Quest Journals
Journal of Research in Agriculture and Animal Science
Volume 13 ~ Issue 1 (January 2026) pp: 06-13
ISSN(Online): 2321-9459
www.questjournals.org

Research Paper

The Relationship between the Population of Sugar Palm Tree (*Arenga pinnata*)and Environmental Factors Where It Grows

Kamilia Hanifah[1], Indriyanto[1*], Surnayanti[1]
[1]*Department of Forestry, Faculty of Agriculture, Universitas Lampung, Indonesia*
[*]*Corresponding Author*

ABSTRACT:*The sugar palm tree (Arenga pinnata) is a multipurpose tree because it has many benefits, both ecological and economic benefits. However, information on the relationship between the population size of sugar palm tree and environmental factors at which it grows is limited.This research aims to analyze the structure of the sugar palm tree population and its relationship with environmental factors where it grows at the area cultivated by the Harapan Baru III Forest Farmer Group in the Wan Abdul Rachman Grand Forest Park, Indonesia.The data was collected through vegetation surveys using nested rectangular plots with a sampling intensity of 2.5%, with a total of 17 nested sample plots. The data collected included the sugar palm tree population based on growth phase, trees species at the research location, altitude, land slope, soil pH, solar radiation intensity, air humidity, and air temperature.Data analysis by calculating density (D), frequency (F), simple linear regression, and Pearson correlation at a 5% significance level.The results showed that the density of sugar palm trees in the seedling phase was 11.8 individuals/ha, the young phase was 45.6 individuals/ha, the reproductive phase was 2.9 individuals/ha, and the post-productive phase was 2.9 individuals/ha.The frequency of sugar palm trees in the seedling phase is 0.2, the young phase is 0.5, the reproductive phase is 2.9, and the post-productive phase is 2.9.Then, the results of the regression and correlation analysis showed that the relationship between the population of sugar palm trees and the environmental factors where they grow had no significant effect.*

KEYWORDS: *sugar palm tree, population, environmental factors.*

R*eceived 08 Jan., 2026;* ***R****evised 18 Jan., 2026;* ***A****ccepted 20 Jan., 2026 © The author(s) 2026.*
P*ublished with open access at* ***www.questjournas.org***

I. INTRODUCTION

Wan Abdul Rachman Grand Forest Park (Tahura, term in Indonesia) is a nature conservation area in Lampung Province, Indonesia with a total area of 22,249.31 ha.Tahura Wan Abdul Rachman is located in a hilly and mountainous landscape with varying heights and has diverse topography.These physiographic conditions cause high heterogeneity of forest ecosystem components, thus supporting the creation of habitat conditions suitable for the growth of various types of plants and animals (UPTD Taman Hutan Raya Wan Abdul Rachman, 2017).In this way, Tahura can play its role according to its function, namely to protect the life support system, preserve the diversity of plant and animal species, and sustainably utilize natural biological resources and their ecosystems(Pemerintah Republik Indonesia, 2024).

One species of plant that grows naturally within the Wan Abdul Rachman Grand Forest Park is the sugar palm tree, scientifically named *Arenga pinnata*(Indriyanto & Indriyanto, 2023). The sugar palm is a member of the Palmae or Arecaceae family (Muda & Awal, 2021). This taxon of plants in the Palmae family is highly diverse and abundant (Lueder et al., 2022).

The presence of sugar palm trees in forest areas generally occurs due to natural reproduction with seeds that are spread by animals(Musdalifah et al., 2022).One of the animals that plays a role in the spread of sugar palm seeds is the palm civet (*Paradoxurus hermaphroditus*) because the palm civet eats ripe sugar palm fruit, while a small portion of the sugar palm trees are planted by humans in their cultivated areas in forest areas (Indriyanto & Indriyanto, 2023).

The sugar palm tree is known as a multipurpose tree with high economic benefits, especially from its fruit, sap, fibers, and leaves (Ruslan et al., 2018). Therefore, the existence of sugar palm trees has an important role in people's lives, especially those living in tropical areas such as Indonesia (Akbar et al., 2025). In addition, sugar palm trees can grow on sloping land, thus playing an important ecological role, especially for soil and water conservation in the river basin area (Wibowo & Lusiana, 2022).

The sugar palm tree is well-known in Indonesia for its diverse benefits, both ecological and economic. In fact, the sugar palm tree has the broadest economic benefits compared to other palm species. This is because almost all parts of the sugar palm tree can be utilized to meet human needs (Mogea et al*.,* 1991), and each part of the tree is commercially valuable due to its high selling value (Azhar et al., 2019). The sugar palm tree and its products are acrucial primary commodities to the global economy. The sugar palm tree is a species of tree that can be used as an alternative source of sap, a raw material for natural sugar(Anggraini et al., 2025).Natural sugar from the sap of the sugar palm tree can be in the form of molding sugar, palm sugar, or crystal sugar, all of which play a significant role in its market value. Therefore, the upstream palm sugar industry and its market sustainability are highly dependent on the sugar palm tree as a source of raw material (Indriyanto & Indriyanto, 2023).

In fact, the sugar palm tree can be found in various regions of Tropical Asia (Haryoso et al., 2020). Another opinion is that the distribution area of the sugar palm tree includes Tropical Asia, East India, Malaysia, Indonesia, and the Philippines with an altitude of 500-700 m above sea level and rainfall of 1,200-3,500 mm/year, but the sugar palm tree can also live at an altitude of 0-1,400 m above sea level (Syahidah et al., 2025).Besides that sugar palm trees can grow in a variety of soil conditions, from lowlands to mountains, as well as on marginal land (Akbar et al., 2025). The growth and sustainability of sugar palm tree populations are influenced by the environmental conditions in which they grow. Environmental factors such as soil texture, water availability, air temperature, and air humidity play a role in optimal sugar palm tree growth (Dewi et al., 2022; Lempang, 2012).Previous research reported that altitude above sea level, land slope, air temperature, air humidity, rainfall, solar radiation intensity, soil type, soil acidity level (soil pH), and plants that live together with sugar palm trees affect the natural regeneration process and distribution of sugar palm trees(Furqoni et al., 2018; Hasibuan et al., 2023; Ulfa et al., 2023). Indriyanto & Indriyanto (2023)stated that differences in altitude, land slope, solar radiation intensity, air temperature, and air humidity affect the population density of sugar palm trees and the production of sugar palm sap that grows naturally in forest areas.

The best population density of sugar palm trees and production of sugar palm sap in forest areas are found in areas with an altitude of 500-700 m above sea level, a land slope of 9-19%, solar radiation intensity under the forest garden stands of 57.6%, an average air temperature of 27.1ºC, and air humidity of 81.8% (Indriyanto & Indriyanto, 2023). Even the quality of sugar palm sap produced by sugar palm trees is influenced by the environmental conditions where they grow (Anggraini et al., 2025).

The population of sugar palm trees in various distribution areas depends on natural regeneration and natural distribution processes, and without intensive human management, even within farmer-cultivated areas (Musdalifah et al., 2022).However, information on the relationship between sugar palm tree populations and the environmental factors in which they grow is still limited. Therefore, this research was conducted to analyze sugar palm tree populations at each growth phase and their relationship to environmental factors in areas cultivated by forest farmers within a national forest park. This research is very useful for developing a scientific basis for efforts to conserve sugar palm trees through protection and planting.

II. Methods

Research Site

The research was conducted from January to February 2025 at the area cultivated by the Harapan Baru III Forest Farmers Group in the Wan Abdul Rachman Grand Forest Park, Lampung Province, Indonesia. The research location map is presented in Figure 1.

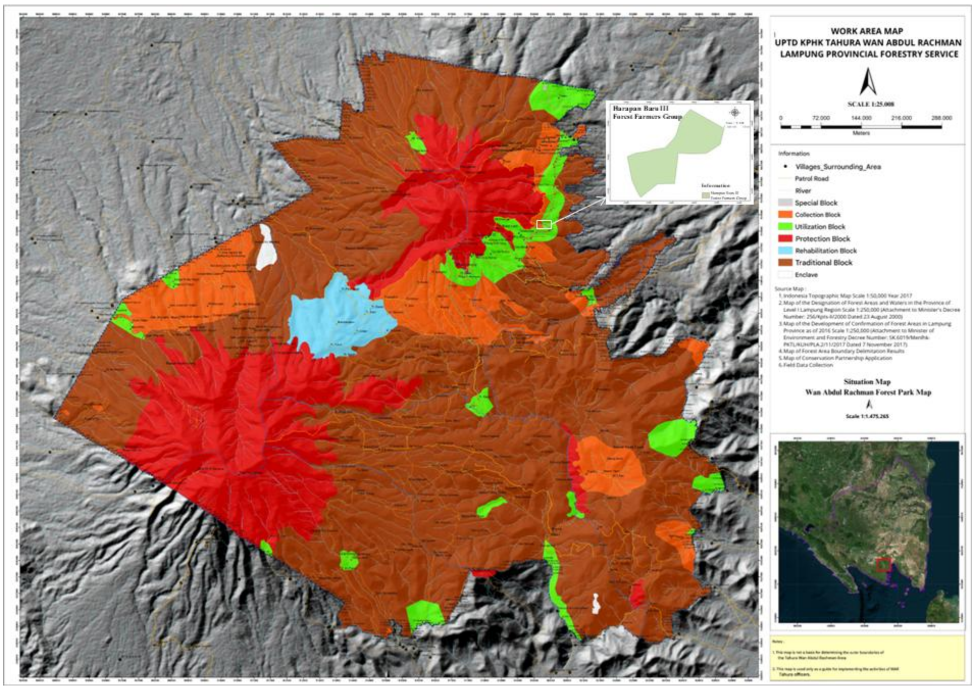

Figure 1. Map of the research site at the farmers' cultivated area of Harapan Baru III Forest Farmer Group in Wan Abdul Rachman Grand Forest Park, Lampung Province, Indonesia (adapted from UPTD Taman Hutan Raya Wan Abdul Rachman, 2017).

Equipment

The equipment used for this research consists of measuring tapes, GPS (global positioning system), haga meter, abney level, thermohygrometer, lux meter, a writing board, ballpoint pens, and tally sheets.

Data Acquisition

Data were collected through a vegetation survey on an area of 16hectare, using a systematic sampling method with a sampling intensity of 2.5%. Seventeen sample plots were used, each in the form of a nested rectangular plots, and at an altitude of 420 to 616 m above sea level. The sample plot measures 20 m × 20 m was used to collect data on post-productive phase sugar palm trees, the sample plot measures 10 m × 10 m to collect data on reproductive phase sugar palm trees, the sample plot measures 5 m × 5 m to collect data on young phase sugar palm trees, and the sample plotmeasures 2 m × 2 m to collect data on seedling/sapling phase sugar palm trees (Indriyanto, 2021).

The sugar palm trees were observed based on the following criteria(Indriyanto & Indriyanto, 2021).

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 data collected includes the number of individual sugar palm trees in each growth phase, other tree species found in the sample plot, altitude above sea level, land slope, soil acidity (pH), solar radiation intensity, air humidity, and air temperature.

Data Processing

The data on the number of individual sugar palm trees that had been obtained were then analyzed to determine the population density of sugar palm trees and the distribution area of each growth phase.The population density of eachgrowth phase of sugar palm tree was calculated using the following formula (Indriyanto, 2021).

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

where
K= the population density of sugar palm tree

X_i= total of individual sugar palm trees in sample plot i
i= 1,2,3.......n
n= total of sample plot
L= total area of all sample plots

The distribution area of sugar palm trees was identified by the frequency value.Frequency is the intensity of finding a species of plant(Indriyanto, 2024). Frequensy indicates the wide or narrow distribution of a plant species in the research area. The frequency of plant species was calculated using the following formula (Indriyanto, 2021; Indriyanto, 2024).

$$\text{Frequency (F)} = \frac{\text{number of sample plots where a particular plant species is found}}{\text{number of all sample plots}} \quad (2)$$

Where F is frequency of plant(sugar palm tree)

The relationship between the population of sugar palm trees (Y) and the environmental factors where they grow (X) was analyzed using simple regression analysis and Pearson correlation analysis at a 5% significance level. The environmental factors where they grow include: altitude above sea level, land slope, soil acidity (pH), solar radiation intensity, air temperature, and air humidity. The regression and correlation analyses were conducted using SPSS (Statistical Package for the Social Sciences) software.

III. RESULT AND DISCUSSION

The Condition of the Sugar Palm Tree Population

The results showed that in the area cultivated by the Harapan Baru III Forest Farmers Group, there were 25 individual sugar palm trees in all sample plots. Thus, the population density of sugar palm trees in the forest farmers' area was 63.2 individuals/ha. The sugar palm tree population encompasses four growth phases: seedling, young phase, reproductive phase, and post-productive phase. The results of the density and frequency analysis of sugar palm trees in each growth phase are presented in Table 1.

Table 1. Density and frequency of sugar palm trees (*Arenga pinnata*) for each growth phase at the cultivation area
of the Harapan Baru III Forest Farmers Group in the Wan Abdul Rachman Grand Forest Park, Indonesia

Number	The growth phase of sugar palm tree	Density (individual/ha)	Percentage of density (%)	Frequency	Percentage of frequency (%)
1.	Seedling	11.8	18.6	0.2	18.8
2.	Young	45.6	72.1	0.5	56.3
3.	Reproductive	2.9	4.7	0.1	12.5
4.	Post-reproductive	2.9	4.7	0.1	12.5
	Total	63.2	100.0	0.9	100.0

Based on Table 1, the density of seedling and young palm trees is greater than that of the reproductive and post-productive phases. Furthermore, the frequency of seedling and young palm trees is greater than that of the adult phase. The presence of more seedling and young palm trees compared to the adult phase indicates that the regeneration process is still ongoing (Indriyanto, 2024).Likewise, if the presence of young plants is lower than that of mature plants, this indicates that the plant regeneration process is not going well. This is in line with Shankar's (2001) statement that if the presence of a species of seedling plant is very limited, this indicates that the regeneration process of that species of plant is low or poor.If a similar condition occurs in a population of sugar palm trees, it can be an indicator of obstacles in the reproduction process, especially in populations of sugar palm trees that grow naturally and are not maintained(Naemah et al., 2022).

Furthermore, the low number of seedling phaseof sugar palm trees may be due to the low number of reproductivephase of sugar palm trees, thus constraining the production of sugar palm seeds for propagation. The low number individual of reproductiveand post-productive phase can be attributed to several factors, such as a lack of intensive maintenance (Webliana & Rini, 2020), 2020), high competition with other plant species for resources for survival and growth, and anthropogenic activities in the area where the sugar palm trees grow(Naemah et al., 2022).These conditions have the potential to disrupt the regeneration and productivity of sugar palm trees in the future(Webliana & Rini, 2020).

Figure 2 shows examples of the physiognomy of sugar palm trees for each growth phase found at the research location.

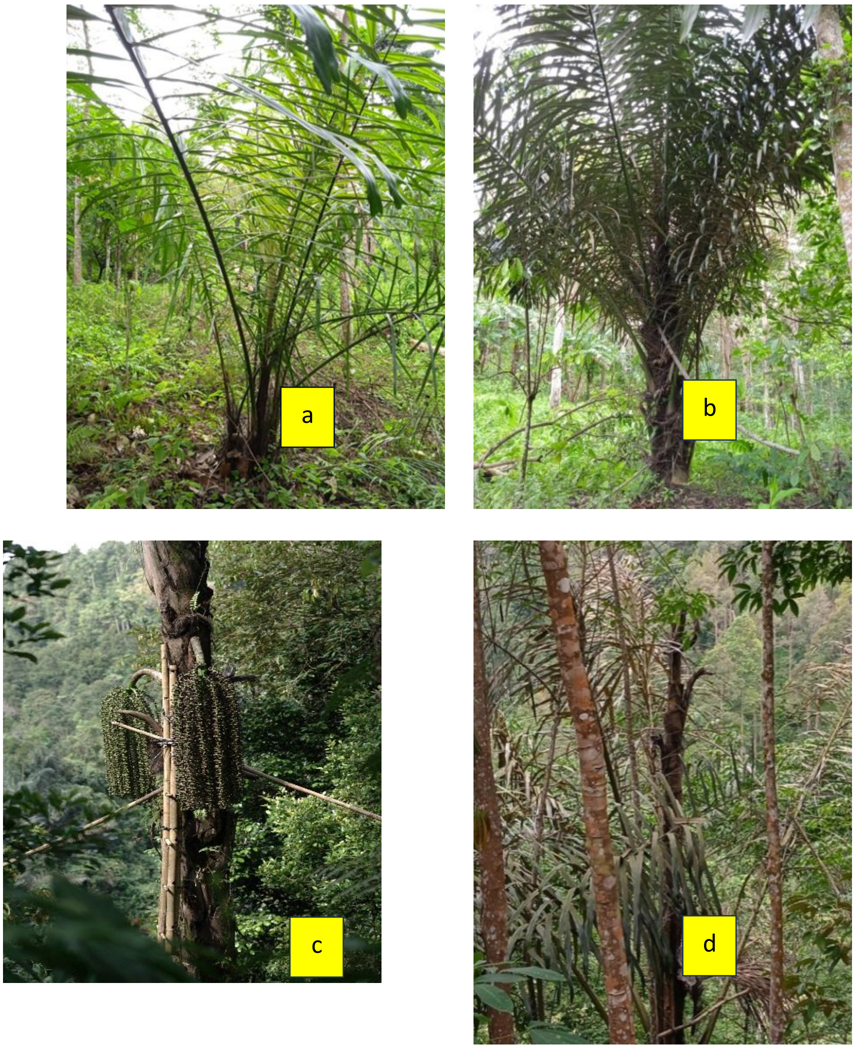

Figure 2. Examples of the physiognomy of sugar palm trees for each growth phase, (a) seedling phase of sugar palm trees, (b) young phase of sugar palm trees, (c) reproductive phase of sugar palm trees, (d) post-productive phase of sugar palm trees.

The population of sugar palm trees at the area cultivated by the Harapan Baru III Forest Farmers Group is influenced by the composition of the plant species that make up the forest garden stands in this area, both those that grow naturally and those cultivated by farmers. Field conditions show that there are 17 species of plants that make up the forest garden stands, including sugar palm (*Arenga pinnata*), rosewood (*Dalbergia latifolia*), kapok (*Ceiba pentandra*), candlenut (*Aleurites moluccana*), durian (Durio zibethinus), mango (*Mangifera indica*), avocado (*Persea americana*), jackfruit (*Artocarpus heterophyllus*), stink bean (*Parkia speciosa*), dogfruit (Archidendronpauciflorum), coffee (*Coffea canephora*), cocoa (*Theobroma cacao)*, rubber (*Hevea brasiliensis*), cloves (*Eugenia aromatica*), nutmeg (*Myristica fragrans)*, jointfir (*Gnetumgnemon*), and areca nut (*Areca catechu*).

The diversity of plant species in forest farmers' cultivated areas creates complex ecological interactions between species, including competition for natural resources. Competition between plant species cultivated in agroforestry systems is intense when the availability of environmental factors required by plants is very limited (Atmoko et al., 2023).Furthermore, environmental factors with very limited availability negatively impact plant growth and development, and can affect the natural regeneration process (Indriyanto, 2017). Sugar palm trees are semi-tolerant, meaning they require light shade during the early phase of growth (seed germination and seedling phase), but subsequent growth phase require sufficient sunlight and adequate growing space for optimal survival, growth, and production (Ramadhani et al., 2024; Samal et al., 2020).

The Relationship between Sugar Palm Tree Population and Environmental Factors

The relationship between the sugar palm tree population and the environmental factors in which it grows was identified using simple linear regression analysis and Pearson correlation analysis. The results of the analysis of variance (F test) in the simple regression analysis between the sugar palm tree population and the environmental factors in which it grows are presented in Table 2.

Table 2. Recapitulation of analysis of variance for regression between sugar palm tree (*Arenga pinnata*) population and environmental factors where it grows

Number	Environmental factors	Sugar palm tree population	
		F_{count}	$F_{table\ (5\%)}$
1.	Altitude	3.401 ns	4.54
2.	Land slope	0.203 ns	4.54
3.	Soil acidity (pH)	0.082 ns	4.54
4.	Intensity of solar radiation	0.735 ns	4.54
5.	Air humidity	0.098 ns	4.54
6.	Air temperature	0.061 ns	4.54

Remark: ns= not significant

Simple linear regression analysis is used to determine the linear relationship between an independent variable (X) and a dependent variable (Y), as well as to test the effect of one independent variable on the dependent variable (Usman & Albar, 2020). In this research, this analysis was used to determine the relationship or influence of the independent variable (environmental factors where the sugar palm tree grows) on the dependent variable (sugar palm tree population). Based on the results of a simple linear regression analysis, it was found that no environmental factors had a linear effect on the sugar palm population at the 5% significance level. This is indicated by the calculated F value for each variable being smaller than the F table value (4.54). However, the altitude factor had a higher value (3.401) than the other environmental factors.This contrasts with the statements of Hasibuan et al. (2023) dan Ulfa et al. (2023)that altitude influences the distribution and growth of sugar palm trees because differences in altitude cause the formation of the earth's surface configuration that can affect changes in air temperature and the intensity of solar radiation received by plants. Differences in altitude cause differences in soil fertility, which is one factor that influences the natural regeneration process of plants (Indriyanto, 2017).Therefore, altitude has the potential to influence changes in the palm population size, although statistical analysis results are not significant. This is likely due to the small altitude range of the observation locations, from 420 to 616 m above sea level, so changes in altitude have not significantly affected the sugar palm tree population.

Furthermore, the closeness of the relationship between the population size of sugar palm trees and environmental factors in their growing areas was investigated using Pearson correlation analysis at a 5% significance level. The correlation value can indicate the direction and strength of the linear relationship between two related variables. The correlation value limit (r) can be written as $-1 \leq r \leq +1$ (Usman & Albar, 2020). The results of the correlation analysis between the population size of sugar palm trees and environmental factors in their growing areas are presented in Table 3.

Table 3. Recapitulation of correlation analysis between sugar palm (*Arenga pinnata*) population and environmental factors where it grows

Number	Environmental factors	Sugar palm tree population	
		Pearson Correlation (r)	Significance
1.	Altitude	-0.403 ns	0.085
2.	Land slope	0.116 ns	0.659
3.	Soil acidity (pH)	-0.074 ns	0.779
4.	Intensity of solar radiation	0.216 ns	0.405
5.	Air humidity	0.081 ns	0.759
6.	Air temperature	0.063 ns	0.809

Remark: ns= not significant

Based on the results of the correlation analysis presented in Table 3, it is known that the Pearson correlation value (r) between the sugar palm tree population and each environmental factor is smaller than the significance value at the 5% level (P-value).This statistically indicates that there is no closeness of relationship between the population of sugar palm trees and the environmental factors where they grow. The correlation value (r) is categorized as very low if the value is -0.40 ≤ r ≤ +0.40 (Usman & Albar, 2020). Based on these results, it is also known that altitude has a higher correlation value than other factors with a value of -0.403.A negative correlation indicates that the higher a place, so the sugar palm tree population tends to decrease, although in this research this was not statistically proven, presumably because the altitude range of the observation location was small, namely from 420 to 616 m above sea level, so that changes in altitude have not shown a real correlation with the sugar palm population.This contrasts with the statement put forward by Ulfa et al. (2023)that the higher a location, the lower the air temperature and solar radiation intensity, which slows plant growth.Plants that grow slowly result in reduced fruit production, low regeneration, and a tendency for population size to decrease.

The insignificant correlation value between the sugar palm tree population and environmental factors at this research location is thought to be due to the limited research area (26 ha) and the small altitude range (420 to 616 m above sea level).

The reality in the field provides information that sugar palm trees are found in locations with a range of altitudes ranging from 420 m above sea level to 579 m above sea level, land slopes of 35–80°, soil acidity (pH) of 4.5–5.5, solar radiation intensity of 743–31,670 lux, air humidity of 74–81%, and air temperature of 25.5–30° C. Based on several previous research results, these conditions are in accordance with the growing conditions for sugar palm trees.However, previous research also provides information that the presence of sugar palm trees in a forest farmer's cultivated area is not always determined by environmental conditions alone, but is also influenced by human intervention, such as the cultivation techniques used by forest farmers (Fatsan et al., 2020)and the selection of plant species cultivated by local forest farmers (Ruslan et al., 2018).As the results of observations at the research location indicate that the presence of sugar palm trees occurs because they grow naturally and not from the results of cultivation activities carried out by forest farmers.These findings confirm that although environmental conditions are considered suitable for growing sugar palm trees, but the socio-cultural aspects, particularly the community's tendency to choose and cultivate certain species of plants, also influence the condition of the sugar palm tree population in an area.

IV. CONCLUDING REMARK

Conclusion

The population of sugar palm trees at the cultivated are of Harapan Baru III Forest Farmers Group is dominated by the young phase with a density of 45.6 individuals/ha and a frequency of 0.5. Then the density of the seedling phase is 11.8 individuals/ha with a frequency of 0.2, the density of the reproductive phase is 2.9 individuals/ha with a frequency of 0.1, and the density of the post-productive phase is 2.9 individuals/ha with a frequency of 0.1. The linear regression between the population size of sugar palm trees and the environmental factors where they grow is not significant at the significance level of 5%. Similarly, the population size of sugar palm trees is not correlated with the environmental factors where they grow at the significance level of 5% with a correlation value (r) of -0.403 to 0.116.

Recommendation

It is necessary to identify sugar palm trees that have superior characteristics as parent trees to support the artificial regeneration process.

Efforts are needed to enrichment planting of sugar palm trees atfarmers' cultivated areas to increase the population of sugar palm trees and improve the population structure based on their growth phases.

ACKNOWLEDGEMENT

Acknowledgements are extended to the lecturers at the University of Lampung who have guided them in carrying out research and writing scientific articles. Thanks are also expressed to UPTD Taman Hutan Raya Wan Abdul Rachman which has permitted research in the forest area, and also the forest farmers who accompanied me in collecting data.

REFERENCES

[1]. Akbar, D. A., Yuniastuti, E., & Supriyono, S. (2025). "Vegetation diversity and distribution patterns of sugar palm (Arenga pinnata Merr.)." *IOP Conf. Series: Earth and Environmental Science* 1515 (2025) 012011: 1–11. https://doi.org/10.1088/1755-1315/1515/1/012011

[2]. Anggraini, T., Anwar, A., Hervani, D., Suhendra, D., Wisnubroto, M. P., Noflindawati, & Nasution, I. H. (2025). "Quality of sugar palm sap (Arenga pinnata) from various production centers in West Sumatra, Indonesia." *B IO D I V E R S IT A S*, 26(2): 859–860. https://doi.org/10.13057/biodiv/d260234

[3]. Atmanto, W. D., Suryanto, P., Adriana, Triyogo, A., Faridah, E., Prehaten, D., &Budiadi. (2023). "Optimalisasipenggunaanlahan

dengansistemagroforestri di Desa Ngancar, Ngawi.” *PengabdianMu: JurnalIlmiahPengabdiankepada Masyarakat*, 8(2):195–204. https://journal.umpr.ac.id/index.php/pengabdianmu/article/view/3938
[4]. Azhar, I., Risnasari, I., Muhdi, Srena, M. F., & Riswan. (2019). “The utilization of sugar palm (*Arenga pinnata*) by the people around Batang Gadis Nasional Park Area.” *IOP Conference Series: Earth and Environmental Science* 305(012016):1–9. DOI:10.1088/1755-1315/305/1/012016
[5]. Dewi, I. K., Indriyanto, & Asmarahman, C. (2022). “Produksi nira aren di areal garapan kelompok tani hutan Harapan Baru I dalam Taman Hutan Raya Wan Abdul Rachman.” *Wanamukti* 25(1):26–35. In Indonesian. DOI:http://dx.doi.org/10.35138/wanamukti.v25i1.381
[6]. Fatsan, A., Sudarsono, S., Dinarti, D., &Maskromo, I. (2020). “Potensihasil dan keragamanfenotipikaren (Arenga pinnata (Wurmb) Merr.) Sulawesi Tenggara.” *BerkalaPenelitian Agronomi*, *8*(2), 7. https://ojs.uho.ac.id/index.php/agronomi/article/view/14544
[7]. Furqoni, H., Junaedi, A., Wachjar, A., & Yamamoto, Y. (2018). “Growth responses of sugar-palm (Arenga pinnata (Wurmb.) Merr.) seedlings to different shading levels.” *Tropical Agriculture and Development*, *62*(2), 55–59. https://www.jstage.jst.go.jp/article/jsta/62/2/62_55/_article
[8]. Haryoso, A., Zuhud, E. A. M., Hikmat, A., Sunkar, A., Darusman, D. (2020). “Ecological aspects and regeneration of sugar palm in the Sasak Community Gardens of Kekait Village, West Nusa Tenggara, Indonesia.” *Jurnal Manajemen Hutan Tropika*, *26*(1), 1–12. https://doi.org/10.7226/jtfm.26.1.1
[9]. Hasibuan, H. S., Wisnubroto, M. P., Edwin, Rezki, D., &Yulistriani. (2023). “Identification and morphological characterization of sugar palm plants (Arenga pinnata Merr.) growing on different altitudes.” *JurnalBudidayaPertanian*, *19*(2), 99–105. https://ojs3.unpatti.ac.id/index.php/bdp/article/view/11229
[10]. Indriyanto. (2021). *Metode Analisis Vegetasi dan Komunitas Hewan*. 2nd ed. Yogyakarta: Graha Ilmu. Indonesian. 253
[11]. Indriyanto. (2017). Ekologi Spesies Pohon. 1th ed. Yogyakarta: Plantaxia. 303 p.
[12]. Indriyanto. (2024). Ekologi Hutan. 8th ed. Jakarta: PT Bumi Aksara. 210 p.
[13]. Indriyanto & Indriyanto, J. N. (2023). “The population and sap production of sugar palm at the farmer’s cultivated area in Wan Abdul Rachman Grand Forest Park.” *Quest Journals: Journal of Research in Agriculture and Animal Science*, *10*(12), 18–28. https://www.questjournals.org/jraas/papers/v10-i12/10121828.pdf
[14]. Lempang, M. (2012). “Pohon aren dan manfaat produksinya.” *Info Teknis EBONI* 9(1):37–54. In Indonesian. http://ejournal.forda-mof.org/ejournal-litbang/index.php/buleboni/article/view/4993
[15]. Lueder, S., Narasimhan, K., Olivo, J., Cabrera, D., Jurado, J. G., Greenstein, L., & Karubian, J. (2022). “Functional traits, species diversity and species composition of a neotropical palm community vary in relation to forest age.” *Frontiers in Ecology and Evolution* 10(678125):1–13. DOI: 10.3389/fevo.2022.678125
[16]. Muda, N, A. & Awal, A. (2021). “Sugar palm (*Arenga pinnata* Wurmb Merr.): A Review on plant tissue culture techniques for effective breeding.” *IOP Conf. Series: Earth and Environmental Science* 715(012016):1–9. DOI:10.1088/1755-1315/715/1/012016
[17]. Mogea, J., Seibert, B., & Smits, W. (1991). “Multipurpose palms: the sugar palm (*Arenga pinnata* (Wurmb) Merr.).” *Agroforestry Systems* 13:111–29. https://www.academia.edu/34655597/Multipurpose_palms_the_sugar_palm_Arenga_pinnata_
[18]. Musdalifah, Djafar, M., &Mukhlisa, A. N. (2022). “Inventarisasinilaikerapatan dan manfaatekonomitanamanaren (Arenga pinnata (Wurmb) Merr.) di KecamatanTompobulu (Studi kasus: Desa Bonto Somba, Bonto Manurung, dan Bonto Manai).” *Jurnal Eboni*, *4*(2), 41–47. https://ejournals.umma.ac.id/index.php/eboni/article/view/1497
[19]. Naemah, D., Payung, D., & Karni, F. (2022). “Potensi tingkat pertumbuhan tanaman aren (*Arengapinnata* Merr.) di Kabupaten Hulu Sungai Tengah Kalimantan Selatan.” *Jurnal Hutan Tropis* 10(1):38–46. In Indonesian. DOI: http://dx.doi.org/10.20527/jht.v10i1
[20]. Pemerintah Republik Indonesia. (2024). Undang-undang Republik Indonesia Nomor 32 Tahun 2024 tentangPerubahan Atas Undang-undangNomor 5 Tahun 1990 tentangKonservasiSumber Daya Alam Hayati dan Ekosistemnya. Jakarta: Kementerian Sekretariat Negara Republik Indonesia. 48 p.
[21]. Ramadhani, H., Anwar, A., & Satria, B. (2024). “Pengaruhtingkatnaungan dan media tanam yang berbedaterhadappertumbuhan dan perkembanganbibitaren (Arenga pinnata Merr.).” *JurnalPertanianAgros*, *26*(1), 5387–5393. https://e-journal.janabadra.ac.id/index.php/JA/article/view/3993
[22]. Ruslan, S. M., Baharuddin, & Taskirawati, I. (2018). “Potensi dan pemanfaatan tanaman aren (*Arenga pinnata*) dengan pola agroforestri di Desa Palakka, Kecamatan Barru, Kabupaten Barru.” *Jurnal Perennial* 14(1):24–27. In Indonesian. http://journal.unhas.ac.id/index.php/perennial
[23]. Samal, I., Mansur, I., Junaedi, A., & Kirmi, H. (2020). “Evaluasipertumbuhanaren (Arenga pinnata (Wurmb)) di lahanpascatambang PT Berau Coal Kalimantan Timur.” *Media Konservasi*, *25*(2), 103–112. https://journal.ipb.ac.id/index.php/konservasi/article/view/32126
[24]. Shankar, U. (2001). “A case of high tree diversity in a sal (Shorea robusta)-dominated lowland forest of Eastern Himalaya: Floristic composition, regeneration and conservation.” *Current Science*, *81*(7), 776–786. https://www.jstor.org/stable/24106397
[25]. Syahidah, Soma, A. S. S., Makkarennu, Taskirawati, I., Chairil, Akbar, M. F., Parasita, N. R. Deradjat, M. I., Utama, A. R., & Ramadhan, M. D. R. (2025). “Morphology of palm sugar trees (Arenga pinnata) at the various topography in South Sulawesi.” *IOP Conf. Series: Earth and Environmental Science 1445 (2025) 012030*, 1–7. https//doi.org/10.1088/1755-1315/1445/1/012030
[26]. Ulfa, M., Indriyanto, &Asmarahman, C. (2023). “Regenerasitanamanaren pada berbagaikondisiekologistempattumbuhnya di areal garapanKelompok Tani Hutan Karya Makmur III.” *JurnalKehutanan Indonesia Celebica*, *4*(2), 225–238. https://celebica.uho.ac.id/index.php/journal/article/view/32
[27]. UPTD Taman Hutan Raya Wan Abdul Rachman. (2017). *Blok Pengelolaan Taman Hutan Raya Wan Abdul Rachman Provinsi Lampung*. Bandar Lampung: Dinas Kehutanan Provinsi Lampung. 49 p.
[28]. Usman, H., & Akbar, P. S. (2020). *PengantarStatistika: Cara MudahMemahamiStatistika* (R. A. Kusumaningtyas, Ed.; 3 ed.). Bumi Aksara. 383 p.
[29]. Webliana, K. & Rini, D. S. (2020). “Potensi dan pemanfaatantanamanaren (Arenga pinnata) di Hutan Kemasyarakatan Aik Bual Kabupaten Lombok Tengah.” *Agrohita*, *5*(1), 25–35. https://core.ac.uk/download/pdf/327184969.pdf
[30]. Wibowo, A. & Lusiana. (2022). “Budidayatanamanarensebagailangkahstrategismewujudkanhutanlestari di Subang.” *Sadeli: Jurnal Pengabdiankepada Masyarakat*, *2*(2), 16–24. https://journal.unwim.ac.id/index.php/sadeli/article/view/484
[31]. Zuhud, E. A. M., Al Manar, P., Zuraida, &Hidayati, S. (2020). “Potency and conservation of aren (Arenga pinnata (Wurmb) Merr.) in Meru Betiri National Park, East Java-Indonesia.” *JurnalManajemen Hutan Tropika*, *26*(3), 212–221. https://journal.ipb.ac.id/index.php/jmht/article/view/29178