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RESEARCH ARTICLE Open Access

Growth Performance of Oil Palm (*Elaeis guineensis* Jacq.) in The Productive Phase of Plant in North Labuhanbatu District

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Abstract

This study describes the condition of rejuvenated oil palm plants, the factors influencing their growth and the improvement efforts that can be undertaken to enhance oil palm productivity. The research was conducted on the institutional land of smallholders participating in the community oil palm rejuvenation program (PSR) that had entered the productive plant period (TM) in North Labuhanbatu Regency. The research location was determined by the agroclimatic typology reason, one of which was determined by the representative altitude. The research location was carried out in 3 locations with different altitudes, including Kuala Beringin Village, Kualuh Hulu District (100-115 masl), Pulo Jantan Village, NA IX-X District (32-38 masl) Terang Bulan Village, Aek Natas District (12-17 masl). The study results showed the growth performance of oil palm in the productive plant phase (TM) in North Labuhanbatu Regency. The selection of research locations was based on agroclimatic typology, particularly representative altitude. The study was carried out in three locations with varying altitudes: Kuala Beringin Village in Kualuh Hulu District (100-115 meters above sea level), Pulo Jantan Village in NA IX-X District (32-38 meters above sea level), and Terang Bulan Village in Aek Natas District (12-17 meters above sea level).

Keywords: Altitude, Growth Phase, North Labuhanbatu, Oil Palm Growth Performance, Plant Productivity

1. Introduction

Oil palm (*Elaeis guineensis* Jacq.) represents a significant plantation crop that is crucial to Indonesia's economic development. The palm oil industry is pivotal, as evidenced by its provision of employment for approximately 16 million individuals, encompassing both direct and indirect job opportunities (Coordinating Ministry for the Economy of Indonesia, 2021). Furthermore, the palm oil sector is instrumental in enhancing national revenue and generating foreign exchange. In 2021, the export value of palm oil reached US$ 28.68 billion, with a total volume of 27.04 million tons (Central Statistics Agency, 2021). This performance indicates a positive growth trend compared to previous years.

The Indonesian palm oil plantation sector is confronted with several challenges, including the low productivity of smallholder oil palm plantations. As reported by the Central Statistics Agency (2020), the productivity of smallholder oil palm plantations in 2020 was 3,429 kg/ha/year of fresh fruit bunches (FFB), while the productivity of plasma oil palm plantations reached 3,352 kg/ha/year and private oil palm plantations 3,984 kg/ha/year, with an average national oil palm productivity of 3,890 kg/ha/year. The low productivity of smallholder and plasma oil palm plantations can be attributed to several factors, including the condition of ageing and damaged plants, the utilization of uncertified and suboptimal seeds, land tenure issues, and the growth dynamics of oil palm plants during the immature plant phase (TBM), which can result in stunted growth. The stunted growth of oil palm plants is caused by a lack of essential nutrients in the soil and the plants themselves, which can inhibit the growth of the oil palm. This will have an adverse effect on future plant production and productivity. As stated by the Directorate General of Plantations, Ministry of Agriculture (2023), the Community Oil Palm Rejuvenation Program (PSR) is a government initiative designed to enhance the productivity and well-being of smallholder oil palm farmers. As evidenced by data from the Agriculture Service of North Labuhanbatu Regency (n.d.), the area of land

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rejuvenated through the community oil palm rejuvenation program between 2019 and 2023 was 1,980.6308 hectares. It is anticipated that the implementation of the community oil palm rejuvenation programme will result in an enhancement of oil palm plant productivity within the North Labuhanbatu Regency.

Oil palm trees are cultivated crops known for their broad adaptability and resilience to diverse environmental conditions (Alam et al., 2020). The significant surge in global palm oil production and consumption has led to the extensive proliferation of oil palm monocultures across various regions, facilitated by large state-owned enterprises, private companies, and smallholder plantations (Rahman et al., 2021). As an annual crop, oil palm possesses distinct advantages, being the most efficient and cost-effective source of vegetable oil (Goenadi et al., 2021). Nevertheless, to achieve optimal yields, oil palm cultivation necessitates favorable environmental conditions (Alam et al., 2023). According to Fiqa et al. (2021), in addition to utilizing high-quality certified seeds, environmental factors play a crucial role in the growth and development of oil palm. These environmental factors can be categorized into biotic and abiotic variables.

Biotic variables encompass living factors such as weeds, insects, diseases, nematodes, herbivores, and soil microorganisms, which can exert beneficial or detrimental effects on the plants, contingent upon their type, population, and interactions. Conversely, abiotic variables pertain to non-living factors, including light, temperature, water, photoperiod, wind, gases, soil texture, structure, organic matter, cation exchange capacity, pH, base saturation, and nutrient availability. The influence of abiotic variables can establish optimal or suboptimal conditions for plant growth, depending on their type, intensity, and duration. The interplay between these environmental variables and the plants forms a complex ecological system.

Plants must be able to adjust to fluctuating environmental conditions through morphological, physiological, and biochemical adaptations. Additionally, they can influence environmental factors via photosynthesis, transpiration, respiration, and secretion processes. The oil palm species thrives and achieves optimal production under favorable environmental circumstances. Specifically, oil palm flourishes in lowland regions at altitudes ranging from 200 to 500 meters above sea level. This species is particularly well-suited to tropical climates characterized by high humidity, predominantly found along the equatorial belt, extending from 15º N to 15º S, where critical climatic elements such as temperature, precipitation, humidity, and sunlight duration play significant roles (Satyawibawa and Widyastuti, 1996; Sitanggang et al., 2018).

The community oil palm rejuvenation initiative has been in operation for several years; however, there is a paucity of information regarding its impacts and outcomes, particularly concerning the growth performance of community oil palm plants and the analysis of nutrient levels in both the soil and the leaves. Such analyses are essential for formulating fertilization recommendations and assessing the growth of oil palm plants within the smallholder rejuvenation program. It is crucial to ascertain whether this program has successfully enhanced the productivity of community oil palm plants. Furthermore, the study aims to provide insights into the condition of rejuvenated oil palm plants, identify growth-influencing factors, and propose improvement strategies to boost productivity. The objectives of this research include evaluating the growth performance of oil palm during its productive phase (TM), identifying the primary environmental factors that govern this performance, and determining necessary corrective measures to optimize growth in the productive phase (TM) within North Labuhanbatu Regency.

2. Material and Methods

2.1. Time and Place

This research was conducted in Kuala Beringin Village (2°32'34.30"N, 99°31'41.59"E), Kualuh Hulu District, Pulo Jantan Village (2°16'46.14"N, 99°46'28.29"E) NA IX-X District and Terang Bulan Village (2°26'8.43"N, 99°41'49.43"E) Aek Natas District, North Labuhanbatu Regency, the research was conducted on the institutional land of smallholders who implemented the community oil palm rejuvenation program (PSR) which had entered the productive plant period (TM) in North Labuhanbatu Regency which is presented in Figure 1. The research period took place from October 2024 to December 2024, starting with the preparation and presentation of the results.

2.2. Research Methods

The materials used in this study are namely Producing Plants (TM), while the tools used in the field are survey tools, dodos/egrek, knives, scissors, scales, rulers, rope meters, machetes, gauze, soil drills, plastic bags, label paper, stationery, and documentation tools. The tools used are GPS (Global Position System), abney level, sample ring, mineral soil drill, field knife, hoe, cutter, plywood or board, plastic bags, rubber bands, labels, stationery, camera, office software (Microsoft Excel), IBM SPSS Statistics 23, google earth pro, GPS Essentials application, SAS Planet, ArcMap 10.8, and Munsel Color Chartbook.

2.3. Tools and Materials

The determination of research location is determined by the agroclimatic typology, one of which is determined by the representative altitude of the place, the research location was carried out in 3 locations with different altitudes, including in Kuala Beringin Village, Kualuh Hulu District (100-115 masl), Pulo Jantan Village, NA IX-X

District (32-38 masl) Terang Bulan Village, Aek Natas District (12-17 masl) in North Labuhanbatu Regency, North Sumatra Province, which are presented in Figures 2, 3 and 4.

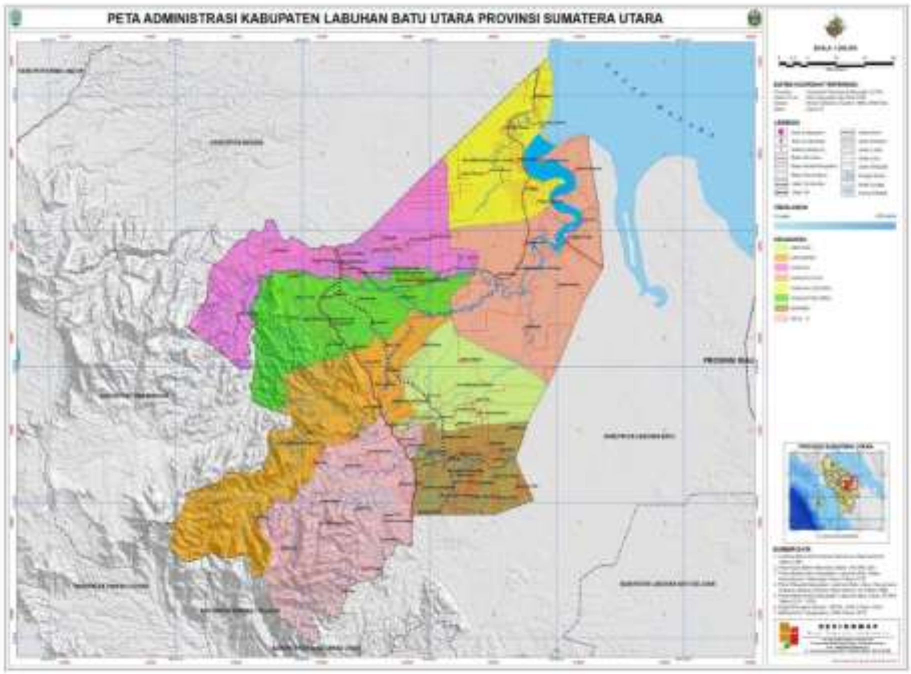


Figure 1. Administrative Map of North Labuhanbatu Regency

Figure 2. Sampling location points for the research in Kuala Beringin Village, Kualuh Hulu District, North Labuhanbatu Regency, altitude 100 – 110 mdpl

Figure 3. Sampling location points for the research in Pulo Jantan Village, NA IX-X District, North Labuhanbatu Regency, altitude 30 – 55 mdpl

Figure 4. The sampling location point of the research in Terang Bulan Village, Aek Natas District, North Labuhanbatu Regency, altitude 20 – 30 mdpl

Starting from plant height, stem diameter, number of fronds, length of the 17th frond, the width of the frond, the thickness of the frond, length, width and area of the leaf blade, then leaf samples were also taken from the 17th frond and the part of the leaf near the lizard's tail as many as 6 strands which are presented in Figure 5.

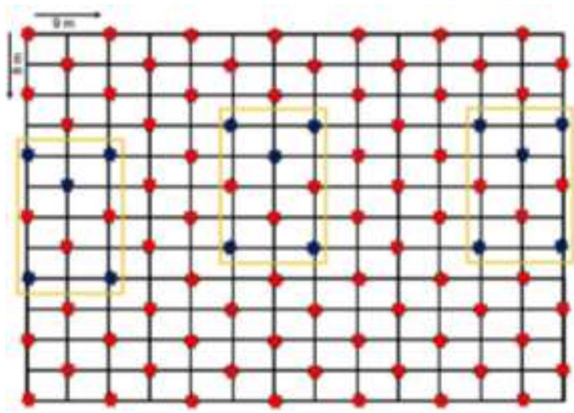


Figure 5. Sketch of zig-zag sampling in Oil Palm Plantation Oil palm plants for performance measurement

2.4. Stages of Research

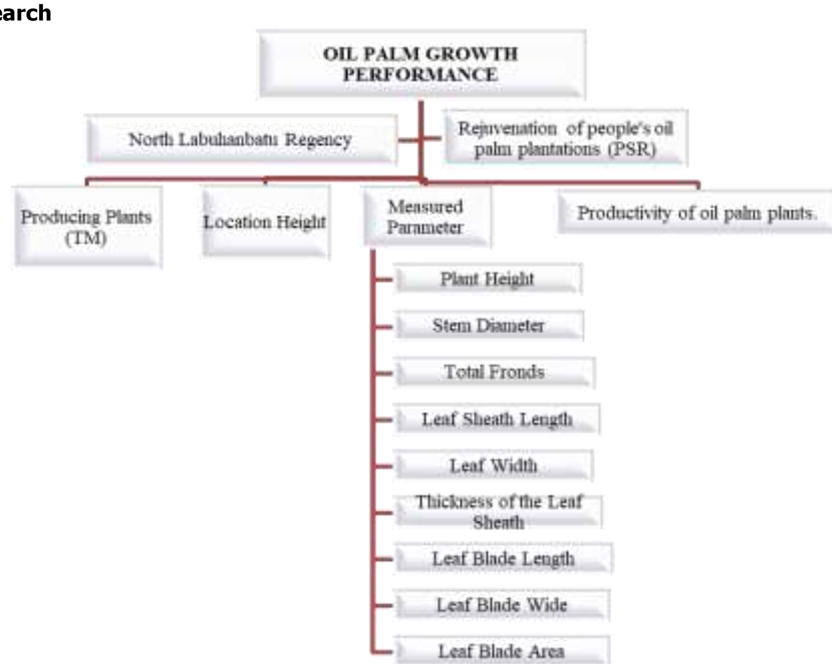


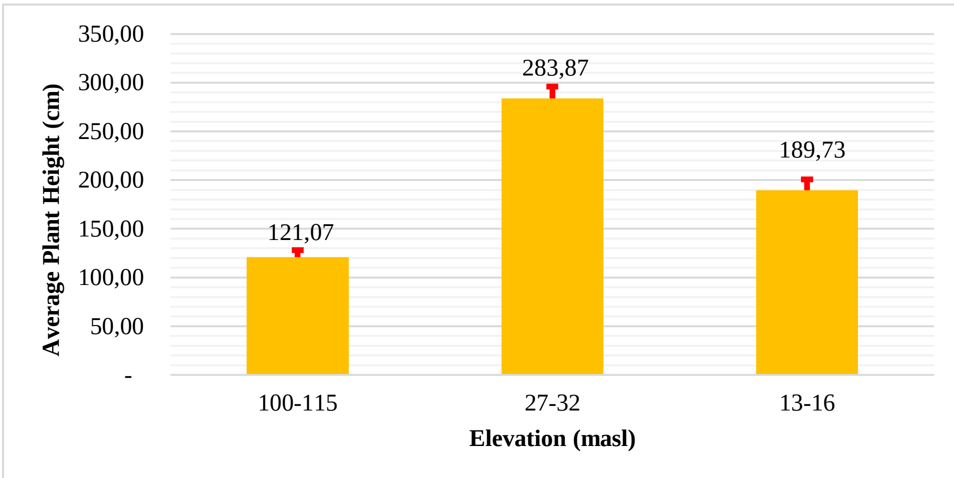
Figure 6. Research flow diagram

3. Results and Discussion

3.1. Oil Palm Growth Performance

The results of measuring the height performance of oil palm plants on plantation land under the People's Oil Palm Rejuvenation (PSR) program, which was carried out at 3 research locations representing different altitudes, can be seen in Graph 1 below.

The results of measurements of the height of oil palm plants at the research location showed that elevations with higher altitudes (27-32 masl) had the highest average plant height (283.8667 cm), elevations with medium altitudes (13-16 masl) had medium average plant heights (189.7333 cm) and elevations with lower altitudes (100-115 masl) had the lowest average plant height (121.0667 cm). Each elevation is included in a different set, indicating that the average plant height between elevations differs significantly. Plant varieties, care, and age greatly influence the growth of oil palm plants.

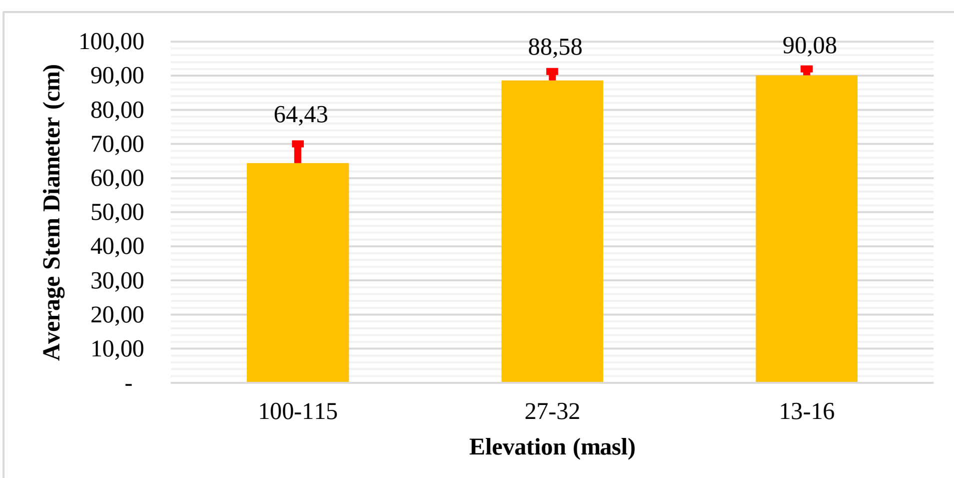


Graph 1. Performance of Oil Palm Plant Height (cm)

The growth of oil palm plants is influenced by environmental variables, one of which is rainfall, soil quality and altitude; in addition, the quality of plant varieties greatly determines the development of oil palm plants supported by fertilization, maintenance and care at the stage of immature plants (TBM) greatly determines the quality and growth of oil palm plants. Oil palms have upright stems and are covered by leaf sheaths. Oil palm plants can grow 45-60 cm per year (depending on the variety. If environmental conditions support growth, the height of the stem will reach 100 cm/year (Ciptadi, 2013).

3.2. Oil Palm Plant Stem Diameter Performance

The trunk of the oil palm is straight and does not branch, in mature plants the trunk diameter reaches 20 - 75 cm. The lower part of the trunk is thicker and fat called bonggol, with a diameter of 60 – 100 cm. The diameter of the trunk that is fat or large will increase the productivity of fresh fruit bunches (FFB), the plant will be sturdy, and more fruit with a large diameter (Ciptadi, 2013).



Graph 2. Performance of Oil Palm Stem Diameter (cm)

In Table 2 and related to Graph 2, the performance of oil palm trunk diameter shows that the largest trunk diameter is found at the lowest elevation (13-16 masl) with an average of 90.08 cm; there is a tendency that the lower the elevation, the larger the diameter of the oil palm trunk. The difference in trunk diameter between elevations of 27-32 masl and 13-16 masl is relatively small (only about 1.5 cm), with a significant decrease in trunk diameter at the highest elevation (100-115 masl).

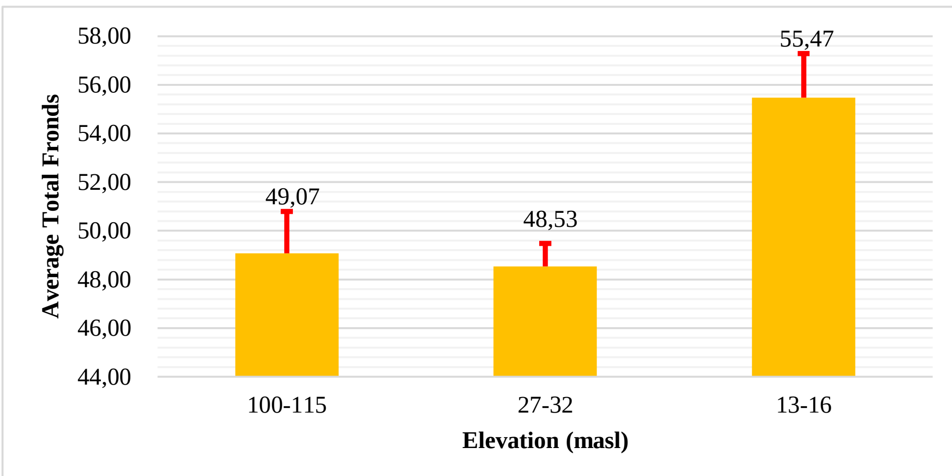
The diameter of oil palm trunks tends to be larger at low elevations, indicating that elevation affects the vegetative growth of plants, whereas plants growing at lower elevations tend to have larger trunk diameters compared to higher elevations.

According to Lubis et al. (2008), oil palm plants grow optimally at an altitude of 0-400 masl, and low elevations provide ideal temperature, humidity, and light intensity for vegetative growth. The optimal temperature for oil palm plants is 24-28°C, which is often found in lowlands, while high elevations can reduce photosynthesis efficiency due to lower temperatures and greater environmental pressure. (Corley & Tinker, 2016).

According to Ciptadi (2013), A fat or large stem diameter will increase the productivity of fresh fruit bunches (FFB), the plants will be sturdy, and more fruit with a large diameter will be cut.

3.3. Performance of the Number of Palm Oil Plant Fronds

Based on the results of the study of the performance of the number of oil palm fronds in Graph 3, it shows that the lowest elevation (13-16 masl) has an average number of huge fronds, with a total of 55.47 or 55 fronds. According to R.H.V Corley and P.B. Tinker (2016), the optimal number of oil palm fronds ranges from 48-56 fronds per tree. The data in the graph shows that all elevations are still within the optimal range.



Graph 3. Performance of the Number of Oil Palm Fronds

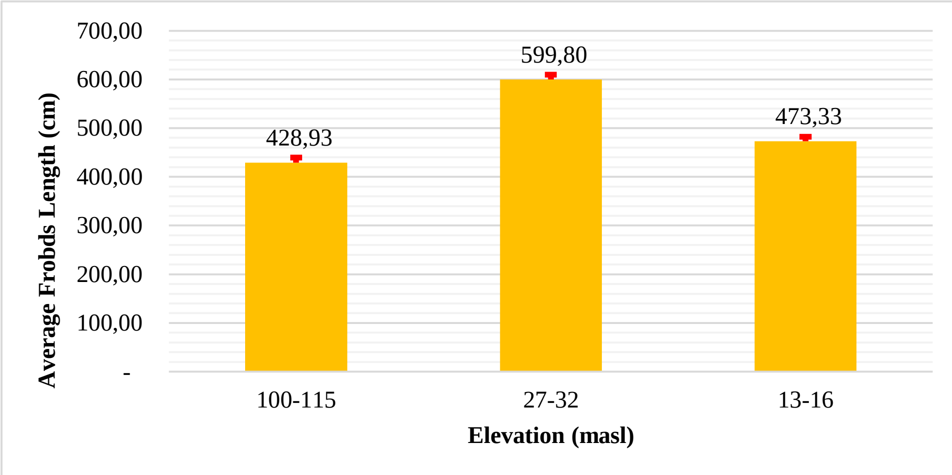
Lubis et al. (2008) stated that altitude affects the growth of oil palm, where optimal growth is at an altitude of 0-400 masl. This is in line with data showing variations in the number of fronds at various altitudes. The number of fronds is correlated with the productivity of oil palm plants. Elevation 13-16 masl shows the highest number of fronds, indicating better productivity potential (Iyung & Pahan, 2008).

In young plants, 30 leaves (commonly called fronds) are produced yearly; in old plants, 18-24 fronds are produced yearly. The optimum number of fronds to obtain maximum production in young oil palm plants or those less than 8 years old is to maintain 48-56 fronds, while in those over 8 years old or in old oil palm plants, 40-48 fronds are maintained, the rest are discarded/sprouted at harvest time. (Ciptadi & Gunawan, 2013).

3.4. Oil Palm Plant Length Performance

According to Corley and Tinker (2016), elevation greatly affects temperature, humidity, and light intensity, all of which contribute to the growth of oil palm plants. Lower elevations with higher temperatures and more stable humidity can support the growth of longer leaves and fronds.

In Graph 4, the performance of the length of oil palm fronds shows that elevations of 27-32 masl have higher frond lengths, followed by elevations of 13-16 masl and the lowest 100-115 masl, according to Pahan. I (2015) said that oil palm leaves are compound leaves, and the length of the leaf frond is around 6.5-9 m (depending on the variety). The shorter the leaf frond, the more oil palm population can be planted per unit area, so the higher the productivity. The land height factor greatly affects plant productivity. Oil palm plants planted in lowlands (elevation <50 masl) have higher productivity compared to those planted in highlands (>100 masl), including in terms of frond length.

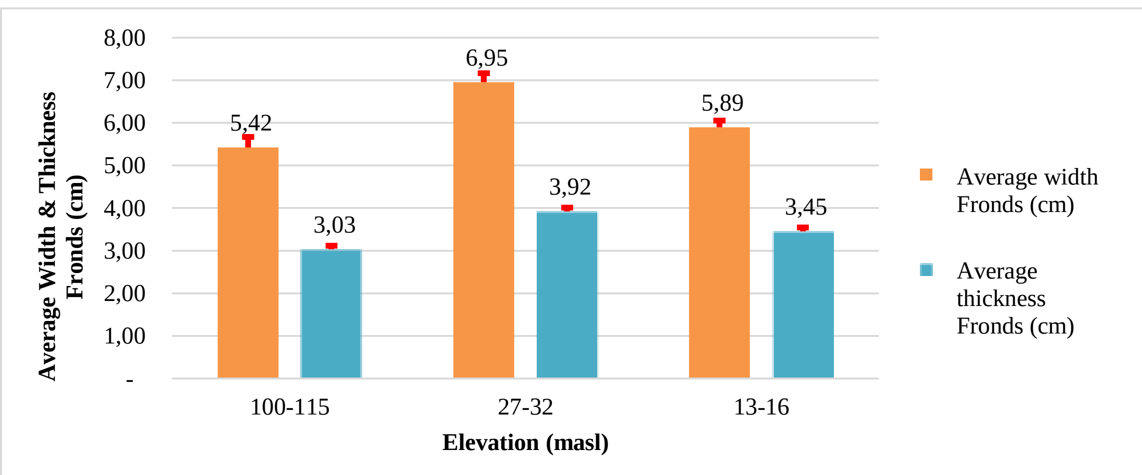


Graph 4. Oil Palm Frond Length Performance

3.5. Performance of Width and Thickness of Oil Palm Plant Fronds

Graph 5. The performance of the width and thickness of oil palm fronds shows that the highest average width and thickness of fronds is at an elevation of 27-32 meters above sea level with an average value of 6.95 cm for the average width of the frond and 3.92 cm for the average thickness of the petiole. The ideal thickness and width of fronds support the productivity of oil palm plants (Iyung & Pahan, 2008).

In general, the width of the frond (petiole) ranges from 5-7 cm with a thickness of 1-1.5 cm, while over the age of 5 years, the width of the frond (petiole) increases to 6-8 cm with a thickness reaching 1.5-2.5 cm, broader and thicker petioles help support larger leaves and increase photosynthesis and can be stronger to support a load of leaves and heavier fresh fruit bunches (FFB). (Iyung Pahan, 2015).

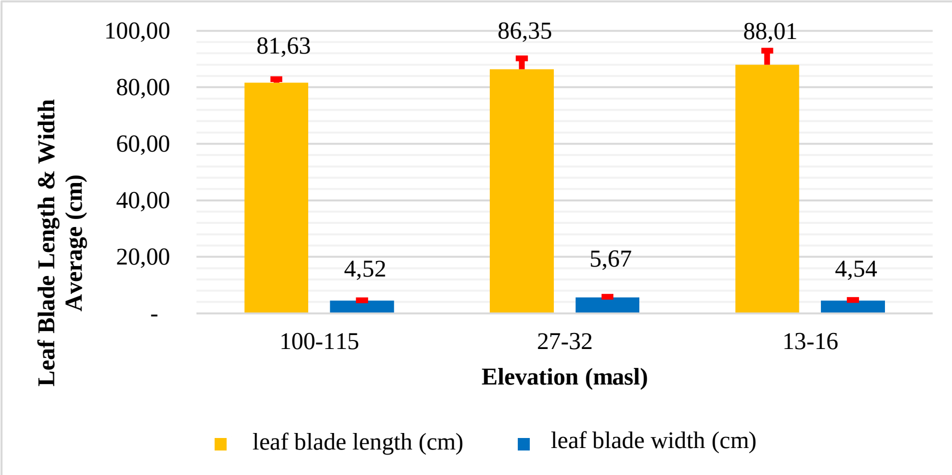


Graph 5. Performance of Width and Thickness of Oil Palm Fronds

3.6. Performance of Length & Width of Oil Palm Leaf Blades

In Graph 6, the performance of the length and width of oil palm leaf blades explains that the length of the leaf blade increases with decreasing elevation. At lower elevations (13-16 masl), the leaf length reaches the highest value (88.01 cm), while at the highest elevation (100-115 masl), the leaf length is shorter (81.63 cm). This shows that oil palm plants have longer leaves in areas with lower elevations.

Meanwhile, the width of the leaf blade does not show the same pattern as the length of the leaf. The highest leaf width was found at medium elevations (27-32 masl) with a value of 5.67 cm, while at low elevations (13-16 masl) and high (100-115 masl), the leaf width was almost the same (4.54 cm and 4.52 cm). Leaf length tends to be more sensitive to changes in elevation than leaf width. This can be caused by environmental factors such as temperature, humidity, and light intensity that differ at each elevation. Elevation affects environmental factors such as temperature, humidity, and light intensity, all of which play an important role in plant growth. At low elevations, temperatures tend to be higher, and humidity is more stable, which can support the growth of longer leaves.

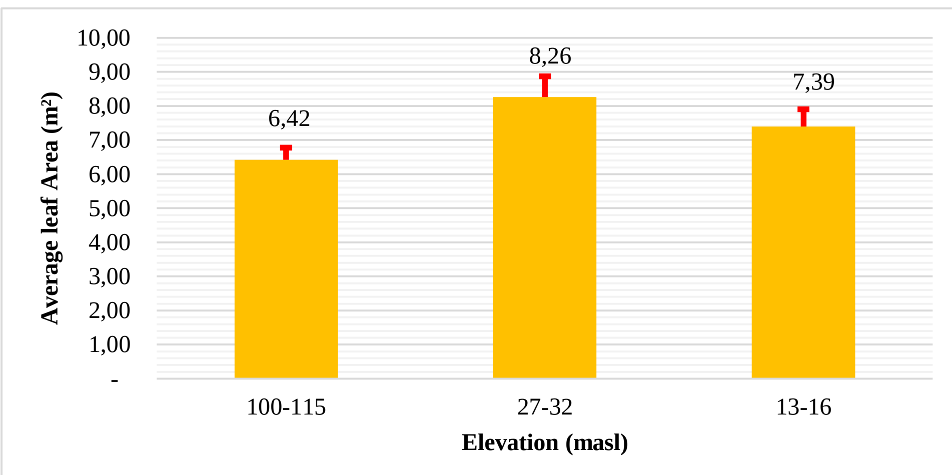


Graph 6. Performance of Length and Width of Oil Palm Leaf Blades

According to Pahan I (2015), The length and width of oil palm leaflets vary depending on the age and variety of the plant. The length of the leaflets on young plants tends to be shorter, and the width of the leaves is narrower compared to older plants. The length of the leaflets ranges from 55 cm to 65 cm, with a width of 2.5 to 4 cm. Oil palm (*Elaeis guineensis*) is a tropical plant that grows optimally at low to medium elevations. Longer leaves at low elevations can be an adaptation to increase photosynthesis efficiency in environments with high light intensity.

3.7. Leaf Area Performance of Oil Palm Plants

The performance of oil palm plants in Graph 7 shows that plants at an elevation of 27-32 meters above sea level show the largest leaf area (8.26 m²). This is in line with research by Lubis et al. (2008), which states that oil palm grows optimally in lowlands, while a decrease in leaf area at higher elevations (100-115 meters above sea level) can inhibit vegetative growth of oil palm.

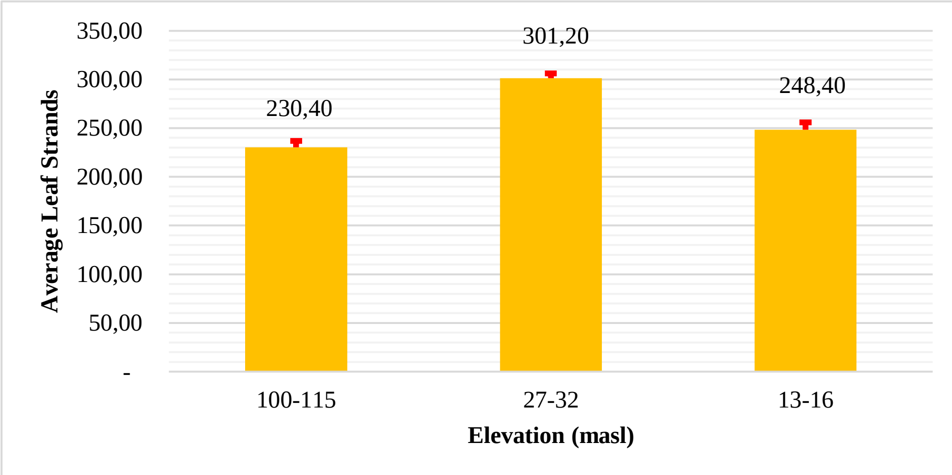


Graph 7. Performance of Oil Palm Leaf Area

According to Pahan I (2015) state that leaf area positively correlates with plant productivity because it is related to photosynthesis ability. This greatly influences the selection of planting locations with the correct elevation, which is crucial for optimizing oil palm growth.

3.8. Performance of the Number of Leaf Strands of Oil Palm Plants

The results of the observation of the performance of the number of oil palm leaves in Graph 8 indicate that the highest number of leaves is at an elevation of 27-32 masl (301.20 leaves). At a lower elevation (13-16 masl), the number of leaves decreases slightly to 248.40, while at a higher elevation (100-115 masl), the number of leaves is even lower, namely 230.40. The medium elevation (27-32 masl) provides optimal conditions for the growth of oil palm leaves. Elevations that are too low or too high can reduce the number of leaves, possibly due to environmental factors such as temperature, humidity, or nutrient availability. The surface area of the leaflets is of significant importance in the process of photosynthesis, whereby energy is produced for the plant.



Graph 8. Performance of the Number of Oil Palm Leaf Strands

Leaves with a greater width can better capture sunlight, which is essential for photosynthesis. This indicates that plants can produce greater quantities of energy for growth and fruit formation. Furthermore, an increase in leaf area will form additional stomata, thereby enhancing the plant's capacity to facilitate the exchange of gases (carbon dioxide and oxygen) and regulate water levels. This, in turn, will lead to more efficient photosynthesis, which will, in turn, enhance the potential for oil palm plants to produce a greater quantity and higher quality of fruit. However, there is an optimal limit to the leaf blade size. If the leaves are of an excessive width, they may cast shade on one another, thereby reducing the efficiency of photosynthesis in the leaves situated beneath them. Furthermore, environmental conditions and nutrient availability must also be conducive to optimal leaf growth (Corley & Tinker, 2016).

4. Conclusion

The conclusion from the analysis of oil palm growth performance in the producing plant phase (TM) in Labuhanbatu Utara District shows that the elevation of the place significantly influences the growth of oil palm plants. Lower elevations tend to provide more favourable environmental conditions for the vegetative growth of oil palm plants, such as plant height, stem diameter, number of midribs, midrib length and width, leaf blade length and width, leaf blade area, and optimal number of leaflets. Thus, choosing the right planting location based on elevation is very important to optimize the growth and productivity of oil palm plants. This research provides a clear picture of the condition of oil palm plants that have been replanted through the smallholder oil palm replanting programme in Labuhanbatu Utara District and helps as a reference for improving and increasing oil palm productivity in the future.

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