Behavior of the organic matter as indicators of the soil quality under soil management systems, Northeastern Brazil, in experiment long-term.

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ABSTRACT

The edaphological conditions of the tablelands in the Northeastern Region of Brazil during ten year of evaluation in long-term plots was studied. The experimental split-plot design was used, with three randomized replications, performing 12 treatments that associate three soil management systems (CC - conventional tillage, cm - minimum tillage, PD – No- tillage) and four green manure species rotations: peanut (Arachis hypogea L.), beans (Phaseolos vulgaris L.), coverage:pea (Cajanus Cajan L.) and sunn hemp (Crotalaria juncea L.), rotated with sweet corn (Zea mays L.). As main results, after ten years of conducting the experiment it was concluded the no-tillage system presented the the highest average compared to other cropping systems, this fact was probably due to low tillage, which provided a greater increase in plant residues of cover crops. The total organic carbon, no-till had higher results compared to other cropping systems. The deployment time of no-tillage crop succession and promote changes in carbon stocks in soil depths evaluated. Minimum tillage systems and no tillage contributed significantly to the increased levels of total nitrogen, possibly due to the large plant cover present in these systems. The higher values for carbon storage in soil were found at a depth of 10-20 cm. The system of continuous cultivation had the lowest inventory values of N, with the use of plant succession

INTRODUCTION

In tropical and subtropical soils organic matter has large contribution to improving the chemical, physical and biological characteristics of them. With the removal of natural vegetation and establishment of agricultural systems, soil is vulnerable to degradation due to loss of organic matter, with appropriate management again acquires a new equilibrium. Therefore, the soil organic matter can be considered a significant indicator of soil quality because it is related to several properties. Changes in organic matter content of the mean changes in these characteristics, which represent the effects of the management system used.

The content of soil organic matter (SOM) is very sensitive with respect to management practices. Most soil attributes is closely related to SOM, the stability of structural aggregates, infiltration and soil water retention, erosion resistance, biological activity, cation exchange capacity (CEC) and nutrient availability to plants.

In the Northeast of Brazil, although it occupies only 24% of the area of the region, the Coastal Plains region (Table lands), being dissected and flattened geomorphological surfaces, concentrate over 50% of the population and generate a large part of the agricultural production, although with a low productivity. Among the factors that explain this low productive behavior, the occurrence of cohesive layers (upper B horizon of most soils) that brings growth of cultivated species is highlighted. Another limitation of great importance is the uneven distribution of rains, of which 80% are concentrated over a period of six continuous months, occurring in many areas of the states of Northeast Brazil (Araújo, 2000).

The logic behind this is that the parameters crucial to improving the quality of soil can serve as indicators of the same vocation for sustainable production of plants and animals in an economically viable way, socially acceptable and environmentally sound. A management system can only be considered sustainable if it maintains or improves soil quality without compromising environmental quality, besides a level that is acceptable to society (Gregorich, 2002).

The corn (Zea mays L.) is the main cereal produced in Brazil and is cultivated in about 14 million hectares. To obtain sustainable yields of this cereal must establish appropriate management systems to keep the soil organic matter and associating crops in succession, with conditions adapted to soil and climatic characteristics of the region. The corn (Zea mays L.) is the main cereal produced in Brazil and is cultivated in about 14 million hectares.

In the northeast region of Brazil, long-term research studies and experiments that investigate the physical behavior of soils under different tillage systems associated to crop successions have been virtually nonexistent, especially with crops of great exploration and market potential, such as sweet corn.

Therefore, the study of organic matter in agroecosystems is a strategic issue in order to obtain sustainability. One option to maintain or improve the stocks of soil organic matter (SOM), as well as carbon, nitrogen and fertility is to employ management systems that may add organic material, providing a balance between the addition and removal of these elements via conservation practices. The stocks of organic matter in any ecosystem are achieved by the interaction of the factors that cause its formation and those that cause decomposition.

To obtain sustainable yields of this cereal must establish appropriate management systems that maintain soil organic matter and associating crops in succession, with conditions adapted to edaphoclimatic characteristics of the region.

METHODS

This study was performed eleven years after the implementation of a long-term experiment, installed in 2001 at the the Rural Campus Experimental Station of the Department of Agronomic Engineering - DAE, at the Federal University of Sergipe - UFS, located in the central portion of the Coastal Plains (Table lands) physiographic region, in the municipality of São Cristovão - State of Sergipe, Northeast of Brazil (geographic coordinates 10°19' S and longitude 36°39' W), with an average level of the sea is 22m. The soil of the experimental site is typical dystrophic Red-Yellow Ultissol (Embrapa, 2006) and Typic Paleudults according to the Soil Taxonomy (Soil Survey Staff, 1999). The region has a climate classified by Köppen, of type As', Tropical rainy season with dry summer and rainfall around 1200 mm per year, with rains concentrated in the period April to September.

The experimental split-plot design was used, with three randomized replications, performing 12 treatments that associate three soil management systems (CC - conventional tillage, cm - minimum tillage, PD – No- tillage) and four green manure species rotations: peanut (Arachis hypogea L.), beans (Phaseolos vulgaris L.), coverage:pea (Cajanus Cajan L.) and sunn hemp (Crotalaria juncea L.), rotated with sweet corn (Zea mays L.). The aim was to analyze the effect of different cropping systems and plants in succession to corn (*Zea mays* L.) the behavior of organic matter of soil on carbon storage and soil N in long-term experiment, deployed in 2001, conducted in the Coastal Plains Lands, the state of Sergipe, in Northeastern of the Brazil.

For determination of soil density and subsequent assessment of carbon stock, collected samples indeformed rings, according Blake, Hartge (1986). For the determination of TOC, sub-samples of air dried soil (TFSA) were crushed and sieved in mesh (2mm) for determination of TOC by the method of wet oxidation with external heating (Yeomans & Bremner, 1988, and Gatto et al., 2009). Total nitrogen was determined by the Kjeldahl method, based in EMBRAPA (1997). The carbon in each of the layers has been estimated according Cardoso et al. (2010).

The scheme of experimental splitplot strip block was utilized, with different soil management systems prepared in strips and different crop succesions to corn in subplots, with three replications distributed randomly. For evaluation and statistical analysis of physical parameters, the Tukey test of means was utilized to a significance level of 5% probability, using the program Sisvar (Furtado, 2003).

RESULTS

In figure 1 are shown the values obtained for the three cropping systems, where are showed the total carbon content. The cover crops and management systems influenced the total carbon content at both depths studied. The DP was the one with the highest averages in comparison to other cropping systems. The highest content of total N in soil tillage are the result of lower decomposition rate of OM in this system.

As for the carbon storage, according to Table 1, it is possible to observe that the cover crops did not differ significantly at 5% probability, the carbon content at a depth of 0-10 cm. In the 10-20 cm depth was significant difference between the figures, and cover crops were peanuts, beans and pigeon pea were higher with respect to carbon storage in soil, differing from crotalaria. Comparing the two studied depths, it was observed that the storage of carbon in the soil differed significantly between the two depths, and at a depth of 10-20cm values were higher.

The management system had higher minimum N stock in the two studied depths (Table 2), differing significantly from other management systems. Between the depths, all management systems showed significant differences, and at 10-20 were found larger inventory values of N.

DISCUSSION

As main results, after ten years of conducting the experiment it was concluded the no-tillage system presented the the highest average compared to other cropping systems, this fact was probably due to low tillage, which provided a greater increase in plant residues of cover crops. The highest contents of total N in soil under no-tillage. The cover crops and management systems influenced the total carbon content at both depths studied. The DP was the one with the highest averages in comparison to other cropping systems, this fact was probably caused due to poor tillage, which provided a greater increase of crop residues of cover crops. The highest content of total N in soil tillage are the result of lower decomposition rate of MO in this system. Besides this fact, the superficial location of crop residues reduces soil-residue contact, slowing decomposition. Other effects, such as non-mechanical fractionation of the waste, lower temperature, higher humidity, lower soil aeration and preservation of surface aggregates, contributing to a lower rate of mineralization of organic N (Amado et al., 2000). In figure 1 and Table 1 are shown the values obtained for the three cropping systems.

According to Dudley et al. (2003), who evaluated the effect of different pulses in the TOC under Alfissol, found that the use of green manures can provide an increase in TOC. These authors observed that the maintenance of the legume residues after each cut promoted increase in TOC content, emphasizing the importance of using this practice to improve soil fertility.

In the conventional management system at a depth of 0-10cm, the cover crop peanuts, beans and pigeon pea were higher in relation to soil carbon levels, differing from sunhemp. The same behavior was repeated at 10-20cm depth (Figure 1). The crotalaria is the group of plants with the lowest C / N ratio of green material, which may also explain this decomposition quite high early in the process, especially in the handling of waste by the incorporation of high concentration of N in shoots (Carvalho et al., 2008). Comparing the two studied depths in the conventional system, it was observed that the carbon content in soil under peanut and sunhemp in the 0-10cm differed significantly from the carbon content of soil at a depth of 10-20cm (Figure 1). According Quaggio and Godoy (1997), the peanut crop is released from the practice of nitrogen fertilizer in the planting. In turn leverages and the residual effect of previous manuring, being excellent in crop rotation, the sequence of previously fertilized crops. According to Moreira and Siqueira (2002) the residual effect of previous crop N serves as a starting dose of favoring management system nitrogen of biological fixation. No least at 0-10 and 10-20cm, the cover crops did not differ significantly between themselves and with depths evaluated (Figure 1).

In no-tillage management system at a depth of 0-10cm, the cover crops pigeon pea and crotalaria were higher with respect to carbon content in soil, different plants beans and peanuts. A possible explanation for the higher values of carbon in the soil grown with sunhemp may lie in the fact that this plant provides a lot of nitrogen to corn, which results in increased biomass returns to the soil as carbon supply at the till. Thus, the cultivation of green manure can promote rotation or other crops in succession, and also with time, increasing the level of soil organic matter, which is directly related to the addition of nitrogen to the soil, or by fixation , or by adding mineral or organic fertilizer (Amado et al., 2002).

In the depth of 10-20cm the same behavior was not repeated, since no significant differences between them. Comparing the two depths measured, it was observed that the carbon content in the soil under and The sunhemp in the 0-10cm differ significantly from the carbon content of the soil at a depth of 10-20cm (Figure 1).

As for the larger values in layer 10-20cm (Table 2), this fact can be explained as a result of the experiment already has ten years, this relationship was also confirmed in studies conducted by Bayer et al. (2000); Sa et al. (2001); Lovato et al. (2004), who observed increases in the most significant amount of C in the surface layers of soil in the early years of tillage, but over time, stocks rose on the most deph. .Other explanation may be due to soil texture, therefore generally more clayey soils have lower rates of carbon mineralization (Mendham et al., 2002) and, consequently, the highest TOC, while the largest losses are observed in the fractions coarser texture (Rawls et al., 2003), which have less protection, colloidal carbon, because according to Neves et. al. (2005), there is the loss of organic material sand fraction given the greater lability, the susceptibility to oxidation and decay of plant debris and fungal hyphae present in this fraction.

The use of legumes in crop rotation systems is an efficient approach for maintenance/recovery of soil carbon storage. According Pontelli et al. (2010) the inclusion of legumes after maize provides a 10% increase in carbon storage.

The levels of the N storage in the two studied depths), differing significantly from other management systems (Table 2. With significant differences the depths, all management systems showed, and at 10-20 were found larger values of N. Amado et al. (2001) found higher values in no tillage systems, in subtropical conditions of south the Brazil. Is there a relationship between the stocks of C and N in the soil, therefore, for greater efficiency to sequester soil C, there is need for periodic additions of N. An economically and environmentally sustainable strategy to add N is the use of legumes in crop rotation systems.

Comparing the systems studied management at both depths evaluated, it is observed that the PD has provided a major input of carbon to the soil, by a larger C/N ratio than the other systems, in present experiment.. The results presented on the C/N ratio is consistent with the literature, for the pulses have a lower C/N ratio, forming a material that exhibits a C/N less than the equilibrium (<28/1), thereby being a material during decomposition releases nitrogen to the crop planted in succession on the debris (DIEKOW et al., 2005). Based on the results, it is assumed that the process of mineralization of nutrients will be superimposed on the immobilization due to the low C/N ratio (Doneda, 2010)

Spagnollo (2004) states that soil quality tends to decrease due to changes in land use caused mainly planting in deforested areas. Still, the help of conservation practices like no-till system has been an option to seek to achieve the sustainability of agricultural land in Brazil.

Soils in tropical regions have a rate of 1 to 5% of carbon, according to varying environmental conditions, type of vegetation and soil texture. The mechanisms that control the carbon cycle are responsible for its dynamics (Albers et al., 2008). Changes in management systems can assist the process of restructuring and therefore increase rates of soil organic carbon, thereby providing a sustainable productive system (Suman et al., 2009).

The soil particulate organic carbon (POC) is the fraction of labile organic carbon, being more sensitive, compared to changes in soil management. The light fraction corresponds to free MO, which represents 10-30% of organic carbon. The C storage in particulate organic matter constitutes the most sensitive indicator of the quality of soil management systems, allowing to verify the effect in the short term (Bayer et al., 2001, 2002). In recent years, the study of organic matter has gained prominence due to growing concern about the quality of the environment. This concern prompted the study of organic matter due to its crucial role in several aspects related to soil and water (Bronick & Lal, 2005).

The physical properties of soil play a key role in the maintenance of soil organic matter, especially in the tropics. Note that the carbon content is closely related to the texture of the soil tends to increase as the level rises the finer size fractions (Feller, 1993). In sandy soils contain generally lower amounts of organic carbon compared to those with finer texture. Coarse textured soils (sandy), as some found in the area of the trays, SOM levels are low, around 10 g.kg-1 or minor (Souza, 1996). These low levels of TOC are found mainly because of the carbon to be more accessible to attack by microorganisms, which discourages its accumulation in soil (Calegari & Medeiros, 2001). In the dry region of northeastern Brazil, the fragility of agricultural production systems is focused on the distribution of rainfall, the low capacity of water storage in soil, shallow soil, and mostly in the low fertility and inadequate management practices, or burning or use of crop residues to feed the flock. This practice leads to degradation of the natural fertility of the soil, causing losses of nutrients and soil depletion (Nunes, 2006). Under the same conditions, the no-tillage adoption is compromised by the difficulty in accumulating and maintaining ground cover, in terms of quantity and quality. The non-accumulation of crop residues due to the small amount added to the soil, given that this is only grown once a year and the crop residues left exposed for a long period on the soil surface (Silva Neto, 2003).

CONCLUSION

The highest contents of total N in soil under no-tillage are the result of lower decomposition rate of MO in this system. Besides this fact, the superficial location of crop residues reduces soil-residue contact, slowing decomposition. Other effects, such as non-mechanical fractionation of the waste, lower temperature, higher humidity, lower soil aeration and preservation of surface aggregates, contributing to lower rates of organic N mineralization. The total organic carbon, no-till had higher results compared to other cropping systems. The deployment time of no-tillage crop succession and promote changes in carbon stocks in soil depths evaluated. Minimum tillage systems and no tillage contributed significantly to the increased levels of total nitrogen, possibly due to the large plant cover present in these systems. The higher values for carbon storage in soil were found at a depth of

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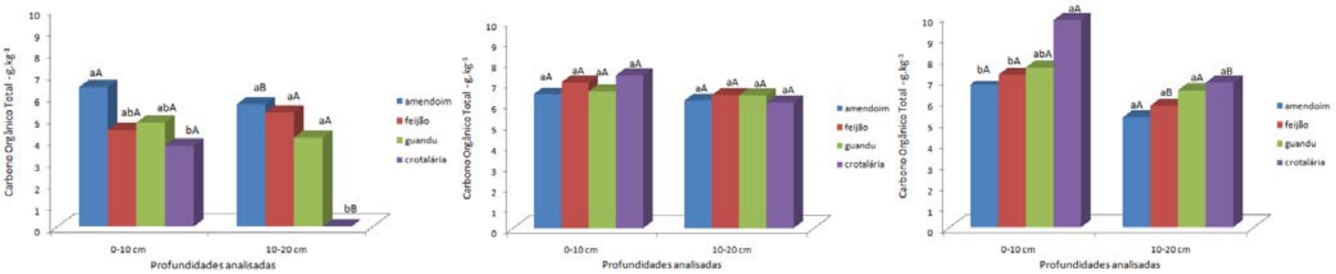

A B C

Figure 1. Concentration of total organic carbon (“carbono orgânico total”) of a Argissol Red Yellow, at deph (“profundidade”) 0-10 and 10-20cm depending on crop sucession(peanut – amendoim, sunhemp – crotalária, beans – feijão and pigeonpea – guandu) in conventional tillage systems (A), minimum tillage(B) and no tillage system (C), cultivated with sweet corn in Coastal Plains of Sergipe. Letras different capital letters in the vertical and horizontal differ statistically by Tukey test at 5% of probabily.

Table 1. Storage of the carbon in function of the tillage system, in deph avaliable.

Tillage systems	Storage of C	
	0-10 cm	10-20 cm
	--------------- Mg.ha^{-1} ---------	
CT	6,90 bB	10,83 bA
MT	10,32 aB	19,19 aA
NT	11,33 aB	19,06 aA

NT – No tillage, MT – Minimum tillage and TC – convencional tillage
Lowercase letters in the column, the capital letters in line, and different letters differ statistically by Tukey test at 5% probability

Table 2. Storage of the nitrogen in function of the tillage system, in deph avaliable.

Plantas de Sucessão	Estoque de N	
	0-10 cm	10-20 cm
	--------- Mg.ha^{-1} ---------	
Feijão	0.7 aB	1.09 aA
Amendoim	0.65 aB	1.32 aA
Guandu	0.63 aB	1.37 aA
Crotalária	0.69 aB	1.24 aA

NT – No tillage, MT – Minimum tillage and TC – convencional tillage
Lowercase letters in the column, the capital letters in line, and different letters differ statistically by Tukey test at 5% probability

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