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Diversity of Arbuscular Mycorrhizal Fungi (AMF) in Burned Forests and Peatlands in Jambi

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Abstract: Indonesian peat is the largest tropical peatland in the world, mostly found on the island of Sumatra. Forest and peatland fires have reduced the area of forests and peatlands, necessitating rehabilitation activities considering the important role of peat in the ecosystem. Rehabilitation activities can be carried out by utilizing the presence of soil microbes in the form of Arbuscular Mycorrhizal Fungi (AMF). Fires in forests and peatlands impact the physical and chemical properties of peat soil, biodiversity, and the presence of Arbuscular Mycorrhizal Fungi (AMF). The purpose of this activity is to study the impact of forest fires on the presence of AMF in forests and peatlands using destructive methods. From this activity, it was found that the impact of peatland fires on the presence of AMF is that peatland fires will damage the natural habitat of AMF, so that the AMF population is significantly reduced; peatland conditions change, with increased soil temperature and changes in soil pH, which can affect the condition of AMF; loss of soil organic matter due to fires can reduce the availability of carbon needed by AMF for its development.

Keywords: Arbuscular Mycorrhizal Fungi; Burned; Peat

Introduction

Peatlands in Indonesia cover 3% of the land area, which are sensitive to climate change (Budiningsih et al., 2024). The area of peatland in Indonesia is only 12% of the world's peatland, covering approximately 13.4 million hectares (Osaki et al., 2016)With 13.4 million hectares, Indonesia is home to the largest tropical peatland in the world and makes up over 36% of all tropical peatlands worldwide (Warren et al., 2017). Indonesian peatlands are mostly found on Sumatra, Kalimantan, and Java; among them, Sumatra has the largest peatland area in the country, with around 5.5 million hectares (Anda et al., 2021). Jambi Province is the province with the third-largest peatland area in Sumatra, covering 736,227.20 hectares, spread across 6 regencies: East Tanjung Jabung Regency (311,992.10 ha), Muaro Jambi Regency (229,703.90 ha), West Tanjung Jabung Regency (154,598 ha), Sarolangun Regency (33,294.20 ha), Merangin Regency (5,809.80 ha), and Tebo Regency (829.20 ha) (Nurjanah et al., 2013).

Peatlands become useless due to their conversion (Veloo et al., 2015). Vegetation biodiversity is one of the many forms of biodiversity found in the highly diverse peatlands (Yuningsih et al., 2018). Because peatlands have been converted into plantations and agriculture, the biodiversity of vegetation has significantly decreased (Turetsky et al., 2015). This is a major problem for conservation and ecosystem protection efforts.

The largest forest and land fires that occurred in Indonesia were recorded in 1981/1982, 1997/1998, 2007, 2013, and 2015 (Sugardiman, 2019). The area of burned forest and land in Jambi Province in 2019 was 56,592.00 ha and in 2023 was 6,539.69 ha (Direktorat Pengendalian Kebakaran Hutan dan Lahan Kementerian Lingkungan Hidup dan Kehutanan, 2024)

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Between the period of 2001-2015, there were 26,623 hotspots in Jambi Province, where the fires occurred on peatland every year, both during El Niño and La Niña. The fires that occur are sometimes exploited by palm oil companies and industrial plantation forests (Prasetyo et al., 2016) . In Muaro Jambi Regency in 2019, the area of burned peatland reached 43,534.6 hectares, an increase from 15,855.8 hectares in 2015 (Ayuningrum dan Nurhayati, 2022). The fires were not only supported by the El-Nino factor but were also caused by land clearing activities through burning, which the local community deemed easier and cheaper. This is also supported by CIFOR/ICRAF, in ten research locations, it was shown that some sources of forest and land fires in Indonesia are fires used for land clearing, fires originating from firearms in land conflict, fires that spread accidentally, and fires related to natural resource extraction (Hero Saharjo & Wibisana, 2017)

The vast areas of burned forests and peatlands need rehabilitation activities. The target for peatland rehabilitation in Indonesia is between 1.05 million hectares 3.44 million hectares from 2022 to 2024 and will continue to be maintained until 2045 (Noor, 2024). Rehabilitation activities on peat can be carried out by utilizing the presence of soil microbes in the form of Arbuscular Mycorrhizal Fungi (AMF) (Muhtarom, c 2020).

Arbuscular Mycorrhizal Fungi are commonly found in peat soil where the peat soil conditions are infertile or marginal land. Peatland ecosystems have different types and densities of arbuscular mycorrhizal fungi (AMF). Plants cultivated in peatland have root systems that contain various types of FMA in large quantities (Atikah dan Purwanti, 2023).

Arbuscular Mycorrhizal Fungi themselves play a role in the formation of organic matter as decomposers, where peat swamp forests in Southeast Asia are often found to have AMF colonizing with other plant species. (Mulyani et al., 2014). The impact of forest fires can alter the structure of soil microorganisms, thereby affecting soil properties and changing the biomass of soil microorganisms. Changes in soil microorganism biomass affect the colonization of FMA on plant roots, which in turn can impact plant health (Lou et al., 2023). The loss of FMA post-fire is also due to the loss of the canopy or crown, which removes the soil layer, especially the O horizon. The response of FMA to fire also varies depending on the intensity and severity of the fire. In addition, the abundance of host species also serves as a limiting factor in FMA colonization.

Method

This type of research is descriptive research, which aims to investigate the state, condition, or other matters mentioned, with the results presented in the form of a research report.

This research was conducted on December 2024 – January 2025 with the population being the burned peatland in Jambi Province and its impact on soil properties, particularly the presence of Arbuscular Mycorrhizal Fungi (AMF). The instrument used in this research consists of secondary data from various types of studies discussing peatland fires and their impact on soil properties, particularly the presence of FMA.

Result and Discussion

Gambut

Type and Distribution of Peat

Peat soil is soil formed from organic minerals (Peraturan Pemerintah Republik Indonesia, 2016) from the accumulation of plant residues or the decomposition of vegetation. The formation process occurs anaerobically, so the decomposition rate is slow, and over time, the accumulation of organic material forms a peat dome, which is more commonly referred to as organosol soil. The level of peat decomposition is classified into fibric, hemic, and sapric. Fibrik is decomposed peat with a fiber content of >66% volume, saprik with a fiber content of <33% volume, and saprik with a fiber content between fibrik and saprik. The fiber content will determine the rate of decomposition, so the lower the fiber content, the higher the rate of decomposition that occurs (Hikmatullah & Sukarman, 2014)

Peatlands are highly sensitive to climate change (Budiningsih et al., 2024) Peat soil has a high carbon content, with physical properties such as low bulk density, high porosity, and chemical properties including low pH, limited nutrients, high C/N ratio, and high cation exchange capacity (CEC) (Syaufina et al., 2022). The limited nutrients in peat soil, according to (Lumbantoruan & Anggraini, 2021) are due to the nutrients in peat soil being bound by carboxylic acids and phenolics

Peat Functions

The structure and function of peatlands vary depending on geomorphological, hydrological, local climatic conditions, and vegetation (Tan et al., 2021). Peatlands have ecological functions including supporting the sustainability of biodiversity, both endemic and rare or endangered wildlife, and being an important habitat for orangutans, storing carbon and playing a crucial role in the global carbon cycle, water catchment areas, and as a buffer for saline ecosystems (Astiani et al., 2021).

The unique structure and function of peatlands contribute to the formation and richness of biota within them. Peatlands support several species that can adapt to waterlogged habitat conditions, acidic soil, and nutrient-poor environments (Minayeva et al., 2017). In addition, peat also functions to control the severity of floods from downstream, can reduce erosion and soil runoff, and filter sediments, toxic materials, and pollution. The most important ecological contribution is that peat protects vital biodiversity, thereby forming a dominant land cover to support conservation activities

The Impact of Fires on Peat

The characteristics found in tropical peatlands can create a high level of plant diversity. The conversion of peatland use results in changes in plant composition on peatland (Dwisutono et al., 2019), one of which is due to fires. The research results of Shiodera et al., (2016), show that unburned peat forests have high tree species diversity, burned peat forests have high recovery potential, but peat forests affected by fire show significant changes in vegetation and structure and are difficult to recover.

The results of the soil chemical properties analysis on burned and unburned land indicate that the content of several soil chemical properties is affected by a one-year-old fire. The soil pH increased, but there was a decrease in the elements of organic C, N, P, and K. The increase in soil pH is caused by the addition of combustion products that are basic in nature, such as ash or charcoal, while the decrease in organic C, N, P, and K elements is suspected to be due to the complete combustion of organic materials (litter or standing vegetation), making them less available. In addition, the slope length can cause a decrease in the chemical properties of the soil due to erosion and leaching. (Choiruddin et al., 2018).

The quantity of plant species, diversity, and individuals were all drastically reduced by the devastating peat fire. As soon as ashes from forest peat fires accumulated in the affected area, the pH, organic matter, humic acid concentration, hydrophobicity, available-N, and available-K all rose. Their availability was only short-lived, though, as they were quickly depleted and washed away, leading to long-term soil damage. Due to its low capacity to retain water, an open and dried peatland was comparatively easy to burn during the dry season but inundated during the rainy one. Fires in tropical forests altered the chemical composition of the soil and drastically decreased plant diversity. It's possible that this forest peat fire may lose its ability to store moisture, carbon, nutrients, and biodiversity (Agus et al., 2019).

The result of Xiang et al. (2015) state that one year after the forest fire, there is an increase in soil pH, phosphorus and nitrogen availability, a decrease in soil moisture, and a relative carbon ratio compared to unburned land. The biomass of the understory vegetation is very low one year after the fire but will recover to the pre-fire vegetation after 11 years. Post-fire with low intensity causes the emergence of pioneer species, while high-intensity fires lead to the emergence of pioneer fern species.

Wijedasa (2016) stated that repeated fires cause peat particles to break down into smaller sizes., resulting in an increase in bulk density, which is also supported by the rate of peatland drying. In addition, the declining physical properties of the soil and the reduction in biodiversity have made the recovery of peatland very slow. The fire that occurred in Jati Mulyo Village, Jambi Province in 2015 had already changed the physical properties of the soil, where the bulk density value was 0.08-0.19 g/cm^3. Then, the same land burned again in 2019, causing the bulk density value to become 0.09-0.22 g/cm^3. The resulting bulk density value depends on the depth of the peat. Bulk density is the weight of a mass of soil per unit volume without the soil pores (Junedi et al., 2023) Based on Wulandari et al. (2023), the deeper the peat layer, the higher the bulk density value, and the bulk density value of peat soil is lower compared to all other types of soil, due to the organic composition as its constituent material.

One of the peat forests that often experience fires in Jambi Province is the Taman Hutan Raya (Tahura) Orang Kayo Hitam. Tahura Orang Kayo Hitam has many species of flora and fauna of peat swamp forest. However, from August to October 2019, a forest fire occurred, covering an area of 256 hectares and destroying 80% of the planted area (Pohan et al., 2023).

Arbuscular Mycorrhizal Fungi (AMF)

The Role and Function of Arbuscular Mycorrhiza

Arbuscular mycorrhizal fungi (AMF) is a fungus that has a symbiotic impact on the plant at the root system level (Prihantoro et al., 2023) Almost 90% of plants associate with mycorrhizae (Lewis, 2016). In line with the statement by Xiang et al. (2015) that FMA is an obligate biotroph that forms a mutualistic symbiosis with more than 80% of vascular plants (Hou et al., 2021; Brundrett, 2002; Atikah dan Purwanti, 2023) where the role of FMA is to provide nutrients to the host plant.

One of the roles of AMF in plants is that AMF helps plants in the absorption of nutrients and water (Huey et al., 2020). Arbuscular Mycorrhizal Fungi obtain sugars from plants, which subsequently increases the root surface area of mycorrhizal plants, allowing them to absorb nutrients and water more efficiently (Huey et al., 2020). The main nutrient absorbed by AMF is phosphorus (P) (Huey et al., 2020; Hou et al., 2021) which is an essential nutrient for plant growth but is limited in availability in the soil. Mycorrhizal plants are capable of increasing phosphorus absorption by 90% compared to non-mycorrhizal plants.

Another role of AMF in plants is that AMF can enhance resistance to environmental stress such as high salinity and bioremediation of heavy metal-contaminated soil, protection of plants from pathogens (Huey et al., 2020; Lewis, 2016), and drought conditions (Huey et al., 2020; Hou et al., 2021). F Arbuscular Mycorrhizal Fungi are capable of inducing plant growth in marginal lands and have the potential to be used as fertilizers or soil conditioners (Atikah dan Purwanti, 2023). The mechanism of FMA in enhancing resistance to environmental stress is that FMA produces bioactive compounds that help reduce cell damage due to oxidative stress and FMA is capable of improving soil structure and increasing its porosity.

The role of FMA in the ecosystem is to participate in the carbon cycle and affect plant communities. The flow of carbon in mycorrhizal plants in large amounts through mycelium will affect the formation and stability of soil aggregates. Plant diversity and the productivity of plant communities also depend on the presence of FMA species diversity, where an increase in fungal diversity will lead to an increase in plant species diversity (Tawaraya & Turjaman, 2016)

The role of FMA as a symbiont can be divided into four functions, namely: (1) FMA is an organism that plays a role in helping plants absorb nutrients, both macro and micro nutrients. In this case, FMA acts as a catalyst in providing nutrients to plant roots; (2) FMA has external hyphal networks capable of absorbing and translocating phosphorus and other mineral nutrients from the soil to the roots, thereby enhancing plant health and resilience to environmental stress; (3) FMA can increase plant resistance to root pathogen attacks; and (4) FMA can help plants absorb water that is unreachable by plant roots (Atikah dan Purwanti, 2023).

Characteristics of Arbuscular Mycorrhizal Fungi in Peat

Mycorrhizae are commonly found in endemic peat soil in Kalimantan, where the peat soil contains a lot of organic matter needed by FMA (Shiodera et al., 2016). FMA Glomales have a higher ability to adapt to adverse environments, one of which is that Glomales are often found naturally in peatlands. Peatlands have a high availability of carbon (Matysek et al., 2019). The presence of FMA is influenced by several environmental factors, including temperature, soil pH, soil moisture, and the availability of nutrients in the soil such as phosphorus, nitrogen, and potassium content. (Nurhalimah et al., 2014).

The presence of FMA is influenced by several environmental factors, including: temperature, soil pH, soil moisture, and the availability of nutrients in the soil such as phosphorus, nitrogen, and potassium (Nurhalimah et al., 2014). The presence of FMA in peat soil is greatly influenced by the low (acidic) pH of the peat soil. The diversity of FMA species in peatlands varies due to the different adaptation abilities and ecological functions of each FMA species. Indigenous Arbuscular Mycorrhizal Fungi among different locations in the peat ecosystem exhibit species variation, reflecting the adaptation of AMF to specific environments. Glomus spp, Acaulospora spp, and Entrophospora spp are common FMA species found in peatland. The low soil pH of less than 4 in peat soil, high moisture content, and availability.

Diversity and Abundance of Arbuscular Mycorrhizal Fungi Due to Fire

FMA affects the ecosystem in its role in enhancing productivity and nutrient cycling, so if there are changes to the environment, it will also impact the mycorrhizal community. In a 1-year fire, it significantly affected the abundance of Diversisporaceae and increased the abundance of Acaulosporaceae. The relative abundance of FMA will return to the same level as found in the control after 11 years (Xiang et al., 2015).

Fires in peatlands cause damage to the peat ecosystem, affecting biodiversity including FMA diversity. Peatland fires can damage the peat layers to a certain depth, leading to the loss of organic material and changes in the physical and chemical properties of the peat, which can alter the habitat conditions for several organisms, including FMA. Changes in temperature and humidity due to fires can affect the growth and reproduction of FMA. This is in line with the research by (Listari et al., 2024) the level of biodiversity is declining, natural succession is disrupted, organic material production is hindered, and the decomposition process is affected are some of the impacts on the biotic environment. Meanwhile, according to (Rillig et al., 2016) although there was a decrease in FMA species diversity after the fire, the total abundance of FMA remained high because several dominant species were able to survive in extreme conditions.

Some FMA species are able to survive post-fire conditions through spores or mycelium networks that remain in the soil. The volume of spores sometimes becomes an important determinant of survival due to fire because smaller spores have a smaller surface area that will absorb less thermal energy during the fire event (Hopkins et al., 2024). Fires that occur during higher sporulation periods can have a stronger effect on spore communities compared to fires at other times of the year (Hopkins et al., 2024) . The FMA fungal spore community and FMA fungal spore sporulation will vary based on the season, the timing of the fire, and the time since the fire, where these changes in the spore community and FMA spore sporulation are driven by fire events specific to certain species (Hopkins et al., 2024).

Xiang et al. (2015) stated FMA plays an important role in helping to shape the soil structure and function of forest ecosystems, where FMA is key in the recovery of soil and understory plants after a fire. The results of Xiang et al. (2015) indicate that FMA communities are resistant to forest fires over a span of decades, where this resistance depends on the growth of plant vegetation and the recovery of soil chemical properties post-fire.

Forest fires have an impact on the reduction of nutrients, but they also affect the abundance and composition of FMA species. Research by Cheng et al. (2023) state that forest fires will reduce the density of FMA, but after the fire, FMA symbiosis will alter root morphology and increase nutrient absorption, demonstrating that FMA are resistant to disease and stress. Fires result in a decrease in biomass, but FMA can recover quickly even with the previous amount of biomass. Burnt forests can enhance decomposition that supports apoplastic pathways and release many nutrients. In addition, forest fires can also increase FMA biomass. The fires that occur also change the physical and chemical properties of the soil, which also affects the survival of mycorrhiza.

The Relationship Between Arbuscular Mycorrhizal Fungi Diversity and the Physical and Chemical Properties of Peat Soil

Muhtarom (2020) stated the growth and development of mycorrhizal spores on plant roots can be influenced by the maturity level of peat soil. Based on the research (Wisnubroto et al., 2024) results of on the potential relationship between arbuscular mycorrhizal fungi and soil properties in critical land, about the potential relationship between arbuscular mycorrhizal fungi and soil properties in critical land, it was found that the soil acidity (pH) value is negatively correlated with the number of spores, where the higher the pH (basic), the lower the number of spores.

Based on the physical properties of peat soil, the range of bulk density (BD) values is from 0.07 to 0.24 g/cm3 and is classified as low. In Sumatra peat, the range of bulk density values is 0.16 – 0.24 g/cm3 in the hemic to sapric layers, and in the hemic layer, the BD value range is 0.14-0.20 g/cm3 (Hikmatullah dan Sukarman, 2014). The difference in BD values between the upper and lower layers is influenced by drainage conditions and the cultivation practices employed.

In terms of soil chemical properties, the pH of peat is classified as acidic, which is related to the content of organic acids containing fulvic and humic acids (Hikmatullah & Sukarman, 2014). The pH will decrease with the depth of the peat, and deforestation of peat forests significantly reduces soil chemical properties including soil pH, soil organic matter, total carbon, total nitrogen, CEC, total P, total K, and the C/N ratio.

The distribution of mycorrhizae in the soil is influenced by factors such as organic matter, carbon, nitrogen, and phosphorus, as well as the amount of cations Ca, K, and Mg that affect plant growth (Janowski dan Leski, 2022). In addition, the P content in the soil is the main factor influencing FMA colonization. The increase in N levels is also a factor in stimulating FMA colonization on roots, so the N content in peat positively affects the growth of FMA hyphae and spores.

There are several obstacles related to the use of AMF in increasing N availability.

Anwar et al. (2020), stated that FMA cannot increase N as much as the ability of mycorrhizae to increase P, where in peatland, the element N becomes a limiting factor. There are several reasons for this, where FMA lacks extracellular proteases and oxidative enzymes that can mobilize N from complex polyphenol proteins, which can dominate N availability in peat soil.

The excessive addition of P and N elements directly to the soil can actually reduce the colonization rate of FMA, and it also affects the absorption of organic C, leading to a decrease in the growth of host plants (Abdullahi et al., 2015). In addition, if FMA produce too many extraradical hyphae compared to intraradical hyphae, it causes a decrease in P absorption in the soil. The difference in hyphal development may be caused by chemical and biological factors in the soil.

Mycorrhizosphere is the part of the roots and mycorrhizal hyphae that is connected to and influenced by microorganisms and soil. The microbial population in the mycorrhiza can change dynamically, influenced by soil type or growth media, the process of enriching certain microbes, and the presence of mycorrhizal and FMA fungal hyphae. Mycorrhizal Fungi Arbuscules themselves have the ability to provide a source of inoculum in the soil through hyphae and soil spores to seek the roots of host plants. Nutrient exchange occurs in arbuscules, so FMA has the ability to provide nutrients to the host, enhancing tolerance to soil toxicity, diseases, and drought (Wisnubroto et al., 2024)

For the improvement of soil physical properties, particularly soil aggregates, the role of the extent and distribution of roots and FMA hyphae is crucial in absorbing and collecting soil material. The material exuded from roots and hyphae plays an important role in the formation of soil aggregates (Wisnubroto et al., 2024)

Implementation of Indigenous Arbuscular Mycorrhizal Fungi Utilization on Endemic Peat Plants in Support of Rehabilitation Activities

Peatland ecosystems have physical, chemical, and biological soil conditions that are vulnerable to degradation (Budiningsih et al., 2024). Degradation and deforestation, especially in peatlands, present quite a difficult challenge to restore, not only due to the slow-growing vegetation but also the complex issues of the soil's physical, chemical, and biological properties. The role of FMA in tropical forests helps in the recovery of damaged forest ecosystems. because its effective and efficient application, FMA is often known for its environmentally friendly biotechnology use.

This results in expensive financial support to restore the functions and services of peatland ecosystems. Revegetation carried out on burned peatland still faces significant challenges, so a technology is needed that can ensure the success of planting, in order to accelerate forest cover formation, increase carbon dioxide absorption, and enhance biodiversity.

The presence of AMF affects plant maintenance in various ecosystems and plays an important role in the peat forest ecosystem (Huey et al., 2020) Arbuscular Mycorrhizal Fungi can enhance the early growth of plants, making AMF play an important role in rehabilitation activities in peat forests, which peatland ecosystems have physical, chemical, and biological soil conditions that are prone to degradation (Budiningsih et al., 2024). This results in expensive financial support to restore the functions and services of peatland ecosystems. According to Nurhalimah et al. (2014) mycorrhizae are one of the soil microorganisms that greatly assist in the nutrient cycle, one of which is indigenous mycorrhizae. Indigenous mycorrhizae have great potential as biofertilizers that can facilitate nutrient absorption in the soil, thereby enhancing plant growth. Indigenous FMA is a microbial technology that can be developed to address soil fertility issues related to drought.

Rehabilitation carried out in tropical forests poses challenges, especially on a large scale, where according to (Tawaraya and Turjaman, 2014), the main obstacle in rehabilitating tropical forests is the slow growth of trees, and it requires proper handling of the physical, chemical, and biological properties of the soil. The use of FMA in rehabilitation plays an important role in accelerating vegetation growth to support ecosystem recovery. Wira Yuwati et al. (2020b), stated that FMA colonization provides benefits for plants in degraded peatlands, with the spore genera found being Glomus, Gigaspora, Scutellospora, and Acaulospora.

Galam (*Melaleuca cajuputi*), which is a native species of peatland, can be colonized by FMA ranging from 57-70%, with the Glomus type being the most commonly found, making mycorrhizae potential as a biofertilizer (Wira Yuwati et al., 2020b). The research by Tuheteru et al. (2015) yang menginokulasi FMA pada bibit longkida (*Nauclea orientalis* L) which inoculated FMA on longkida seedlings (*Nauclea orientalis* L) in flooded land conditions like peat, was also able to increase biomass and N accumulation in the roots. Based on Yuwati et al. (2021) , to support rehabilitation, especially in the recovery of total N, P, K, and CEC, reducing C/N concentration, and increasing soil pH, improvements in peat soil conditions are necessary. Inoculation of mycorrhiza on native species can enhance resilience and growth, and it can also help in providing nutrients, whether during flooding or drought (Turjaman et al., 2019a). Dyera pollyhylla has been identified as colonized by FMA in peat swamp forests (Turjaman et al., 2019b), and the research results also show that there are 20 tree species colonized by 72% with FMA in the peat swamp forests of Sumatra, including 14% from the Dipterocarpaceae family.

Several studies have shown that FMA can enhance seedling growth and FMA colonization is positively correlated with increased phosphorus in the soil (Osaki et al., 2016). The application of two or more types of FMA can enhance the early growth of plants, and three types of FMA, namely G. intraradices, G. mosseae, and G. caledonium, increased the dry weight of Eucalyptus stems within 20 weeks after inoculation (Osaki et al., 2016).This is in line with Clemmensen dan Parker (2023) who state that the fungal community in peat is dominated by mycorrhizae, where the loss of carbon in the peat also leads to a decrease in mycorrhizal abundance..

Conclusion

The occurrence of forest and peatland fires results in changes to the physical, chemical, and biological properties of peat. Changes in the biological properties of the soil impact the loss of biodiversity in peat and affect the presence of soil microbes, namely Arbuscular Mycorrhizal Fungi. A more in-depth study is needed regarding the impact of fires on peatlands that burned in different years and repeated fires on the existence of FMA.

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References

Abdullahi, R., Lihan, S., Edward, R., & Demie, L. S. (2015). Effect of arbuscular mycorrhizal fungi and poultry manure on growth and nutrients contents of maize in different soil type. *Journal of Advances in Agriculture*, *4*(2), 428–437. http://dx.doi.org/10.24297/jaa.v4i2.4274

Agus, C., Azmi, F. F., Widiyatno, Ilfana, Z. R., Wulandari, D., Rachmanadi, D., Harun, M. K., & Yuwati, T. W. (2019). The Impact of Forest Fire on the Biodiversity and the Soil Characteristics of Tropical Peatland. In *Hanbook of Climate Change and Bidiversity*. Springer International Publishing. Retrieved from https://www.springerprofessional.de/en/the-impact-of-forest-fire-on-the-biodiversity-and-the-soil-chara/16079404

Anda, M., Ritung, S., Suryani, E., Sukarman, Hikmat, M., Yatno, E., Mulyani, A., Subandiono, R. E., Suratman, & Husnain. (2021). Revisiting tropical peatlands in Indonesia: Semi-detailed mapping, extent and depth distribution assessment. *Geoderma*, *402*, 115235. https://doi.org/10.1016/J.GEODERMA.2021.115235

Anwar, G., Lilleskov, E. A., & Chimner, R. A. (2020). Arbuscular mycorrhizal inoculation has similar benefits to fertilization for Thuja occidentalis L. seedling nutrition and growth on peat soil over a range of pH: implications for restoration. *New Forests*, *51*(2), 297–311. https://doi.org/10.1007/s11056-019-09732-x

Astiani, D., Ekamawanti, H. A., Ekyastuti, W., Widiastuti, T., Tavita, G. E., & Suntoro, M. A. (2021). Tree species distribution in tropical peatland forest along peat depth gradients: Baseline notes for peatland restoration. *Biodiversitas Journal of Biological Diversity*, *22*(7). https://doi.org/10.13057/biodiv/d220704

ATIKAH, T. A., & PURWANTI, E. W. (2023). The effect of peat soil and sandy soil on the growth of Eleutherine palmifolia and arbuscular mycorrhizal diversity. *Biodiversitas Journal of Biological Diversity*, *24*(8). https://doi.org/10.13057/biodiv/d240818

Ayuningrum, R., & Nurhayati, A. D. (2022). Analysis of the distribution of hotspot and burn area in Muaro Jambi district, Jambi Province. *IOP Conference Series: Earth and Environmental Science*, *959*(1), 012057. https://doi.org/10.1088/1755-1315/959/1/012057

Brundrett, M. C. (2002). Coevolution of roots and mycorrhizas of land plants. *New Phytologist*, *154*(2), 275–304. https://doi.org/10.1046/j.1469-8137.2002.00397.x

Budiningsih, K., Putera, P. B., Nurlia, A., Ulya, N. A., Nurfatriani, F., Salminah, M., Yuniati, D., & Widarti, A. (2024). Peatland restoration research: a global overview with insights from Indonesia. *Journal of Ecology and Environment*, *48*, 27. https://doi.org/10.5141/jee.24.037

Cheng, Z., Wu, S., Du, J., Liu, Y., Sui, X., & Yang, L. (2023). Reduced Arbuscular Mycorrhizal Fungi (AMF) Diversity in Light and Moderate Fire Sites in Taiga Forests, Northeast China. *Microorganisms*, *11*(7), 1836. https://doi.org/10.3390/microorganisms11071836

Choiruddin, I., Donantho, D., & Nur Hartanto, R. M. (2018). The Impact of Land Fires on Soil Chemicals Propertiest (pH, Organic Carbon, Nitrogen, Phosphor, and Potassium). *Jurnal Agroekoteknologi Tropika Lembab*, *1*(1), 11–15. http://dx.doi.org/10.35941/jatl.1.1.2018.1503.11-15

Clemmensen, Karina. E., & Parker, T. . C. (2023). Understanding the role of fungi in peatland degradation after drainage. *New Phytologist* , *240*, 10–12. http://dx.doi.org/10.1111/nph.19196

Direktorat Pengendalian Kebakaran Hutan dan Lahan Kementerian Lingkungan Hidup dan Kehutanan. (2024, December 14). *SiPongi Sistem Pemantauan Karhutla*. Retrieved from https://sipongi.menlhk.go.id/

Dwisutono, A. N., Budi, S. W., & Istomo, I. (2019). Plant Diversity in Different Land Use Types at The Peat Hidrological Unit (PHU) of Mendahara – Batanghari River, Jambi Province. *Media Konservasi*, *24*(2), 141–151. https://doi.org/10.29244/medkon.24.2.141-151

Hero Saharjo, B., & Wibisana, G. (2017). Community Role to the Forest Fire Control in Mount Ciremai National Park. *Jurnal Silvikultur Tropika*, *08*(2), 141–146. https://doi.org/10.29244/j-siltrop.8.2.141-146

Hikmatullah, & Sukarman. (2014). Physical dan Chemical Properties of Cultivated Peat Soils in Four Trial Sites of ICCTF in Kalimantan and Sumatra, Indonesia. *J Trop Soils*, *19*(3), 131–141. https://doi.org/10.5400/jts.2014.v19i3.131-141

Hopkins, J. R., McKenna, T. P., & Bennett, A. E. (2024). Fire season and time since fire determine arbuscular mycorrhizal fungal trait responses to fire. *Plant and Soil*, *503*(1–2), 231–245. https://doi.org/10.1007/s11104-024-06500-5

Hou, L., Zhang, X., Feng, G., Li, Z., Zhang, Y., & Cao, N. (2021). Arbuscular mycorrhizal enhancement of phosphorus uptake and yields of maize under high planting density in the black soil region of China.

Scientific Reports, *11*(1), 1100. https://doi.org/10.1038/s41598-020-80074-x

Huey, C. J., Gopinath, S. C. B., Uda, M. N. A., Zulhaimi, H. I., Jaafar, M. N., Kasim, F. H., & Yaakub, A. R. W. (2020). Mycorrhiza: a natural resource assists plant growth under varied soil conditions. *3 Biotech*, *10*(5), 204. https://doi.org/10.1007/s13205-020-02188-3

Janowski, D., & Leski, T. (2022). Factors in the Distribution of Mycorrhizal and Soil Fungi. *Diversity*, *14*(12), 1122. https://doi.org/10.3390/d14121122

Junedi, H., Mastur, A. K., & Zuhdi, M. (2023). *Study of Changes in Physical Properties of Burnt Peat: A Case Study in Jati Mulyo Village, Jambi Province, Indonesia* (pp. 290–297). https://doi.org/10.2991/978-2-38476-110-4_31

Lewis, J. D. (2016). Mycorrhizal Fungi, Evolution and Diversification of. In *Encyclopedia of Evolutionary Biology* (pp. 94–99). Elsevier. https://doi.org/10.1016/B978-0-12-800049-6.00251-1

Listari, J., Sudira, P., Ananda, R., Saputra, R. F., & Fatmawati. (2024). Efek Kebakaran Hutan Terhadap Lingkungan Hidup Dan Sumber Daya Alam Di Pekanbaru. *Scientica*, *3*(1), 658–671. Retrieved from https://jurnal.kolibi.org/index.php/scientica/article/view/3896

Lou, H., Cai, H., Fu, R., Guo, C., Fan, B., Hu, H., Zhang, J., & Sun, L. (2023). Effects of wildfire disturbance on forest soil microbes and colonization of ericoid mycorrhizal fungi in northern China. *Environmental Research*, *231*, 116220. https://doi.org/10.1016/j.envres.2023.116220

Lumbantoruan, S. M., & Anggraini, S. (2021). Formulasi pupuk hayati dalam memacu pertumbuhan jagung di tanah gambut cekaman kekeirngan . *Jurnal Agroqua*, *19*(2), 345–353. DOI: 10.32663/ja.v%vi%i.2309

Matysek, M., Leake, J., Banwart, S., Johnson, I., Page, S., Kaduk, J., Smalley, A., Cumming, A., & Zona, D. (2019). Impact of fertiliser, water table, and warming on celery yield and CO2 and CH4 emissions from fenland agricultural peat. *Science of The Total Environment*, *667*, 179–190. https://doi.org/10.1016/j.scitotenv.2019.02.360

Minayeva, T. Y., Bragg, O. M., & Sirin, A. A. (2017). Towards ecosystem-based restoration of peatland biodiversity. *Mires and Peat*, *19*, 1–36. DOI: 10.19189/MaP.2013.OMB.150

Muhtarom, N. (2020). Analisis keragaman fungi mikoriza arbuskuklar (FMA) di beberapa vegetasi lahan gambut. *Jurnal Agrofood*, *2*(2), 23–20. Retrieved from https://jurnal.polteq.ac.id/index.php/agrofood/article/view/59

Mulyani, R. B., Sastrahidayat, I. R., Abadi, A. L., & Djauhari, S. (2014). Exploring ectomycorrhiza in peat swamp forest of Nyaru Menteng Palangka Raya Central Borneo. *Journal of Biodiversity and Environmental Sciences*, *5*(6), 133–145. Retrieved from https://innspub.net/exploring-ectomycorrhiza-in-peat-swamp-forest-of-nyaru-menteng-palangka-raya-central-borneo/

Noor, Y. R. (2024, September). *Lahan Basah (Mangrove dan Gambut) sebagai Penopang Utama Perwujudan ASTA CITA Presiden-Wakli Presiden Indonesia Terpilih 2024*. Wetlands International. Retrieved from https://indonesia.wetlands.org/id/blog/lahan-basah-mangrove-dan-gambut-sebagai-penopang-utama-perwujudan-asta-cita-presiden-wakil-presiden-indonesia-terpilih-2024-2029/

Nurhalimah, S., Nurhatika, S., & Muhibuddin, A. (2014). Eksplorasi mikoriza vesikular arbuskular (VMA) Indigenous pada tanah regosol di Pamekasan, Madura. *Jurnal Sains Dan Seni Pomits*, *3*(1), 2337–3520. Retrieved from https://www.neliti.com/publications/15377/eksplorasi-mikoriza-vesikular-arbuskular-mva-indigenous-pada-tanah-regosol-di-pa

Nurjanah, S., Octavia, D., & Kusumadewi, F. (2013). *Identifikasi Lokasi Penanaman Kembali Ramin (Gonystylus bancanus Kurz) di Hutan Rawa Gambut Sumatera dan Kalimantan* (E. T. Komar, Ed.). Forda Press. Retrieved from https://cites.org/sites/default/files/ndf_material/The%20assessment%20of%20ramin%20plantation%20requirement%20Technical%20report%20Indonesian.pdf

Osaki, M., Nursyamsi, D., Noor Muhammad, Wahyunto, & Segah, H. (2016). *Tropical Peatland Ecosystems* (M. Osaki & N. Tsuji, Eds.). Springer Japan. https://doi.org/10.1007/978-4-431-55681-7

Peraturan Pemerintah Republik Indonesia. (2016). *PRESIDEN REPU BLIK INDONESIA*.

Pohan, W. S., Syarifuddin, H., & Hamzah, H. (2023). Analisis Tingkat Pengetahuan dan Partisipasi Masyarakat dalam Pencegahan dan Pengendalian Kebakaran Lahan Gambut di Taman Hutan Raya Orang Kayo Hitam (Studi Kasus: Desa Seponjen dan Desa Sungai Aur, Kecamatan Kumpeh, Kabupaten Muaro Jambi, Provinsi Jambi). *Jurnal Ilmiah Universitas Batanghari Jambi*, *23*(1), 1018. https://doi.org/10.33087/jiubj.v23i1.3293

Prasetyo, L. B., Dharmawan, A. H., Nasdian, F. T., & Ramdhoni, S. (2016). Historical Forest fire Occurrence Analysis in Jambi Province During the Period of 2000 – 2015: Its Distribution & Land Cover Trajectories. *Procedia Environmental Sciences*, *33*, 450–459. https://doi.org/10.1016/j.proenv.2016.03.096

Prihantoro, I., Karti, P. D., Aditia, E. L., & Nisabillah, S. (2023). Kualitas Fungi Mikoriza Arbuskula (FMA) yang Diproduksi dengan Teknik Fortifikasi dan Fertigasi Berbeda pada Pertumbuhan Indigofera zollingeriana. *Jurnal Ilmu Pertanian Indonesia*, *28*(3), 377–385. https://doi.org/10.18343/jipi.28.3.377

Rillig, M. C., Lehmann, A., Aguilar-Trigueros, C. A., Antonovics, J., Caruso, T., Hempel, S., Lehmann, J., Valyi, K., Verbruggen, E., Veresoglou, S. D., & Powell, J. R. (2016). Soil microbes and community coalescence. *Pedobiologia*, *59*(1–2), 37–40. https://doi.org/10.1016/j.pedobi.2016.01.001

Shiodera, S., Atikah, T. D., Apandi, I., Seino, T., Haraguchi, A., Rahajoe, J. S., & Kohyama, T. S. (2016). Peat-Fire Impact on Forest Structure in Peatland of Central Kalimantan. In *Tropical Peatland Ecosystems* (pp. 197–212). Springer Japan. https://doi.org/10.1007/978-4-431-55681-7_12

Sugardiman, R. A. (2019). *Sidik Untuk Pengarusutamaan Pencegahan Kebakaran Hutan dan Lahan* (A. Wibowo, T. Widayati, A. S. Aliati, Nuraeni, & Sunarno, Eds.). Direktorat Jenderal Pengendalian Perubahan Iklim Kementerian Lingkungan Hidup Dan Kehutanan. https://ditjenppi.menlhk.go.id/

Syaufina, L., Saharjo, B. H., Nurhayati, A. D., Putra, E. I., & Wardana. (2022). Soil responses on peatland fire' case studies in Jambi and Central Kalimantan. *Journal of Tropical Silviculture*, *13*(1), 66–71. Retrieved from https://www.researchgate.net/publication/3618...Gambut-Studi-Kasus-di-Jambi-dan-Kalimantan-Tengah.pdf

Tan, Z. D., Lupascu, M., & Wijedasa, L. S. (2021). Paludiculture as a sustainable land use alternative for tropical peatlands: A review. *Science of The Total Environment*, *753*, 142111. https://doi.org/10.1016/j.scitotenv.2020.142111

Tawaraya, K., & Turjaman, M. (2016). Mycorrhizal Fungi in Peatland. In *Tropical Peatland Ecosystems* (pp. 237–244). Springer Japan. https://doi.org/10.1007/978-4-431-55681-7_15

Tuheteru, F. D., Kusmana, C., Mansur, I., & Iskandar, I. (2015). Response of Lonkida (Nauclea orientalis L.) towards Mycorrhizal Inoculum in Waterlogged Condition. *BIOTROPIA*, *22*(1). https://doi.org/10.11598/btb.2015.22.1.416

Turetsky, M. R., Benscoter, B., Page, S., Rein, G., van der Werf, guido R., & Watts, A. (2015). Gobal vulnerability of peatlands to fire and carbon loss. *Natural Geoscience*, *8*, 11–14. https://doi.org/10.1038/NGEO2325

Turjaman, M., Herdyantara, B., Faulina, S. A., Agustini, L., Irianto, R. S. B., Hidayat, A., Wahno, I., Murdani, Tjahyono, B., & Indrayadi, H. (2019a). Mycorrhizal colonization of indigenous tropical tree species grown in peat swamp forests of Sumatera, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *308*(1), 012049. https://doi.org/10.1088/1755-1315/308/1/012049

Turjaman, M., Herdyantara, B., Faulina, S. A., Agustini, L., Irianto, R. S. B., Hidayat, A., Wahno, I., Murdani, Tjahyono, B., & Indrayadi, H. (2019b). Mycorrhizal colonization of indigenous tropical tree species grown in peat swamp forests of Sumatera, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *308*(1), 012049. https://doi.org/10.1088/1755-1315/308/1/012049

Veloo, R., Ranst, E. van, & Selliah, P. (2015). Peat Characteristics and its Impact on Oil Palm Yield. *NJAS: Wageningen Journal of Life Sciences*, *72–73*(1), 33–40. https://doi.org/10.1016/j.njas.2014.11.001

Warren, M., Hergoualc'h, K., Kauffman, J. B., Murdiyarso, D., & Kolka, R. (2017). An appraisal of Indonesia's immense peat carbon stock using national peatland maps: uncertainties and potential losses from conversion. *Carbon Balance and Management*, *12*(1), 12. https://doi.org/10.1186/s13021-017-0080-2

Wijedasa, L. S. (2016). Peat soil bulk density important for estimation of peatland fire emissions. *Global Change Biology*, *22*(9), 2959–2959. https://doi.org/10.1111/gcb.13364

Wira Yuwati, T., Noveani Rusalinda Rahmi, A., Surya Hakim, S., & Badruzsaufari. (2020a). The Abundance of Arbuscular Mycorrhiza Infective Propagules Under Galam Stand at Shallow Peat of South Kalimantan. *BIO Web of Conferences*, *20*, 03008. https://doi.org/10.1051/bioconf/20202003008

Wira Yuwati, T., Noveani Rusalinda Rahmi, A., Surya Hakim, S., & Badruzsaufari. (2020b). The Abundance of Arbuscular Mycorrhiza Infective Propagules Under Galam Stand at Shallow Peat of South Kalimantan. *BIO Web of Conferences*, *20*, 03008. https://doi.org/10.1051/bioconf/20202003008

Wisnubroto, M. P., Armansyah, Anwar, A., & Suhendra, D. (2024). Eksplorasi dan Identifikasi Fungi Mikoriza Arbuskular (FMA) serta Karakteristik Tanah Lahan Pasca Tambang Batu Bara pada Tingkat Kelerengan Berbeda di Kecamatan Talawi, Kota Sawahlunto. *Jurnal Agrikultura*, *35*(1), 112–125. https://doi.org/10.24198/agrikultura.v35i1.53685

Wulandari, N. A. K., Yupi, H. M., & Saputra, R. H. (2023). Analisis karaktersiktik fisik tanah gambut tropis pada tata guna lahan perkebunan palawija. *Jurnal Teknika*, *7*(1), 62–70. https://doi.org/10.52868/jt.v7i1.9115

Xiang, X., Gibbons, S. M., Yang, J., Kong, J., Sun, R., & Chu, H. (2015). Arbuscular mycorrhizal fungal communities show low resistance and high resilience to wildfire disturbance. *Plant and Soil*, *397*(1–2), 347–356. https://doi.org/10.1007/s11104-015-2633-z

Yuningsih, L., Bastoni, Yulianty, & Harbi, J. (2018). Analysis Of Vegetation On Burnt Peat Forest Land In Ogan Komering Ilir (Oki) Regency, South Sumatra Province, Indonesia. *Sylva*, *VII*(2), 58–67. Retrieved from https://jurnal.um-palembang.ac.id/sylva/article/view/1541

Yuwati, T. W., Rachmanadi, D., Pratiwi, Turjaman, M., Indrajaya, Y., Nugroho, H. Y. S. H., Qirom, M. A., Narendra, B. H., Winarno, B., Lestari, S., Santosa, P. B., Adi, R. N., Savitri, E., Putra, P. B., Wahyuningtyas, R. S., Prayudyaningsih, R., Halwany, W., Nasrul, B., Bastoni, & Mendham, D. (2021). Restoration of Degraded Tropical Peatland in Indonesia: A Review. *Land*, *10*(11), 1170. https://doi.org/10.3390/land10111170