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Soil Fungi in an Over-burned Tropical Rain Forest in Bukit Bangkirai, East Kalimantan

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ABSTRACT

A study was conducted in Bukit Bangkirai forest, East Kalimantan, to understand the impact of forest fire on the existence of soil fungi. Three permanent plots were used for the research, i.e. undamaged plot (K), lightly damaged plot (LD), and heavily damaged plot (HD). Each plot was 1 ha and divided into 100 sub-plots (10 m x 10 m). For observation of soil fungi, in the center of the five randomly selected sub-plots from each plot was made a sampling plot (2 m x 2 m). After removing the organic matter surface (O layer), soil sample was collected from top layer (A) and second layer (B) in each of the five sampling plots. Soil fungi were isolated using dilution plate method and they were incubated at room temperature (27-28 ^{o}C). This process was replicated two times for each soil sample. The result indicated that forest fire decreased the diversity and population of soil fungi. The highest soil fungi population was found in the undamaged (K) plot at the top layer (A) (389.0 colonies/mg dry soil), while the lowest population was in the lightly damaged plot (LD) at the second layer (B) (12.3 colonies/mg dry soil). *Gongronella butleri* was dominant species in the area of the tropical rain forest which was fired in Bukit Bangkirai, East Kalimantan.

Key words: damaged and undamaged plots, colony, population, soil fungi, soil layer.

INTRODUCTION

According to Garty (1991) fire is a frequently occurring natural event, with almost all of the fires caused by lightning. In Indonesia, the forest fire occur almost every year mainly due to human activities such as clearing for large-scale plantation. The fire occured between 1997 and 1998 were aggraved because of the El Nino effect, which has caused Indonesia suffer from drought. In 1997, forest fire has destroyed at least 2 million ha forest in Indonesia. The fire resulted in loss of biodiversity and may alter soil physicochemical properties and thus affected the composition of soil microflora. Soil fungi have great influence on the cycling of nutrients, therefore determine soil fertility and promote plant growth.

The present work was designed to investigate the effect of fire on the population, composition and distribution of soil fungi in an over-burned tropical rain forest in Bukit Bangkirai, East Kalimantan.

MATERIAL AND METHOD

Description of areal study

The experiment was conducted in a conservation forest, Bukit Bangkirai, East Kalimantan. The last fire occured in this forest was in mid of 1998. Three permanent plots, each represented undamaged (K), lightly damaged (LD), and heavily damaged (HD) sites, were established. Each plot was ± 1 ha. At the time of study (July 2002), LD and HD plots were occupied by ferns and macarangas. Some parts of LD plot occupied by Dipterocarps trees. The plot was then divided to (10 m x 10 m) sub-plots.

Collection of soil sample

Each sub-plot was selected to assess the presence of soil fungi. Sampling plots (2 m x 2 m) were established at the center of the selected sub-plots, that is, each of the three plots included five sampling-plots. Soil samples for the fungous study were taken from the top layer (A) and the second layer (B) for each sample after removal of the surface organic matter. All the sample were kept in plastic bags and transported to the laboratory. These samples were air-dried and passed through 2 mm-mesh before the analysis of pH, total N, total organic C, and C/N ratio; and the isolation of soil fungi. Data were analyzed using Analysis of Variance (ANOVA) and the least significant different (LSD) test.

Isolation of soil fungi

Soil fungi were isolated using the serial dilution plate technique (Suciatmih, 1999). A dilution of 1 part of soil to 1,000 parts of medium was used for planting. Two plates were used for each sample and incubated at room temperature (27^{o}C) for 3-5 days. “taoge sucrose agar” (TSA) containing streptomycin sulfate and amcillin antibiotics at the rate of 0.1 g/ 1000 ml and 0.05 g/1000 ml respectively was used for soil fungi. All fungi appearing during the incubation were transferred to TSA slant. The number of fungal colonies developing on each plate was counted and the number of fungi per mg of dry soil was calculated. Fungi identification follows Domsch *et al.* (1980), and Ellis (1993).

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Table 1. Soil properties, pH and layer of plot.

Plot	Soil pH		Total organic content (%)	Total N (%)	C/N ratio	Soil layer (cm)
	H_2O	KCl				
KA	4.292 ± 0.423a	3.538 ± 0.242a	1.72 ± 0.58cd	0.114 ± 0.045bc	0.096 ± 0.031ab	7,9 ± 074 a
KB	4.578 ± 0.242ab	3.948 ± 0.250ab	1.01± 0.49abc	0.058 ± 0.018a	0.058 ± 0.018a	
LDA	4.748 ± 0.254abc	3.808 ± 0.143ab	1.62 ± 0.50bc	0.102 ± 0.024abc	0.101± 0.025ab	5,4 ± 0,65 a
LDB	5.010 ± 0.055c	4.124 ± 0.076b	0.74 ± 0.26ab	0.066 ± 0.014ab	0.068 ± 0.013a	
HDA	4.290 ± 0.323a	3.534 ± 0.662a	2.58 ± 1.44d	0.132 ± 0.054c	0.130 ± 0.056b	9,7 ± 3,8 a
HDB	4.854 ± 0.334bc	4.094 ± 0.292b	0.47 ± 0.38a	0.064 ± 0.055ab	0.062 ± 0.052a	

Note: Value followed by the same letter in the same column are not significantly (*p<0.05*) different as determined by the least significant different (LSD) test. K= undamaged site, LD= lightly damaged site, HD= heavily damaged site, A= top layer, B= second layer.

RESULT AND DISCUSSION

Result of this study indicated that there were significant differences each in total N, C/N ratio, and total organic C to soil layer (p< *0.05*). The top (A) layer contained more total organic C, total N, and C/N ratio than those in the second (B) layer (Table 1). Soil pH of both top (A) and second (B) layers of all plots were acid. There were significant differences in soil pH (both H_2O and KCl) to soil layer (p< *0.05*). Soil pH at the top (A) layer was lower than the second (B) layer.

Table 2. Population of soil fungi at different soil layers.

No	Plot	Soil layer	Colonies/mg dry soil
1	K	A	389.0 a
2		B	35.8 c
3	LD	A	128.4 b
4		B	12.3 c
5	HD	A	209.0 b
6		B	19.6 c

Note: Value followed by the same letter in the same column are not significantly (*p<0.05*) different as determined by the least significant different (LSD) test. K= undamaged site, LD= lightly damaged site, HD= heavily damaged site, A= top layer, B= second layer.

Table 3. Correlation between fungal colony and soil properties

Soil properties	Regresion
Total organic content (C)	Y= 37.2 + 70.5 x (r= 0.4307*)
Total N	Y= 129.6 + 38.3 x (r= 0.07)
C/N ratio	Y= 284.9 – 6.5 x (r= -0.16)
pH (H_2O)	Y= 1253 – 242 x (r= -0.6 **)
pH (KCl)	Y= 958.7 – 215 x (r= -0.53**)

Note: ** significantly different (*p<0.01*). * significantly different (*p<0.05*).

In general, soil under study had high sand fraction. Soil texture of K, LD, and HD plots at the top (A) layer were (sand 68.25%, silt 27.75%, clay 4.0%), (sand 73.5%, silt 23.5%, clay 3%), and (sand 85.4%, silt 13.4%, clay 1.2%) respectively, while at the second layer of K, LD, and HD plots were (sand 69.0%, silt 27.5%, clay 3.5%), (sand 73.75%, silt 23.25%, clay 3.0%), and (sand 85.4%, silt 13.4%, clay 1.2%) respectively. Soil of K plot had higher silt and clay fraction than that of other plots. Soil that has higher clay and silt fraction may have better attachment for microbes.

There were significant differences in the population of soil fungi to plot (p< *0.01*), soil layer (p< *0.01*), and interaction between plot and soil layer (p< *0.05*). Undamaged (K) plot at the top (A) layer had significantly higher spore population than that in the damaged (both LD and HD) plots, while at the second (B) layer, there were no significant differences in soil fungal population between plots (Table 2). Results obtained clearly indicated that there was a marked decrease in the number of colonies with increasing layer depth. Lower fungal colony in deeper layer is in accordance with results reported by Eicker (1970). The higest number of fungal colonies was isolated from soils collected from K plot at the top (A) layer and the lowest came from LD plot at the second layer. Population of soil fungi was affected by forest fire. Fungal population in the damaged (both LD and HD) plots were lower than that in the undamaged (K) plot (Table 2). It could be considered that forest fire lead to a reduction and possibly the elimination of soil fungi.

A significant and positive correlation (p< *0.05*) was established between the fungal population and total organic C, while between the fungal population and soil pH (both H_2O and KCl) was a significant and negative correlation (p< *0.01*) (Table 3). It means that there were a decrease in the total organic C content and an increase in soil pH respectively to the second layer, accompanied by a rapid decrease in colony numbers. Brown (1958), found that there is a general tendency for fungus population to be poorer in the deeper layers of soil even if other factors are the same. It is probable that the combined effect of a number of factors, such as carbon content, pH, total N, C/N ratio, and probably some other factors, act together to bring about this vertical decrease in numbers. In this study there were no correlation between C/N ratio and total N to fungal colony. Waid (1960), lists temperature, moisture, carbon dioxide, and oxygen concentration, size of soil-pore spaces, durability of fungal mycelium, interaction between soil fungi and soil fauna and soil reaction as factors which may influence the growth and mycelium production of fungi in soil.

Diversity of soil fungi also tend to decrease by forest fire. The damaged (both LD and HD) plots, appeared to have lower diversity of soil fungi namely 26 and 25 species respectively than the undamaged (K) plot namely 31 species (Table 4). Thirty seven apparently different fungi were isolated from the soils of the three plots, 18 of them have been identified to species and 19 of them to genus. Except for *Cancellidium, Gliocephalis*, and *Helicorhoidion* almost all the species identified were common, typical soil fungi which have been recorded worldwide (Ito and Nakagiri, 1997a,b; Ito, *et al*., 1999; Ito *et al.*, 2001).

Table 4 shows the frequency of detection of fungi isolated from soil of plot. *Gongronella butleri* (Lendner) Peyronel and Dalvesto was detected in the highest frequency from the 60 samples used (30.0%) and from all six soil samples. According to Domsch *et al*. (1980), this fungus has a worldwide distribution with apparently higher frequencies in (sub) tropical regions. Suciatmih (2002) reported that this fungus was also found in Halimun

Mountain at 700 m asl. The second dominant species was *Penicillium* sp.1 (28.3%). *Cancellidium, Gelasinospora retispora, Gliocladium virens, Helicorhoidion,* and *Talaromyces wortmannii* were detected in lowest frequency (1.7%). Prominent genera were *Aspergillus, Penicillium* and *Trichoderma,* which each had four species.

CONCLUSION

Forest fire affected the diversity and population of soil fungi. The damaged (both LD and HD) plots, appeared to have lower diversity and population of soil fungi than that of the undamaged (K) plot. The highest fungal population was isolated from soils collected from undamaged (K) plot at the top (A) layer while the lowest was is from LD plot at the second layer. A significant and positive correlation ($p< 0.05$) was established between the fungal population and total organic C, while between the fungal population and soil pH (both H_2O and KCl) were significant and negative correlation ($p < 0.01$). *Gongronell butleri,* was the highest frequency, while *Cancellidium, Gelasinospora retispora, Gliocladium virens, Helicorhoidion,* and *Talaromyces wortmannii* were of low frequency.

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Tabel 4. Fungi isolated from soil of plot and their frequency of isolation.

Fungi	K		LD		HD		Freq (%)[a]
	A	B	A	B	A	B	
Absidia corymbifera (Cohn) Sacc.& Trotter	-	1	3	-	2	2	13.3
Aspergillus flavus Link ex Gray	4[b]	2	1	1	-	-	13.3
Aspergillus kanagawaensis Nehira	-	3	2	-	3	1	15.0
Aspergillus niger van Tieghem	2	1	2	-	2	-	11.7
Aspergillus sp.	3	2	1	1	-	-	11.7
Cancellidium sp.	-	-	1	-	-	-	1.7
Chaetomium sp.	1	1	1	1	1	-	8.3
Cladosporium herbarum (Pers.) Link ex S.F. Gray	3	-	2	-	-	2	11.7
Coniothyrium sp.	3	1	-	-	-	-	6.7
Cunninghamella echinulata (Thaxt.) Thaxt.	-	1	-	-	3	-	6.7
Curvularia lunata (Wakker) Boedijn	1	1	-	-	-	-	3.3
Emericella nidulans (Eidam) Vuill	3	-	2	1	2	1	15.0
Eupenicillium parvum (Raper & Fennell) Stolk&Scot	2	2	1	1	-	1	11.7
Eupenicillium sp.	-	-	1	1	1	-	5.0
Gelasinospora retispora Cain	-	-	1	-	-	-	1.7
Gliocephalis sp.	3	1	-	-	-	-	6.7
Gliocladium solani	2	2	-	-	-	-	6.7
Gliocladium virens Miller, Giddens & Foster	-	-	-	-	1	-	1.7
Gongronella butleri (Lendner) Peyronel & Dalvesto	3	3	3	3	3	3	30.0
Gnomonia sp.	4	2	1	1	2	1	18.3
Helicorhoidion sp.	-	-	1	-	-	-	1.7
Mortierella sp.	1	1	-	-	-	1	5.0
Mucor sp.	1	1	-	1	-	-	5.0
Neurospora crassa	-	-	1	-	1	-	3.3
Penicillium sp.1	4	3	3	3	2	2	28.3
Penicillium sp.2	-	-	-	-	2	1	5.0
Penicillium sp.3	4	3	2	2	2	1	23.3
Penicillium sp.4	2	2	-	-	-	-	6.7
Pestalotiopsis sp.	1	2	1	-	-	2	10.0
Rhizoctonia sp.	6	-	-	-	-	-	10.0
Syncepalastrum sp.	3	-	-	-	-	-	5.0
Talaromyces wortmannii (Klocker) C.R. Benjamin	-	-	-	-	-	1	1.7
Talaromyces sp.	3	3	4	3	6	-	31.7
Trichoderma harzianum Rifai	3	2	2	2	2	2	21.7
Trichoderma polysporum (Link ex Pers.) Rifai	1	-	1	1	2	2	11.7
Trichoderma viride Pers ex Gray	1	1	1	1	1	1	10.0
Trichoderma sp.	2	-	1	1	-	-	6.7
Sterile dark mycelium	6	4	1	-	1	2	23.3
Sterile white mycelium	4	3	-	-	2	1	16.7
Total number of strains	68	56	40	24	41	27	
Number of samples	10	10	10	10	10	10	60

Note: a: Total number of positive samples/total number of samples x 100. b: Number of positive samples in each soil layer. K= undamaged site, LD= lightly damaged site, HD= heavily damaged site, A= top layer, B= second layer. Freq.= frequency.

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