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Research Paper

The Population and Sap Production of Sugar Palm at the Farmer's Cultivated Area in Wan Abdul Rachman Grand Forest Park

Indriyanto[1*], Jananda N. Indriyanto
[1]*Department of Forestry, Faculty of Agriculture, Universitas Lampung, Indonesia*
[*]*Corresponding Author: indriyanto.1962@fp.unila.ac.id*

ABSTRACT
The source of sap for the palm sugar industry owns by forest farmers generally comes from sugar palm trees that naturally grow at cultivated lands in forest area. Therefore, the sustainability of the industry highly depends on the population of sugar palm trees and their sap production. This research aims to analyze the density, frequency, distribution pattern of sugar palm tree population, and their implication for the total sap production. The data was collected using nested rectangular plots with a sampling intensity of 2.5%, covering individual number of sugar palm trees, another tree species, altitude, land-slope, solar radiation intensity, air temperature and humidity, and daily sap volume. The result shows that the sugar palm trees naturally grow in clumped pattern, with the population density of the trees varies according to each altitude zone. The highest density (39.5 individuals/ha) can be found at an altitude of 500—700 m above sea level and has a solar radiation intensity of 57.6% under forest garden stands. Further, the natural regeneration process plays a pivotal factor in determining the frequency, density, and population of sugar palm tree. Low values of frequency and population density of sugar palm tree indicates that the natural regeneration process occurred suboptimal. Consequently, it affected the development of both the trees and therefore influencing the average sap produced. The population of sugar palm trees can increase naturally if the availability of the parental tree is well maintained and the farmers do not use pesticides in controlling weeds, which can also kill sugar palm seedlings.
Keywords: *Density, Distribution pattern, Frequency, Sugar palm tree*

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I. INTRODUCTION

Sugar Palm Tree and Their Significance

The occurrence of sugar palm trees and its products are main commodity that is critical towards world economic condition. As the alternative of sugarcane, palm sugar play significant role in the market value. Following this, the upstream industry of palm sugar and sustainability of the market highly depends on the sugar palm trees as its source material.

The sugar palm tree (*Arenga pinnata* (Wurmb.) Merr.) is classified into genus Arega, family Palmae or Arecaceae, and subphylum Angiospermae (Muda & Awal, 2021). The family Palmae itself contains various plantation taxon with a great population number across the world (Lueder et al., 2022). One of the taxon is genus Arenga, which consists of 24 species that includes sugar palm three as its member (Muda & Awal, 2021). According to Kurniawan et al. (2018), some of the member of family Palmae have some economical values for the society, such as coconut (*Cocos nucifera*), oil palm (*Elaeis guineensis*), nypa palm (*Nypa fruticans*), lontara (*Borassus flabellifer*), and sugar palm. However, above all the member of family Palmae, the sugar palm tree is considered as most economically beneficial (Azhar et al., 2019) because almost each part of the tree could be utilized commercially (Mogea et al., 1991).

The sugar palm trees can be found in all tropical region across Asia (Muda & Awal, 2021), but they are endemic to the Malaysia, Indonesia, The Philippines, Myanmar, Papua New Guinea, and India. The sugar palm trees can live in the areas with altitudes of 700—1,200 m a.s.l. and temperatures between 19º C and 27º C. In Indonesia, sugar palm tree could be found naturally or cultivated on low altitude areas up to 1,400 a.s.l (Setiawan, 2014; Widarawati et al., 2017). However, optimal palm tree growth occurs at elevations ranging from 500 to 700 m.a.s.l. (Lempang, 2012; Astuti et al., 2014) and at elevations of 500 to 800 m.a.s.l. (Sebayang, 2016; Widarawati et al., 2018). The ideal air temperature range for the growth of sugar palm tree in Indonesia is approximately between 20°C and 25°C (Effendi, 2010; Setiawan, 2014; Widarawati et al., 2017). To support better palm tree growth, a minimum air temperature of 25°C is required (Puturuhu et al., 2011), along with high annual rainfall, exceeding 1,200 mm/year (Apriyanto et al., 2020; Sebayang, 2016), or within the range of 1,200 to 3,500 mm/year (Setiawan, 2014). Furthermore, the sugar palm trees can grow in various types of soil. However, the clay soil, muddy soil, and sandy soil with pH of ≥ 4 are considered most suitable environment for their growth is sandy (Setiawan, 2014; Apriyanto et al., 2020).

Sugar Palm Tree in Indonesia and Their Utilization

The occurrence of sugar palm trees are relatively abundant and they are distributed throughout almost all regions of Indonesia (Ruslan et al., 2018; Adalina & Sawitri, 2021; Mahmud et al., 2021). Azhar et al. (2021) and Martini et al. (2012) suggest that palm trees can be categorized as multifunctional or versatile trees, serving both ecological and economic functions. The main ecological functions of sugar palm trees include supporting wildlife natural habitats (Withaningsih et al., 2021) and providing palm fruit as a food source for bats, boars, and other small mammals (Muda & Awal, 2021), as well as for the Tonkean macaque (*Macaca tonkeana*), bees (*Apis cerana*), palm civets (*Paradoxurus hermaphroditus*), and Sumatran orangutans (*Pongo abelii*) (Martini et al., 2012). Sugar palm trees also play a critical role in soil and water conservation. The roots of the sugar palm trees can generate an dense and extensive system that penetrate to a depth of approximately 6 meters (Rianawati et al., 2021; Sari et al., 2021), serving a vital system in soil binding and preventing erosion (Azhar at al. (2021). The presence of sugar palm trees also contributes to the diversity preservation of palm tree species, which holds various benefits for the local community in Indonesia (Kurniawan et al., 2018). For instance, sugar palm trees are known for having shade tolerance and require a condition where they are sheltered by surrounding trees (Farida, 2017). Consequently, they are suitable for cultivation as a component of forest stands, forest garden stands, and mixed forest-garden stands.

From an economic perspective, the proper utilization of non-wood products from sugar palm trees can provide significant opportunities to improve the economy of local community (Withaningsih et al., 2021). This is because various parts of the tree can be utilized for multiple purposes (Ruslan et al., 2018; Oerta et al., 2021). For example, the sap, which is the primary product of sugar palm trees, can be directly consumed as a refreshing beverage (Lempang, 2012). The sap can also be processed into various products such as palm sugar, palm syrup or palm wine (Lempang, 2012), nata pinnata (Lempang, 2017; Ruslan et al., 2018), as well as for making vinegar (Adalina & Sawitri, 2021) and bioethanol (Effendi, 2010; Sembiring et al., 2019). Additionally, the core of mature palm tree trunks can be utilized for palm flour as it contains a significant amount of starch (Kurniawan et al., 2018). The young fruit, called "kolang-kaling," has digestive health benefits and often be used for sweets and an ingredient in cold beverages (Febriyanti et al., 2017). Palm leaves are used for roofing material and as wrappers for sugar and food, while the palm fiber is employed for brooms, handicrafts, and as a water-absorbing material (Ruslan et al., 2018). Additionally, extracts from the palm roots can be used as an insecticide and traditional medicine for treating kidney stones (Kurniawan et al., 2018).

As the demand of the community increases, the utilization of palm trees has become a target of interest for the development of non-wood forest products, particularly palm sap obtained from tapping the staminate of palm trees (Lempang, 2012; Kalla et al., 2019). In Indonesia, the local communities typically harvest palm sap from wild-growing palm trees in forests or plantations (Febriyanti et al., 2017; Naemah et al., 2022). This practice is also adopted by the local farmer of the Talang Mulya Forest Farmer Group (FFG), who lives in the vicinity of and managing cultivation areas within the Wan Abdul Rachman Grand Forest Park. Currently, five members of Talang Mulya FFG process palm sap into palm sugar to supplement their household income. These individuals are Aripin, Arji, Edi, Muslim, and Sori (Gapoktanhut Wana Raya, 2019). They utilize palm sap from naturally growing palm trees that coexist with other Multipurpose Trees Species (MPTS) within the cultivation areas. The sustainability and development of the palm sugar industry rely heavily on the presence of palm trees. Therefore, this research aims to assess the population and palm sap production in the cultivation areas of KTH Talang Mulya by analyzing the density, frequency, and distribution pattern of palm trees at different growth phases, as well as palm sap production from productive-phase palm trees growing at three different elevational zones.

II. METHODS

Research Location

The research was conducted at the Talang Mulya FFG's cultivation area in the Traditional Block of the Bandar Lampung Resort, part of the Wan Abdul Rachman Grand Forest Park (Tahura in Indonesian), Lampung, Indonesia (Figure 1).

The Talang Mulya FFG is member of the 14 Forest Farmer Group associations of Wana Raya, all of whom are farmers managing cultivation areas within the Wan Abdul Rachman Grand Forest Park (GFP). They have a total of 51 active members who cultivate an area of 47.95 hectares across the Wan Abdul Rachman GFP. In all of the cultivation areas managed by these farmers, forest stands have been established, consisting of various tree species under the MPTS program, which has been cultivated since 1998.

The number of tree species in each cultivation area varies from 4 to 11 species, with a total of approximately 25 species, dominated by 7 main species: durian (*Durio zibethinus*), nutmeg (*Myristica fragrans*), rubber (*Hevea brassiliensis*), stink beans (*Parkia speciosa*), jointfir (*Gnetum gnemon*), langsat (*Lansium domesticum*), and candlenut (*Aleurites moluccana*) (Gapoktanhut Wana Raya, 2019). The research site shares a direct border with the Talang Mulya Village of Pesawaran District, Lampung Province.

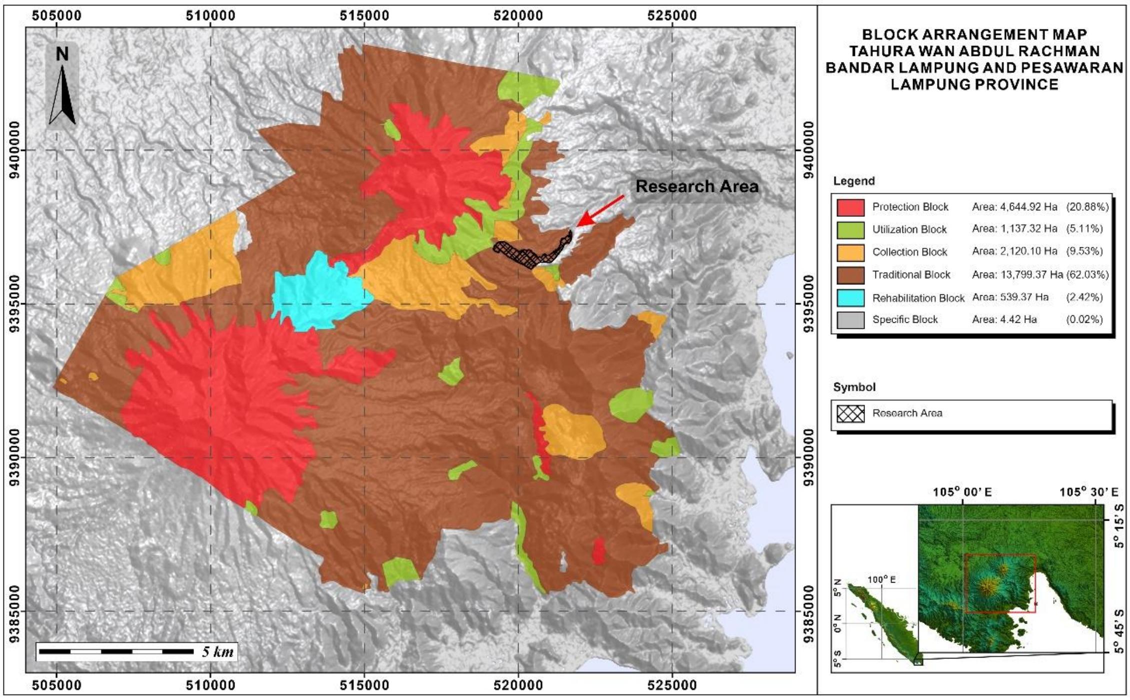

Figure 1. Map of the research site at the farmers' cultivated area of Talang Mulya Forest Farmer Group in Wan Abdul Rachman Grand Forest Park, Lampung Province (adapted from UPTD Taman Hutan Raya Wan Abdul Rachman, 2017)

The Talang Mulya FFG's cultivation area are located at elevation range of 210 to 822 m.a.s.l. (Gapoktanhut Wana Raya, 2019). According to the Schmidt-Ferguson classification, Talang Mulya FFG' cultivation area has a wet climate condition (type B) with an average annual rainfall of 1,627.2 mm, average air humidity of 81.7%, and average air temperature of 28.1°C (UPTD Taman Hutan Raya Wan Abdul Rachman, 2017). There are three soil types composing this area: *Dystropepts*, *Humitropepts*, and *Kanhapludults*; although *Dystropepts* present as predominant soil type, covering approximately 94.31% of the Wan Abdul Rachman GFP area (UPTD Taman Hutan Raya Wan Abdul Rachman, 2017).

Equipment

The equipment used for this research consists of measuring tapes, a clinometer, a handheld GPS, measuring string, stakes, an abney level, a thermohygrometer, a lux meter, a measuring glass, a writing board, ballpoint pens, and tally sheets.

Data Acquisition

The observation and data acquisition were performed multiple times within a five-month period from August to December 2021. The data were acquired through field vegetation survey using 30 nested rectangular plots from an overall 47.95 ha survey area with 2.5% sampling intensity. Four plot types were used for observing each palm tree phase: 1) 2 × 2 m for seedling phase; 2) 5 × 5 m for young phase; 3) 10 × 10 m for reproductive phase; and 4) 20 × 20 m for post-reproductive phase. The nested plots were design following the Figure 2.

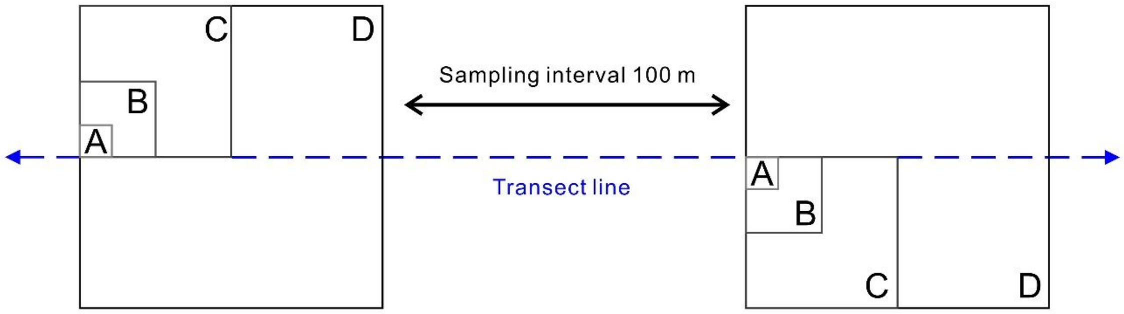

Figure 2. Design of nested rectangular sample plots used in this research.
A= 2 m x 2 m sample plot for observing sugar palm trees in the seedlings phase.
B= 5 m x 5 m sample plot for observing sugar palm trees in the young phase.
C= 10 m x 10 m sample plot for observing sugar palm trees in the reproductive phase.
D= 20 m x 20 m sample plot for observing sugar palm trees in the post-reproductive phase.

The sugar palm trees were observed based on the following criteria:

1. Seedling phase: those within initial sprouting stage and having maximum height of 1.5 meters.
2. Young phase: those exceeding 1.5 meters in height and are approaching the flowering phase.
3. Reproductive phase: those which are currently flowering or fruiting, or are in a flowering/fruiting phase.
4. Post-productive phase: those which are no longer in the flowering/fruiting phase, or they have grown flowers/fruits on stems less than 1 meter above the ground surface.

The research area is located in three different elevation zones: < 500 m.a.s.l., 500–700 m.a.s.l., and > 700 m.a.s.l. Therefore, the sample plots were systematically arranged using 100 m-interval along three transect lines parallel to the terrain slope or aligned with changes in elevation. The detailed configuration of the sample plots is shown in Figure 3.

The collected data include number of individual sugar palm trees at each growth phase, age of sugar palm tree, adjacent tree species within the sample plots, altitude and slope, percentage of sunlight radiation intensity beneath the palm tree canopy, air temperature and humidity, sap production, and morphological characteristics of the 12 sampled trees currently tapped by the farmers.

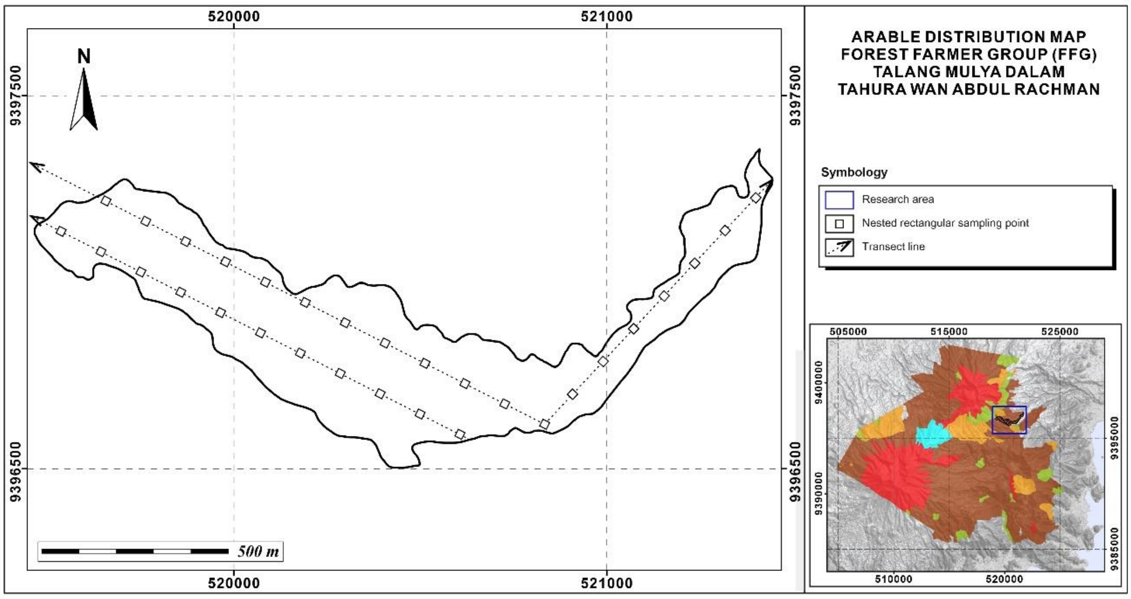

Figure 3. Layout of research sample plots at the farmers' cultivated area of Talang Mulya Forest Farmer Group in Wan Abdul Rachman Grand Forest Park, Lampung Province.

Data Processing

1. Population Density of Sugar Palm Tree

The population density represents number of individual sugar palm tree per area unit, which is defined following the calculation of Indriyanto (2021).

$$K = \frac{\sum_{i}^{n} x_i}{L} \qquad (1)$$

where
K= The population density of sugar palm tree
Xi= Total tree population within the i-sample plot
i= 1, 2, 3, ..., n
n= total of sample plot
L= Total area of all sample plots

2. Frequency of Sugar Palm Tree

The frequency of sugar palm tree was calculated following Indriyanto (2021), based on the intensity of sugar palm tree found in the studied area.

$$F = \frac{\text{Total number of sample plots with the occurrence of sugar palm tree}}{\text{Total number of all plot samples}} \qquad (2)$$

Where F is frequency of sugar palm tree founded in studied area. Further, the frequency of sugar palm tree is classified as follow of Indriyanto (2021).
a. High frequency if F> 0.67.
b. Moderate frequency if 0.33≤ F ≤ 0.67.
c. Low frequency if F< 0.33.

3. Distribution Pattern of Sugar Palm Tree

The internal distribution pattern of sugar palm tree was analyzed using Morisita Index following the equation of Ludwig & Reynolds (1988).

$$Id = (n)\frac{\sum_{i=1}^{n} X_i^{\,2} - N}{N(N-1)} \qquad (3)$$

where
Id= Morisita Index
n= Total number of all sample plots
N= Individual totals within all sample plots
Xi= Individual totals within i-sample plot

The internal distribution patterns based on Morisita Index can be further classified as follow (Ludwig & Reynolds, 1988).
a. Id= 1: The internal distribution of sugar palm trees occurs randomly.
b. 1< Id ≤n: The internal distribution of sugar palm trees occurs as a clamped.
c. Id=0: The internal distribution of sugar palm trees occurs uniformly.

Additionally, the internal distribution of sugar palm tree was tested using χ^2 following these equations.

$$\chi^2_{\text{count}} = \frac{n\sum_{i=1}^{n} X_i^{\,2}}{N} - N \qquad (4)$$

$$\chi^2_{\text{table}} = \chi 2_{(df;p)} = \chi 2_{(n-1;0,05)} \qquad (5)$$

If $\chi^2_{count} > \chi^2_{table}$, then the internal distribution of sugar palm trees statistically occurs randomly at 5% significance level. On the contrary, if $\chi^2_{count} > \chi^2_{table}$, then the internal distribution of sugar palm trees was determined according to the observation results at 5% significance level (Ludwig & Reynolds, 1988).

4. The Sap Production

The sap production represents the volume of sap that was cultivated from the stalks of the sugar palm flowers, particularly the staminates. The sap was harvested twice a day at the dawn and dusk. Therefore, the average sap production is calculated using the following equation.

$$V = \frac{(V_1 + V_2)}{2} \qquad (6)$$

where
V = Average sap volume from individual sugar palm tree harvested in a day
V1 = Sap volume from individual sugar palm tree harvested in the dawn
V2 = Sap volume from individual sugar palm tree harvested in the dusk

III. RESULT AND DISCUSSION

Population Density of Sugar Palm Tree

The population density of sugar palm tree in the arable area of Talang Mulya FFG estimated around 94.8 individual/ha, which showing a slight variation depending on the local environment where they grow. This includes altitudes and land slopes, microclimatic conditions (i.e., solar radiation intensity, average air temperature, and humidity), and adjacent species that live close to the sugar palm trees. The distributions of population density of sugar palm tree are shown in Table 1.

Table 1. The density of sugar palm trees population under different environmental conditions at the farmers' cultivated area within Talang Mulya Forest Farmer Group (FFG) of Wan Abdul Rachman Grand Forest Park, Lampung Province

Altitude and slope of the land	Microclimatic conditions in forest garden stands	Growth phase of sugar palm trees	Density (individual/ha)	Adjacent species to the sugar palm tree
Elevation <500 m asl. Slope 8—17%.	Solar radiation intensity 62.3%. Average air temperature 27.4 ºC. Humidity 81.6%.	Seedling	11.4	Avocado, durian, dogfruit, rubber, candlenut, nutmeg, stink bean, jointfir. Inter-tree spacing= 3.56 m.
		Young	8.8	
		Productive	8.4	
		Post-productive	2.6	
		Total	31.2	
Elevation 500—700 m asl. Slope 9—19%.	Solar radiation intensity 57.6%. Average air temperature 27.1º C. Humidity 81.8 %.	Seedling	14.6	Avocado, michelia, clove, langsat, durian, dogfruit, rubber, candlenut, nutmeg, stink bean, jointfir. Inter-tree spacing= 3.53 m.
		Young	11.6	
		Productive	10.2	
		Post-productive	3.1	
		Total	39.5	
Elevation >700 m asl. Slope 11—19%.	Solar radiation intensity 59.2%. Average air temperature 27.1º C. Humidity 81.7%.	Seedling	9.6	Hairy fig, langsat, durian, rubber, jack, candlenut, nutmeg, stink bean, tamalan tree, jointfir. Inter-tree spacing= 3.54 m.
		Young	6.4	
		Productive	5.7	
		Post-productive	2.4	
		Total	24.1	
Total population density of sugar palm tree (individual/ha)			94.8	

Elevation where the sugar palm tree lives play a significant environmental factor influencing their life cycle. In the Talang Mulya FFG, the sugar palm trees occur in the area with an elevation ranges of 210 to 822 m.a.s.l., which falls within the favorable elevation ranges of 0 to 1,400 m.a.s.l for the sugar palm tree to grow (Setiawan, 2014; Widarawati et al., 2017; Gapoktanhut Wana Raya, 2019). The population densities of sugar palm tree has inflexed correlation with altitudes, showing incremental values (39.5 individual/ha at 500–700 m.a.s.l) up to certain threshold of altitudes before decreasing (24.1 individual/ha at >700 m.a.s.l) in area with higher altitudes (Table 1). This indicates that the elevation highly influences the population of palm trees and is in alignment with the previously observed elevations of 500—800 m.a.s.l. for the trees to properly grow

(Harahap, 2017; Widarawati et al., 2018). Furthermore, the optimal palm tree growth might be achieved because of the required ecological factors for suitable growth environment was met. The appropriate range of ecological factors for plants allows the physiological processes to proceed effectively and increases plant vitality, thereby promoting favorable population development. Any ecological factors that exceed or fall short of the tolerance range for plants can lead to suboptimal physiological processes, reduced vitality, and poor growth (Indriyanto, 2017).

Moreover, the Talang Mulya FFG is situated within three distinct elevation zones, consisting of terrains with slopes ranging from 8–17%, 9–19%, and 11–19%, all falling under the category of moderately flat to slightly steep terrain (Table 1). As suggested by Puturuhu et al. (2011), these moderately flat to steep terrains provide favorable conditions for palm tree growth due to their morphological characteristics that reduce susceptibility to waterlogging during the rainy season. Consequently, the terrains where the sugar palm tree grow will support the ecological and physiological processes of the trees by enhancing drainage and aeration.

In addition to the elevation, the canopy shade within the agroforestry stands also influences the density of sugar palm trees, where it directly affects microclimate conditions (i.e., sunlight radiation, air temperature, and humidity) for the development of the trees. These microclimate conditions, in turn, have a direct implication on the physiological processes of sugar palm trees, which subsequently influencing their growth, vitality, and population density (Indriyanto, 2017). In Talang Mulya FFG's cultivated area, the highest density of sugar palm tree populations is observed in forest garden stands with 57.6% of sunlight radiation beneath the canopy, despite having relatively consistent air temperature and humidity in all elevation levels (Table 1). This suggest that sunlight radiation intensity is one of the critical microclimate elements affecting variations in population density of sugar palm tree. This aligns well with the assertion by Paulina (2017) that sugar palm trees is shade tolerance and, in fact, require shade to reduce sunlight radiation intensity (Farida, 2017). Hence, they naturally rely on other trees for shading to reduce the sunlight intensity.

The sugar palm trees in arable area of Talang Mulya FFG have a low population density with total of 94.8 individual/ha or about 4,546 individual in all elevation zones (Table 1). This value is relatively low compared to other naturally occurred sugar palm tree in South Kalimantan, where it has population densities of 13,005 individuals/ha and 90 individuals/ha for seedling phase and reproductive phase in Hulu Sungai Tengah Regency (Naemah et al., 2022), and a seedling phase of 24,000–25,000 individuals/ha and reproductive phase of 24,000–25,000 individual/ha in Banjar Regency (Naemah et al., 2021). The low value of population density in the arable area of Talang Mulya FFG indicates that the natural regeneration of palm tree is less than satisfactory. This could be resulted from an initially low population density of sugar palm trees in reproductive phase that acts as seed source or the extensive utilization of almost every reproductive palm trees by the local community, which resulted in an insufficient availability of fruit/seeds for regeneration purposes. Additionally, the prevailing practice among local farmers of using pesticides for weed control also poses a significant threat as it can inadvertently lead to the mortality of very young sugar palm seedlings.

Frequency of Sugar Palm Tree

The frequency of sugar palm trees serves as an indicator of the intensity of their occurrence within our observation sample plots. A higher frequency value signifies a greater abundance of sample plots housing sugar palm trees, whereas a lower frequency values indicate less sugar palm tree population within the sample plots. It is essential to note that the maximum attainable frequency value stands at 1 (Indriyanto, 2021). As the consequence, the higher the frequency value approaching the value of 1, it signifies a heightened presence of sugar palm tree in all tree population, and *vice versa*.

The frequency of sugar palm tree in arable area of Talang Mulya FFG is shown in Figure 4. We find that the intensity of encountering sugar palm trees in their seedling, young, and reproductive phases can be categorized into moderate frequency, having values of 0.43, 0.52, and 0.52, respectively. However, the sugar palm trees in the post-reproductive phase has a frequency of 0.11 and can be categorized into the low intensity. Similar to its population density, the variable frequency of sugar palm trees is affected by the dynamics of the sugar palm's natural regeneration process. This process hinges on several key factors, including the availability of parent trees and the fruit/seeds, the germination process, and the conducive environmental conditions required for successful growth (Indriyanto, 2010). One paramount factor contributing to the observed lower frequency of sugar palm trees in the arable area of Talang Mulya FFG is the scarcity of fruit/seeds as a germination source due to a naturally limited population density of parent trees, the excessive utilization of sugar palm fruits by the local community, or local practice of pesticide usage for weed control that have inadvertently led to the decline and mortality of sugar palm seedlings.

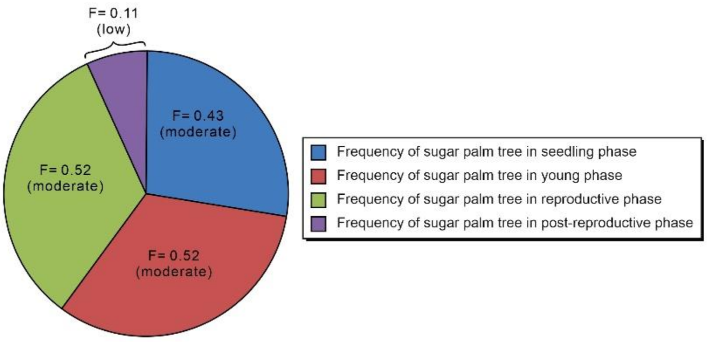

Figure 4. The frequency (F) of sugar palm trees for each growth phase at the cultivated area of Talang Mulya FFG.

The Distribution Pattern of Sugar Palm Tree

The distribution pattern of sugar palm trees represents the internal distribution of the trees within a living environment. Using the Morisita Index, the distributions of sugar palm tree for each growth phase are shown in Table 2.

Table 2. The distribution pattern based on the Morisita Index for each growth phase of sugar palm trees at the cultivated areas of Talang Mulya Forest Farmer Group of Tahura Wan Abdul Rachman, Lampung Province

Number	Growth phase	Morisita Index (Id)	χ^2_{count}	χ^2_{table}	Distribution pattern
1.	Seedling	36.83	53.82	103.02	Clumped
2.	Young	29.70	41.31	103.02	Clumped
3.	Reproductive	23.53	40.80	103.02	Clumped
4.	Post-reproductive	23.24	23.26	103.02	Clumped

The sugar palm tree in FFG Talang Mulya cultivated area occurs naturally while coincidentally living together with MPTS plants cultivated by the local farmers. As shown in Table 2, the sugar palm tree in all growth phases have clumped patterns, which indicates that the sugar palm trees grow naturally with an indication of variable growing environments and specific reproduction methods that ultimately affect their internal distribution patterns (Indriyanto, 2019; Kalla et al., 2019).

The reproduction of palm trees primarily occurs generatively through seeds (Bernhard, 2007). While ripe palm fruits typically fall to the ground, their seeds do not necessarily germinate directly beneath the parent tree due to the involvement of wild animals in the seed dispersal. For example, a palm civet (*Paradoxurus hermaphroditus*) has been previously mentioned having a strong preference for consuming ripe palm fruits (Parikesit et al., 2019) and facilitating palm seed dispersal (Gunawan et al., 2018; Withaningsih et al., 2021). When ripe palm fruits are consumed, seeds are ingested and are subsequently excreted by the civet. With palm seeds remaining intact during the civet's digestive process, the seed-containing feces will thereby disperse palm seeds to locations corresponding to the civet's roaming range. Seeds mixed with civet feces are more likely to germinate, which results in the growth of seedlings in close proximity to one another and ultimately leading to a clumped distribution pattern within the palm tree population.

The Sap Production

The sap production was observed from 12 productive-phase palm trees tapped by the local farmers. The results are presented in Table 3.

The average sap yield of 12 sugar palm tree samples in Talang Mulya FFG is 18.4 liters per tree per day. This value is relatively low compared to sap yields in other areas. For instances, Dewi et al. (2022) reported that in the cultivated area of the Harapan Baru I FFG within the Wan Abdul Rachman GFP has a higher sap production, reaching a rate of 29.8 liters per tree per day at an elevation of 417 m.a.s.l. Similarly, the daily sap production In South Tapanuli was estimated around 25 liters/tree (Harahap, 2017), while in South Kalimantan, the highest daily sap production per tree reaches 20.83 liters per tree (Fatriani et al., 2012).

Table 3. The sap production of 12 productive phase sugar palm trees at different altitudes on the area cultivated by Talang Mulya Forest Farmer Group

Altitude and slope of the land	Number of tree	Age of sugar palm* (year)	Daily sap production for each tree every day (l/tree/day)			Number of tapped sugar palm flower
			Tapped in the afternoon	Tapped in the morning	Total	
Elevation <500 m asl.	1	22	11.3	7.2	18.5	1
Slope 8—17%.	2	18	10.5	6.9	17.4	1
	3	20	11.2	7.1	18.3	1
	4	25	10.1	6.3	16.4	1
	Average		10.8	6.8	17.6	
Elevation 500—700 m asl.	5	15	11.6	7.8	19.4	1
Slope 9—19%.	6	15	11.5	7.8	19.3	1
	7	20	13.3	9.2	22.5	1
	8	20	12.2	8.4	20.6	1
	Average		12.1	8.3	20.4	
Elevation >700 m asl.	9	20	11.3	7.2	18.5	1
Slope 11—19%.	10	18	10.3	6.8	17.1	1
	11	26	10.1	6.1	16.2	1
	12	15	10.2	6.7	16.9	1
	Average		10.5	6.7	17.2	
Average daily sap production for each tree every day (l/tree/day)			11.1	7.3	18.4	

*) The estimated age of sugar palm trees were based on information from farmers who cultivate the sugar palm sap

Based on Table 3, the elevation where the palm tree lives may determine the amount of sap produced. The trees that live within the elevation ranges of 500 to 700 m a.s.l. have a slightly higher sap production with an average value of 20.4/tree/day compared to the trees that live at other elevation ranges (Table 3). Dewi et al. (2022) mentioned that sap production of sugar palm tree shows a positive correlation with elevation, especially the one lives at elevation ranges of 361 to 417 m.a.s.l. This suggest that the higher elevation where the sugar palm tree lives, the higher sap that can be produced. In addition to the elevation range of 500—700 m.a.s.l., the microclimatic condition (i.e., solar radiation intensity) could further enhance the daily sap production of an individual tree (Table 1). The less exposure the solar radiation, the sugar palm tree tends to have significantly higher sap productions throughout the day. This indicates that the elevation and microclimatic conditions where the sugar palm tree lives play significant roles in the development of both the trees and therefore increasing their overall daily sap production.

Alternatively, the age of sapped sugar palm trees also affects the total sap production in cultivated area of Talang Mulya FFG. The majority of the tapped trees have an age range of 15–20 years old and falls into the productive age category, although a small percentage falls into the less productive age category, with ages between 22 and 26 years (Table 3). This aligns with Effendi (2010) that sugar palm trees aged between >10 years and 20 years are considered productive, with the ability to produce a high and stable sap yield. However, after reaching an age of >20 years, sap production begins to decline. Consequently, it resulted in an overall lower sap production rates, even though sugar palm trees aged between 22 and 26 years can still produce sap.

IV. CONCLUDING REMARK

Conclusion

The sugar palm trees in the cultivation areas of Talang Mulya FFG have a limited occurrence with a low population density of 94.8 individuals/ha: 35.6 individuals/ha of seedling, 26.8 individuals/ha of young, 24.3 individuals/ha of reproductive, and 8.1 individuals/ha of post-productive phases. The limited occurrence of sugar palm trees is also reflected in their low frequency values (F) of 0.11—0.52, which indicates a low intensity of tree encounters. The population density of sugar palm trees varies based on elevation and percentage of sunlight intensity beneath the forest canopy, with the highest density of 111.0 individuals/ha at a 57.6% of sunlight intensity beneath the canopy.

The average sap production from productive sugar palm trees aged 15—26 years is 18.4 liters/tree/day, which is considered low compared to sap production in other regions. The regeneration of sugar palm trees occurs naturally as indicated by their clumped distribution pattern that commonly observed in naturally growing sugar palm trees elsewhere.

Recommendation

The population density of sugar palm trees in the cultivation areas within the Wan Abdul Rachman GFP needs to be enhanced to support the development of the community-owned palm sugar industry in the surrounding forest and to increase the diversity of non-timber forest products that can be utilized by the community. Increasing the population density of sugar palm trees can be achieved through enrichment planting, ensuring the availability of parent trees as a source of fruit/seeds, and encouraging farmers not to use pesticides for weed control, which could potentially harm young sugar palm seedlings as well.

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