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Research Paper

The Extent of Attack and the Level of Pest and Desease Attack on Nutmeg Trees

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ABSTRACT:*The nutmeg tree (Myristica fragrans Houtt.) is a tree that produces fruit and seeds that have high economic value.The productivity of nutmeg fruit and seeds at the area cultivated by the Harapan Baru III Forest Farmer Group in the Wan Abdul Rachman Grand Forest Park has decreased, allegedly due to pest and disease attacks.Therefore, research was conducted at the forest farmer group's cultivated area to determine the types of damage as signs of pest and disease attacks, analyze the area of attack and the level of attack, and analyze the distribution of pest and disease attacks on nutmeg trees.Data collection was carried out through vegetation surveys with systematic sampling and a sampling intensity of 2.8%.Twenty nested sample plots were arranged in a nested rectangular plots design.The data collected includes the species of trees that make up the forest garden stands and the types of damage that occur to the nutmeg tree organs.The results of the research showed that there were 11 types of damage as signs of pest and disease attacks, namely open wounds, necrosis, leaves with holes, leaves curl, black spots on the leaves, yellow spots on the leaves, leaf rust, insect bites on the leaves, brown spots on the fruit, black spots on the fruit, and fruit cancer.The extent of attack reached 100% of the 66 individual nutmeg trees that was observed.However, the level of pest and disease attacks on the nutmeg tree population is in the very light category (average percentage of tree organ damage is 5.68%).The distribution of signs of pest and disease attacks on nutmeg trees was found in all sample plots.*

KEYWORDS: *nutmeg trees, pests and diseases, types of damage.*

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I. INTRODUCTION

The nutmeg tree (*Myristica fragrans* Houtt.) is native to the Maluku Islands. It is a major spice commodity that has dominated the global market since the 16th-century spice trade (Tariq et al., 2025). Indonesia accounts for 75% of global nutmeg production, with major exports going to China, Vietnam, Germany, and the US. This supports the livelihoods of millions of smallholder farmers in Maluku, Aceh, North Sulawesi, and Lampung(Rafani, 2025; Refika, 2025).Nutmeg tree organs such as seeds and mace, as well as its essential oil, are widely used in international culinary arts, the pharmaceutical industry (with the antioxidants myristicin and elemicin), and cosmetics industry (Kuete, 2017; Paijo et al., 2021). However, nutmeg plantation productivity is hampered by attacks by plant pest organisms (OPT) such as borers and pathogenic fungi, as well as tropical climate change (Climate et al., 2009; Suryadi, 2017). These biotic constraints have prompted farmers to adopt traditional agroforestry systems for nutmeg cultivation as a strategy to improve the growing environment and restore nutmeg tree productivity.

The most disruptive pest and disease attacks on nutmeg tree growth and productivity are stem borers (*Batocerahercules and Zeuzeracofea*), mealybugs, thrips, and fruit flies that attack leaves, as well as pathogens that attack fruit through perforation and tissue extraction(Umasangaji et al., 2018).The dominant pathogenic fungi that cause nutmeg tree diseases include fruit rot (*Colletotrichum gloeosporioides*), leaf spots (*Stigminamyristicae*), white root decay (*Rigidoporuslignosus*), and fruit cancer (*Phytophthora palmivora*) with symptoms of necrosis, black/yellow spots, and young fruit falls (Tjokrodiningrat et al., 2016; Zulkaidhah et al., 2024). In humid tropical environments, secondary infections are often triggered by mechanical injuries from harvesting or storms. This is also accelerated by microclimatic conditions that support the cycle of fungal spores and insect vectors(Climate et al., 2009). Conventional insecticide-based control is limited in effectiveness due to resistance and environmental impacts, so farmers choose to improve nutmeg cultivation techniques with agroforestry systems for natural control through biodiversity (Kementerian Pertanian, 2022). Multi-strata canopies in agroforestry systems, such as in forest garden stands, can create complex environmental conditions, thereby inhibiting the spread of pests and diseases, and increasing the occurrence of positive associations between nutmeg trees and other tree species (Indriyanto, 2024).

Nutmeg trees in agroforestry systems are planted mixed with durian (*Durio zibethinus*), stink bean (*Parkia speciosa*), coffee (*Coffea spp.*), and cocoa (*Theobroma cacao*), among others, thus producing a shady-humid microclimate that allows for the creation of conditions conducive to the proliferation of pest organisms (Ariandi et al., 2018; Indriyanto et al., 2017). A dense canopy can reduce the intensity of solar radiation to below the optimal photosynthesis threshold (25,000-75,000 lux), slowing the vegetative growth of nutmeg and increasing the relative humidity (67--85%) which is ideal for the life cycle of pathogenic fungi (Jonis, 2014). The multi-strata structure of forest garden can inhibit the spread of pests through direct contact between species (Indriyanto et al., 2017)and retain rainwater flow that carries spores from shade trees to understory plants (Safe'i et al., 2022). Although agroforestry systems can increase the biodiversity of natural antagonists, plant competition for solar radiation and nutrients can also reduce the resistance of nutmeg trees to complex biotic-abiotic factors(Climate et al., 2009). This phenomenon is clearly observed in the forest areas of Lampung Province, Indonesia, which integrate agroforestry systems within protected forest areas and grand forest park areas.

Wan Abdul Rachman Grand Forest Park is located at an altitude of 50 m to 1,661 m above sea level, representing a unique conservation area model because it contains natural forests and forest gardens (UPTD Taman Hutan Raya Wan Abdul Rachman, 2017). The forest gardens were built together with forest farmer groups (FFG) who utilize land at Traditional Blocks by applying MPTS (multi-purpose tree species) agroforestry techniques) (Indriyanto, 2022a). In the forest farmer's cultivated area, the physiognomy of forest garden stands is visible with a classic multi-strata structure composed of nutmeg, durian, candlenut, stink bean, dogfruit, jointfir, cocoa, coffee, and others from the seedling phase to mature trees (Indriyanto et al., 2017). The typical wet tropical climate of Lampung Province, Indonesia, has high rainfall of 2,000-3,500 mm/year, air temperature around 27°C, and high humidity, supporting nutmeg productivity, but it is also not free from plant pests and diseases (Jonis, 2014). Farmers who are members of the Harapan Baru FFG practice tree cultivation without the use of chemical pesticides to comply with conservation regulations. This location is an ideal representation for understanding the interaction of agroforestry microclimates with the dynamics of pests and diseases in conservation areas.

Therefore, an identification of the types of damage to nutmeg trees at the area cultivated by the Harapan Baru III FFG in the Wan Abdul Rachman Grand Forest Park was conducted to determine the types of damage as signs of pest and disease attacks to analyze the causal factors, analyze the extent of attack, the level of attack, and the distribution of pest and disease attacks. The main benefit of the research results is as a scientific basis for developing strategies to prevent increasing pest and disease attacks and control them quickly and precisely.

II. Methods

Research Site

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

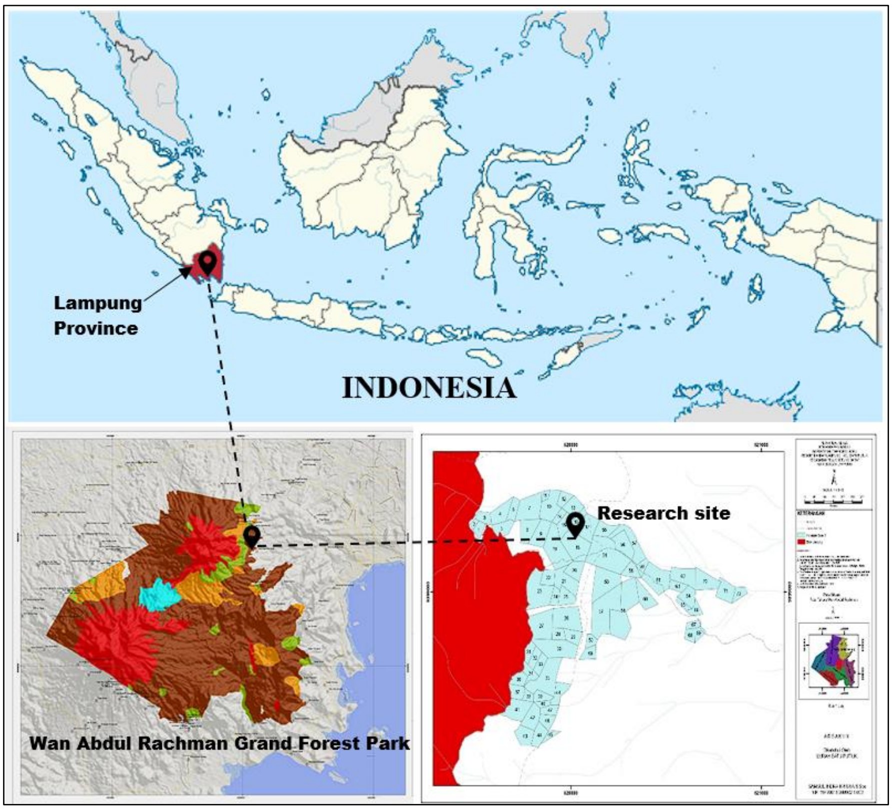

Figure 1. Map of the research site at the farmers' cultivated area of Harapan Baru III FFG in Wan Abdul Rachman
Grand Forest Park, Lampung Province, Indonesia (adapted from UPTD Taman Hutan Raya Wan Abdul Rachman, 2017).

Equipment

The equipment used for this research consists of string of raffia,wooden stakes,measuring tapes, GPS (global positioning system), haga meter, thermohygrometer, lux meter,digital camera,a writing board, ballpoint pens, and tally sheets.

Data Acquisition

Data were collected through a vegetation survey, using a systematic sampling method with a sampling intensity of 2.8%. twenty sample plots were used, each in the form of a nested rectangular plots. The shape and size of the nested plots in the nested rectangular plots design can be seen in Figure 2.The layout of nested plots in the area cultivated by the Harapan Baru III FFG is presented in Figure 3.

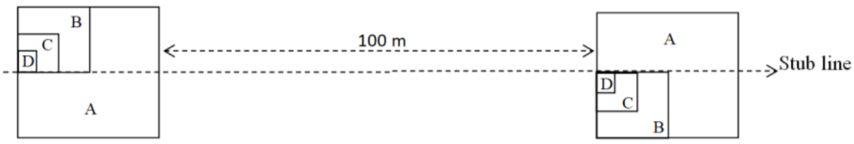

Figure 2. Shape and size of the nested plots in the nested rectangular plots design (Indriyanto, 2021).
Remark: A= plot measuring 20 m x 20 m for observation of mature trees phase
B= plot measuring 10 m x 10 m for observation of poles phase
C= plot measuring 5 m x 5 m for observation of saplings phase
D= plot measuring 2 m x 2 m for observation of seedlings phase and undergrowth

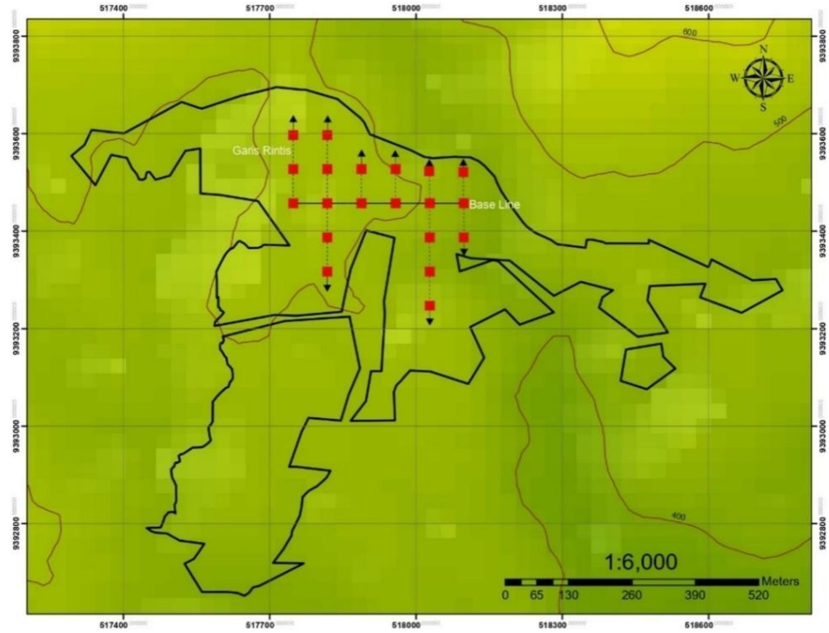

Figure 3. Layout of nested plots at the farmers' cultivated area of Harapan Baru III FFG in Wan Abdul Rachman
Grand Forest Park, Lampung Province, Indonesia.

The data collected includes the types of trees that make up the forest garden stands, the types of damage to the four main organs of the nutmeg tree (trunk, branches, leaves, and fruit), the percentage of the number/area of nutmeg tree organs that are damaged, and the growing environment (air temperature, air humidity, and altitude).

Data Processing

The density of each tree species in the forest garden stand was analyzed to illustrate the population size of each tree species. The density of each tree species was calculated using the following formula(Indriyanto, 2021). The density data was then presented in the form of a stem histogram.

$$\text{Density (D)} = \frac{\text{number of individuals of a plant species}}{\text{area of entire sample plot}} \quad (1)$$

The extent of pest and disease attack (LS) on nutmeg trees is the percentage of nutmeg trees affected by pests and diseases, indicating visible signs or symptoms of attack on their organs. The extent of attack per tree was analyzed using a formula adapted from Asmaliyah et al. (2010).

$$\text{LS} = \frac{\text{Amount of trees attacked by pest and diseases in the sample plot}}{\text{Total amount of trees in the sample plot}} \times 100\% \quad (2)$$

The level of attack or level of damage to nutmeg trees in each sample plot was calculated using the formula proposed by Kilmaskossu & Nerokouw (1993) as follows.

$$\text{I} = \frac{\sum_{i=0}^{5}((n_i.v_i)}{\text{N.V}} \times 100\% \quad (3)$$

Remark:
I= level of attack or damage per plot
n_i= amount of trees with a certain level of damage qualification
v_i= classification value of a certain level of attack or damage
N= the total amount of trees in a plot
V= the value of the highest level of attack or damage classification

Scoring and determining the level of damage refers to the criteria listed in Table 1.

Table 1. Values or scores related to the percentage of damage to nutmeg tree organs and the level of damage refer to the following criteria (Kilmaskossu & Nerokouw,1993)

Number	Percentage of organ damage (%)	Value (score)	The level of attack/damage
1.	0—<1	0	Healthy (not attacked)
2.	1—20	1	Very light attack
3.	21—40	2	Light attack
4.	41—60	3	Medium attack
5.	61—80	4	Heavy attack
6.	81—100	5	Very heavy attack

III. RESULT AND DISCUSSION

The Density of Trees Population that Composing Forest Garden Stands

Nutmeg trees grow together with 14 other tree species to form a forest garden stand. The densities of these 15 tree species are shown in Figure 4.

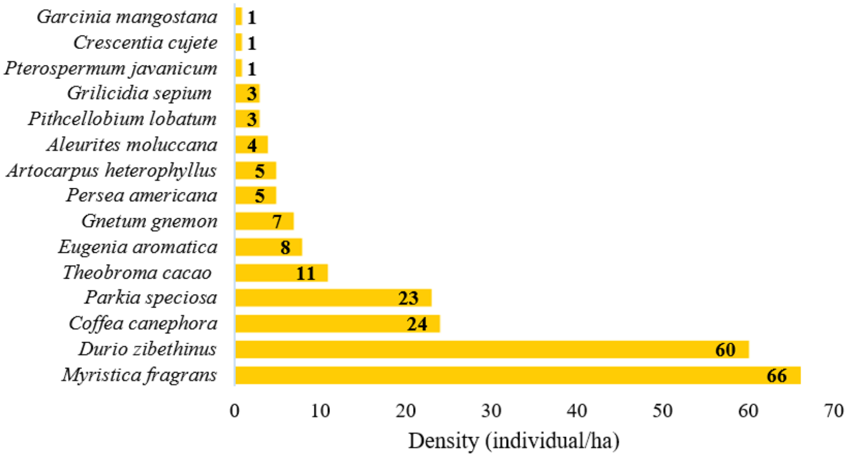

Figure 4. The density of tree species population that make up the forest garden stands at the area cultivated by TheHarapan Baru III FFG in the Wan Abdul Rachman Grand Forest Park, Lampung Province, Indonesia.

The total tree density at the research site was 222 individuals/ha. Based on the data at Figure 4, four tree species had a much higher population density than the other 11 tree species. The four tree species with the highest densities were nutmeg (*Myristica fragrans*) at 66 individuals/ha, Durian (*Durio zibenthinus*) at 60 individuals/ha, coffee (*Coffea canephora*) at 24 individuals/ha, and stink bean (*Parkia speciosa*) at 23 individuals/ha. Therefore, the nutmeg tree population in the forest garden stands was the largest compared to the populations of other tree species. The most abundant tree species indicates that this tree species is currently the most preferred by forest farmers (Indriyanto, 2022a).

The Types of Damage

The observations wasaconducted on 66 nutmeg trees revealed 11 types of damage to the trunk, branches, leaves, and fruit. These eleven types of damage include open wounds, necrosis, black and yellow spots on leaves, brown spots on leaves, leaves with holes, insect bites on leaves, leaf rust, leaf curl, brown spots on fruit, black spots on fruit, and fruit cancer. The percentage of damage to each tree organ was 0.30% on the trunk, 0.23% on branches, 24.24% on leaves, and 1.30% on fruit. Illustrations of each type of damage and the suspected possible causes of the damage are presented in Table 2.

Table 2. Types of damage and percentage of damage to each nutmeg tree organ, as well as possible causal factors

Nutmeg tree organ	Photo of the form of tree organ damage.	Types of damage to tree organs	Percentage of tree organ damage (%)	Possible cause of damage
Stem		Open wound	0.30	Mechanical factors, such as machete slashes or blows with hard objects carried out by humans(Girsang, 2022).
Stem		Necrosis		Attacks by stem borer pests such as insects from the genus Batocera(Pesireron et al., 2019).
Branch		Open wound	0.23	Mechanical factors, such as machete slashes or blows with hard objects carried out by humans(Girsang, 2022).
Leaf		Yellow and black spots on the leaves	24.24	Yellow spots and black spots on the leaves are thought to be caused by fungal infections from the genus Fusarium, particularly *Fusarium oxysporum* and *Fusarium solani* which commonly attack plants in humid and shaded conditions (Halma et al., 2023).
Leaf		Brown spots on the leaves and leaves with holes		Brown spots and perforated leaves are thought to be related to infection by the fungus *Nigrosporasphaerica* which causes necrosis in leaf tissue until the leaves fall off (Halma et al., 2023).
Leaf		Insect bites on the leaves		Damage in the form of holes on the leaves is thought to be caused by beetles from the families Chrysomelidae and Curculionidae (Patty, 2013), leaf beetle (*Epilachna indica*), and possibly by grasshopper bites (*Spathosternum*) (Nurfadila et al., 2024).
Leaf		Leaf rust		Leaf rust like this is generally caused by the fungus *Hemileiamyristicae*(Halma et al., 2023).

Leaf		Leaves curl		Signs of aphid infestation or herbicide poisoning (Afriliya &Al Fajar, 2019).It can also be due to certain nutritional deficiencies.
Fruit		Brown and black spots on the fruit	1.30	Infection by the fungus *Stigminamyristicae* and/or the fungus *Colletotrichum spp.* (Kalay et al., 2015).
Fruit		Fruit cancer		Infection by various types of fungi such as *Phytophthora palmivora* and *Colletotrichum spp.* humans (Girsang, 2022).
Average percentage of damage (%)			6.52	

Based on Table 2, nutmeg trees experienced organ damage. Damage to nutmeg tree organs, whether on the stem, branches, leaves, or fruit, indicates signs of pest and disease attacks or disturbances from other factors. Tree damage caused by pests and diseases is generally related to microclimate conditions or environmental sanitation that stimulates the development of pest and disease organisms. In fact, the heterogeneous composition of tree species mixed with nutmeg trees in forest garden stands has advantages from various aspects related to the regulation of natural processes. The heterogeneity of forest garden stands also increases the resistance of each tree species to pest and disease disturbances (Indriyanto, 2010). The presence of pest and disease attacks on nutmeg trees in forest garden stands can most likely still be suppressed naturally because forest garden stands are not too dense with a total tree population density of 222 individuals/ha.Forest garden stands that are not too dense allow for sufficient light penetration and adequate air circulation, making the under-canopy environment unsuitable for the development of pests and diseases in nutmeg trees. In contrast, overly dense forest garden stands have been shown to increase the risk of pest and disease attacks on nutmeg trees, as has been the case in the Maluku region (Girsang, 2022; Pesireron et al., 2020). The combination of biotic and abiotic factors is the primary basis for the emergence of various types of damage to various nutmeg tree organs (Assagaf et al., 2021). These environmental characteristics illustrate that agroforestry systems can support tree growth. However, if forest garden stands are too dense and the proportion of each tree species combined is unbalanced, it is possible for pests and diseases to attack trees with low resistance (Wattimena & Makaruku, 2022).

Leaf damage caused by pathogens is the most common form of damage and is characterized by the appearance of black spots, yellow spots, and changes in leaf color, indicating an active infection process. These symptoms indicate an attack by fungi such as Alternaria, Pestalotiopsis, Curvularia, and Fusarium (Fajrin, 2021). These fungi are a group of pathogenic fungi known to grow more rapidly in humid environments with low light intensity. According to Fajrin (2021), leaf spot is a major disease in nutmeg cultivated under dense shade. The increasingly widespread development of spots has the potential to significantly reduce the photosynthetic area, thus impacting the plant's vegetative growth. The spread of the disease will occur when the environment is humid, which can stimulate the growth of fungal spores (Susanto et al., 2020).

Leaf damage such as curled leaves, curly leaves, or incompletely developed leaf blades can also be caused by nutritional imbalances, particularly boron, magnesium, nitrogen, and calcium, as these nutrients play a crucial role in leaf tissue formation and plant metabolic activity.Nutrient deficiencies in nutmeg trees often cause symptoms similar to infectious diseases (Latuamury et al., 2024). Cases elsewhere (in Sulawesi) indicate that densely planted forest garden often cause nutmeg trees to experience leaf deformation, which disrupts new tissue formation due to nutrient deficiencies (Ariandi et al., 2018). Densely planted forest garden increase inter-tree competition for various factors (Indriyanto, 2017). These physiological symptoms indicate that nutmeg trees require better nutrient management, particularly in agroforestry systems, which have higher levels of inter-tree nutrient competition than monoculture systems (Widayanti et al., 2020).

Damage to nutmeg tree stem and fruit was found to a lesser extent, but still indicates a pest or disease infestation that should be monitored, especially if environmental conditions are conducive to pest development. Localized necrosis of nutmeg tree stems can indicate the presence of pathogens such as Phytophthora or Ganoderma. Both these groups of pathogens are frequently reported to attack the base of the stem and roots of nutmeg trees in various nutmeg growing areas(Susanto et al., 2020). Furthermore, decreased fruit quality, characterized by tissue hardening and a blackish-brown discoloration, indicates early signs of fruit canker, particularly in fruit with superficial wounds. Haikal et al. (2020)statedthat untreated fruit wounds, in humid environments, can act as entry points for fungi that cause fruit canker. These findings should be carefully considered to ensure appropriate preventive measures against potential development of problems in nutmeg fruit and tree stems.

The Extent of Pest and Disease Attacks

The extent of pest and disease attacks on each sample plot is percentage of trees attacked by pests and diseasescompared to the total amount of trees in the sample plot (Asmaliyah et al., 2010). Observations of all nutmeg trees in each sample plot yielded data on the amount of nutmeg trees attacked by pests and diseases. Data on the amount of nutmeg trees in each sample plot and the amount of nutmeg trees attacked by pests and diseases are presented in Figure 5.

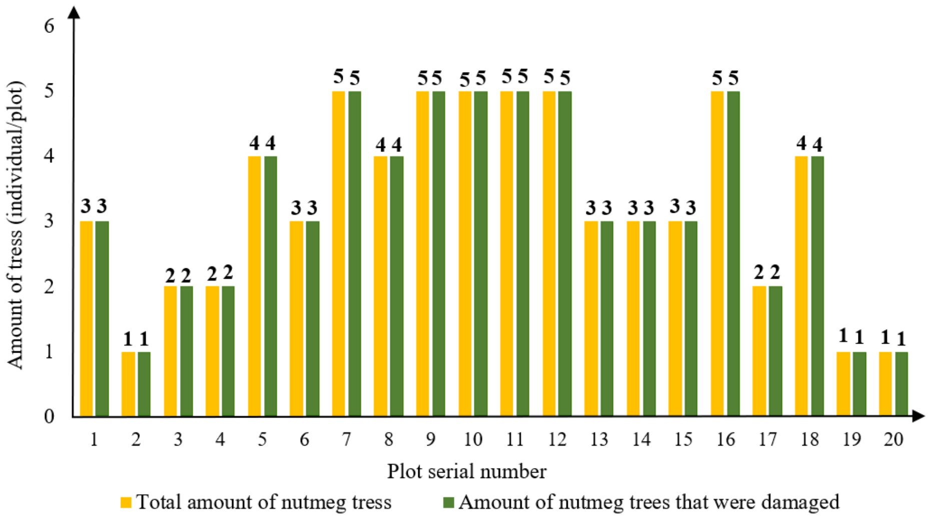

Figure 5. Illustration of the amount of nutmeg trees attacked by pests and diseases in each sample plot and the total amount of nutmeg trees in each sample plot.

Based on the comparison between the amount of nutmeg trees attacked by pests and diseases (experiencing organ damage) and the total amount of nutmeg trees in each sample plot (Figure 5), it can be stated that the attack area (LS) at each sample plot is 100%. This indicates that the percentage of pest and disease attacks on nutmeg trees is very high because the LS value in all sample plots reaches 100%. Furthermore, it can be stated that not a single nutmeg tree in the sample plot is free from pest and disease attacks.Although the level of pest and disease attacks has not been discussed, observing the LS value which reaches the maximum (100%) shows that the organisms causing pest and disease on nutmeg trees are in the process of working evenly throughout the forest farmer's cultivated area.The uniformity of the attack rate is suspected because the factors that stimulate the spread of pests and diseases are uniform across sample plots, especially environmental factors that support the development of pests and diseases. According to (Susanto et al., 2020), the high percentage of attack incidents is the influence of a combination of biotic factors (organisms causing pests and diseases) and fluctuating changes in environmental factors where they grow.

In addition to environmental factors, forest cultivation practices carried out by forest farmers also contributed to the high incidence of attack in the research sites. For example, the use of local seeds from unselected parent trees generally results in low nutmeg tree resistance, resulting in a nearly uniform response to pests and diseases throughout all growth phases (Gibson, 2021). Furthermore, seeds collected from tree is not selected generally exhibit poor growth quality and poor adaptability to various environmental changes (Indriyanto, 2022b). Therefore, the use of seeds from suitable seed sources can increase the resistance of planted trees to pests and diseases and eliminate the occurrence of pest and disease disturbances (Indriyanto, 2010).

Furthermore, a diverse tree species composition along with nutmeg trees can maintain environmental conditions suitable for nutmeg tree growth, thus maintaining the tree's long-term resilience. In addition to pest and disease disturbances, nutmeg trees are highly susceptible to dry conditions, necessitating a mix of other tree species to prevent drought (Wattimena & Makaruku, 2022). Forest gardens, as a form of agroforestry, are highly suitable for nutmeg cultivation because the forest garden's stand composition can protect nutmeg trees from changes in environmental conditions such as solar radiation and wind, which can weaken the nutmeg tree's immune system (Fauziyah et al., 2015).

The Level of Pest and Desease Attack

The level of pest and disease attack on nutmeg trees is an important indicator in monitoring the health and effectiveness of nutmeg tree population management. Analysis of the level of attack is based on the percentage of damage to nutmeg tree organs, then categorized into certain levels of attack according to the criteria proposed by Kilmaskossu & Nerokouw (1993). The results of the analysis of the level of pest and disease infestation on nutmeg trees at the research site are presented in Table 4.

Table 4. Percentage of organ damage and level of pest and disease attacks on nutmeg trees in each sample plot

Number of sample plot	Percentage of organ damage (%)	Score	Level of pest and disease attacks
17	13.75	1	Very light attack
18	11.88	1	Very light attack
12	9.25	1	Very light attack
19	8.75	1	Very light attack
20	8.75	1	Very light attack
11	7.60	1	Very light attack
16	7.00	1	Very light attack
15	6.67	1	Very light attack
6	6.25	1	Very light attack
3	6.25	1	Very light attack
5	5.94	1	Very light attack
8	3.75	1	Very light attack
10	3.25	1	Very light attack
4	3.12	1	Very light attack
9	3.00	1	Very light attack
1	2.94	1	Very light attack
7	2.75	1	Very light attack
14	2.58	1	Very light attack
2	1.75	1	Very light attack
13	1.37	1	Very light attack
The average of all sample plots	5.68	1	Very light attack

Based on the results of the attack level analysis presented in Table 4, it can be stated that nutmeg trees at all sample plots are categorized as very light attack with a score of 1. A score (value) of 1 at all sample plots indicates that organ damage is considered not yet developed into a condition that disrupts the physical and physiological condition of the nutmeg tree. Although all sample plots show symptoms of attack (LS = 100%), the percentage of organ damage is still within minimal limits so that it has not caused physiological disturbances to the nutmeg tree. This indicates that pest and disease attacks are evenly distributed but not intense, so that the nutmeg tree is able to maintain its physiological function despite damage to some of its organs.

In fact, the presence of plant pests and diseases does not always correlate with the level of physical damage they cause to plants (Sarianti & Subandar, 2022). Therefore, an analysis of the extent of the attack (incidence) and the level of damage is necessary as distinct epidemic parameters (Arifah, 2023). Furthermore, Arifah (2023)stated that this phenomenon demonstrates the presence of pest populations throughout the area, but the ability to suppress the development of signs and symptoms is crucial for maintaining the physiological condition of the plant, especially in mature nutmeg trees. This is in line with Surachman (2023)statement that mature nutmeg trees show the ability to maintain the photosynthesis process effectively even though there are mild infection symptoms on the leaf surface.

Distribution of Attack Locations

The distribution of pest and disease attacks can be seen on the map of the distribution of attack locations in the area cultivated by the Harapan Baru III FFG, which is presented in Figure 4.

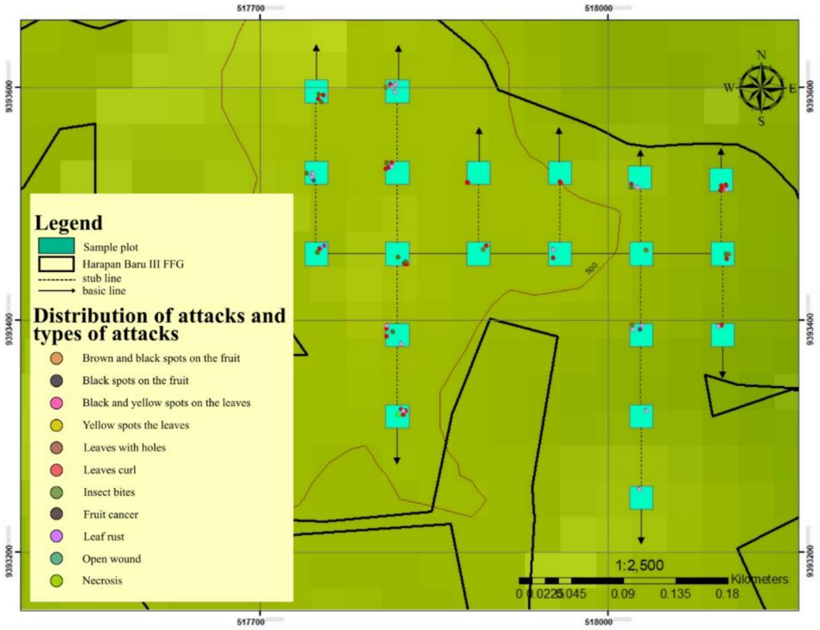

Figure 4. Map of the distribution of locations of pest and disease attacks on nutmeg trees at the cultivated area of the Harapan Baru III FFG in the Wan Abdul Rachman Grand Forest Park, Lampung Province, Indonesia.

The distribution of pest and disease attack on nutmeg trees is evident from the diverse types of damage. Therefore, more detailed mapping is needed to understand the prevalence of each type of damage in each sample plot. Furthermore, an illustration of the amount of each type of damage in each sample plot is presented in Figure 5.

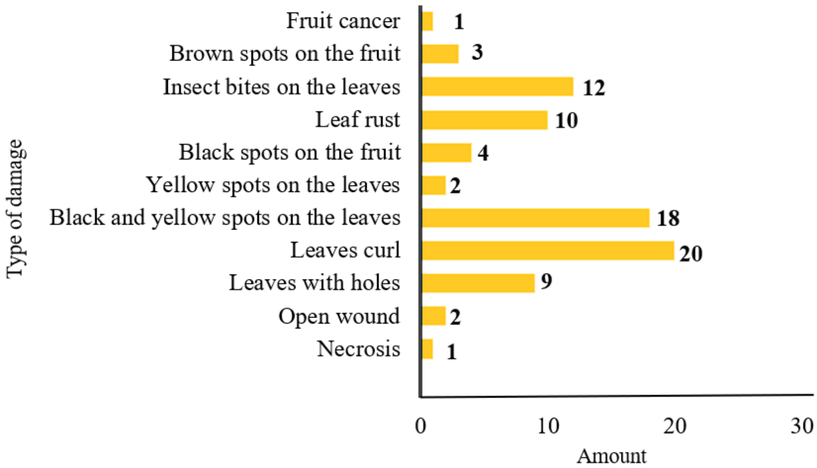

Figure 5. Illustration of the amount of each type of damage to nutmeg trees at the area cultivated by farmers of the Harapan Baru III FFG in the Wan Abdul Rachman Grand Forest Park, Lampung Province, Indonesia.

The even distribution pattern indicates that forest garden management at the research site has not been able to create an environment low in pests and diseases. Given that the forest farmers' cultivation area is within a conservation area, crop rotation is prohibited. Tree branch pruning is also prohibited, thus improving environmental sanitation through pruning will not occur. This situation requires alternative strategies, such as managing litter on the forest floor to prevent it from becoming a breeding ground for pests and diseases. Improving sanitation through intensive litter management can reduce the presence of pathogen inoculum that persists on fallen leaves and infected twigs. An ecologically based approach that considers microclimate and improves vegetation structure has been shown to reduce pest and disease intensity in nutmeg plants in various cultivation areas(Girsang, 2022).

Furthermore, the possibility of microbial interactions within plant tissues that play a role in inhibiting the development of severe symptoms should also be considered as a supporting factor for more effective management, although further research is needed to confirm their role. Thus, the currently homogeneous pattern of attack distribution can be gradually altered through management strategies that are more responsive to microenvironmental conditions and vegetation structure. Such an approach offers the opportunity to improve the overall health of nutmeg plants in the agroforestry system at the research site. Ahmadi (2022)state that this type of interaction mechanism has been reported to play a role in reducing pathogen virulence in several species of trees.

IV. CONCLUDING REMARK

Conclusion

The type of tree organ damage can be a sign of pest and disease attack. Eleven types of damage have been identified on the stem, branches, leaves, and fruit of nutmeg trees. The amount of damage types is quite diverse, and the extent of pest and disease attack (LS) value reached 100%, meaning it occurred on all the nutmeg trees sampled. However, the level of attack/damage is still categorized as very light, allowing for environmental sanitation improvements to suppress the development of pests and diseases.

Recommendation

Research is needed to investigate the relationship between changes in extreme environmental conditions and the number of types of damage to nutmeg trees, the extent of attack/damage, and the level of pest and disease attack. This will strengthen the scientific basis for improving the environmental conditions where nutmeg trees grow.

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REFERENCES

[1]. Afriliya, F., & Al Fajar, B. (2019). "Keanekaragaman jenis-jenis penyakit dan cara pengendaliannya di pembibitan kelapa sawit (*Elaeis guinensis* Jacq.) PT Perkebunan Nusantara I Langsa." *Jurnal Biologica Samudra 1*, 1(1): 34–40. 1518-Analisis Penyakit dan Pengendaliannya di Pembibitan Kelapa Sawit - Studocu.

[2]. Ahmadi, A. E. 2022. "Keanekaragaman Kapang Endofit Tanaman Pala (*Myristica fragrans*) Berdasarkan Daerah Internal Transcribed Spacer (ITS) rDNA. *Skripsi*. Program Studi Biologi, Fakultas Sains dan Teknologi. Jakarta: Universitas Islam Negeri Syarif Hidayatullah. 69 p.

[3]. Ariandi, E. A., Duryat, & Santoso, T. (2018). "Essential oil rendemen analysis of nutmeg (*Myristica fragrans*) seeds in various classes of sunlight intensity at Batu Keramat Village, Kota Agung Subdistrict, District of Tanggamus." *Jurnal Sylva Lestari*, 6(1): 24. https://doi.org/10.23960/jsl1625-32

[4]. Arifah, F., Aini, L. Q., & Muhibuddin, A. (2023). "Molecular and morphological characterization of fungi isolated from nutmeg (*Myristica fragrans)* in North Sulawesi, Indonesia." *Biodiversitas*, *24*(1), 441–453. https://doi.org/10.13057/biodiv/d240151

[5]. Asmaliyah. (2010). "Pengendalian hama pada hutan tanaman dalam upaya mendukung peningkatan produktivitas hutan." *Prosiding Seminar Hasil-hasil Penelitian Peran Iptek dalam Mendukung Pembangunan Hutan Tanaman Rakyat*. Pusat Penelitian dan Pengembangan Hutan Tanaman, Badan Penelitian dan Pengembangan Kehutanan. Bogor: Departemen Kehutanan. Bogor.185-192 p.

[6]. Assagaf, M., Irsoi, Hidayat, Y., Cahyaningrum, H., Ibrahim, A., Aji, H. B., & Susanto, A. N. (2021). "Management on biotic stress to improve the nutmeg quality in North Moluccas, Indonesia." *E3S Web of Conferences*, *306*(03014), 1–7. https://doi.org/10.1051/e3sconf/202130603014

[7]. Climate, I., Adaptation, C., Ivan, H., & Agroforestry, I. (2009). *How t o Pr ot ect Our Nutmeg fr om Clima t e Chang e ?. ICCAS_nutmeg_ FS_en_2018.pdf*. Diakses pada Tanggal 23 Januari 2025.

[8]. Fajrin, I. A. (2021). *Identifikasi Penyakit Bercak Daun pada Tanaman Pala (Myristica fragrans) di Bawah Naungan Rapat*. Skripsi S1 Fakultas Pertanian. Serang: Universitas Sultan Ageng Tirtayasa. https://eprints.untirta.ac.id/view/subjects/S1.type.html%0A

[9]. Fauziyah, E., Kuswantoro, D. P., & Sanudin. (2015). "Prospek pengembangan pala (Myristica fragrans Houtt.) di hutan rakyat." *Jurnal Ilmu Kehutanan*, *9*(2), 32–39. https://www.researchgate.net/publication/373277693_Prospek_Pengembangan_Pala_Myristica_fragrans_Houtt_di_Hutan_Rakyat

[10]. Gibson, A. K. (2021). "Genetic diversity and disease: the past, present, and future of an old idea." *Evolution*, 76(S1): 20–36. https://doi.org/10.1111/evo.14395

[11]. Girsang, N. S.SS. (2022). "Hama dan penyakit tanaman pala serta pengendalian secara pengendalian hama terpadu." Balai Besar Perbenihan dan Perlindungan Tanaman Perkebunan Medan. Direktorat Jenderal Perkebunan. https://balaimedan.ditjenbun.pertanian.go.id/hama-dan-penyakit-tanaman-pala-serta-pengendalian-secara-pengendalian-hama-terpadu/

[12]. Haikal, F. F., Safe'i, R., & Darmawan, A. (2020). "Importance of monitoring of forest health in management of community forests: case study of HKM Beringin Jaya managed by KTH Lestari Jaya 8." *Jurnal Hutan Pulau-Pulau Kecil*, 4(1): 31–43. https://doi.org/10.30598/jhppk.2020.4.1.31
[13]. Halma, E.,Ilhatul, M., Ramadani, A. H., A'in, N. K., & Solekha, R. (2023). "Pengaruh nfeksi jamur *Culvularia andropogonis*terhadap anatomi jaringan epidermis daun serai wangi (*Cymbopogon nardus* (L.) Rendle)." *Biology Education, Science, and Technology*, 6(2): 345–351.
[14]. Indriyanto. (2010). *Pengantar Budidaya Hutan.*2nd ed. Jakarta: PT Bumi Aksara. 234 p.
[15]. Indriyanto. (2017). *Ekologi Spesies Pohon*. 1th ed. Yogyakarta: Plantaxia. 303 p.
[16]. Indriyanto, Tsani, M. K., Bintoro,A., Duryat., & Surnayanti. (2017). "Identifikasi tingkat kerusakan tegakan hutan di areal KPPH Talangmulya." *Prosiding Seminar Nasional Darmajaya*. 207-216.http://repository.lppm.unila.ac.id/id/eprint/4119
[17]. Indriyanto. (2021). *Metode Analisis Vegetasi dan Komunitas Hewan*. 2nd ed. Yogyakarta: Graha Ilmu. 253 p.
[18]. Indriyanto (2022a). "Composition, domination, and similarity level of stand among farmers'cultivated blocks at Wan Abdul Rachman Grand Forest Park." *Jurnal Penelitian Kehutanan Wallacea*, 11(2):139-151. http://dx.doi.org/10.18330/jwallacea.2022.vol11iss2pp139-151
[19]. Indriyanto. (2024). *Ekologi Hutan*. 8th ed. Jakarta: PT Bumi Aksara. 210 p.
[20] .Indriyanto. (2022b). *Teknik dan Manajemen Pesemaian*.1st ed. Yogyakarta: Plantaxia. 310 p.
[21]. Jonis, I. (2014). *Budidaya Tanaman Pala. UPT Balai Pelaksana Penyuluhan Pertanian*, Perikanan, Kehutanan, dan Ketahanan Pangan Kecamatan Tanjung Raya. 27 p.
[22]. Kalay, A. M., Lamerkabel, J. S. A., & Thenu, F. J. L.(2015). "Kerusakan tanaman pala akibat penyakit busuk buah kering dan hama penggerek batang di Kecamatan Leihitu Kabupaten Maluku Tengah." *Agrologia*, 4(2): 88-95. https://doi.org/10.30598/a.v4i2.204
[23]. Kementerian Pertanian. (2022). Outlook Pala Indonesia 2022. *Pusat Data dan Sistem Informasi Pertanian.* Jakarta: Sekretariat Jenderal Kementerian Pertanian. 108 p. Outlook_Pala_2022.pdf
[24]. Kilmaskossu, S. T. E. & Nerokouw, J. P. (1993). "Inventory of forest damage at Faperta Uncen Experiment Gardens in Manokwari Irian Jaya Indonesia." *Proceedings of the Symphosium on Biotechnological and Environmental Approaches to Forest and Disease Management*. Bogor: SEAMEO.
[25]. Kuete, V. (2017). *Medicinal Spices and Vegetables from Africa*. Academic Press. https://doi.org/10.1016/B978-0-12-809286-6.00023-6
[26]. Latuamury, R., Batmomolin, P., & Niwele, A. (2024). "Effect of ethanol extract of nutmeg leaves (Myristica fragrans) on hispathotic features of diabetic rats (*Ratus norvegicus*)." *Omni Health Journal*, 1(3): 76–84.
[27]. Nurfadila, N., Dharmaputra, O. S., Retnowati, I., Widayanti, S., & Ambarwati, S. (2024). *Sejarah, Permasalahan, Solusi, dan Manfaat Pala*. 1st ed. Bogor: Southeast Asian Regional Centre for Tropical Biology. 116 p.
[28]. Paijo, A. R. H., Indriawan, R. T., Karisoh, M. R., Susmantoyo, A. P. M., Suryanto, E., & Runtuwene, M. R. J. (2021). "Kemampuan ekstrak sekuensial daging buah pala sebagai agen hipoglikemik untuk penyerapan glukosa." *Chemistry Progress*, 14(2):1-101. https://doi.org/10.35799/cp.14.2.2021.37114
[29]. Patty, J. (2013). "Kerusakan tanaman pala akibat hama san penyakit di Karloming, Kesui, Kabupatem Seram bagian Timur." *Jurnal Budidaya Pertanian,* 9(1): 47-51
[30]. Pesireron, M., Kaihatu, S., Suneth, R., & Ayal, Y. (2019). "Perbaikan teknik pengendalian hama dan penyakit perkebunan pala banda (*Myristica fragrants* Houtt) di Maluku." *Jurnal Penelitian Tanaman Industri*, 25(1): 37-45. https://doi.org/10.21082/littri.v25n1.2019.45-58 [31]. Rafani, I. (2025). *Policy Development of Indonesia's Nutmeg*. Policy Development of Indonesia's Nutmeg | FFTC Agricultural Policy Platform (FFTC-AP). Diakses pada Tanggal 23 Januari 2026.
[32]. Refika, D. (2025). *Apa Itu Pala, Rempah-rempah Legendaris Indonesia*:*Nutmeg, Indonesia's Legendary Spice*. Diakses pada tanggal 23 Januari 2025.
[33]. Safe'i, R., Kaskoyo, H., & Darmawan, A. (2022). "Analisis kesehatan pohon dengan menggunakan metode forest health monitoring: studi kasus pada tiga fungsi hutan di Provinsi Lampung." *In Virtual Seminar dan Konferensi Nasional Universitas Brawijaya Malang*, 1–15. Naskah_SeMNASN MAPIAUB 2020_R.Safe'i.pdf
[34]. Sarianti & Subandar, I. (2022). "Insidensi dan severitas penyakit antraknosa pada tanaman bawang merah di Kampong Tanah Bara Kecamatan Gunung Meriah Kabupaten Aceh Singkil." *Jurnal Pertanian Agros*, 24(1): 202–210. http://dx.doi.org/10.37159/jpa.v24i1.1529 [35]. Surachman, N. A., Indriyanto, & Asmarahman, C. (2023). "Analisis tingkat kerusakan tegakan di areal garapan Kelompok Tani Hutan Karya Makmur III." *Celebica, Jurnal Kehutanan Indonesia,* 4(1): 1–13. https://doi.org/10.33772/jc.v4i1.5
[36]. Suryadi, R. (2017). "Research strategy of cultivation to improve productivity and competitiveness of nutmeg." *Perspektif*, 16(1): 1–13. https://doi.org/10.21082/PSP.V16N1.2017.01-13
[37]. Susanto, A., Prasetyo, A. E., Priwiratama, H., & Syarovi, M. (2020). "Laju fotosintesis pada tanaman kelapa sawit terinfeksi karat daun *Cephaleuros virescen.*" *Jurnal Fitopatologi Indonesia*, 16(1): 21–29. https://doi.org/10.14692/jfi.16.1.21-29
[38]. Tariq, D., Sultan, M. T., Noman, A. M., Raza, H., Akram, S., Mohamed, H. M., Khan, M. A., Imran, M., Hussain, M., Memon, A. G., Atif, M., Mohamed, G. A., Ibrahim, S. R. M., & Jbawi, E. Al. (2025). "Nutmeg beyond spice: a review on its therapeutic potential, safety and industrial promise." *Food Science and Nutrition*, 13(10): 1-19. https://doi.org/10.1002/fsn3.71053
[39]. Tjokrodiningrat, S., Ashari, S., Syekhfani, S., & Aini, N. (2016). "The characteristics of nutmeg (*Myristica fragrans* Houtt.) growth using agroforestry system in Ternate Island, Indonesia. " *Russian Journal of Agricultural and Socio-Economic Sciences* 10(58):13-23. https://www.bing.com/ck/a?!&&p=208de7f71bb38f50acac16fe1f14d224b1d97f47c82d52bfea19fdd2485256f0JmltdHM9MTc2OTIxMjgwMA&ptn=3&ver=2&hsh=4&fclid=36eeab8f-b047-6b99-3157-bd90b1026a0c&u=a1aHR0cHM6Ly9yam9hcy5jb20vaXNzdWUtMjAxNi0xMC8&ntb=1
[40]. Umasangaji, A., Patty, J. A., & Rumakamar, A. . 2018. "Kerusakan tanaman pala akibat serangan hama penggerek batang (*Batocera hercules*)." *Agrologia*, 1(2): 163–169. 288747-kerusakan-tanaman-pala-akibat-serangan-h-b9f6211d.pdf
[41]. UPTD Taman Hutan Raya Wan Abdul Rachman. (2017). *Blok Pengelolaan Taman Hutan Raya Wan Abdul Rachman Provinsi Lampung*. Bandar Lampung: Dinas Kehutanan Provinsi Lampung. 73 p.
[42]. Wattimena, A. Y. & Makaruku, M. H. (2022). "Karakteristik budidaya tanaman pala (Myristica fragran Houtt.) pola dusung di Kecamatan Leihitu dan Leihitu Barat Kabupaten Maluku Tengah." *Agrinimal Jurnal Ilmu Ternak Dan Tanaman*, *10*(1), 38–44. https://doi.org/10.30598/ajitt.2022.10.1.38-44
[43]. Widayanti, E., Bintoro, A., & Duryat. (2020). "Struktur dan komposisi vegetasi agroforest pala (*Myristica fragrans)* di Kecamatan

Sumberejo Kabupaten Tanggamus." *Jurnal Silva Tropika*, *4*(1): 229-240. https://online-journal.unja.ac.id/STP/article/view/8588/5852
[44]. Zulkaidhah, Z., Wardah, W., Rukmi, R., Hapid, A., Wahyuni, D., & Hamka, H. (2024). "Fungal pathogen prevalence in *Myristica fragrans* Houtt. (Nutmeg) nurseries: insights from Central Sulawesi, Indonesia." *International Journal of Design and Nature and Ecodynamics*, 19(1): 13–18. https"//doi.org/10.18280/ijdne.190102