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Microbial Activity of Rhizospheric Soil and Leaf Litter on Livestock Farms Sown with Bothriochloa Pertusa (L) A. Camus and Dichantium Aristatum

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Abstract

Soil use and management can significantly affect the labile and humified fractions of soil organic matter, to the detriment of biological activity. The aim of the present study was to evaluate the microbial activity of rhizospheric soil and rhizospheric soil plus litter on cattle farms cultivated with Bothriochloa pertusa (L) A. Camus and Dichantium aristatum pastures. Samples of soil, litter and the combination of soil + litter were collected from cattle farms in the municipality of Corozal, department of Sucre, Colombia. The respiratory activity of the soil was determined using the incubation method. The results of the present study indicate that the treatments with the lowest respiration rate (mg g-1 h-1 of C-CO2) was in soils, followed by leaf litter and was higher in the treatments where soil and leaf litter were combined. The highest respiration rate was related to the combined treatments of soil and Bothriochloa pertusa litter. In conclusion, the rate of microbial respiration in soil is an important indicator of microbial activity and soil health. Measurement of microbial respiration rate can be used to assess soil health and monitor soil quality.

Keywords: *Soil, Litter, Pasture, Respiration, CO2.*

Introduction

The pastures of the Colombian Caribbean are made up of high productive potential grasses such as guinea (*Panicum máximum*), angleton (*Dichanthium aristatum*), puntero (*Hyparrhenia rufa*) and pará (*Brachiaria mutica*), some naturalized species such as colosuana or kikuyina (*Bothriochloa pertusa*), becoming an exclusive source of animal feed. According to Barea (2002), it is considered that the sustainability of both natural ecosystems and agroecosystems depends mainly on the balance between the biological components of the soil; in fact, it is accepted that the current trend in microbiology research is the study of microorganisms from the point of view of diversity, ecology, genetics, biochemistry and physiology in relation to plant nutrition and protection.

According to Lloyd and Taylor, (1994), soils are the largest reservoir of carbon in terrestrial ecosystems and the largest source of atmospheric CO_2, which is produced by a process called soil respiration. Soil respiration is defined as the total production of CO2 per unit area and time, and is due to the respiration of soil organisms, roots, mycorrhizal hyphae, and to a lesser extent, to the biochemical oxidation of carbon compounds.

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Soil respiration rates have also been measured in a variety of ecosystems in order to assess microbial activity, nutrient recycling, carbon and energy fluxes, root dynamics, and other processes taking place there (Singh and Gupta, 1977; Burbano, 1989). Soil respiration represents one of the largest fluxes in the global carbon cycle: 55 Petagrams C yr-1 (1 Pg = 1015g), which is 9-10 times the amount emitted by burning fossil fuels.

Nutrient cycling occurs as a consequence of microbial activity and is especially important in low fertility ecosystems. As indicated by (Tótola & Chaer, 2002), the activity of soil microorganisms can be assessed in several ways, such as: measurement of their biomass, the activity of certain soil enzymes, basal microbial respiration, among others. Such biological and biochemical properties of the soil are considered sensitive indicators (Carvalho, 2005) that can be used to monitor environmental disturbances, thus constituting important tools to guide the planning and validation of management practices (Matsuoka et al., 2003). As stated by (Peña et al., 2005), it is well known that biochemical attributes that denote edaphic processes of ecosystems, such as microbial respiration, are more sensitive to capture alterations in the environment.

Like other metabolic processes, respiration is dependent on the physiological state of the cell and is influenced by several soil factors, such as: moisture, temperature, structure, nutrient availability, texture, C/ N ratio, presence of organic residues, among others (Carvalho, 2005).

High respiration rates can mean, in the short term, the release of nutrients to plants and, in the long term, loss of soil organic carbon to the atmosphere (Parkin et al., 1996). In tropical pasture soils, organic matter plays a central role in maintaining fertility. However, some agricultural and forestry practices, such as the use of amendments and fertilizers (Della Bruna et al., 1991), have been commonly associated with the reduction of organic matter content, mainly due to the stimulation of microbial respiration.

Thus, in an attempt to understand the dynamics of organic carbon in pasture ecosystems, the objective of the present study was to evaluate the microbial activity of rhizospheric soil and rhizospheric soil plus litter on cattle farms cultivated with the pastures *Bothriochloa pertusa* (L) A. Camus and *Dichantium aristatum.*

Material and Methods

Sampling and material preparation. Sampling was carried out on cattle farms in the municipality of Corozal, Department of Sucre, Colombia. Two cattle farms were selected, one cultivated with *Bothriochloa pertusa* (L) A. Camus and the other with *Dichantium aristatum*. Samples were collected in the first period of 2024 in June. They were randomly demarcated, 10 points in each sampling site were selected, in each area simple soil samples and leaf litter samples of each predominant pasture species were taken. For soil sampling, soil was sampled to a depth of 20 cm and litter was removed. A 0.04 m2 grid was used for the sampling of the leaf litter, and the material was stored in a plastic bag. The samples were labelled separately and transported to the microbiological research laboratory for microbiological analysis.

In the Microbiological Research Laboratory, soil samples were sieved (2 mm mesh) and litter samples were homogenized and chopped into fragments of less than 4 cm in length. The materials were immediately incubated to determine microbial activity.

Incubation method: A soil sample is incubated in a closed container and the amount of CO2 produced is measured. The process steps for determining the amount of CO2 produced are described as follows: The CO2 release was evaluated at 12, 24, 36, 48, 48, 60, 72, 84, 96, 108

and 120 h of incubation. For this purpose, glass flasks with a volume equal to 800 mL containing the different combinations of rhizosphere soil and beaker with 20 mL NaOH 0.5 mol L-1 were hermetically sealed and incubated at 25 °C in the dark. The mass of substrate/flask was either corresponding to 150 g rhizosphere soil (S1 and S2), 25 g pasture litter (H2 and H6) and 150 g rhizosphere soil + 25 g pasture litter (SR+H1 and SR+H2) by weight of dry material. At each evaluation time, the flasks were opened and the NaOH solution was changed. Immediately after removal of the beakers, 1 mL of 50 % BaCl2 solution was added and three drops of the indicator phenolphthalein 1 % were added.

The remaining NaOH, precipitated as Na2CO3, was titrated as HCl 0.5 mol L-1. From the volume of HCl consumed, the amount of C-CO2 released per gram of dry substrate carbon was calculated. Previously, the units of the soils used in the incubation were corrected for 30 % (approximately 60 % gives the retention capacity of both soils). The grass litter unit was not altered and remained close to 75 % (Xavier de Carvalho, et al., 2008).

Results and Discussion

Figure 1 shows the respiratory rate of rhizospheric soil (mg g-1 h-1 of C-CO2) of livestock farms with the presence of *Bothriochloa pertusa* (L) A. Camus (S1) and *Dichantium aristatum* (S2). The results obtained show that the microbial activity of the rhizospheric soil microorganism populations is higher up to 24 hours after the start of the experiment, being higher for the rhizospheric soil of *Bothriochloa pertusa* (L) A. Camus (S1) compared to that of *Dichantium aristatum* (S2).

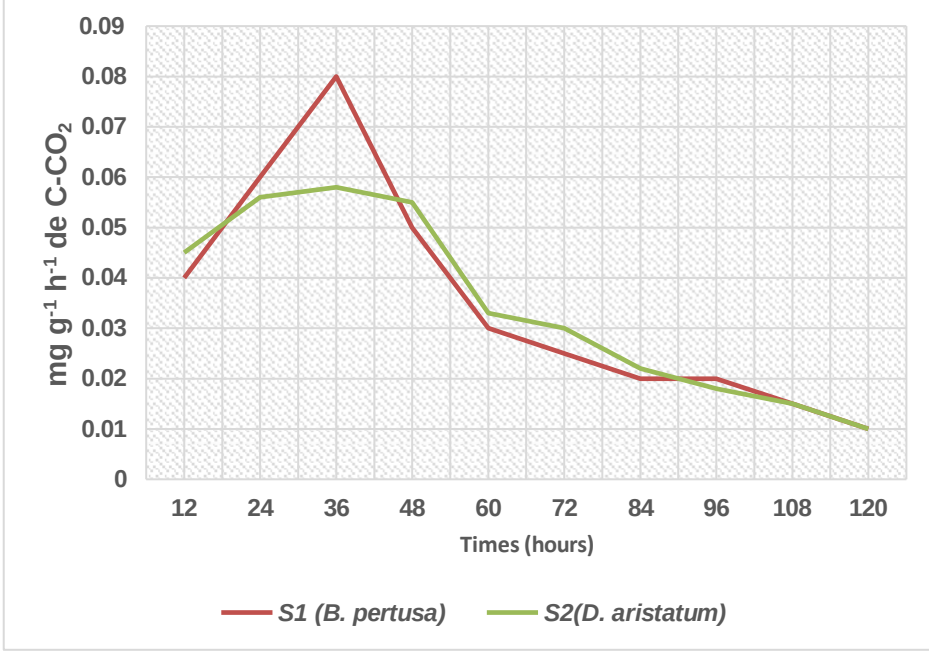

Figure 1. Soil Respiration Rate of Cattle Farms with *Bothriochloa Pertusa* (L) A. Camus (S1) And *Dichantium Aristatum* (S2).

Figure 2 shows the respiratory rate (mg g-1 h-1 of C-CO2) of litter of *Bothriochloa pertusa* (L)

A. Camus (H1) and *Dichantium aristatum* (H2). The results show that the respiratory behaviour of the microbial populations in litter of both grass species had a similar pattern with maximum activity at 84 hours after the incubation of the experiment. If we compare the respiratory rate of litterfall with the rate obtained for rhizospheric soil, it is inferred that the presence of litterfall influences the microbial activity of the populations, indicating that microbial populations require organic matter for their growth and respiratory activity.

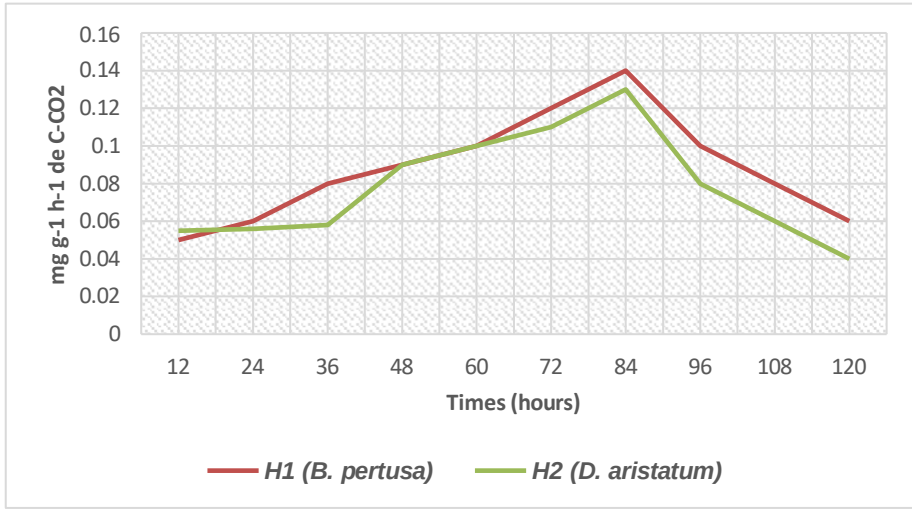

Figure 2. Leaf Litter Respiration Rate of Bothriochloa Pertusa (L) A. Camus (H1) And Dichantium Aristatum (H2).

Figure 3 shows the respiration rate of rhizospheric soil + leaf litter (mg g-1 h-1 of C-CO2) of *Bothriochloa pertusa* (L) A. Camus (SR+H1) and *Dichantium aristatum* (SR+H2). When the respiratory rate was evaluated for Bothriochloa pertusa (L) A. Camus (SR+H1), the maximum respiratory rate was found at 84 hours of incubation of the experiment with values of 0.2 mg g-1 h-1 of C-CO2, while for *Dichantium aristatum* (SR+H2) for the same incubation time it corresponded to 0.14 mg g-1 h-1 of C-CO2. The present study shows that when rhizospheric soil is mixed with leaf litter, a higher respiration rate is found with respect to the respiration rate obtained for rhizospheric and leaf litter soil of both pasture species. Also, the results indicate that rhizospheric soil + leaf litter of *Bothriochloa pertusa* (L) A. Camus (SR+H1) contains higher microbial activity compared to the activity of *Dichantium aristatum* (SR+H2).

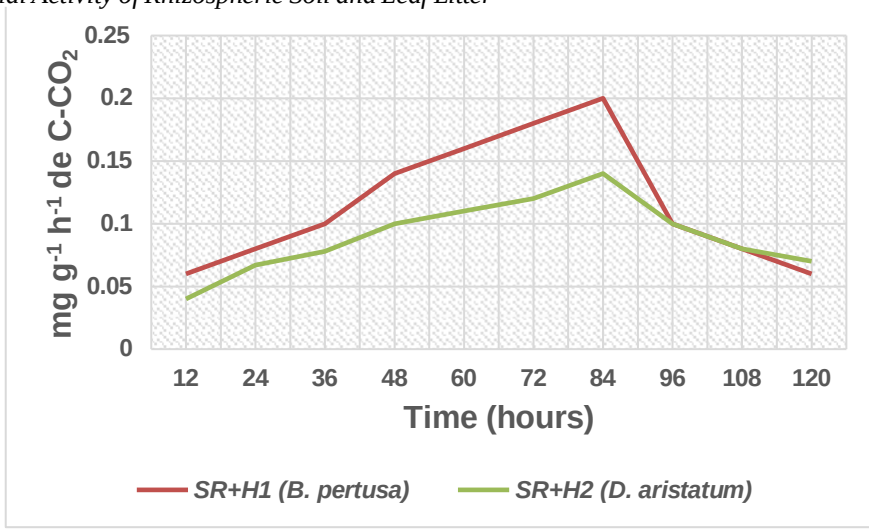

Figure 3. Respiratory Rate of Rhizospheric Soil + Leaf Litter of *Bothriochloa Pertusa* (L) A. Camus (SR+H1) And *Dichantium Aristatum* (SR+H2).

Active organic matter, which represents about 10-20 % of the total soil organic matter, is constituted by the microbiota responsible for the decomposition processes of organic substrates (labile fraction) and for the resynthesize of substances that give rise to other metabolic products such as mucilages, gums, acids, enzymes, extracellular polysaccharides and of course CO2. Thus, the measurement of respired carbon dioxide is an estimate of the activity and, therefore, of the microbial presence; such activity varies according to different factors, such as land use, mineralogy, vegetation cover, management practices, quality of the residues entering the system (Mora, 2006). Cultivation practices exert numerous direct and indirect biological effects on soil microbial populations. The influence of ploughing is very strong on bacterial populations immediately after soil disturbance, the number of micro-organisms increases 20 and 30 times. This is due to the modification of porosity conditions and thus of the flow of gases and water through the void spaces (Mora, 2006).

Scientific evidence shows that the decomposition of organic matter is an ecosystemic process mediated by heterotrophic organisms that use dead organic material or detritus as a habitat and source of carbon and energy, this gas is produced mainly through the metabolism of microflora and plant roots, being the microbial decomposition of organic compounds the most important process that generates it. According to Pérez et al. (1998), during decomposition, part of the carbon is returned to the atmosphere in the form of CO_2, while another part is transformed into other simpler compounds or stored in the microbial structures themselves.

As stated by Carmona et al. (2006) in particular, the metabolic respiration of the community of organisms associated with organic detritus is the process that releases carbon into the atmosphere in the form of CO2. In this way, heterotrophic respiration contributes to decomposition, along with other processes such as humification and fragmentation of the detritus. Micro-organisms respire continuously and respiration rate is a reliable index of growth rate. Factors affecting growth also influence respiration to the same degree.

As suggested by Sánchez et al. (2008), decomposition and nutrient release rates are determined by the quality of the organic matter. The quality of the plant material is defined by the organic

constituents and nutrient contents. The carbon quality of an organic material depends on the proportions of soluble carbon, cellulose (hemicellulose) and lignin; in this case the quality refers to the energy available to decomposing organisms.

Soil respiration is driven by both biotic and abiotic factors (Walker et al., 2004; Monson et al., 2006; Orwin et al., 2016). Previous studies have demonstrated the importance of geographic location (Campbell et al., 2004; Whitaker et al., 2014), climate (temperature and rainfall) (García-Palacios et al., 2012; Karhu et al., 2014), soil properties (Delgado-Baquerizo et al., 2016) and plant features (Raich and Tufekciogul, 2000; Knowles et al., 2015) as key predictors of soil respiration. However, current models are not able to accurately predict the variation in soil C stocks and respirations, leading to a high level of uncertainty for these predictions. Identifying new major predictors of soil respiration that allow the improvement of predictive models is one of the major challenges that we are facing today.

The rate of microbial respiration in soil refers to the amount of carbon dioxide (CO_2) produced by soil microorganisms per unit time and mass of soil. This attribute is important and of applicability as schematized in figure 4.

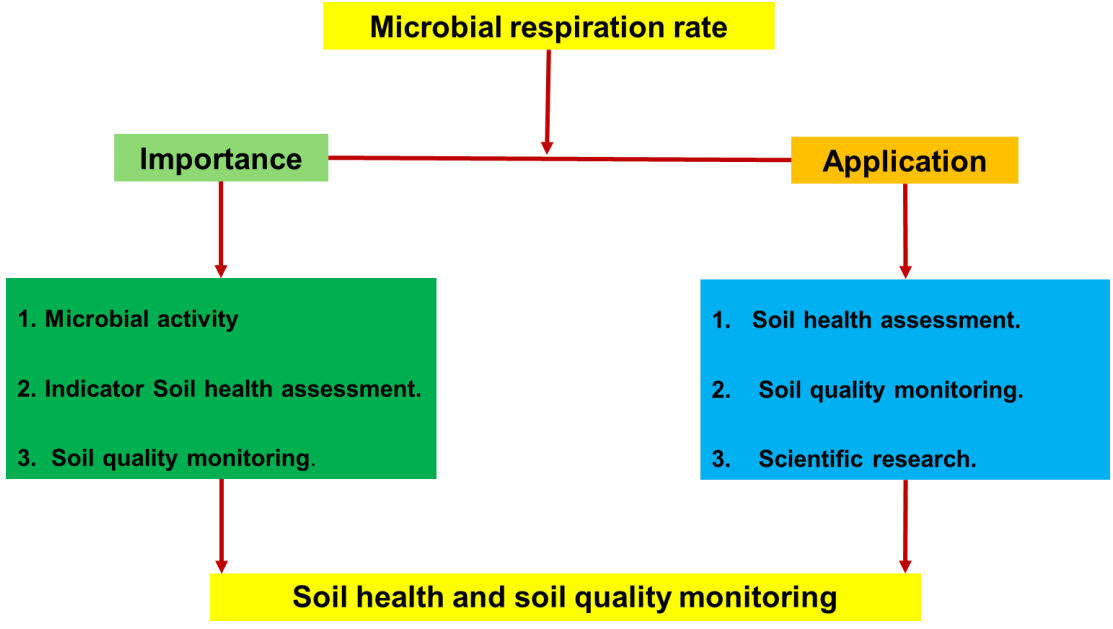

Figure 4. Diagram of the Importance and Application of Microbial Respiration Rate in Soil.

Conclusion

The material with the highest microbial activity (highest C-CO2 release) was the leaf litter of B. pertusa (L) A. Camus, the one with the lowest CO2 respiration was the soil of cattle farms with *Dichatum aristatum*, which in its application avoids risks in the soil-plant system associated with oxidation of the soil material and increases soil fertility.

In conclusion, soil microbiological indicators are important to assess soil quality and soil health. Soil microorganisms play an important role in organic matter decomposition, nutrient cycling and disease suppression. Understanding soil microbiological indicators can help to improve plant productivity and soil healthhe determination of microbiological indicators of soil quality

involves a series of steps and techniques to assess the presence and activity of micro-organisms in the soil. Understanding microbiological indicators of soil quality can help to assess soil health and improve plant productivity.

Formulas, models and equations for assessing the quality of soil microbiological indicators can be used to evaluate soil microbiological quality indicators. The evaluation of these indicators can help to assess soil health and improve pasture productivity.

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Author Contribution.

Alexander Perez Cordero: experiment execution, data analysis. Donicer Montes V and Yelitza Aguas M, conceptualization, writing - revision and editing. All authors have read and approved the manuscript.

Conflict of Interest.

All the authors of the manuscript declare that they have no conflict of interest.

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