Jurnal Ilmu Pertanian Indonesia (JIPI), Oktober 2022
ISSN 0853-4217
EISSN 2443-3462
Vol. 27 (4) 502−513
http://journal.ipb.ac.id/index.php/JIPI
DOI: 10.18343/jipi.27.4.502

Physical Property Changes of Peatland upon Conversion of Oil Palm Plantation to Corn Cropping in Kinali, West Pasaman, West Sumatera

(Perubahan Sifat Fisik Lahan Gambut yang Dikonversi dari Perkebunan Kelapa Sawit ke Pertanaman Jagung di Kinali, Kabupaten Pasaman Barat, Sumatera Barat)

Mimien Harianti*, Teguh Budi Prasetyo, Junaidi, Gusmini, Anggun Fitria Yenad

(Diterima Mei 2022/Disetujui September 2022)

ABSTRACT

The decrease in oil palm production in Kinali, West Pasaman Regency, has become the factor that makes the farmers convert their peatlands to corn cropping. This study aimed to examine the physical characteristics (irreversible drying) of peatlands due to the conversion of oil palm to corn cropping. Some observations and samplings were conducted by applying a transect method, as it was perpendicular to the collection drain for 2, 200, and 400m from the main drains in three locations as the uses of the lands: (1) oil palm plantations, (2) <2-year corn cropping, (3) >2-year corn cropping. In each land, 3 sample points were taken with 2 repetitions at a depth of 0–20 cm and 20–40 cm. The physical properties of peatlands that have been converted from oil palm plantations to corn cropping include the water content increasing from 286.4 to 348.5 and 322.7%, the ash content decreasing from 55.2 to 43.5 and 47.5%, with C-organic increased by 25.9 to 30.7 and 32.4%, fiber content increased from 27.1 to 32.1 and 28.7%, and the volume weight of the peat tended to be similar (0.3 g/cm^3). In all land use, irreversible drying occurred; in the oven at 50°C dan 70°C with a drying time of 3×24 hours, and at 150°C, and the drying time of 1×24 hours, the moisture content of 232–256% in oil palm plantation, 269–290% in <2-year corn cropping, and 394–440% in >2-year corn cropping. Irreversible drying occureds more quickly on the peatlands in oil palm plantations rather than in corn cropping.

Keywords: corn cropping, irreversible drying, palm oil plantation, peatland

ABSTRAK

Penurunan produksi kelapa sawit di Kinali Pasaman Barat memicu petani mengonversi lahan gambutnya ke pertanaman jagung. Penelitian ini bertujuan mendeskripsikan sifat fisik (pengeringan takbalik) gambut di lahan konversi kelapa sawit menjadi pertanaman jagung. Sampel diambil dengan metode transek, tegak lurus dari saluran drainase berdasarkan jarak 2, 200, dan 400 m dari saluran utama di tiga lokasi lahan: (1) perkebunan kelapa sawit, (2) pertanaman jagung dengan umur konversi ≤ 2 tahun, dan (3) pertanaman jagung dengan umur konversi ≥ 2 tahun. Di setiap jenis penggunaan lahan diambil 3 titik sampel dengan 2 ulangan di kedalaman 0–20 cm dan 20–40 cm. Sifat fisik pada lahan gambut yang sudah dikonversi dari perkebunan kelapa sawit menjadi pertanaman jagung di antaranya kadar air meningkat dari 286 menjadi 348 dan 323%, kadar abu menurun dari 55 menjadi 44 dan 48% dengan C-Organik meningkat dari 26 menjadi 31 dan 32%, kadar serat meningkat dari 27 menjadi 32 dan 29%, dan bobot volume gambut cenderung sama, 0,3 g/cm^3. Pada ketiga penggunaan lahan sudah terjadi peristiwa kering takbalik, yaitu pada oven suhu 50°C dan 70°C dengan lama pengeringan 3×24 jam, dan pada suhu 150°C lama pengeringan 1×24 jam, dengan kadar air 232–256% pada kelapa sawit, 269–290% pada pertanaman jagung ≤2 tahun, dan 394–440% pada pertanaman jagung ≥ 2 tahun. Peristiwa kering takbalik lebih cepat terjadi pada lahan gambut di perkebunan kelapa sawit dibandingkan di pertanaman jagung.

Kata kunci: kering takbalik, perkebunan kelapa sawit, pertanaman jagung, lahan gambut

INTRODUCTION

Indonesia has the largest peatland area in the tropical zones, or 20.6 million ha (2022). West Sumatra is one of the provinces in Indonesia that covers extensive peatlands, around 210.234 ha (including peatland that contains mineral-peat). Based on the total area, peatlands are only spread around the west coast areas, and the largest one can be found in Pesisir Selatan Regency, 95.000 ha (45.1%), and in Pasaman is 82.000 ha (39.2%) (Wahyunto *et al*. 2004). Peatlands are sensitive to change that has no benefit caused by peat properties. It causes some peatlands to become unsuitable for agriculture. However, peatland is one of the marginal land types chosen by the government and the community for agricultural area expansion.

Peatland clearing in West Sumatra, especially in West Pasaman Regency, is generally used for oil palm cultivation. However, due to limitations in land management and human resources, some peat plantation areas are converted into productive lands, such as corn cropping. The conversion of the peatlands

Agriculture Faculty, Andalas University, Unand Campus, Limau Manis, Padang 25163
* Coressponden Author: Email: mimienh@agr.unand.ac.id

into corn cropping in Kinali, West Pasaman, covering 276 ha areas, was mainly due to the transfer of ownership of the peatland by the Rural Unit Cooperation (KUD) Dastra in Kinali District and the human resources for managing the land are only from the surrounding community. For animal feed, compared with the price of oil palm, the price of corn is preferable.

There is an anxiety that the conversion of peatland into corn plantations will cause several changes in the physical properties of peat, such as decreasing peat quality, which affects its function. The construction of a drainage channel at the beginning of the land clearing for oil palm lowers the water level of the peat deeply, causing a consistent surface layer that is aerobic, especially the surface layer of peat. Suwondo *et al.* (2012) stated that the clearing of peatlands can cause changes in the water system (hydrology), namely changes in the peat water level in the area, and can affect the decrease in the peat surface (subsidence) and cause irreversible drying. It is in line with Radjagukguk (2000), who stated that plant cultivations also impact peat's physical properties, which causes peat subsidence rate to increase quickly as weight increases the peat volume. The conversion of oil palm land into corn cropping impacts peat stability due to land canopy cover. The oil palm canopy is more expansive than the corn plant, which decreases access to solar radiation on peatlands in oil palm land cover. Vegetation cover affects the amount of solar radiation received on the ground surface, and the denser the vegetation cover, the lower the radiation reaching the ground surface (Hazrina & Risdiyanto 2018).

A land that has good physical properties can have a good impact on the quality of the environment and plant development as well. Increasing the level of weathering and the depth of peat impacts the plant growth and determines which plants can be planted on the peatland. The physical characteristics of peat are essential for agriculture, such as the volume weight, moisture content, subsidence (decrease in the peat layer's surface), peat maturity (fiber content), ash content, and irreversible drying. Therefore, this study aimed to identify the physical properties of peat and observe the occurrence of irreversible drying on land that has been converted from oil palm plantations to corn cropping in Kinali, West Pasaman Regency, West Sumatra.

MATERIALS AND METHODS

Setting of the Research

This research was conducted from December 2020 to July 2021 in Kinali, West Pasaman Regency, West Sumatera. Kinali is on 00°03' North Longitude–00°11' South Latitude, and 99°45' to 100°04' East Longitude, and the total number of the areas is 482.64 km^2. The samples were taken in the peatlands, with several criteria, namely (1) having palm oil plantations, (2) having corn cropping that have been converted for ≤ 2 years, and (3) and corn cropping that have been converted for ≥ 2 years.

Procedures

Observations and samplings were conducted by applying a transect method since it is perpendicular to the canal or collection drain on peatland that has been converted from oil palm plantations to corn plantations with two different conversions, for <2 years and >2 years. Samples were collected based on the distance from the canal, 2, 200, and 400 m from the main channel (Figure 1) at three sampling locations: (1) oil

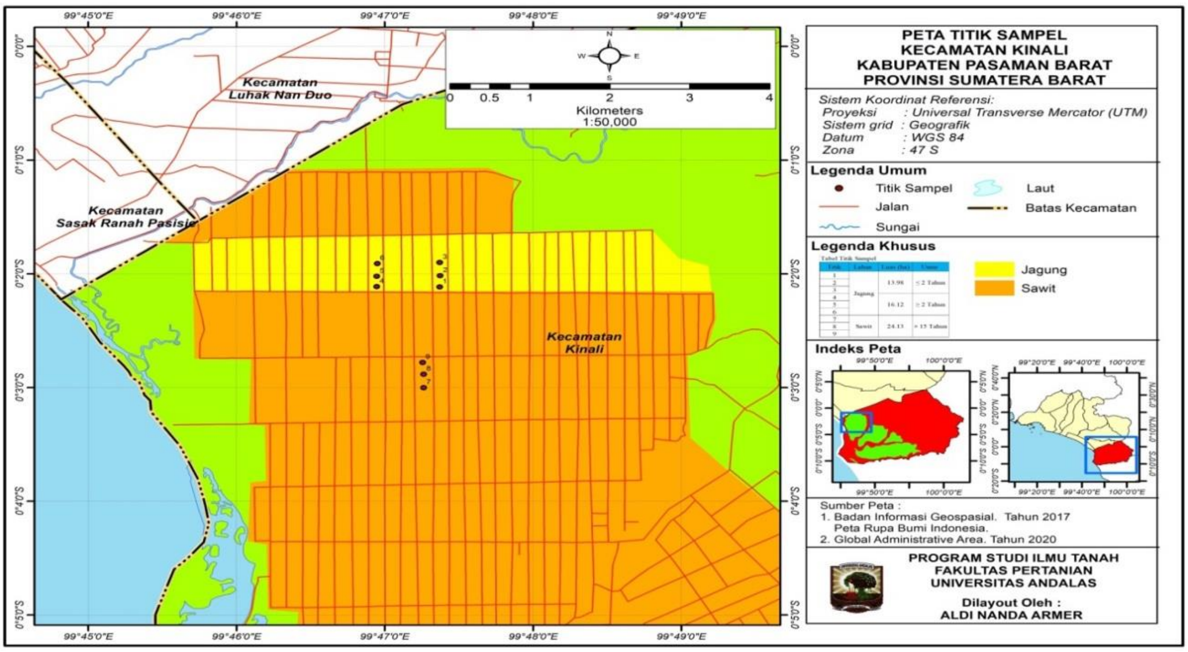


Figure 1 Map of peat sampling points.

palm plantations, (2) oil palm plantation that has been converted to corn croppings for <2 years, and (3) oil palm plantation that has been converted to corn cropping for >2 years (Table 1). For each land use, 3 sample points were taken with two repetitions at 0–20 cm depth and 20–40 cm. The number of peat samples taken was 36 pieces (3 sample points × 2 replications × 2 depth × 3 land use).

Analysis on Peat Physical Properties

The peat physical properties was analyzed at the Laboratory of Peat, Faculty of Agriculture, Andalas University, Padang. The parameters covers volume weight, moisture, ash, fiber content, and irreversible drying.

- **Volume weight (g/cm^3)**

The peat volume was measured by applying Gravimetric method and using intact peat samples. The purpose of peat volume weight analysis is to identify the mass weight of peat solid and as a determinant of the level of peat maturity.

- **Moisture content (%)**

The moisture contents measured in the peatlands are the weight of moisture content percentage (%) and the volume of moisture content percentage (%), so the gravimetry method was applied using disturbed peat samples. The aim of analyzing peat water content was to identify the ability of peat to absorb and store water and determine peat maturity level.

- **Ash content (%) and C -Organic (%)**

The ash and C-organic contents measurements were conducted using the dry ashing method and disturbed peat. The ash content analysis aimed to determine the level of inorganic content and the level of organic content in the peat.

- **Fiber content (Peat Maturity) (%)**

Peat fiber content was measured using the syringe method and disturbed peat samples. The purpose of this analysis is to identify the level of peatland productivity and peat maturity level.

- **Irreversible drying (%)**

The method applied in measuring irreversible drying on peat was by using oven and water drop penetration time, by weighing 10 g of peat materials, and putting them on the oven at 3 different temperatures (50, 70, and 105 °C) and 3 different times (1×24 hours, 2×24 hours, and 3×24 hours). Afterward, the samples in the oven were dripped with 5 mL of water for 5, 10, and 15 minutes and taking note of the time the sample can no longer absorb water or irreversible drying occured.

Data Processing

The data of the peat sample analysis were compared with the table of the criteria of peat physical properties. The data were presented in a descriptive form. Data from each analysis were correlated to identify which quality of peatlands had changed.

RESULTS AND DISCUSSION

Condition of Research Location and Its Characteristics: The Use of Peatland

Kinali District is located in West Pasaman Regency, approximately 30 km from West Pasaman, Simpang Ampek. It has two *nagari*es, namely Nagari Kinali and Nagari Katiagan, and the population is about 75794. It covers 482.64 km^2 areas on an altitude of 0–1332 masl. This district is bordered by Luhak Nan Duo District in the north, by Tigo Nagari District in the east, by the Indian Ocean in the west, and by Tigo Nagari

Table 1 Sampling Points

Land use	Order of peat	Area (ha)	Sample point	Coordinate
Oil palm plantation	Histosol	24.13	1	99°47'18.10" East Longitude and 0°2'58.69" South Latitude
			2	99°47'18.42" East Longitude and 0°2'52.59" South Latitude
			3	99°47'18.43" East Longitude and 0°2'45.85" South Latitude
Corn plantation (conversion age ≤ two years)	Histosol	13.98	4	99°47'36.97" East Longitude and 0°2'8.49" South Latitude
			5	99°47'37.16" East Longitude and 0° 2'2.57" South Latitude
			6	99°47'36.95" East Longitude and 0°1'56.06" South Latitude
Corn planting (conversion age ≥ two years)	Histosol	16.12	7	99°46'53.84" East Longitude and 0°2'8.09" South Latitude
			8	99°46'53.81" East Longitude and 0°2'1.35" South Latitude
			9	99°46'53.56" East Longitude and 0°1'55.86" South Latitude

Subdistrict, Agam Regency. Land use is dominated by agricultural lands, such as 2.99% rice fields, 84.29% non-rice fields, and 12.72% non-agricultural land (Statistics Indonesia, BPS 2021).

According to the data from the Meteorological, Climatological, and Geophysical Agency (BMKG) Station Class II at Padang Pariaman, Kinali District, the average rainfall from 2013 to 2020 was 3445.25 mm/year, with the highest average rainfall in October, 492.88 mm/year, and the highest average rainfall in October, 492.88 mm/year. The lowest was in January at 153 mm/year (rainfall data in Kinali, West Pasaman Regency). According to Schmidt and Ferguson (1951), the climate type in Kinali District is categorized as type A (very wet) since the wet season is more dominant than the dry season in this area. This type of climate is based on the comparison value (*Q*) between the average number of dry and wet seasons. According to the calculation, the *Q* value in this region was 0.023. Wet seasons are months with rainfall >100 mm/month, while dry seasons are months with rainfall <60 mm/month. This research was conducted in wet season.

Based on the peat map made by *Tim Survei Pusat Penelitian Gambut dan Agroklimat Bogor* (1990), the peat in the study location belongs to the great group Tropaquepts (11.99%), Humitropepts (0.75%), Tropopsamments (3.27%), Troposaprists (26.66%), and Hydrandepts (57.30%). The peat samples used for this study were taken on peat of Histosol with 15,459 ha areas (Map of Peat Types in Kinali District, West Pasaman Regency). Troposaprist is part of the great group in sub-ordo Saprist. This sub-ordo of saprists is Histosols peat which contains organic matter that has been completely decomposed. The fiber content was less than 1/6 parts when kneaded by hand and has a weight volume greater than 0.2 g/cm^3. This peat was found in areas with high peat water levels that tend to fluctuate (Fiantis 2015).

In this study, we analyzed the peatlands planted with oil palm and peatland that have been converted from oil palm plantations to corn croppings for about 1–3 years. The corn croppings were converted from oil palm plantation for <2 years and >2 years. In all land uses, there is a drainage system in the form of a middle ditch, or it can be called a secondary ditch (Table 2).

- **Palm oil plantation**

These oil palm plantations were managed by local farmers conventionally by using inorganic fertilizers (urea) and organic fertilizers (manure) every year, and some were left after the plantation. In addition, there was the enrichment of organic matter from palm fronds which accumulate and rot on the surface of the peat. As a result, the peat moisture level on this land was relatively low, approximately 33–49 cm, with a peat thickness of ± 3 m. The oil palm plantation is presented in Figure 1.

- **The conversion of palm oil plantation to corn croppings**

At the research location, the water level in the corn field that has been converted for <2 years is relatively shallow, around 25–50 cm, with a peat thickness of ± 2.4 m. It is the same with the >2-year corn cropping, which was 28–50 cm, with a peat thickness of ± 3.5 m. The land condition for corn cropping with conversion age <2 years is presented in Figure 2, and for the corn cropping with conversion age >2 years is in Figure 3. Dead palm trunks were still left among the corn plants in both figures. According to the information from the local farmers, the oil palm plantations were old (± 25 years) and killed using chemical treatment.

Physical Properties Changes of Peatlands due to Conversion of Oil Palm to Corn Cropping

- **The water level height**

The physical properties of peat are essential to consider in peatland management. The management can be done by regulating the water system (hydrology) or making drainage channels that can change the peat water level to decrease or increase in-depth and can

Table 2 Irreversible drying in the peat in Kinali, West Pasaman, based on the rewetting time

Land use	Drying process (hour)	Depth (cm)						
		0–20			20–40			
		Temperature (°C)						
		50	70	105	50	70	105	
		Rewetting process (minute)*						
Palm oil plantation	1×24	15	10	5	15	10	5	
	2×24	10	10	5	10	10	5	
	3×24	5	5	5	5	5	5	IRD*
≤2-year corn cropping	1×24	15	10	5	10	10	5	
	2×24	10	10	5	10	5	5	
	3×24	5	5	5	5	5	5	IRD*
≥2-year corn cropping	1×24	15	10	5	10	5	5	
	2×24	10	10	5	10	5	5	
	3×24	5	5	5	5	5	5	IRD*
				IRD*			IRD*	

Description: * time for rewetting the peat material and it is no longer able to absorb water (there has been an irreversible drying) and * IRD = Irreversible drying.

Figure 2 Oil palm plantation ages > 15 years at Kinali West Pasaman.

Figure 3 Corn cropping with conversion ages < 2-year.

affect the condition of peat water level according to the plant needs. The results of the water level at the research location are presented in Figure 4. There was a difference in water level based on the distance of the drainage channel; the farther the distance from the drainage channel, the more shallow the water level or closer to the peat surface. The lowest water level was at a distance of 400 m, and the highest was at a distance of 2 m. In other words, the farther the distance from the drainage channel, the lower the water level, and the more water is retained. Hence, the water content was also higher. This finding is in line with Azri (1999) *cit* Adji *et al.* (2019) that the lower the peat water level, the closer it is to the drainage channel due to the higher movement of peat water into the channel, causing a reduction in the peat water content. Drying due to the peat's low water level causes the peat's water retention power to decrease, and the drainage channels can affect the decrease in the peat water level.

In terms of land use, the lowest peat water level was in oil palm plantations, and the highest was in corn cropping with a conversion age of <2 years. However, due to the age, peat water level conversion tended to decrease since the oil palm plant consumes and requires higher water than the corn plant for its growth and production. A previous study by Harahap and Darmosarkoro (1999) stated that oil palm plants require water from 1500 to 1700 mm/year. Meanwhile, corn plants need about 1,026 mm of water per year with four planting periods (Sirait *et al.* 2020).

The average water level for oil palm plantations was 41.3 cm, while peatland, which has been converted to corn cropping for <2 years, was 34.1 cm, and that has been converted for >2 years was 37.3 cm. Based on the Government Regulation No. 71 of 2014 Article 23 paragraph 3 concerning Protection and Management

Figure 4 Corn cropping with conversion ages ≥ 2 years.

of Peat Ecosystems, peat ecosystems with cultivation functions are considered damaged if the peat water level on peatlands is more than 0.4 m (40 cm) below the peat surface. Therefore, the water level and peat ecosystem in the study location are still within reasonable limits based on the water level.

- **Moisture content**

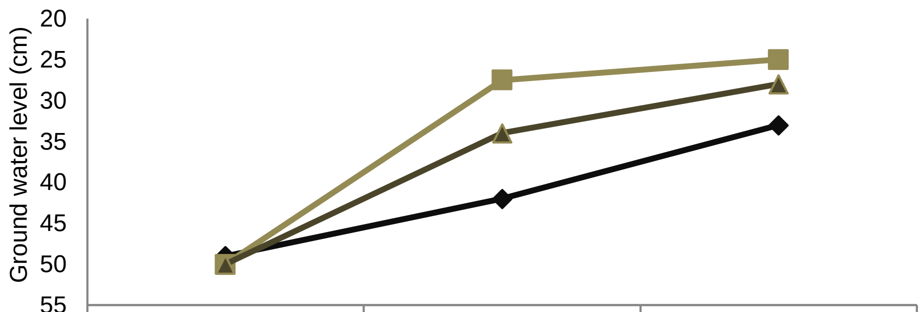
Peatlands have a relatively high capacity and ability to absorb water based on their dry weight. The results of observations of the moisture content of each peatland use are presented in Figure 5. Based on the distance from the drainage channel, the farther the distance from the drainage channel, the higher the moisture content. It is affected by the peat water level, and the lower the peat water level, the lower the moisture content (Figure 4). Meanwhile, Simatupang *et al.* (2018) argue that a high peat water level will increase the moisture content. In Figure 5, the moisture content in each land use at the study location was classified into minor to medium criteria (ASTM D-4427 1992). The moisture content of each land ranged from 163 to 495%. In oil palm plantations, the moisture content was 163.76–486.92%, while in the <2-year corn croppings ranged from 195.15 to 495.81%, and in the >2-years corn cropping ranged from 185.09 to 495.58%. There was an increase in moisture content after the conversion of peatland from oil palm plantations to corn cropping. Based on the conversion age, the water content in corn plantations with a conversion age of <2 years was higher than in corn plantations with a conversion age of >2 years.

From the depth viewpoint, generally at 0–20 cm, the moisture content was lower than in the depth of 20–40 cm. At 0–20 cm, the moisture content was around 163.76–309.4%, while at 20–40 cm, it was 203.85–495.81%. At 0–20 cm and 20–40 cm, the highest moisture content was found in <2-year corn cropping at 400 m distance from the drainage channel, as caused by the peat water level (Figure 4). Hence, the lower the peat water level, the lower the moisture content. Suswati *et al.* (2011) also stated that the upper part of the peat generally contains dry peat since the drainage channels have been made.

- **Volume weight**

The volume weight is one of the physical properties of peat that indicates the mass of the solid in a particular volume. The land conversion carried out in the study area affected the weight value of the peat volume, as presented in Figure 6. The farther the distance from the drainage channel, the lower the volume weight value in all lands. The volume weight value in oil palm plantations was 0.22–0.46 g/cm^3, corn cropping with a conversion age of 2 years was 0.18–0.41 g/cm^3, and corn cropping with a conversion age 2 years was 0.20–0.43 g/cm^3. Wahyunto *et al.* (2005) also informs that the volume weight value of peat generally ranges from 0.05 to 0.40 g/cm^3. The volume weight value of peat is based on the level of decomposition, on peat sub-order fibrists is > 0.1 g/cm^3, on sub-order hemists is 0.1–0.2 g/cm^3, and on sub-order saprists is > 0.2 g/cm^3. Thus, the volume weight of peat at the research location was categorized into the level of sapric-hemic maturity.

The highest volume weight value was found in the peat of oil palm plantations, and the lowest was in corn cropping with a conversion age of <2 years. It is due to the maturity level of the peat and its fiber content, where the higher the fiber content and the more hemic the peat, the lower the volume weight value. Noor (2001) states that the lower the peat maturity (raw), the lower the peat volume weight (fibric < hemic < sapric).



	2 m	200 m	400 m
Oil palm plantation	49	42	33
Corn plantation (conversion ages < 2 years)	50	27,5	25
Corn plantation (conversion ages ≥ 2 years)	50	34	28

The distance from canal (cm)

Figure 5 Ground water level based on landuse dan the distance from canal.

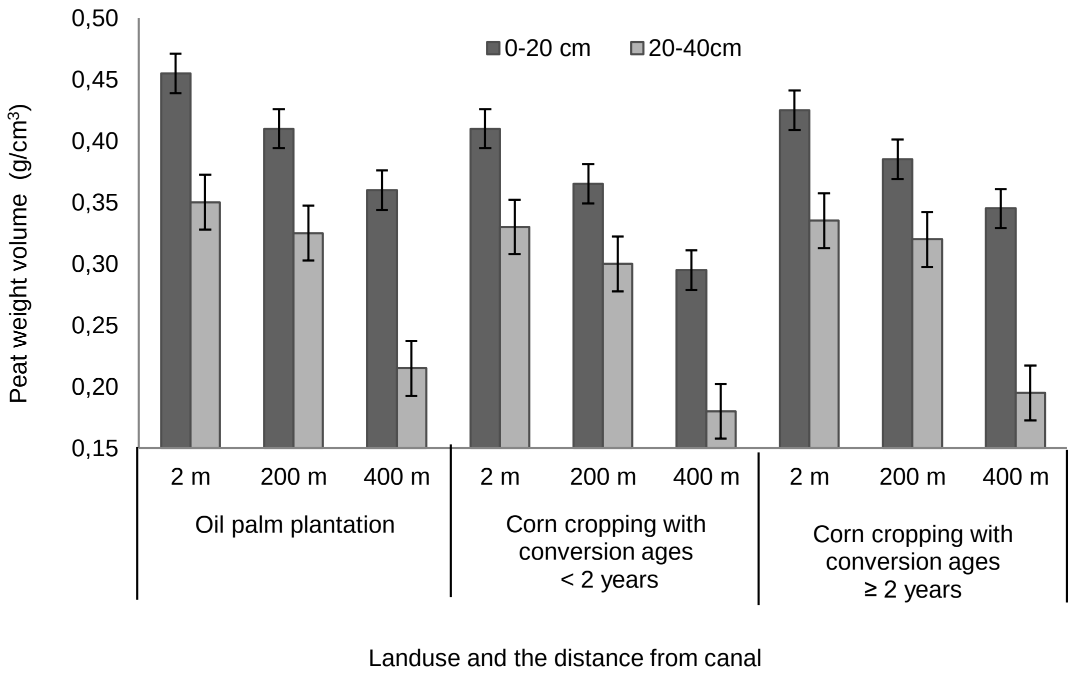


Figure 6 Fiber content based on landuse and the distance from canal.

Figure 6 also shows that all land uses at a depth of 0–20 cm had a higher volume weight value than at 20–40 cm. It is because peat's volume weight value was categorized into high criteria at 0–20 cm deep. Meanwhile, the criteria wee medium to high at a depth of 20–40 cm. This condition is due to peat maturity (Figure 7), which generally has a sapric maturity level in the 0–20 cm layer, while in the 20–40 cm layer, it has a hemic maturity level. Therefore, the higher the BV value of the peat, the higher the decomposition rate and the more mature the peat.

- **Fiber content (peat maturity)**

Peat has three maturity levels, namely sapric (ripe), hemic (half ripe), and fibric (raw). Peat maturity can be identified from the value of its fiber content. Fibers are pieces of plant tissue that have rotted but still have cell structures of the original plant. Our observations on peat maturity levels in each land use are presented in Figure 7. The distance from the drainage channel indicated that the farther the distance from the drainage channel, the higher the fiber content value for each land use, since the closer the distance to the drainage channel, the higher the level of peat decomposition. In

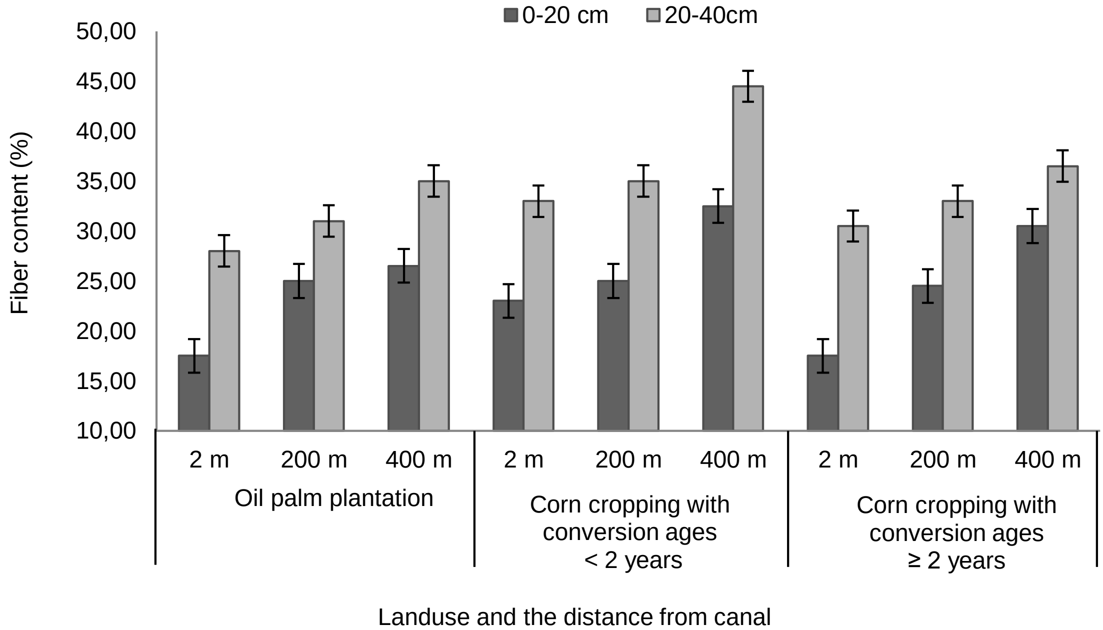


Figure 7 Fiber content based on landuse and the distance from canal.

addition, the high fiber content was also caused by the high moisture content (Figure 4), where the lower the peat water level, the slower the decomposition rate, and the higher the peat fiber content.

There was a difference in fiber content after peatland conversion from oil palm plantations to corn cropping. In oil palm plantations, the fiber content was 17–35%, while in corn cropping at <2 years of conversion age, it was 23–44.5%, and in corn cropping at conversion age of >2 years, it was 17.5–35.5%. Thus, the fiber content in oil palm plantations and 2-year corn cropping had fiber content that was not significantly different, which is only 0.5% different. Meanwhile, the <2-year corn cropping had a higher fiber content than the other two land uses. Hence, the longer the age of land conversion, the lower the peat fiber content and the faster the decomposition rate. This phenomenon is in line with Dikas (2010) that the age and duration of plant management could affect the decomposition rate since the longer time of peatland management increases the decomposition rate.

The value of fiber content in each land use at a depth of 0–20 cm was lower and relatively more mature than at a depth of 20–40 cm due to the faster decomposition rate. Therefore, at a depth of 0–20 cm, it had criteria for sapric peat maturity, and at a depth of 20–40 cm, it has 2 criteria for peat maturity, namely sapric and hemic. Each land use had a sapric peat maturity level because in Kinali District, the peatlands had been cleared and drained by making drainage channels for oil palm plantations for a long time. The land clearing could cause a decrease in the peat water level, and the decomposition process of organic matter could occur completely. In general, the peat decomposition level in the top layer or above the peat water table is higher and further than the peat layer below the peat water level.

- **Ash content**

The ash content indicates the volume of mineral material contained in the peat. Ash content is also one of the properties of peat fertility level. The peat ash content in the research location is presented in Figure 8. Based on the distance from the drainage channel, the ash content for all land uses showed that the farther the distance from the drainage channel, the lower the ash content value, which means that the mineral content is also getting lower. This fact was due to differences in peat decomposition, which can be seen in the fiber content data (Figure 7); the farther it is from the drainage channel, the higher the fiber content indicates the low peat ash content. It was also due to the high moisture content, and the decomposition process becomes slower. It is in line with Yondra's (2017) statement that the higher the ash content, the higher the maturity level of the peat.

Based on each land use, the average peat ash content in oil palm plantations was 31.47–72.12%, in < 2-year corn cropping was 15.50–66.35%, and in > 2-year corn cropping was 24.44–68.66%. In view of the conversion age, the moisture content in <2-year corn plantations was higher than in >2-year corn cropping. This fact is related to the peat maturity level (Figure 7). The longer the land conversion, the more mature the peat, and the faster the decomposition rate, and the ash content are also higher. Harianti (2017) also argues that increasing plant age can increase ash content, indicating that the level of peat decomposition has been high, so the ash content increases.

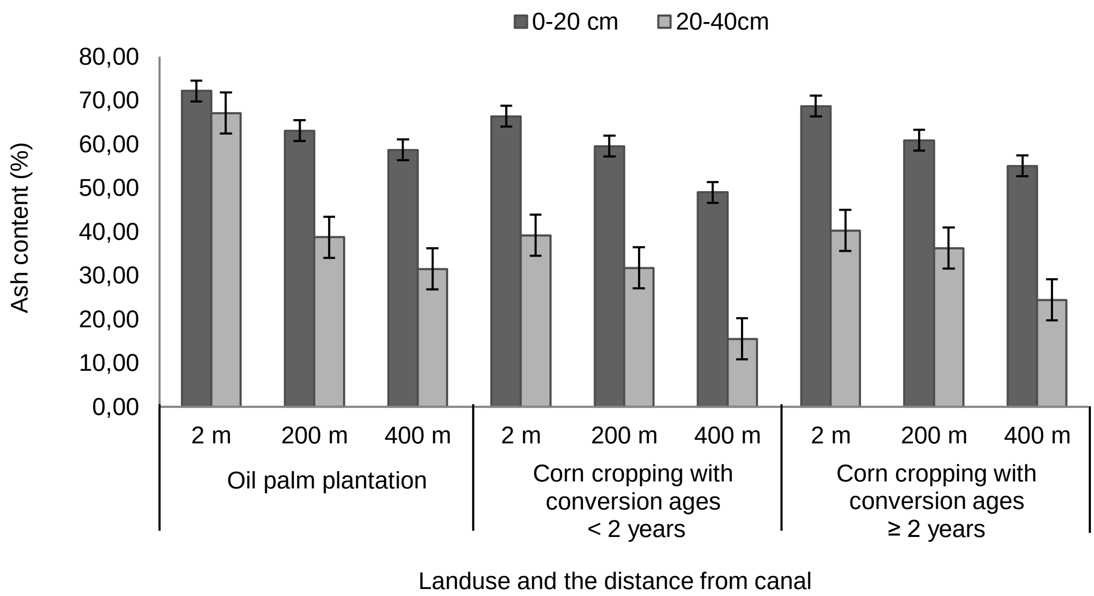


Figure 8 Ash content based on landuse and the distance from canal.

In Figure 8, the value of ash content in each land use at a depth of 0–20 cm was higher than at a depth of 20–40 cm. Because more intensive land management was carried out on the peat top layer (0–20 cm), which could cause the peat mineralization process to increase, the ash content at a depth of 0–20 cm was higher. Therefore, the peat ash content in the study area was high, indicated that the mineral content was also high and had good peat fertility. Meanwhile, Noor *et al.* (2016) argue that peat's high and low fertility can be indicated by the high and low levels of ash (non-organic contents). Hence, the higher the peat ash content, the better the fertility of the peat.

Peat is divided into three fertility levels: fertile peat (eutrophic), peat with medium fertility (mesotrophic), and less fertile peat (oligotrophic). Based on the ash content, the peat found in the research location was eutrophic peat with a high fertility level, as characterized by >14% ash content, since the peatlands in this study are coastal peat and adjacent to river flows. Moreover, river flows can carry peat particles such as sand, dust, and clay, which cause the peat in this research area to have high mineral content, and due to the influence of sea tide. Barchia (2017) also states that the formation of eutrophic peat is influenced by brackish water from a mixture of seawater and river water.

- **C-organic content**

C-organic content is one of the indicators of determining the quality of organic matter and the rate of decomposition of peat, where organic C is oxidized to produce CO_2, and by increasing the decomposition rate of organic matter, the level of C-organic in peat will decrease. The percentage of organic C in the study area is presented in Figure 9. Based on the distance from the drainage channel in all land uses, the further it was from the drainage channel, the higher the organic C content. This phenomenon was due to the peat's maturity level or fiber content (Figure 7), indicating that the farther the distance from the drainage channel, the higher the fiber content of the peat material. It was in line with Simatupang *et al.* (2018) statement that the maturity level of peat could be identified if the decomposition rate is high, and the carbon stock will be smaller in peat.

Based on the result of peatland conversion, there is an increase in organic C levels. However, in oil palm plantations, the organic C-value was lower than in peatlands that have been converted to corn cropping. Based on the conversion age, the organic C content in <2-year corn cropping was higher than in >2-year corn cropping. This fact was due to the appropriate peatland management and the time of land management. Hence, the longer the conversion age, the lower the organic C content. In addition, the high levels of C-organic in corn cropping land were caused by the addition of organic matter from root biomass left after harvesting. Dikas (2010) also informs that conducting peatland management for a long time can accelerate the rate of decomposition and the process of peat maturation, and the C-organic content of peat becomes low.

C-organic content in all peatlands increased based on the peat depth. At 0-20 cm, the organic C content was lower than peat at a depth of 20–40 cm since the top layer of peat had a higher decomposition rate than the below. In all land uses, the value of C-organic content at 0–20 cm was 16.18–29.60%, and at 20–40 cm was 19.10–49.02%. Overall, the value of organic C levels at the research location was very high since the

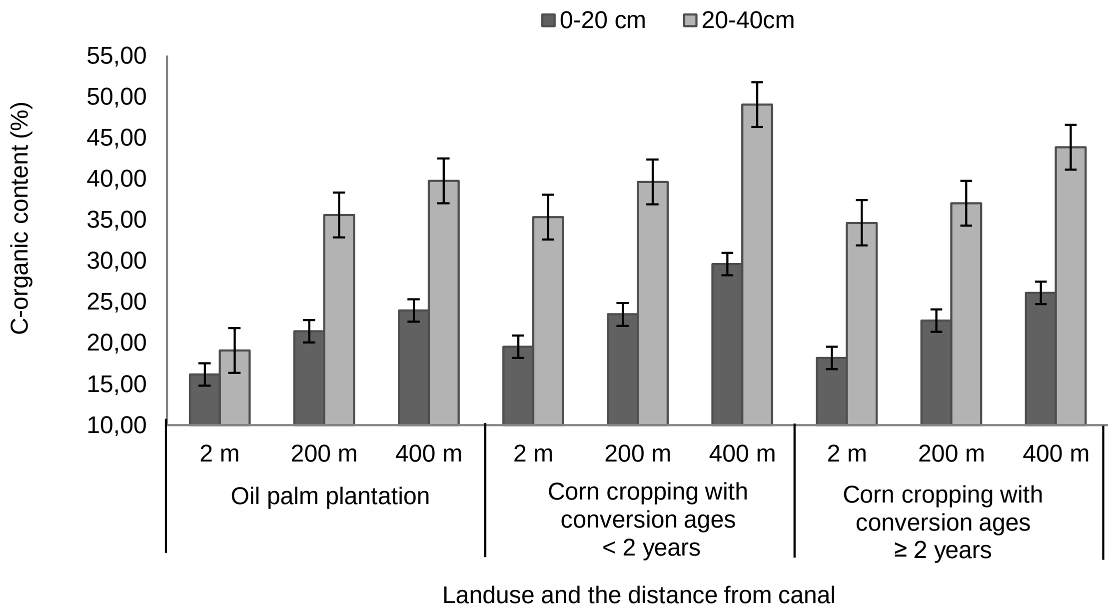


Figure 9 C-organic content based on landuse and the distance from canal.

C organic levels were >12%. Meanwhile, Subagyo *in* Noor *et al.* (2016) find that every 1 meter of peat material thickness can store between 400–700 tons of C org/ha.

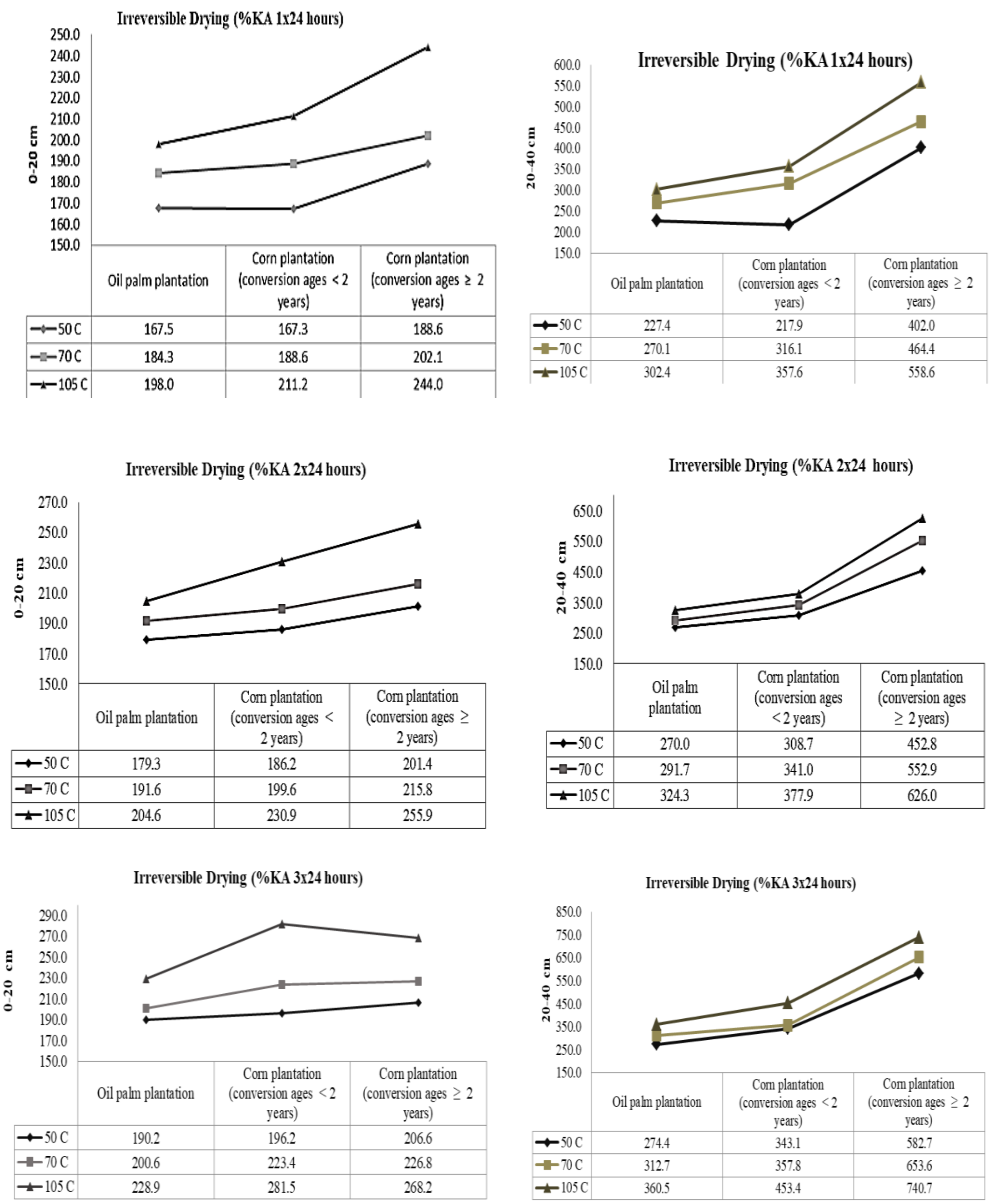
- **Irreversible drying**

Irreversible drying is a characteristic of peat where the condition is no longer absorbing water, and the nature of peat changes from water-loving (hydrophilic) to water-repellent (hydrophobic) after an intensive drying process. Irreversible drying is related to the ability of peat to store, hold, and release water. Irreversible drying of peat could be identified based on the percentage of water content after drying at a specific temperature and different drying times (Figure 10). The highest moisture content was found at an oven temperature of 105°C with a drying time of 3×24 hours (187.3–895.9%), and the lowest water content was at 50°C with a drying time of 1×24 hours (150.5–486.6%). The water content is the amount of water lost from the peat material after being baked at a specific temperature and time. The greater the temperature used to heat the peat material, the greater the moisture content lost since, the longer the heating time, the higher the peat moisture content. This is in line with Yulianti *et al.* (2009), that the longer the time spent for drying, the greater the potential of irreversible drying occurs on peat.

The results of the irreversible drying could be identified based on the ability of the peat to absorb water after intensive drying, namely by rewetting the peat material that had been baked (Table 2). After the rewetting process, peat material in all land uses was no longer able to absorb water, or there is an occurrence of irreversible drying at 50 °C and the drying time 3×24 hours, with about 170.6–688.2% moisture content. Meanwhile, at a 70°C and the drying time 3×24 hours, the moisture content was 170.6–688.2%, and 179.5–797.8% moisture content at a temperature of 150°C and drying time 1×24 hours. The water content was 187.3–895.9% after 5 minutes rewetting process. In the three land uses, peatlands converted to corn cropping with a conversion age of <2 years and corn cropping conversion age of >2 years experience irreversible dry events faster than oil palm plantations.

The peat material experienced the fastest irreversible drying, at a depth of 20–40 cm compared to a depth of 0–20 cm. In Figure 7, peatland that had been converted into corn cropping had a peat maturity level that was still hemic, with fiber content ranging from 30.50 to 36.50%. It is revealed in Table 2 that after rewetting at 20–40 cm, the irreversible drying occurs at 70°C with a drying time of 2×24 hours and 5 minutes rewetting on converted land. It is in line with Bisdom *et al.* (1993) *cit* Yulianti *et al.* (2009). They stated that peat material that has been partially decomposed have greater irreversible drying characteristic than that has been decomposed.

Changes in the peat physical properties can be seen in the irreversible drying conditions that can occur if the land is continuously heated. For example, irreversible drying will occur more quickly in the dry season. In addition, it is supported by lower groundwater level fluctuations in the dry season. In addition, the peat conditions in corn cropping have low water holding capacity due to the addition of high fiber content, and there are also differences in the root weight of each plant. This affects the evaporation and evapotranspiration of the peat, whereas the oil palm plant has a low evaporation rate due to a large canopy cover rather than the corn plant.



(a)	Oil palm plantation	Corn plantation (conversion ages < 2 years)	Corn plantation (conversion ages ≥ 2 years)
50 C	167.5	167.3	188.6
70 C	184.3	188.6	202.1
105 C	198.0	211.2	244.0

(b)	Oil palm plantation	Corn plantation (conversion ages < 2 years)	Corn plantation (conversion ages ≥ 2 years)
50 C	227.4	217.9	402.0
70 C	270.1	316.1	464.4
105 C	302.4	357.6	558.6

(c)	Oil palm plantation	Corn plantation (conversion ages < 2 years)	Corn plantation (conversion ages ≥ 2 years)
50 C	179.3	186.2	201.4
70 C	191.6	199.6	215.8
105 C	204.6	230.9	255.9

(d)	Oil palm plantation	Corn plantation (conversion ages < 2 years)	Corn plantation (conversion ages ≥ 2 years)
50 C	270.0	308.7	452.8
70 C	291.7	341.0	552.9
105 C	324.3	377.9	626.0

(e)	Oil palm plantation	Corn plantation (conversion ages < 2 years)	Corn plantation (conversion ages ≥ 2 years)
50 C	190.2	196.2	206.6
70 C	200.6	223.4	226.8
105 C	228.9	281.5	268.2

(f)	Oil palm plantation	Corn plantation (conversion ages < 2 years)	Corn plantation (conversion ages ≥ 2 years)
50 C	274.4	343.1	582.7
70 C	312.7	357.8	653.6
105 C	360.5	453.4	740.7

Figure 10 Irreversible Drying based on %KA with different temperatures, baking times and depths. (a) depth 0–20 cm (%KA 1x24 hours), (b) depth 20–40 cm (%KA 1x24 hours), (c) depth 0–20 cm (%KA 2x24 hours), (d) depth 20 –40 cm (%KA 2x24 hours), (e) depth 0–20 cm (%KA 3x24 hours), (f) depth 20–40 cm (%KA 3x24 hours).

CONCLUSION

The physical properties of peatlands that have been converted from oil palm plantations to corn cropping include increased moisture content from 286.4 to 348.5 and 322.7%. The ash content decreased from 55.2 to 43.5 and 47.5%, with C-organic increase by 25.9 to 30.7 and 32.4%. The fiber content increased from 27.1% to 32.1% and 28.7%, and the volume weight of the peat tends to be similar (0,3 g/cm^3). In all land uses, irreversible drying occured. In the oven at 50°C and 70°C with a drying time of 3×24 hours and a temperature of 150°C, and the drying time is 1×24 hours with 232–256% moisture content in oil palm plantation, 269–290% in <2-year corn cropping, and 394–440% in >2-year corn cropping. Irreversible drying occured more quickly on the peatlands in oil palm plantations rather than on corn plantations, at 20–40 cm.

REFERENCES

Adji FF, Damanik Z, Teguh R, Suastika KG. 2019. Pengaruh jarak dari saluran drainase terhadap karakteristik lahan gambut pedalaman Kalimantan

Tengah (Studi Kasus: Kanal penghambat dan dampak pembasahan). Prosiding Seminar Nasional Lingkungan Lahan Basah. 4(2): 226–232.

Agus F, Wahyunto, Sosiawan H, Subiksa IGM, Setyanto P, Dariah A, Maswar, Neneng L, Nurida, Mamat HS, Las I. 2014. Pengelolaan berkelanjutan lahan gambut terdegradasi untuk mitigasi emisi GRK dan peningkatan nilai ekonomi. Di dalam: *Program Indonesia Climate Change Trust Fund* (ICCTF) *Fase II*. Prosiding Seminar Nasional: Jakarta, 18–19 Agustus 2014. Bogor (ID): Badan Penelitian dan Pengembangan Pertanian. Hlm 1–23.

Barchia MF 2017. *Gambut Agroekosistem dan Transformasi Karbon*. Yogyakarta (ID): Gajah Mada University Press

Dikas TM. 2010. *Karakterisasi Fisik Gambut di Riau pada Tiga Ekosistem (Marine, Payau, dan Air Tawar)*. Bogor (ID): Institut Pertanian Bogor.

Harahap I, Darmosarkoro. 1999. Pendugaan kebutuhan air untuk pertumbuhan kelapa sawit di lapang dan aplikasinya dalam pengembangan sistem irigasi. *Jurnal Penelitian Kelapa Sawit.* 7(2): 87–104.

Harianti M. 2017. *Karakteristik Enzim di Rizosfer Kelapa Sawit pada Lahan Gambut*. Bogor (ID): Institut Pertanian Bogor.

Noor M. 2001. *Pertanian Lahan Gambut: Potensi dan Kendala*. Yogyakarta (ID): Kanisius. 174 hlm.

Noor M, Nursyamsi D, Alwi M, Fahmi A. 2014. Prospek Pertanian Berkelanjutan di lahan Gambut: Dari Petani ke Peneliti dan Peneliti ke Petani. *Jurnal Sumberdaya Lahan.* 8(2): 69–79.

Noor M, Masganti, Agus F. 2016. *Pembentukan dan Karakteristik Gambut Tropika Indonesia*. *Lahan Gambut Indonesia.* Edisi Revisi. Bogor (ID): Badan Penelitian dan Pengembangan Pertanian. 253 hlm.

Radjagukguk B. 2000. Perubahan sifat-sifat fisik dan kimia gambut akibat reklamasi lahan gambut untuk pertanian. *Jurnal Ilmu Gambut dan Lingkungan.* 2(1): 1–15.

Sabiham S. 2010. *Properties of Indonesian Peat in Relation to the Chemistry of Carbon Emission*. Bogor (ID): Bogor Agricultural University.

Sabiham S, Tarigan SD, Haryadi, Las I, Agus F, Sukarman, Setyanto P, Wahyunto. 2012. Organic carbon storage and management strategies for reducing carbon emission from peatlands: A case study in oil palm plantations in West and Central Kalimantan, Indonesia. *Land Degradation and Pedology*. 55(3): 426–434.

Simatupang D, Astiani D, Widiastuti T. 2018. Pengaruh tinggi muka air gambut terhadap beberapa sifat fisik dan kimia gambut gambut di Desa Kuala Dua, Kabupaten Kubu Raya. *Jurnal Hutan Lestari.* 6(4): 988–1008.

Sirait S, Aprilia L, Fachruddin. 2020. Analisis neraca air dan kebutuhan air tanaman jagung (*Zea mays* L.) berdasarkan fase pertumbuhan di kota Tarakan. *Jurnal Rona Teknik Pertanian*, 13(1): 99–113. https://doi.org/10.17969/rtp.v13i1.15856

Suswati D, Hendro B, Shiddieq D, Indradewa D. 2011. Identifikasi sifat fisik lahan gambut Rasau Jaya III Kabupaten Kubu Raya untuk pengembangan jagung. Perkebunan dan Lahan Tropika. *Jurnal Teknologi Perkebunan & PSDL.* 1: 31–40. https://doi.org/10.26418/plt.v1i2.408

Suwondo, Sabiham S, Sumardjo, Pramudya B. 2012. Efek Pembukaan Lahan terhadap Karakteristik Biofisik Gambut pada Perkebunan Kelapa Sawit di Kabupaten Bengkalis. *Jurnal Nature Indonesia.* 14(2): 143–149. https://doi.org/10.31258/jnat.14.1.143-149

Wahyunto S. Ritung, Suparto, Subagjo H. 2005. *Sebaran Gambut dan Kandungan Karbon di Sumatera dan Kalimantan.* Bogor (ID): Wetlands International. 281 hlm.

Yondra. 2017. *Kajian Sifat Kimia Lahan Gambut Pada Berbagai Landuse*. Pekanbaru (ID): Universitas Riau. 10 hlm.

Yulianti N, Sabiham S, Ardiansyah M, Sutarta ES, Darmosarkoro W. 2009. Potensi kehilangan karbon akibat pembentukan pasir semu pada lahan gambut yang dikonversi menjadi agroekosistem kelapa sawit. *Jurnal Agripeat*. 10(1): 13–18.