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Pest and Disease in the Gayo Coffee Agroforestry System, Central Aceh

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ABSTRACT

The agroforestry system is a land management approach that considers social, economic, and environmental factors. Gayo coffee (*Coffea arabica*) is the primary commodity for the residents of Mude Nosar Village in Central Aceh, where the agroforestry technique is applied. However, pest and disease attacks on coffee plants reduce productivity. Pest and disease identification research has yet to be completed. The purpose of this study was to identify the different types of pests and diseases to determine the attack intensity and control potential in the Gayo coffee agroforestry system. Purposive sampling, vegetation analysis, and pest and disease attack calculation were the methods used. The Forest Pathology Laboratory detected symptoms of the attack by examining the fungus' macroscopic and microscopic structure. The pests discovered included fleas (*Heteropsylla cubana*) and caterpillars (*Hyposidra talaca*). The diseases discovered were anthracnose and leaf rust. The intensity of fleas, anthracnose, and leaf rust attacks was less than 30% each. Using coffee skin waste, livestock manure, and natural enemies, may control pests and conditions in the Gayo coffee agroforestry system while also implementing organic agroforestry management. Natural enemies include *Trichoderma harzianum*, weaver ants (*Oecophylla smaragdina*), and spiders (Araneae) are suggested.

Keywords: agroforestry, Central Aceh, disease, Gayo coffee, pest

INTRODUCTION

The agroforestry system is a land management system that integrates forestry, agricultural, fisheries, and livestock plants into a single land unit while considering environmental, economic, and social factors (Fahruni 2017). Agroforestry is critical to biodiversity conservation efforts because it combines plant species with numerous semi-natural local and foreign species (Atangana *et al*. 2014; Hartoyo *et al*. 2021).

Local communities in Mude Nosar Village, Bintang District, Central Aceh Regency, Aceh Province, have long practiced agroforestry, with Gayo coffee as the principal product. Gayo coffee was made using Arabica coffee (*Coffea arabica*), typically grown in the shadow of lamtoro (*Leucaena leucocephala*) trees. The production in the village has declined in recent years owing to insect and disease attacks. The database on vegetation diversity in the Gayo coffee agroforestry system is still quite low; furthermore, no pests or diseases have been identified, nor have any viable management measures been implemented. Based on this background, the goals of this study were to identify the types of pests and diseases in Mude Nosar Village's Gayo coffee agroforestry system, examine the intensity of their attacks, and assess the possibility for integrated pest control.

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METHODS

Time and Location

The study was carried out in August−September 2021 at the Gayo coffee agroforestry system in Mude Nosar Village, Central Aceh Regency. Pest and disease identification took place in November and December 2021 at the Forest Pathology Laboratory, Department of Silviculture, Faculty of Forestry and Environment, IPB University.

Tools and Materials

Stationery, binoculars, thermohygrometer, GPS (Global Positioning System), paper and sticky tape, Microsoft Excel and Word, tweezers, cork borer, spatula, jar bottle, Erlenmeyer flask, pan, stirrer, knife, test tube, cotton, aluminum foil, petri dish, plastic wrap, spirit lamp, tweezers, tray, slide glass and lid, and filial bottle were used in this study. The following ingredients were used: potato dextrose agar (PDA), chloramphenicol, sterile water, filter paper, 70% alcohol, label paper, and glycerol.

Study on Biophysical Aspect

Temperature, humidity, sunshine duration, and exposure time were all collected as biophysical data. The data were collected from four stations (Malikussaleh Station, Maimun Saleh, Sultan Iskandar Muda, and Cut Nyak Dien Nagan Raya).

Collecting Pest and Disease Data

To collect pest and disease data, 20 m × 20 m sample plots were created. Purposive sampling was used to construct the sample plot. Pest and disease observations were conducted in agroforestry system plots, with a primary focus on shade trees such as lamtoro (*L. leucocephala*) and avocado (*Persea americana*), as well as the principal commodity, Gayo coffee plants.

Disease identification involves several steps, including isolation of diseased plant parts, purification, rejuvenation, and transfer to the identification stage. Isolation involves extracting pieces of the infected plant and disinfecting them with alcohol and sterile water. Furthermore, purification was accomplished by transferring the mycelium mold to a fresh cup containing PDA. Identification began once the isolate's results have been thoroughly purified; the isolate was then printed and preserved on a glass slide. All these operations, including isolation, purification, and preparation testing, were carried out under sterile settings. Identification was performed once the hyphae has grown on the glass slide.

Analysis of Pest and Disease Intensity

Pest observation was carried out with binoculars using symptoms and indicators from 15 observation plots. In addition, the interview method was used to reinforce the data collected. Field samples were collected and observed in the laboratory. Data analysis to observe disease attacks was calculated based on the proportion of attacks (*P*) and attack intensity (*IS*) using the following formula.

a. Percentage of attacks (*P*)

$$P=\frac{\sum \text{Number of infected plants in a sample plot}}{\sum \text{Total number of oberserbed plants}}\times 100\%$$

b. Attack Intensity (*IS*)

$$IS=\frac{\sum \text{Number of infected plants}}{\sum \text{Number of observed plants}}\times 100\%$$

The scale and level of damage used to calculate the intensity of pest and disease attacks are classified as shown in Table 1.

RESULTS AND DISCUSSION

Biophysical Aspect

Biophysical data were obtained from observations and literature. Observational data consisted of temperature and humidity measurements, while literature data consisted of rainfall intensity and exposure time. Data were collected in the field in the center of the plot using a thermohygrometer (Table 2). Rainfall intensity, exposure time, humidity, and temperature (maximum and minimum) were obtained from local BMKG data (Table 3). BMKG data was obtained from 4 stations (Malikussaleh, Maimun Saleh, Sultan Iskandar, and Cut Nyak Dien Nagan Raya) to complement field observations.

Identified Pests and Diseases

Pests and diseases, including leafhopper pests (*Heteropsylla cubana* Crawford) and anthracnose disease, affected lamtoro plants. Pests found included the inchworm caterpillar (*Hyposidra talaca*), as well as anthracnose and leaf rust diseases. Meanwhile, avocado plants were infected with anthracnose on the foliage and fruit rot caused by *Botryodiplodia ribis*. Anthracnose affects three plants: lamtoro, coffee plants, and avocados. This disease is caused by the fungus *Collectotrichum* sp., which can affect any portion of the plant. In addition, leaf rust affects coffee and avocado plants. This disease is caused by the fungus *Hemileia vastatrix*. According to Nuraeni (2015), leaf hopper pests are the most serious threat to lamtoro trees because they target the stems, leaf buds, shoots, and young leaves, inhibiting their growth. Meiln *et al*. (2017) found that the primary pests of coffee plants are fruit borer beetles (*Hypothenemus hampei*), branch borer beetles (*Xylosandrus* spp), green aphids

Table 1 Classification of the level of damage caused by pests and diseases (Asmaliyah *et al*. 2016)

Damage level	Visible signs of damage intensity (%)	Value
Healthy	0	0
Light	$0 < x \leq 20$	1
Somewhat severe	$20 < x \leq 50$	2
Severe	$50 < x \leq 90$	3
Very severe	$x \geq 90$	4

Table 2 Field data from Mude Nosar Village, Central Aceh

Plot	Temperature (ºC)	Humidity (%)
1	26	67
2	25.5	67
3	26.9	82
4	26	67
5	24.1	74
6	23.8	78
7	27.5	57
8	28.8	68
9	25.9	74
10	27.5	65
11	26.1	77
12	26	67
13	29.8	68
14	32.5	52
15	31.4	56

Table 3 Biophysical parameters of the study area based on BMKG data

BMKG Station	Min temperature (℃)	Max temperature (℃)	Humidity (%)	Rainfall	Sunshine duration
		August			
Malikussaleh	23.5	31.2	84.2	5.3	6.2
Maimun Saleh	24	30	80	6.4	4.2
Sultan Iskandar Muda	23.9	32.5	77	10.6	4.4
Cut Nyak Dien Nagan Raya	22.6	31.1	89.9	18.9	3.7
		September			
Malikussaleh	23.5	31.2	84.6	1.5	5.8
Maimun Saleh	24	31	79.5	8.9	4.2
Sultan Iskandar Muda	23.4	32.8	78.7	12.5	4.5
Cut Nyak Dien Nagan Raya	22.5	31.8	87.8	4.9	5.2
		October			
Malikussaleh	23.4	30.9	85.1	6.7	6.2
Maimun Saleh	24.6	30.9	80.7	5	5.5
Sultan Iskandar Muda	24	32.5	79.4	17.8	4.3
Cut Nyak Dien Nagan Raya	22.7	31.8	89	10.4	5.5

(*Coccus viridis*), mealybugs (*Ferrisia virgate*), caterpillars (*Zeuzera coffeae*), and root pests such as nematodes (*Pratylenchus coffeae*). Putri and Sodik (2019) mentioned that diseases in Arabica coffee include leaf rust, leaf spots, anthracnose, and upas fungus.

Pests in The Gayo Coffee Agroforestry System

Pests in the Gayo coffee agroforestry system include leafhopper pests on lamtoro and caterpillars on the leaves. Field observations revealed that leafhoppers were yellowish on fresh leaf stems and bare trees (Figure 1). Rahadi (2019) noted that bugs that suck plant shoots cause lamtoro shoots to wilt, shrivel, become stunted, and fail to develop. Another insect discovered was the inchworm, which produced uneven holes in the leaves (Figure 2). The inchworm attacks every part of the leaf. This attack begins when the inchworm hatches from egg to prepupa, causing holes in the coffee leaves until only the veins remain (Hidayah *et al*. 2017).

Diseases in the Gayo Coffee Agroforestry System

The diseases discovered were leaf rust by *H fastatrix*, anthracnose by *Colletotrichum* sp. on all types of Gayo coffee agroforestry stands (Gayo coffee, lamtoro, and avocado), and fruit rot disease on avocado fruit (*Persea americana*) (Figure 3). The attack discovered in the coffee agroforestry system was the presence of yellow-brown patches on the upper and lower leaf surfaces. The upper surface symptoms were yellow-brown in the middle, whereas the lower surface had yellowish-white flour in the center of the orange spots. Different coffee plants had a yellow-brown tint that stretched from the leaf edge to the leaf veins in an irregular pattern. Anthracnose was

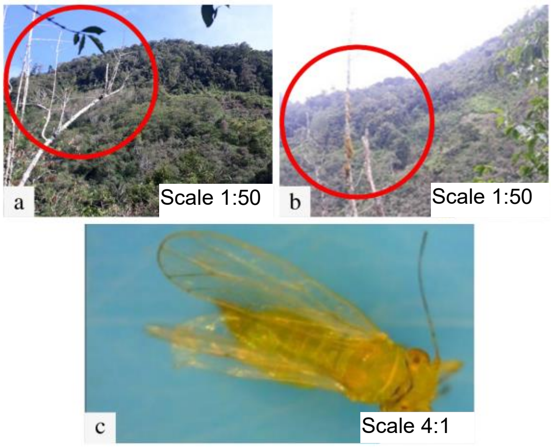

Figure 1 Symptoms and signs of leafhopper attack in the field: a) and b) symptoms of leafhopper infestation, c) leafhopper (*Heteropsylla cubana*) (Nuraeni 2015).

Figure 2 Symptoms and signs of inchworm (*Hyposidra talaca* Wlk) infestation on Gayo Coffee leaves, causing irregular holes in the leaf surface.

identified in all three types of stands: Gayo coffee, lamtoro, and avocado. Figure 4 depicts the discovery of dead Lamtoro trees in one population.

Other symptoms can be detected in lamtoro and coffee plants that are planted close together (Figure 5). Three lamtoro trees were discovered dead. The condition of the three lamtoro trees had deteriorated from trunk to roots. The remaining lamtoro trees' main trunks and branches were drying out, and the roots of the three lamtoro trees had begun to rot. Falling leaves and dry branches were among the symptoms observed in Gayo coffee plants. The distance between damaged plants can influence the disease's spread. Windy conditions, such in Mude Nosar Village, allow fungal spores to spread quickly and easily, infecting adjacent plants.

The isolation results revealed that the mycelium of the fungus in both lamtoro and Gayo coffee had the same features (Figure 5), namely growing with a somewhat rough texture, white on the edge, and blackish in the middle (clearly visible at the bottom of the cup). The microscopic identification revealed chlamydospores and conidiophores. Chlamydospores are modified asexual spores with thickened hyphal walls, dark in color, with strong cell walls. The conidia discovered were cylindrical, straight, and hyaline. According to Watanabe (2002), these traits are the fungus *Colletotrichum* sp. *Colletotrichum* sp. attacks can spread if not addressed with treatments, such as reducing the intensity of the shade offered (Irawan *et al*. 2015). According to Junaidi *et al*. (2018), anthracnose attacks can be generated by an imbalanced plant composition due to the tendency to employ certain clones that have the potential to be broken by new races of leaf fall disease pathogens, causing disease attacks to proliferate on a large scale. Avocado fruit rot disease was discovered in the observation plot, with symptoms including brown to blackish fruit surfaces, rough surface textures, and black spots on hard, spherical fruit flesh (Figure 6).

Disease identification was carried out macroscopically on a plate and microscopically using

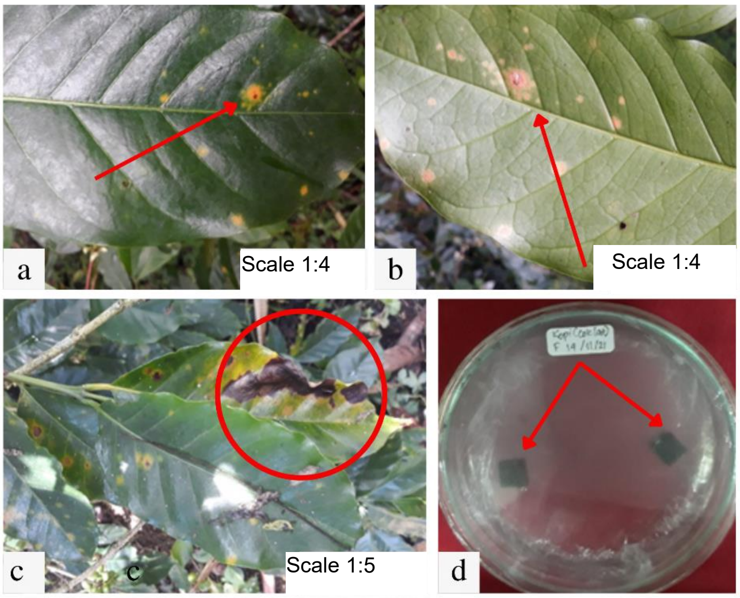

Figure 3 Gayo coffee leaf rust attack: a) initial symptoms on the upper surface of coffee leaves, b) initial symptoms on the lower surface of coffee leaves, c) advanced symptoms of spots that widen to brown, d) isolation of coffee leaf.

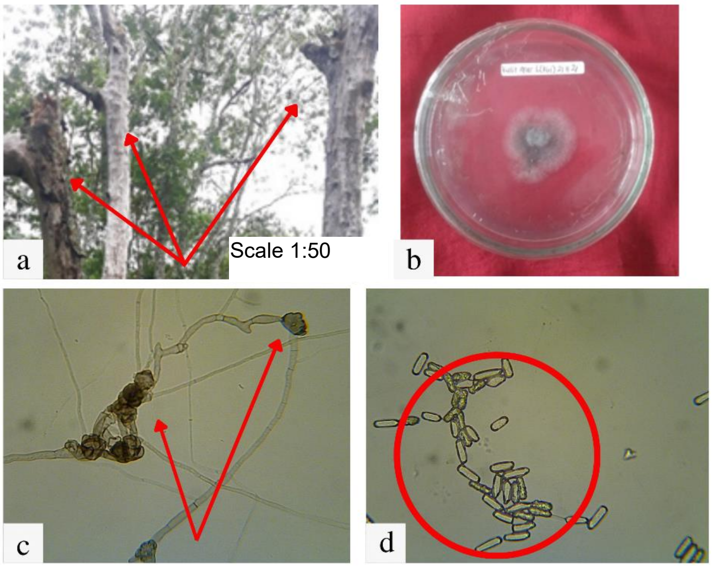

Figure 3 Causes of antharacnose in lamtoro: a) dead lamtoro trees in 1 population, b) isolation of lamtoro roots, c) chalamydosdopores of *Colletotrichum* sp., d) conidia (spores) of *Colletotrichum* sp.

riddle preparation. Macroscopic examination on a plate revealed mycelium that is evenly dispersed and grows rapidly. *Botryodiplodia* sp. has thin mycelium growth, which is evenly spread lengthwise and white in color, has hyaline, simple, and aggregated conidiophores. When mature, conidia are solitary, elliptical, or cylindrical in shape and have two cells. According to Barnett and Hunter (1998), *Botryodiplodia* sp. are either parasitic or saprophytic and can affect agricultural and forestry plants.

Intensity of Pest and Disease Attacks

Pest and disease attacks were calculated based on the area and severity of attack on the observation plots. The calculated included leafhopper pests on lamtoro, leaf rust, and anthracnose. Leafhopper pest infestations were discovered in numerous research plots. This is seen by the area of attack (Figure 7). The findings reveal the expansion of pest attacks, which could affect the growth of lamtoro. Leafhopper (*Heteropsylla cubana*) infestations of lamtoro were

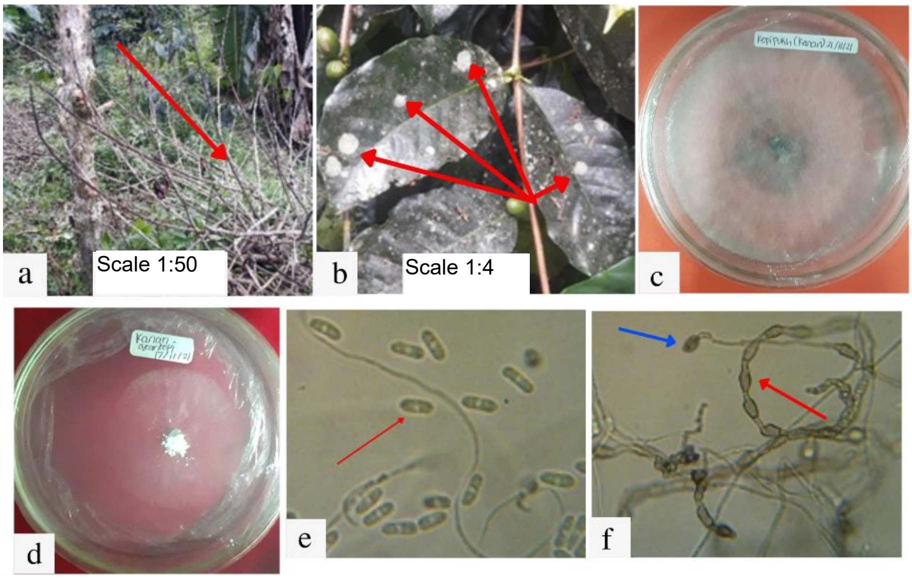

Figure 4 Causes of anthracnose in Gayo coffee plants: a) dead Gayo coffee plants, b) initial symptoms on coffee leaves, c) isolation of coffee root symptoms, d) isolation of coffee leaf symptoms, e) conidia of *Colletotrichum* sp., f) chlamydospores (red arrows) and appressoria (blue arrows) of *Colletotrichum* sp.

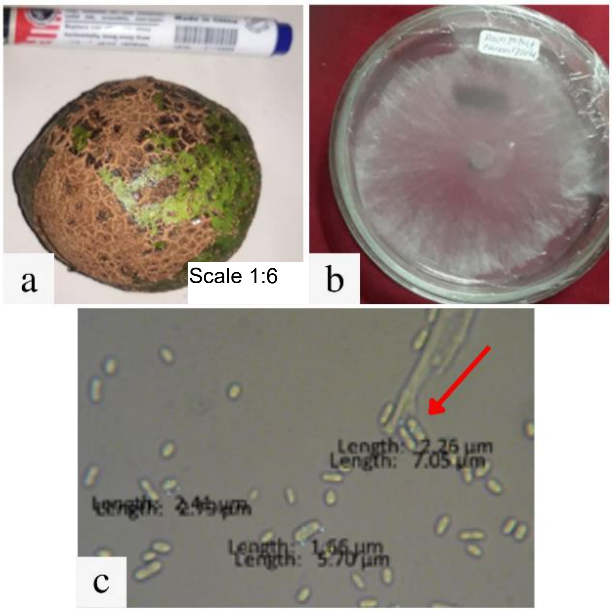

Figure 5 Avocado fruit disease attack: a) field symptoms on avocado fruit, b) repeated isolation 1, c) repeated isolation 2.

found in plots 1, 7, 8, 9, 11, and 12. Plot 1 had the highest damaged area at 57%, followed by plots 8 and 9 at 50%, plots 7 and 12 at 43%, and plot 11 at 25%. Plot 1 also had a higher percentage of afflicted trees, with four out of seven trees affected. These findings indicate that leafhopper attacks were widespread and had the ability to impede the growth of lamtoro plants.

Leafhopper attacks necessitate intensity calculations to determine the severity of the infestation (Figure 8). The attack intensity on lamtoro revealed the highest value in plot 1 (21%). Plots 7 and 12 showed similar intensities of 14%, while plots 8 and 9 had 12%. The lowest intensity was seen in plot 11, with 6%. According to the graph, numerous lamtoro trees failed to grow due to leafhopper attacks on their shoots. This can prevent the lamtoro, which acts as a shade for Gayo coffee plants, from doing its purpose properly. The findings of observations at Mude Nosar Village, revealed that the shade factor influences temperature, humidity, and rainfall. Pruning can raise the temperature or lower it by providing shade. According to Nuraeni (2015), leafhoppers produce secretions that

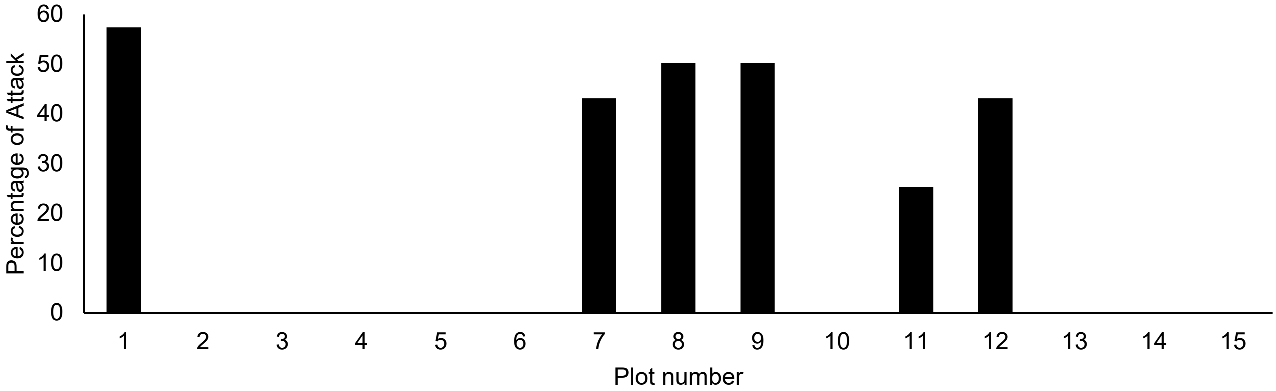

Figure 6 The extent of the attack of leafhopper pests on (*L. leucocephala*). Differences in the percentage of pest attacks are likely influenced by differences in rainfall intensity across the observation plots (Rauf *et al*. 2017).

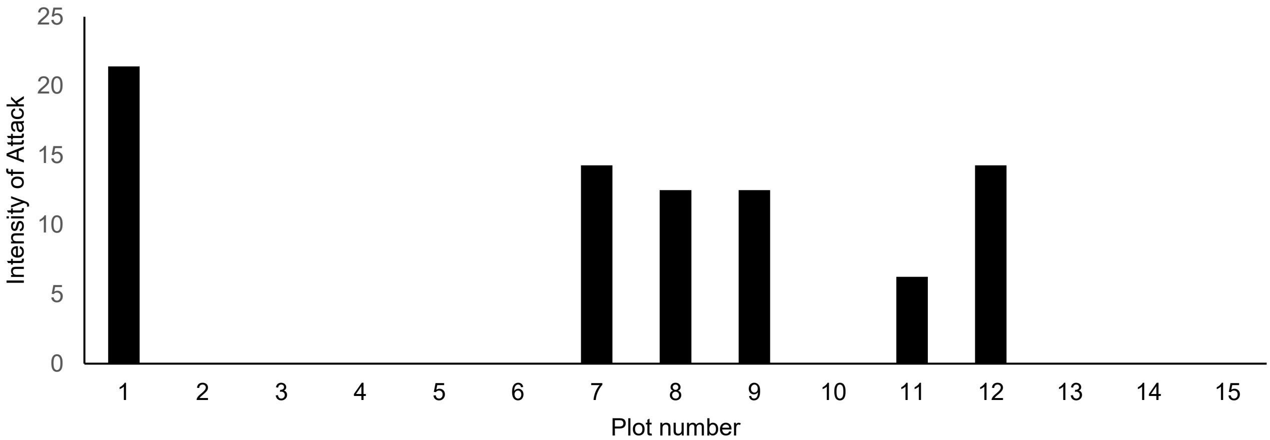

Figure 7 Pest attack intensity of leafhopper (*Heteropsylla cubana*) on lamtoro (*Leucaena leucocephala*). Differences in the percentage of pest attacks are likely influenced by differences in rainfall intensity across the observation plots (Rauf *et al*. 2017).

promote the formation of sooty mold, preventing light from reaching the leaf surface and limiting photosynthesis and plant production. Repeated attacks result in wilting, defoliation, branch dieback, or death of the host tree.

Furthermore, diseases in coffee plants are distributed across large areas. This is evident from the plots taken, which included 15 plots with two diseases attacking them: leaf rust and anthracnose caused by *Colletotrichum* sp. Figure 9 depicts the relatively low distribution of attacks in Mude Nosar Village.

The percentage of leaf rust caused by *H. vastatrix* was highest in plot 11 (78%), while other plots had less than 40%. This high incidence of infection was consistent with the prevalence of leaf fall disease, which reached 56% in plot 11. The plot 11 was particularly dense since it was shaded by boundary trees like jackfruit and avocado that grew beyond the plot along the main road. Meanwhile, plots 1, 3, 4, 5, 6, 7, 9, 12, 14, and 15 demonstrated reduced infection rates ranging from 10 to 30%. Anthracnose attacks can be produced by a variety of reasons, including the existence of disease sources, vulnerable hosts, and an environment conducive to pathogen development (Azizly *et al*. 2020). According to Irawan *et al*. (2015), the shadow factor can contribute to the spread of disease attacks, hence reducing shade is required to prevent the spreading. Furthermore, the area of leaf rust attacks has a higher value than anthracnose. This indicates that the leaf rust disease is spreading at a higher rate. Disease intensity is proportional to the severity of the disease attacking the plant (Zeni *et al*. 2021). The intensity of anthracnose must be assessed to determine the extent of damage caused by leaf rust and anthracnose on Gayo coffee (Figure 10).

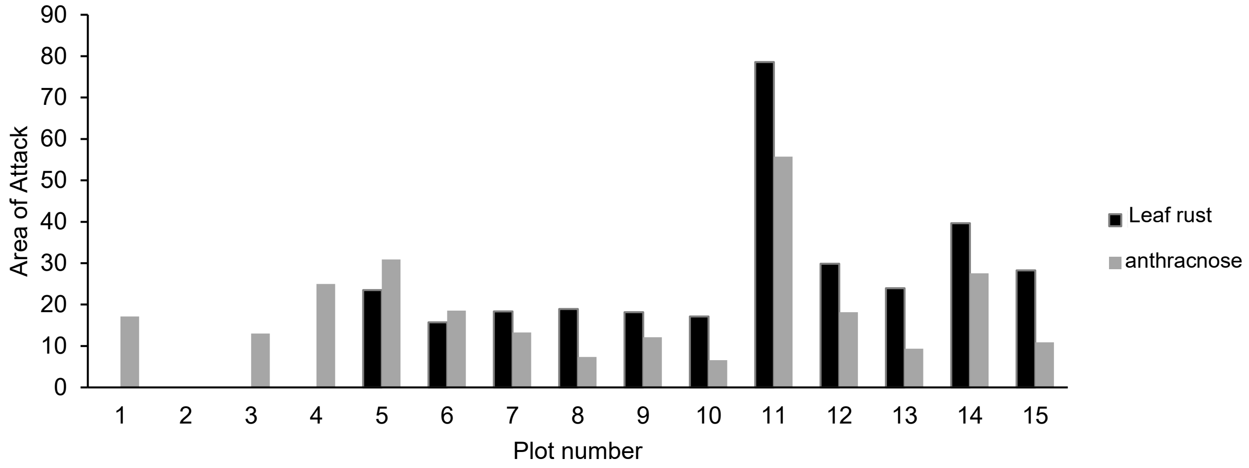

Figure 8 The extent of disease attacks on Gayo coffee plants, which are influenced by the presence of pathogen sources, susceptible hosts and favorable environmental conditions (Azizly *et al*. 2020).

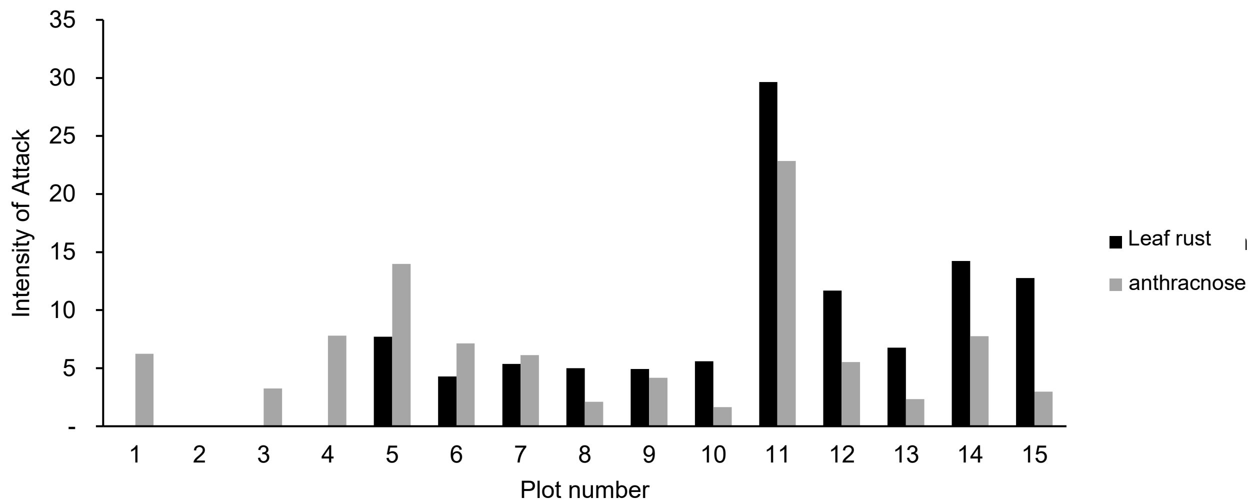

Figure 9 The attack intensity (IS) of Gayo Coffee plant diseases, which are influenced by the presence of pathogen sources, susceptible hosts and favorable environmental conditions (Azizly *et al*. 2020).

There was a correlation with the severity of disease attacks, with the highest recorded in plot 11. The severity of leaf fall disease reached 22%, while leaf rust disease reached 29%. In other plots, both diseases had severity levels less than 15%. Plot 2 had no signs of leaf fall or leaf rust disease. According to the findings of interviews with garden owners, the planting age of plot 2 was still very young, namely within the last two years of planting, therefore there is no percentage of plot 2. Plant age can have an impact on disease attacks as well. Supriatna *et al*. (2017) found that the percentage of attacks and level of damage increased as the age of the stand increased.

Potential for Integrated Pest and Disease Control

Biological control of pests and diseases is also an option. This strategy employs pest-control species such as predators, parasitoids, diseases, and antagonistic agents. According to Mulyani and Heviyanti (2017), parasitoids are insects that parasitize other insects or arthropods; predators are animals or insects that prey on other insects; and pathogens are groupings of bacteria or microbes that cause insects to become ill and eventually die. According to Surata (2008), biological agents are microorganisms that interfere with or limit the growth of diseases that cause plant disease. The finding of biological agents, specifically *Trichoderma* sp., while isolating dead lamtoro roots and coffee roots may be one approach for integrated pest and disease control using biological means. This condition is extremely advantageous to farmers since Trichoderma can prevent pest and disease infestations. Figure 11 displays the identification for *Trichoderma* sp.

Aini *et al*. (2013) found that *T. harzainum* and *T. kongii* effectively prevent *Colletotrichum* sp. attack by 83%. According to Herliyana *et al*. (2011), *Trichoderma* sp. can suppress Ganoderma attack on sengon plants. The disease isolation yielded *Trichoderma* sp. in the Gayo coffee agroforestry system in Mude Nosar Village, indicating that the area has natural biological control agents in its soil. Harmaningrum (2015) stated that *Trichoderma* sp. can produce cellulase, which can break the cell walls of pathogenic fungi, coil and penetrate pathogenic hyphae, and produce antibiotics that are harmful to antagonistic pathogens. Other natural enemies observed in the research plot include weaver ants (*Oecophylla smaradigna*) and spiders (Figure 12), that may act as pathogen predators on coffee plants. Weaver ants discovered in the observation plot serve as a vital function in biological control and can act as pollinators and help to preserve ecosystem equilibrium. According to Aprizal (2019), these ants can serve as predators for a variety of pests, including green ladybugs, leaf caterpillars, fruit pests, mites, and leafhoppers.

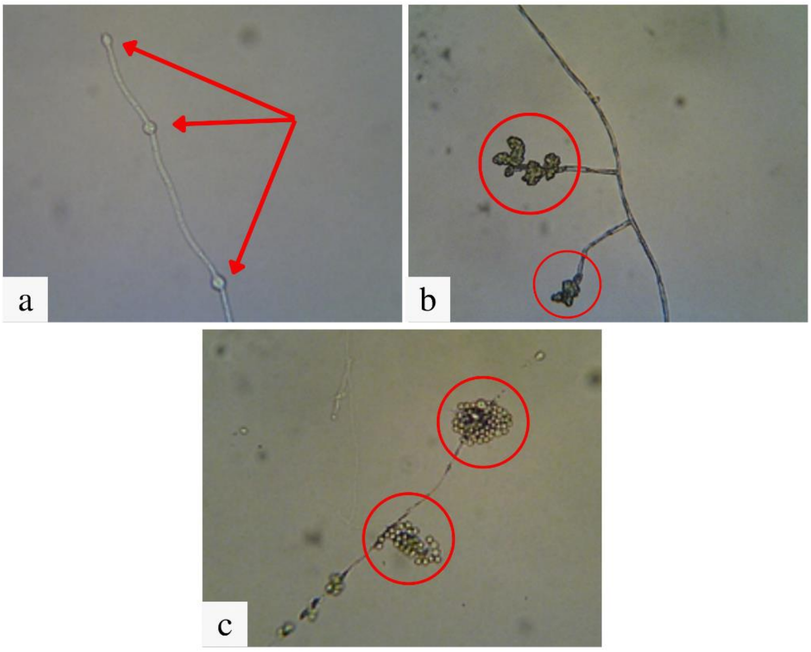

Figure 10 Microscopic identification produced *Trichoderma* sp.: a) chlamydospores in lamtoro, b) conidiophores and conidia in lamtoro, c) spores or conidia.

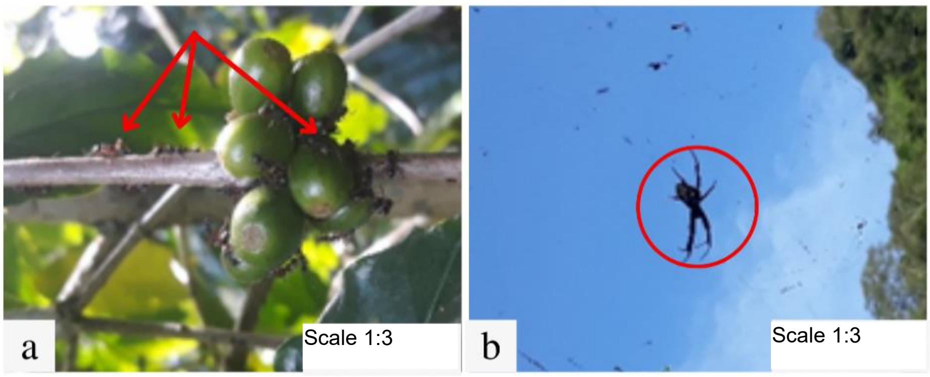

Figure 11 Weaver ants (*Oecophylla smaradigna*) and spiders in the Gayo coffee agroforestry system.

CONCLUSION

Pests and diseases discovered in the Gayo coffee agroforestry system include leafhopper on lamtoro (*L. leucocephala*), caterpillar on Gayo coffee, anthracnose caused by *Colletotrichum* sp. on Gayo coffee and lamtoro leaves, and leaf rust. The intensity of leaf rust attacks was 29% higher than that of leafhopper pest attacks and Gayo coffee leaf fall disease. The highest disease attack on Gayo coffee was discovered in plot 11, while leafhopper pests were observed in plot 1, which was near to the rice field area. Integrated pest and disease control in the Gayo coffee agroforestry system using organic agroforestry management techniques such as coffee skin waste and livestock manure, as well as natural enemies are suggested. Natural enemies include *T. harzianum*, weaver ants (*Oecophylla smaragdina*), and spiders (Araneae).

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