



Comparison of Intensive and Non-Intensive Cocoa Cultivation on Cocoa Pod Diseases In Nglanggeran Village

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Abstract

Cocoa (*Theobroma cacao* L.) is one of Indonesia's main plantation commodities, but its productivity is hampered by pod diseases such as black pod (*Phytophthora palmivora*) and anthracnose (*Colletotrichum gloeosporioides*). This study, conducted in Nglanggeran Village, aimed to assess the incidence and severity of disease under different cultivation practices, as well as to observe the symptoms caused by the diseases on the pods. Twenty trees were deliberately selected, with 10 trees from intensive cultivation and 10 from non-intensive cultivation. The incidence and severity of disease were measured every 5 days. Incidence was calculated by comparing the number of healthy pods with the number of diseased pods, while intensity was calculated using a scoring system. The data were analyzed to compare the intensity and incidence between cultivation practices. The results showed that the incidence and intensity of anthracnose were higher than those of black pod. Intensive cocoa cultivation can suppress the spread of disease and produce more pods.

Keywords: Anthracnose disease, black pod disease, cocoa cultivation, Nglanggeran

INTRODUCTION

Cacao (*Theobroma cacao* L.) is an important industrial commodity in Indonesia. Indonesia is the third largest cocoa exporter in the world after Nigeria and the Ivory Coast. Cocoa is the main ingredient in chocolate products and contains bioactive compounds and flavonoids that are beneficial to health. However, Indonesia's cacao production has continued to decline from 734,795 tons in 2019 to 632,120 tons in 2023. Low productivity is caused by suboptimal cultivation techniques, old plants, and pest and disease attacks (Keytimu et al., 2023).

Cacao development faces upstream and downstream constraints, especially disease attacks that can reduce yields by 30-40% (Saputro et al., 2020). The main diseases affecting pre-harvest cocoa pods are black pod disease caused by *Phytophthora palmivora* (Keytimu et al., 2023). Another disease that attacks cocoa pods is anthracnose, caused by the pathogen *Colletotrichum gloeosporioides* (Maryani & Daniati, 2019). Cultivation practices greatly affect the spread of cocoa diseases. Poor practices such as poor sanitation, infrequent pruning, and unbalanced fertilization exacerbate black pod, while the implementation of GAP can reduce disease by up to 70% and increase yields by up to 45% (Khairad et al., 2024). Therefore, this study aims to identify the dominant cocoa pod diseases in Nglanggeran, analyze their incidence and severity, and evaluate the effect of intensive versus non-intensive cultivation practices on disease dynamics.

LITERATURE REVIEW

Cacao (*Theobroma cacao* L.) is a perennial plant with high economic value. The most commonly used part of the cacao tree is its beans which are processed into chocolate (Gutiérrez et al., 2025). Cacao has taproots. The branches of the cacao tree consist of two types orthotropic (upright) and plagiotropic (horizontal). The leaves are oval and pink in color, turning dark green

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when mature (Riono, 2020). The pod is an oval pod 15–30 cm with 20–60 beans, (Martono, 2014). Cacao trees grow well in environments with an annual rainfall of 1,800–3,000 mm. The humidity required for cocoa cultivation is 80–90%, and the temperature must be between 24–28 °C (Sutomo et al., 2018).

A decline in cocoa yield can occur due to disease attacks on cocoa pods, such as black pod disease and anthracnose. Black pod disease is one of the main problems in production. This disease attacks both young and ripe pods. Black pod disease is caused by *Phytophthora palmivora*, which starts with the appearance of small spots on the pods. Infected pods shows symptoms of wet rot, characterized by a dark brown color with clear boundaries that spread to cover the entire surface of the pods (Rumahlewang et al., 2022). The fungus *Colletotrichum gloeosporioides* causes anthracnose disease. *Colletotrichum* fungal infection is more common in young pods than in mature pods. Anthracnose, which occurs when young pods are infected, causes wilting with brown spots that develop into concave brown patches (Maryani & Daniati, 2019).

GAP (Good Agriculture Practices) is a guide on how to grow fruit and vegetable crops correctly, using environmentally friendly systems and producing products that are safe for consumption (Nahreni et al., 2020). Farmers who apply Good Agricultural Practices (GAP) guidelines in cocoa cultivation can reduce environmental conditions that support pathogen growth (Olamigoke & Oluwasegun, 2020). The spread of plant diseases is greatly influenced by the environment. Spore germination and spread are accelerated by high temperatures, excessive humidity, and rainfall, which increase infection 30–50% (Nazarov et al., 2020). Studies show that the application of GAP, such as regularly cleaning the garden, pruning infected branches, using fertilizers and pesticides as recommended, and replacing damaged plants, tends to produce healthier and more disease-resistant plants. This increases plant resistance to disease by strengthening the plant's physiological system (Olutegbe & Sanni, 2021). Farmers who do not implement GAP often experience several obstacles such as low productivity, poor product quality, and relatively lower income (Firdaus et al., 2024).

RESEARCH METHOD

This study was conducted using direct observation methods with a total of 20 samples, with 10 plant samples taken from each cultivation method (Figure 1 and Figure 2). The first plot represented intensive cultivation with maintenance practices including the use of manure and NPK fertilizer, routine pruning, and the use of shade trees for cocoa pods. The second plot was non-intensive, with no proper maintenance this plot was not given any specific fertilizer and no pest or disease control was carried out. Diseased plant samples were collected using a directed random sampling method, with criteria for plants showing symptoms of disease and pathogen damage, where these symptoms were documented using a camera. Disease intensity and incidence observations were conducted at 5-day intervals where every damage caused by disease in cocoa pod was given a certain score according to the scale of damage that occurs. The disease incidence was calculated using a formula:

$$DI = \frac{n}{N} \times 100\%$$

DI = Disease Incidence

n = Number of Pods Attacked

N = Number of Pods Observed

while the disease intensity was calculated using a formula.

$$IS = \frac{\sum(ni+vi)}{V \times Z} \times 100\%$$

- IS = Attack Intensity (%)
 n = Number of plants or plant parts on the v-scale
 V = Scale value of crop damage
 N = Number of observed sample plants or plant parts
 Z = Highest damage scale value.

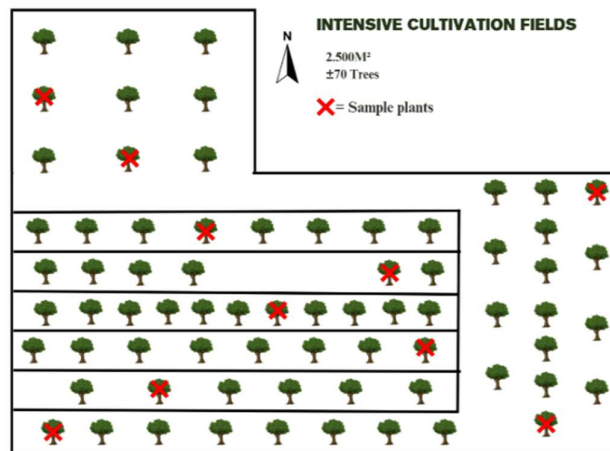


Figure 1. Sampling Pattern On Intensive Cultivation Field

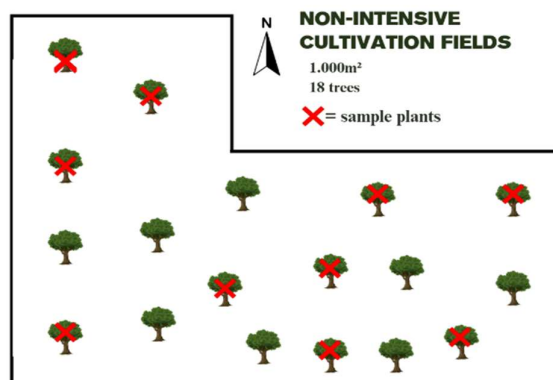


Figure 2. Sampling Pattern On Non-Intensive Cultivation Field

FINDINGS AND DISCUSSION

Cultivation and Land Conditions

Data related to cocoa cultivation was obtained from interviews with farmers to gather information about cultivation practices and the condition of the land used as the research site. The intensive land used for the research was planted with cocoa clones Sulawesi. Cocoa cultivation actively began in 2004, so the average age of cocoa trees in Gunung Kidul is around 21 years, with

cocoa beans obtained from the local agricultural office.

The area of intensive cocoa cultivation field is 2500 m² with 70 cocoa trees, while the area of non-intensive fields is 1000 m² with 18 trees. Cocoa plant maintenance on intensive land includes fertilization with organic fertilizer (processed cow and goat manure) twice a year by spreading the fertilizer around the cocoa trees in a circle. Chemical fertilizers are used to stimulate flowering and fruiting when there is a decline in yield. The fertilizers used are NPK mutiara and MKP. Pest control on intensive land is carried out in an integrated manner, where for diseases such as VSD, infected parts of the plant are cut, burned, and then buried, while for pests, natural enemies such as rang-rang ants are used for whiteflies and chemicals such as vectar.

Other treatments include pruning shoots and branches, where intensive farmers perform two types of pruning: light pruning, which is done routinely once a week and every day when it rains to remove water shoots, and heavy pruning, which is done once a month to cut long branches. The purpose of pruning is to standardize or equalize the height of cocoa trees to around 4 meters, thereby facilitating harvesting and maintenance. In addition, pruning is also carried out to reduce humidity in order to prevent the spread of disease, especially black pod. Additional plant maintenance is provided by planting shade trees such as durian and avocado to protect the plants and stabilize the temperature around the land. Land sanitation includes soil cultivation and manual weeding.

Non-intensive cocoa land management is carried out in a simple and irregular manner. Interviews revealed that compost and NPK fertilizer are not applied regularly, but only once a year after land clearing, depending on the availability of fertilizer received by farmers. If farmers do not receive compost and NPK fertilizer, then in that year the cocoa trees will not be fertilized at all. The land is also not cleared intensively, only about 3 to 4 times a year. Pest and disease control does not use pesticides, but relies solely on land clearing as a preventive measure. In addition, shade trees, such as cloves, are planted on non-intensive land. Shade trees reduce extreme temperatures and protect cocoa plants from extreme temperature changes.

Figure 3 shows the condition of a cacao field. In intensively cultivated areas, the soil surface appears clear of fallen leaves and debris. Meanwhile, in non-intensively cultivated areas, the soil surface is covered in leaf litter and debris.



Figure 3. The condition of Cacao Fields, (a) Intensive Cultivation Fields, (b) Non-Intensive Cultivation Fields

Figure 4 show a heatmap of number of pods at the first and second observation period on intensive and non-intensive cultivation. Cacao field with non-intensive cultivation showed fewer pods than gardens with intensive cultivation. In the first and second observation periods, the number of pods in gardens with intensive cultivation tended to be the same. The number of pods in the second observation period appeared to be fewer than in the first period on land with non-intensive cultivation.

The Disease on The Cacao Pod

After observing the symptoms of the disease, two different symptoms were identified in the cocoa plants. Black pod disease attacks young cocoa pods as well as ripe cocoa pods that are ready for harvest. Black pod disease is caused by *Phytophthora palmivora* (Rumahlewang et al.,2022). In the early stages of infection, this disease generally appears as black spots on the top or base of the cocoa pods. Infected pods shows symptoms of wet rot, with the pod turning brown and developing a clear boundary line, as shown in Figure 5 (a-c). The spots are initially brown, then turn black and spread rapidly, eventually covering the entire pod (Sastrahidayat, 2014). The fungus spreads to the beans. When cocoa pod infected with this disease are cut open, the cocoa beans will be seen to be rotten, making them unfit for processing (Supriati & Siregar, 2015).

Anthraxnose is a disease that attacks cocoa and causes sunken brown spots. The cause of this disease is the fungus *Colletotrichum gloeosporioides* (Asare et al., 2021). Infection in cocoa pods causes wilting with brown spots that develop into sunken brown spots (anthracnose) (Figures 3d). The pods then become hard, small, and dry (Figure 5e). Infection in mature pods causes dry, sunken rot (anthracnose) and wilting at the tip (Figure 5f).

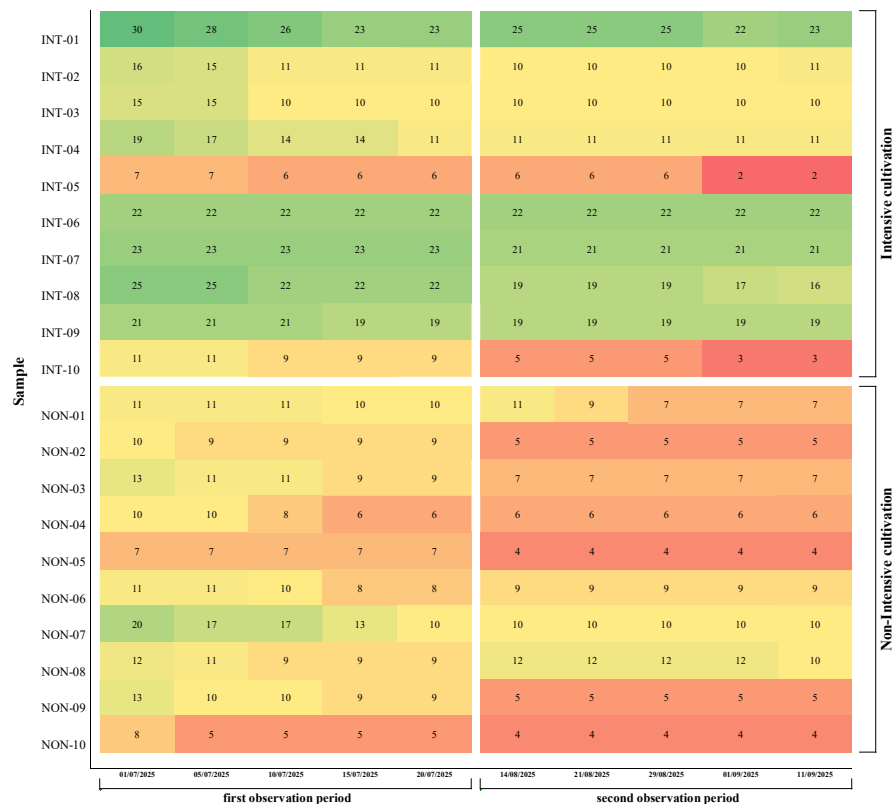


Figure 4. Heatmap of number of pod at the first and second observation period on intensive and non-intensive cultivation.



Figure 5. Symptoms of Black Pods (a-c) and Anthracnose (d-f) disease on cacao. (a) Early infection with dark brown lesions at the base of the pod, (b) Expanding necrotic area covering the pod surface, (c) Black pod that attacks ripe cocoa, (d) Black spots on cocoa beans, (e) The bottom of the pod begins to dry out and shrink, (f) Anthracnose attack on young pod.

Figure 6 illustrates the incidence of Anthracnose disease during the first and second observation periods under intensive and non-intensive cultivation practices. In the first observation period (July 1–20, 2025), the incidence of Anthracnose was generally higher in intensive cultivation compared to non-intensive cultivation. The intensive cultivation showed a sharp increase from around 20% on July 1 to nearly 28% by July 10, after which it remained relatively stable until July 20. In contrast, non-intensive cultivation started at a similar level (~19%), decreased to around 12% on July 5, and then gradually increased, reaching about 16% by July 20. During the second observation period (August 14–September 11, 2025), the trends between the two cultivation systems became more comparable. Intensive cultivation maintained a stable incidence of around 20–22% until September 1, after which it rose slightly to nearly 26% by September 11. Non-intensive cultivation, on the other hand, consistently showed higher incidence during this period, fluctuating between 25% and 27%, before aligning with the intensive cultivation level (~26%) on September 11.

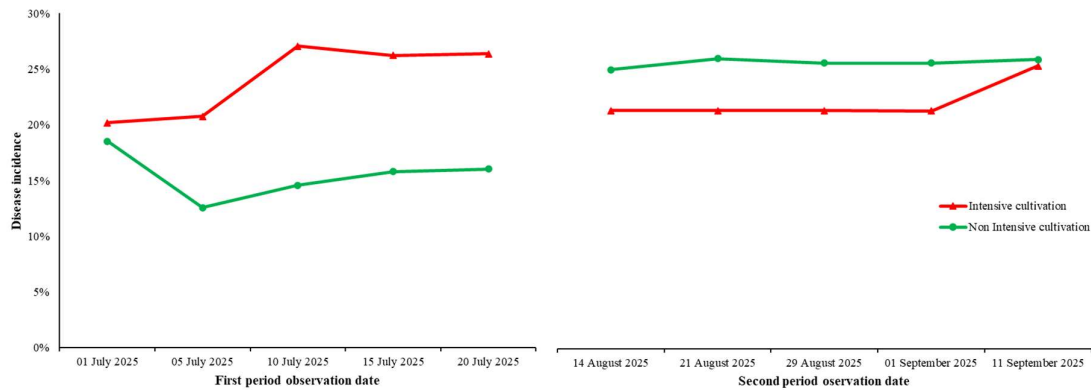


Figure 6. Anthracnose Disease incidence at the first and second observation period on intensive and non-intensive cultivation.

Figure 7 shows the incidence of Black Pods Disease during the first and second observation periods under intensive and non-intensive cultivation practices. In the first observation period (July 1–20, 2025), disease incidence was consistently higher in non-intensive cultivation compared to intensive cultivation. Non-intensive cultivation started at approximately 7% on July 1 and gradually increased to around 10% by July 15–20. In contrast, intensive cultivation maintained a much lower incidence, starting at about 3% and only slightly increasing to around 4% over the same period. During the second observation period (August 14–September 11, 2025), the overall incidence of Black Pods Disease remained relatively stable and low in both cultivation systems. Non-intensive cultivation consistently recorded about 5% incidence throughout this period, while intensive cultivation showed nearly no incidence, with values close to 0–1%.

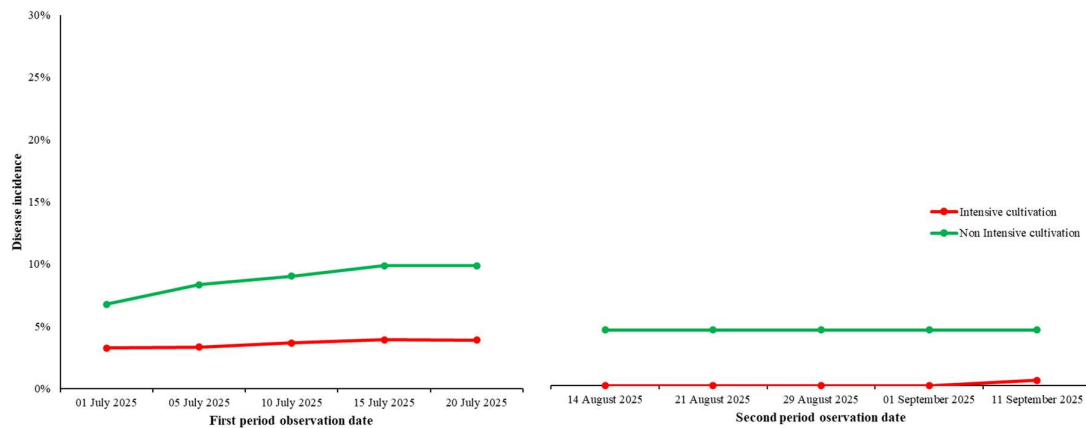


Figure 7. Black Pods Disease incidence at the first and second observation period on intensive and non-intensive cultivation.

Figure 8 presents the severity of anthracnose disease during the first (left panel) and second (right panel) observation periods under intensive and non-intensive cultivation systems. In the first observation period (1–20 July 2025), disease severity in both cultivation systems gradually increased over time. Under intensive cultivation, severity started at around 6% and fluctuated,

reaching approximately 14% by 20 July. In contrast, non-intensive cultivation showed a more gradual increase, starting at about 5% and reaching around 8% by the end of the period. In the second observation period (14 August–11 September 2025), disease severity was consistently higher in non-intensive cultivation. Severity increased from about 8% on 14 August to nearly 16% on 11 September. Meanwhile, intensive cultivation showed a slower progression, starting at around 6% and reaching approximately 13% at the end of the period. Overall, the results indicate that anthracnose severity tended to be higher under intensive cultivation during the first observation period, whereas in the second observation period, non-intensive cultivation showed higher disease severity.

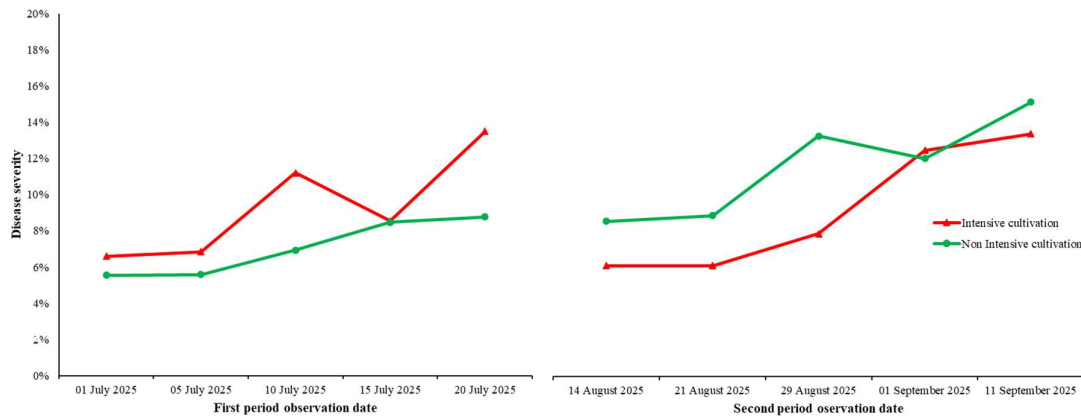


Figure 8. Anthracnose Disease severity at the first and second observation period on intensive and non-intensive cultivation.

Figure 9 illustrates the severity of Black pod disease during the first and second observation periods under intensive and non-intensive cultivation systems. In the first observation period (1–20 July 2025), disease severity under non-intensive cultivation was consistently higher than under intensive cultivation. Non-intensive cultivation started at around 4% and gradually increased to approximately 7% by 15 July, remaining stable thereafter. In contrast, intensive cultivation showed very low severity, starting at about 2% and only reaching around 3% by the end of the period. In the second observation period (14 August–11 September 2025), a similar pattern was observed. Non-intensive cultivation maintained severity levels of 4–5% across the observation dates, whereas intensive cultivation remained extremely low, close to 1% throughout.

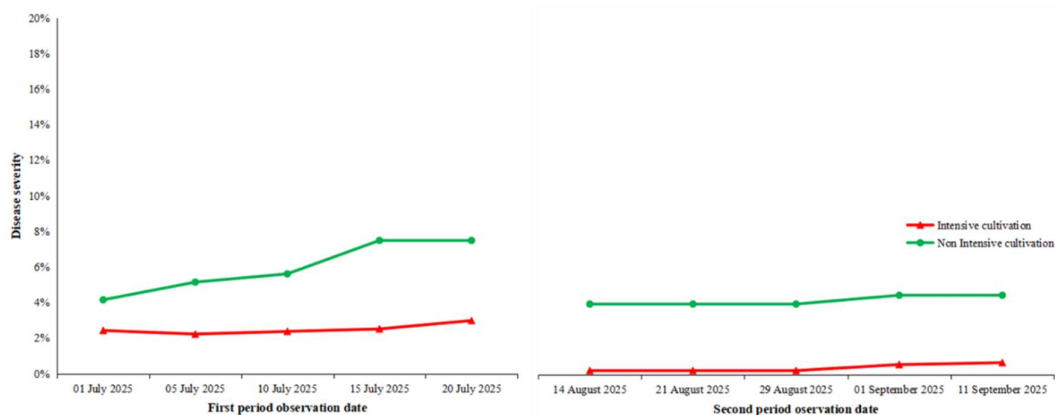


Figure 9. Black Pods Disease severity at the first and second observation period on intensive and non-intensive cultivation.

In general, the incidence of anthracnose and black pod diseases in cocoa was below 30%, with severity levels under 20%, both under intensive and non-intensive cultivation systems. This pattern was consistent across the two observation periods. The incidence and severity of anthracnose tended to be higher than those of black pod under both cultivation systems. Among these two diseases, however, black pod caused damage more rapidly than anthracnose, indicating that its control requires greater priority. The data further suggest that efforts to suppress black pod development were more effective compared to anthracnose control. On the other hand, anthracnose development on cocoa pods appeared to compete with black pod infection, as pod already colonized by anthracnose were less susceptible to subsequent black pod invasion. From the cultivation perspective, intensive practices were more effective in suppressing black pod than non-intensive practices, suggesting that black pod management is closely associated with proper cultivation methods. Conversely, anthracnose development was not markedly influenced by cultivation system.

Although disease development under intensive and non-intensive cultivation systems did not differ substantially, the number of disease-free pods varied. This was attributed to the lower total pod production under non-intensive cultivation compared to intensive cultivation (Figure 4). Consequently, the number of pods remaining free from disease symptoms was also lower in non-intensive systems. To increase the quantity of high-quality cocoa pods, it is therefore necessary to enhance overall pods production. Differences in cocoa yield were strongly influenced directly by cultivation practices and indirectly by disease development on stems, leaves, roots, and pods.

Meanwhile, the relatively similar disease progression between intensive and non-intensive cultivation systems suggests that natural control processes occurring in non-intensive systems can suppress disease development to a level comparable to the integrated management applied under intensive systems. Nevertheless, non-intensive cultivation consistently produced fewer pods. Although natural control is functional, it does not always ensure production levels close to the genetic potential of the cultivated varieties. Thus, integrated disease management remains essential to achieve optimal cocoa production.

Environmental factors such as temperature, humidity, and light intensity greatly influence the development, spread, and infection of *Phytophthora palmivora*. Due to high humidity during the rainy season, rainwater splashes help *P. palmivora* spread from the soil to the aerial tissues of plants. The epidemic of black pod disease is also influenced by other factors, such as the population of *Iridomirmex cordatus* ants, which help spread *P. palmivora* inoculum to plant tissues. *P. palmivora* can attack the base of the trunk, trunk, branches, leaves, and cocoa pod (Wartono & Taufik, 2021). The most severe attacks occur on the pod, which rots. *Phytophthora* is usually heterothallic, meaning that oomycetes have the ability to reproduce sexually and asexually, which allows for morphological diversity in the pathogen. In addition, *phytophthora* usually also has pathogenicity diversity, which affects the severity of different diseases. Black pod disease is usually controlled by maintaining environmental and physical hygiene, namely by picking and discarding diseased pod. Black pod disease has been treated using endophytic fungi as biological agents, biofungicides made from clove oil and lemongrass, synthetic fungicides, and resistant plants (Wartono & Taufik, 2021).

Environmental conditions, especially rainfall, humidity, temperature, and wind, greatly influence the development and spread of *Colletotrichum gloeosporioides*. Long rainy seasons moisten leaves, encouraging spore germination and dispersal through raindrops, which causes outbreaks in several regions in Indonesia. Relative humidity above 96% causes disease, with spore germination rates reaching 95-100%. The ideal infection temperature is 25–28 °C, but extreme conditions below 5 °C or above 40 °C inhibit spore survival. Additionally, after rainfall, wind currents accelerate the spread of conidia, increasing the likelihood of infection in surrounding

plants. These conditions indicate that warm, humid, and rainy environments are highly conducive to the spread of *Colletotrichum gloeosporioides* (Febbiyanti, 2020). *C. gloeosporioides* disease spreads through spores carried by wind or rain. Spores usually spread at night, especially during rain (Syamsafitri et al., 2021). The use of resistant varieties, through cultural, mechanical, and chemical methods, is a way to stop the spread of *Colletotrichum gloeosporioides* in cocoa. Preventive measures, such as keeping the land clean, using high-quality beans, and applying fungicides before an attack, are very helpful in reducing the incidence of disease. Plant-based fungicides are an environmentally friendly and safe method of control that can be used sustainably (Selviani et al., 2021).

CONCLUSIONS

This result of this study show that is that black pod (*Phytophthora palmivora*) and anthracnose (*Colletotrichum gloeosporioides*) are the main diseases affecting Nglanggeran cocoa. Although anthracnose is more frequent and more severe, black pod develops more rapidly. Intensive cultivation suppresses black pod better than non-intensive cultivation, but does not really affect anthracnose. In general, the incidence is <30% and the severity is <20%; the number of pods affects the yield, with intensive cultivation producing healthier pods. To increase cocoa productivity, the implementation of good agricultural practices (GAP) is necessary.

LIMITATION & FURTHER RESEARCH

The limitations of the study are those characteristics of design or methodology that impacted or influenced the interpretation of the findings from your research. Further research should suggest the number of gaps in our knowledge that follow from our findings or to extend and further test of the research.

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