The Effect of Land Burning on the Presence and Density of Soil Fungi

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Abstract. Land clearing through cutting and burning is often used as a method of agricultural land management. Still, it has an impact on land ecology, one of which is the impact on soil microorganisms and fungi. This land burning study is a simulation of shifting cultivation. This study aimed to determine the effect of land burning on the types and densities of fungal populations and determine fungi that are adaptive to burning. This study used a descriptive method, namely a description of the types and densities of fungi and the types of fungi that are adaptive to land burning. Soil samples were taken from the land area before and after burning and then analyzed to identify the types and diversity of fungi that were successfully isolated. The results showed that land burning affected the types and densities of fungal populations. Six types of fungi were found before burning and 42 d after burning: *Trichoderma* sp., *Phytium* sp., *Penicillium* sp., *Aspergillus* sp., *Gliocladium* sp., and *Fusarium* sp. The population density of 48-68×10^3 CFU/g before burning decreased to 32-57 ×10^3 CFU/g 14 d after burning. The population increased to 28 days after burning, to 49-69×10^3 CFU/g. The four types of fungi that are adaptive to burning are *Trichoderma* sp., *Phytium* sp., *Penicillium* sp., *and Aspergillus* sp.

Keywords: Land Burning, Population Density, Soil Fungi, Adaptive Fungi

1 Introduction

Shifting cultivation practices are carried out by clearing land in a certain area, cutting down and burning forests, and planting various food crops [1]. Forest burning is carried out by some land-clearing companies to make it easier [2], where it is often practiced in shifting cultivation systems. This shifting cultivation is carried out from generation to generation based on the experience of the community in opening land, cultivating land, and planting until harvest to meet daily needs[3]. Burning carried out during land clearing with a shifting cultivation system impacts land ecology, both macro and micro. The impact of burning on land ecology at the macro level is a decrease in the number and diversity of species and has a negative impact on human health [4], [5]. This decrease in species also reduces soil microorganisms such as fungi.

Soil fungi are soil microbes that play an important role in the nutrient cycle that determines soil fertility and can increase plant growth. Fungi play a role in the

© The Author(s) 2025
K. P. Candra et al. (eds.), *Proceedings of the International Conference of Tropical Agrifood Feed and Fuel 2024 (ICTAFF 2024)*, Advances in Biological Sciences Research 47,
https://doi.org/10.2991/978-94-6463-825-7_18

formation of phosphorus and help micronutrients enter plant roots. Several studies have shown that soil biotic diversity can be used as an indicator of soil fertility status [6]. Fertile soil is filled with hundreds of millions to billions of microorganisms per gram of soil.

The soil is a habitat for various microorganisms. Microorganisms are a group of organisms that are microscopic or small. In general, the number of microorganisms in soil is much higher than that in air or water [7]. The main role of soil microorganisms is in the decomposition of dead organic matter. Bacteria and fungi decompose dead matter by breaking carbon bonds, releasing CO_2, small molecules, and organic molecules, and releasing nitrogen into the soil. Microorganisms also aid the absorption of nutrients from the soil by plant roots. Fungi play a role in the formation of phosphorus and help micronutrients enter plant roots [8].This study aimed to determine the effect of land burning on population density and types of soil fungi, and to identify fungi that are adaptive to the impact of burning.

2 Materials and Methods

2.1 Time and Place

This research was conducted from February to April 2023. The sampling was conducted in Petung Village, Penajam District, Penajam Paser Utara Regency, East Kalimantan Province, Indonesia.

2.2 Experimental Design.

This research was conducted using a descriptive method by calculating the fungal population (method Total Plate Count, TPC) [9] and identifying the types of soil fungi that were successfully isolated on the burned land, so that an overview of the population density, types, and diversity of soil fungi on the burned land can be obtained.

2.3 Research Procedure

Field Activities. Before land burning, soil samples were collected (Figure 1a) for analysis at the Pest and Plant Disease Laboratory. Land burning lasted for ± one day or until the branches and litter were completely burned (Figure 1b). The burned sample plot had a diameter of 2 m and the area outside the burning area was 1 m away. Furthermore, after burning, samples were taken at nine points spread across the center of the fire point, on the edge, and one meter outside the burning area (Figure 1c). Sampling was conducted from the ground surface to a depth of 40 cm from the surface. The soil sample to be analyzed was taken as much as 1 kg at each sample point.

Laboratory Activities. Laboratory activities begin with the isolation of soil fungi, both before and after burning. In the center burning area (C), only one sample point was isolated. In the edge areas burning (E) and outside burning (O), four sample points were

compiled into one sample. Isolation was performed using the dilution method. Soil samples (1 g) were diluted to a concentration of 10^{-3}. One milliliter of the dilution result was taken 1 mL and poured into a petri dish containing 10 mL of potato dextrose agar (PDA) medium that had been evenly frozen. Furthermore, it was incubated at a temperature of 28°C for four days. On the fifth day, the population was calculated by observing the colonies growing on the PDA media. The fungal population in 1 g of soil (Colony Forming Units) was calculated by dividing the number of colonies growing in the Petri dish by the dilution factor in CPU/gram units. In this method, it is assumed that one colony originates from one fungal cell [10]. The formula for calculating the fungal population is as follows: average number of colonies divided by 10 multiplied by the dilution factor [9]. Fungi were identified by microscopic observation of morphology and comparison with a fungal identification book [11].

(a) (b) (c)

Fig. 1. Experimental procedure. Soil sampling before land burning (a), land burning with a sample plot area of ± 3.14 m^2 (b), and soil sampling points after land burning (c). T = center burning (1), P = edge burning (2, 3, 4, 5), and L = outside burning (x).

Data Analysis. After the population and type of fungi were known, an analysis of the diversity index, abundance, and evenness [12] of fungi in the soil was performed. The Shannon-Wiener diversity index was calculated using the following equation:

$$H' = -\sum (p_i \,.\, \ln p_i)$$

Description:

H' = Shannon-Wiener Diversity Index

p_i = ni/N

n_i = Number of individuals of type i

N = Number of all types of individuals

The diversity index value criteria (H') were divided into three categories as follows:

$H' < 1$: Low diversity

$1 < H' < 3$: Medium diversity

$H' > 3$: High diversity.

The evenness index was calculated using the following equation:

$$E = \frac{H'}{\ln S}$$

Description:
E = Evenness index (value ranges from 0-1)
H' = Diversity index
S = Number of species
ln = Natural logarithm
The criteria for the evenness index value ranges from to 0-1 with categories the following:
$0 < E \leq 0.4$: Low population evenness
$0.4 < E \leq 0.6$: Medium population evenness
$0.6 < E \leq 1.0$: High population evenness

The dominance index was expressed as quantity C, using the following formula:

$$C = \sum (p_i)^2$$

Description:
C = Dominance index
p_i = Proportion of the number of individuals of the i-th species to the total number of individuals of all species
The criteria for dominance index values were as follows:
$0 < C \leq 0.5$: low dominance (no one dominates)
$0.5 < C \leq 1.0$: high dominance (there is a species that dominates)

3 Results and Discussion

Based on the results of soil isolation in the field two days before burning (DBB) and 42 days after burning (DAB) at a depth of 0-40 cm, there was a change in the density of the fungal population (Table 1). On the 14th day, there was a decrease in population density because the soil temperature increased due to land burning, which could have caused the death of soil microbes. Changes in soil temperature greatly affect the life of microbes in the soil. Soil temperature also affects the physical, chemical, and biological properties of soil, thereby reducing the availability of food for microbes [13]. One factor that supports the life of soil microbes is the availability of sufficient food and water [14]. The level of the soil fungal population is influenced by the availability of food, water, and exudates produced by plants. Population density began to increase after 28 DAB observations. After 14 DAB, the soil temperature returned to normal, so that the microbes at a depth of 40 cm had begun to develop to the surface of the soil, and microbes were able to adapt and reproduce, so that the population increased and its increase exceeded the population density before land burning. The increase continued until the last observation 42 DAB. The trends in population density and population density change are presented in Table 1 and Figure 2.

Six types of fungi were successfully isolated from the soil before burning and identified based on a comparison of the morphology of the observation results and books on fungi [15], [16], namely, *Trichoderma* sp., *Gliocladium* sp., *Fusarium* sp., *Phytium* sp., *Penicillium* sp., and *Aspergillus* sp. (Table 2). The morphology of the fungi is shown in Figure 3. The types of fungi decreased at 14 DAB and 28 DAB, but after 42 DAB, the number of fungal species increased, as before land burning (Table

2). Four types of fungi are adaptive to land burning: *Aspergillus* sp., *Penicillium* sp., *Pythium* sp., and *Trichoderma* sp. This is also in accordance with research in Thailand showing that the fungi that are often found after land burning are Aspergillus and Penicillium [17].

Table 1. Soil fungal population density before and after land burning

Observation time	Population (CFU/g)		
	T	P	L
2 days before burning (DBB)	52×10^3	68×10^3	52×10^3
14 days after burning (DAB)	32×10^3	47×10^3	57×10^3
28 days after burning (DAB)	58×10^3	60×10^3	60×10^3
42 days after burning (DAB)	92×10^3	74×10^3	75×10^3

Notes: T, P, and L refer to the notes in Figure 1.

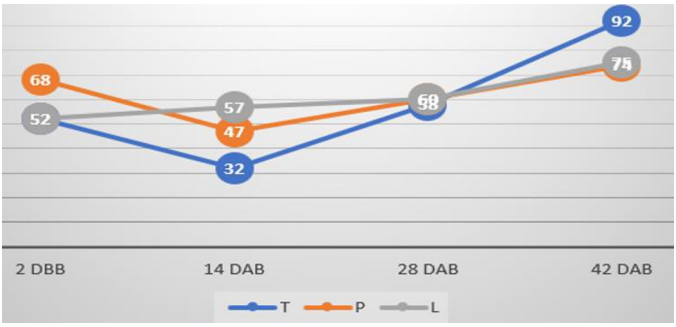
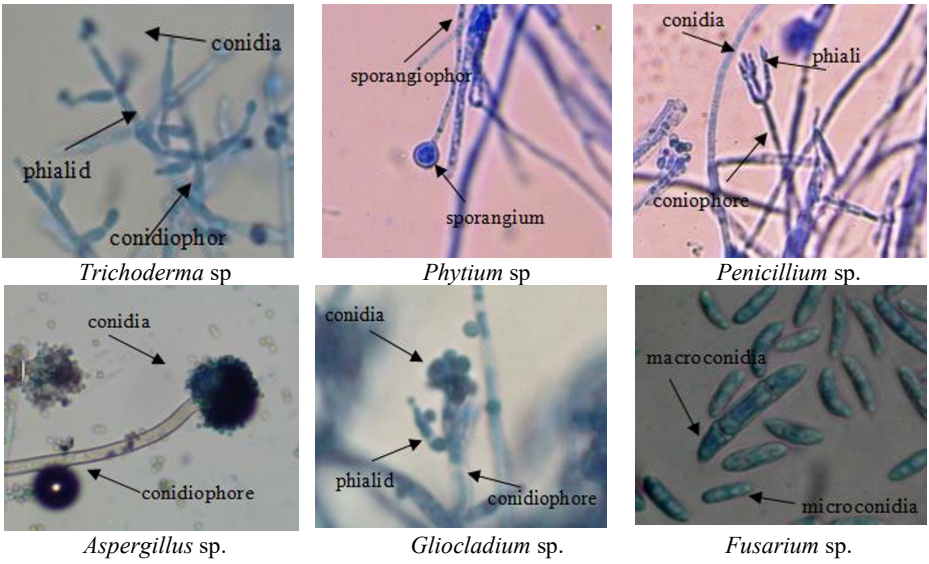


Fig. 2. Density of fungal population (CPU/g). DBB = day before burning, DAB = day after burning

Table 2. Presence of fungi in soil before and after land burning

No	Fungi name	Days Before Burning (DBB)	Days After Burning (DAB)		
		2	14	28	4
1	*Trichoderma* sp.	+	+	+	+
2	*Gliocladium* sp.	+	-	-	+
3	*Fusarium* sp.	+	-	-	+
4	*Pythium* sp.	+	+	+	+
5	*Penicillium* sp.	+	+	+	+
6	*Aspergillus* sp.	+	+	+	+

The diversity index before and after land burning was included in the medium category. The evenness index before and after land burning is included in the high category. The dominance index before and after land burning is included in the low category.



Trichoderma sp *Phytium* sp *Penicillium* sp.

Aspergillus sp. *Gliocladium* sp. *Fusarium* sp.

Fig. 3. Soil fungi isolated from land before and after land burning

Table 3. Diversity, evenness and dominance index of fungi on totally center, edge, and outside burning

Observation time	H'	E	C
2 days before burning	1.651	0.923	0.217
14 days after burning	1.344	0.970	0.273
28 days after burning	1.354	0.903	0.297
42 days after burning	1.317	0.735	0.236

Notes: H'=diversity index, E=evenness index, dan C = dominance index

4 Conclusion

Land-burning affected the density of fungal populations. Population density decreased 14 days after land burning but increased more than before burning. Of the six types of fungi found, four were adaptive to the impact of burning, namely *Trichoderma* sp., *Phytium* sp., *Penicillium* sp., and *Aspergillus* sp., which were found in all observations. Agricultural cultivation on burned land should be carried out 42 days after burning the land because it has stabilized the development of microorganisms.

Acknowledgments. We thank the Dean of the Faculty of Agriculture, Mulawarman University, who provided the plant pest and disease laboratory facilities to support this research.

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