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Oil Palm Biomass Production At Sei Air Hitam Plantation, First Resources Rokan Hulu, Riau

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ABSTRACT

The oil palm biomass production study was conducted at PT Perdana Inti Sawit Perkasa 1, Sei Air Hitam Plantation (SAHE), First Resources, Rokan Hulu Regency, Riau Province, Sumatra. The collected data consisted of special data and general data. Special data refers to primary data collected through field sampling. Two sample plants were selected for the sampling process. The first sample was taken from Block A29, planted in 2000. The second sample was taken from Block B25, planted in 1995. Both sample plants were grown in the same environment, with identical soil and moisture conditions, ensuring no variation in their characteristics. Destructive sampling was conducted to obtain leaf, stem, and root data. Descriptive analysis was used to analyze the data. Sample 1 had a total biomass of 382.3 kg dry weight or 1,317.3 kg fresh weight. Sample 2 had a biomass of 659.4 kg dry weight or 2,083.0 kg fresh weight. On average, one hectare of oil palm plantation produced 76.8 tons of dry weight or 245.8 tons of fresh weight biomass.

Keywords: *biomass, oil palm, production*

1. INTRODUCTION

The demand for palm oil and its derivatives continuously increases due to the growing global population. Apart from being used for food consumption, palm oil is now being utilized for biodiesel production. Biodiesel is a renewable fuel made from plant oils or animal fats. It is considered an environmentally friendly alternative to conventional fuel, as it emits relatively cleaner exhaust emissions (Busyairi et al., 2020). Cultivating oil palm trees can also reduce greenhouse gas emissions, particularly carbon dioxide (CO2). During photosynthesis, oil palm plants absorb CO2 and store it as biomass. The more biomass the plants have, the greater the amount of CO2 they can store. Accurately measuring biomass in oil palm plants can be achieved through direct techniques, such as direct measurement. However, biomass calculations can also be done indirectly using allometric equations in certain situations and conditions. By measuring the amount of carbon stored in the biomass of oil palm plants, it is possible to determine the extent to which they absorb CO2 from the atmosphere (Sutaryo, 2009).

The plant biomass primarily determines the carbon stock variation in oil palm plantations. This carbon stock can be traded globally, allowing for the exchange of efforts to mitigate pollution generated by specific industries. The fundamental principle behind calculating carbon stock lies in the carbon cycle, exemplified by the biomass of oil palm plants.

Palm oil is derived from the oil palm fruit, which produces both crude palm oil (CPO) and palm kernel oil. According to Mangoensoekarjo (2008), the oil palm fruit is a hard drupe that grows in clusters known as fruit bunches. These bunches can contain up to 1.600 fruits, which are oval to rounded in shape. The size of the fruit ranges from 2-5 cm, weighing up to 30 g. The fruit comprises different parts, including the exocarp (fruit skin), mesocarp (fiber), and seeds. The exocarp and mesocarp together form the pericarp, while the seeds consist of the endocarp (shell) and the core (kernel). The core contains the endorperm or white organ and the core itself. The mesocarp and core are the parts of the fruit that yield oil. It takes approximately 5-6 months after pollination for the oil palm fruit to reach maturity and be ready for harvest.

The majority of carbon present in the atmosphere consists of carbon dioxide (CO2), methane (CH4), and chlorofluorocarbons (CFCs). These gases are classified as greenhouse gases and contribute to the phenomenon of global warming (Yulianti, 2009). Carbon reserves within terrestrial ecosystems are categorized into two parts: carbon above the surface and carbon below the surface or within the soil. Aboveground carbon encompasses tree biomass, understory plant biomass (including shrubs with a diameter less than 5 cm, creeping plants, and weeds), necromass (dead tree or plant parts), and litter (fallen plant parts such as leaves and twigs). Subsurface carbon includes root biomass, soil organic matter (composed of decomposed plant, animal, and human remains), and extensive areas of peatland (Hairiah, 2007). The amount of carbon present in biomass at a specific time is referred to as carbon stock (Noor'an et al., 2010). Biomass is defined as the total mass of living material above the surface of a tree and is measured in tons of dry weight per unit area (Brown S, 1997). In general, 1 ton of crude palm oil (CPO) production requires 5 tons of fresh fruit bunches (FFB). On average, the processing of 1 ton of FFB results in the generation of 0.23 tons of empty husks (JJK) and 0.65 tons of liquid palm oil waste (POME) (Stichnothe, 2011).

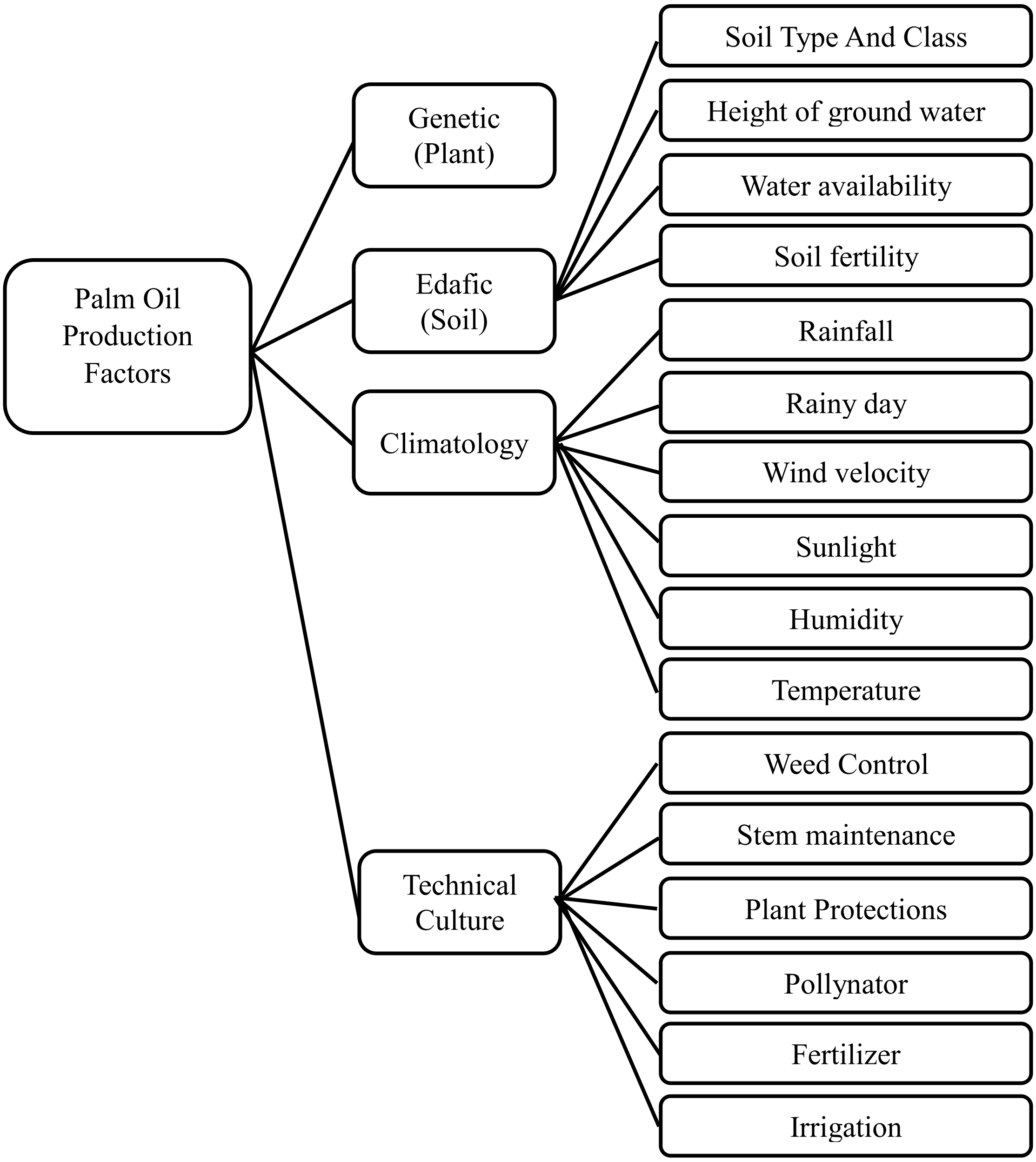

Figure 1. Factors influencing oil palm production (processed from various sources)

2. MATERIAL AND METHODS

Observations were carried out at PT Perdana Inti Sawit Perkasa 1. Sei Air Hitam Plantation (SAHE), First Resources, Rokan Hulu Regency, Riau Province, Sumatra. The data collected includes special data and general data. Particular data is primary data collected through field sampling, interviews, and observations. Observations in the field include calculating the dry weight of oil palm plant parts by taking samples of oil palm plants located in several different blocks. The parts of the oil palm plant whose dry matter was observed were roots, stems, fronds, leaves. The destructive sample is then used as a basic assumption for carrying out biomass allometry of the entire plantation. As supporting data, stem height, diameter, and number of fronds are measured for one hectare of sample plants/block.

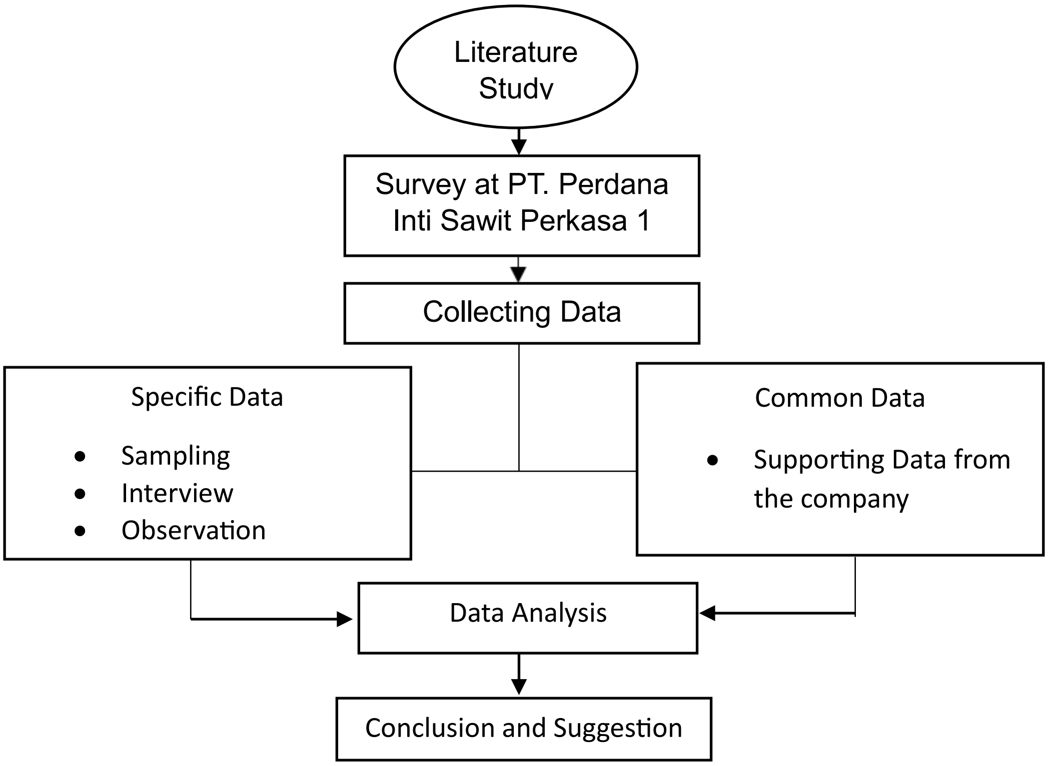

Figure 2. Stages of research implementation

Sampling was carried out on two sample plants. The first sample was in Block A29 with a planting year 2000. The second sample was in Block B25 with a planting year 1995. The sampling technique was the same as the sampling technique in the first stage. The two sample plants grow in the same environment, with the same soil and humidity conditions, so there is no difference in character between the two plant samples. As supporting data, measuring stem height, stem diameter, and number of fronds for one hectare of plants was carried out in Block B25.

The sampling process is carried out by cutting down plants. The stem is divided into three parts: bottom, middle, and top. Then, samples were taken from each part. Samples were taken from the lower, middle, and upper midribs. Three leaves were taken from each midrib sample and divided into three parts: the lower, middle, and upper leaves. Three samples were taken from each leaf: the lower, middle, and upper leaves. Meanwhile, root samples were taken by digging a hole measuring 30x30x30 cm at a distance of 1 meter from the plant. All samples were weighed to obtain wet weight. The oven is used to obtain the dry weight of the sample in the PKS laboratory. All samples were oven at 102ºC. The length of oven time varies for each sample. Stem samples require 4x24 hours of oven time to obtain a constant dry weight. Midrib samples require 3x24 hours, and leaf and root samples require 2x24 hours.

General data is secondary data that the company has managed. Secondary data includes daily, monthly, and annual production data and company administrative archives. Data includes Afdeling area, environmental data, soil data, garden maintenance (fertilization, IPM, weed control, etc.), human resource data, factory data, production data, etc. Secondary data supports and complements primary data and studies production management systems in oil palm plantations.

Data analysis uses descriptive analysis. The data was then compared with literature and literature, as well as standard norms for oil palm cultivation and company operational standards.

3. RESULT AND DISCUSSION

Oil palm biomass production relies on destructive measurements. As per the company's policy, the felling of two oil palm trees currently in production is permitted. The implementation follows a proposed method, which involves sampling various parts of the plant and subsequently making adjustments to estimate the biomass of a single tree. However, due to technical constraints, the observation of fresh fruit bunches (FFB) was not conducted during this study. Instead, existing literature references were utilized to estimate the biomass of FFB. The application of plant biomass enables the estimation of carbon stocks within oil palm plants. Biomass, in this context, refers to the total production above the tree's surface and is quantified in units of dry weight per unit area, typically measured in tons (Brown S, 1997). Palm oil biomass is produced through the process of photosynthesis, where carbon dioxide (CO2) and water (H2O) are converted into carbohydrates (CH2O) using solar radiation. This conversion occurs in the green chloroplasts of leaves, where chlorophyll absorbs the sunlight (Pahan, 2010). Photosynthesis is a vital process that enables the synthesis of energy or food substances, such as glucose, with the aid of sunlight, nutrients/minerals, CO2. and water. It serves to assimilate carbon, as free carbon is transformed into sugar during photosynthesis. The equation representing this process is 6H2O + 6CO2 + light → C6H12O6 (glucose) + 6O2. When studying root biomass, researchers conducted sampling rather than extensive excavation. Various parts such as stems, leaves, midribs, and roots are sampled to estimate the biomass of a single oil palm plant.

Sampling for estimating biomass in one oil palm plant was conducted on trees in the 2002 planting year (sample 1) and 1995 (sample 2). The two sample plants were taken from almost the same growing environment, including the same soil type and other environmental conditions. Sample plants were taken from blocks, e.g., Blocks A29 (sample 1) and B25 (sample 2). The age of sample 1 plants is 11 years, and sample 2 plants is 18 years. The two sample plants are Tenera oil palm plants from Marihat (Dura x Psifera). The total height of sample 1 plants is 12 meters, and sample 2 is 16 meters (Table 1)

3.1 Stem Biomass

Stem observations were conducted by sampling at three distinct points representing mature, intermediate, and juvenile stems. These points were positioned at approximately ¼, 2/4. and 1/4 of the total stem length for each sample. The findings from these observations indicate variations between sample 1 and sample 2. as presented in Table 1.

Table 1. Weight of oil palm trunk biomass of sample plants

	Sample Plant	Stem Height (m)	Weight (kg)			
			Upper Stem	Center Stem	Lower Stem	Total
Wet Weight	Tan 1	4	85,7	126,6	112,7	325,5
	Tan 2	9	17,6	256,0	87,0	514,6
Dry Weight	Tan 1	4	19,4	27,2	24,4	70,9
	Tan 2	9	48,0	56,6	20,4	124,9

Note: Tan 1: Plant Sample 1. Tan 2: Plant Sample 2

Table 1 shows that sample 1 plants with a stem height of 4 meters and a wet stem weight of 325.5 kg produced a dry weight/biomass of 70.9 kg. Sample plant 2 has a stem height of 9 meters and a wet weight of 514.6 kilograms, producing a dry weight/biomass of 124.9 kg.

3.2. Frond Biomass

Frond biomass was carried out on 2 sample plants by classifying the fronds into three categories of fronds, namely lower, middle, and upper leaves. Determination of the number of lower, middle, and upper is based on the physical appearance of the midrib. The lower frond leaves are fully developed, old, and dark green on each leaflet. Middle leaves are leaves that have opened completely but still have a light green color. The upper midrib is from the bud leaves to the young leaves. From each leaf position, one leaf is taken for sampling. Each leaf frond sample is divided into three positions: the lower, middle, and upper fronds. All samples were baked for 3x24 hours at 102 ºC. Table 2 shows the biomass weight of the fronds of sample 1 with 27 fronds is 42.3 kg. The biomass weight of sample 2 plants with 35 fronds was 131.1 kg. The dry weight of the midrib is obtained from the sum of the dry weights of the lower, middle, and upper midribs. Plant sample 1 has eight lower midribs, 13 middle midribs, and six upper midribs. Plant sample 2 has ten lower midribs, 19 middle midribs, and six upper midribs.

Table 2. Average biomass weight of oil palm fronds from sample plants

	Plant Sample	Total Fronds	Weight (kg)			
			Upper Fronds	Center Fronds	Lower Fronds	Total
Wet Weight	Tan 1	27	26,4	67,4	51,2	144,9
	Tan 2	35	52,4	201,7	104,4	358,6
Dry Weight	Tan 1	27	7,6	20,0	14,6	42,3
	Tan 2	35	14,7	79,6	36,8	131,1

Note: Tan 1: Plant Sample 1. Tan 2: Plant Sample 2

3.3. Leaf Biomass

Leaf samples were collected from each midrib sample, ensuring that the midrib category and the position of the leaflets on the midrib matched the sampling method for leaves (midribs). The samples were taken from the midrib's bottom, middle, and top. The leaflets were then placed in an oven for 2x24 hours at a temperature of 102 ºC. During measurement, the leaflets were cut crosswise to include the midrib of the leaflets. In the case of sample plant 1. there were a total of 27 midribs. Out of these, 8 were lower midribs with an average of 292 leaflets, 13 were middle midribs with an average of 286 leaflets, and 6 were upper midribs with an average of 296 leaflets. For sample plant 2. there were a total of 35 fronds. Among these, 10 were lower fronds with an average of 320 leaflets, 19 were middle fronds with an average of 326 leaflets, and 6 were upper fronds with an average of 292 leaflets. According to Table 3. the biomass weight of the leaves from sample plant 1 was 44.0 kg when wet, which resulted in a dry weight of 18.5 kg. On the other hand, sample plant 2 had a total leaf biomass weight of 56.9 kilograms when dry, derived from a wet weight of 125.9 kg.

Table 3. The average weight of young oil palm leaf biomass from sample plants.

	Plant Sample	Total Fronds	Weight (kg)			
			Upper midrib leaflets	Center midrib leaflets	Lower midrib leaflets	Total
Wet Weight	Tan 1	27	13,3	17,9	12,8	44,0
	Tan 2	35	19,8	73,7	32,4	125,9
Dry Weight	Tan 1	27	5,5	7,5	5,4	18,5
	Tan 2	35	8,6	33,4	14,9	56,9

Note: Tan 1: Plant Sample 1. Tan 2: Plant Sample 2

3.4 Root Biomass

Root samples were taken by digging a hole measuring 30x30x30 cm in a disk at a distance of 0.5 meters from the stem. For the record, the radius of the disk is 2 meters. This position is expected to represent the total root weight of the plant by calculating the plant root weight conversion = ((3.14x4)/0.09) x root sample weight.

The roots obtained were oven-dried at 102 ºC for 2x24 hours. Table 4 shows that the oven results show that the biomass and conversion weight of sample 1 plants is 155.9 kg dry weight from 376.4 kg wet weight. Sample 2 plants obtained a biomass weight of 147.3 kg dry weight from 336.6 kg wet weight. Considering that the dynamics of root development are closely related to soil type, cultivation practices, and groundwater levels, the estimation of root weight needs to be applied according to local principles. Interestingly, the root weight from the measurement results shows that sample 2 plants, which are greater in the aboveground biomass variable than sample 1 plants, have lower root weights.

Table 4. Average weight of oil palm root biomass of sample plants

Overall Weight	Sample Plant	Weight (kg)
Wet Weight	Tan 1	376,4
	Tan 2	336,6
Dry Weight	Tan 1	155,9
	Tan 2	147,3

Note: Tan 1: Plant Sample 1. Tan 2: Plant Sample 2

3.5 Calculation of Plant Biomass Weight

From calculating the biomass weight per plant part, the biomass weight for one sample plant can be obtained as presented in Table 5. The biomass weight for sample 1 is 382.3 kg dry weight from a total wet weight of 1 317.3 kg. Sample 2 plants showed a greater total biomass, namely 659.4 kg dry weight or 2 083.0 kg wet weight. In both sample plants, leaves and roots have a biomass proportion of more than 50% of the biomass of oil palm plants. The proportion of biomass is then followed by stem biomass and stem biomass. On average, the weight of oil palm biomass excluding FFB is 1.2 tons wet or 0.6 tons dry weight (Table 6).

Table 5. Biomass weight of each oil palm sample plant

Overall Weight	Sample Plant	Weight (kg)				
		Stem	Fronds	Midrib	Root	Total
Wet Weight	Tan 1	325,5	144,9	470,5	376,4	1.317,3
	Tan 2	514,6	358,6	873,2	336,7	2.083,0
Dry Weight	Tan 1	70,9	42,3	113,2	155,9	382,3
	Tan 2	124,9	131,1	256,1	147,3	659,4

Note: Tan 1: Plant Sample 1. Tan 2: Plant Sample 2

Table 6. Average biomass weight of 1 oil palm plant per Ha

Overall Weight	Stem	Fronds	Leaf	Root	Total (kg)
Wet Weight	1.113,6	347,9	122,1	336,7	1.920,4
Dry Weight	270,3	126,9	55,2	147,3	599,6

Calculating biomass weight for 1 Ha of oil palm plants is done by measuring the average stem diameter, stem height, and number of fronds on 1 Ha. The author took samples in Block B25, where the plant population was 128 plants Ha-1. Block B25 is the same location where samples were taken for plant 2. Thus, the author suspects that each sample's wet and dry weights are the same as for sample plant 2. The calculations show that the biomass weight of oil palm plants per Ha is 76.7 tonnes, with a dry weight of 245.8 tons and a wet weight (Table 7).

Table 7. Average biomass weight of oil palm plants per Ha

	Plant Weight (kg)	Population per Ha	Overall Weight (ton)
Wet Weight	1.920,4	128	245,8
Dry Weight	599,6		76,7

From biomass weight analysis, it can be seen how much plants can absorb nutrients from the soil. Apart from that, it can also be known how efficient fertilization is carried out in oil palm plantations. Apart from nutrient uptake, biomass weight is also influenced by plant age. The difference in biomass weight can be seen from sample plants with different planting ages, namely sample 1 with a plant age of 13 years and sample plant 2 with a plant age of 18 years. From the results of biomass weight analysis, the two sample plants have quite large differences in weight. The age of the plant also influences the production of oil palm plants; the older the plant, the higher the production of fresh fruit bunches. The greater the plant biomass, the crop production will also increase.

Estimating carbon stocks using a biomass approach can be done based on the results of research conducted by previous researchers. Yulianti (2009) studied the conversion results from biomass using the carbon content of the oil palm dimensions; palm oil biomass carbon is obtained in the range of 0.7-16.43 tons Ha-1. The greatest biomass carbon accumulation is found in the stem except in young oil palm plants, where biomass carbon accumulates in the midrib. The relationship between oil palm planting age and biomass carbon shows a sigmoid pattern: a gradual increase at the beginning of growth. It continues to increase, and at a certain age, there tends to be no further change (constant).

Regarding production potential and productivity, plants must be able to fulfil all agronomic and physiological assumptions, where plants can adapt to the environment where they grow and receive sufficient supplies of nutrients and water without pests and disease. One of the limiting factors for plant production is solar radiation, which is used as an energy source in photosynthesis (Pahan, 2010). As explained, oil palm biomass is formed from the process of photosynthesis. Thus, plant production and productivity are influenced by the size of the plant biomass.

Based on the findings of Stichnothe H (2011), it is generally observed that the production of 1 ton of Crude Palm Oil (CPO) requires 5 tons of fresh fruit bunches (FFB). Analysing the data obtained from the Sei Air Hitam plantation office, the plant productivity records for 2007-2012 reveal interesting insights. Specifically, oil palm plants that were planted in 1995 (sample plant 2) and had a productivity rate of 170.39 tons ha-1 over six years yielded 34.08 tons of CPO ha-1. On the other hand, oil palm plants planted in 2000 (sample plant 1) had a cumulative productivity of 94.46 tons over six years, producing 18.89 tons of CPO ha-1.

The biomass calculation reveals that the plant in sample 2 possesses a greater weight of biomass in comparison to the plant in sample 1. This disparity arises since the plant in sample 2 is 5 years older than the plant in sample 1. The overall biomass production is significantly influenced by the plant's size, specifically the stem's height and the number of fronds present. Additionally, the number of palm fronds directly impacts the production of fresh fruit bunches in oil palm plants. Furthermore, midribs play a crucial role in photosynthesis, which is essential for food production in oil palm plants.

4. CONCLUSION

In samples 1 and 2. the leaf and root biomass contribute to more than 50% of the total biomass of oil palm plants. Specifically, sample 1 plants have a dry weight of 382.3 kg or a wet weight of 1.317.3 kg, while sample 2 plants have a dry weight of 659.4 kg or a wet weight of 2.083.0 kg. Based on the proposed assumptions, the biomass weight of oil palm plants per hectare is estimated to be 76.8 tons dry weight or 245.8 tons wet weight. It is worth noting that older plants exhibit a higher biomass compared to younger plants.

It is widely acknowledged that the evaluation of oil palm plantations' productivity can be achieved through biomass production. Hence, conducting a comprehensive investigation into biomass becomes imperative, particularly focusing on the ratio of leaves and roots in oil palm plants across various soil types and growing conditions.

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