
Research Article

Composition, structure, and level of weed diversity in oil palm plantation in Pagar Merbau Village, Tanjung Morawa, Indonesia

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Abstract

Weed vegetation growth affects the growth and production of oil palm plants. To control weeds in plantation land, especially by using herbicides or bioherbicides, weed vegetation analysis is needed. This research was conducted to determine the composition, structure, and level of diversity of weeds in oil palm plantations owned by the community of Pagar Merbau village, Tanjung Morawa District. The method used is a descriptive method with sampling technique done by purposive sampling. The results of the analysis showed that weeds found were 7 families, 10 species, and 3153 individuals. Weed species found were: *Clidemia hirta*, *Borreria alata*, *Mimosa invisa*, *Setaria barbata*, *Ageratum conyzoides*, *Paspalum conjugatum*, *Ottlochloa nodosa*, *Cyclosorus aridus*, *Calopogonium mucuoides*, *Ophioglossum reticulatum*. *Ottlochloa nodosa* is a type of weed that has the highest importance value index 66.52% (1323 individuals) and *Setaria barbata* is a type of weed that has the lowest important value index of 1.00% (4 individuals). Weed diversity index in this oil palm plantation is in the moderate category ($H' = 1.3741$). The weed control system to be carried out in this oil palm plantation must consider the dosage and types of herbicides and bioherbicides used so that it does not have the potential to reduce the level of diversity of weeds of grass or broadleaf weeds.

Introduction

Palm oil (*Elaeis guineensis* Jacq.) is one of the mainstay industrial plants for the Indonesian economy, which is able to survive in the event of a prolonged economic crisis (Handayani et al. 2014). This plant is one of the types of plantation plants that are in an important position in the agricultural sector in general, and the plantation sector in particular (Nasution et al., 2014). Palm oil production has been managed in a variety of products, to be able to

meet the needs of the community, especially as a source of vegetable oil and even today can be a source of phytonutrients (Wattanapenpaiboon and Wahlqvist, 2003).

One of the factors that can affect the growth and production of oil palm is the distribution and density of weeds in oil palm plantations. Weeds can reduce the level of productivity of cultivated plants because weeds that grow on agricultural land can lead to competition with cultivation plants in the process of absorbing

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nutrients, capturing light and absorbing water, and can be a hiding place for pests. Weed is a plant species that comes from wild species and has the ability to adapt to environmental changes (Kilkoda et al., 2015). Weeds are easy to grow in areas that are nutrient-poor to those that are rich in nutrients. Physically weeds compete with cultivated plants in terms of the acquisition of space, light, water, nutrients, important gases, and chemicals (allelopathy) which are secreted (Pahan, 2013). As under water pressure conditions, weeds can reduce yields by more than 50% only through moisture competition (Abouzienna & Haggag, 2016). In addition to damaging product quality, weeds can cause 10-80% loss of crop yields and cause health and environmental hazards (Rao & Chauhan, 2015).

Various weed control techniques have been carried out in oil palm plantations such as manual techniques, mechanical cultivation, herbicide use or integrated weed management (Deribe, 2018). However, what is often used in oil palm plantations is the application of herbicides because they are considered to be more practical and profitable compared to other controls, especially when viewed in terms of less labor requirements and relatively shorter implementation time (Barus, 2003). Weed control in principle is an attempt to increase crop competitiveness and weaken weed competitiveness. Wrong cultivation practices will result in increasing the competitiveness of weeds, if one or several weed species are "killed" then they will be replaced by other species, this will likely cause more severe problems than previous species. Weed control must pay attention to the implementation techniques in the field or technical factors, the costs required or economic factors (Pahan, 2013).

Palm oil is the most productive vegetable oil crop per unit area and is very important for the economies of developing countries such as Malaysia and Indonesia. However, this is also very controversial because of its impact on biodiversity. Herbicide input to control vegetation of understorey plantations is very high, which is likely to damage native biodiversity, but may become unnecessary just because it protects oil palm yields. Reducing the use of herbicides

must be encouraged in oil palm plantations, this will not only reduce plantation costs, but increase soil biodiversity, and ecosystem functions (Ashton-Butt et al., 2018). Application of herbicides on plantations can have a long-term negative impact on the environment, health and biodiversity. Such as the application of the methyl methulfuron herbicide which at certain doses is effective in controlling total weeds in oil palm plantations, but it actually results in changes in weed communities (Koriyando et al., 2014). Weeds are a major obstacle in crop production, but as part of a major producer in agricultural systems, weeds may be an important component in agroecosystems to support biodiversity (Marshall et al., 2003). Each oil palm plantation area has different weed conditions, such as in the oil palm plantation area along the coast of Cermin, Serdang Bedagai Regency, the level of plant diversity is moderate. There were about 7 types of weeds found, and the most common type of weed was *Asystasia intrusa* (Sitinjak et al., 2018). Then in the oil palm plantation area in Salang Tungir Village, Deli Serdang Regency, around 10 species of weeds from 8 families were found. In this plantation area, there are broad-leaved, narrow-leaf weeds, grasses, and dominate ferns (*Dryopteris aridus*) (Siregar et al., 2021).

The condition of weeds in oil palm plantations is an important factor for applying effective weed management techniques in maximizing oil palm growth and production, while simultaneously paying attention to biodiversity. The effectiveness of applied herbicides and bioherbicides is influenced by many factors including weed species, weed density, frequency, and distribution of weeds in oil palm plantations. Therefore, this research needs to be done to determine the composition, structure, and level of diversity of weeds in oil palm plantations owned by the community of Pagar Merbau Village, Tanjung Morawa District.

Materials and methods

This research was conducted from June to December 2020 on the people's plantation land in Pagar Merbau Village, Tanjung Morawa Sub-district, Deli Serdang Regency, North Sumatra, which was at an altitude of $\pm 0 - 65$ meters

above sea level. The materials used are newsprint, cardboard, raffia, plastic bags, writing paper, and alcohol. The tools used are scissors, gauges, rulers, machetes, cater knives, cameras, stationery, ovens, books or literature on the identification of plant species, GPS, and loop. The method used is descriptive method. The sample plot in this study uses the quadratic plot method and by sampling using purposive sampling, with a total of 32 plots. The area of the experimental sample is 1 m² (1m x 1m) in one unit (plot). Each plot was formed in square boxes with bamboo and rope as square dividers and boundary markers.

The procedure in carrying out this research is to begin with preparing the necessary tools and materials, making random plots at the research location, taking plants or weeds from each plot that has been determined, then counting and recording the characteristics of each type of weed observed, the samples observed then carefully removed, then put into a plastic bag that has been labeled according to the plot, identification of samples based on plant identification techniques or literature containing information about plant or weed species, and the

last stage is analyzing the data that has been obtained from the results identification.

Identification of plant diversity was carried out in the oil palm plantation area in Pagar Merbau Village, Tanjung Morawa Subdistrict, with the following steps: 1) Sample maps made with a size of 1 m² are placed at random, then the types of plants or weeds that grow in the plots are taken or removed, then put into plastic. 2) Identify the types of plants/weeds that exist by using a description book based on their morphological characteristics such as leaf shape, stem shape or roots of the weed, then determine the species name, morphology and reproduction, life cycle and place of growth. 3) Plants or weeds that have been identified are separated by type group. 4) Data on the type and number of plants or weeds for each plot are then summarized in a table, followed by analysis.

The parameters observed were species density (D), relative density (RD), species frequency (F), relative frequency (RF), Importance Value Index (IVI), which were analyzed using the formula according to [Muller-Dombois & Ellenberg \(1974\)](#), namely:

$$\text{Species Density} = \frac{\text{Number of individuals of a species}}{\text{Square area}}$$

$$\text{Relative Density} = \frac{\text{Number of individual density of a species}}{\text{Density of all species}} \times 100 \%$$

$$\text{Species Frequency} = \frac{\text{Number of plots found by a species}}{\text{Number of all plots}}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100 \%$$

$$\text{Significant value index} = \text{Relative Density} + \text{Relative Frequency}.$$

Observational data were analyzed using the Shannon-Wiener Diversity Index, with the following formula ([Michael, 1995](#)):

$$H' = - \sum_{i=1}^R p_i \ln p_i \quad \text{or} \quad H' = - \sum \left[\left(\frac{n_i}{N} \right) \ln \left(\frac{n_i}{N} \right) \right]$$

Formula description: H' = Shannon Wiener's diversity index, p_i = Proportion of species to one in the total sample, n_i = Number of individuals of all species, N = Total number of individuals of all species. The criteria for the Shannon - Wiener (H') diversity index value are as follows: if $H' < 1$; low diversity value, if 1

$< H' \leq 3$; moderate diversity value, and if $H' > 3$; high diversity value.

Results and discussion

The composition of weeds in oil palm plantation

The results showed that weeds growing in the area of oil palm plantations owned by the

community of Pagar Merbau Village were 7 families consisting of 10 species of weeds with a total of 3153 individuals. Weed species found were: *Clidemia hirta*, *Borreria alata*, *Mimosa invisa*, *Setaria barbata*, *Ageratum conyzoides*, *Paspalum conjugatum*, *Ottlochloa nodosa*, *Cyclosorus aridus*, *Calopogonium mucudoinae*, *Ophioglossum reticulatum*. The oil palm plantations show a composite mix of broadleaf weeds (1776 individuals) and grass (1377 individuals). The types of weeds found in higher numbers are *Ottlochloa nodosa*, which can reach up to 1323 individuals, then followed by *Borreria alata* species (963 individuals), and *Ageratum*

conyzoides species (593 individuals). Whereas the least number of weeds were *Setaria barbata* (4 individuals) (Table 1). *Ottlochloa nodosa* is a type of grass weed that has a very high potential in competing with other types of weeds, so that this type of weed is found in almost every plot in high numbers. In addition to genetic factors, the microclimate on oil palm plantations in Pagar Merbau Village is likely to be very supportive for the growth of *Ottlochloa nodosa* weed species. The opposite may occur in the *Setaria barbata* weed, making it difficult to compete with other types of weeds.

Table 1. Composition of weeds in oil palm plantations in Pagar Merbau Village

No	Family	Weed Species	Group	Number (individual)
1	Lytheraceae	<i>Clidemia hirta</i> (L.) G. Don	Broadleaf	5
2	Rubiaceae	<i>Borreria alata</i> (Aubl.) DC.	Broadleaf	963
3	Ophioglossaceae	<i>Ophioglossum reticulatum</i> L.	Broadleaf	6
4	Asteraceae	<i>Ageratum conyzoides</i> L.	Broadleaf	593
5	Thelypteridaceae	<i>Cyclosorus aridus</i> (D.Don.) Ching	Broadleaf	24
6	Fabaceae	<i>Calopogonium mucunoides</i> Desv.	Broadleaf	47
		<i>Mimosa invisa</i> Mar.	Broadleaf	138
7	Poaceae	<i>Ottlochloa nodosa</i> (Kunth) Dandy	Grass	1323
		<i>Paspalum conjugatum</i> Berg.	Grass	50
		<i>Setaria barbata</i> (Lam.) Kunth.	Grass	4
Total				3153

Ottlochloa nodosa is a type of weed that has segmented stems, which in certain segments can grow roots to absorb nutrients from the soil surface. Then the green leaves are straight and elongated, making them more adaptable to temperature, humidity, and sunlight intensity. Spread naturally, but can be planted with seeds or rooted stems. This is likely to help these types of weeds to survive stronger and multiply faster. *Ottlochloa nodosa* is a grass species that grows on yellow-red podsolic soil types (Tarsono & Kaswari, 2016). While *Setaria barbata* includes long-stemmed grass weeds that can reach about 10-150 cm in length, without nodal roots, or roots from the lower knot, feathered sheaths, long narrowed leaf blades with a width of about 2 cm, branches ride. Spread only with seeds. This is likely to make this type of weed only grow in certain places so that it has a limited number of individuals.

According to Deribe (2018), weeds compete with oil palm plants to get moisture and plant nutrients, while some grasses and perennial sedges produce root exudates that are poisonous to oil palm plants. The effects of weeds on oil palm plants include water pressure during the dry season, lack of essential elements, yield decline and quality. Weeds grow very varied in varied environmental conditions to form vegetation. The ecological amplitude of all species that grow in vegetation is not the same. Different weeds respond differently to the effects of changes in ecological factors, rainfall, relative atmospheric humidity, light availability, temperature, edaphic, topological and biotic factors (Tikariha et al., 2016). According to Sidik et al. (2018) that the application of certain herbicides can cause rapid population dynamics of certain weed species because of their different responses to herbicides. Some species

may be less susceptible to certain herbicides while other species are more susceptible. Effect of herbicide application on changes in weed composition and weed seed banks is influenced by herbicide characteristics and weed responses to herbicide applications. Information about the composition of weeds and their relationship to altitude in each land will be useful in the selection of weed processing methods and is needed to illustrate the relative ranking of weeds. The most aggressive and difficult to control weeds are identified at different altitudes (Sintayehu, 2019).

The structure of weeds in oil palm plantation.

The results of weed vegetation analysis in the study area (oil palm plantations) show that *Ottlochloa nodosa* is a type of weed that has the highest density and frequency values that can reach 40.09 density value with a relative value of 41.96% and the frequency value reaches 0.85 with the relative value is 24.56%. Then followed by species *Borreria alata* and *Ageratum conyzoides*. While the type of weed that has the lowest density (0.12) and frequency (0.03) is *Setaria barbata*. This can be seen more clearly in Table 2.

Table 2. The structure of weeds in an oil palm plantation in the village of Pagar Merbau

No	Weed species	Total	D	RD (%)	F	RF (%)	IVI (%)
1	<i>Clidemia hirta</i>	5	0.15	0.16	0.06	1.75	1.91
2	<i>Borreria alata</i>	963	29.18	30.54	0.76	21.93	52.47
3	<i>Mimosa invisa</i>	138	4.18	4.38	0.52	14.91	19.29
4	<i>Ageratum conyzoides</i>	593	17.97	18.81	0.79	22.81	41.61
5	<i>Cyclosorus aridus</i>	24	0.73	0.76	0.09	2.63	3.39
6	<i>Calopogonium mucunoides</i>	47	1.42	1.49	0.15	4.39	5.88
7	<i>Ophioglossum reticulatum</i>	6	0.18	0.19	0.06	1.75	1.94
8	<i>Ottlochloa nodosa</i>	1323	40.09	41.96	0.85	24.56	66.52
9	<i>Paspalum conjugatum</i>	50	1.52	1.59	0.15	4.39	5.97
10	<i>Setaria barbata</i>	4	0.12	0.13	0.03	0.88	1.00
Total		3153	95.55	100.00	3.45	100.00	200.00

Note: D = Absolute Density, RD = Relative Density, F = Absolute Frequency, RF = Relative Frequency, IVI = Important Value Index.

The important value index of weeds found in the study area is the *Ottlochloa nodosa* species which has the highest value of around 66.52%, which is then followed by *Borreria alata* (52.47%) and *Ageratum conyzoides* (41.61%). This means that this type of weed has an important role compared to other weeds, its ability to survive and reproduce can be seen from its importance value index. The structure of weeds that predominately grows in these oil palm plantations is the *Ottlochloa nodosa* weed which is a type of grass, followed by *Borreria alata* and *Ageratum conyzoides* species from the broadleaf weed group (Figure 1).

According to Simangunsong et al. (2018), the dominance level of weed *O. nodosa* that dominates in each open area is positively correlated to the level of light intensity, and negatively correlated to the humidity level. Satria-

wan & Fuady (2019) also argues that weed species that grow and dominate in the oil palm region depend on location, local climate, and the received light. Such as the species of *Axonopus compress* and *A. gangetica*, which are often used as cover crops in oil palm plantations in Malaysia. Growth density of both types of weeds is influenced by sunlight conditions, which are obtained from the shade or canopy of oil palm plants. Type of weed *A. compress* is a stronger competitor than *A. gangetica* in both density under full sun and high density in the shade (Samedani et al., 2013). Adesina et al. (2012) also argue that the presence of several weeds in almost all areas indicates that their growth and development can occur under different light conditions, while the limitation of some weeds in certain areas shows the requirements for special conditions for growing.

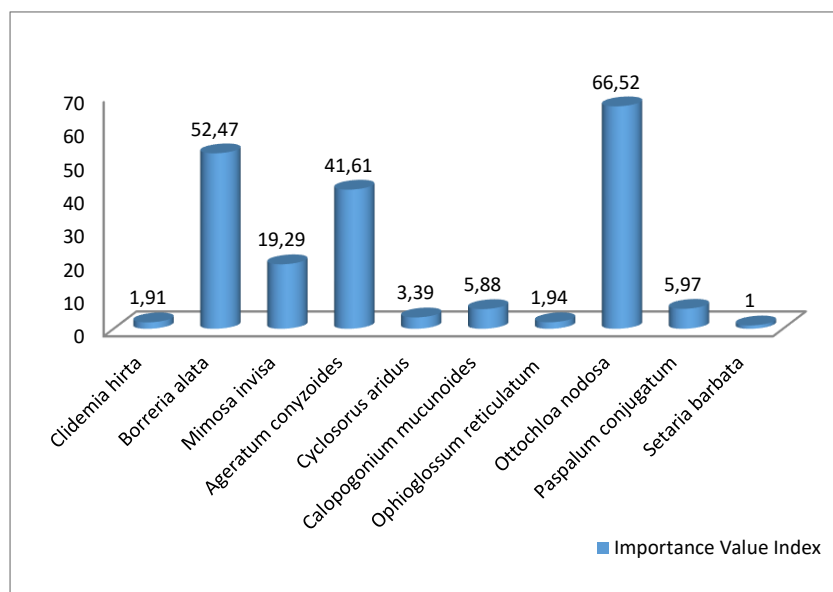


Figure 1. Importance Value Index (IVI) of weeds in the oil palm plantation of Pagar Merbau Village

Likewise, the *Ottochloa nodosa* weed species may have high potential in competition and adapt to various environmental factors in oil palm plantations so that it has the highest importance value index compared to other weed types, which are then followed by *Borreria alata* and *Ageratum conyzoides* weed species. The importance value index is directly proportional to the relative density and relative frequency of weed growth in plantations. This is very important to be considered in determining the dosage and type of herbicide that will be used to control weeds in plantations. If weed control methods at the oil palm plantations are still not quite right, there is a possibility that weed density will increase. This will have a negative impact on the growth and production of oil palm plants. According to Peiris & Nisanka (2016), almost all types of weeds can cause major damage to crops on plantations, are fully tolerant of herbicides and cannot be controlled by using herbicides. These weed species have the ability to turn plantations into units that are completely unproductive and economically unfit for a period of one to two years depending on the herbicide tolerant weed species that exist. This weed is able to suppress plant growth, turn leaves into yellow and cause defoliation. Ronchi & Silva (2006) also argue that the level of competition of weeds with plant growth depends on species

and weed density in plantations. Then according to Gebreegziabher et al. (2018), the most important weed species with regard to the Importance Value Index. Weed control strategy planning in the future must consider weed diversity. Many useful weeds are invasive species, indicating that they are plant resources, which are common and inexpensive for rural communities and can represent alternative resources in the future. Because invasive weeds can affect the natural habitat of native flora, integrating weed exploitation into weed management strategies can reduce weed populations while maintaining agrobiodiversity in the long term (Srithi et al., 2017). Such types of weeds *Nephrolepis bisserata* can be exploited for protection on plantations, which may be more effective than the use of any herbicide due to the high diversity of weed flora (Essandoh et al., 2011).

The level of weeds diversity in oil palm plantations

Based on the analysis of the vegetation diversity index, the level of weed diversity in oil palm plantations in the village of Pagar Merbau has been determined. Weed species found the highest level of diversity (0.36) were *Ottochloa nodosa* and *Borreria alata*, then followed by *Ageratum conyzoides* with an index value of 0.31. Whereas weed species with a lower level of

diversity (0.009) are *Setaria barbata* (Figure 2). Although each species's level of diversity is low, from 0.009 to 0.36, overall the diversity of species in this oil palm plantation using the Shannon-Weaner vegetation diversity index calculation is obtained $H' = 1.3741$. Because this species diversity index is more than 1 but

less than 3, the weed diversity index in this oil palm plantation is in the medium category. This level of diversity is likely due to various environmental factors and weed control systems used so far in the oil palm plantation, for example the use of various types of herbicides with different concentrations.

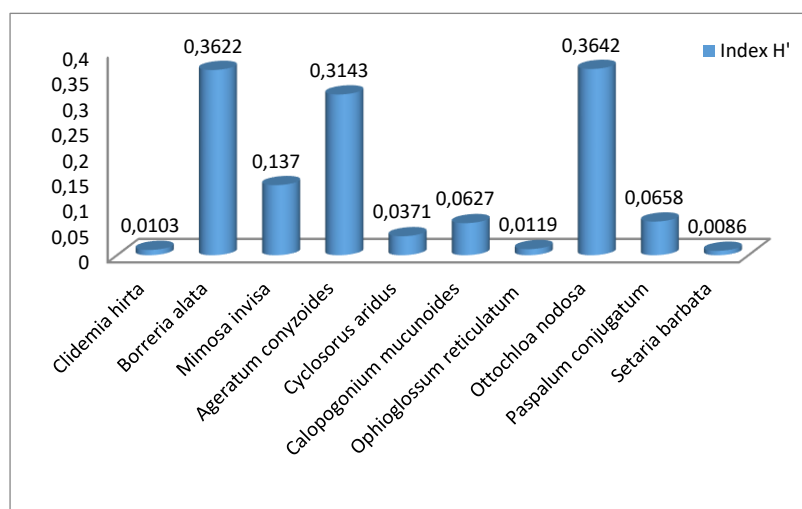


Figure 2. Weed diversity index in oil palm plantations in the village of Pagar Merbau

According to Nkoa et al. (2015), studies on the abundance and distribution of weed populations are very helpful in determining how a population changes over time in response to the selective pressures applied by agronomic practices. Like the use of herbicides, limiting plant diversity in the cropping system. Weed species that are able to withstand this agronomic selective pressure are ecologically well adapted and always become more difficult to manage. In addition, low plant diversity in agroecosystems can cause agroecosystems to be more vulnerable to invasion by new species. Mohamad et al. (2010) argues that there is a positive correlation between the percentage of weeds killed and the reduction in weed growth. An increase in the percentage of weed killings was followed by an increase in the percentage of weed growth reduction, with an indication that weeds began to recover and began to produce shoots 16 weeks after application. Treatments that produce less efficacy cause weeds to grow back and recover faster or in a shorter time. Thus, the distribution of certain weed species with ubiquitous behavior correlates

with local ecological factors. However many species with ubiquitous behavior gather together regardless of various regions (Henri et al., 2017). Such as the coverage, composition, and diversity of weed species in pine forests are controlled by site-specific factors which include absolute height, location, and quadratic aspects on the dune; soil nitrogen, potassium and phosphorus content; soil pH and humidity; light conditions; and the thickness of the horizon (Tilk et al., 2017). Then Sarada et al. (2002) found very high diversity of weed species in mature oil palm plantations and maximum weed species evenness in open conditions. Thus, in addition to the type and dosage of herbicides, a variety of environmental factors (site-specific factors) can affect the level of weed diversity in plantations. In decreasing the level of weed diversity, it is likely that there will be loss of one or more weed species, which play a role in ecosystems and life. Like weed *Mimosa* sp. is a legume species that can be developed in oil palm fields to increase the N content in the soil (Tarsono & Kaswari, 2016). Then *Ageratum conyzoides* can be useful as a drug

(Shrivastava et al., 2016). *Ottlochloa nodosa* is a type of grass commonly eaten by cattle or goats in oil palm plantations, while *Setaria barbata*, besides being often used as cattle feed, can also be useful as a medicinal ingredient.

The level of weed species diversity is not only influenced by the type and concentration of herbicides used, but various factors involved in plantations so that it is not easy to find a method of controlling weeds on plantations to increase growth and production of staple crops, and can also increase diversity of weed species on plantations the. But the role of management in community restructuring and diversity of weed species can be useful in developing weed strategies and management (Golmohammadi et al., 2018). Diversity within weed communities in oil palm plantations can help formulate a sustainable weed management strategy (Samedani et al., 2014). A successful and sustainable weed management system is a system that uses a combination of techniques rather than relying on one method (Abouziena & Haggag, 2016). The single method will not provide adequate long-term weed management, instead it often results in the development of resistance. While on the other hand there is an increasing need to reduce crop losses to feed the increasing human population. Therefore, there is a need to develop an effective and sustainable integrated weed management program (Chauhan, 2020). Integrated weed management includes preventive, mechanical, cultural, chemical and biological methods, recommended in crop production systems and in aquatic and forest ecosystems (Rao & Chauhan, 2015). According to Byrne et al. (2018), crop rotation, cultivation techniques, manipulation of sowing dates and increased crop competition are recognized as useful strategies. Combining these strategies to provide effective grass weed control might be the key to reducing dependence on herbicides. Then Pan et al. (2019) also states that mixed cropping systems have a higher natural capacity to control weeds and their diversity. This can be used as a basis for finding an effective method, which is a combination of several methods in controlling weeds in oil palm plantations, so that it can be a step in balancing the

need for weed control with requirements for biodiversity and sustainable production methods.

Conclusion

Weeds found in oil palm plantations in the village of Pagar Merbau, Tanjung Morawa District, Deli Serdang Regency are 7 families, 10 species, and 3153 individuals. The number of broadleaf weeds is 1776 individuals and 1377 grass weeds. The *Ottlochloa nodosa* weed has the highest Importance Value Index (INP) (66.52) and the *Setaria barbata* weed has the lowest Importance Value Index (1.00). The types of weeds that have the highest diversity index are *Ottlochloa nodosa* and *Borreria alata*, and the lowest are *Setaria barbata*. The level of weed diversity index overall in oil palm plantations in the village of Pagar Merbau was $H' = 1.3741$ included in the medium category. Thus, the oil palm plantations must use integrated methods in controlling weeds so that the diversity index does not decrease.

Author's declaration

Authors declare that there is no conflict of interest.

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