and MN were more efficient to deposit organic matter in the 10-20 cm soil layer (Table 4), which may be attributed to the release of organic compounds by roots and/or the soil fauna agreeing with results of AratanI et al. (2009), and Bonini and Alves (2011) that studying the quality of soil under different systems of use and management, verified that native forest area presented better quality of the soil, when compared to the areas submitted to antropic action.

In the 20-40 cm-soil layer, EVE and MN showed highest values for 7.93-2.0 mm aggregates (759.4 and 723.6 g kg^{-1} respectively), followed by EGR (523.6 g kg^{-1}) and PAS (576.6 g kg^{-1}) with intermediate values and POU (311.6 g kg^{-1}), which showed the lowest value for aggregates of bigger size. Such a behavior among management systems was intimately related to organic matter contents.

In aggregates of smaller sizes (2-1, 1-0.5, 0.5-0.25, and < 0.25 mm), POU showed higher values, once this treatment showed lower value of bigger size aggregates (7.93-2.0 mm). In the remaining treatments (EGR, EVE, PAS and MN), as they showed higher quantity of bigger size aggregates (7.93-2.0 mm), there was a reduction in the quantity of smaller size aggregates, evidencing better structural soil conditions, as also verified through the mean weight diameter values.

The values for liquid limit, plastic limit and plasticity index are showed in Table 3. In the 0-10 cm soil layer the liquid limit showed the highest value in MN (give the value), however not differing from treatments EGR, EVE and POU. Treatment PAS, although showing the lowest value (give the value), did not differ from EGR, EVE and POU. Contrarily to the results observed for liquid limit, no difference was verified between values of plastic limit, however, while evaluating values for plasticity index it was found that the highest values were recorded in EVE and MN, management systems that also showed higher values of organic matter (Table 4). These results are in agreement with Braida et al. (2006), who worked on the importance of organic matter in the definition of values for consistency limits for cultivated soils, due to its higher specific surface which promotes higher water holding capability. Lower values of plasticity index were observed for management systems EGR, POU and PAS.

In the 10-20 cm-soil layer, the liquid limit showed higher value for MN, as a result of the higher content of organic matter, followed by EGR, PAS, EVE and POU with the lowest value. For plastic limit and due to the higher content of organic matter, treatment MN showed the highest value, followed by EGR, PAS, EVE and POU, corroborating results from Silva et al. (2006), whom mentioned that increments of organic matter contents tended to increase the plastic limit. For plasticity index, treatments EVE and MN showed higher values (24 and 23, respectively); EGR (14) and POU (16) intermediary values and PAS the lowest value (04). Plasticity index is greatly influenced by the organic matter content. In fact, the higher the organic matter content in the soil, the higher the plasticity index tends to be (Vasconcelos et al., 2010).

In the 20-40 cm-soil layer, higher values of liquid limit are observed for EGR and MN, followed by EVE and PAS, which are not statistically different. The lowest value was observed in POU, which also did not differ statistically from PAS. For plastic limit, treatment EGR showed the highest value, not differing statistically from PAS, and followed by EVE, POU and MN, which also did not differ statistically from PAS. The plasticity index in this layer showed higher values in MN and EVE, treatments which also showed higher values of organic matter. Treatment EGR showed an intermediary value for plasticity index and organic matter and treatments PAS and POU showed lower values, with no statistical difference among them.

In the correlation between the liquid limit, plastic limit and plasticity index with the organic matter contents (Table 3), positive values for organic matter are verified for all variables studied, a fact that corroborates data obtained by Silva et al. (2006), and Vasconcelos et al. (2010).

Table 3. Liquid limit (LL), plastic limit (LP), plasticity index (IP) and coefficient of correlation with organic matter (MO) in dystrophic cohesive Yellow Latosol under different management systems

Treatment [(1)]	LL	LP	IP
	------------------------------------ g kg^{-1} -----------------------------------		
0-10 cm			
EGR	145 ab[(1)]	132 a	13 c
EVE	142 ab	104 a	38 b
PAS	161 ab	153 a	08 c
POU	124 b	111 a	13 c
MN	225 a	160 a	65 a
10-20 cm			
EGR	151 b	137 b	14 b
EVE	130 c	106 c	24 a
PAS	097 d	093 d	04 c
POU	142 b	126 b	16 b
MN	200 a	177 a	23 a
20-40 cm			
EGR	148 a	126 a	22 b
EVE	143 b	114 b	29 a
PAS	117 c	108 b	09 cd
POU	134 bc	117 ab	17 c
MN	148 a	114 b	34 a
MO	0.76**	0.81**	0.78**

Note. [(1)] Means followed by the same letter do not significantly differ at 5% probability by the Tukey test. ** r significant at 1% probability. MO: organic matter.

For RP, values above the critical limit of 2 MPa were recorded (Figure 1a), starting at a soil depth of 10 cm indicating that these soils were compacted throughout the whole profile (0-40 cm).

The prominent RP (2.55 MPa) in the top layer of MN may be associated to a strong cohesion, (Figure 1), typical for yellow Latosols from the coastal tablelands region. In the EVE and PAS areas compaction could have been due to cattle treading which increased soil density. POU presented higher RP in the depths of 20-30 cm, reaching 5 MPa, this soil was characterized by a degraded area with grass as soil cover. Amongst treatments, soil humidity varied from 4.0 to 5.2% for EGR; 5.9 to 6.0% for EVE; 6.1 to 8.5% for PAS; 4.5 to 8.8% for POU and 6.9 to 8.9% for MN, that is to say, it varied in a relatively homogeneous manner in deepness between treatments.

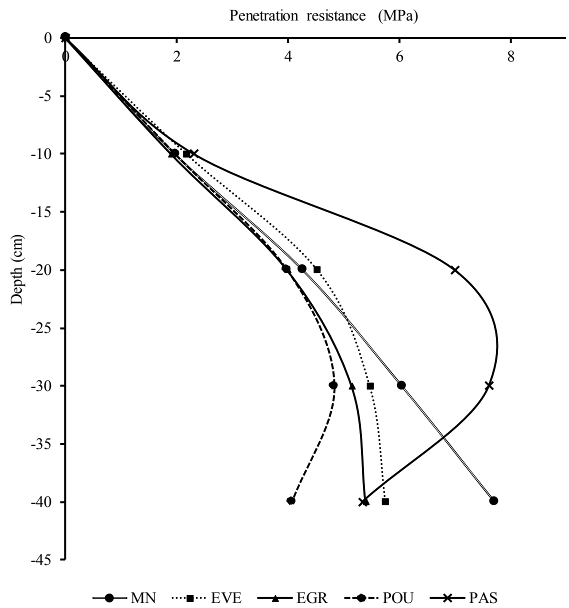

Figure 1. Mean values of penetration resistance in native forest (MN), *Eucalyptus* with grass (EGR), eucalyptus with spontaneous vegetation (EVE), pasture with animal grazing (PAS) and fallow area (POU)

The PAS showed higher RP values in the soil layers from 20 to 30 cm depth (7.2 MPa). All treatments presented high compression from 20 cm depth (> 4 MPa), representing cohesion. Similar values were observed by Giarola et al. (2003) when evaluating cohesive soils in the state of Bahia, Brazil. In general, the RP of the different management systems had a similar behavior, that is, they presented high compression from 20 cm depth (> 4 MPa), except for PAS, which recorded high RP when compared to other management systems of soil. This demonstrated that the continuous use of grass in cohesive yellow Latosols of the coastal plain region in Bahia requires specific management practices with the objective of reducing the negative effect of cohesion on the physical attributes of the soil.

The values of COT ranged from 5.69 to 38.22 g kg^{-1} (Table 4). There was a significant difference between the treatments when compared to the control treatment, MN, with the exception of the EVE treatment, which statistically did not differ from the MN, however, differed from the EGR, which can be explained by the greater diversity of plant species than in EVE. No variation in the total organic carbon content was verified in depth, except for EVE. However, reduction trends in total organic carbon content are present in all other treatments.

Table 4. Total organic carbon at different depths for different management systems

Treatment	0-10 cm	10-20 cm	0.20-0.40 cm
	g kg^{-1}		
EGR	10.42 bA	10.79 bA	12.68 abA
EVE	38.22 aA	26.94 aB	21.23 aB
POU	08.63 bA	07.15 bA	05.68 bA
PAS	11.61 bA	08.26 bA	07.28 bA
MN	30.19 aA	29.37 aA	22.90 aA

Note. * Means followed by the same capital letter in the row and small letter in the column do not significantly differ at 5% probability.

Values of carbon stock enable the analysis of the soil as a CO_2 reservoir. In this sense, all treatments demonstrated a higher tendency of carbon storage in the 20-40 cm soil layer (Figure 2), due to a higher thickness of the layer. Independently of the depth, treatments MN and EVE constituted the systems which showed the higher values of carbon storage. Neves et al. (2004), and Rangel and Silva (2007) also observed that native forest and *Eucalyptus*-bearing soils have a higher carbon storage capacity in depth, when compared to pasture areas. This effect has been attributed to a greater input of residues in the soil surface, due to barks, leaves and branches from *Eucalyptus* and due to a great deepening of the radicular system. A well distributed carbon along the evaluated soil layers was also noticed (Table 4), which may be attributed, according Gatto et al. (2010), to the soil class (Latosols), usually profound and well-drained soils, facts that facilitate radicular growth and consequently carbon distribution in deepness.

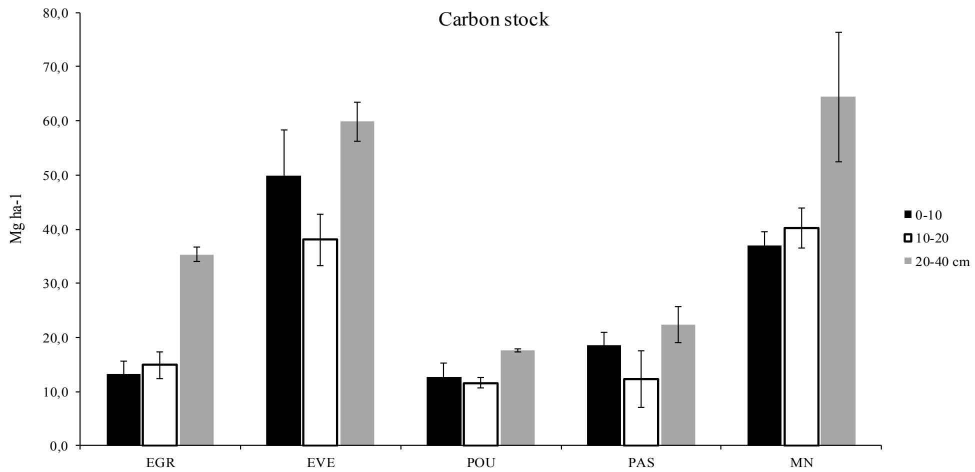

Figure 2. Carbon stock from 0-10, 10-20 and 20-40 cm layers in a yellow Latosol under different management systems. Native forest (MN), *Eucalyptus* with grass (EGR), eucalyptus with spontaneous vegetation (EVE), pasture with animal grazing (PAS) and fallow area (POU)

Another variable which reveals important information about the carbon in cultivated soil was the variation of these when compared to MN (Rangel & Silva, 2007). It allowed detecting a storage or a release of C-CO_2 to the atmosphere by the management systems. In the present study was found that all management systems, except EVE, induced a reduction of the carbon stock in the 0-0.10 cm-layer (Figure 3), when compared to MN. This fact, according to Rangel and Silva (2007), revealed that these systems were more vulnerable and could experience oxidation of carbon in the soil surface, henceshowing that MN had an important role in carbon sequestration (Neves et al., 2004). In the 10-20 cm layer, a tendency of higher carbon gathering was noticed among soil management systems.

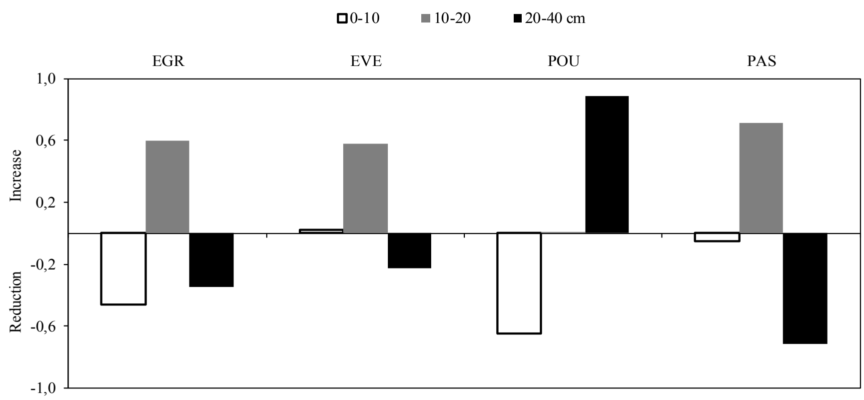

Figure 3. Organic carbon stock variation from 0-10; 10-20 and 20-40 cm-layers of different management systems with reference to the native forest system (MN)

Note. Positive values show increase in the C stock when compared to MN.

4. Conclusion

The management systems involving *Eucalyptus* with spontaneous vegetation and native forest contributed to the stability of large aggregates in the 20-40 cm-layer, when compared pasture with animal grazing and fallow as well. In all management systems, the mean weight diameter value was proportional to the organic carbon content. The rise of organic matter content of the soil in cultivated areas (EGR, EVE) increased the consistency limits, supported by a positive correlation between means of soil consistency and organic matter content. Soil management systems with *Eucalyptus* and pasture contributed to accelerate the oxidation process and carbon loss, and behaved like C-CO_2 emitters when compared to native forest areas.

References

Andrade, R. da S., & Stone, L. F. (2009). Índice S como indicador da qualidade física de solos do cerrado brasileiro. *Revista Brasileira de Engenharia Agrícola e Ambiental, 13*(4), 382-388. https://doi.org/10.1590/S1415-43662009000400003

Aratani, R. G., Freddi, O. S., Centurion, J. F., & Andrioli, I. (2009). Qualidade física de um Latossolo Vermelho Acriférrico sob diferentes sistemas de uso e manejo. *Revista Brasileira de Ciência de Solo, 33*, 677-687. https://doi.org/10.1590/S0100-06832009000300020

Argenton, J., Albuquerque, J. A., Bayer, C., & Wildner, L. P. (2005). Comportamento de atributos relacionados com a forma da estrutura de Latossolo Vermelho sob sistemas de preparo e plantas de cobertura. *Revista Brasileira de Ciência do Solo, 29*, 425-435. https://doi.org/10.1590/S0100-06832005000300013

Bonini, C. S. B., & Alves, M. C. (2011). Estabilidade de agregados de um Latossolo Vermelho degradado em recuperação com adubos verdes. calcário e gesso. *Revista Brasileira de Ciência de Solo, 35*, 1263-1270. https://doi.org/10.1590/S0100-06832011000400019

Brady, N. C., & Weil, R. R. (2008). Soil architecture and physical properties. In N. C. Brady, & R. R. Weil (Eds.), *The nature and properties of soils* (14th ed., pp. 121-172). New Jersey: Pearson Prentice Hall.

Braida, J. A., Reichert, J. M., Veiga, M., & Reinert, D. J. (2006). Resíduos vegetais na superfície e carbono orgânico do solo e suas relações com a densidade máxima obtida no ensaio Proctor. *Revista Brasileira Ciência do Solo, 30*, 605-614. https://doi.org/10.1590/S0100-06832006000400001

Centurion, J. F., Cardoso, J. P., & Natale, W. (2001). Efeito de formas de manejo em algumas propriedades físicas e químicas de um Latossolo Vermelho em diferentes agroecossistemas. *Revista Brasileira de Engenharia Agrícola e Ambiental, 5*(2), 254-258. https://doi.org/10.1590/S1415-43662001000200013

Conte, O., Wesp, C. L., Anghinoni, I., Carvalho, P. C. F., Levien, R., & Nabinger, C. (2011). Densidade agregação e frações de carbono de um Argissolo sob pastagem natural submetida a níveis de ofertas de forragem por longo tempo. *Revista Brasileira de Ciência de Solo, 35*, 579-587. https://doi.org/10.1590/S0100-06832011000200027

Donagema, G. K., Campos, D. V. B. de, Calderano, S. B., Teixeira, W. G., & Viana. J. H. M. (2011). *Manual de métodos de análise de solo* (2nd ed., Documentos 132, p. 225). Rio de Janeiro: Embrapa-CNPS.

EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária). (2006). *Sistema Brasileiro de Classificação de Solos* (2nd ed., p. 300). Rio de Janeiro: Embrapa Solos.

EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária). (2011). *Manual de métodos de análise de solo* (2nd ed., Documentos 132, p. 230). Centro Nacional de Pesquisa de Solos, Embrapa Solos, Rio de Janeiro.

Freixo, A. A., Machado,. P. L. O. A., Guimarães, C. M., Silva, C. A., & Fadigas, F. S. (2002). Estoque de carbono e nitrogênio e distribuição de frações orgânicas de Latossolo do cerrado sob diferentes sistemas de cultivo. *Revista Brasileira de Ciência do Solo, 26*(2), 425-434. https://doi.org/10.1590/S0100-06832002000200016

Gomes, R. L. R., Da Silva, M. C., Da Costa, F. R., De Lima Junior, A. F., De Oliveira, I. P., & Da Silva, D. B. (2015). Propriedades físicas e teor de matéria orgânica do solo sob diferentes coberturas vegetais. *Revista Eletrônica Faculdade Montes Belos, 9*(1).

IBGE (Instituto Brasileiro de Geografia e Estatística). (2006). Retrieved from http://www.sidra.ibge.gov.br/bda/pecua/default.asp?z=t&o=24&i=P

Jong van Lier, Q. (2001). Oxigenação do sistema radicular: Uma abordagem física. *Revista Brasileira de Ciência do Solo, 25*, 233-238. https://doi.org/10.1590/S0100-06832001000100025

Kaschuk, G., Alberton, O., & Hungria, M. (2011). Quantifying effects of different agricultural land uses on soil microbial biomass and activity in Brazilian biomes: Inferences to improve soil quality. *Plant and Soil, 338*(1-2), 467-481. https://doi.org/10.1007/s11104-010-0559-z

Kiehl, E. J. (1979). *Manual de edafologia: Relação solo-planta* (p. 264). São Paulo: Agronômica Ceres.

Lourente, E. R. P., Mercante, F. M., Alovisi, A. M. T., Gomes, C. F., Gasparini, A. S., & Nunes, C. M. (2011). Atributos microbiológicos. químicos e físicos de solo sob diferentes sistemas de manejo e condições de cerrado. *Pesquisa Agropecuária Tropical, 41*, 20-28.

Luciano, R. V., Bertol, I., Barbosa, F. T., Kurtz, C., & Fayad, J. A. (2014). Propriedades físicas e carbono orgânico do solo sob plantio direto comparados à mata natural. num Cambissolo Háplico. *Revista de Ciências Agroveterinárias, 9*(1), 9-19.

Melo, V. F., Moura, R., Toledo, F. H., Lima, V. C., & Chidin, A. A. (2008). Morfologia de agregados de Latossolos Bruno e Vermelho do estado do Paraná. avaliada por imagens obtidas em scanner. *Revista Brasileira de Ciência de Solo, 32*, 85-99. https://doi.org/10.1590/S0100-06832008000100009

Nascimento, P. C., Lani, J. L., Mendonça, E. S., Zoffoli, H. J. O., & Peixoto, H. T. M. (2010). Teores e características da matéria orgânica de solos hidromórficos do Espírito Santo. *Revista Brasileira de Ciência de Solo, 34*, 339-348. https://doi.org/10.1590/S0100-06832010000200007

Prevedello, J., Vogelmann, E. S., Kaiser, D. R., Fontanela, E., Reinert, D. J., & Reichert, J. M. (2014). Agregação e matéria orgânica de um argissolo sob diferentes preparos do solo para plantio de Eucalipto. *Pesquisa Florestal Brasileira, 34*(78), 149-158. https://doi.org/10.4336/2014.pfb.34.78.456

Queiroz, C. E., Stone, L. F., Brito, F. E. P., Didonet, A. D., Moreira, J. A. A., & Leandro, W. M. (2011). Sistemas de preparo do solo e culturas de cobertura na produção orgânica de feijão e milho. II-Atributos biológicos do solo. *Revista Brasileira de Ciência do Solo, 35*(2), 603-611. https://doi.org/10.1590/S0100-068320110 00200029

Silva, A. J. N., Cabeda, M. S. V., & Carvalho, F. G. (2006). Matéria orgânica e propriedades físicas de um Argissolo Amarelo Coeso sob sistemas de manejo com cana-de-açúcar. *Revista Brasileira de Engenharia Agrícola e Ambiental, 10*, 579-585. https://doi.org/10.1590/S1415-43662006000300007

Silva, V. R., Reinert, D. J., & Reichert, J. M. (2000). Resistência mecânica do solo à penetração influenciada pelo tráfego de uma colhedora em dois sistemas de manejo do solo. *Ciência Rural, 30*(5). https://doi.org/ 10.1590/S0103-84782000000500009

Souza, Z. M., Leite, J. A., & Beutler, A. N. (2004). Comportamento de atributos físicos de um latossolo amarelo sob agroecossistemas do amazonas. *Engenharia Agrícola, 24*(3), 654-662. https://doi.org/10.1590/S0100-69162004000300017

Stolf, R. (1991). Teoria e teste experimental de formulas de transformação dos dados de penetrômetro de impacto em resistência do solo. *Revista Brasileira de Ciência do Solo, 15*, 229-235.

Tormena, C. A., Roloff, G., & Sá, J. C. M. (1998). Propriedades físicas do solo sob plantio direto influenciadas por calagem. preparo inicial e tráfego. *Revista Brasileira de Ciência do Solo, 22*, 301-309. https://doi.org/ 10.1590/S0100-06831998000200016

Vasconcelos, R. F. B., Cantalice, J. R. B., Oliveira, V. S., Costa, Y. D. J., & Cavalcante, D. M. (2010). Estabilidade de agregados de um Latossolo Amarelo Distrocoeso de Tabuleiro Costeiro sob diferentes aportes de resíduos orgânicos da cana-deaçúcar. *Revista Brasileira de Ciência de Solo, 34*, 309-316. https://doi.org/10.1590/S0100-06832010000200004

Vasconcelos, R. F. B., Cantalice, J. R. B., Silva, A. J. N., Oliveira, V. S., & Silva, Y. J. A. B. (2010). Limites de consistência e propriedades químicas de um Latossolo Amarelo distrocoeso sob aplicação de diferentes resíduos da cana-de-açúcar. *Revista Brasileira de Ciência do Solo, 34*, 639-648. https://doi.org/10.1590/ S0100-06832010000300005

Wendling, B., Jucksch, I., Mendonça, E. S., & Neves, J. L. N. (2005). Carbono orgânico e estabilidade de agregados de um Latossolo Vermelho sob diferentes manejos. *Pesquisa Agropecuária Brasileira, 40*, 487-494. https://doi.org/10.1590/S0100-204X2005000500010

Xavier, F. A. S., Maia, S. M. F., Oliveira, T. S., & Mendonça, E. S. (2006). Biomassa microbiana e matéria orgânica leve em solos sob sistemas agrícolas orgânico e convencional na Chapada da Ibiapaba-CE. *Revista Brasileira de Ciência do Solo, 30*, 247-258. https://doi.org/10.1590/S0100-06832006000200006

Yeomans, J. C., & Bremner, J. M. (1988). A rapid and precise method for routine determination of organic carbon in soil. *Communications in Soil Science and Plant Analysis, 19*, 1467-1476. https://doi.org/10.1080/00103628809368027

Copyrights