SOIL RESPIRATION AND BULK DENSITY UNDER ORGANIC AND CONVENTIONAL FARMING SYSTEMS

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RESUMO

O objetivo deste estudo foi avaliar, no campo, a respiração e a densidade do solo em áreas sob agricultura convencional e orgânica. As avaliações foram feitas em diferentes parcelas estabelecidas com sistema de cultivo orgânico com seis, nove, doze, quinze, dezoito e vinte e um meses de implantação em comparação com o sistema convencional. As parcelas foram divididas em quatro transectos (subparcela) e em cada subparcela foram avaliadas a respiração, a densidade e a porosidade do solo. A respiração do solo foi significantemente maior no sistema de cultivo orgânico com quinze, dezoito e vinte e um meses de implantação quando comparando com o cultivo convencional. A densidade do solo diminuiu após quinze meses de adoção do sistema orgânico. Os resultados mostraram que a adoção de práticas do sistema orgânico aumenta a atividade biológica e decresce a densidade do solo ao longo do tempo.

Palavras - chave: teste de campo; avaliação do solo; atividade biológica.

RESPIRAÇÃO E DENSIDADE DO SOLO SOB SISTEMAS DE AGRICULTURA ORGÂNICA E CONVENCIONAL.

ABSTRACT

The aim of this study was to evaluate, in the field, the soil respiration and bulk density under conventional and organic farming plots. The evaluations were made in different plots established as conventional farming system and organic farming system with six, nine, twelve, fifteen, eighteen and twenty one months old. Plots were divided in four transects (subplots) and in each subplot were evaluated soil respiration, bulk density and porosity. The soil respiration was significantly greater in organic farming system with fifteen, eighteen and twenty-one months old as compared with conventional farming. Soil bulk density decreased fifteen months after adoption of organic system. The results showed that the adoption of practices in organic farming plots increases microbial activity and decreases soil bulk density over time.

Keyword: field test; soil evaluation; biological activity.

INTRODUCTION

Conventional farming has played an important role in improving food and fiber productivity to meet human demands but has been largely dependent on intensive inputs of synthetic fertilizers and pesticides (TU et al., 2006). Problems arising from conventional practices have led to the development and promotion of organic farming system that account for the environment and public health as main concerns (ARAUJO et al., 2009). However, organic farming is a sustainable method of agriculture which aims to improve soil health and productivity through the use of crop rotation, legume cover crop, animal green manure, and organic compost. The practices in organic farming system focus the use of farm-derived renewable resources and biological processes and interactions that will provide an acceptable crop yield (SILVA et al., 2014). In this context, an organic farming system represents an important method that improves soil quality.

Soil quality is the capacity of a specific kind of soil to function and is generally assessed by measuring a minimum data set of soil properties, such as soil respiration and soil bulk

density. Soil respiration is one the most used parameter for quantifying microbial activities in soil (SILVA et al., 2014) and presents a closed relationship with some important soil properties, such as bulk density (PANDEY et al., 2011). On the other hands, soil bulk density is important for root growth and for the movement of air and water through the soil. Therefore, increased bulk density could reduce the transportation of water and air through the soil, and, consequently, contribute to the decline in soil biological activity and, finally, lead to a decrease in crop yield (GADJA et al., 2016).

In order to evaluate the soil properties in organic farming systems, the United State Department of Agriculture (USDA) developed a kit of selected field procedures to evaluate or indicate the level of one or more soil functions (USDA, 2001). However, it should be adapted to tropical regions, such as Brazil, and used by researchers or landowners to assess the quality of their soil. Thus, in this study we used these field procedures to evaluate the soil respiration and soil bulk density in conventional and organic farming plots in Northeast Brazil.

MATERIAL AND METHODS

The field study was carried out at the Irrigation District of Piauí (DITALPI, Parnaiba) Brazil (03°05' S; 41°47' W; 46 m) in an experimental field. The climate is rather dry with a mean precipitation of 1,000 mm yr^{-1} and an annual mean temperature of 30°C. The soil type is a Typic Quartzipsamment in US soil taxonomy.

The evaluations were done in January 2013 from seven different plots planted with "acerola" orchard (*Malpighia glaba*) and established at the following management: a) conventional farming system (CONV); b) organic farming system with six months old (ORG6); c) organic farming system with nine months old (ORG9); d) organic farming system with twelve months old (ORG12; e) organic farming system with fifteen months old (ORG15); f) organic farming system with eighteen months old (ORG18); g) organic farming system with twenty one months old (ORG21). The size of the organic and conventional areas varied between 5000 and 10000 m^2. Each plot was divided in four transects which represented replication. The practices of conventional and organic management are given in Table 1.

Table 1. Conventional and organic management practices (applied annually) on experimental plots.

Specific annual inputs and practices used	
Conventional farming system	Organic farming system
Organic matter input	
None	Rock phosphate (0.5 t ha^{-1}); Cow compost (24 kg $plant^{-1}$); "carnauba" straw (100 L $plant^{-1}$); MB4[a] (1.2 t ha^{-1}).
Chemical input	
Urea (0.5 kg $plant^{-1}$); Super single phosphate (0.03 kg $plant^{-1}$); Potassium chloride (0.03 kg $plant^{-1}$); Micronutrients (0.05 kg $plant^{-1}$).	None
Plant protection	
Weed control	
Mechanical	Straw mulch
Disease and insect control	
Chemical (thresholds)	Alternative methods (Plant extracts, bio-control)

[a] MB4 contain calcareous plus micronutrients.

Conventional system, managed since 2004 (crop rotation cowpea/watermelon). Organic plots received inputs of green manure, 0.5 t ha^{-1} of rock phosphate and 1.2 t ha^{-1} of MB4 (calcareous plus micronutrients).

Soil moisture was determined from soil cores taken from seven sites from the 0-10 cm depths. Soil sub samples (10 g) were weighed into aluminum dishes. These dishes were placed in a 105 $\pm$ 2°C oven for 24 h, and the dry weight was then recorded. Gravimetric soil moisture was

the difference in soil weights before and after oven drying. Bulk density and water-filed pore space (WFPS) was determined according to USDA (2001).

The evaluation of soil respiration in field was based on the determination of CO_2 evolved from known areas of undisturbed soil surface. Cylinder plastics (internal diam. 15 cm, height 30 cm, wall thickness 5 mm) were installed to a depth of 5 cm. The NaOH solution was placed in an open glass jar above the soil surface and the area was covered with a metal cylinder closed at the upper end. After the incubation for 24 h, the NaOH solution is removed and the CO_2 concentration is measured by titration with HCl. Soil respiration rates were adjusted to equivalent at 60% WFPS through the equation described by Parkin et al. (1996).

The study was carried out in a completely randomized design with four replicates and the data were analyzed statistically by using ASSISTAT (SILVA; AZEVEDO, 2009). When a significant F value was detected, the means were compared by the Duncan test ($P < 0.05$).

RESULTS AND DISCUSSION

The results of soil moisture, soil bulk density, water-filled pore space (WFPS) and soil respiration from conventional and organic farming plots are shown in Table 2.

Table 2. Soil moisture, soil bulk density, (WFPS) and soil respiration conventional and organic farming systems.

	Soil moisture ($g\ g^{-1}$)	Bulk density ($g\ cm^{-3}$)	WFPS (%)	Soil respiration ($\mu g\ CO_2\ g^{-1}\ d^{-1}$)
CONV	0.20 ± 0.01 a	1.51 ± 0.6 b	46.7 ± 4.3 b	33.9 ± 5.5 c
ORG6	0.24 ± 0.03 a	1.40 ± 0.5 ab	50.9 ± 5.1 ab	54.6 ± 8.6 b
ORG9	0.26 ± 0.02 a	1.41 ± 0.4 ab	53.4 ± 5.5 a	56.6 ± 6.5 b
ORG12	0.25 ± 0.01 a	1.39 ± 0.5 ab	52.6 ± 4.9 a	65.7 ± 8.2 a
ORG15	0.27 ± 0.03 a	1.35 ± 0.4 a	54.9 ± 6.1 a	67.0 ± 9.5 a
ORG18	0.26 ± 0.03 a	1.37 ± 0.3 a	53.8 ± 5.6 a	68.7 ± 8.5 a
ORG21	0.27 ± 0.04 a	1.31 ± 0.4 a	53.2 ± 5.0 a	69.2 ± 8.3 a

Means followed by the same letter within each column are not significantly different at 5% level by Duncan's test.

Soil moisture showed small variations among the different plots, but without significant differences. It occurred because all plots are irrigated daily and therefore the soil moisture became similar. The values of WFPS were significantly higher in organic farming plots with nine, twelve, fifteen, eighteen and twenty-one months old as compared with the conventional plots. This index was used for adjusted soil respiration in field to equivalent values at 60% WFPS according equation described by Parkin et al. (1996). The highest WFPS found in organic plots are important for soil microbial activity, measured by soil respiration, since it could contribute for high CO_2 and O_2 diffusion through soil pores (TUCKER, 2014).

Soil bulk densities were lower in organic farming system with fifteen, eighteen and twenty one month old as compared with the conventional plots. The lower bulk densities measured in organic plots can be due to long-term addition of compost and "carnauba" straw that contributed to increase in organic matter content and, therefore, contributing for lower soil bulk density. Thus, the agricultural practices in organic farming plots may increase water infiltration; soil surface protection against erosion; water retention by the plus lower evaporation due to the presence of plant residues; aeration and porosity after the root depth; soil organic matter contents which increases the aggregates stability, microbial activities, soil fertility and nutrient turnover (BALDOCK; KAY, 1987). Swezey et al. (1998) and Glover et al. (2000) found lower soil bulk densities in organic apple orchards plots utilizing composted amendments as compared to conventional plots. These results are important as according to Williams et al. (2017), organic practices decreased the soil bulk density and can suggest that organic farming reduces the soil's susceptibility to compaction.

The soil respiration was highest in organic farming plots with twelve, fifteen,

eighteen and twenty-one months old (Table 2). It suggests a positive effect of organic farming practices on soil microbial activity and indicates that the improvement occurs twelve months after the adoption of organic farming practices. The lower values for soil respiration were found in conventional farming plots. The higher soil respiration in the organic farming plots is an indicative of high biological activity and can suggest rapid decomposition of organic residues into nutrients available for plant growth. The long-term effect of addition of an exogenous source of organic matter, as organic compost and straw, stimulates the heterotrophic microorganisms (SAFFIGNA et al., 1989). Matyas et al. (2018) found an increase in soil respiration between organic and conventional soils resulting from the application of more organic matter to the filed under organic farming system. According to Lai et al. (2013) the organic matter constitutes one of the most important sources of the energy and nutrients for the microbial development.

CONCLUSION

Our results showed that the organic farming practices promote lower soil bulk density and higher soil porosity and microbial activity, measured by soil respiration, compared to conventional farming practices.

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