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Seasonal effect of land use type on soil absolute and specific enzyme activities in a Brazilian semi-arid region

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ABSTRACT

Tropical environments are considerable contributors to overall soil carbon loss to the atmosphere. Land use effects on soil chemical attributes have been well documented mainly in humid environments; however, less attention has been paid to the changes in soil enzymatic activities in dry ecosystems that is a sensitive indicator in ecological processes, due to its importance in soil dynamics and microbial activity. The present study is part of interdisciplinary project that investigated the effect of land cover type and seasonal variation on absolute and specific enzymatic activities per unit of soil organic carbon (SOC) and per microbial biomass carbon (MBC). We assessed five different land use type (Tropical dry forest-TDF, protected area with Angico –ANA, protected area with Ipê-TAB, Scrub area-SCR and agricultural area with maize-M) and five areas of each land use in three layers: 0–0.05, 0.05–0.10 and 0.10–0.20 m. The samples were collected at rainy season 1 in April 2014 (RS1), dry season October 2015 (DS) and rainy season 1 April 2016 (RS2). The conversion of the preserved area provided a reduction in absolute enzymatic activities, especially in the SCR and M. The reductions were of 76% for β-glucosidase, 95% for urease and 72% for acid phosphatase. The specific enzymatic activities per unit of MBC increased with the change of soil use, except in M. The enzymatic activity per unit of SOC in the TDF area was higher in relation to the other areas evaluated, except for specific activity of acid phosphatase. The land use type influenced the absolute and specific soil enzyme activities, but not show a clear trend of seasonal effect.

1. Introduction

The conversion from natural ecosystem to agricultural usage contributes approximately 17% of global greenhouse gas (GHG) emissions (Lybbert and Sumner, 2012). In this sense, tropical environments have been one of the major contributor to carbon emission to the atmosphere (Earles et al., 2012), and understanding the effects of land use changes becomes critical. However land cover changes effects are much less understood in seasonally dry tropical ecosystems, (Blackie et al., 2014; Hoekstra et al., 2005).

These ecosystems are among the most endangered forests (Lepers et al., 2005) with few areas under protected legal status (FAO, 2010; Green et al., 2013). South America accounts for more than half (54.2%) of the remaining Tropical dry forests, including the two most extensive contiguous areas, one in southeastern Bolivia, Paraguay and northern Argentina (Särkinen et al., 2011) and one in the northeast Brazil, which covers most of the semiarid area and is the largest remaining area of dry tropical forest in the world (de Almeida-Cortez et al., 2016)

Studies that help clarify soil C and N dynamics in semi-arid regions are highly important since they affect GHG emissions and are affected by anthropogenic changes in soil cover, as well as the climatic conditions (Sampaio et al., 2012; Sousa et al., 2012).

Nevertheless there is limited knowledge of the extent and magnitude of these impacts in relation to the management systems practiced and the seasonal variations on the dynamics of the biogeochemical cycles (Campo and Merino, 2016), although. Some studies have indicated seasonal effects (Campo and Merino, 2016; Cuevas et al., 2013; Marín-Spiotta and Sharma, 2013; Ribeiro et al., 2016).

Enzymatic activities can play a significant role in the influence of soil dynamics and microbial functions (de Medeiros et al., 2017)and changes in microbial community through human intervention are known to affect soil enzymatic activities, since the former are the main

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drivers for the latter (Bowles et al., 2014; de Medeiros et al., 2015; Smith et al., 2015).

On the other hand, as extracellular enzymes are immobilized in the humic and mineral fractions of the soil, their activity is also conditioned by factors such as vegetation composition, management practices, soil pH, moisture content and soil temperature, aggregate stability and compaction (Benitez et al., 2005; Raiesi and Beheshti, 2014). Thus, the absolute enzymatic activity does not allow to verify if the observed effects are due to soil microbial biomass and organic matter contents or enzymatic activity *per se* (Raiesi and Beheshti, 2014; Wang et al., 2012)

Thus, several studies have used specific enzymatic activities (global enzymatic activity in relation to soil microbial biomass (CBM) or soil organic carbon (SOC) per unit of C to compare biochemical activity in soils with different organic C levels (Trasar-Cepeda et al., 2008). These variables have been shown to be a good indicator of microbial change in tropical forests, including depth (Weintraub et al., 2013) as shown by several studies (de Medeiros et al., 2015; de Medeiros et al., 2017; Raiesi and Beheshti, 2014; Wang et al., 2012). For example, in dry tropical environments, specific enzyme activity was more sensitive to conversion of forests to agriculture than to global (de Medeiros et al., 2015).

Many studies evaluate the conversion of natural ecosystems especially in humid environments. However, there is still a gap on the understanding of the conversion of drier areas using sensitive tools. This is especially true for the Brazilian semiarid, which is important both due to its extension and to it strong seasonal leaf loss, in response to the very irregular rainfall (Maia et al., 2007). Thus, the objective of the present study was to evaluate the impact of conversion of dry tropical forests to anthropic areas with different types of land cover and seasonal variation on absolute and specific enzymatic activities in tropical areas of the Brazilian semi-arid region.

2. Materials and methods

2.1. Study area and soil samples

The study area is in Serra Talhada - Pernambuco State, Northeastern Brazil (7°59′31″S and 38°17′59″W), with an altitude of 430 m (Fig. 1). The climate in the region is BSh Köeppen (Alvares et al., 2013) semi-arid hot climate, with average annual temperature of 28 °C, average yearly rainfall precipitation of 600 mm, concentrated from January to April. According to the Brazilian classification system the soil is Luvisol chromic (Solos, 2013).

Soil samples were collected in April 2014 (rainy season 1, RS1), October 2015 (Dry season, DS) and April 2016 (rainy season 2, RS2) in areas with different land cover type, namely: Tropical dry forest (TDF), protected area with Angico (ANA), protected area with Ipê (TAB), Scrub area (SCR) and agricultural area with maize (M). Prior to soil samples five repetition plots of 0.4 ha were established under each land cover and soil samples were collected from each plot in the layers: 0–0.05, 0.05–0.10 and 0.10–0.20 m. Triplicate soil samples were collected from each plot and layer under each land cover typ. The all areas are located next to each other.

Five areas were selected:

- Tropical dry forest - Caatinga (TDF – 7°57′47.0″S, 38°23′01.5″W): reasonably preserved, but used for uncontrolled grazing;
- Angico Forest (ANA - 7°57′07.5″S, 38°23′56.1″W): it has been covered with Angico (*Anadenanthera* sp.) since 1978. Before 1978 it was cultivated with cotton (*Gossypium hirsutum*) and palm (*Opuntia ficus-indica*);
- Ipê Forest (TAB - 7°57′10.1″S, 38°23′45.5″W): cultivated with buffel grass (*Cenchrus ciliaris*) and cotton (*Gossypium hirsutum*). It underwent natural regeneration from 1998 by Ipê (*Tabebuia chrysotricha*);
- Scrub (SCR - 7°57′16.2″S, 38°23′45.4″W): covered with Scrub for > 20 years. Predominance of black jurema (*Mimosa tenuiflora*), white jurema (*Piptadenia stipulacea*), quince (*Croton sonderianus*), mallow (*Waltheria indica*), arboreal, Juá (*Zizyphus joazeiro*) and herbaceous plants.
- Conventional farming (M - 7°57′15.4″S, 38°23′49.1″W): Cultivated with maize (*Zea mays*) conventionally from 2005 to 2015, but under fallow due to the severe drought from 2011 to 2013. The farmer has applied an unknown amount of sheep dung over the cultivated time.

2.2. Soil physical attributes

The soil texture analysis (sand, clay and silt contents) was performed in a hydrometer using sodium hexametaphosphate as the dispersing agent, according to Loveland and Whaley (1991) (Table 1).

2.3. Soil chemical attributes, organic carbon content (SOC) and microbial biomass carbon (MBC)

The following chemical attributes were determined: pH in water (1:2.5), available P, exchangeable K^+, Al^{3+}, Ca^{2+} and Mg^{2+}. The P and K^+ were extracted through Mehlich^{-1}, and K^+ was quantified by flame photometry while P by the colorimetry method. The nitrogen was measured with the combustion method at a temperature of 925 °C in an elemental CHNS-O analyzer (Perkin Elmer PE-2400). The SOC content was determined through hot oxidation with potassium dichromate, according to Yeomans and Bremner (1988) (Table 2).

The soil microbial biomass carbon (MBC) content was determined through the irradiation method (Mendonça, 2005), followed by extraction with 0.5 M K_2SO_4 and the carbon content in the extracts was determined through the colorimetric method (Bartlett and Ross, 1988) (Table 2).

2.4. Absolute and specific enzyme activities

The soil urease (URE EC. 3.5.1.5) activity was determined using urea as substrate, according to Kandeler and Gerber (1988), β-glucosidase (Beta EC 3.2.1.21) in ρ-nitrophenyl-β-D-glucoside substrate according to Eivazi and Tabatabai (1988) and acid phosphatase (Pac EC. 3.1.3) in ρ-nitrophenyl phosphate according to Eivazi and Tabatabai (1977). All product absorbances were measured in spectrophotometer (Libra S22, Biochrom, Cambridge, England).

The specific activities were obtained by the division by SOC (Acosta-Martínez et al., 2003) and MBC (Raiesi and Beheshti, 2014).

2.5. Data analysis

Data were analyzed through ANOVA followed by the Student Newman-Keul's test at 5% probability when appropriate. The Pearson correlations between measured soil variables were determined across the land uses and soil depths.

3. Results

3.1. Absolute enzyme activities

The TDF area showed the highest absolute enzymatic activities in the first two layers (0–0.05 and 0.05–0.10 m) and in rainy periods, except for acid phosphatase activity. The lowest absolute activities of Beta and URE were observed in the conventional farming area (M).

The TDF area showed the highest enzymatic activity of Beta in the first two layers, in all evaluated periods, except in the dry period (Fig. 2). In the last layer evaluated (0.10–0.20 m) the TDF area did not present significant difference in relation to the other systems of land use.

Overall all layers that the largest reductions in Beta activity occurred in the SCR and M areas. The area of Maize presented a reduction in Beta activity of 48, 54 and 64% in RS1, DS and RS2, respectively,