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The Growth of PB 260 Clone of Rubber Plant on Peatland

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Abstract: The expansion of the area for the cultivation of rubber plants is hampered by the fact that the availability of mineral land has begun to decrease, so many have started to plant rubber on marginal lands such as peatlands. Peatlands for agriculture have many limiting factors, but if peatlands are adequately managed with drainage as well as ameliorant and fertilizing inputs, then peatlands have the potential to be used as agricultural land. However, information on research results related to rubber cultivation on peatlands still needs to be improved, so this study was carried out to observe the growth of rubber plants of PB 260 clones on peatlands. The research was carried out for five years from 2013 to 2018 in Sungai Rengit Village, South Sumatra, using rubber planting material in a polybag of PB 260 clones. The observations' parameters were stem girth, peat water level, and peat subsidence. The results showed that the growth of PB 260 clones during the immature plant period on peatland was not significantly different from rubber plants on mineral soils. There was never any puddle at the research location, and the peat water level was maintained because the drainage channels were well-made. During the five years of observation, the highest peat water level occurred in the rainy season at 27 cm from the peat surface, while the lowest peat water level occurred in the dry season, which was more than 150 cm from the peat surface. The peat decline reached 25 cm during the five years of observation.

Keywords: peat subsidence, peat water level, stem girth

1. Introduction

Rubber plants have wide adaptability and can grow in various soil and climatic conditions, but their growth will be more optimal if planted in areas with more suitable environmental conditions [1]-[3]. Unfortunately, the area's expansion is hampered because dry land availability has begun to decrease, so many have started trying to plant rubber on marginal lands such as tidal and peat land.

Peat soil contains more than 30% organic matter. The land is categorized as peatland if it has a peat thickness of more than 50 cm. Land with a peat thickness of less than 50 cm is called peat land. Peat is formed from the decomposition of organic materials such as leaves, twigs, or shrubs, which take place slowly and under anaerobic conditions [4]. Fahmuddin and Subiksa [5] reported that the physical characteristics of peat that are important in its use for agriculture include water content, bulk density (BD), bearing capacity, subsidence, and irreversible drying. The water content of peat soils ranges from 100% – 1,300% of its dry weight [6]. High water content causes low bulk density, soft peat, and low load-bearing capacity [7].

The bulk density of peat soil in the top layer varies from 0.1 to 0.2 g/cm^3 depending on the degree of decomposition. Fibric peat, generally located in the lower layers, has a BD lower than 0.1 g/cm^3; coastal peat and peat in river basins can have a BD value of > 0.2 g/cm^3. That is due to the influence of mineral soils [8]. The volume of peat will shrink when peatland is drained, resulting in subsidence of the soil surface. In addition to volume shrinkage, subsidence occurs due to decomposition and erosion. Another physical property of peat soil is that it does not dry out. Dried peat with a moisture content of < 100% (by weight) cannot absorb water again when wet. This dry peat has the same characteristics as dry wood, which is easily washed away by the flow of water and easily burned in a dry state [9].

Based on the level of fertility, peat in Indonesia is classified as oligotrophic (poor) to mesotrophic(medium), and only a few are classified as eutrophic (fertile). Based on its maturity, peat is divided into three, namely fibric (if the original vegetative material is still recognizable or only slightly decomposed), hemic (if the decomposition rate is moderate), and sapric (if the decomposition level is advanced). Peat soil has a low pH, high cation exchange capacity (CEC), low base saturation, content of K, Ca, Mg, P, and low microelements (Cu, Zn, Mn, and B) [5].

Indonesia's peatlands are still extensive and have the potential to be developed into plantations. Indonesian Soil Research Institute, Agency for Agricultural Research and Development [10] issued a map of the distribution and area of Indonesian peatlands. Based on the results of spatial calculations from updating the peat map using data from the latest research results, the total area of peatland in Indonesia's three main islands, namely Sumatra, Kalimantan, and Papua, is 14,905,574 hectares. In contrast, the shallow peatland area (< 100 cm) is 5,241,348 hectares. The largest peatland is on Sumatera Island, which is 6,436,649 hectares with almost the same area between the shallow depth (50-100 cm) and very deep (> 300 cm). The widest distribution of peatlands in Sumatra is in Riau, South Sumatra, and Jambi province, while the area of peat in other provinces is < 262.000 hectares.

The extent of peatlands in Indonesia has great potential to be used as plantation areas. Thus far, there are no large-scale rubber plantations planted on peatlands. Farmers generally plant peatlands with rubber, and comprehensive information about the potential for rubber cultivation on peatlands has yet to be available. However, Watson [2] and Yew [11] stated that peatland with a depth of > 50 cm is the main limiting factor in plant cultivation due to its ability to support stems and also supply nutrients for rubber plants. In addition, rubber cultivation in peat areas has obstacles, such as plants easily falling when they mature. Therefore, planting rubber on peatlands must pay attention to the type of clone used, which has a light crown shape to reduce the obstacles to tilting or falling plants. The potential for peatlands is enormous, and there needs to be more information about rubber plantations on peatlands, prompting this research to be carried out, which aims to determine the growth of PB 260 clones of rubber plants on peatlands.

2. Material and Methods

2.1. General Conditions of Research Locations

The research was carried out on peatlands owned by farmers in Sungai Rengit Village, Talang Kelapa District, Banyuasin Regency, South Sumatra Province. The peatlands in the research location are classified as shallow peatlands with a peat thickness of 1.5 – 2 m and a maturity level of sapric peat. The results of the analysis of the physical properties of peat showed that the bulk density was 0.53 g/cm^3. The high density of peat at the research location compared to the density of peat, in general, is due to the maturity level being included in the sapric category. In addition, according to Tie and Lim [8], peat in the watershed can have a density of > 0.2 g/cm^3 due to the influence of mineral soils. The results of the analysis of the chemical properties of peat are presented in Table 1.

Based on the soil nutrient criteria for rubber plants [12], the research location had low to high nutrient content (N, P, K, Ca, and Mg), but there are no visible signs of nutrient deficiency. The analysis showed that fertilization must be done as a source of plant nutrients, especially P, K, and Mg. In addition, peat has a very acidic pH value (4.17), is C-organic, and has a very high CEC.

Table 1. The results of the chemical properties analysis of peat at the research site

Parameter	Value	Criteria*
pH H_20	4.170	very acid
Organic C (%)	13.740	very high
N (%)	0.640	high
P_2O_5 (ppm)	1.280	very low
K (me/100 gr)	0.018	very low
Ca (me/100 gr)	0.350	low
Mg (me/100 gr)	0.706	intermediate
CEC (me/100 gr)	87.690	very high

Remarks : * Based on soil nutrient classification for rubber plants [12]

2.2. Methods

The research started from 2013 to 2018. Rubber planting was carried out in October 2013. This research used conventional seedlings (one whorl rubber planting material) of PB 260 clone. This clone was used due to the shape of the plant crown, such as cypress [13], thereby reducing the crown's weight and is expected to reduce slanted or fallen plants.

Cultivation techniques such as plant care were carried out according to general standards. The inorganic fertilizers used were single fertilizers urea, TSP, KCl, and kieserite, with each nutrient content of 46% N, 46% P_2O_5, 60% K_2O, and 26% MgO. The fertilization dose in the first year follows the general dose [14]. Fertilization was carried out four times a year. The research used the recommended spacing of 6 x 3 m. Observations were made on 25 plants in the interior of the research plot. Planting on peatland was planted deeper (± 20 cm from the grafting). The parameters of the observations were made, among others:

1) The stem girth was measured at a height of 100 cm from the grafting junction. The measurement of the stem girth was carried out once a year. Observational data on the growth of girth on peatlands were compared with data on the growth of plant girth on mineral soils of the ultisol type (Experimental Garden of Indonesian Rubber Research Institute, Sembawa, Banyuasin, South Sumatra) at the same age and clones using the t-test.
2) The peat water lever was measured by measuring the water depth in the installed pipe. Observations were made starting at six months and then every three months.
3) Peat subsidence was measured by measuring the height of the paralon from the peat surface. Paralon pipes are installed in the research area where the paralon walls have been perforated so water can enter the paralon. Observations were made at one year and then every three months.
4) Rainfall data was taken from the nearest Climatology Station, the Indonesian Rubber Research Institute Climatology Station, 20 km from the research location.

3. Results and Discussion

3.1. *Result*

The growth of rubber plants can be seen in the increase in the number of girths from the age of one year to the age of five years. The results of observations of the increase in stem girth of the rubber plant of PB 260 clone every year on peat land and mineral land are shown in Table 2. The growth data of the rubber plant of PB 260 clone on mineral land were taken from the experimental garden of the Indonesian Rubber Research Institute in Sembawa, South Sumatra. The data compares peatlands' effect on rubber plants' growth.

Table 2. Average growth of rubber stem girth of PB 260 clone for five years

Plant age	Stem girth (cm)*	
	Peatland	Mineral land
1	7.50a	8.30a
2	16.80a	19.70a
3	26.70a	27.10a
4	35.30a	34.10a
5	42.20a	41.70a

Remarks: Numbers followed by the same letter in the same row show no significant difference at the 5% level

Ideally, the girth of rubber plants in mineral soils at age five has reached a minimum of 45 cm. However, in this research, the girth of rubber plants on mineral soils at age five only reached 41.70 cm, and on peatlands was 42.20 cm. That was due to a climatic anomaly that caused a long dry spell in 2015. According to Wijaya [15], rubber plants grow well when the average annual rainfall is 1,500-3,000 mm/year with 0-2 dry months. The annual average rainfall during the immature plant period in 2013-2018 was ideal for rubber growth, namely 2,686 mm/year with two dry months, but in 2015 when the plants were three years old, El-Nino occurred, so the annual rainfall was only 1,775 mm/yr with five dry months. The average monthly rainfall data for 2013-2018 and monthly rainfall in 2015 can be seen in Figure 1.

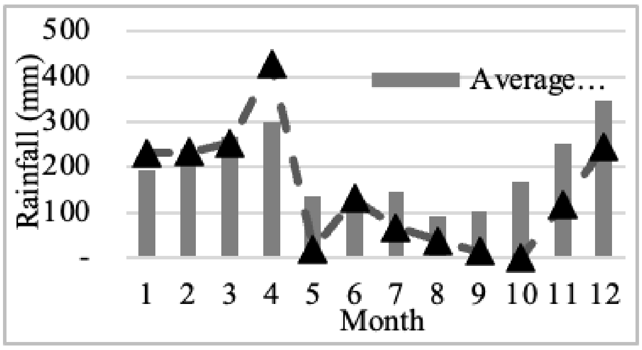

Figure 1. Average monthly rainfall in 2013-2018 and monthly rainfall in 2015

Peat water level observations were carried out from six months to five years of age. The observed data and monthly rainfall are shown in Figure 2. The graph shows fluctuations in the peat water level under rainfall in the same month. These data show that at 24 months, the deep peat water level was > 140 cm, and the rainfall during the previous four months was also very low (<100 mm).

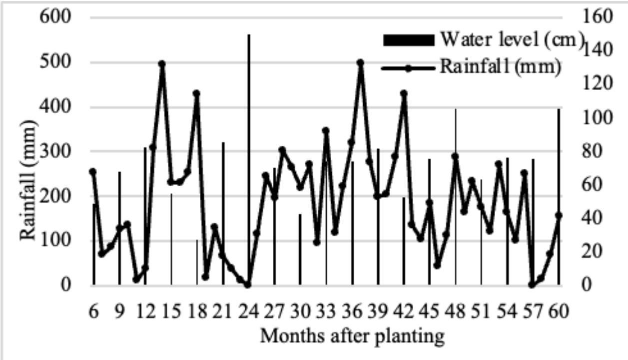

Figure 2. Water level and rainfall fluctuations until 60 months after planting (MAP)

Observational data on peatland subsidence from one year to five years are shown in Figure 3. Until the rubber plantations are five years old, the peat subsidence has reached 25 cm, with the highest decline occurring at the beginning of land clearing, namely when the plants are one year old with the peat water level subsides up to 18 cm.

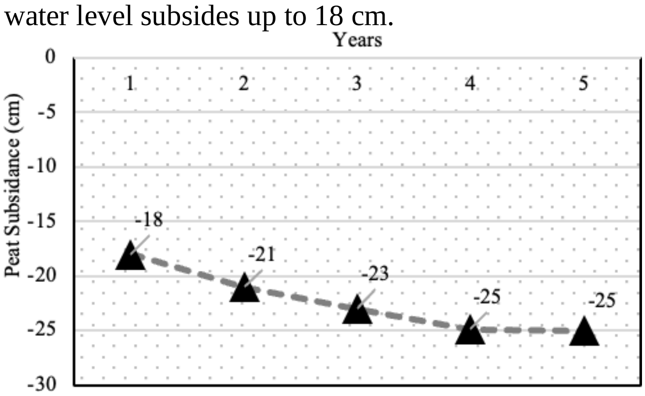

Figure 3. Graph of peat subsidence up to 5 years of observation

3.2. *Discussion*

Rubber clones of PB 260 on peatland showed a higher growth of stem girth than growth on mineral soils until three years. However, at the age of four and five years, the growth of stem girth in mineral soils was higher. The stem girth between the two soil types only differed from 0.4 cm to 2.9 cm, with an average growth of more than 7 cm per year. The t-test results showed no significant difference between the average growth of stem girth on peatlands and mineral soils during the five years of observation (Table 2). The same thing was conveyed by Budianto et al. [16] that the productivity and agronomic characteristics of oil palm plants, such as the number of midribs and female flowers, did not have a significant difference between oil palm plants grown on peatlands and mineral soils.

Currently, few farmers are planting rubber on peatlands because the carrying capacity of peat is low compared to mineral soils, and the water level is shallow, so when the plants are large, they easily tilt and fall. From the results of this study, it can be proven that plants can grow well up to the age of five years, and no fallen plants were found on shallow peat with sapric maturity level and water level > 45 cm. Other plantation crops, such as oil palm, will experience the same problems when planted on peat. Namely, plants tilt and fall easily and stunted growth if the peat water level cannot be maintained > 45 cm.

The growth of the rubber plant of the PB 260 clone on peatland was similar to the growth on mineral soil in the Experimental Garden of the Indonesian Rubber Research Institute, which used maintenance according to standard operating procedures. The observation showed that the growth of rubber plants on peatlands with maintenance according to standards and good drainage conditions could make plants grow more optimally. Good drainage will be achieved if the land has drainage channels for draining water into rivers and sluice gates to regulate the water level. On the other hand, maintenance of non-standard rubber plants will inhibit growth. Saputra et al. [17] reported that the stems of rubber plantations on peatlands owned by farmers with poor maintenance only had 37.6 cm in diameter at the age of five years.

When the plant was five years old, the stem girth of the rubber plant PB 260 clone on peatland and mineral soils had yet to reach tapping maturity because the stem girth was < 45 cm. Therefore, the ripe criteria for tapping rubber plants were the size of the stem girth > 45 cm which has reached a minimum of 60% of the total plant population [18]. However, in both locations, tapping maturity was only reached after the plants were 5.5 years old. That is because when the plant is three years old (in 2015), there is a long dry season (dry months of 5 months/year), so the growth of rubber plants is hampered. Rubber plant growth will be optimal if the dry months (rainfall <100 mm/month) in one year total of 0-2 dry months [17].

One of the factors that influence the cultivation of rubber plants is climate. Rubber plants require rainfall between 1,500 - 3,000 mm/year and optimal rainfall at 1,500 mm/year, with the number of rainy days between 100-150 days/year [15]. The existence of an El-Nino climate anomaly can cause a longer dry season than usual, so it impacts plant growth [19]. Wijaya [20] reports that long droughts occurred in Indonesia in 1991, 1994, and 1997, and last occurred in 2014-2016. This long dry event has an impact on decreasing fluctuations in growth and latex yields [21], increasing fire risk [20], the longer period of immature plants being longer, and sometimes the death of very young rubber plants [22]. In addition, the results of the study of Saputra et al. [23] in the experimental garden of the Indonesian Rubber Research Institute showed that the 2015 El Nino in the South Sumatra region had an impact on decreasing the growth of rubber plants of PB 260 clone by 65% compared to the previous year.

The regulation of the groundwater level in peatlands is crucial to paying attention to the sustainability of the ecosystem and the continuity of plant productivity on peatlands. If the peat water level decreases, the soil surface will dry and be vulnerable to peatland fires [24]. On the other hand, if the peat water level rises, there will be inundation or flooding. Therefore, water management control on peatlands aims to suppress the decline in environmental functions due to the drainage process for lowering the water level but can still meet the growing requirements for plants [25].

At the research location, a drainage channel has been appropriately managed so that the peat water level is maintained and there is no puddle. The research location is adjacent to the oil palm plantation area, where there is a primary drainage channel that leads directly to the river and a secondary channel from the plantation blocks to the primary channel, as well as a tertiary channel from inside the plantation block to the secondary channel. In the primary canal, there are sluice gates that function to regulate the water level. If the water level in the land has reached 50 cm, the floodgates are closed so that if the water level in the river is shallower, the river water cannot enter the land. Just before the dry season, the water level in the land has reached 60 cm, so the water gates are closed to retain water in the land so that the peatlands do not dry out easily because peatlands are prone to fires.

The rainfall conditions strongly influence the fluctuation of the peat water level at the time of observation. The observations showed fluctuations in water level following variations in rainfall. When the rainfall is low, the water level rises. In April 2015 (18 MAP), the highest peat water level (27 cm from the peat surface) was seen due to high rainfall, namely > 400 mm. Meanwhile, October 2015 (24 MAP) was a long dry season with only 0.2 mm of rainfall, so the peat water level was > 150 cm, and drainage channels were also dry (Figure 2). Wakhid et al. [26] reported that fluctuations in peat water levels in rubber plantations in Central Kalimantan in 2015 were also seen to follow variations in rainfall. The peat water level is close to the soil surface in the rainy season and deep in the soil during the dry season. The same thing was also conveyed: in the 2015 dry year, the highest water level occurred at the end of April, and the lowest was deep in the ground measured at the end of October 2015.

The peat subsidence until the age of the plant is one year (October 2014) is quite large, namely 18 cm. Observations of peat subsidence data showed that there was fairly high peat subsidence at the beginning of planting, but after two years of planting, the peat subsidence began to decline. At the age of two to five, the peat subsidence only increased by 4 cm (Figure 3). The construction of drainage channels on peatlands can increase oxygen by about 1.4 – 1.9 higher than during inundated/anaerobic conditions [27]. These conditions change the conditions of anaerobic microbes (such as bacteria and fungi) into aerobic microbes. According to Landry and Rochefort [28], the decomposition of organic matter in aerobic conditions can be 50 times faster than in anaerobic conditions. That can cause fairly high peat subsidence until the rubber plant is one year old. In addition, drainage can also cause changes in the peat structure to become hydrophobic [29] so that peat volume shrinkage can occur and the peat surface will decrease. Making drainage is unavoidable and impacts on lowering the peat surface, but if drainage is not made on peatlands, then the land cannot be managed as plantation land. Efforts to minimize the impact of peat subsidence on rubber plantations are planting rubber deeper to reduce falling plants.

4. Conclusion

The growth of stem girth of rubber plant PB 260 clones on peatland with sapric maturity level during the immature plant period was not significantly different from that of rubber plants on clones and at the same age on mineral soils. The average annual growth of the girth is more than 7 cm. In addition, the results of observations of peat water level show fluctuations that follow variations in rainfall. The water level will rise when the rainfall is low, and vice versa. During the five years of observation, the highest peat water level occurred in the rainy season in April 2015, which was 27 cm from the peat surface, while the lowest peat water level occurred in the dry season in October 2015, more than 150 cm from the peat surface. The peat subsidence reached 25 cm during the five years of observation, with the highest decline occurring at one year of plant age, 18 cm.

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