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Soil carbon stocks and humification index under Brazilian livestock production systems in the Atlantic forest biome.

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Introduction

Carbon dioxide (CO_2) is a one of the greenhouse gases (GHG) which has caused some of the global climate changes (GCG). Today the CO_2 concentration in the atmosphere reaches 400 ppm mark according to the latest reports (NOAA, 2015). Brazil is one of the most important countries in the global livestock and according to the United Nations (UN) livestock is responsible for 14.5% of GHG emissions (RURAL BR, 2014). Agriculture can be an important ally for the CO_2 mitigation concentration in the atmosphere because contains

3.3 times (about 2500 gigatons) more than carbon the atmosphere (760 gigatons). CO_2 atmospheric can be converted to vegetable mass through biota photosynthesis and this carbon will be retain on soil through a well management of this mass. This mechanism is named as "carbon sequestration".

The SOM (soil organic matter) is defined as a mixture of compounds in various decomposition stages resulting from plants and animals biodegradation. The chemical characteristics of this organic material are an important indicator for the soil quality classification and about the management practices adopted to that soil. Stable fractions (or humidified) of SOM are directly influenced by soil management, humification index shows how the MOS is stable, ie resistant to microbial decomposition. According to Embrapa Agrobiology, more than 50% of the areas under pasture are in the degradation process. Thus, the SOM decreases, and carbon returns to the air in the form of CO_2 (ALVES et al., 2003).

The main goal of this study was to evaluate the effects of recovery of pastures, under different management systems in the Atlantic Forest Biome, on soil carbon stocks (SCS) and SOM humification, aiming at identifying GHG mitigation alternatives for the cattle raising sector in Brazil. The work also aims to conduct a comparative study of the carbon stocks in the depths of 0-30 cm and 0-100 cm.

Material and Methods

The experiment was carried in two different grazing systems for cattle and a forest native area located in the Embrapa's Southeast Livestock Research Center in São Carlos / SP. The first area is a recovery grazing system (A3), which is performed liming and fertilization with nitrogen (urea) and the second area corresponds to a degraded system where any kind of correction or control was not performed (A4), both under *Brachiaria decumbens* pasture. A native forest area near from the experiment (Atlantic Forest) was used as a positive reference. Samples were collected at the following depths 0-5, 5-10, 10-20, 20-30, 30-40, 40-60, 60-80 and 80-100 cm in six field replicates for each of the three areas concerned. Carbon stocks and SOM quality evaluation were studied in both pasture systems and in the forest area.

The samples preparation consisted of soil drying at room temperature and cleaning the samples, such as the removal of roots and plant residues, and soil homogenization. The soil was gently crushed using a mortar and pestle and passed through a 100 mesh sieve for elemental carbon analyses (CHNS) and the humification index determination.

In a previous study, Xavier (2014) compared methods for soil C stocks calculation: estimation based on a fixed mass (VELDKAMP, 1994) and in order to correct differences caused by land use changes in the soil density estimation using the normalized C content of each soil layer (ELLERT; BETTANY, 1995; SISTI et al., 2004). The SCS were corrected for each system evaluated using as a reference equivalent soil mass under native vegetation (Atlantic Forest), or using the equivalent mass calculation.

For SOM evaluation quality pellets were made from soil to 100 mesh. Then, the samples were analyzed by Laser-Induced Fluorescence Spectroscopy (LIFS) equipped with a diode laser emitting continuous wavelength of 405nm with a power source of around 200 mW. The spectral window was 475-800 nm, with an intensity of 0-4000, integration time 500 ms. For obtain the humification average index were collected five spectra for each sample.

The ratio of the area under fluorescence emission bands and the total organic C content (g kg^{-1}) was defined as the SOM humification index (H_{LIFS}) (MILORI ET AL., 2006).

Results and Conclusions

In this work SCS were evaluated in two ranges layers, 0-30cm and 30-100cm both evaluations using equivalent mass calculation. The results showed that until 1m-depth A3 showed the highest SCS with 142 Mg ha^{-1} versus 99 Mg ha^{-1} of A4 and MT with 115Mg ha^{-1}. The SCS for the first 30 cm layers, A3 showed a SCS with 64Mg ha^{-1}, A4 with 39Mg ha^{-1} and MT with 50 Mg ha^{-1}. The interesting aspect of this trial results was the different contributions of soil layers. Carbon stocks calculated for the 0-30 cm layers represented an average of 43% of the total C accumulation and the 30-100 cm layers with about 57% of the total C stocks, for all pasture systems. Therefore, it is important to emphasize the importance of sampling deep soil layers, especially when studding pastures established with grasses with abundant root system such as *Brachiaria.* Results indicate that the most amount of soil C is stored in deep layers.

For the SOM quality, lower humification indexes were obtained for the surface layers of all soils where occurrence of labile C derived from a continuous supply of fresh material from the cover vegetation and animals (Figure 2). In deeper layers, there is an increase in the H_{LIFS} due to the presence of more recalcitrant C, provided by unsaturated organic compounds containing double bonds and condensed rings.

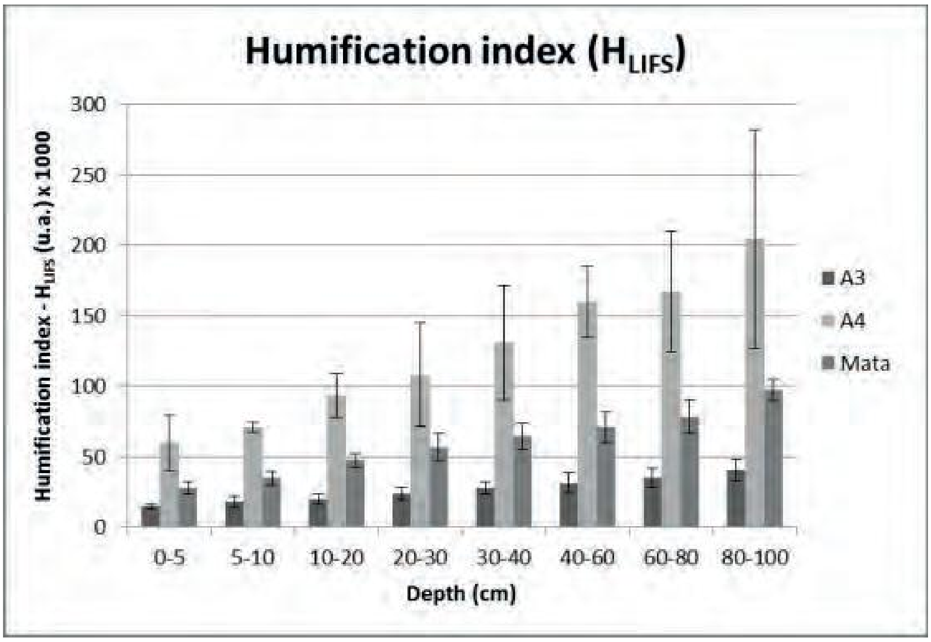

Figure 1: Humification index (H_{LIFS}); A3 – recovering system, A4 – degraded system, MT – Native forest

The analyses of SOM humification complements soil C stocks because the LIFS technique measures recalcitrant C, what can be a sensitive indicator of variances caused by changes in land use and soil management. The "vulnerability" of C is checked in this kind of assessment. In this study, A3 systems, which had the highest C stock values, are susceptible to CO_2 losses if the management is not appropriate, mainly due to the high lability of their soil C, especially at the surface layers.

The soil C stocks associated with the humification indexes showed an alarming situation due to the carbon stored there has a lower humification degree in all layers. This fact reminds us of the fragility of this system to inadequate management. Systems with high C stocks are susceptible to CO_2 losses to atmosphere if the management is not appropriate, mainly due to the high lability of soil C. Results indicate the capacity of well managed tropical grasses to mitigate GHG emissions from livestock production systems.

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