FIRE EFFECTS ON SOIL FUNGI IN A CERRADO VEGETATION AREA ACCORDING TO THE COLLECTION PERIOD

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Resumo

Efeitos do fogo nos fungos do solo em área de vegetação de cerrado em função do tempo de coleta. O Cerrado é reconhecido pela sua biodiversidade, mas atualmente é considerado um bioma ameaçado. Este trabalho objetivou avaliar os impactos do fogo de baixa intensidade sobre a abundância e riqueza das comunidades de fungos habitantes num Latossolo Vermelho Amarelo em Cerrado *Sensu Stricto.* Foram definidos cinco tratamentos em parcelas controle e queimadas, que representam as coletas do solo em função do tempo pós queima prescrita em diferentes épocas. Os efeitos do fogo foram analisados nas camadas de 0-5 e 15-20 cm de profundidade do solo. Para análise estatística foram utilizados os índices de Shanon-Wiener, Simpson e Berger-Parker. Foi constatada redução significativa (ANOVA teste de Dunnett p> 0,05) de 33,3% na abundância total (UFC.g^{-1}), na camada superficial e perfil mais profundo do solo (15-20 cm) das parcelas queimadas em relação às parcelas controle. Porém, houve recolonização dos fungos aos 2 meses após a queima. Foram encontrados 21 gêneros de fungos, sendo verificado maior diversidade nas parcelas queimadas em comparação às não queimadas. O índice de Shanon-Wiener máximo foi H´=0,85 na profundidade 15-20 cm nas parcelas queimadas. Quanto ao índice de dominância foi encontrado valor máximo de 70% pelo gênero *Aspergillus* (no tratamento antes da queima na profundidade 15-20 cm). As flutuações na diversidade de fungos após a queima não foram afetadas pelo fogo, mas sim pelos índices pluviométricos nos tratamentos após a queima. A equidade foi uniforme e mostrou diferenças na riqueza numérica nas parcelas queimadas e controle. A precipitação pluviométrica teve grande impacto na rapidez de recuperação dos fungos.
Palavras-chave: Savana, microrganismos, diversidade, queima prescrita.

Abstract

The Cerrado is recognized for its biodiversity, but is currently considered a threatened biome. This study aimed to evaluate the impacts of low-intensity fire on the abundance and richness of fungal communities in a Red Yellow Latosol in *Sensu Stricto* Cerrado. Five treatments were defined in control and burned plots, which represent the soil collections as a function of the periods after prescribed firing. The fire effects were evaluated in the 0-5 and 15-20 cm layers of soil depth. For statistical analysis, the Shanon-Wiener, Simpson and Berger-Parker indexes were used. A significant reduction of 33.3% was observed (ANOVA; Dunnett Test p> 0,05) in total abundance (UFC.g^{-1}), in the superficial layer and in the deeper soil profile (15-20 cm) of the burned plots when compared to the control plots. However, it was observed a fungi recolonization at 2 months after burning. A total of 21 fungi genera were found, and more diversity was observed in the burned plots compared to non-burned. The maximum Shanon-Wiener index was H´=0,85 in the 15-20 cm depth for the burned plots. For the dominance index, a maximum value of 70% was observed for the *Aspergillus* genus (in the treatment before burning for the 15-20 cm depth). The fluctuations in the diversity of fungi after burning were not affected by the fire, but by the rainfall indexes in the treatments after burning. The equity was uniform and showed differences in the numerical richness in burned plots and control. Rainfall has a great impact on the fungal recovery speed.
Keywords: Savannah, microrganisms, diversity, prescribed firing.

INTRODUCTION

Fire is part of many natural systems, mainly in temperate ecosystems in both hemispheres, being in the Cerrado biome one of the most frequent practices of vegetation management. In the last 30 years, the frequency of fire increased in several places in Brazil, mainly in the north of the Minas Gerais, west of Bahia, Piauí and east of Tocantins States, due to the growth of forestry, livestock and mainly agricultural activities that use the cutting and burning techniques (BORGES *et al*., 2016). Despite its importance in the understanding and development of ecosystems, the consequences of fire on the soil microbiota and its diversity have been little studied and, therefore, practically unknown.

The impacts of this practice on the biochemical properties of the soil varies depending on the ecosystem and characteristics of the burn, such as intensity, duration and frequency. Direct heat transferred to the soil during burning can lead to microbial mortality. Regarding the fungi, it is known that some groups are more sensitive to temperature elevation than others, which may result in the selective elimination of specific groups, causing changes in the community and frequency of these soil organisms (SHEN *et al.,* 2016).

Although the use of fire as a land management tool is a common practice in Brazil, there are few studies carried out in the cerrado biome of Tocantins and other States that are in the process of expanding the country's agricultural frontier. Thus, it is evident the need of studies that show the effects of burning on the fungi inhabitants and decomposers of soil substrates, in order to subsidize actions of management of the areas destined to agricultural activities, with the intention of establishing more preserved agropastoral systems as well as to reduce soil damages. It is believed that the prescribed burning can affect the fungal population of soils at different depths.

Thus, the present study aimed to evaluate the impacts of a low intensity burn in Cerrado vegetation, based on the abundance and diversity of the soil fungi at different depths.

MATERIAL AND METHODS

The study was carried out at the Verdes Mares Farm in the Sucupira municipality, Tocantins State, Brazil, located at 11º 59 '36 "S of latitude and 48º 58' 15" W of longitude, with an altitude of 257 meters. According to the classification of Thornthwaite, the location is inserted in the C2wA'a climatic region, characterized by having a humid climate, with moderate water deficiency. The rainy season is well defined (from October to April) with 75% of precipitation in the period, followed by a dry season when the occurrence of forest fires is high. The average annual rainfall varies from 1,600 to 1,800 mm and the average annual temperature varies from 26 to 27º C. The relative humidity of the annual average air is 70%, and in the rainy season average rates are higher than 80% and in the dry period around 50% (SEPLAN, 2012).

The soil of the studied area is a Yellow Red Latosol (EMBRAPA, 2013). In the surroundings of the farm, the landscape is dominated by a mosaic of crops of soy and pastures. The location of the experiment do not show evidences of anthropic interference, being covered by a Cerrado vegetation classified as a *Sensu Stricto* Cerrado (RIBEIRO; WALTER, 2008).

The prescribed burnings were carried out in October of 2015, at times between 11:05 am and 20:05 pm, always in favor of the wind. Burnings were carried out in 20 plots, with each experimental plot presenting dimensions of 10 m in width and 20 m in length, with fireplaces of 0.50 m. Each plot contained a control treatment, which consisted in the collection of soil before the firing execution. To measure the propagation velocity ($m.s^{-1}$) and flames height (m), a demarcation was carried out on every two meters in the plots length direction. Data collection of fire behavior and determination of the moisture content of the fuel material followed the methodologies recommended by Batista *et al.* (2013).

The determination of the forest fuel amount was based on the destructive method proposed by Brown *et al.* (1982). Before the firing, the mean air temperature (ºC), relative air humidity (%) and average wind speed (ms^{-1}) were determined from a portable meteorological station (model Kestrel® 4000), installed in the experiment area. The intensity of the fire line was obtained by the equation proposed by Byram (1959), according to Equation 1:

$$I = H * w * r$$

In which: H = the combustion heat of the material ($kcal.kg^{-1}$); w = the forest fuel amount ($kg.m^{-2}$) and r = fire propagation velocity ($m.s^{-1}$). The calorific value (H) used was 3,705 $kcal.kg^{-1}$, a value frequently used to verify the fire behavior in savannas, as reported in the literature (GRIFFIN, FRIEDEL, 1984).

The treatments were represented by the time of the soil samples collected after the prescribed burning, being: Control (T0) - before burning (end of dry season); Treatment 1 (T1) - 24 hours after burning (end of dry season); Treatment 2 (T2) - 2 months after burning (beginning of rainy season); Treatment 3 (T3) - 4 months after burning (middle of the rainy season); Treatment 4 (T4) - 6 months after burning (end of rainy season) and; Treatment 5 (T5) - 8 months after burning (beginning of drought).

During the period of the experiment, accumulated precipitation data were obtained from the National Meteorology Institute database (INMET, 2015). In order to evaluate the impact of the prescribed burning on the fungal populations in the different layers of the soil, three random samples were collected at 0-5 cm and 15-20 cm depths, obtaining a composed sample of each plot . According to the recommendation of Díaz-Raviña *et al.* (2012), the samples were stored in plastic bags and packed in foam boxes to maintain the temperature around 4 °C.

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In the laboratory, the microorganisms present in the soil samples were evaluated in three replicates by the plate dilution method, with a dilution factor of 10^{-4}. The culture medium was composed of Potato (250 g) + Dextrose (20 g) + Agar - agar (20 g), with antibiotic Chloramphenicol 50 mg (0.2 $g.L^{-1}$) to avoid bacterial contamination. A volume of the solution was spread on the surface of the culture medium with the aid of a Drigalski spatula. The plates were sealed with PVC film, identified and incubated for 72 hours. After this period, the number of colonies on the surface of the culture medium was counted for five days. Then, the conversion to Colony Forming Units ($CFU.g^{-1}$) were made, as proposed by Dhingr and Sinclair (1985) and according to the Equation 2:

$$UFC\ g^{-1} = (NC\ ^{1}/_{FD}\ ^{1}/_{V})/P$$

In which: NC is the number of CFU on the plate; FD the dilution factor; V the inoculated volume on the plate; P is the weight of the sample.

All the collected fungi were identified at the genus level as a function of the assimilation, reproduction and resistance structures formed in the medium. The data were submitted to variance analysis (ANOVA) applied between the control and burned plots. When ANOVA indicated a significant difference ($P \leq 0.05$), the Dunnett test was applied, with a confidence interval of 95%. The chi-square test was used to evaluate differences before and after the fire use (24 h) between treatments at two soil depths. For the dats analysis, the Margalef, Shanon-Wiener, Simpson, Berger-Parker (MAGGURAN, 2011) and Jaccard indexes were estimated. The Margalef index is a measure used to estimate the biodiversity of a community based on the numerical distribution of individuals of different species as a function of the total number of individuals in the analyzed sample. The higher the index value, the greater the diversity of the sampled community (KANIESKI *et al*., 2012).

To determine the diversity, equity and dominance, the data were processed in the software DiVES v3.0 (RODRIGUES, 2015). The Jaccard coefficient of similarity was estimated using the XLSTAT 2017 software.

RESULTS

Before burning (T0), at the end of the dry season, the abundance $CFU.g^{-1}$ in the control plots were 47,970 ± 21,056.59 and 56,040 ± 15,079.3, at the 0-5 cm and 15-20 cm depths, respectively. The differences between the two values were not statistically significant according to the ANOVA test. As for the chi-square test, the contingency of the individuals showed dependence ($p < 0.0001$) among all evaluated plots and depths (Table 1).

Table 1. Abundance of Colony Forming Units ($CFU.g^{-1}$) in a PDA medium from two cerrado soil depths submitted to fire treatments and evaluated at different times of collection in the municipality of Sucupira, Tocantins, Brazil, from 2015 to 2016.

Tabela 1**.** Abundância de Unidades Formadoras de Colônias (UFC g^{-1}) formadas em meio de cultura BDA proveniente de duas profundidades de solo de Cerrado submetido à queimada e avaliado em diferentes épocas, no município de Sucupira, Tocantins, nos anos de 2015 a 2016.

Treatment	Depth	
	0-5 cm	15-20 cm
Before burn (T0)	47.970 ±21.056,59	56.040 ±15.079,3
24 hours after burn (T1)	32.345 ±14.353,30*	11.905 ±9.463,70*
2 months after burn (T2)	107.010 ±56.162,59	105.685 ±74.620,48
4 months after burn (T3)	109.640 ±47.272,9	44.705 ±41.416,78
6 months after burn (T4)	77.520 ±40.575,81	63.350 ±41.538,82
8 months after burn (T5)	74.845 ±53.340,72	35.425 ±77.057,97

Averages ± standard deviations followed by * indicate significant statistical difference between the means of the plots submitted to the prescribed burning and the control plot by ANOVA and Dunnett´s test (p> 0.05). Rainfall distribution in the treatments, where: T0: end of dry season; T1: end of dry season; T2: beginning of rainy season; T3: middle of rainy season; T4: end of rainy season; T5: beginning of dry season.

It was observed, for the treatment with two months after burning (T2) a recover of the mivrofungi communities with values of 107,010 ±56,162.59 $CFU.g^{-1}$ at the first 5 cm of soil and of 105,685 ±74,620.48 of $CFU.g^{-1}$ at the 15-20 cm soil depth.

Table 2. Contingencies of the populations of fungi microflora as a function of pre-and post-firing samples prescribed from the vegetation, in the layers of 0-5 cm and 15-20 cm of soil depths.

Tabela 2. Contingências das populações de microflora fúngica em função de amostragens pré e pós queima prescrita da vegetação, nas camadas de solo de 0-5 cm e 15-20 cm de profundidade.

T0: Before burn					**T1: 24 hours after burn**			
Genre	**SQP1**	**QP1**	**SQP2**	**QP2**	**SQP1**	**QP1**	**SQP2**	**QP2**
Aspergillus	11083	15442	2750	54500	12183	4971	2200	2600
Chaetonium	550	1414	-	707	550	942	-	235
Cladosporium	12750	8778	1100	2835	12750	950	1100	1657
Curvularia	-	-	-	-	-	235	-	-
Fusarium	550	1657	-	235	550	-	-	-
Mucor	-	942	1650	1650	1100	707	1100	235
Penicillium	11050	12585	2766,6	5921	11066	3542	3866	3071
Phoma	-	-	-	-	-	-	-	1650
Pythium	450	4971	-	235	4400	11164	-	2128
Rhizoctonia	-	235	-	3314	-	-	-	-
Synchytrium	-	235	-	4985	-	3314	-	-
Trichoderma	-	1657	-	235	-	1892	-	942
Verticillium	550	2357	550	1657	-	235	550	707
T2: 2 months after burn					**T3: 4 months after burn**			
Genre	**SQP1**	**QP1**	**SQP2**	**QP2**	**SQP1**	**QP1**	**SQP2**	**QP2**
Alternaria	-	-	-	-	-	942	-	-
Aspergillus	70450	41392	47183	43535	4550	49485	4433	11407
Aureobasidium	-	-	-	-	-	-	550	-
Chaetonium	-	714	-	471	-	950	1650	707
Cladosporium	12766	19492	11650	2128	4433	1657	-	1892
Curvularia	-	-	-	-	-	1657	-	235
Fusarium	-	-	-	2614	4433	2364	1100	942
Mortierella	-	-	-	-	-	471	-	942
Mucor	-	6892	3316	714	2766	3085	2766	3321
Penicillium	29400	22350	7766	13307	24966	31400	550	5685
Phialophora	-	-	-	-	-	235	-	1185
Phoma	550	-	31083	31871	-	-	5000	-
Pythium	-	4514	-	1657	3866	6878	6100	3800
Rhizopus	-	-	-	-	-	-	-	707
Synchytrium	1100	3085	2766	6171	-	5928	2750	14271
Trichoderma	-	-	-	-	7183	9978	-	-
Verticillium	-	714	-	-	-	-	-	-
T4: 6 months after burn					**T5: 8 months after burn**			
Genre	**SQP1**	**QP1**	**SQP2**	**QP2**	**SQP1**	**QP1**	**SQP2**	**QP2**
Alternaria	1666	471	-	-	-	-	-	-
Aspergillus	72200	37585	20516	34485	29966	55200	6100	15442
Bipolaris	-	-	-	-	-	1178	-	-
Chaetonium	2750	1885	1666	4742	2216	5685	-	24521
Cladosporium	-	1428	4983	2378	4416	2135	-	707
Curvularia	-	-	550	471	-	-	-	-
Fusarium	550	235	-	-	-	-	-	-
Mucor	-	707	-	-	-	471	-	-
Papularia	-	235	-	-	-	-	-	-
Penicillium	550	4278	550	235	550	1178	-	1650
Pestalotia	550	-	-	3785	-	471	550	714
Phoma	6650	2842	1100	1185	550	471	500	-
Pythium	12183	12342	12200	13314	-	7592	-	1178
Rhizoctonia	-	235	-	-	-	-	-	-
Rhizopus	-	-	-	-	-	-	-	-
Synchytrium	1100	4035	-	6392	4966	4507	-	707
Trichoderma	-	2371	-	1657	7216	6642	1650	1892
Verticillium	-	-	-	3085	-	-	-	-

SQ = not burned area; Q = burned area; P1= depth 1 (0-5 cm); P2= depth 2 (15-20cm).

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Table 2 presents the contingency of fungal microflora populations as a function of the evaluation period before and after the vegetation burn, in the 0-5cm and 15-20cm soil layers. The results indicated that the majority of the fungal community suffered constant variation in its composition in relation to the evaluated characteristics. In all treatments there were differences in the amounts and types of fungi.

Regarding the effects of burning on the presence-absence of genera in the different treatments, the results are presented in Table 3. Twenty-one genera were identified throughout the study period, covering the two sampled soil depths.

Table 3. Presence-absence of genera according to the evaluation period after the vegetation burn, in the 0-5 cm and 15-20 cm soil layers.

Tabela 3. Presença-ausência de gêneros em função da época de avaliação pré e após a queima da vegetação, nas camadas de 0-5 cm e 15-20 cm de profundidades do solo.

Fungi genus	Treatments - 0-5 cm Depth											
	T0		T1		T2		T3		T4		T5	
	C	Q	C	Q	C	Q	C	Q	C	Q	C	Q
	0-5cm Depth											
Alternaria	-	-	-	-	-	-	-	×	×	×	-	-
Aspergillus	×	×	×	×	$\times_{+}$	×	×	×	$\times_{+}$	$\times_{+}$	$\times_{+}$	$\times_{+}$
Aureobasidium	-	-	-	-	-	-	-	×	-	-	-	-
Bipolaris	-	-	-	-	-	-	-	-	-	-	-	×
Chaetonium	×	×	×	×	-	×	-	×	×	×	×	×
Cladosporium	×	×	×	×	×	×	×	×	-	×	×	×
Curvularia	-	-	-	×	-	-	-	×	-	-	-	-
Fusarium	×	×	×	-	-	×	×	×	×	×	-	-
Mortierella	-	-	-	-	-	-	-	×	-	-	-	-
Papularia	-	-	-	-	-	-	-	-	-	×	-	-
Penicillium	×	×	×	×	×	×	×	×	×	×	×	×
Pestalotia	-	-	-	-	-	-	-	-	×	-	-	×
Phialophora	-	-	-	-	-	-	-	×	-	-	-	-
Phoma	-	-	-	-	×	-	-	-	×	×	×	×
Pythium	×	×	×	×	-	×	×	×	×	×	-	×
Rhizoctonia	-	×	-	-	-	-	-	-	-	×	-	-
Rhizopus	-	-	-	-	-	×	-	×	-	-	-	-
Synchytrium	-	×	-	×	×	×	×	×	×	×	×	×
Trichoderma	-	×	-	×	-	×	×	×	-	×	×	×
Verticillium	×	×	×	×	-	×	-	-	-	-	-	-
	Treatments- Depth 15-20 cm Depth											
Aspergillus	×	$\times_{+}$	×	×	×	×	×	×	×	×	$\times_{+}$	×
Aureobasidium	-	-	-	-	-	-	×	-	-	-	-	-
Chaetonium	-	×	-	×	-	×	×	×	×	×	-	$\times_{+}$
Cladosporium	×	×	×	×	×	×	-	×	×	×	-	×
Curvularia	-	-	-	-	-	×	-	×	×	×	-	-
Fusarium	-	×	-	-	×	×	×	×	-	-	-	-
Mortierella	-	-	-	-	-	-	-	×	-	-	-	-
Mucor	×	×	×	×	×	×	×	×	-	-	-	-
Penicillium	×	×	×	×	×	×	×	×	×	×	-	×
Pestalotia	-	-	-	-	-	-	-	-	-	×	×	×
Phoma	-	×	-	×	×	×	×	-	×	×	×	-
Pythium	-	×	-	×	×	×	×	×	×	×	-	×
Synchytrium	-	×	-	-	×	×	-	×	×	×	-	×
Trichoderma	-	×	-	×	-	-	×	×	-	×	×	×
Verticillium	×	×	×	×	-	-	-	-	-	×	-	-

×= Presence; - = Absence; C= control plots; Q= Prescribed burn plots; × followed by +: dominant genre according to the Berger-Parker dominant index with D above 0.5.

As can be seen in Table 4, regarding the richness and diversity, equity and dominance indexes, some treatments presetned a variation for the two evaluated soil depths. For the equity values in the 0-5 cm depth, no changes were noticed and for the 15-20 depth, it was observed a variation for both indexes and for the Simpson´s dominance. On the other hand, the Margalef and Shanon-Wiener diversity indexes in the prescribed burning plots presented higher values in the T3 and T4 treatments, with Margalef index showing a lower value at the T2.

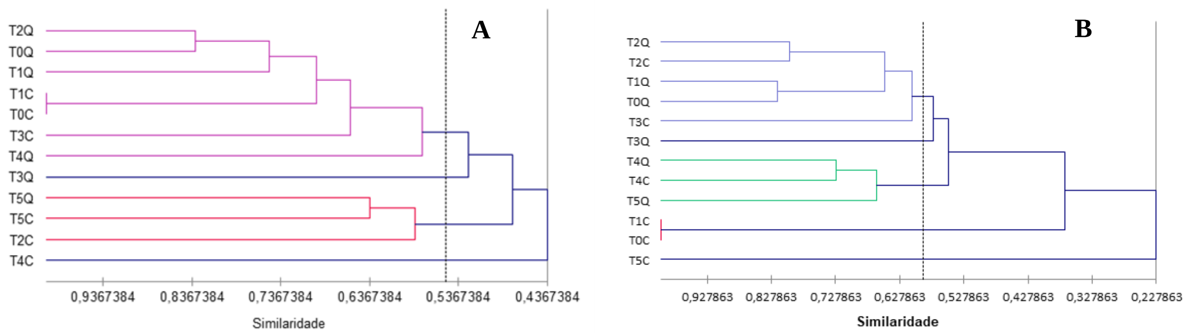
Table 4. Richness and diversity, equity and dominance indexes for the fungi genre for the treatments.
Tabela 4. Riqueza e índices de diversidade, equidade e dominância de gêneros nos tratamentos.

T/P	S		D_{Mg}		H´		J´		λ		D	
	1	2	1	2	1	2	1	2	1	2	1	2
T0 C	8	5	3.71	3.40	0.68	0.61	0.76	0.88	0.23	0.22	0.30	0.33
T0 Q	11	11	4.30	3.99	0.80	0.50	0.77	0.48	0.20	0.52	0.31	0.71
T1 C	8	5	3.70	3.32	0.68	0.61	0.75	0.87	0.23	0.24	0.29	0.44
T1 Q	10	9	4.34	4.58	0.77	0.85	0.77	0.89	0.22	0.14	0.40	0.23
T2 C	6	8	2.15	3.05	0.45	0.66	0.58	0.73	0.44	0.29	0.60	0.43
T2 Q	11	10	3.79	3.41	0.72	0.66	0.69	0.66	0.25	0.29	0.40	0.42
T3 C	8	9	3.13	4.84	0.65	0.85	0.72	0.89	0.30	0.14	0.48	0.24
T3 Q	15	12	5.21	4.83	0.74	0.84	0.63	0.77	0.27	0.19	0.43	0.32
T4 C	9	8	3.56	3.69	0.42	0.62	0.44	0.69	0.56	0.31	0.73	0.47
T4 Q	13	11	4.88	4.03	0.67	0.73	0.60	0.70	0.34	0.28	0.55	0.48
T5 C	7	4	3.07	2.49	0.55	0.40	0.65	0.66	0.39	0.48	0.60	0.69
T5 Q	11	8	3.91	3.05	0.58	0.54	0.55	0.60	0.44	0.38	0.64	0.52

S= Genre richness, D_{Mg}= Margalef´s diversity index; H´= Shanon-Wiener´s diversity index; J´= Pielou equity index; λ=Simpson´s dominance index; D= Berger-Parker´s dominance index; T=Treatament; P=Depth; 1= 0-5 cm depth; 2= 15-20 cm depth; C=control plots; Q= prescribed burn plots.

According to the dendrogram of the coefficient of similarity (Ij), the maximum diversity was observed in the 0-5cm layer (83%) for T0 and T2, for the control plots and plots with prescribed burn. However, the minimum percentage of 31% was observed between the control plots, in treatments 0 and 5 (Figure 1A). At the 15-20 cm layer and between the burned plots of treatments 0 and 1, the maximum value of similarity (Ij) was 82% and inversely proportional to the control plots of treatments 0 and 5, which were were around 12.5% (Figure 1B).

According to the dendrogram (Figure 1C and D), the genotypes of fungi presented the maximum similarity proportions of 100% between *Penicillium* e *Aspergillus* which with more presence. *Aureobasidium*, *Mortierella* and *Phialophora* were the less present genus for both evaluated soil depths. For the 15-20 depth, the most similar fungi were *Bipolaris* and *Alternaria*, *Rhizoctonia* and *Rhizopus.*



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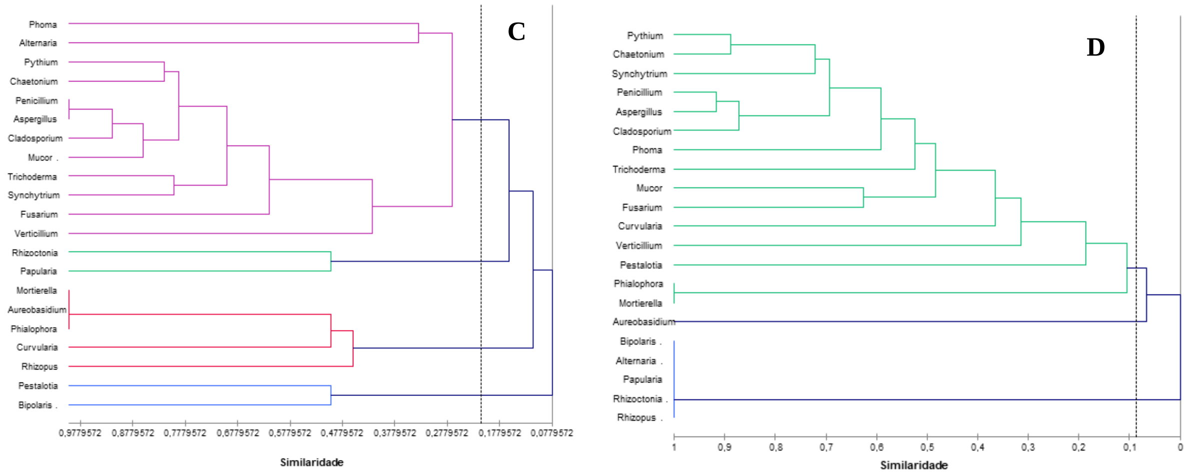

Figure 1. Dendrogram of similarity (Ij) of 0-5 cm (**A**) and 15-20 cm (**B**) soil depths. Dendrogram of similarity between genera (Ij) of the 0-5 cm (**C**) and 15-20 cm (**D**) soil depths.

Figura 1. Dendrograma de similaridade (Ij) das profundidades: 0-5 cm (**A**) e 15-20 cm (**B**). Dendrograma de similaridade entre gêneros (Ij) das profundidades de 0-5 cm (**C**) e 15-20 cm (**D**).

DISCUSSION

According to Santos and Maia (2013), microorganisms are used in the study of soil quality due to the capacity to give a fast reponse according to soil changes. Regarding the experiment, in the T1 treatment performed 24 hours after the prescribed firing, it was verified that the meteorological variables did not suffer significant variations according to the conditions observed during the burning period on the previous day, being thus considered similar. However, in spite of this similarity, a significant reduction of 32.3% in total abundance (UFC.g^{-1}), of fungi in the superficial layer (0-5 cm) and 11,9% in a deeper soil profile (15 -20 cm) in the burned plots in relation to the control plots were observed. The reduction recorded may be related to the biomass attributes, activity and CO_2, considered very sensitive to the fire effect as demonstrated in literature.

In a study carried out in a pasture area, Vieira *et al.* (2016) observed a significant reduction of the microbial biomass (80%) of the 0-5 cm soil layer where vegetation was burned, when compared to the result found at the same soil depth, with no burning practice.

In the subsequent treatments (T2, T3 and T4, respectively) the samples were collected during the rainy season (beginning, middle and final), with the following cumulative precipitation values: 196.8 mm (T2); 562 mm (T3) and 177.2 mm (T4) (INMET, 2015). During this period it was observed that in some treatments there was variation, with the indexes of richness and diversity, equity and dominance of fungi in the period due to rainfall. The importance of precipitation in studies such as this one is that it is a variable that has a direct influence on the abundance and richness of fungi in native vegetation (LAZAROTTO, 2014).

The highest values of abundance of micro-fungi in the most superficial layer of the soil (0-5 cm) were observed in the treatment of four months after burning (T3), being 109,640 CFU.g^{-1}. In relation to the 15-20 cm depth, the highest microfungi population index value in the burned plots was observed in the treatment with two months after burning (T2). At the end of the rainy season (when the precipitation reduced 68%), in the superficial layer, there was a population decrease of microfungi to 77,520 ± 40,575.81 of CFU.g^{-1}, while in the 15-20 cm depth the inverse occurred, with an increase of 29% in relation to T3.

There are reports in the literature of immediate effects after fire, such as biomass reduction, reduction of catalytic activity and species richness. The impacts on microorganisms are higher in the soil surface horizons, due to the fact that the microbial population tends to be more abundant in these layers (REDIN *et al*., 2011).

In the *Sensu Stricto* Cerrado, a study on the microfauna properties (protozoa), in a period of three months after the fire, revealed favorable conditions for the populations of these microorganisms, similar to control plots. According to the authors' conclusion, the fire would not have caused significant changes in the structure of the protozoan community, but only the initial reduction in population density, evidencing that these microorganisms are adapted to environmental conditions imposed by the fire application (PIEROZZI *et al.*, 2016).

In the contingency of fungal microflora populations as a function of sampling time after vegetation burn, variation in microfungal community composition was observed in the two layers evaluated in relation to the evaluated characteristics. The amount and the fungi genera varied in the different treatments, being the majority of the observed genera typical of soil, being some considered of agronomic importance due to its phytopathogenic or for being antagonistic.

It was observed a difference between the control plots with those with prescribed burning regarding the numerical richness of genre. In the period of higher precipitation, the burned plots presented the highest number of genera at the two depths, 0-5 and 15-20 cm, with a total of 15 and 12 genera, in the treatment T3, with 4 months after burning. Treatment 4 (T4), with 6 months after burning, was the second in diversity of genera in the two depths. Garcia *et al.* (2015) carried out a study in native vegetation (dense forests and Cerrado) on the soil microfungi in the rainy season and in the dry season, beng able to identify 17 genera present in the soil, 12 from the rainy season and 11 genera in the dry season. According to Meira Junior (2017), the occurrence of fire prevails the development of species that are resistant to temperature, and because there is a small number of species, the diversity is consequently reduced with a tendency to local homogeneity.

The diversity, equity and dominance indices between the 20 plots (burned and control), at the 0-5cm depth showed no alterations. At the 15-20 cm depth, the values of the equity index (J'= 0.48) and Simpson dominance (λ = 0.52) showed a higher proportion of a genus before the burning practice. According to the Berger Parker index, this result was attributed to the genus *Aspergillus* that presented 71% of incidence. Garcia *et al.* (2015), analyzing the diversity of fungi in the Tangará da Serra region, at the 0-20 cm soil depth in Cerrado covered with native vegetation, found *Penicillium* as dominant, with a 28% of incidence in the samples, followed by *Trichoderma,* with 18% dominance. These results are different from those found in this present study.

For all treatments, the values of Margalef and Shanon-Wiener diversity in the burned plots were higher in T3 and T4 (DMg = 5.21, 4.88). In T2, the Margalef index presented a lower value (DMg = 2.15).

An example of how the use of fire by burnings prescribed in vegetation management causes interference in communities of soil micro-fungi can be given by the study of Oliver *et al.* (2015) where they describe that long-term burns and different regimes for nearly a quarter of a century in the forests of the Southwest of the United States have demonstrated that such practice does not affect the richness and diversity of soil fungi communities, in contrast with what was observed in areas with burnings with frequencies of 2 and 3 years, that presented lower diversity.

Even with the passage of fire, the values obtained with the application of the Margalef and Shanon-Wiener diversity indexes in the burned plots showed that the diversity of micro-fungi in the soil continued to be medium-high, demonstrating the significant diversity that can be found in soils of native vegetation of Brazilian biomes, as in the case of the Cerrado biome. To exemplify how diversity differs in distinct types of vegetation, we can cite the results found by Lazzarotto *et al*. (2014) who, by comparing the richness and abundance of fungi of a native forest and a monoculture of eucalyptus, found by the application of the Shannon-Wiener Index the values of H '= 1.55 for the first environment and H' = 0.62 for the second.

After the fire passage, the equity, ie, the pattern of the individuals among the species were normalized and consequently the index of dominance of Simpson, except in the control plots and T2 (2 months after burning) in which there was domain of *Aspergillus*. A similar occurrence was observed in the control and precribed burned for the 0-5 cm layer, in T4 and T5, which showed dominance of the *Aspergillus* (73%) and *Chaetonium* (60%) genus.

In relation to the fungi genus, the dendrogram showed the maximum similarity proportions of 100% between *Penicillium* and *Aspergillus*, being these, therefore, the most present genera. *Aureobasidium, Mortierella* and *Phialophora* were the least present genera, at the 0-5cm of soil depth. Cavalcanti *et al.* (2006) carried out research on soils in the Caatinga ecosystem, collected samples at both the surface and 20 cm depth, isolating 1,230 colony forming units (CFU) that were represented by species of the genus *Aspergillus*. At the depth of 15-20 cm, the most similar fungi were *Bipolaris* and *Alternaria*, *Rhizoctonia* and *Rhizopus*. All four genera are considered disease-causing pathogens in cultivated plants. There was also a 100% similarity between *Alternaria*, *Papularia, Rhizoctonia* and *Rhizopus*; and between *Mortierella* and *Phialophora*. Kutorga et al. (2012) studied fungal communities after a Pinus mugo fire on the Curonian Spit peninsula in western Lithuania and determined that the temporary succession of fungal communities after the fire kept all taxonomic and functional groups defined.

CONCLUSIONS

● Fluctuations in fungal diversity in the soil over time were not affected by fire, but by the seasonality of precipitation rates during treatments after burning.
● The diversity found was considered medium-high, according to the results of the indexes used and comparative with studies in the literature.

● Equity analysis between control and burned plots resulted in higher values of fungal diversity for burnings, demonstrating, for reasons not identified in this study, that there is a tendency for diversity to increase over a given period of time in Cerrado areas that were burned.
● The variation of seasonal rainfall showed that this meteorological variable has a greater influence on the soil fungi community than the fire passage in burning practices.

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