Vegetation Composition and Structure under Mature Oil Palm (*Elaeis guineensis* Jacq.) Stands

Yenni Asbur[1], Yayuk Purwaningrum[1] and Mira Ariyanti[2]
[1]*Departement of Agrotechnology, Faculty of Agriculture, Islamic University of North Sumatra, Jalan Karya Wisata Gedung Johor, Medan 20144, Indonesia.*
[2]*Department of Agronomy, Faculty of Agriculture, PadjadjaranUniversity. Jalan Raya Bandung-Sumedang km.21, Jatinangor, West Java, Indonesia*

Keywords: Analysis of Vegetation, Composition, Structure, Oil Palm.

Abstract: Generally, vegetation under oil palmstands are still considered as weeds or disturbing plants that must be controlled and the benefits are stillbelowestimations. It is necessary to conduct research concerning identification of vegetation and structure composition under oil palmstands which can be used as cover crop by considering its ecological value. The research was conducted in 9, 13, and 18 years old of mature oilpalm plantation in PTPN VII, South Lampung, Indonesia. The study used squares method, measuring 1 mx 1 m,by systematic sampling. Each location used a 1 mx 1 m observation plot withtotal observationsplot is25 plots per location. At each square, it was recorded and counted the type and number of individual weed, and then each type was separated, and dried to calculate the dominant value. The data obtained were analyzed by calculating K, KR, F, FR, D, DR, INP, and SDR. The results showed that there were differences of composition and vegetation type under9,13, and 18 years old of oil palmstandsand thebiodiversity was classified as high to very high.

1 INTRODUCTION

Generally,matureoil palmestatewas characterized by humid and sheltered environment. Legumeswhich are usedas cover crops for young oil palm tree is intolerant to shadeso that when the canopy begins to cover each other, the legumes will be replaced naturally by vegetation that is tolerant to shade and low soil fertility, such as *Asystasiagangetica*, *Nephrolepisbiserrata*, *Mikaniamicrantha*, *Axonopuscompressus*, *Cytococcum* sp., *Paspalumconjugatum* and others.

Vegetation under tree stands is an important component in forest and plantation ecosystems; therefore, its role must be taken into account. Vegetation under tree stands is a cover crops layer that consists of herbs, shrubs, lianas and ferns. In the forest ecology, basic vegetation is the strata that is quite important to support the life of other plant species (Manan, 1976).

Generally,in oil palm estate, vegetation under oil palm stands is called weed; therefore, it must be controlled. However, according to the principles and criteria of Roundtable Sustainable Palm Oil (RSPO) and Indonesia Sustainable Palm Oil (ISPO), especially in the sense of environmental responsibility, natural resources conservation, biodiversity as well as technical guidance application of oil palmcultivation and processing with respect to soil conservation and water (PusatInformasiKelapaSawit, 2013), theweeds underoil palm stands should be managed wisely by utilizing them as cover crops,as part of soil and water conservation.

Some researches indicate that vegetation under oil palm stands have important roles in returning nutrients to the soil, reducing surface erosion, reducing nutrient losses, and increasing soil carbon stocks. Maswar(Maswar,2009) shows that each vegetation biomass under oil palmstands contribute to return carbon to the soil as carbon stocks ranging from 8.0-10.4 t C/ha.

Asburet al. (Asburet al.2014; 2016) and Ariyantiet al. (Ariyanti et al.2017) showed that *Asystasiagangetica*(L.) T. Anderson within 30 days can be decomposed by 90.0% -96.6% and contained several nutrients such as N, P, K, effectively reduce erosion and N, P, K nutrient loss, and able to

Asbur, Y., Purwaningrum, Y. and Ariyanti, M.
Vegetation Composition and Structure under Mature Oil Palm (Elaeis guineensis Jacq.) Stands.
DOI: 10.5220/0008888302540260
In *Proceedings of the 7th International Conference on Multidisciplinary Research (ICMR 2018)* - , pages 254-260
ISBN: 978-989-758-437-4

increase the availability of groundwater in the dry season. Ariyantiet al. (Ariyanti et al.2016) also shows that *Nephrolepisbiserrata*Kuntze effectively reduces water loss due to percolation and runoff. In addition, *N. biserrata* also effectively increases water availability in oil palmplantation during the dry season based on its water balance.

Generally, vegetation under oil palmstands are still considered as weeds or disturbing plants that must be controlled and the benefits arestill below estimations. It is necessary to conduct research concerning identification of vegetation and structure composition under oil palmstands which can be used as cover crop by considering its ecological value.

2 MATERIALS AND METHODS

The research was conducted on 9(TM-6), 13(TM-10), and 18(TM-15) years old of mature oil palm plantationat RejosariBusiness Unit, PTPN VII,Natar District,South Lampung, Indonesia.

The study usesquares method, measuring 1 mx 1 m,by systematic sampling(Oosting, 1948). Each location used a 1 mx 1 m observation plot withtotal observationsplot is25 plots per location.

Measurement of abiotic environment was conducted before vegetation analysis. Such measurement is light intensity, temperature and humidity in each experimental site using multimeter tool (modified by AgungYogaswara).Such preliminary observation was conducted to collect the general description of the research site and the oilpalm plantation.

At each square, it was recorded and counted the type and number of individuals weed, then each type was separated, and dried to calculate the dominant value. The data obtained were analyzed by calculating the density (K), relative density (KR), frequency (F), relative frequency (FR), dominance (D), relative dominance (DR), Important Value Index (INP), and Summed Dominance Ratio (SDR). The formula is as follow:

$$K = \frac{\text{Number of individu}}{\text{Sampling Area}} \quad (1)$$

$$KR = \frac{\text{Density of a Type}}{\text{Density of All Type}} \text{x } 100\% \quad (2)$$

$$F = \frac{\text{Number of observation plot for a type}}{\text{Total Observation Plot}} \quad (3)$$

$$FR = \frac{\text{Frequency of a type}}{\text{Frequency of All Type}} \text{x } 100\% \quad (4)$$

$$D = \frac{\text{Dry weight of a type}}{\text{Individul number of a type}} \quad (5)$$

$$DR = \frac{\text{Dominance of a type}}{\text{Dominance of All type}} \text{x } 100\% \quad (6)$$

$$INP = KR + FR + DR \quad (7)$$

$$SDR = \frac{INP}{3} \quad (8)$$

Diversity and stability of each area can be calculated using the Shannon Diversity Index. Shannon's diversity index can be calculated using the Ludwig and Reynold equation (Ludwig and Reynold,1988):

$$H' = -\sum_{i=1}^{s} (pi) \ln p \quad (9)$$

Where: H': Diversity Index; Pi: INP / N; INP: Important Value Index Type i; N: Number of Important Value Indexes of All Types.

Data on weed vegetation structure were analyzed quantitatively among three age groups (9, 13, and 18 years).

3 RESULTS AND DISCUSSION

According to the result of vegetation analysis on 9, 13 and 18 years old of oil palm plantation, it is known that the vegetation composition is not much different (Table 2).

Table 2 shows that there is a difference in vegetation composition under 9, 13 and 18 years old of oil palmstands.In 9 years old, there are 5 types of ferns, 15 species of broadleaf, 11 species of grasses and 1 type of nutgrass. In 13 years old, there are 7 types of ferns, 24 species of broadleaf, 16 types of grasses and 1 type of nutgrass. In 18yearold oil palm, there are 9 types of ferns, 25 broadleaf species, 13 species of grasses and 1 type of nutgrass. However, the similarities of all ages are the dominance of broadleaf species.Soenarsono and Sarangih (Soenarsono and Sarangih,1988) stated that common vegetation found under oil palmstands is mixed vegetation of ferns, broadleaves, grasses, and nutgrass, but dominated by broadleaves species.

According toAfrianti et al. (Afrianti et al.2015), broad-leaved vegetationis found dominant in3-7 years old of oilpalm estate in Rokan Hulu. However,Adriadiet al. (Adriadiet al.2012); Putrie and Praman (Putrie and Praman,2017) found that in 8-yearold of oil palmestate in Kilangan, MuaroBulian, BatangHari and in Petai village, SingingiHilir, KuantanSingingi, the dominant species are grasses.

In these 9, 13, and 18 years of oil palm estate, the most dominant vegetation is *Nephrolepisbiserrata*Kuntze of ferns type with density 23.5 individuals/m^2, 24.4 individuals/m^2, and

40.7 individuals/m^2respectively. Other dominant species are broadleaves speciesof*Asystasiagangetica* (L.) T. Anderson, namely 28.8 individuals/m^2, 17.2 individuals/m^2, and 18.8 individuals/m^2, respectively. Other dominantspecies are*Paspalumconjugatum* Berg with a density of 15.0 individual/m^2, 24.9 individual/m^2, 30.9 individual/m^2 respectively.

N. biserrata is a fernspecies originating from Tropical Asia (Old World Tropics) (Burkill, 1966). This plant has a smooth and scaly leaf surface, 2 cm length and width of 1 cm. The leaf shape pushes and the end is split, while the leaf edge is serrated. The size of the fertile leaves (spore) is larger than the sterile leaves (nospore). In Indonesia, *N. biserrata* is easy to find in plantations, especially in oil palm. This plant is easy to adapt because epiphytic, and it has dry resistance and creeping rhizome (Putri, 2012).*N. biserrata* can also be found in highlands, dry areas such as deserts, watery or swampy areas and shady forests (Efendi, 2009).

Besides*N. biserrata*, the other dominant vegetation, is *Asystasiagangetica* (L.) T. Anderson. *A. gangetica*is a perennial plant originating from Africa, Arabia (Adetula, 2004), India (Holm *et al*., 1977) and first introduced to Malaysia in 1876 and 1923 as ornamental plants (Wiart, 2000). In contrast to *N. biserrata, A. gangetica*is invasive weeds in oil palm plantationdue to its ability to produce large quantities of seeds, which are estimated 27 million seeds per hectare (Priwiratama, 2011), catapulted as far as 6 m (Adetula, 2004), and easy to germinate that itcan quickly dominate the land. New plants can also grow from the stem base when touching the ground (Priwiratama, 2011), and within 6 weeks already flowering and produce seeds (Adetula, 2004).

Paspalumconjugatum is a weed-grass found in plantation, and as animportant weed on some crops (Adriadiet al., 2012).*P. conjugatum* is perennial grass, spread rapidly above ground level with a distance of 5-15 cm, each plant produces roots and leaf buds with a height up to 30 cm. Such grass has a soft, deep green bar with a width of 1 cm and a length up to 20 cm, hairy on both surfaces, and wrinkled edges. There is a ligula, that is a very short membrane with a length of less than 1 mm with a long rim of hair behind it. According to Holm et al. (Holm et al. 1977), an individual *P. conjugatum* can produce 1,500 seeds that spread easily and germinate immediately. The original habitat is forests and forest edges in humid tropics, but now found in many plantations and other annual croplands. *P. conjugatum*is grown well in full sunlight and tolerant to partial shade, as well as tolerance to poor acid soils (Cabi, 2018).

The data analysis showsvegetation structure under oil palm stands based on relative density (KR), relative frequency (FR), relative dominance (DR), important value index (INP) and Summed Dominance Ratio (SDR) of the 10 dominant vegetation types for each year of oil palm(Table 3).

In the 9, 13, and 18 years old of oilpalm plantation, there are two vegetation types with the highest SDR values namely *Nephrolepisbiserrata*Kuntze (19.6%, 18.7%, and 25.9%), and *Asystasiagangetica* (L.) T. Anderson (16.5%, 9.2%, and 8.9%), respectively.Vegetation with the lowest SDR values is different from each age of palmoil. In the 9 year old of oil palm, the lowest SDR values were *Mucunacochinsinensis* (0.1%), while in 13 years old is *Hyptisrhomboidea* Mart. and Gal. (0.2%), and 18 years old is *Urenalobata* L. and *Passiflorafoetida* L. (0.3%). This shows that *N. biserrata* and *A. gangetica* are most dominant among other species in this oil palm plantation.

In the three different ages, *N. biserrata* and *A. gangetica*has higher relative density, relative frequencies and relatively dominance than other vegetation, because the twospecies have the largest number of individuals and always found in every plot and its wide spread. In turn, *N. biserrata* and *A. gangetica* have the highest INP and SDR.

Besides*N. biserrata* and *A. gangetica*, other vegetations that havehigh relative density, relative frequencies and relatively dominance in each of oil palm plantationare*S. indica., P. conjugatum, A. compressus, S. spontaneum, S. plicata, A. cuneatum, A. tenerum,* and *E. hirta*at 9yearold oil palm plantation; *S. indica, O. compositus, A. compressus, B. mutica, S. spontaneum, E. hirta,* and*C. hirta*at 13 years old; and *P. conjugatum, S. indica, C. oxyphyllum, S. spontaneum, C. hirta, A. compressus, O. nodosa,* and*O. barrelieri*at 18 yearsold.

Shannon diversity index is divided into several criteria, namely H> 3.0 (very high), H = 1.5-3.0 (high), H = 1.0-1.5 (moderate), and H <1 (low) (Margurran, 2004). Accordingly, the biodiversity index (H') in 18 and 13 years old of oil palm plantationfor all weeds is 3.1 and 3.2 (very high), and 2.9 (high) in 9 years old. Adriadi et al. (2012) confirm such a finding for oil palmplantation in Kilangan, MuaroBulian, Batang Hari which shows the index of biodiversityis also high, ie 3.14. Thebiodiversity value of an organism depends on the large number of individuals found in the community (Odum, 1996).

Abiotic environmental factors in different ages of palm oil estate are presented in Table 1. The diversity of vegetation species grown in palm oil is influenced by the growing environment. Sastroutomo (1990) explains that vegetation species that grow in one place and another place will be different, either on the same or different plantation, because the vegetation will adapt to the appropriate environmental conditions for its growth.

Table 1: Measurement data of abiotic environmental factors in different ages of oil palmlplantation, RejosariBusiness Unit, PTPN VII,Natar District, Regency of South Lampung.

Environmental factors	Age (Year)		
	9	13	18
Temperature (°C)	25.2-30.0	25.4-27.3	25.2-29.1
Light intensity (lux)	926.1-1054.0	974.2-985.4	675.4-843.1
Air humidity (%)	59.2-70.4	71.4-77.1	60.2-62.0
Soil humidity (%)	51.2-55.3	55.1-60.0	51.3-58.1

Table 1 shows that the abiotic environment in the palm oil plantation is already shaded with humidity above 50% and low light intensity. This shows that *N. biserrata* and *A. gangetica* are shade tolerant vegetation, because higher SDR values than other vegetation (Table 3).

Abiotic environmental conditions are also associated with optimum growingrequirement for vegetation that grows well at such conditions, including *A. gangetica*. According to vegetation analysis in Table 2,*A. gangetica* is a vegetation that grows well in mature oilpalmstands, either 9, 13, and 18 years old. Although the density of *A. gangetica* is the highest in the stands of 9 year old, *A. gangetica* is still able to grow well in oil palm stands aged 13 and 18 years. This indicates that *A. gangetica* is able to grow well in a shaded condition. Such a character makes A. *gangetica*able to be used as cover crop in matureoil palm plantations.

4 CONCLUSIONS

There is different vegetation composition under 9, 13, and 18 years old of oil palmstands but dominated by broadleaves vegetation.

According to SDR value, the vegetation structure under 9, 13 and 18 years old of oil palm stands is dominated by *Nephrolepis biserrata* Kuntze, *Asystasia gangetica* (L.) T. Anderson, *Paspalum conjugatum* Berg., *Stachytarpheta indica* (L.) Vahl., *Saccarum spontaneum*, and*Axonopus compressus*.

The biodiversity of vegetation under 9, 13 and 18 years old of palm oil stands is fall in high to very high (2.93-3.23).

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APPENDIX

Table 2: Vegetation composition under different age of oil palmstand,Rejosari business unit, PTPN VII, Natar district, Regency of South Lampung.

No.	Family	Species	Density per m^2		
			9years	13 years	18years
			……..……individu/m^2……..……		
	Ferns				
1	Nephrosidaceae	*Nephrolepis biserrata* Kuntze	23.5	24.4	40.7
2	Athryoideae	*Diplazium esculentum*	-	0.2	1.0
3	Licopodiaceae	*Licopodium seanum*	-	-	1.1
4	Athryoideae	*Diplazium asperum*	-	-	1.2
5	Thelypteridaceae	*Cyclosorus aridus*	0.8	1.3	0.9
6	Ophioglossaceae	*Ophioglossum reticulatum*	0.5	0.9	0.6
7	Gleicheniace	*Dicranapteris linearis*	-	-	1.2
8	Woodsiaceae	*Atryrium sorzogonense*	-	-	0.5
9	Dicksoniaceae	*Dicksonia blumei*	-	0.2	0.7
10	Adiantaceae	*Cheilanthes tennifolia*	-	0.3	-
11		*Adiantum tenerum*	3.1	-	-
12	Aspleniaceae	*Asplenium cuneatum*	1.8	0.2	-
	Broadleaf				
1	Acanthaceae	*Asystasia gangetica* (L.) T. Anderson	28.8	17.2	18.8
2		*Emilia sonchifolia* L.	-	-	0.5
3	Asteraceae	*Chromolaena odorata* (L.)	-	0.6	2.0
4		*Mikania micrantha*	2.1	1.9	2.1
5		*Elephantopus tomentosus* L.	-	-	0.2
6		*Clibadium surinamense* L.	-	0.3	-
7		*Ageratum conyzoides* L.	4.3	3.5	-
8		*Crassocephalum crepidioides*	-	0.2	-
9	Verbenaceae	*Stachytarpheta indica* (L.) Vahl.	10.4	12.0	6.2
10		*Lantana camara* L.	0.5	-	0.6

No.	Family	Species	Density per m^2		
			9years	13 years	18years
			……..……individu/m^2……..……		
11	Euphorbiaceae	*Croton hirtus* L. Herrit	0.8	0.6	1.7
12		*Euphorbia hirta L.*	2.2	5.0	2.2
13		*Phyllanthus niruri L*	0.4	0.8	0.8
14		*Euphorbia heterophylla* Jacq	-	0.7	1.0
15	Convolvulaceae	*Ipomoea spp*	-	-	1.2
16	Oxalidaceae	*Oxalis barrelieri* L.	1.4	2.4	3.3
17	Melastromataceae	*Clidemia hirta* Don.	3.4	4.8	6.2
18	Leguminoceae	*Pueraria triloba*	-	-	0.4
19		*Mucuna bracteata*	1.8	1.1	-
20		*Mucuna cochinsinensis*	0.1	-	-
21		*Pueraria javanica*	-	0.4	-
22	Rubiaceae	*Borreria latifolia*	-	0.7	0.8
23		*Borreria laevis* (Lamk) Griseb.	1.0	0.6	0.4
24	Labiatae	*Hyptis brevipes* Poit.	-	-	0.4
25		*Hyptis rhomboidea* Mart. & Gal.	-	0.2	-
26	Passifloraceae	*Passiflora foetida* L.	-	0.7	0.3
27	Capparidaceae	*Cleome rutidosperma* DC.	2.5	0.7	2.1
28	Mimosaceae	*Mimosa pudica* Linn.	-	0.2	0.6
29		*Mimosa invisa* Mart.	-	-	0.1
30	Malvaceae	*Sida rhombifolia* L.	-	0.2	0.2
31		*Urena lobata* L.	-	-	0.2
32		Semaian liar kelapa sawit/tukulan	-	0.8	0.8
33	Melastomaceae	*Melastoma malabathricum* L.	1.7	2.4	-
	Grass				
1	Gramineae	*Ottochloanodosa* (Kunth.) Dandy	3.5	3.6	8.1
2		*Saccarumspontaneum*	7.0	11.0	14.2
3		*Cyrtococcumacrescens* (Trin.) Stapf	-	3.5	3.4
4		*Cyrtococcumoxyphyllum*Stapf	-	4.4	17.7
5		*Oplismenuscompositus* (L.) Beauv.	-	20.9	1.2
6		*Axonopuscompressus* (Swartz) Beauv.	12.8	12.4	7.1
7		*Paspalumconjugatum* Berg.	15.0	24.9	30.9
8		*Digitariaadscendens* (HBK) Henr.	-	-	1.5
9		*Digitariasetigera*	-	-	0.8
10		*Setariaplicata* (Lamk) T.Cooke	7.0	11.1	1.7
11		*Setariabarbata*(Lam.) Kunth.	0.4	0.5	-
12		*Sporobolusdiander*(Retz.) Beauv.	-	0.3	-
13		*Paspalumcommersonii*Lamk	-	0.9	2.1
14		*Brachiarapaspaloides*	-	-	0.7
15		*Brachiariamutica*	-	9.6	-
16		*Brachiariadistachya*Linn.	1.7	6.9	-
17		*Cynodondactylon* (L.) Pers.	0.5	0.2	3.0
18		*Dactylocteniumaegyptium*(L.) Richt.	-	0.2	-
19		*Eleusineindica (*L.) Gaertn.	1.0	1.4	-
20		*Imperatacylindrica* L.	4.5	-	-
21		*Chentothecalappacea*(L.) Desv.	5.1	-	-
	Nutgrass				
1	Cyperaceae	*Cyperuskyllingia*Endl.	2.6	4.2	6.7

Table 3: Ten vegetation species with high SDR (Summed Dominance Ratio) under different age of oil palmstand,Rejosari business unit, PTPN VII, Natar district, Regency of South Lampung.

No.	Species	KR (%)	FR (%)	DR (%)	INP (%)	SDR (%)
	9 Years					
1	*Nephrolepisbiserrata*Kuntze	15.4	5.5	37.9	58.9	19.6
2	*Asystasiagangetica* (L.) T. Anderson	18.9	5.3	25.2	49.5	16.5
3	*Stachytarphetaindica* (L.) Vahl.	6.8	5.0	8.5	20.3	6.8
4	*Paspalumconjugatum* Berg.	9.8	4.8	1.8	16.4	5.5
5	*Axonopuscompressus*	8.4	4.1	3.3	15.8	5.3
6	*Saccarumspontaneum*	4.6	4.8	0.6	10.0	3.3
7	*Setariaplicata (Lamk)* T.Cooke	4.6	4.6	0.4	9.6	3.2
8	*Aspleniumcuneatum*	1.2	3.6	4.3	9.1	3.0
9	*Adiantumtenerum*	2.1	3.1	3.2	8.3	2.8
10	*Euphorbia hirta*L.	1.4	4.3	2.2	7.9	2.6
	Diversity Index (H′) = 3.1 (very high)					
	13 Years					
1	*Nephrolepisbiserrata*Kuntze	12.1	4.3	39.7	56.1	18.7
2	*Asystasiagangetica* (L.) T. Anderson	8.5	4.1	15.1	27.7	9.2
3	*Stachytarphetaindica* (L.) Vahl.	5.9	3.7	9.9	19.6	6.5
4	*Paspalumconjugatum* Berg.	12.4	3.9	3.0	19.3	6.4
5	*Oplismenuscompositus (L.) Beauv.*	10.4	4.1	1.6	16.1	5.4
6	*Axonopuscompressus*	6.2	3.9	3.2	13.3	4.4
7	*Brachiariamutica*	4.7	3.4	2.9	11.0	3.7
8	*Saccarumspontaneum*	5.5	3.5	0.9	9.9	3.3
9	*Euphorbia hirta*L.	2.5	2.2	4.0	8.7	2.9
10	*Clidemiahirta*Don.	2.4	3.7	2.3	8.4	2.8
	Diversity Index (H′) = 3.2 (very high)					
	18 Years					
1	*Nephrolepisbiserrata*Kuntze	20.3	4.1	53.2	77.6	25.9
2	*Asystasiagangetica* (L.) T. Anderson	9.4	4.1	13.4	26.8	8.9
3	*Paspalumconjugatum* Berg.	15.4	4.1	3.0	22.5	7.5
4	*Cyrtococcumoxyphyllum*Stapf	8.8	3.9	0.6	13.3	4.4
5	*Saccarumspontaneum*	7.1	3.5	0.9	11.5	3.8
6	*Clidemiahirta* Don.	3.1	3.9	2.5	9.4	3.1
7	*Stachytarphetaindica* (L.) Vahl.	3.1	4.1	2.1	9.3	3.1
8	*Axonopuscompressus* (Swartz) Beauv.	3.6	3.7	1.5	8.7	2.9
9	*Ottochloanodosa* (Kunth.) Dandy	4.1	3.0	0.3	7.4	2.5
10	*Oxalis barrelieri*L.	1.6	3.3	1.7	6.6	2.2
	Diversity Index (H′) = 2.9 (high)					