Microbial diversity as an indicator of soil quality in corn consortiums with forage

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ABSTRACT

This study tends to evaluate the systems that seek to conserve or increase organic matter, such as no-till and intercropping of crops. The estimate of soil microbiota is reduced among the various beneficial effects on agricultural systems. The increase in organic matter, is important for the soil microbiota, since such organisms, is of great importance in crops, as it displays symbolism of extreme importance for a plant, legume or grammatical. The objective of this study was to evaluate microbial diversity as an indicator of soil quality through the conservation of maize with forage (grasses and legumes). The experimental design will be a randomized blocks in bands without a $6 \times 2$ factorial scheme with 4 replications, the first factor being a monoculture and four consortia: (1) single corn, (2) corn + *Brachiaria ruziziensis*, (3) corn + *Brachiaria brizantha* cv. BRS Piatã, (4) corn + styling Campo Grande (*Stylosanthes capitata* (80%)) and *Stylosanthes macrocephala* (20%)) and (5) corn + *Panicum maximum*. The second factor will consist of inoculation with *Azospirillum brasilense*. The maize's intercrop with *B. ruziziensis* presents greater fungal diversity at depths, greater bacterial diversity in the 0–10 cm layer and greater microbial diversity in the total 0–10 cm layer. Corn with *B. ruziziensis* showed superiority when there was no inoculation in both depths, and corn with *B. brizantha*, *P. maximum*, and Campo Grande styles when there was inoculation of *A. brasilense* in the 10–20 cm layer.

Key words: Stylish, *B. brizantha*, *B. ruziziensis*, *Azospirillum*.

INTRODUCTION

Soil is one of the most important and usable natural resources in the world, but it is a non-renewable resource. Due to the intense use in agricultural systems, there is a need to find new technologies that help to maintain the good preservation of this very important resource. Systems that seek to conserve or increase organic matter, such as no-till and intercropping of crops, have been evaluated. Stimulation of soil microbiota, physical soil conditioning, biological and chemical buffer effect, thermal control and better water retention stand out among the various beneficial effects on agricultural systems (Ungera et al., 1991; Conceição et al., 2005; Boulal et al., 2011). The crop intercropping system which is a basic component of a conservation management system, can reduce the loss of total organic carbon in the soil, by maintaining plant residues on the soil surface and physical protection of organic matter in soil aggregates, as well serve as protection against erosion, weeding and soil water preservation (Six et al., 2004; Conceição et al., 2008; Zotarelli et al., 2012).

Soil organic matter, in this sense, plays an important role in being considered the main indicator of soil quality, serving as a basis for agricultural sustainability (Lal, 2004). Several factors can contribute in maintaining, decreasing or increasing the rate of organic matter in the soil, the main ones are the rate of mineralization of organic matter, soil
texture and the climate, acting strongly in the stock (Costa et al., 2013).

In the Brazilian Cerrado, the system of integration between agriculture and livestock in no-tillage has been researched, which consists of the implantation of intercropped cultivation of annual crops with forage species (Cobucci, 2001). In this agroecosystem, one to two monocultures are grown sequentially per year, plus the cultivation of a crop, consisting of the intercropping of an early crop with forage, generally species of the genus Brachiaria (Jakelaitis et al., 2004).

The no-tillage system with crop-livestock integration favors the increase in soil aggregation rates and the levels of light organic matter in the 0–10 cm layer, compared to the no-tillage system, without brachiaria (Loss et al., 2011). In this system, the increase in organic matter, which is of paramount importance for the soil microbiota, since such organisms are of great importance in crops, as they present a symbiosis of extreme importance for the plant, legume or grass (Ventura et al., 2018).

Maintaining and/or improving soil quality in continuous cultivation systems is essential to ensure agricultural productivity and environmental quality for future generations (COSTA et al., 2013). In this sense, soil organic matter and microbial diversity play an important role, being considered the main indicator of soil quality, serving as a basis for agricultural sustainability (Lal, 2004; Moura et al., 2018).

Because of the importance of soil quality, the good results in the intercropping of maize with forage grasses and forage legumes and in the paramount importance of growth-promoting microorganisms, the objective of this work was to evaluate microbial diversity as an indicator of soil quality through intercropping between maize and forage grasses (Brachiaria ruziziensis, Brachiaria brizantha BRS Piatã and Panicum maximum), and legume (Stylosanthes macrocephala, Stylosanthes capitata) whether or not using inoculation with Azospirillum brasilense.

**MATERIALS AND METHODS**

The experiment was conducted on the premises of the Federal Institute Goiano campus Rio Verde in the experimental field and Laboratory of Agricultural Microbiology located in the city of Rio Verde, in Goias. It is located at latitude 17° 48' 28" S and longitude 50° 53' 57" O with an average altitude of 720 meters and the average annual temperature is 27.5 °C and the average rainfall is 1650 mm per year.

The experimental design will be randomized blocks in bands in the factorial scheme of 6 x 2 with 4 replications, the first factor being a monoculture and four consortia: (1) single corn, (2) corn + Brachiaria ruziziensis, (3) corn + Brachiaria brizantha cv. BRS Piatã, (4) corn + styling Campo Grande (S. capitata (80%) and S. macrocephala (20%)) and (5) corn + Panicum maximum. The second factor will consist of inoculation with A. brasilense with the strain Ab-V5 through the inoculant Biomax Premium Maize and without inoculation.

In the field experiment, plots of 4.5 m x 10 m will be used, resulting in a total area of 45 m², with a spacing between lines of 0.45 m. The corn cultivar used in the experiment will be BRS 2020. The fertilization of the experiment will be used based on the recommendation of Embrapa as a reference for soil analysis. Phytosanitary applications will be carried out according to the need in the field. Weed control will be carried out by applying post-emergent herbicide when planting the crop and by hand weeding.

The samples were collected randomly, with each repetition composed of rhizospheric soil in each plot. They were collected at a depth of 0 to 5 cm and 5 to 10 cm, homogenized and stored under refrigeration. The number of fungi and bacteria was determined by quantification of colony-forming units (CFU) using the inoculation method of suspensions diluted in potato-dextrose-agar agar, with four replications per dilution.

From the collected samples, 1.0 g of soil was removed and diluted in a conical flask, adding 10.0 mL of distilled water, the same procedure is performed until the dilution of 10⁻⁶. Petri dishes with the inoculated medium were incubated at room temperature (± 35°C) and counting colonies of fungi and bacteria were performed five days after incubation. The data were submitted to the Shapiro-Wilk normality test, transformed by the equation \((x + 1)^{0.5}\), the analysis of variance and the means compared by the Tukey test (5%).

**RESULTS AND DISCUSSION**

Effects on fungal diversity were observed in the 0 – 10 cm and 10 – 20 cm layers, when corn intercropped with forage inoculated or not with A. brasilense (Table 1).

Were observed in the 0 – 10 cm layer, superiority in the intercropping of corn with B. ruziziensis to intercropping and single corn. Besides, maize consortia with B. ruziziensis showed superiority when there was no inoculation and corn with B. brizantha when there was inoculation of A. brasilense. The maize intercrop with B. brizantha showed superiority when there was no inoculation in the 10 – 20 cm layer, to the intercrop of corn with P. maximum and single corn.

While comparing the consortia, brachiaria were influenced by fungal diversity, as well as a bacterial inoculant. The fungal community tends to gradually increase with the cultivation of plants (MIRANDA; MIRANDA, 2007a), with the preparation of the soil (MIRANDA; MIRANDA, 2007b) and the application of correctives and fertilizers (MIRANDA; MIRANDA, 2003), therefore, the management Soil changes its physical,
chemical and mainly, biological properties (RAMOS et al., 2012), the density and diversity of fungal species stands out (LEAL et al., 2009).

The effects on bacterial diversity were observed in the 0 – 10 cm and 10 – 20 cm layers, when corn intercropped with forage inoculated or not with A. brasilense (Table 2).

In the 0 – 10 cm layer, the corn intercrop with B. ruziziensis showed superiority to the other treatments and in the intercrop of corn + P. maximum and single corn when there was no inoculation. The intercropping of corn + P. maximum, showed higher values when there was inoculation with A. brasilense to the treatment that did not occur. The intercropping with corn and styles showed superiority to the other intercropping and single corn when A. brasilense was inoculated. The corn intercropping with B. ruziziensis and B. brizantha to single corn when there was no inoculation.

Forage grasses have high densities of the root system, with periodic renewal and uniform distribution of soil exudates (CUNHA et al., 2011), improving biological attributes (Carneiro et al., 2008), allowing native rhizobia strains to perform biological fixation (CARMEIS FILHO et al., 2014). The use of forages, such as brachiaria, brings benefits to improve soil structure and increase organic matter, due to native nitrogen-fixing microorganisms or inoculants, with bacteria of the genus Azospirillum (Fancelli, 2009).

Effects on microbial diversity were observed in the 0 – 10 cm and 10 – 20 cm layers, when corn intercropped with forage inoculated or not with A. brasilense (Table 3).

In the 0 – 10 cm layer, the corn intercrop with B. ruziziensis showed superiority to the other intercrops and single corn. Regarding inoculations, corn with B. ruziziensis showed better results when there was no inoculation and corn with P. maximum when there was the inoculation of A. brasilense. In the 10 – 20 cm layer, when there was no inoculation, the corn consortium with B. ruziziensis and B. brizantha were superior to the others and when there was inoculation, the corn consortium with styling showed the best result. When observing the inoculations, the corn consortia with B. ruziziensis, B. brizantha, and P. maximum presented the best responses when there was no inoculation and corn with styling when there was the inoculation of A. brasilense.

It is noted that inoculation with A. brasilense affects the total microbial diversity in the 10 – 20 cm layer in grass forage and benefits the grassy legume, depending on the consortium used, with the beneficiary being the corn consortium with B. ruziziensis in the layer from 0 – 10 cm. Microorganisms are ideal indicators because they are very sensitive to changes and show variations in their community when subjected to stressful environments.
Table 3: Mean CFU values of total soil microorganisms in monocultures and consortia with forages.

<table>
<thead>
<tr>
<th>Total Microorganisms (UFC 10^6)</th>
<th>0 – 10 cm</th>
<th>10 – 20 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. brasilense</td>
<td>Without inoculation</td>
</tr>
<tr>
<td>Single Corn</td>
<td>32.00 aA</td>
<td>13.75 cA</td>
</tr>
<tr>
<td>Consortia</td>
<td>33.50 aB</td>
<td>11.00 aA</td>
</tr>
<tr>
<td>Corn + B. ruziziensis</td>
<td>38.75 aA</td>
<td>37.00 bC</td>
</tr>
<tr>
<td>Corn + B. brizantha</td>
<td>69.50 aA</td>
<td>31.50 bC</td>
</tr>
<tr>
<td>Corn + P. maximum</td>
<td>49.50 aA</td>
<td>57.50 bA</td>
</tr>
<tr>
<td>CV (%)</td>
<td>20.72</td>
<td>18.39</td>
</tr>
</tbody>
</table>

Means followed by the same lower case letters in the columns and upper case letters in the row are statistically equal by the Tukey test at 5% significance.

(Moreira and Siqueira, 2006). Consortia promotes better conditions for the development of the diversity of soil microbiota (Soares et al., 2010), which may be poorly understood, with oscillation in soil layers and the competition of native microorganisms with those that will be inserted through inoculants, knowing that the number of microorganisms tends to increase by adopting sustainable management and for a longer cultivation period (Moura et al., 2018).

The fungal and bacterial diversity in the consortium in layers 0 – 10 and 10 – 20 cm did not show a linear behavior, with presence in both, but with variable values. In Pereira’s work (2015), even with the presence of fungi in all layers, the deeper layers showed a decrease in the diversity of bacteria.

CONCLUSIONS

The maize intercrop with B. ruziziensis showed greater fungal diversity in both depths, greater bacterial diversity in the 0 – 10 cm layer and greater total microbial diversity in the 0 – 10 cm layer.

Corn with B. ruziziensis showed superiority when there was no inoculation, in both depths, and corn with B. brizantha, P. maximum and styling Campo Grande when there was inoculation of A. brasilense in the 10 – 20 cm layer.

REFERENCES


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