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Research Article

Morphological Characteristics and Chlorophyll Content of Dominant Weed Leaves After Peatland Fires in Oil Palm Plantation Areas

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Abstract: The weeds are high adaptability plants after peatland fires. The response of the dominant weeds growing after the fire is an important factor in weed control efforts to increase the yield of oil palm plantations on post-fire peatlands. The present study was conducted at the Kurao oil palm plantation, Lubuk Basung, West Sumatra, Indonesia. The weeds were collected by using the Quadrat method with random placement of 20 plots in post-fire and unburnt locations. The leaf morphological characteristics were determined by the descriptive method. While the chlorophyll content of leaves was measured by using calorimetry in the spectrophotometer. A total of 25 species and 17 families of weeds were collected in the present study. The *Peperomia pellucida* is the most dominant species collected with an important value index of 36.41% and follows by *Ageratum conyzoides* with an important value index of 28.99%. In the present study, we confirmed the differences in all aspects of the morphological characteristics of *Peperomia pellucida* leaves between post-fire and unburnt locations. Meanwhile, in *Ageratum conyzoides* leaves only show differences in several aspects. Furthermore, there were differences in the chlorophyll content of *Peperomia pellucida*, while *Ageratum conyzoides* did not show any differences in chlorophyll content.

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1. Introduction

Indonesia has a 14.9 million hectares of peatland area which is located in Sumatra, Kalimantan, Papua, Sulawesi, and on several small islands (Maftu'ah and Indrayati, 2013; Masganti et al., 2014; Maftu'ah and Nursyamsi, 2019; Reflinur et al., 2019; Yuwati et al., 2021). The peatland degradation will be increasing in the coming decade due to human activities such as fires, mining, etc. (Masganti et al., 2014; Wahyunto and Dariah, 2014; Nelson et al., 2021; Yuwati et al., 2021). Along with the increasing population and decreasing availability of plantation land, this has encouraged the conversion of peatlands into plantation land, especially oil palm plantations (Irma et al., 2018).

The oil palm (*Elaeis guineensis*) is the biggest cultivated plant commodity in Indonesia and has provided a very important role in the economy and country's development, as increasing demand for oil palm products (Prasetyo and Zaman, 2016). One of the post-fire peatlands was converted into an oil palm plantation located in Kurao, Lubuk Basung, West Sumatra, Indonesia. The post-fire area is generally overgrown with weeds. The weeds are unwanted, harmful, dangerous, or economically detrimental plants (Mokoginta et al., 2021). Anthropocentrically, the term weed is applied to species growing around cultivated plants and is considered detrimental to the growth and yield of cultivated plants (Moenandir, 2010). Weeds as active allelopathic plants are shown its activities through allelochemical exudation (Jabran et al., 2015). Allelochemicals in weeds can interfere growth of surrounding plants slowing growth and germination due to competitiveness with cultivated plants in obtaining resources (Siyar et al., 2019). The presence of weeds as competitors for cultivated plants can reduce oil palm production by up to 20% (Barus, 2003). Based on these factors, weed management is very important in increasing agricultural potential, because uncontrolled weeds in agricultural landscapes can reduce agricultural yields (Sonmez and Alp, 2019; MacLaren et al., 2020; Mujdeci et al., 2020; Suleymanov et al., 2020).

The weeds that grow on post-fire peatlands have a high adaptability to extreme environmental stress. Therefore, weed control is necessary. In controlling weeds, information is needed regarding biological factors, such as morphological characteristics and chlorophyll content which will show its adaptability to fire. In general, plants can recognize and regulate their own organ and tissue activities in response to environmental changes (Sugiura et al., 2016). The response of plants will be seen in the appearance of plants as a form of adaptation to the environment. After the fire, it will affect the anatomy, morphology, and physiology of a plant. The occurrence of fires will cause environmental changes such as increased light intensity, increased evaporation of leaves, and decreased water content in the soil. The leaves as plant organs have an important role in adaptation to environmental changes in the strategy of temperature regulation against abiotic stress (Lin et al., 2017). The plasticity of leaves is important as a place for the process of photosynthesis and the exchange of materials and energy with the external environment. The plant adaptation strategy depends on internal physiology and external morphology formed by leaf responses to environmental changes (Wang et al., 2016).

In connection with the negative effects caused by weeds on the peatlands the plantation crops, the study of weeds by using the biological approach is important to understand the peatlands after fires. Nowadays, the information on the biological aspects of weeds is still inadequate and limited, especially in morphological characteristics and physiological responses, especially in the form of chlorophyll content from weeds that predominantly grow in oil palm plantations of post-fire peatlands. Therefore, the aim of the present study is to understand the response of morphological characteristics and chlorophyll content of weed leaves that predominantly grow after peatland fires in oil palm plantation areas.

2. Material and Methods

This study was conducted in January-April 2021, in the oil palm plantation of Kurao, Lubuk Basung, West Sumatra, Indonesia. The Observation plots were made using the Quadrat method by randomly placing 20 plots with a size of 1×1 meter to record all types of weeds found on 2 hectares of oil palm plantations.

The weeds that grow dominantly are known based on the following important value index equation:

$$\text{Density} = \text{Number of individuals/Sample plot area} \quad (1)$$

$$\text{Relative Density (\%)} = \text{Density of a species/Density of all species} \times 100 \quad (2)$$

$$\text{Frequency} = \text{Number of plots found of a species/Number of all plots} \quad (3)$$

$$\text{Relative Frequency (\%)} = \text{Frequency of a species/Frequency of all species} \times 100 \quad (4)$$

$$\text{Important Value Index (\%)} = \text{Relative Density} + \text{Relative Frequency} \quad (5)$$

The sampling of weed leaves was selected from two dominant weed species growing in post-fire and unburnt locations. Leaf samples were taken from 20 individuals of each species. Leaves are taken using shears, then labeled according to the sampling location. The observation and measurement of leaf morphological characters are as follows: leaf length, leaf width, petiole length, and number of leaf vein branches. Then the samples were put into plastic bags and then put into jet fresh (a container filled with ice) and immediately taken to the Plant Physiology Laboratory (Biology Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang) to examine the chlorophyll content.

For the preparation of leaf extracts, leaf samples were cut into small pieces and weighed at 1 gram. The sample pieces were crushed in a mortar and then extracted with 96% ethanol. After all the leaf chlorophyll pigment has dissolved (marked with white pulp), the chlorophyll extract is filtered with filter paper and put into a 100 ml volumetric flask and 96% ethanol is added until the volume of the extract reaches the limit of 100 ml. Furthermore, testing the chlorophyll content of the leaves using Calorimetry with a Spectrophotometer. Measurement of chlorophyll content was carried out by measuring the absorbance of the chlorophyll extract of weed leaves using a cuvette on a spectrophotometer at a wavelength of 649 and 665 nm. After that, chlorophyll was measured using the formula of Wintermans and de Mots (1965) as follows:

$$\text{Chlorophyll a (mg L}^{-1}) = 13.7 \times (OD665) - 5.76 \times (OD649) \quad (6)$$

$$\text{Chlorophyll b (mg L}^{-1}) = 25.8 \times (OD649) - 7.7 \times (OD665) \quad (7)$$

$$\text{Total chlorophyll (mg L}^{-1}) = 20.2 \times (OD649) + 6.1 \times (OD665) \quad (8)$$

Data on morphological characteristics and chlorophyll content of dominant weed leaves were analyzed using the t-test with a 5% confidence level.

3. Results and Discussion

3.1. The species of weeds collected in the post-fire of oil palm plantation

A total of 25 species of weeds were collected, and it belonging to 17 families and 3 303 individuals (Table 1). *Peperomia pellucida* and *Ageratum conyzoides* were the two dominant weed species found in the present study with an important value index of 36.41% and 28.99% respectively.

Table 1. Weeds in the post-fire oil palm plantation area and their frequency and density

Family	Species	Total number of individuals of species	Number of quadrats in which the species occurred	Frequency	Relative Frequency (%)	Density	Relative Density (%)	Important Value Index (%)
Acanthaceae	*Asystasia gangetica*	12	4	0.20	2.84	0.60	0.36	3.20
Asteraceae	*Ageratum conyzoides*	606	15	0.75	10.64	30.30	18.35	28.99
	Cyanthilium cinereum	3	1	0.05	0.71	0.15	0.09	0.80
	Elephantosus tomentosus	45	6	0.30	4.26	2.25	1.36	5.62
	Praxelis clematidea	520	8	0.40	5.76	26.00	15.74	21.42
	Syndrella nodiflora	2	1	0.05	0.71	0.10	0.06	0.77
Cleomaceae	*Cleome rutidosperma*	2	2	0.10	1.42	0.10	0.06	1.48
Cyperaceae	*Cyperus aromaticus*	220	6	0.30	4.26	11.00	6.66	10.92
	Cyperus escullentus	22	3	0.15	2.13	1.10	0.67	2.79
Dryopteridaceae	*Dryopteris flix-mas*	53	12	0.60	8.51	2.65	1.60	10.12
Euphorbiaceae	*Chamaesyce hirta*	11	1	0.05	0.71	0.55	0.33	1.04
Lomariopsidaceae	*Neprolepis cordifolia*	26	4	0.20	2.84	1.30	0.79	3.62

Table 1. Weeds in the post-fire oil palm plantation area and their frequency and density (continued)

Family	Species	Total number of individuals of species	Number of quadrats in which the species occurred	Frequency	Relative Frequency (%)	Density	Relative Density (%)	Important Value Index (%)
Lygodiaceae	*Lygodium circinatum*	3	2	0.10	1.42	0.15	0.09	1.51
Lythraceae	*Cuphea carthagenensis*	42	5	0.25	3.55	2.10	1.27	4.82
Melastomaceae	*Melastoma malabathricum*	24	7	0.35	4.96	1.20	0.73	5.69
Phyllanthaceae	*Phyllanthus niruri*	24	9	0.45	6.38	1.20	0.73	7.11
Piperaceae	*Peperomia pellucida*	898	13	0.65	9.22	44.90	27.19	36.41
Plantaginaceae	*Veronica montana*	42	3	0.15	2.13	2.10	1.27	3.40
Poaceae	*Axonopus compressus*	151	9	0.45	6.38	7.55	4.57	10.95
	Digitaria sanguinalis	194	7	0.35	4.96	9.70	5.87	10.84
Pteridaceae	*Adiantum capillus-veneris*	2	1	0.05	0.71	0.10	0.06	0.77
Rubiaceae	*Mitracarpus hirtus*	218	8	0.40	5.67	10.90	6.60	12.27
	Oldenlandia corymbosa	1	1	0.05	0.71	0.05	0.03	0.74
	Spermacoce alata	181	12	0.60	8.51	9.05	5.48	13.99
Verbenaceae	*Stachytarpheta indica*	1	1	0.05	0.71	0.05	0.03	0.74
Total		3303	141	7.05	100	165.15	100	200

3.2. Morphological characteristics leaves of dominant leaves

The morphological characters of *Peperomia pellucida* leaves showed the differences in all aspects between post-fire and unburnt locations. On the other hand, the *Ageratum conyzoides* showed differences in the aspects of leaf length, leaf width, and petiole length (Table 2).

Table 2. Average leaf length, leaf width, petiole length, and number of branches of *Peperomia pellucida* and *Ageratum conyzoides* leaf veins at post-fire locations compared to unburned locations in Kurao, Lubuk Basung

Species	Location	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Number of leaf vein branches
Peperomia pellucida	Post-fire	2.66^{a}	2.21^{a}	1.02^{a}	5.50^{a}
	Unburnt	2.21^{b}	2.16^{b}	0.80^{b}	4.80^{b}
Ageratum conyzoides	Post-fire	5.80^{a}	3.76^{a}	1.96^{a}	7.00
	Unburnt	5.83^{b}	4.33^{b}	1.40^{b}	7.60

Notes: Numbers followed by the same letter are not significantly different at the 5% significance level.

The difference in leaf size in post-fire location is a response of plants to the environmental changes which is very influential on the growth and morphology of leaves. The leaves collected at the post-fire location are bigger than the leaves from the unburnt location. Huang et al., (2007) explained that fires generally increase post-fire nutrient availability and plants can respond by increasing leaf nutrient concentrations. The morphological characteristics of leaves is changes in response to the long-term adaptation of plants to different light capacities of the photosynthetic process (Pandey and Sinha, 2009). The plants respond to light stress conditions by increasing the leaf surface area to capture more sunlight (Francis and Gilman, 2019). This theory is in accordance with the results of the present study which is the leaf morphological characteristics, are higher in post-fire locations compared to unburnt locations.

Inside the leaf veins there is a transport network that functions to transport food so that with an increase in the number of branches of the leaf bones, the activity of the xylem and phloem also increases. The xylem in the vascular tissue functions to transport water and nutrients, while the phloem functions to transport the results of photosynthesis (Chatri, 2013). The differences in leaf growth are also caused by differences in environmental conditions in post-fire and unburnt locations, which will affect the physiological growth of plants. According to Schulze et al., (2005), plant growth is strongly influenced by chemical and physical environmental factors which include temperature, humidity, light intensity, rainfall, and nutrients in the soil.

3.3. The chlorophyll content of the dominant weed leaves grew

There was a difference in the chlorophyll content of *Peperomia pellucida* between post-fire and unburnt locations. In the unburned location, the chlorophyll content was higher, namely 17.022 mg g^{-1} and in the post-fire location, namely 14.572 mg g^{-1}. In *Ageratum conyzoides*, the chlorophyll content between post-fire and unburnt locations was not shown any differences, the results can be seen in Table 3.

The results of the previous study by Vauzia et al., (2019) showed that the chlorophyll content of Jabon leaves (*Anthocephalus cadamba* [Roxb] Miq.) at two different locations showed significant differences, with the parameters of the light intensity factor and soil factor in the Nyalo river area, South Coast and Lubuk Alung area, Padang Pariaman. However, in *Peperomia pellucida*, post-fire environmental changes cause changes in chlorophyll content. At post-burn locations, the chlorophyll content is lower because fires cause higher light intensity. The higher the light intensity, the higher the chlorophyll content of plants, but on the other hand, too high a light intensity can also reduce leaf chlorophyll levels (Salisbury and Ross, 1995). At high light intensity, plants have thicker leaves and mesophyll cells, longer palisade cells, and more spongy cells (Wang et al., 2016).

Table 3. T-test results for chlorophyll content of 2 dominant species in post-peatlands fire and not burning in oil palm plantation areas

Sample	Location	Chlorophyll a	Chlorophyll b	Average total chlorophyll content (mg L^{-1})
Peperomia pellucida	Post-fire	7.420	7.027	14.57^{a}
	Unburnt	9.324	7.550	17.02^{b}
Ageratum conyzoides	Post-fire	16.856	14.976	32.17^{a}
	Unburnt	15.438	16.987	32.69^{a}

Notes: Numbers followed by the same letter are not significantly different at the 5% significance level.

While *Ageratum conyzoides*, it is not show any difference in chlorophyll content between post-fire and unburnt locations. We assumed that this condition was correlated with the ability of *Ageratum conyzoides* to survive in environments with high light intensity. This result is similar to the previous study of Ariningsih (2009) which stated that the *Ageratum conyzoides* lives by requiring sufficient light intensity and they grow rapidly. The pH of the soil is one of the environmental factors that influence this condition. In post-fire locations, the soil pH is usually lower than normal and we recorded the value as five in the present study. The pH value in the present study is higher than the previous study of Hartatik et al. (2011). Generally, the peat soils in Indonesia have acidic pH smaller than four, due to their high organic matter content (Hartatik et al., 2011). The higher value in soil pH at post-fire location in the present study was caused by residual ash from burning which can increase cation exchange so that it tends to increase the soil pH (Putri et al., 2017). At the unburnt location, the pH of the soil is close to normal (6.2), due to the treatment of unburnt location with some fertilizers to increase the pH and the productivity of oil palm. The previous study of Ramadhan et al. (2018) have find a similar condition and they assumed that the addition of Dolomite lime fertilizer will affect increasing the soil pH. However, the adaptation of plants to post-fire conditions on peat soils is very diverse and it depends on the abilities of each species. The previous study of the characteristics of stomata and chlorophyll contents of *Anthocephalus cadamba*, *Terminalia catappa,* and *Mallotus leucodermis* regenerating with sprouts and seeds after burning at peat swamp forest in Batang Alin have different regeneration mechanisms and showed different response on environmental changes after burning (Vauzia et al., 2016; Des et al., 2021).

The chlorophyll content in *Peperomia pellucida* and *Ageratum conyzoides* have different responses to post-fire environmental conditions. *Ageratum conyzoides* was able to adapt and compete in physiological aspects better than *Peperomia pellucida*. This means that different plants will respond to different chlorophyll content in post-fire environmental conditions.

Conclusion

There were 25 types of weeds consisting of 17 families that grew on post-fire peatlands. The dominant species growing were *Peperomia pellucida* with an important value index of 36.41% and *Ageratum conyzoides* with an important value index of 28.99%. The morphological characters and chlorophyll content of *Peperomia pellucida* leaves showed differences between post-fire and unburnt locations, while the *Ageratum conyzoides* species did not show any differences in chlorophyll content and morphological characters in the aspect of the number of leaf veins. However, it showed differences in the aspects of leaf length, leaf width, and leaf stalks in post-fire and unburnt locations.

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