Evaluation of Microbial Biomass in Agroforestry Systems Using Forage Cactus and *Leucaena leucocephala* and *Gliricidia sepium*

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The XXIV International Grassland Congress / XI International Rangeland Congress (Sustainable Use of Grassland and Rangeland Resources for Improved Livelihoods) takes place virtually from October 25 through October 29, 2021.

Proceedings edited by the National Organizing Committee of 2021 IGC/IRC Congress
Published by the Kenya Agricultural and Livestock Research Organization

Presenter Information

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Sub-Theme 4: Wildlife, Tourism and Multi-Facets of Rangeland/Grassland

Biodiversity and ecosystem services of rangelands/grasslands

Concurrent session: Forage legume ecosystem services in sustainable livestock systems

Title: Evaluation of Microbial Biomass in Agroforestry Systems using Forage Cactus and *Leucaena leucocephala* and *Gliricidia sepium*

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Key words: Agroforestry systems; Edaphic microorganisms; Microbiological analyzes.

Abstract

Vegetation type can affect soil microbiology in agroforestry systems. Plants release different organic exudates in the rhizosphere, affecting microbial growth. This study evaluated the effect of forage cactus intercropped with different tree legumes on soil microbial biomass. The research was performed in a tropical semiarid Regosol at Caruaru Experimental Station, Agronomic Institute of Pernambuco, Northeast Brazil. Treatments included: i) *Gliricidia sepium* (Jacq.) Steud and forage cactus IPA-Sertânia (*Nopalea cochenillifera* Salm Dyck); and ii) *Leucaena leucocephala* [Lam.] de Wit.) and forage cactus IPA-Sertânia. Treatments were allocated in a randomized complete block design in a split-split-plot scheme, with four replications. Main plots consisted of agroforestry system, split-plot was the distance from tree rows, and split-split-plot soil depths. Organic fertilization with cattle manure was applied aiming a rate of 200 kg N ha^{-1}. Tree legumes were planted in double rows spaced 9 x 1 x 0.5 m and cactus planted between double rows spaced by 1 x 0.25 m. Plot size measured 960 m^2. Soil collection occurred in the rainy period (April 2019). Samples were collected at depths of 0-10 cm and 10-20 cm at 0, 1.5, 3.0, and 4.5 m away from legume rows. Response variables included soil basal respiration (SBR), microbial biomass C (C-mic), and metabolic quotient (qCO_2). Data were subjected to analysis of variance using SAS. Means were compared by Tukey test at 5% significance. No significant difference was observed for SBR, MBC, and qCO_2, with average values of 9.36, 202.98, and 0.05, and standard error 1.16, 10.90 and 0.01, respectively, in the different distances away from tree legumes. Introduction of arboreal legumes did not cause changes in microbial biomass. Microbial activity was similar in soils under forage cactus intercropped with Leucaena or Gliricidia.

Introduction

The forage cactus (*Opuntia* sp. and *Nopalea* sp.) is a viable alternative in animal feeding in semi-arid tropical environments because it is adapted to the edaphoclimatic conditions. In Brazil, it is estimated that there are approximately 600 thousand hectares cultivated with forage cactus (Dubeux Júnior et al., 2013). The intercropping of cactus with tree legumes allows the complementation of the levels of protein and fiber for the ruminant diet (Goveia et al., 2016), increases the availability of N in the system, and promotes greater litter deposition. The N input favors the process of nutrient cycling, by adding material with low C:N ratio (Oli et al., 2018), resulting in improvements in the chemical, physical, and biological characteristics of the soil. Microorganisms, because they are responsible for various ecological functions of the environment and sensitive to changes in land use (Gessner et al., 2010), are commonly used as soil quality indicators, through analysis of microbial biomass carbon, microbial respiration, and metabolic quotient. Studies show that plant cover and management practices adopted in agriculture are among the factors responsible for variations in the soil microbial community (Azevedo et al., 2019; Ren et al., 2019). Recently, changes in soil microbiota have been identified in a transect gradient moving away from legume rows (Lira Junior et al., 2020). Thus, the objective was to evaluate the effect of intercropping tree legumes with forage cactus on microbial biomass and microbial activity of the soil.

Material and Methods

The study was conducted at the Caruaru Experimental Station of the Instituto Agronômico de Pernambuco, IPA (8º 14' S and 35º 55' W). According to FAO (2014), the predominant soil in the experimental area is Regosol. The climate of the site is dry and hot semiarid, classified as BSh in the Köppen classification, with average rainfall of 727.1 mm/year. Treatments tested included: i) forage cactus IPA-Sertânia (*Nopalea cochenillifera* Salm Dyck) and Leucaena [*Leucaena leucocephala* (Lam.) de Wit.]; ii) forage cactus IPA-Sertânia and Gliricidia [*Gliricidia sepium* (Jacq.) Steud]. The experimental design was in randomized blocks with four repetitions, in a scheme of split-split plots. The main plot was formed by the intercropped systems, the split-plot constituted by the distances from the central row of tree legumes (0.0; 1.5; 3.0; and 4.5 m) and the split-split plot formed by the soil layers (0-10 and 10-20 cm). The experiment was established in March 2011. The tree legumes were planted in three double rows (each plot), spaced 9 x 1 x 0.5 m, with the forage cactus IPA-Sertânia planted between the double rows at 1 x 0.25 m spacing (Miranda et al., 2019). The density of tree legumes was 4,000 plants/ha and forage cactus 32,000 plants/ha. In June 2018, the experimental area was fertilized with bovine manure to supply 200 kg N ha^{-1}. The soil was collected in April (rainy season) in depths 0-10 and 10-20 cm to 0.0, 1.5, 3.0, and 4.5 m from the central row of legumes. Soil basal respiration (SBR) was determined by quantifying the C-CO_2 released by the microbial respiration process (Mendonça and Matos, 2005). The C content of microbial biomass (C-mic) was estimated by the irradiation-extraction method (Islam; Weil, 1998). The metabolic quotient (qCO2) was calculated by the ratio between SBR and C-mic (Anderson; Domsch, 1993). The data were submitted to variance analysis using the SAS/STAT® 14.1 Proc Mixed (SAS, 2015) and treatment averages were compared by PDIFF and adjusted to Tukey ($P<0.05$).

Results

No significant difference ($P>0.05$) was observed between the different intercropped systems, the distances from tree legumes, and soil depths. The average values observed for SBR, C-mic and qCO2 were 7.7 µg C-CO_2 g^{-1} d^{-1}; 177.6 mg kg^{-1}, and 0.05 µg C-CO_2 g^{-1} C-mic d^{-1} in the 0-10 cm depth , while in the 10-20 cm depth they were 10.9 µg C-CO_2 g^{-1} d^{-1}; 228.3 mg kg^{-1}, and 0.05 µg C-CO_2 g^{-1} C-mic d^{-1}, respectively (Figure 1).

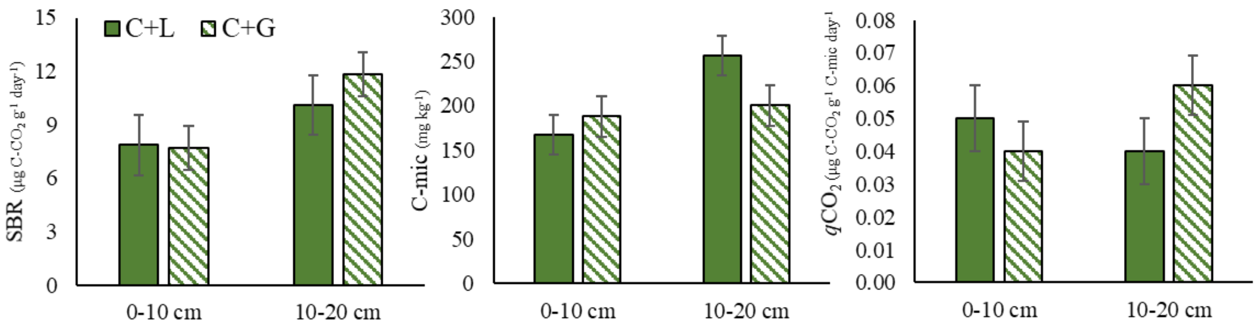

Figure 1. Soil basal respiration (SBR), soil microbial biomass carbon (C-mic) and metabolic quotient (qCO_2) in intercropped systems with forage cactus in the 0- to 10- and 10- to 20-cm soil depths. C+L: intercropped forage cactus and Leucaena; C+G: intercropped forage cactus and Gliricidia. The bars indicate the standard error of the average.

Discussion

The activity and microbial biomass were similar in the different cropping systems (Figure 1). The results found in this study are similar to soils under cultivation of native vegetation in tropical environment (Cardozo Junior et al., 2016), indicating that intercropped forage cactus systems are sustainable and beneficial for microbial biomass. It is worth noting that the low values of qCO2 found in the two depths indicate that microbiota is being efficient, losing less CO2 per unit of biomass, resulting in a greater incorporation of carbon in the microbial cells (Müller et al., 2014), indicating greater microbial diversity.

Conclusions

Microbial activity and microbial biomass were similar in different cropping systems using forage cactus and tree legumes (Leucaena and Gliricidia).

Acknowledgement

The authors D. C., M. V. F. S. and M. A. L. J. thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq, Brazil), for the scholarships granted. All authors would like to thank Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), for the financial support (Financial Code 001).

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