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Study of Rainfall on Palm Oil Productivity in Pt. Gemilang Sejahtera Abadi East Kalimantan

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Abstract— *Palm oil requires optimal environmental conditions to obtain the maximum production potential. Apart from pedological factors, oil palm distribution patterns are also greatly influenced by climatic factors, particularly rainfall. Water availability plays a crucial role in the entire growth cycle of oil palm plants, and the root system absorbs the water stored in the soil. The aim of this study was to examine rainfall, which is a limiting factor for oil palm productivity. This research uses a qualitative descriptive analysis method, by collecting secondary data in the form of afdeling work maps, rainfall data (mm) and productivity data for the last 9 years. The close relationship between productivity and rainfall was determined by correlation and regression tests using the R Studio application. The water deficit and evapotranspiration were estimated and calculated using the Tailliez Method. The soil on plantation land is dominated by Typic Hapldults. Long Mesangat Estate Gardens is classified as climate type A (very wet) with a Q value of 0.05%, has an average rainfall of 2867 mm/year with 168 rainy days. Throughout the last 9 years there has been no water deficit on plantation land. The evapotranspiration value never exceeded the distribution of rainfall values each year in the excess water category (Surflus). The correlation coefficient (r) value is -0.20. Negative values indicate that if rainfall increases, productivity decreases. The coefficient of determination (R^2) between the rainfall and productivity was 0.04.*

Keywords— *Palm Oil; Productivity; Rainfall.*

I. INTRODUCTION

Oil palm is a plant that can grow well in the lowlands of tropical areas; one of the countries suitable for the cultivation of oil palm is Indonesia. The potential profitability of palm oil plantations has encouraged the conversion of many forest areas and traditional plantations to palm oil plantations. This plant can be used in the food, textile (lubricant), cosmetics, pharmaceutical, and biodiesel industries [5]. The demand for palm oil continues to increase annually. This encourages palm oil plantations to continue to increase their planting area. Until 2020, the area of oil palm plantations is estimated to be around 14.9 million hectares with oil palm fruit production of 48.3 million tons [2].

The East Kalimantan Province plays a significant role in its contribution to palm oil production. According to data [6] In 2020, the area of oil palm plantations in this province reached 1.3 million hectares with fresh fruit bunches (FFB) production of 17,721,970 tons, equivalent to 3.8 million tons of *Crude Palm Oil* (CPO). This figure is expected to continue to increase in line with the continued increase in the demand for palm oil raw materials. The oil palm is a plantation crop that shows a high level of tolerance to suboptimal environmental conditions. However, to achieve optimal growth and high productivity, it is necessary to fulfill special conditions known as the conditions for growing oil palm plants. Similar to other cultivated plants, oil palms require optimal environmental conditions to obtain maximum production potential. The key influencing factors include climate and soil conditions, apart from genetic factors, treatments applied, and other variables [4].

Apart from pedological factors, oil palm distribution patterns are also greatly influenced by climatic factors, particularly rainfall, rain (mm), and rainy days (days). The water requirement for oil palm plants is around 4.10 - 4.65 mm/day [18]. The ever-increasing expansion of oil palm plantation areas must be accompanied by adequate water availability to ensure optimal production of Fresh Fruit Bunches (FFB). Water availability plays a crucial role in the entire growth cycle of oil palm plants, the root system absorbs water stored in the soil. [9] stated that palm oil plants are included in the category of plants that require relatively high water availability. This groundwater source generally comes from rainfall, while the use of irrigation systems is relatively rare because irrigation technology in Indonesia still incurs significant investment costs and is not yet able to cover large areas optimally [14].

Understanding the ability of plants to adapt to a particular climate requires access to detailed climate data spanning several decades, including the monthly mean values and climate distribution patterns throughout the year. Most commercial oil palm plantations are built in areas that have a positive water balance for 6 months or more, namely conditions where rainfall is greater than evapotranspiration in the plantation [16]. The amount of annual rainfall in most parts of Indonesia is sufficient to meet the needs of palm oil plants. However, in certain areas, especially those located south of the equator, the distribution of rain is often a problem or limiting factor because there is a clear dry season and a real water deficit. This results in the disruption of growth, flower, and fruit development, which can ultimately affect the decline in oil palm production.

According to [17] the effects of water deficit on production are: (i) flower abortion, (ii) decreased sex ratio, (iii) increased number of male flowers, (iv) decreased oil yield and (v) longer fruit ripening. Visually, the first symptom visible on oil palms due to water deficit is the presence of more than one spear leaf that does not open. Rainfall can be considered the main factor limiting palm oil yield potential [15]. The aim of this research

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is to examine rainfall which is a limiting factor in oil palm productivity.

II. Materials and Methods

This research is located on the plantation of PT. Gemilang Sejahtera Abadi, which is located in Long Mesangat District, East Kutai Regency, East Kalimantan Province (Figure 1), in the period March 2023 to September 2023.

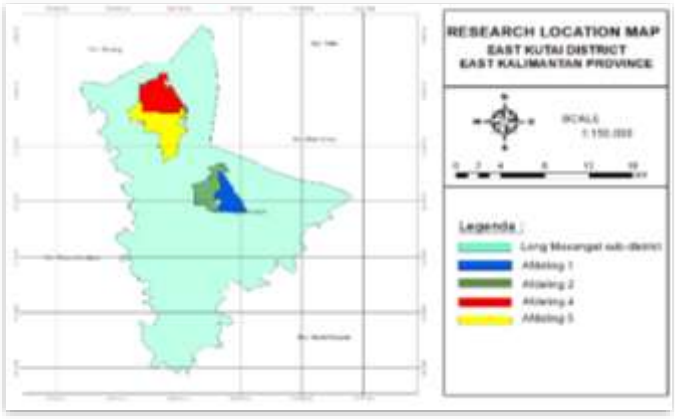

Figure 1. Map of research locations

This research uses a qualitative descriptive analysis method, by collecting secondary data in the form of rainfall data (mm) for the last 9 years, palm oil productivity data for the last 9 years and afdeling work maps as a reference in making afdeling maps. Determining the close relationship between productivity and rainfall was carried out using correlation and regression tests using *R Studio*. A regression test is a statistical tool used to forecast or predict the value of the dependent variable (Y) when the value of the independent variable (X) is known. The regression line equation states the relationship between the conductivity variable (X axis) and other variables (Y axis). The magnitude of the contribution of variable X to Y is expressed in the determinant coefficient value, namely R^2 x 100%. The higher the R2 value, the greater the influence of variable X on Y. Water deficit and evapotranspiration are estimated and calculated using the Tailliez method using the Mocrisoft Excel program.

III. Results and Discussion

General Conditions of the Area

The research area is located in Long Mesangat Estate (LME), which is the ninth plantation of PT Gemilang Sejahtera Abadi. LME started operating in 2006 with a core plantation area of ± 3000 ha. The Long Mesangat Estate plantation is dominated by the development of oil palm in two stages of growth, namely the juvenile phase (aged 9-13 years) with an area of 2,315 ha (62.57%) and the mature phase (aged 14-20 years) with an area of 1,384 ha. (37.43 %). The type of seed used is the DxP *Socfindo LaMe* variety. The soil on plantation land is dominated by the *Typic Haplduls* soil type (Figure 2). *Typic Hapludults*, namely soil types classified in the United States Department of Agriculture (USDA) soil classification system, are included in the Ultisols soil order [13].

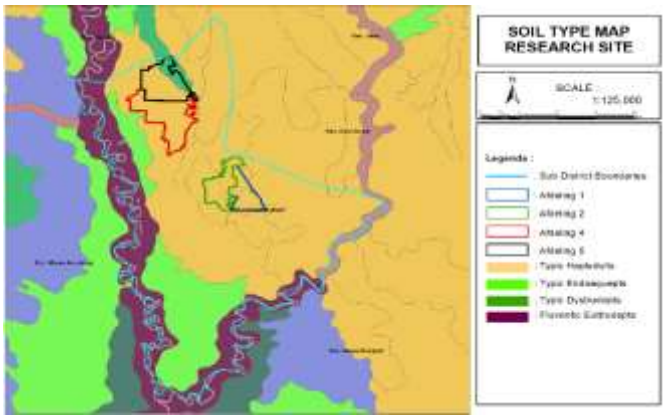

Figure 2. Soil Type at the Research Location

This soil develops from clay and sandstone which are often found on land with a slope of more than eight percent, on tectonic landforms, hills and mountains. Afdeling 1 and 2 are located in hilly areas, while afdeling 4 and 5 are on flat landforms. The soil has a very thick solum thickness (100 to 150 cm), moderate to good drainage, the color of the top layer of soil is dark brown and the bottom layer is yellowish brown to yellowish red, the texture is medium, the block structure is slightly rounded, the consistency of the moist condition is firm [22].

Climate

Rainfall and rainy day data were obtained from PT. The GSA of the Long Mesangat Estate, garden includes data on rainy days and rainfall for the last 9 years (2014 – 2022). The results of these data were used to determine the climate classification according to Schmidt-Ferguson. The climate type was determined using the value Q = (average dry month/average wet month) × 100%. Long Mesangat Estate Gardens is classified as climate type A (very wet) with a Q value = 0.05%, has an average rainfall of 2867 mm/year with 168 rainy day.

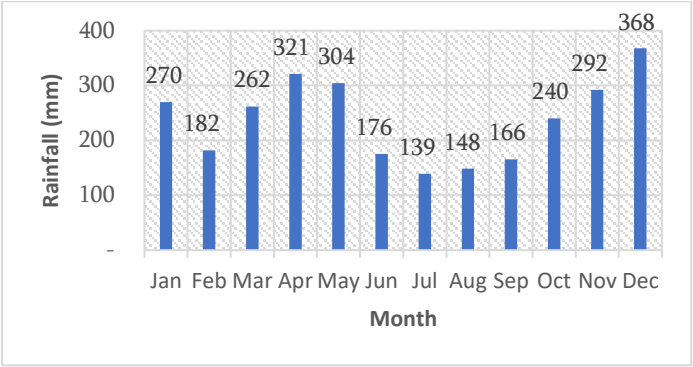

Figure 3. Average monthly rainfall throughout 2014-2022

According to the criteria (Schmidt and Ferguson (1975) in [9] Wet months are characterized by an average rainfall of >100 mm/month, while dry months have an average rainfall of <60 mm/month. Based on the rainfall that occurred from to 2014-2022, it ranges from to 1,700-3,600 (Figure 3). Water deficit analysis was carried out and the results were that throughout the last 9 years there had been no water deficit on plantation land.

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Water deficit can disrupt the growth and development of oil palm because oil palm requires rainfall of more than 1,250 mm/year and is evenly distributed throughout the year [3]

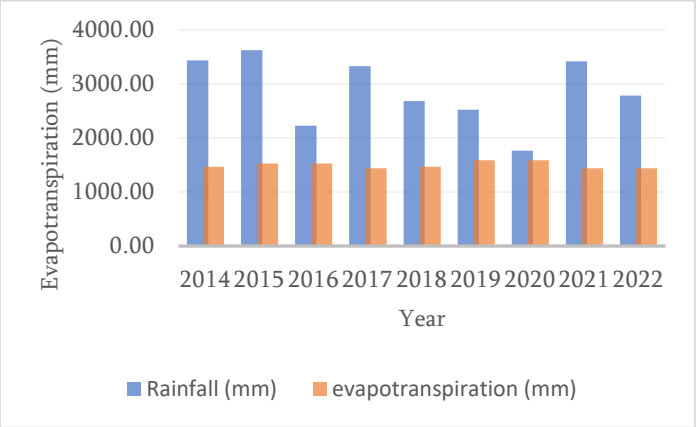

Figure 4. Average rainfall and evapotranspiration throughout 2014-2022

The Based on evapotranspiration analysis over the last nine years, it can be concluded that plantation PT. GSA Long Mesangat Estate belongs to the excess water (surflus) category. The evapotranspiration value never exceeded the distribution of rainfall values each year (Figure 4). Water balance refers to the calculation of water input and output at a location over a certain period of time. Through the water balance, the conditions of excess water (surplus) or lack of water (deficit) can be identified [8]. The application of water balances is a common practice in the context of oil palm cultivation, where these calculations are used to project the optimal water supply and drainage system requirements for oil palm growth and production. Based on land suitability criteria for rainfall in PT. GSA Long Mesangat Estate is included in the S2 (Suitable) class [1] Oil palm plants are plants that require relatively large amounts of water.

The Effect of Rainfall on Productivity

Rainfall data and palm oil productivity data at PT. GSA Long Mesangat Estate shows fluctuating values, the highest productivity was achieved in 2022 and the lowest productivity in 2016 (Figure 5). Fluctuations in annual rainfall are among the factors causing fluctuations in palm oil production per year. A study [9] stated that the effect of low rainfall on productivity was observed within a period of 2 to 24 months. This is caused by plants experiencing drought stress that affects their physiological conditions and productivity [21].

This study indicates that there is a fluctuating comparison between rainfall and palm oil productivity. It can be observed that an increase in the amount of rainfall or a decrease in rainfall each year is not consistently followed by a decrease or increase in oil palm productivity (Figure 5). Palm oil production tends not to follow rainfall fluctuations because oil palm plants have good adaptation to climate variations, and several factors support the insensitivity of oil palm production to rainfall fluctuations, namely root ability, long growth phases, and plantation management. Oil palm can grow and produce relatively stably under various climatic conditions, including periods of fluctuating rainfall. The amount of rainfall required for optimal growth and yield of oil palm ranges from 2,000 to 2,500 mm per year, with the criteria of no water shortage and even distribution throughout the year. The minimum figure of 2,000 mm is not an absolute indicator, because effective requirements only range from 1,300 to 1,500 mm per year. The critical factor that must be considered is the absence of water shortages exceeding 250 mm [4].

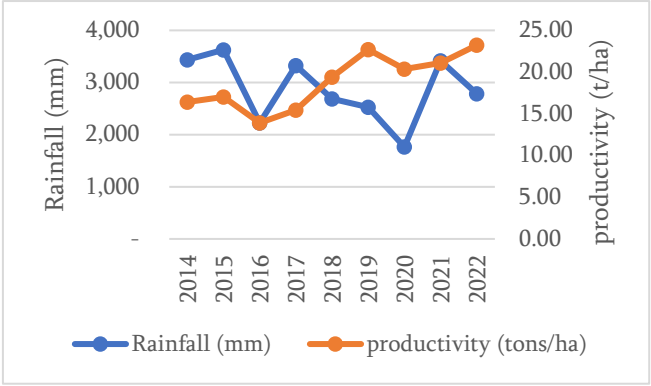

Figure 5. Palm oil productivity and rainfall

Rainfall that reaches very high levels also has the potential to reduce oil yield in the same month owing to the impact of excessive humidity. In addition, as presented in research by [11] rainfall has a significant influence on palm oil production [7] and very high rainfall can also have a negative impact on oil yield in the same month due to high humidity levels. As stated by [10] excessive rainfall can result in a decrease in the activity of the insect Elaeidobius kamerunicus, which in turn can result in a decrease in fruit set and definitely reduce productivity. A report on plantations in Aek Kuo, North Sumatra, also indicated a decline in palm oil productivity of up to 20% as a result of significant fluctuations in rainfall and less-than-optimal drainage systems [19].

Correlation and Regression of Rainfall on Palm Oil Productivity

Correlation analysis between rainfall and palm oil productivity showed a correlation coefficient (r) of -0.20. Based on the coefficient interval, the relationship between rainfall and oil palm productivity was weak. Rainfall does not always directly affect palm oil productivity, but rather involves complex interactions between rainfall and various other factors. Study by [12] stated that there is no significant influence of rainfall on palm oil productivity, with a weak correlation coefficient. The relationship between rainfall and palm oil productivity is negative, which means that if rainfall increases, productivity decreases. In contrast to previous research [20] The relationship between rainfall and palm oil productivity is negative, which means that if rainfall increases, productivity decreases. In contrast to previous research [20], the rainfall factor has a positive effect on oil palm productivity, with an average total rainfall of 1550-2060 (mm/yr). The coefficient of determination (R^2) between rainfall and productivity is 0.04 (Figure 6). Thus, in managing palm oil production, factors other

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than rainfall must be optimally managed to achieve greater production.

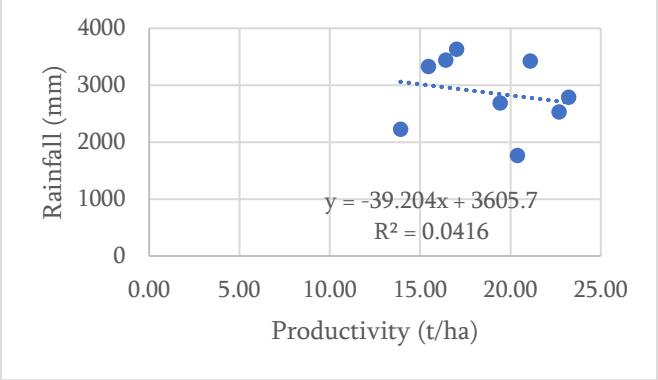

Figure 6. Regression equation for rainfall and oil palm productivity

IV. Conclusion

Monthly rainfall fluctuations are one of the factors that cause fluctuations in palm oil production per year. Long Mesangat Estate Gardens is classified as climate type A (very wet) with a Q value = 0.05%, has an average rainfall of 2867 mm/year with 168 rainy days. Correlation analysis between rainfall and palm oil productivity obtained a correlation coefficient (r) of -0.20, a negative value, which means that if rainfall increases, productivity decreases. Garden management must be carried out to manage excess water (surplus) on rainy days.

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