Response of the Soil Microbial Community to Fertilization Practices in Agricultural and Native Cerrado Systems in Brazil

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Introduction

Changes in land use are drastically affecting the Cerrado region in Central Brazil, where native areas are rapidly being replaced by agricultural areas. Main land uses in the area include pastures (ca. 45 million hectares) and crops (e.g., soybean, rice) (ca. 12 million hectares). Recent studies suggest that land use changes can alter Cerrado ecosystems, for instance, by changing precipitation regimes and dry period frequencies.

Because microorganisms have an important role as regulators of major biogeochemical cycles, they can significantly affect nutrient cycling and ecosystem functioning. In a previous study conducted in the Cerrado region by our group, we observed that season and vegetation type were the two main factors affecting the variability (PC1=34.9%) of the microbial community. Shifts in the structure and dynamics of microbial communities may also occur due to changes in the physical and chemical characteristics of their microenvironments as a result of the implementation of different management techniques. A management technique widely use when converting native areas to agriculture is fertilizer application, which may affect the distribution of organic C and N between labile and stable soil pools.

Phospholipid fatty acid (PLFA) analysis is a useful technique to study microbial community structure and identify specific groups of microorganisms that may have a significant role in the community. This technique was utilized to assess the effect of different fertilization practices on the microbial community structure in native Cerrado areas. In addition, we evaluated the relationship between the fungal to bacterial ratios and the N availability in the system.

Typical Cerrado Vegetation

Study Sites

Cerrado native areas were situated at the Ecological Reserve of IBGE (Instituto Brasileiro de Geografia e Estatística), located 35 km south of Brasília (15º26'S, 47º53.1'W)(Figure 1). The cerrado stricto sensu has a canopy cover of 20% to 50% and is composed of trees (3 to 6 m height) and shrubs. The soil is characterized as a Dark Red Oxisol. The pasture site is located at the EMBRAPA-Cerrados experimental station, 45 km east of Brasília (15º39'S, 47º45'W). The site was originally a cerrado stricto sensu area and was converted to *Brachiaria brizantha* in 1982.

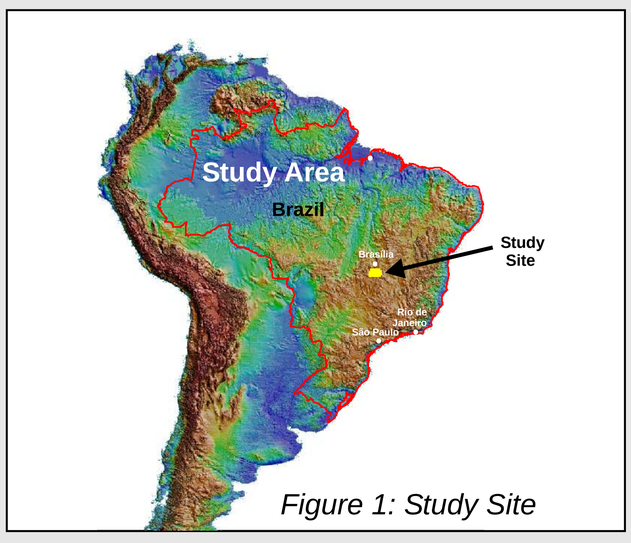


Figure 1: Study Site

Experimental Approach

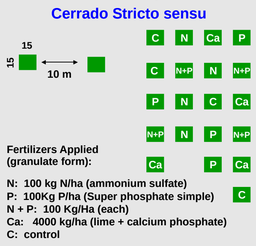
Soil samples 0-5 cm 10-20 cm
↓
Sieving
↓
PLFA extraction
↓
GC / GC-MS analysis

- Fertilization frequency: Beginning (Nov) and end (March) of wet season.
- Experiments started 1998
- Samples collected for PLFA analysis: June 2001

Other analyses included: N-mineralization, Total inorganic N, Trace gas measurements

Fertilization Experiment

Cerrado Stricto sensu



Fertilizers Applied (granulate form):
N: 100 kg N/ha (ammonium sulfate)
P: 100Kg P/ha (Super phosphate simple)
N + P: 100 Kg/Ha (each)
Ca: 4000 kg/ha (lime + calcium phosphate)
C: control

Results and Discussion

- Fungal to bacterial PLFA ratios are good indicators of the relative abundance of fungal and bacterial biomass in the system. Figure 2 shows no significant difference in the relative abundance of these groups in the native areas. There is a significantly higher ratio in the pasture relative to the native areas. This difference is basically due to a lower bacterial biomass in the pasture. The abundance of fungi stays at a similar value throughout the different areas. Fungi: bacteria ratios tend to be negatively correlated to the mineral N concentration in some managed soil.

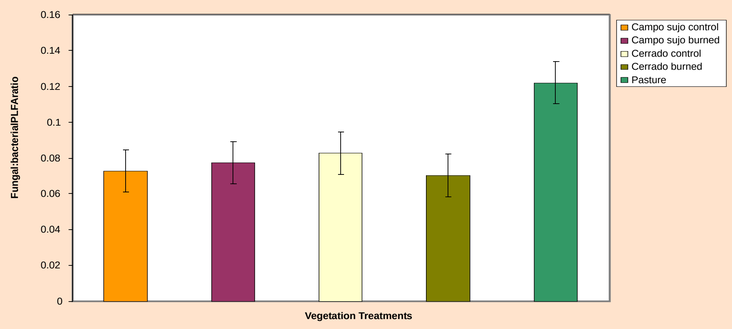


Figure 2: Fungi:Bacteria PLFA ratios in native and converted areas.

- A comparison of the concentration of available nitrogen in the native areas to that of the pasture (Figure 3), indicated that N is lower in the pasture relative to the other sites for most months. This result suggests that the bacterial biomass decreases in response to the lower availability of N, while the fungi due to their physical advantage (the hyphae) are able to cover a bigger area, allowing them to scavenge for resources and therefore maintain a similar biomass.

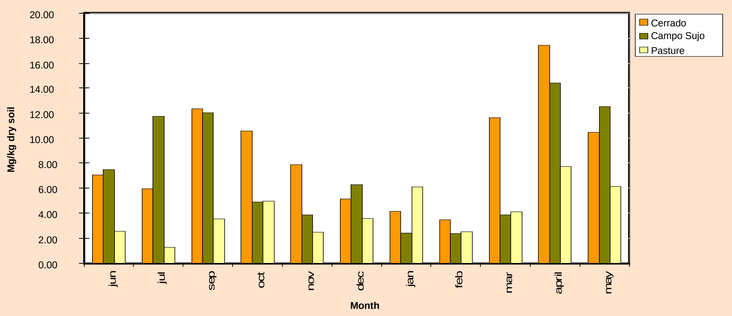


Figure 3: Available nitrogen in native and coverted Cerrado soils.

- The fungi:bacteria ratios only show a significant difference under the P treatment, where there is a significant increase 10 days after application, suggesting a P limitation in the fungi community in native Cerrado soils (Figure 4).

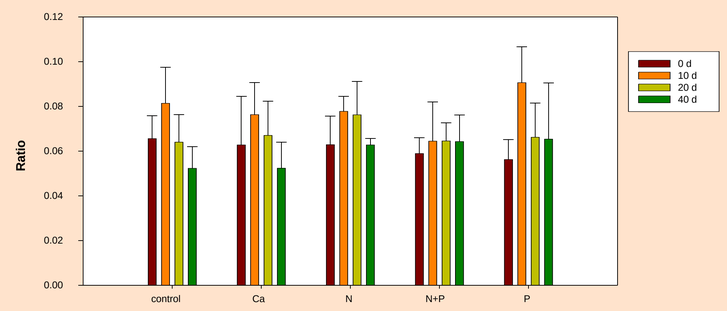


Figure 4: Fungi: Bacteria ratios in Cerrado soils under different fertilization treatments over a 40 day period.

- In figure 5, the ratio of 16:1w7t to 16:1w7c is significantly higher in the fertilization treatments relative to the control. This result suggests that the fertilizers are causing a shift in the allocation of resources in specific microbial groups maybe in response to a shift in the availability of C substrates.

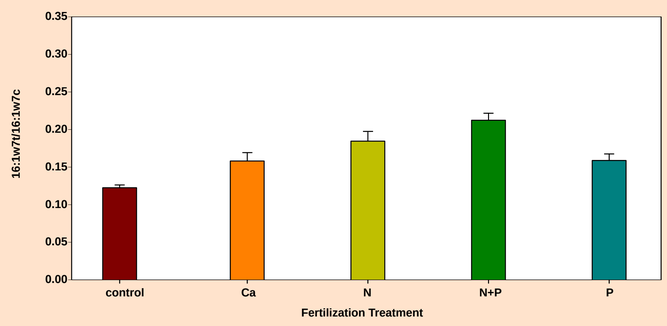


Figure 5: Trans to cis 16:1w7 ratio as an indicator of stress in soil microbial communities under different fertilization treatments

- Microbial community analysis shows two basic community structures (Figure 6). The control and Ca treatments are not significantly different from each other, but are significantly different from the N, P, and N+P treatments under PC1 which explains 31.5% of the variability in the samples. PLFAs that are indicators of Gram + bacteria are more predominant in the N, P, and N+P treatments, while Gram negative biomarkers are more abundant in the Control and Ca treatments. The results in the control are consistent with what we have observed before during the dry season when Gram negative indicators are dominant in the community.

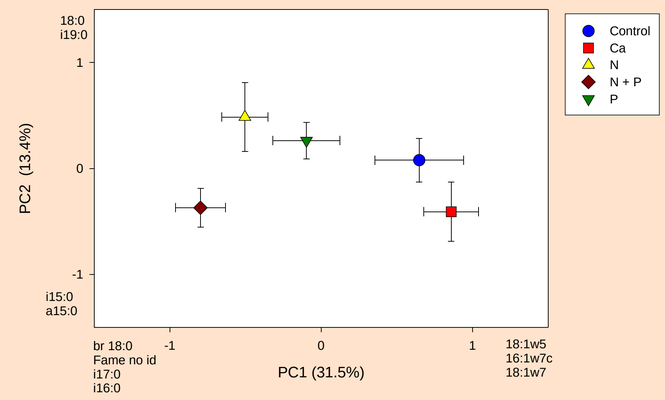


Figure 6: Effect of different fertilization treatments on the microbial community structure in Cerrado Soils.

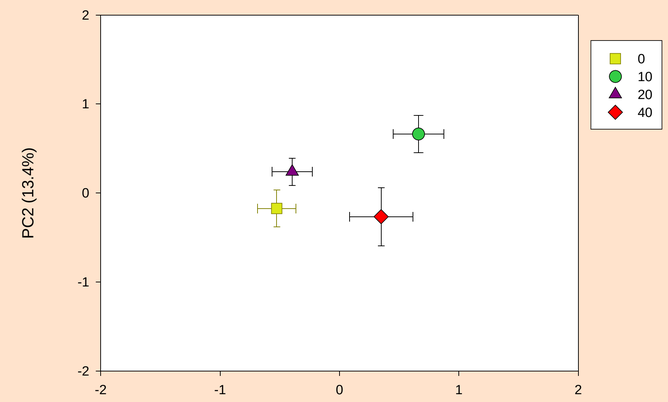


Figure 7: Microbial community structure in fertilized Cerradosoils as a function of time (days after fertilization treatments were applied).

- Researchers have indicated that addition of N increases the utilization of older soil organic matter by Gram + organisms. Our results indicate that addition of N and P to the system shifts the microbial community to a community dominated by Gram positive bacteria as well, which suggests a response of this microbial group to a different pool of organic matter. Some possibilities are increased utilization of plant exudates in response to the fertilization treatments or higher utilization of older C pools that become more available in the presence of N.

Conclusions

- High fungi:bacteria PLFA ratios may be useful indicators of low N availability in Cerrado soils.

- Nutrient amendments (N, P, N+P) produce a shift in the microbial community, possibly in response to availability of more stable soil organic matter pools.