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Absolute and specific enzymatic activities of sandy entisol from tropical dry forest, monoculture and intercropping areas

Erika Valente de Medeiros*, Krystal de Alcantara Notaro, Jamilly Alves de Barros, Wendson da Silva Moraes, Aline Oliveira Silva, Keila Aparecida Moreira

[a] Laboratory of Microbiology, Federal Rural University of Pernambuco, Academic Unit of Garanhuns, Bom Pastor Av. s/n, Garanhuns,Pernambuco 55292-270, Brazil

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ABSTRACT

The transformation of tropical dry forests in intensive agricultural areas affects soil organic carbon with consequence in microbial and enzymatic activities, regardless of the type of use. The activities of soil enzymes (fluorescein diacetate hydrolysis dehydrogenase, β-glucosidase, arylsulfatase, urease, acid phosphatase and alkaline phosphatase), total organic carbon (TOC) and soil microbial biomass carbon (MBC) were measured in sandy entisol covered with forest, monocultures (grass, prickly-pear cactus, pepper and cucumber) and intercropping (corn and cowpea; cassava, pigeon pea and cowpea). The data showed that the TOC content decreased with land use. The quantity of MCB was increased in soil covered with monoculture and intercropping related to forest. There was a change in the different sandy entisols uses in relation to enzymatic activities. The soils with prickly-pear cactus monoculture were highest in enzyme activity, except to alkaline phosphatase. The tropical dry forest conversions in monoculture do not follow the same model of intercropping to enzyme activity. In sandy entisol, the specific enzymes activities per unit of TOC and MBC were more important in explaining differences between soils than absolute enzyme activities. We recommend the use of specific enzymes activities per unit of TOC and MBC to be used as a tool for detecting changes in sandy entisol. By multivariate analysis intercropping and forest create a similarity group related to enzymes activities, TOC and MBC, demonstrating that less intensive practices like intercropping causes less impacts on balance of biogeochemical cycles and organic matter dynamics than monoculture in sandy entisols of tropical dry forest. This is the first record of these parameters in the region and can serve as indicators to promote its use as a tool in the decision-making of the farmers to avoid soil degradation.

1. Introduction

The conversion of native forests to intensive croplands can cause losses in the productive capacity of some soils. The tropical dry forests (TDF) are the ones that most suffer this process in the world (Hoekstra et al., 2005), mainly change to pasture cropping (Murgueitio et al., 2011).

When forests are converted to cropland, intensive practices used in the soil produce changes in ecosystem processes and functions, mainly related to carbon (Khormali et al., 2009; Beheshti et al., 2012), contributing to the loss of this element in the soil in which it is of great importance for the agro ecosystems balance (Jiménez et al., 2011).

Therefore, some producers are concerned about practices that are less harmful to soil and environment, as agroforestry (Notaro et al., 2014), crop rotation (Acosta-Martínez et al., 2014) and intercropping (Jamshidi et al., 2013). These practices may respond differently to the monoculture, with respect to soil quality because intensive agricultural practices and organic pollution are major causes of soil degradation (Gianfreda et al., 2005). This quality depends on a large number of chemical, biological, physical, microbiological and biochemical parameters (Chaer et al., 2009; Kandeler, 2007), of which the latter two are the most sensitive as they respond rapidly to changes (Bastida et al., 2008).

Soil enzyme activity is a sensitive biochemical indicator of soil quality because it is related to soil organic matter decomposition

* Corresponding author. Tel.: +55 87 96038599/37645500; fax: +55 87 37645520.
E-mail addresses: evmbio@gmail.com, valente@uag.ufrpe.br (E.V.d. Medeiros), krystal.notaro@gmail.com (K.d.A. Notaro), jamilly_barros@hotmail.com (J.A.d. Barros), wendsonufrpe@gmail.com (W.d.S. Moraes), alineoliveirasilva6@gmail.com (A.O. Silva), moreiralab@yahoo.com.br (K.A. Moreira).

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(Raiesi and Beheshti, 2014) and participates the nutrient cycling (mainly C, N, P and S). It is also capable of reflecting ecosystem processes (Doran and Zeiss, 2000). Several studies have proposed the measurement of enzyme activities in the soil under different land uses and management worldwide (Ekenler and Tabatabai, 2002; Acosta-Martínez et al., 2007; Xiu-Mei et al., 2008; Pandey et al., 2014; Rasool et al., 2014) and have indicated their potential for the evaluation of impacts resulting from management, agricultural activities and soil contamination (Deng and Tabatabai, 1997).

Overall, the enzymatic activity is presented in absolute terms, but it does not reflect the part of microorganisms in this production (Acosta-Martínez et al., 2003). Therefore, some studies show the importance of evaluating the enzymatic activities in relation to soil microbial biomass (MBC) and soil organic carbon (TOC), known as specific enzymatic activities (Wang et al., 2012; Raiesi and Beheshti, 2014).

Multivariate principal component analysis (CPA) can analyze which variables best explain the differences between the treatments and has been used to determine which parameters are most sensitive to detect differences, to be used as a tool for monitoring soil quality. This analysis has been used in studies of the soil, in physical (Mota et al., 2014), microbial (Notaro et al., 2014) and biochemical (Pandey et al., 2014; Tan et al., 2014) attributes.

With these considerations, this work aimed to: (1) evaluate whether the conversion of forest in monoculture follows the same models of intercropping in relation to soil organic carbon, soil microbial biomass, absolute and specific enzyme activities in sandy entisol. (2) Determine which variables are most important for monitoring the soil quality these areas by multivariate principal component analysis.

Table 1
Means of pH, microbial biomass carbon (MBC) and total organic carbon (TOC) of sandy entisols from tropical dry forest, monoculture and intercropping areas.

Land use	Culture	pH	TOC	MCB	FDA
Forest	TDF	5.76	23.81	18.52	30.08
Intercropping	CORNCOWP	6.31	14.4	70.37	5.00
Intercropping	CASPIGPCOWP	5.52	11.34	31.48	21.00
Monoculture	GRASS	7.14	13.19	40.74	8.91
Monoculture	PRICK	5.69	23.49	72.22	36.52
Monoculture	PEPPER	6.43	23.57	77.78	19.66
Monoculture	CUKE	7.24	14.56	27.78	30.00

TOC: total organic carbon (g kg^{-1}); MCB: microbial carbon biomass (mg kg^{-1}); FDA: fluorescein diacetate hydrolysis (μg hydrolysates g^{-1} of soil).

2. Materials and methods

2.1. Study area

The study areas were located at tropical dry region in Pernambuco state, northeast Brazil (Fig. 1, Table 1). The areas present similar climate, topography and altitude (75 m). The region's climate, according to Köppen classification, is the As' (i.e., hot and humic) type. The average annual rainfall is around 782 mm.

The soil samples were collected in the dry season with a hot semiarid climate. The areas selected were: TDF—tropical dry forest (utilized as a control to verify the changes); intercropping 1 = corn, cowp–*Zea mays* + *Vignia unguiculata*; intercropping 2 = CASPIGPCOWP–*Maninot esculenta* + *Cajanus cajan* + *Vignia unguiculata*; monoculture 1 = GRASS–*Pennisetum purpureum*; monoculture 2 = PRICK–*Opuntia oleracea*; monoculture 3 = PEPPER *Capsicum*

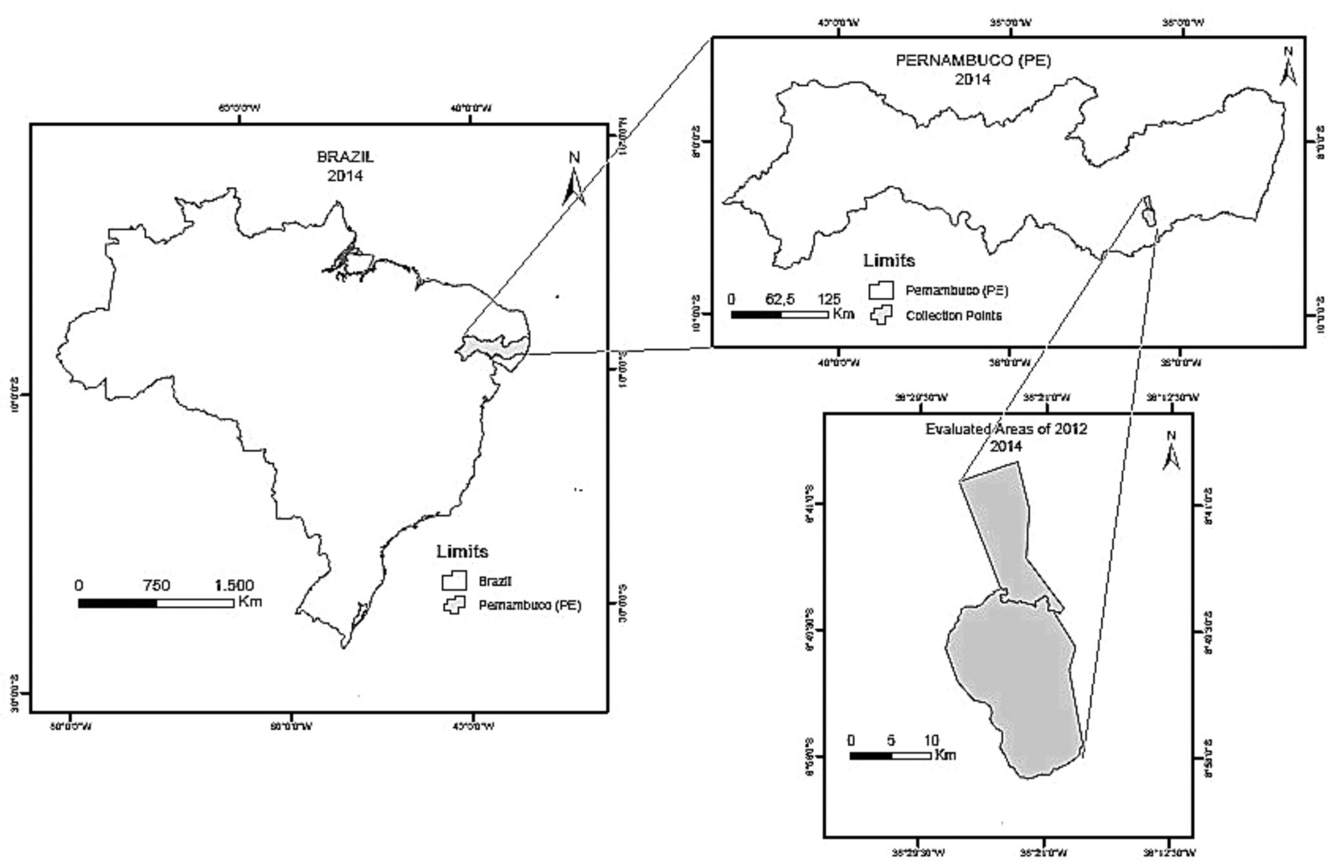

Fig. 1. Map showing the location of soil samples collected.