Available online at:
http://journal.unila.ac.id/index.php/tropicalsoil
DOI: 10.5400/jts.2023.v28i1.17-22

Characteristics of Peat with Different Depths in Supporting Growth and Productivity of Oil Palm

Ida Nursanti*, Hayata and Bangun

Fakultas Pertanian Universitas Batanghari, Jl.Slamet Riyadi, Jambi-36121, Indonesia
**e-mail: ida_unbari@yahoo.co.id*

Received 24 October 2022, Revised 24 November 2022; Accepted 05 December 2022

ABSTRACT

The potential for oil palm production on peatlands is very diverse; different types of peat, maturity, and depth significantly influence yields. This study aims to determine the characteristics of peat with different depths in supporting the growth and productivity of oil palm. The research was conducted at the PT Kaswari Unggul Palm Oil Plantation in Jambi Province using laboratory surveys and test methods. Observations done were Plant height, Number of Fresh Fruit Bunches (FFB), Stem Circumference, FFB Weight, Midrib Length, Palm Oil Productivity, Light Intensity. Soil analysis were available-P, total-Fe-, total N, organic-C and CEC, pH, Al-exchange, total-K, Soil Moisture, and Peat Maturity. In shallow peat, the soil is more completely decomposed and provides nutrients that can be absorbed by plants so that plants grow better. The results showed that the shallow peat has a maturity level of sapric peat (very ripe) and peat in hemic maturity (slightly mature). Also, the depth of peat will affect the value of total-N, pH, available-P, and K-exchange and does not affect organic-C, total-Fe, CEC, and Al-exchange. Moreover, the growth and production of oil palm on shallow peat were better than on deep peat.

Keywords: Palm oil growth, peat depth, production

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is the leading commodity of Indonesian plantations. Palm oil significantly contributes to the Indonesian economy through private companies, state-owned companies, and smallholders, supplying 85% of global palm oil. Indonesia has 14 million hectares of oil palm (Purnomo et al., 2020). Oil palm is a plant with a wide adaptation distribution, can grow in various agroecosystems, and provides production potential ranging from dry land (Ultisol, Inceptisol, Oxisol) to the soil that develops in tidal swamp agroecosystems into peat and acid sulfate (Pahan, 2008).

Jambi Province is a province that has the third largest peatland on the island of Sumatra. The area of peatland in Jambi province reaches 736,227.20 ha or 14% of the total area of Jambi province, which is spread over six regencies, Tanjung Jabung Timur Regency covering an area of 311,992.10 ha, Muaro Jambi Regency covering an area of 229,703.90 ha, Tanjung Jabung Barat Regency covering an area of 154,598 ha, Sarolangon Regency covering 33,294.20 ha, Marangin Regency covering an area of 5,089.80 ha, and Tebo Regency covering an area of 829.20 ha. (Nurjanah et al., 2013)

The success of the development of plantation crops on peatlands is strongly influenced by the physical and chemical conditions of the peat soil, including the thickness of the peat that is allowed to be reclaimed for agricultural/plantation land < 400 cm; low fertility rates, both macro, and micro; and the level of soil acidity is relatively high, pH <3.5 (very acidic), with a relatively high organic acid content. (Agus et al., 2014; Inisheva 2006; Wösten et al., 2008)

Regarding soil fertility, peat is very diverse, and the nature and character of the soil are strongly influenced by the soil chemical, physical and biological properties. Soil chemical characteristics and characteristics on peatlands include very low/acidic pH of peat soil, low availability of macro and microelements, except for available P and Fe (high) and total N content (medium), cation exchange capacity (CEC) and low base saturation (BS). The limiting factor of this peat soil is its low fertility. The decomposition of lignin-rich woody material in peat soils occurs under anaerobic conditions, producing aliphatic and phenolic acids where most of these acids are toxic to plants (Agus et al., 2020; Middleton et al., 2012; Nurulita et al., 2016; Septiyana et al., 2017)

Classified peat into three levels of fertility based on the content of P_2O_5, CaO, K_2O, and ash content, namely; (1) eutrophic peat with high fertility with P_2O_5 > 0.25%, CaO > 4.0%, K_2O > 0.10%, and ash > 0.25%; (2) mesotrophic peat with moderate fertility with P_2O_5 0.20-0.25%, CaO 1-4.0%, K_2O 0.10%, and ash 0.20-0.25%; (3) oligotrophic peat with low fertility with P_2O_5 content of 0.05-0.20%, Ca0 0.25-1%, K_2O 0.03-01%, and ash 0.05-0.20% (Hartatik et al. 2011).

Oil palm can grow well in soils characterized by a low pH and a sulfate horizon, overlying sulfide material, mostly pyrite (FeS_2) if proper water management practices are followed (Shamshuddin et al., 2014). Oil palm plantations on the peatland can produce FFB 20.25-23.74 Mg ha^{-1}, according to Soewandita (2018) type of peat has a significant effect on the production of palm oil, ranging from 9.47 - 22.92 Mg ha^{-1}. Mature peat has an effect most significant on the results, saprik peat showed different results between 19.48 - 22.92 Mg ha^{-1} compared to hemic peat, which ranged from 9.47 - 13.37 Mg ha^{-1}.

The productivity of oil palm plantations in Malaysia shows yields for shallow peat of 19.1 Mg ha^{-1}, 16.5 Mg ha^{-1}on medium peat, and 11.9 Mg ha^{-1} on deep peat (Pahan, 2008). Winarna et al. (2017) reported that the productivity of oil palm plantations on sabrik peatland could reach 22 Mg ha^{-1} if appropriately managed.

The research by Veloo et al. (2015) found that different peat types significantly affected oil palm yields. Peat maturity has the most crucial influence on yield. Sapric peat showed a yield range of 19.48-22.92 t ha^{-1} compared to hemic peat, which ranged from 9.47-13.37 Mg ha^{-1}. The potential for oil palm production on peatlands is generally low and very diverse; therefore, it is necessary to study the growth and production of oil palm (*Elaeis guineensis* Jacq.) at different peat depths in an area.

MATERIALS AND METHODS

This research was carried out at the PT Kaswari Unggul Oil Palm plantation, which is located in Dendang District, East Tanjung Jabung Regency, Jambi Province, from January to March 2021. Soil samples were analyzed in the Jambi Agricultural Technology Study Center laboratory.

The tools and materials used are maps, meters, peat drills, lux meters, Leaf Color Charts, cameras, GPS (Global Positioning Sistem), soil Moist pH meters, oil palm scales, stationery, oil palm plant variety D x P SP 2 aged 17 years old uniform planted in peat areas with a depth of 0-100 cm and 0-300 cm.

The experimental design was carried out unformatted (Unformatted Trials), and the location was chosen intentionally (purposively) because, at that location, there were plants under study and were uniform. Determination of sampling locations based on differences in peat soil depth, namely:

P1: Depth 100 cm (1 m)

P2: Depth 300 cm (3 m)

A preliminary survey conducted that the area contains 300 ha of shallow peat (0-100 cm) and 200 ha of deep peat (0-300 cm) blocks in the form of blocks are limited by drainage channels (canalization) with a water level of 60 cm. At this stage, the field's observation points are determined based on map analysis. The sample point consists of 3 points. Each point is determined using GPS (global positioning system). The distance between the first point and the drainage channel is 50 meters. The distance between the first point and the next point is 100 meters. The peat soil depth measurement at each location was drilled using a peat drill from the top layer to the mineral soil layer. The land (block) chosen as the sampling site was peat with a depth of (0-100 cm) and (0-300 cm).

Sampling in this study uses the Systemic Sampling method. The location of the sampled plants was recorded at the coordinates and altitude of the place using GPS. The data were analyzed using tabulation and methods of inference method data paired t-test with a standard of 5%. If the plant population is more than 100, the sample plants are taken 15%, while if the plant population is less than 100, the sample plants are 50%.

Observations consisted of Plant height (cm), Number of Fresh Fruit Bunches (FFB), Stem Circumference (cm), FFB Weight (kg), Midrib Length, Palm Oil Productivity (ton ha^{-1}), and Light Intensity. Soil analysis consists of; Available P (Bray-I), Fe-total (diethylene triamine penta acetic acid extract), total N (Kjeldahl), organic-C (Walkley Black), and CEC (NH_4OAc pH 7 titration), pH H_2O (1:1) electrometric method, Al- exchange (N KCl titration), total-K, Soil Moisture, and Peat Maturity (Von Posh Scale Test).

RESULTS AND DISCUSSION

The results of data analysis from observations of oil palm plantations from different peat depths are listed in the following table. Based on Table 1 shows that the plant height of oil palm cultivated on

Table 1. The average value of oil palm variables at different peat depths.

No	Description	Peat Depth		p-value
		P1 Shallow (100 cm)	P2 Deep (300 cm)	
1	Plant Height (cm)	703.3	617.3	0.001*
2	Stem Circumference (cm)	205.0	195.9	0.112
3	Midrib length (cm)	635.3	633.3	0.856
4	Number of Bunches	3.4	3.6	0.364
5	Bunch Weight (kg)	17.4	15.2	0.031*
6	Palm Oil Productivity (Mg ha^{-1})	21.7	19.7	

Note: *Significantly different $p < 0.05$

shallow peat was significantly different from the plant height on deep peat. The weight of oil palm bunches cultivated on shallow peatlands significantly differs from that of bunches on deep peatlands. The results of observations on stem circumference, midrib length, and the number of bunches were not significantly different at different conditions in the peat. Oil palm productivity was 21.7 Mg ha^{-1} on shallow peatlands and 19.7 Mg ha^{-1} on deep peatlands.

The results of observations on the light intensity on shallow peatlands were 733.3 (lux), not significantly different from the light intensity on deep peat, which was 780 (lux). Meanwhile, the soil moisture for shallow peatlands was 69.7%, significantly different from that for deep peatlands, which was 76.5%.

From Table 2, the results of soil observations showed that the level of peat maturity in Shallow Peat was in the Saprik type, namely mature peat, and Inner Peat was in the Hemic peat type, namely semi-ripe peat. Shallow peat maturity is saprik H8, while deep peat is Hemik H7. These results are based on the Von Posh Scale Test. Von Post Humification Scale for measurement of the degree of decomposition of dead plant matter, sing parameters such as fibre integrity, color and viscosity of exudate, and presence of colloidal particles, it creates a descriptive framework across a wide range of organic soils. It assigns a numerical value from 1 (undecomposed) to 10 (colloidal). The USDA / FAO compressed von Post's 10 steps into three levels (fibric, hemic, and sapric). H7 has decomposed peat containing much amorphous material with a faintly recognizable plant structure. H8 was a highly decomposed peat with a large amorphous material and indistinct paln structure. Kirana et al. (2016) state that on Sumatran peatlands, hemic (deep) peat and sapric (shallow) peat were found. Based on the decomposition level of peat, hotspot clusters are primarily found in 'hemic' peat land maturity level, and land uses a type of swamp forest.

Peat depths will get different total-N, pH, P Bray 1 (available-P), and K-dd soil. At a depth of shallow

Table 2. Peat maturity rate.

No	Coordinate	Depth	Maturity	Description
1	S=01.28044° E=103.88228°	100 cm	Saprik	H9
2	S=01.28409° E=103.86514°	100 cm	Saprik	H8
3	S=01.28333° E=103.86533°	100 cm	Saprik	H8
4	S=01.28792° E=103.85954°	300 cm	Hemik	H7
5	S=01.28915° E=103.85953°	300 cm	Hemik	H7
6	S=01.28849° E=103.85955°	300 cm	Hemik	H7

Note: S: South, E: East, H: Humification

Table 3. The results of Peat Soil Analysis on total-N, Available-P, CEC, pH, organic-C, K- exchange, Al-exchange and total-Fe.

Peat Depth	Total-N (%)	Organic-C (%)	Available- P (mg kg^{-1})	pH	Total-Fe (%)	CEC (cmol(+) kg^{-1})	Al-exchange (cmol(+) kg^{-1})	K-exchange (cmol(+) kg^{-1})
P1 shallow peat (100 cm)	0.19m	13.28h	23.3m	5.5a	12.86m	11.6h	0.99 l	0.14 l
P2 deep peat (300 cm)	0.10 l	11.99h	27.60h	4.0va	8.43m	18.85h	0.52 l	0.04vl

Lowercase letters in each column indicate the criteria for assessing soil properties (LPT 1983) l: low, m: medium, h: high, va: very acid, a: acid, vl: very low.

peat, the total N is in the medium criteria and lower when compared to the Deep peat in the low criteria. Shallow peat has lower P availability (medium criteria) when compared to deep peat (high criteria). The pH for shallow peat is acidic; while for deep peat, it is very acidic. K-exchange is at low criteria in shallow peat and very low in deep peat (Table 3).

The peat soil had a very high organic matter content, and the low total concentration of exchangeable cations (Ca, Mg, K, Cu, and Zn) indicate that peat exchange sites are dominated by acidic cations (H^+, Al^{3+}, and Fe^{2+}). Soil available P, exchangeable K^+, Mg^{2+}, Ca^{2+}, $Cu^{2+,}$ and Zn^{2+} were all low, which could be due to rapid uptake by plants at the site, as reported by Hashim et al. (2019). A reported range for NH^{4+} and NO^{3-} is not available.

From the soil analysis in Table 3, it can also be seen that there was no difference in organic-C, total-Fe, CEC, and Al-exchange at different depths of peat. Organic-C is in high criteria, total-Fe is in medium criteria, and K—exchange is in low criteria. From the research results on two different land conditions, the productivity of FFB (Fresh Fruit Bunches) on shallow peat is higher than on deep peat. The productivity of FFB in shallow peat is 21.71 Mg ha^{-1}, while deep peat is 19.69 Mg ha^{-1}. The difference is presumably because the physical and chemical properties of the soil are very different. Shallow peat is classified as sapric peat, which has a higher maturity level than deep peat, Hemic, and semi-ripe peat. In shallow peat, the soil is more fully decomposed/mature and provides nutrients that can be absorbed by plants so that plants grow better. According to Holding and Streich (2013), the increased vegetative growth of plants will affect the increased absorption of nutrients and water by plants, and the rate of photosynthesis of plants also increases so that more photosynthate is produced. Therefore more nutrients are absorbed by plants, and plants absorb more and more nutrients. Many photosynthates accumulating in roots, stems, and leaves will affect crop yields.

Shallow peat maturity is sapric maturity, while deep peat has hemic maturity; this aligns with the opinion (Nuria et al., 2016) the more profound the peat layer, the higher the humidity, maturity, and maturity and ash content, and lower soil fertility. It causes the growth and production of palm oil to be not optimal.

At PT. Kaswari Unggul setting of the water level has been done well. Ditches in each block as production evacuation access and overflow channels remove and regulate the water level so that flooding does not occur in the rainy season and does not recede in the dry season. Efforts to increase production by fertilizing two rotations in one year on shallow peat soil and deep peat with the same type and dose of fertilizer, namely, dolomite as much as 1 kg plant^{-1}, NPK fertilizer as much as 3 kg plant^{-1}.

The growth of stem circumference and height of oil palm plantations on shallow peatlands is better than on deep peatlands; this can be caused by higher soil N-total content and higher soil pH, and nutrients can be absorbed by plants well in shallow peatlands. Yanto (2016) explained that the availability of nutrients that plants can absorb is one factor that affects plant growth in cell enlargement, which results in the diameter of the stems of oil palm plants. Furthermore, Soewandita (2018) stated that the pH value of peat decreased significantly based on the depth of the peat cover, the CEC value significantly increased according to the increase in the depth of the peat layer, while the exchangeable K and Ca values were low due to leaching. Ratmini et al.

(2012) found that the decrease in pH in deep peatlands was due to the accumulation of organic acids because peat was still the peat with a lower maturity level.

Healthy and fertile oil palms are oil palms with dark green leaves and slightly younger midribs (Pahan, 2008). The Leaf color on shallow peat palm oil was 4.6 (light green); on deep peat, the average leaf color was 3.6 (light green). The average light intensity on shallow peat is 733.3 feet per candle, while the average light intensity for deep peat is 780 feet per candle. These results indicate that the light intensity of deep peat is 46.7 feet higher than shallow peat. The light-intensity oil palm plants need around 50% to 75% (Jailani et al., 2018).

The soil analysis showed that shallow peat and deep peat had high organic C values, consisting of shallow peat at 13.28 % and deep peat at 11.99 %. A shallow peat N value of 0.19% is moderate compared to a 0.10% deep peat N value is low. According to (Hartatik et al., 2011), the availability of N for plants is relatively low in peat soil because N in peat soil is available in the form of organic N. Therefore, N fertilization is needed to meet the optimal N needs of plants.

According to (Astin et al., 2022), the availability of K-dd in the soil is strongly influenced by parent material/type of soil organic matter. The K value in shallow peat is low at 0.14%, and in very low peat at 0.04%. The P value in deep peat is higher than in shallow peat, namely, deep peat at 27.6 ppm and shallow peat at 23.3 ppm. This increase in total P-value is thought to be due to applying P fertilizer to oil palm plants. In line with the research by (Purnomo et al., 2020), that the P fertilizer applied to peat soil in Rasau Jaya, Kubu Raya Regency, West Kalimantan, could improve soil chemical properties, including increasing soil pH, available and potential P, and base saturation. The P fertilizer effectively increases plant growth and yield of sweet corn. Phosphorus is the second essential nutrient after N, where phosphorus promotes root growth, seed, and fruit formation, activating enzymes and promoting generative plant growth (Purnomo et al., 2020). A deficiency of elemental phosphate can lead to reduced cell division, carbohydrate metabolism, dissolved protein levels, and dry matter accumulation (Lambers and Plaxton 2015).

Cation exchange capacity (CEC) on deep peat soil is higher than on shallow peat, namely 18.85 ppm deep peat and 11.60 ppm shallow peat (Table 10). Agus et al., 2014, explained that the high CEC value of a type of soil, especially peat soil, is strongly influenced by the reaction of the soil or pH-soil, base saturation, the number of base cations, types of organic matter, liming and fertilization. The average pH value from field research on shallow peat is 5.5 and deep peat 4, and the moisture content of shallow peat is 69.7%, while deep peat is 76.5%. It is also explained by Pahan. (2008) that the optimal soil acidity for oil palm is pH 5.0-6.0, and the optimal humidity for oil palm plants is 75%.

CONCLUSIONS

Shallow peat has a more mature level of peat (sapric) than deep peat (hemic). Different peat depths showed different total-N, pH, P Bray 1 (P-available), and K- exchange, and there is no difference in organic-C, total-Fe, CEC, and Al-exchange. Oil palm growth (plant height, stem circumference, midrib length, number of leaves) on shallow peat was better than on deep peat. The productivity of oil palm FFB (Fresh Fruit Bunches) on shallow peat land is 21.71 Mg ha^{-1} higher than on deep peatland (19.69 Mg ha^{-1}).

ACKNOWLEDGMENT

We want to thank the Rector and Chairman of the Institute for Research and Community Service of Batanghari University Jambi, Faculty of Agriculture, for supporting this research.

REFERENCES

Agus C, ZR Ilfana, FF Azmi, D Rachmanadi, Widiyatno, D Wulandari, PB Santosa, MK Harun, TW Yuwati and T Lestari. 2020. The effect of tropical peat land-use changes on plant diversity and soil properties. *Int J Environ Sci Te* 17: 1703-1712. doi: 10.1007/s13762-019-02579-x.

Agus F, M Anda, Jamil and A Masganti. 2014. Lahan gambut indonesia pembentukan, karakteristik, dan potensi mendukung ketahanan pangan. *Badan Penelitian Dan Pengembangan Pertanian.* IAARD Press, pp131-160. (in Indonesian)

Astin EM, W Seran, ME Pellondo and AD Ruku. 2022. Laju dekomposisi seresah dan ketersediaan unsur hara makro di bawah tegakan jati (*Tectona* Grandis) di Kabupaten Kupang. *J Wana Lestari* 6: 217-228. (in Indonesian).

Hartatik W, IGM Subiksa and A Dariah. 2011. Sifat kimia dan fisik tanah gambut. In: Pengelolaan Lahan Gambut Berkelanjutan. Balai Penelitian Tanah. Bogor. 45-56. (in Indonesian).

Hashim SA, CBS Teh, and OH Ahmed. 2019. Influence of water table depths, nutrients leaching losses, subsidence of tropical peat soil and oil palm *(Elaeis guineensis* Jacq.) seedling growth. *Malays J Soil Sci* 23: 13-30.

Holding DR and AM Streich. 2013. *Plant growth processes: transpiration, photosynthesis, and respiration*. The Board of Reagents of the University of Nebraska, pp.1-10.

Inisheva LI. 2006. Peat soils: genesis and classification. *Eurasian Soil Science* 39: 699-704. doi: 10.1134/S1064229306070027.

Jailani, YTM Astuti and A Himawan. 2018. Pengaruh berbagai macam kompos dan intensitas cahaya terhadap bibit kelapa sawit di Pre-Nursery. *J Agromast* 3: 14 p. (in Indonesian)

Kirana, A Puspa, IS Sitanggang and L Syaufina. 2016. Hotspot pattern distribution in peat land area in Sumatra based on spatiotemporal clustering. *Procedia Environ Sci* 33: 635-645. doi: 10.1016/j.proenv.2016.03.118.

Lambers H and WC Plaxton. 2015. Phosphorus: back to the roots. In: *Phosphorus Metabolism in Plants*. Wiley Blackwell, United Kingdom, pp 3-22.

Middleton, Maarit, P Närhi, H Arkimaa, E Hyvönen, V Kuosmanen, P Treitz and R Sutinen. 2012. Ordination and hyperspectral remote sensing approach to classify peatland biotopes along soil moisture and fertility gradients. *Remote Sens Environ* 124: 596-609. doi: 10.1016/j.rse.2012.06.010.

Nuria PG, G Rein, RM Hadden, CM Belcher and JM Yearsley. 2016. Effects of spatial heterogeneity in moisture content on the horizontal spread of peat fires. *Sci Total Environ* 572: 1422-1430. doi: 10.1016/j.scitotenv.2016.02.145.

Nurjanah S, D Octavia and F Kusumawi. 2013. *Identifikasi lokasi penanaman kembali ramin (Gonystylus Bancanus* Kurz*) di hutan rawa gambut Sumatra dan Kalimantan*. Forda Press bekerjasama dengan pusat penelitian dan pengembangan konservasi dan rehabilitasi, badan penelitian dan pengembangan kehutanan dan international tropical timber organization, Bogor. 64 p. (in Indonesian).

Nurulita Y, EM Adetutu, H Gunawan, D Zul and AS Ball. 2016. Restoration of tropical peat soils: the application of soil microbiology for monitoring the success of the restoration process. *Agr Ecosyst Environ* 216: 293-303. doi: 10.1016/j.agee.2015.09.031.

Pahan I. 2008. *Panduan lengkap kelapa sawit*. Jakarta: Penebar Swadaya. Jakarta. 404 p. (in Indonesian).

Purnomo H, B Okarda, A Dermawan, QP Ilham, P Pacheco, F Nurfatriani and E Suhendang. 2020. Reconciling oil palm economic development and environmental conservation in Indonesia: A value chain dynamic approach. *Forest Policy Econ* 111: 102089. doi: 10.1016/j.forpol.2020.102089.

Ratmini S. 2012. Karakteristik Dan Pengelolaan Lahan Gambut Untuk Pengembangan Pertanian. *J Lahan Suboptimal* 1: 197-206. (in Indonesian).

Septiyana, A Sutandi and LT Indriyati. 2017. Effectivity of soil amelioration on peat soil and rice productivity. *J Trop Soils* 22: 11-20. doi: 10.5400/jts.2017.v22i1.11-20.

Shamshuddin J, EA Azman, Rs Shazana, CF Ishak, QA Panhwar and UA Naher. 2014. Properties and management of acid sulfate soils in southeast asia for sustainable cultivation of rice, oil palm, and cocoa. *Adv Agron* 124: 91-142. doi:10.1016/B978-0-12-800138-7.00003-6

Soewandita H. 2018. Kajian pengelolaan tata air dan produktivitas sawit di lahan gambut (studi kasus: lahan gambut perkebunan sawit PT Jalin Vaneo di Kabupaten Kayong Utara, Propinsi Kalimantan Barat). *J Sains & Teknologi Modifikasi Cuaca* 19: 41-50.

Veloo R, EV Ranst and P Selliah. 2015. Peat characteristics and its impact on oil palm yield. *NJAS – Wagen J Life Sc* 72: 33-40. doi: 10.1016/j.njas.2014.11.001.

Winarna M, Yusuf A, Rahutomo S, Sutarta ES. 2017. Impacts of the water table and soil ameliorant on soil moisture, co2 emission, and oil palm yield on peat soil. *J Penelitian Kelapa Sawit* 25: 147-160.

Wösten JHM, E Clymans, SE Page, JO Rieley and SH Limin. 2008. Peat-water interrelationships in a tropical peatland ecosystem in Southeast Asia. *Catena* 73: 212-224. doi: 10.1016/j.catena.2007.07.010.

Yanto K, Adiwarman and Nurbaiti. 2016. Pemberian pupuk organik cair terhadap pertumbuhan bibit kelapa sawit (*Elaeis Quineensis* Jacq) pada pembibitan utama. *JOM Faperta* 3: 1-12.