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Article

Soil organic matter fractions, chemical attributes and aggregation under forestry and agricultural systems

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Abstract

The aim of this work was to evaluate the influence of the conversion of forest systems to agricultural systems in the organic matter compartments, aggregation and soil chemical attributes, in the Atlantic Forest. The evaluated systems were: annual crop (ACr); perennial agriculture (PAg); pasture; and secondary forest early (SFES), medium (SFMS), and advanced stage (SFAS). Soil samples were collected at the layer of 0-5 cm depth and quantified the total organic carbon (TOC), C of humic substances, oxidizable C, granulometric fractions of soil organic matter (SOM), soil chemical attributes, soil aggregation and glomalin-related soil protein (GRSP-total and GRSP-easily extractable) in different aggregate classes. It was observed a reduction of the TOC, particulate organic carbon (POC), humic substances and oxidizable C in the PAg and ACr areas comparing to pasture and forest systems. Moreover, the pH values increased whereas P content decreased in comparison with SFAS. As for aggregation, the PAg and the ACr decreased by around 35% and 20% the mean weight diameter of aggregates, respectively, compared to the average values found in the forestry systems, and 34% and 45%, respectively in relation to pasture. In general, GRSP-total were reduced by agriculture. Thus, it appears that the agriculture which has been practiced is altering negatively the soil chemical, physical and biological attributes.

Keywords: particulate organic carbon, oxidizable fractions, humic substances, glomalin

Introduction

The conversion of a native forest area to intensive agricultural use can promote changes in soil physical, chemical and biological attributes (Lisbôa & Miranda, 2014; Machado et al., 2014). The removal of the soil natural vegetal cover promotes a reduction of the vegetal material deposition, resulting in a decrease of the soil organic matter content (SOM) over time (Machado et al., 2014).

The SOM is constituted of different fractions that have different degrees of lability, which are not altered in the same magnitude when changes in the land use are carried out. Bernini et al. (2009) observed that the conversion of forest to pasture in Acre state, Brazil, promoted a reduction in total organic carbon (TOC) and particulate organic carbon (POC), whereas the oxidizable carbon fractions (F2 and F4) were not altered. According to the literature, (Loss et al. 2009; 2014a), the POC is effective to evaluate changes in OC contents which occur as result of agricultural management, especially at the first centimeters of the soil. On the other hand, Fontana et al. (2011), evaluating the SOM compartments in Atlantic Forest soils, observed that among the SOM fractions, the TOC was the most adequate fraction to show differences between soil use systems.

A more specific way to evaluate OC

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content and, consequently, the effect of land use and management practices on soil quality is related to the evaluation of humic substances (fulvic acids, humic acids and humina) (Fontana et al., 2011; Loss et al., 2014a; Machado et al., 2014). Humic substances (HS) constitute 85% to 90% of the total OM reserve, while at the same time being dynamic, reflecting changes in land use, HS are also one of the fractions responsible for the SOM accumulation (Paula et al., 2013).

Several studies consider OM and its fractions as the main agents for stabilization of soil aggregates (Bochner et al., 2008; Mandiola et al., 2011). According to some authors (Coutinho et al., 2010; Santos et al., 2012), higher soil OC content promotes greater stability of soil aggregates, and this, in turn, provides greater physical protection for the OM.

In forest areas the litterfall, in conjunction with the plant root system, continuously provides OM to the soil, which favors the maintenance of the microbial activity and biomass, as well as its diversity (Silva et al., 2012; Costa et al., 2015). Such conditions, over time, also directly influence the formation of soil aggregates that become more stable by having in their composition organic compounds binding the soil particles (Portugal et al., 2010).

The aim of this work was to evaluate the influence of the conversion of forest systems to agricultural systems in the organic matter compartments, aggregation, and soil chemical attributes, in the Atlantic Forest biome, in Pinheiral county, Rio de Janeiro state, Brazil.

Materials and Methods

The experiment was carried out in Pinheiral county, located in the region of "Médio Paraíba Fluminense", in the sub-basin of Cachimbal river. The area is located at the following coordinates: 22° 33' S and 22° 38' S latitudes and 43° 57' W and 44 ° 05' W longitudes. The climate of the region, according to Köppen's classification was identified as Am – Rainy, monsoon tropical climate with dry winter, where the mean temperature (°C) and precipitation (mm) values, from November 2009 to June 2010, were 22.14 °C and 57.50 mm, respectively. Six areas were selected for carrying out this study, which were: secondary forest early stage (SFES), secondary forest medium stage (SFMS), secondary forest advanced stage (SFAS), pasture, perennial agriculture (PAg) and annual crops (ACr) (Table 1). All the areas are located in the upper third of hillside position, the soil was classified as "Cambissolo Háplico Tb Distrófico típico" (Inceptisol).

In each of the study areas a plot of 20 x 20 meters was delimited, where soil samples were collected. In order to evaluate soil aggregation, five undisturbed samples were collected in the layer of 0-5 cm depth, using a cutting blade. For the evaluation of the soil organic matter and chemical attributes, in each area, three composite samples were collected at the layer of 0-5 cm depth, each composite sample was formed from five simple samples. After collection, the samples were air-dried, broken and passed through a 2.00 mm mesh sieve.

The soil chemical attributes (pH, P, K, Ca, Mg, Na, Al, H+Al e Valor V) were analyzed according to Embrapa (1997), the total organic carbon (TOC) was analyzed according to Yeomans & Bremmer (1988), and the SOM granulometric fractionation were determined according to Cambardella & Elliott (1992), obtaining the particulate organic carbon (POC) and the mineral-associated carbon (MAC). About 20 g of soil and 60 mL of sodium hexametaphosphate solution (5g L^{-1}) were stirred for 15 hours on a horizontal shaking machine. The suspension was then passed through a 53 µm sieve. The material retained on the sieve (POC) was dried at 50°C in a stove, quantified in relation to its mass, ground in a gral of porcelain and then analyzed for the TOC content (Yeomans & Bremmer, 1988). The MAC was obtained from the difference between TOC and POC.

For the chemical fractionation of soil organic matter (SOM), the organic carbon content of the humina (C-HUM), humic acid (C-HAF) and fulvic acid (C-FAF) fractions were quantified according to the International Humic Substance Society (IHSS) (Swift, 1996).

The stability of aggregates was determined by the method of water-stable aggregates (Yooder, 1936).

Glomalin in soil aggregate classes (8-4, 4-2, and 2-0,5 mm) was quantified as glomalin-

Table 1. History and description of land use systems in the region of "Médio Vale Paraíba do Sul", Rio de Janeiro state, Brazil

Abbreviation	History and description of the area[1]
SFES	Secondary forest early stage: sparse forest cover, which is characteristic of an early-successional stage (CONAMA, 1994), originated by use of the area until 1985 with spontaneous pasture, managed by annual cutting and occasional burnings, when it was occupied by small farmers, who fenced the area, allowing then the forest regeneration.
SFMS	Secondary forest medium stage: In a contiguous area at the same elevation as SFES area and that until 1985, was covered by spontaneous pasture with the initial formation of shrubbery vegetation (capoeira), being protected until the present day, which allowed the development of the typical medium-successional stage.
SFAS	Secondary forest advanced stage: dense vegetal covering and better structured than the previous ones, which allows to classify it in this successional stage. (CONAMA, 1994) – probably the succession began after the decline in coffee production in the region and it constitutes the oldest fragment in the lower portion of the sub-basin.
Pasture	It has been explored with spontaneous pasture since the 1950s and it was formed in the 1990s with *Brachiaria decumbens*, and then maintained by annual cutting and controlled burning – over the years resurfaced in this landscape the grass known as Bahia grass (*Paspalum notatum*), which came to coexist with the brachiaria introduced.
PAg	Perennial agriculture: until the 1990s this area was used as pasture. After this period, this area returned to be used for subsistence agricultural activities (corn and beans), in the present day it is cultivated with citrus. The conventional system of soil preparation is used (without fertilization and liming), with periodical manual weeding.
ACr	Annual crops: it has been used for subsistence agricultural activities (corn, beans, cassava) for approximately 20 years, which is cultivated with cassava in this present days. The conventional system of soil preparation is used (without fertilization and liming), with periodical manual weeding.

Silva et al. (2012) adapted by Menezes (2008)

related soil protein (GRSP). Two fractions of GRSP (easily extractable glomalin - EEG; total glomalin - TG) were distinguished according to the extraction conditions (Rillig, 2004). The easily extractable glomalin was obtained from the autoclave extraction using 1 gram of soil sample and 8 mL of 20 mM sodium citrate solution, pH 7.4, at a temperature of 121 °C for 30 min. The total glomalin content was obtained using 1 gram of soil sample and 8 mL of 50 mM sodium citrate, pH 8.0, at 121 °C for 60 min. For extraction of this fraction, more than one autoclaving cycle (3 to 13 cycles depending on the sample) was required until the sample color was that of light yellow. In both fractions, after autoclaving, centrifugations were performed at 5000 g for 20 min, which the supernatant was removed for subsequent quantification of protein. The quantification of glomalin was performed by the Bradford method (Wright et al., 1996), available at www.usda.gov, using bovine serum albumin. The GRSP concentrations for both fractions were corrected to mg g^{-1} of soil, considering the total volume of supernatant and the dry soil mass.

The data were evaluated for homoscedasticity, by the Cochran test and normal distribution of residues, by the Lilliefors test. Subsequently, the data were submitted to analysis of variance and the Bonferroni t-test, at 5% of probability. The relationships between soil attributes were determined by Pearson's correlation analysis. These tests and analyses were carried out using SAGE-5.0 statistical software (Sistema de Análises Estatísticas e Genéticas – Universidade Federal de Viçosa) and SISVAR-5.0 statistical software. Principal component analysis (PCA) was performed using PAST software (Paleontological Statistics Software Package for Education and Data Analysis), with the variables whose correlation with the F1 and F2 axes were ≥0,70. This analysis was used to reduce the dimensions of the data and, consequently, to facilitate the analysis by the correlation circle graph (Pearson).

Results and Discussion

Soil Organic Matter Fractions

Soil use systems with annual crops and perennial agriculture promoted reductions in the total organic carbon (TOC) content, which were 28% and 38%, respectively, in relation to the average value found in the forest systems (TOC = 23.01 g kg^{-1}). There were no significant changes in the TOC content between forest and pasture areas (Table 2). However, it was found that pasture showed TOC contents, about 43% and 69% higher than PAg and ACr, respectively.

The highest POC values were observed in the SFMS and pasture areas, followed by SFAS and SFES areas, whereas the lowest POC values were found in the agricultural areas (Table 2). It was verified that the POC values in the SFMS were 249% and 364% higher than in those found in the PAg and Acr areas, respectively. Loss et al. (2009) studying areas with different vegetation covers, verified that the POC content showed higher values in the areas where the greatest deposition of plant residues occurred.

Table 2. Total organic carbon (TOC), C of humic substances, oxidizable C and SOM granulometric fractions (g kg-1) of a Cambissolo Háplico (Inceptisol) under agricultural systems (Annual crops – Acr; and perennial – PAg), pasture and secondary forest in three successional stage (Advanced – SFAS; Medium – SFMS; and Early – SFES),at the layer of 0-5 cm depth.

Fractions	Agricultural systems					
	SFAS	SFMS	SFES	Pasture	PAg	Acr
TOC	21.17a	23.67a	24.20a	23.88a	16.70b	14.18b
POR	7.22b	10.91a	8.27b	10.29a	3.12c	2.35c
MAC	13.94a	12.76a	15.93a	13.60a	13.60a	11.83a
C-HUM	14.05a	12.32b	12.72b	12.77b	8.19c	6.53d
C-HAF	2.79a	2.19a	1.21b	2.58a	1.49b	1.09b
C-FAF	3.85a	2.88b	4.30a	3.41a	2.20c	1.58c
F1	5.01a	4.79a	5.69a	4.79a	2.98b	2.95b
F2	3.04b	3.46b	1.71c	5.88a	3.00b	1.78c
F3	7.07a	5.24a	5.24a	5.20a	1.53b	1.17b
F4	4.64a	3.50a	3.80a	3.36a	1.63b	1.17b

Average values sharing the same letter do not differ by Scott-Knott test at 5%.

The lowest COP values in the agricultural areas may result in changes in the stability of the macroaggregates (> 250 μm) and negatively reflect the soil resistance to external pressures (Loss et al., 2014a; Blair, 2000). Therefore, the soil can become more sensitive to compaction and more susceptible to erosive processes (Loss et al., 2014a).

By observing the POC average values it was possible to note differences between the three forest areas evaluated. This same pattern was not observed for the TOC content, where the areas of SFAS and SFES were statistically the same as the SFMS area (Table 2). This fact shows that POC was more efficient in identifying changes caused by the different stages of regeneration. Loss et al. (2009) observed that the POC was a more sensitive indicator comparing to the TOC to detect differences between types of soil management. According to Heide et al. (2009), since POC is a labile fraction with a higher recycling rate of the organic constituents, the changes in their stocks promoted by soil management are usually perceived in the short-term, whereas the TOC takes a longer time. There were no significant differences in the mineral-associated carbon (MAC) content in the studied areas (Table 2).

About the alkaline-soluble fractions, it was observed that the highest average values of C-HUM and C-HAF were found, in general, in the forest and pasture areas, and this could be related to the quality of the vegetal material, litterfall, and root contribution of grasses. Moreover, in these areas, due to the non-mobilization of the soil, organic matter is possibly more preserved. On the other hand, the lowest carbon content associated with the humic substances were verified in the ACr and PAg areas, which may be due to a greater soil mobilization, which possibly intensifies the SOM mineralization (Cunha et al., 2012; Silva et al., 2012), disfavoring the formation of humic substances.

For the oxidizable fractions, it was

verified that the F2 fraction was the only one, among the others fractions, that showed a difference between the forest systems, showing the highest values in the SFAS and SFME areas. No significant differences were found for the F1, F3, and F4 fractions between forest systems and pasture, whereas values found for F2 fraction that was higher in the pasture area. All oxidizable fractions decreased their values when passing from forest systems and pasture to agricultural systems, except for the F2 fraction that did not show differences between SFAE, SFME, and PAg. This shows that the management adopted in these areas is contributing to the change in the TOC content and consequently to the oxidizable fractions.

Soil chemical attributes

For the soil chemical attributes, the pH values showed differences between areas, which were lower in the SFAE comparing to the other areas (Table 3). This pattern may be due to the highest values of Al content and potential acidity (H + Al) found in the SFAE area in relation to the others.

Table 3. Soil chemical attributes of a Cambissolo Háplico (Inceptisol) under agricultural systems (Annual crops – Acr; and perennial – PAg), pasture and secondary forest in three successional stage (Advanced – SFAS; Medium – SFMS; and Early – SFES), at the layer of 0-5 cm depth.

Areas	pH	P	K	Ca	Mg	Na	Al	H+Al	V
		mg dm^{-3}	----------------------------cmol$_c$ dm^{-3}-------------------------						(%)
	0-5 cm								
SFAS	4.08 c	19.52 a	0.18 c	2.33 b	1.07 c	0.03 a	1.07 a	7.00 a	34 c
SFMS	5.89 a	11.15 b	0.59 a	5.27 a	3.47 a	0.05 a	0.00 c	5.77 b	62 a
SFES	5.82 a	14.56 a	0.39 b	2.03 b	1.77 b	0.05 a	0.60 b	7.23 a	37 c
Pasture	5.21 b	15.49 a	0.63 a	3.07 b	3.77 a	0.05 a	0.07 c	5.97 b	55 b
Acr	5.49 b	8.20 b	0.23 c	1.80 b	3.43 a	0.06 a	0.17 c	4.47 c	55 b
PAg	5.42 b	8.82 b	0.20 c	2.27 b	2.40 b	0.06 a	0.10 c	4.53 c	55 b

Average values sharing the same letter do not differ by Scott-Knott test at 5%.

No significant variations were observed in Ca contents between the agricultural areas and the SFAE and SFES. On the other hand, there was a reduction of Ca and K contents (around 60%) in the areas of agricultural activity compared to the SFME area. The pasture area showed significantly higher K, Ca and Mg contents than the forest systems in the advanced and early successional stages (Table 3). Losset al. (2014a) also observed higher contents of these nutrients in pasture area in relation to the native forest, in an Argisol (Ultisol), in Acre state, Brazil.

The agricultural and pasture areas showed higher saturation values (V) than the forest fragments in the early and advanced successional stages (Table 3). This pattern indicates that vegetation nutrition in forests is supported, possibly, by the nutrients cycling, with great accumulation of the organic matter, being released gradually by the roots and branches decomposition and then incorporated into the soil (Barreto et al., 2006).

Lower P values were found in the ACr and PAg areas comparing to the forest areas (advanced and early stage) and the pasture area (Table 3). This pattern may be related to a reduction in soil organic matter content in agricultural areas (Machado et al., 2014).

Soil aggregation

The mean weight diameter (MWD) of the soil aggregates ranged from 2.71 to 4.92 mm, the lowest value was observed in the PAg area and the highest one in the pasture area. The geometric mean diameter (GMD) showed the same results as the MWD (1.96 to 2.50 mm in PAg and pasture areas, respectively), although the difference was not significant. It can be observed that the PAg and the ACr reduced the MWD of the soil aggregates by 35% and 20%, respectively, in relation to the average values (4.14 mm) found in the forest systems, and 34% and 45%, respectively, in relation to average values of the pasture area (Table 4). This pattern may be related to the lowest increment of the TOC observed in the agricultural areas, addition to the exposure of the soil to the more intense impact of various elements, comparing to the forest and

Table 4. Soil Aggregate stability indexes of a Cambissolo Háplico (Inceptisol) under agricultural systems (Annual crops – Acr; and perennial – PAg), pasture and secondary forest in three successional stage (Advanced – SFAS; Medium – SFMS; and Early – SFES), at the layer of 0-5 cm depth.

Areas	MWD	GMD
	Mm	
SFAS	4.22 a	2.29 a
SFMS	3.88 a	2.20 a
SFES	4.32 a	2.14 a
Pasture	4.92 a	2.50 a
Acr	3.27 b	2.24 a
PAg	2.71 b	1.96 a

Average values sharing the same letter do not differ by Bonferroni test at 5%. MWD - mean weight diameter; GMD - geometric mean diameter.

pasture systems (Loss et al., 2014b). Evaluating soil aggregation and organic matter in different soil use systems, in Paraná state, Brazil, Loss et al. (2014b) observed that the agricultural activity (conventional tillage) reduced the aggregation indexes (MWD and GMD) when compared to the forest and pasture areas.

The vegetation is one of the factors that directly interfere in the soil carbon contents and its aggregation, due to the deposition of deciduous material to the soil, in addition to the cementing effect of root exudates and its mechanical action. (Beldini et al., 2010) The forest systems (SFES, SFME, SFAE) have denser (ranging from partially closed to closed) and larger vegetation (herb-shrub, shrub-tree) (Menezes, 2008), when compared to agricultural areas, thus, they have higher deposition of litterfall, and as a consequence, a larger increase of C to the soil, which promotes better aggregation indexes.

Significant and positive correlations were observed at 5% probability level between the MWD and TOC (r = 0.90), as well as with some of the SOM compartments (POC, r=083; C-Hum, r=0,89; C-FAF, r=0,85; F1, r= 0,83; F3=0,82; e F4, r=0,80), whereas the GMD correlated only with F2 fraction (r = 0, 90). Nobre et al. (2015) observed positive correlations between aggregation indexes (GMD and MWD) and the TOC and POC contents.

The three forest systems showed similar values for the GMD and MWD. It was verified that the soils in the different areas showed aggregation indexes (MWD) higher than 0.55 mm. Soares et al. (2005) state that aggregates with the MWD values higher than this value (0.55 mm) are relatively more resistant to breaking and dispersion, resulting in lesser susceptibility to changes in soil characteristics when subjected to a correct management.

Glomalin-related soil protein in soil aggregate classes

The GRSP (easily extractable glomalin - EEG; total glomalin - TG) in three different classes of aggregates (C1, C2, and C3), as well as the average of the three classes in each area, can be visualized in Table 5. In relation to the EEG contents, it was verified that there was no difference between the areas in each class of aggregates (C1, C2, and C3), not even when the average of classes was observed. However, the pasture (C2 and C3) and ACr areas (C3) showed lower contents of this fraction in the lowest classes of soil aggregates.

Significant differences were observed for the TG between the areas within each class of soil aggregates, except for class C2, and also when the average of the classes in each area was performed. In relation to the classes average, greater increases in this fraction were observed in the areas in later successional stages (SFAE and SFME), as well as in the classes C1 and C3. Higher TG contents in these areas may be related to the accumulation of this protein over time, since it presents high soil stability (Rillig et al., 2004). Moreover, the highest TG contents in these forest systems when compared to the agricultural areas may have contributed to the highest values of soil carbon in these areas, since glomalin, through the formation of soil aggregates, plays an important role in soil carbon storage (Rillig et al., 2004).

There were differences between the soil aggregate classes only in the pasture and SFES areas, with C1 and C2, whose aggregates size

Table 5. Total glomalin (TG) and easily extractable glomalin (EEG) in soil aggregate classes of a Cambissolo Háplico (Inceptisol) under agricultural systems (Annual crops – Acr; and perennial – PAg), pasture and secondary forest in three successional stage (Advanced – SFAS; Medium – SFMS; and Early – SFES), at the layer of 0-5 cm depth.

Classes	SFAS	SFMS	SFES	Pasture	PAg	Acr
	EEG (mg g^{-1} soil)					
C1	1.34 aA	1.42 aA	1.59 aA	2.27 aA	1.86 aA	1.67 aA
C2	1.26 aA	1.79 aA	2.21 aA	1.68 bA	1.49 aA	1.71 aA
C3	1.67 aA	1.73 aA	1.56 aA	1.27 bA	1.19 aA	0.90 bA
Mean	1.42A	1.65A	1.79A	1.74A	1.51A	1.43A
	TG (mg g^{-1} soil)					
C1	4.84 aC	6.99 aA	6.21 aB	5.59 aB	3.92 aC	4.59 aC
C2	6.97 aA	6.82 aA	5.73 aA	6.10 aA	5.94 aA	5.68 aA
C3	4.78 aA	5.64 aA	3.56 bB	3.07 bB	3.03 aB	3.01 aB
Mean	5.53 B	6.48 A	5.17C	4.92C	4.30C	4.43C

Average values sharing the same letter do not differ by Scott-Knott test at 5%. C= Size class of soil aggregates; C1 = 8-4 mm; C2 = 4-2 mm; C3 = 2-0,5 mm.

have larger diameters, with higher TG values. This pattern may be an indication of the participation of this protein in the formation and stabilization of soil aggregates, although no significant correlations were observed between glomalin fractions and aggregation indexes. These data agree with those found by Wright et al. (2007), who evaluated glomalin in different size classes of soil aggregates in a no-tillage system, observed that the glomalin contents increased parallel to the increase of the soil aggregates size.

In the C3 class of aggregates, it was verified that the EEG content showed positive correlations (5% of significance) with four (C-HUM, r = 0.86, F1, r = 0.80, F3, r = 0.85, F4 , R = 0.80) of out the ten SOM compartments evaluated. On the other hand, in classes C1 and C2, only the TG showed significant correlations (5% of significance), and these correlations were with the POC (r = 085) and C-FAF (r = 0.82), respectively. Nobre et al. (2015) observed high correlations of EEG and TG with OCD and POC. According to these authors, the contribution of glomalin to the soil carbon stock and carbon sequestration is evident (Báez-Pérez et al., 2010). The high correlations observed between glomalin and carbon suggest that this protein contributes, directly, to the soil carbon pool (Nobre et al., 2015).

Principal component analysis

As a tool to distinguish the evaluated areas, two principal components (Factor 1 and Factor 2) were obtained for the soil chemical, physical and biological attributes (Figure 1). It was observed that the distribution of the selected variables showed accumulated variance of 87.94% for the F1 and F2 axes, respectively. The F1 and F2 axes were able to explain 63.45% and 24.49% of this variance, respectively (Figure 1). The F1 axis was able to separate the SFAE, SFMS, SFES and pasture areas from the ACr and PAg areas. The variables that contributed most to this separation were C-HUM, C-FAF, F1, F3 and F4 fractions, P content, and H + Al content, since they showed the highest values of correlation coefficients with the F1 axis ($r \geq 0.90$). The variables that contributed most to the F2 axis were K and Mg content, with correlation coefficients higher than 0.80.

It can be observed that the areas showed distinct separations, dividing into two groups (Figure 1). The first group consisted of the agricultural areas, which was positioned in the lower left quadrant, that is, opposite from the disposition of most variables used in this analysis, as well as from the other study areas (Figure 1). The second group, formed by the pasture, SFAS, SFMS and SFES areas, is located in the upper right quadrant (pasture and SFMS) and in the lower right quadrant (SFAS and SFES) of the dendrogram, being more related to the soil chemical, physical and biological attributes.

Thus, the negative influence of agricultural activity under the aforementioned soil attributes is verified. This fact may be due to the lowest rates of deposition of plant material by these systems, resulting in a low incorporation of organic matter into the soil, which may reflect in low C contents in its different compartments, as well as lower aggregation indexes and biological activities, represented in this work by MWD and glomalin, respectively. In addition, the

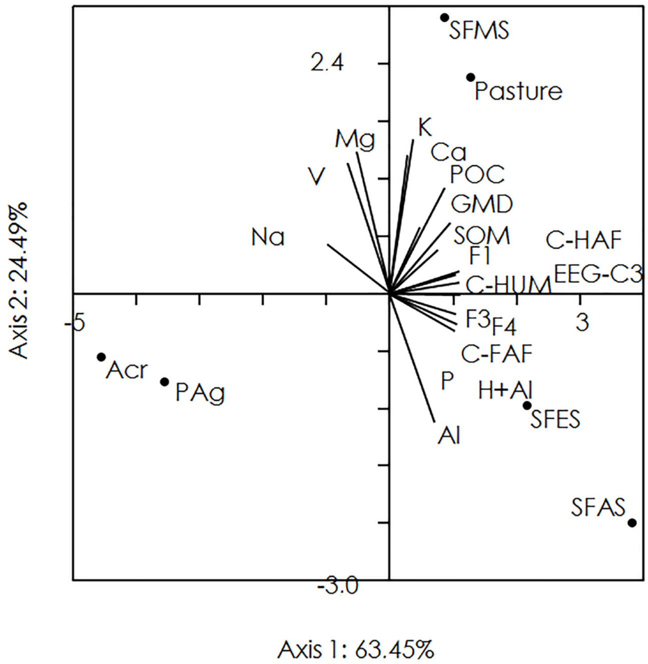

Figure 1. Principal component analysis dendrogram (B) of soil physical, chemical and biological attributes of a Cambissolo Háplico (Inceptisol) under agricultural systems (Annual crops – Acr; and perennial – PAg), pasture and secondary forest in three successional stage (Advanced – SFAS; Medium – SFMS; and Early – SFES),at the layer of 0-5 cm depth.

soil mobilization in the topsoil layer by successive weeding makes the organic matter more susceptible to microbial attack, which increases the mineralization rate of this layer (Cunha et al., 2012; Silva et al., 2012).

Assessing soil physical, chemical and total organic carbon in areas of annual agriculture (cassava) and forest systems (Secondary Forest, shrubbery vegetation -Capoeira, and banana in a crop-forest integration systems), in the Atlantic Forest biome, Silva et al. (2006) verified, through principal component analysis, separation between the agricultural system and the forest systems, whereby the chemical variables and the TOC were more related to forest systems, as observed in this present study.

Conclusions

The conversion of forest to agriculture results in an expressive decline in the contents of the soil organic matter compartments, accelerating the mineralization process, disfavoring the formation of the humic substances. In addition, it reduces the P content, soil aggregation index (MWD), and soil protein content related to glomalin.

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