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Evaluation of some microbiological attributes of the soil in two different management systems

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Abstract
The maintenance of organic matter in tropical soils and the use of soil quality indicators that can express its changes in sustainable agricultural systems is very important for monitoring the health of these ecosystems with high productivity and longevity. The aim of this experiment was to evaluate, through enzymatic responses of microbiological activity, variations resulting from different cultivation systems under sandy soil conditions in western of São Paulo State. In this purpose, the measurement of the parameters microbial biomass carbon (MBC), microbial biomass nitrogen (NBM), dehydrogenase (DNSE), basal respiration (BR) and the metabolic quotient (qCO_2) in two culture systems characterized by being a succession of annual crops with soybean/corn (annual crops) and the other under perennial pasture of the genus *Urochloa* (pasture), respectively. It was verified that the two systems presented different behaviors related to the evaluated microbiological attributes, showing higher values in the evaluated microbial attributes in the area where *Urochloa* grass was cultivated.
Keywords: microbial biomass; soil quality indicators; soil management; soil health.

Avaliação de atributos microbiológicos do solo em dois diferentes sistemas de manejo

Resumo
A manutenção da matéria orgânica em solos tropicais e o uso de indicadores de qualidade do solo que possam expressar suas alterações em sistemas agrícolas sustentáveis é de grande importância para o monitoramento da saúde desses ecossistemas com alta produtividade e longevidade. Buscou-se neste experimento avaliar dois diferentes sistemas de cultivo sob condições de solos arenosos do oeste paulista, respostas diferentes nas atividades microbiológicas, decorrentes destes manejos. Neste sentido, procedeu-se a mensuração dos parâmetros carbono da biomassa microbiana (CBM), nitrogênio da biomassa microbiana (NBM), desidrogenase (DNASE), respiração basal (RB) e o quociente metabólico (qCO_2), em dois sistemas de cultivo agrícola caracterizados por serem sucessão de culturas anuais com soja/milho (cultivos anuais) e o outro sob pastagem perene do gênero *Urochloa* (pastagens), respectivamente. Verificou-se que os dois sistemas apresentaram comportamentos diferentes relacionados aos atributos microbiológicos avaliados, apresentando maiores valores dos atributos biológicos na área onde havia o cultivo da gramínea do gênero *Urochloa*.
Palavras-chave: biomassa microbiana; indicadores de qualidade do solo; manejo de solo; saúde do solo.

1 Introduction

The use of agricultural practices that provide the accumulation of biomass in the soil both in quantity and diversity and, consequently, greater microbial activity, is essential for maintaining soil fertility and its sustainable use (GUIMARÃES *et al.*, 2017). Despite the wide variability of alternative production systems, such practices basically consist of keeping the soil covered for almost the entire agricultural year, either with cover crops or straw during the crop's off-season period, promoting nutrient cycling and protecting the soil physically, providing greater balance to the system (OLIVEIRA *et al.*, 2017).

Due to the intensification of restrictions on deforestation in new areas, soybean and corn crops have expanded into new spaces and local arrangements that have very specific characteristics such as physical granulometric compositions, composed of high quantities of sandy fractions (CORDEIRO; ECHER, 2019; SILVA *et al.*, 2020) and low levels of organic matter (CORDEIRO *et al.*, 2022).

Available estimates indicate that Brazil has an area of approximately 180 million hectares of pasture, and approximately 70% of them present themselves under some level and degradation process (EMBRAPA, 2013; DIAS-FILHO, 2014). This fact, associated with the growing demand for food, bioenergy and forest products, in contrast to the need to mitigate deforestation and greenhouse gas emissions, require solutions and insights from a multidisciplinary approach that enable the encouragement of socioeconomic development without compromising the sustainability of natural resources.

According to studies done by Hartemink and Huting (2007), approximately 900 million hectares of the world's land surface is composed of sandy soils. They represent about 8% of the Brazilian national territory and in some national regions they can even represent 20% of its total (DONAGEMMA *et al.*, 2016). Examples of this landscape photo physiognomy are exactly located in the regions of the new agricultural frontiers, as is the case of the states of Maranhão, Tocantins, Piaui and Bahia.

Soybean crop yields in these areas have been relatively low (CORDEIRO; ECHER, 2019) as these soils generally have a sandier texture with low levels of organic matter and periods of water deficit at the time of planting. In view of these contexts, special attention must be given to cultivation practices and soil management (crop rotation, no soil disturbance-no till practice (PD), etc.) as well as the use of genetic materials adapted to these adverse edaphoclimatic conditions (LIU *et al.*, 2020; OLIVEIRA *et al.*, 2019; STEWARD *et al.*, 2018). The western region of São Paulo also presents similar aspects of climate and soil. The search for the maintenance and/or increase of organic matter contents in soil profiles under these conditions becomes a fundamental factor for the stability of agricultural systems that aim at high biodiversity and within sustainable bases.

The rapid degradation of the soil under agricultural explorations in the world and in tropical countries in the last 10 years, aroused a concern on the part of scientific research as well as of producers focused on aspects of the quality and health of soils in these ecosystems (LAL; PIERCE, 1991; CALAZANS, 2010).

The present study aimed to evaluate the behavior of some microbiological attributes under conditions of sandy soils in the wester of São Paulo under two management systems. The first was implemented in an area submitted to soybean-corn succession and the second under perennial pasture of the genus of *Urochloa* grass.

2 Material and Methods

2.1 Experimental Area

The study was carried out in the city of Presidente Prudente/SP, located in the western region of the state of São Paulo, at the geographic coordinates Latitude 22º07'21.06''S and Longitude 51º23'17.71''W. It has an average annual temperature of 21.6 °C, with a hot and rainy summer and a cold and dry winter. The region has an annual accumulated rainfall of 1,558 mm, and 72.8% (1,134 mm) of the precipitation is distributed between the months of October to March. The average annual air temperature is 24.3 °C, with the months of January (26.6 °C) and December (26.6 °C) being the hottest and the months of June (20.9 °C) and July (20.9 °C) are the coldest (BARBOSA, 2020). In addition, it is being in the Atlantic Forest biome with a predominance of sparse arboreal vegetation (GRATON *et al.*, 2015).

The areas under study are located on Campus II of the Western University of São Paulo state, in Presidente Prudente/SP. One area being used with annual crops in succession (soy-corn) and another with perennial crop (pasture of the *Urochloa* genus). The soil is characterized as Dystroferric Red Yellow Ultisol and climate characteristics are similar in the two experimental areas, with the cultivation system as the main difference between them.

2.2 Methodological Process

The execution of this study was divided into three main phases: field work; laboratory work and results analysis. In the first phase of the study, 20 sampling points were allocated in two experimental areas, the first of which established with annual/succession crop (soybean/corn) and the second area established with perennial crop (pasture of the *Urochloa* genus). All points were georeferenced using the Google Earth application, as shown in Figures 1 and 2.

Figure 1. Annual crop area collection points.

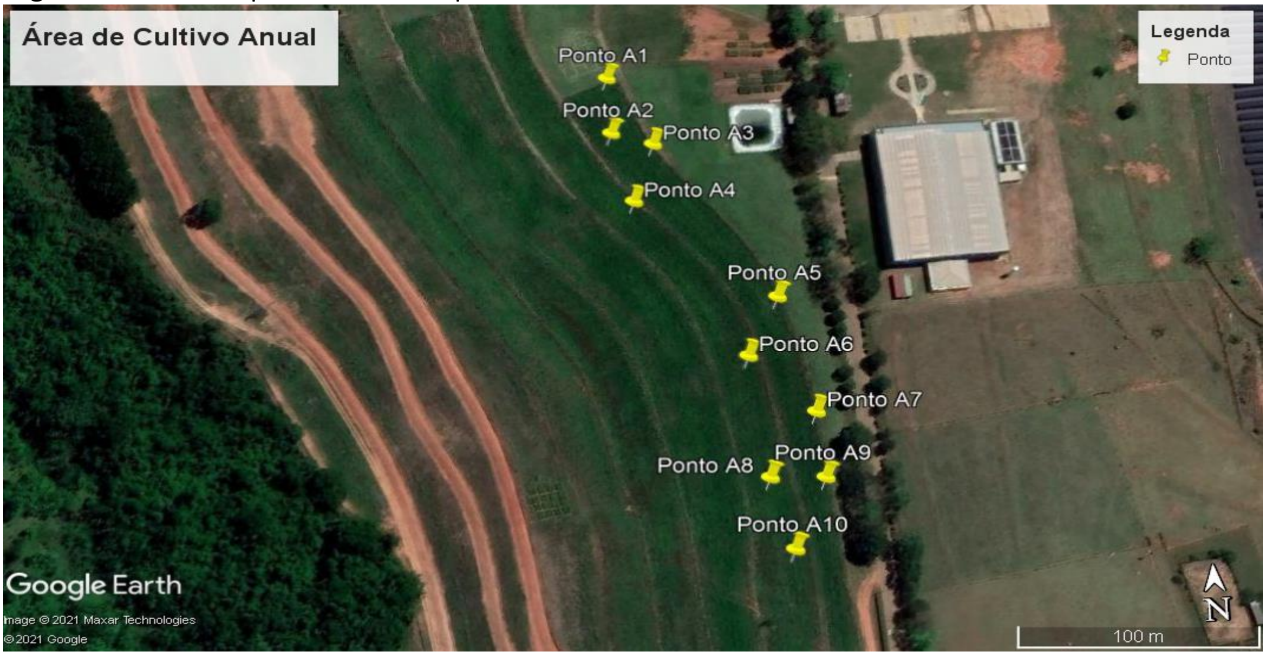
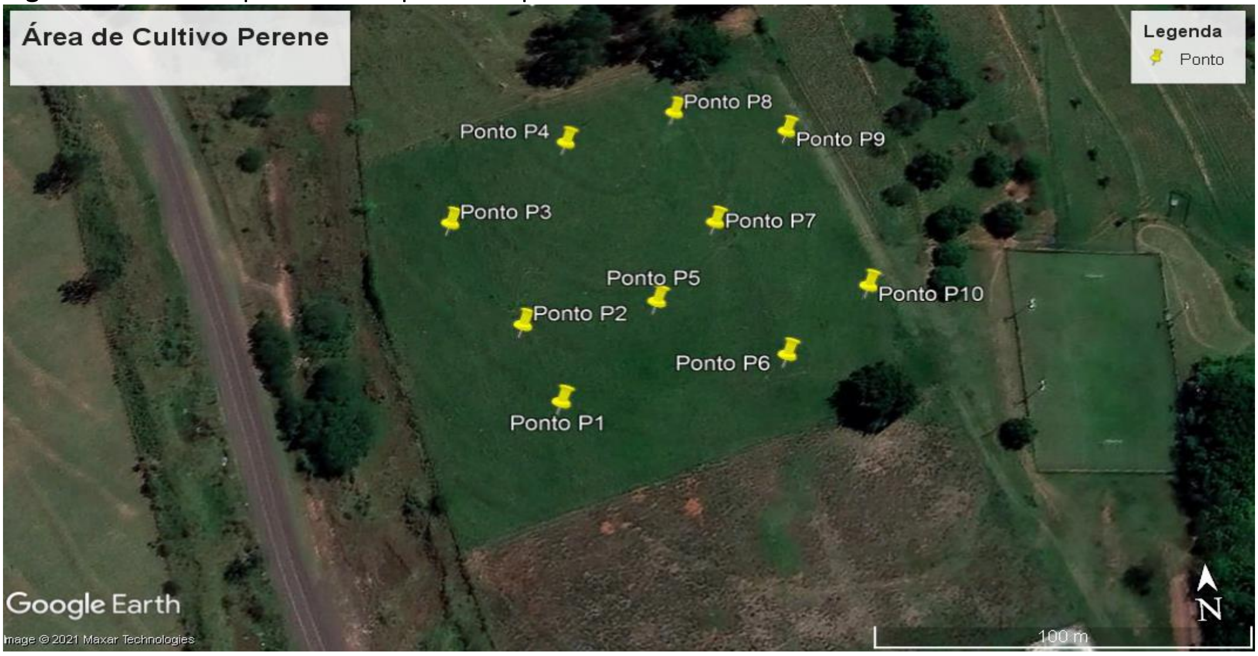


Figure 2. Collection points of the perennial pasture.



Soil collections at each of 20 points were carried out with the aid of a Dutch auger at a depths of 0-10 cm. At each point, four simple soil samples were collected and mixed to obtain a composite soil sample (Figure 3).

Figure 3. Simple sample collection system.

All samples were placed in plastic bags, properly identified and sent to the laboratory. In the second phase of the study, the samples were stored under refrigeration and subsequently subjected to analysis of microbial biomass carbon, microbial biomass nitrogen, dehydrogenase, respiration and metabolic quotient (qCO_2).

Microbial biomass carbon analysis was performed according to the methodology described by Ferreira, Camargo and Vidor (1999). The microbial biomass nitrogen was determined following the methodology described by Tedesco *et al.* (1995). The dehydrogenase enzyme analysis was carried according to Van Os and Ginkel technique (2001). Soil respiration was determinated using the methodology cited by Jenkinson and Powlson (1976), and the metabolic quotient (qCO_2) followed the methodology of Anderson and Domsch (1993).

After obtaining all the results, these data were submitted to statistical analysis to verify the existing pattern in the area. The data were subjected to a variance analysis (ANOVA) for each microbiological variable and a comparison was made between the means made by the T test at a 5% significance level. For this, the ASSISTAT software version 7.7 was used.

3 Results and Discussion

3.1. Variance Analysis of the microbiological attributes

According to the variance analysis (Table 1), it can be noted that there was a statistically significant difference for all variables under study, except for the metabolic quotient.

Table 1. Analysis of variance and comparison of means for the microbiological attributes analyzed between the Crop Systems - System 1 characterized by succession of annual crops with soybean/corn (SASM) and System 2 conducted under perennial pasture of the genus *Urochloa* (SPPU) at the time of evaluation period.

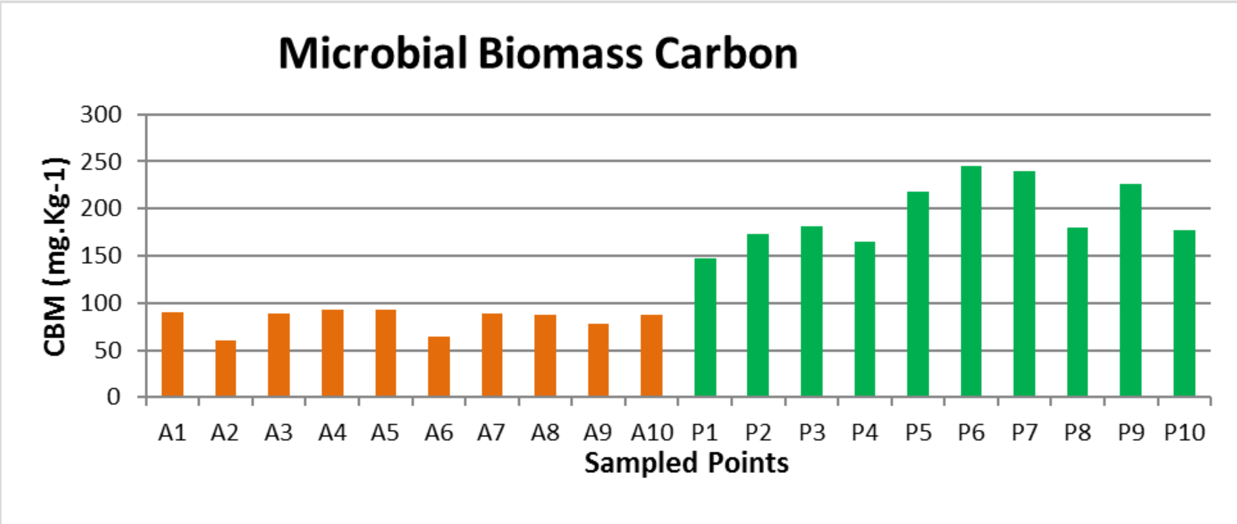
Atribute	F Value	CV	DMS
CBM	98.3165*	18.18%	23.75886
NBM	10.5808*	21.02%	1.78477
Respiration	15.9855*	29.08%	0.07343
Dehydrogenase	53.8805*	22.02%	1.88679
qCO_2	0.3838 $^{n.s.}$	32.26%	0.07011

*Significant at the 1% probability level (p < .01) ; $^{n.s}$. Not significant at the 1% probability level (p >= .05)

3 .2 Carbon Microbial Biomass

The Microbial Biomass Carbon (MBC) was higher for the pasture area of *Urochloa* when compared to the area of annual cultivation with soybean/corn succession. The MBC of the pasture area was on average 57.54% higher than that of the area with annual crops. (Figure 4)

Figure 4. Microbial Biomass Carbon for the two Cultivation Systems at the twenty sampling points sampled on May 13, 2021. A = Annual crops; P=Pasture.



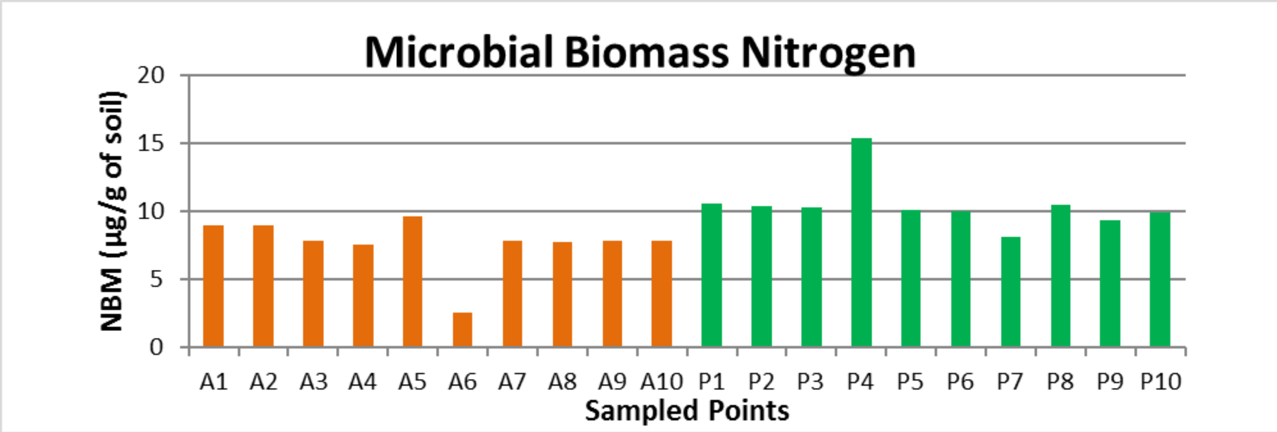
This may have been due to the greater accumulation of aboveground and subsurface biomass (roots) in the pasture area when compared to annual crops that were well uncovered and that underwent the soil preparation action during planting each new year. The pasture area may be showing a behavior like what has been reported in the literature (SILVA, 2008; HOFFMANN *et al.*, 2018), about not disturbing the soil and, therefore, favoring the action of the soil microbiota and consequently the activity of Soil Microbial Biomass (BMS) under study.

Regarding the values presented by the two management systems, it was noted that they had some variations at the time of analysis, not showing a constant behavior. The incidence of light and photosynthesis that determine the accumulation of biomass in the pasture area, it may have favored greater carbon drainage to the soil and contributed to an increase in Microbial Biomass carbon to also be positive changed in the experimental area. Through knowledge of the photosynthesis and characteristics such as the expansion rate and the dynamics of appearance and death of tillers for different species, it is possible to explain the dominance or disappearance of certain species from a specific community or ecosystem and consequently its botanical composition (EGGERS *et al.*, 2004).

3 .3 Microbial Biomass Nitrogen (MBN)

The Microbial Biomass Nitrogen (MBN) attribute was higher for the pasture area of the genus *Urochloa* when compared to the annual cultivation area with soybean/corn succession. The NBM of the pasture area was on average 26.52% higher than that of the area with annual crops (Figure 5).

Figure 5. Microbial Biomass Nitrogen for the two Cultivation Systems at the twenty sampling points sampled on May 13, 2021. A= Annual crops; P=Pasture.



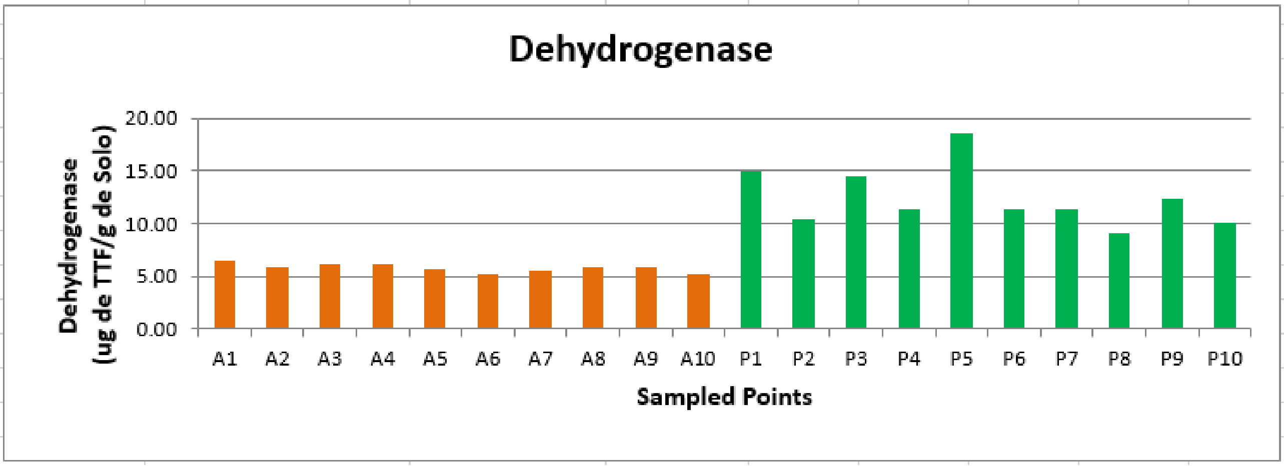
The results obtained (Figure 5), in the two management systems, may indicate that the less explored environment with less movement of implements and anthropic actions (pastures) aggregates values for the size of the NBM compartment, presenting larger dimensions, indicating that losses possibly they are smaller (SOUZA, 2005).

Among the several studies related to the growth of the microbial biomass can mention the research carried out by Nascimento *et al.* (2009), which evaluated two management systems, and these no-tillage (NT) and conventional tillage (PC), and defaults to the native forest. They concluded from the data that the tillage system had NBM values superior to the conventional tillage. The pastures experimental area is very close to no-tillage area. It might want to analyze and assume that the NBM behavior is likely to respond in a nearby magnitude to that of the no till practice.

3 .4 Dehydrogenase activity

The attribute dehydrogenase enzymatic activity (DNASE) was higher for the pasture area of the genus *Urochloa* when compared to the area of annual cultivation with soybean/corn succession. The DNASE of the pasture area was on average 53.1% higher than that of the area with annual crops (Figure 6)

Figure 6. Dehydrogenase for the two Crop Systems at the twenty sampling points sampled on May 13, 2021. A= Annual crops; P=Pasture.



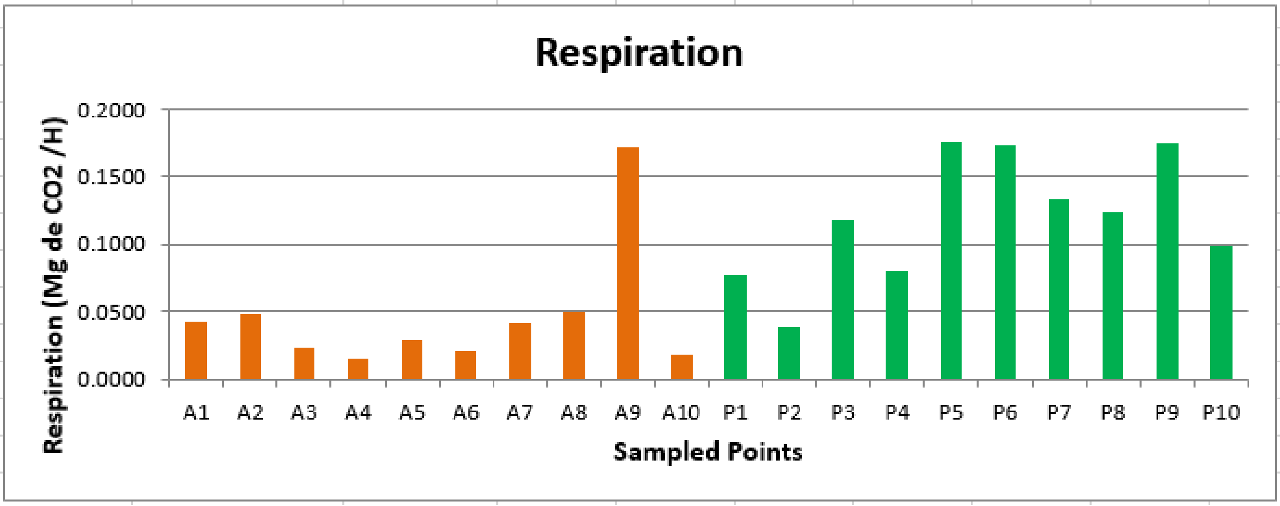
According to works by Pereira *et al.*, (2016), successful corn soybean crops under grass stubble present grain yields and improvement in soil microbiological conditions. However, adverse weather conditions such as water stress can negatively contribute to these productive factors. Furthermore, the supply of nitrogen to the system can acidify the environment where there is no vegetation cover, preventing root development and aerial biomass supply, harming the microbiological attributes of these systems.

One possible cause for the efficiency of annual crop area have been lower this attribute when compared to areas of pasture can result from lack of ground cover, intensive absence of water for a period in summer causing water stress and low development of root system and negative effect production of aboveground biomass. Accordingly, the pasture area of *Urochloa* can be preserved soil moisture for longer, providing the emission of tillers and new roots under these circumstances, also increase expressing the enzyme dehydrogenase activity.

This aspect is in line with the work of Tahir *et al.* (2015) and Nivelle *et al.* (2016) who found that cover crops can improve the microbiological properties of the soil because of root growth, release of exudates, enzyme activity and increase in soil organic carbon.

3 .5 Basal Respiration

Figure 7. Basal respiration for the two Cultivation Systems in the twenty sampling points sampled on May 13, 2021. A= Annual crops; P=Pasture.



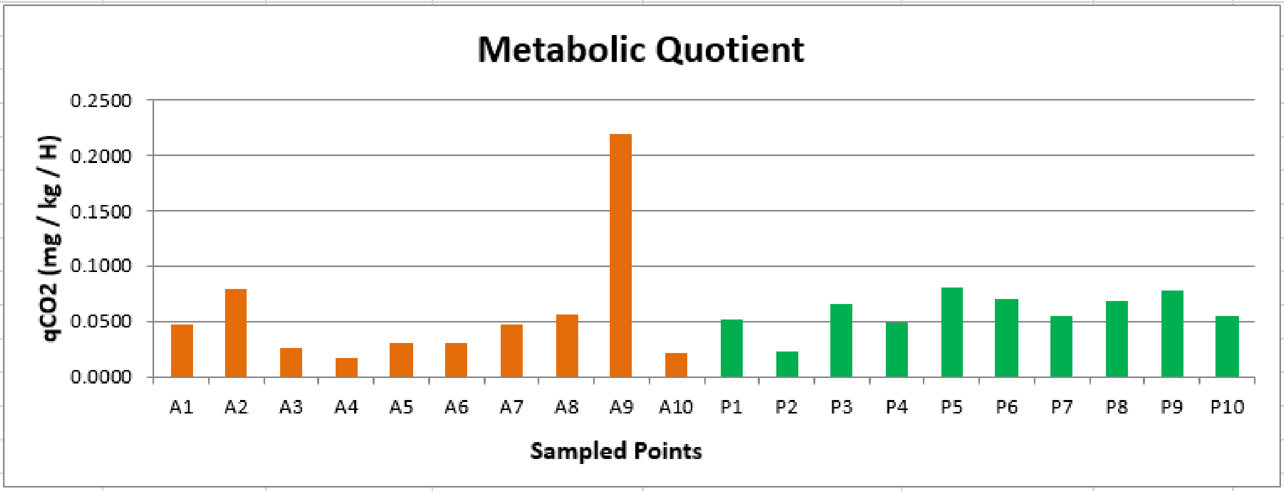
The attribute BR activity was higher in the pasture area of the genus *Urochloa* when compared to the annual crop area with soybeans/corn. The pasture area BR averaged is 61.56% larger than the area of annual crops. In just one point around annual crops (A9) the value was close to that other of the pasture area (Figure 7).

Tavares and Muniz (2019) report that in areas with less anthropogenic action, the respiratory activity of microbial biomass is greater. This can be a parameter to justify the highest values of this attribute for the pasture area. High respiratory levels of microorganisms in the soil can be seen positively, which can positively influence the decomposition of organic waste, promoting greater cycling of nutrients, that the factors are aligned and provide adequate conditions for its use and contributing to energy gains within the considered system (ALVES, 2011).

3.6 Metabolic Quotient (qCO_2)

The attribute qCO_2 activity only showed higher (in absolute value) at the point A9 of annual crop area with soybeans/corn (Figure 8). It may be an "outlier" point, or it may be disturbed by altering respiratory rates. In the other points in the two areas there is a balance in this attribute showing that there are no differences in CO2 losses comparing the two systems.

Figure 8. Metabolic Quotient (qCO_2) for the two Cultivation Systems in the twenty sampling points sampled on May 13, 2021. A= Annual crops; P=Pasture.



Low qCO_2 values reveal an efficient biomass that provides a greater incorporation of carbon due to a lower release in the form of CO_2 (ALQUINO *et al.*, 2005). In this aspect, both annual crop and pasture systems appear to be equivalent. It is verified that there are differences between the microbial attributes evaluated in the two cultivation systems, but that the metabolic quotient remained stable. That is, changes may be occurring in microbial behavior but without drastically altering metabolism in terms of carbon loss from the system.

4 Conclusions

The two Cultivation Systems presented different behaviors when their soil quality attributes MBC, MBN, Dehydrogenase, Basal Respiration were compared.

In general, Crop System - pasture showed higher values in the evaluated microbial attributes in improving soil quality conditions than Crop System – annual crops.

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