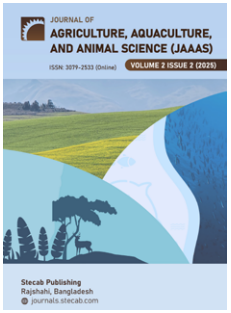

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Research Article

Yield Impact of Panicle Anthracnose Caused by *Colletotrichum gloesporioides* on Mango Gowers in Samal District, Samal Island: A Quantitative Assessment

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About Article

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ABSTRACT

This study evaluated the incidence of mango panicle anthracnose and its impacts on farmers in Samal District, Samal Island. Results show that mango production is largely managed by middle-aged to older farmers, mainly male, with limited formal education and small to medium farm sizes. While this reflects strong farming experience, it also limits the adoption of improved management practices due to lack of technical training. Panicle anthracnose, caused by Colletotrichum gloeosporioides, was identified as a major constraint to mango production. Most respondents observed moderate to severe infection, particularly during the wet season, with 11–50% of trees and panicles affected annually. The disease was found to reduce yield, lower fruit quality, and cause high postharvest rejection rates. Consequently, income losses exceeding 50% were reported by many growers. Farmers rely heavily on fungicide applications during flowering and fruiting, but limited access to extension services and sustainable options reduces effectiveness. Coping measures include frequent fungicide use, adjusted induction schedules, and farmer-to-farmer collaboration. Although interest in resistant varieties was expressed, adoption remains low. The study concludes that anthracnose remains a persistent and economically damaging disease. Strengthening farmer capacity and promoting integrated, sustainable management are essential to safeguard production and income.

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1. INTRODUCTION

In the Philippines, mango is a major fruit crop and is considered one of the country's top export products. In 2022, the country produced about 737,000 metric tons of mangoes (Philippine Statistics Authority [PSA], 2023). But despite the crop's value, diseases like anthracnose continue to reduce productivity and export quality (Bureau of Plant Industry [BPI], 2021). The Department of Agriculture has identified mango anthracnose as a serious concern for mango growers and exporters.

Samal Island, located in Davao del Norte, is well known for its sweet Carabao mangoes. Mango farming plays an important role in the island's economy, especially for small farmers who rely on seasonal mango harvests. However, local farmers have reported poor flowering and fruiting in recent years. The City Agriculture Office of Samal (2022) noted that panicle anthracnose is one of the main causes of flower drop and low yields during the mango season.

Some farmers in Samal have experienced yield losses of up to 50% in orchards heavily affected by the disease (Reyes *et al.*, 2023). These losses impact household income, market supply, and overall farm sustainability. From the time when anthracnose problems during the flowering stage are often not recorded in aspect, there is little quantitative data offered to guide proper organization strategies (Gonzales *et al.*, 2021; Medina & Tanyag, 2020).

This study aims to ration the actual yield loss caused by panicle anthracnose in mango farms on Samal Island. It will also assess how extensive the disease is and how it affects production. The findings will help grow better control measures and support farmers with practical solutions. It will also provide valued data to guide local and national policies for mango production and plant disease organization.

1.2. Statement of the problem

This study examines the impact of panicle anthracnose on mango production in Samal Island, focusing on farmer livelihoods and management practices. Caused by Colletotrichum gloeosporioides, the disease severely affects flower panicles, reducing fruit set and yield. Despite widespread recognition, little quantitative data exist on its incidence, severity, and socioeconomic effects in the area. The study addresses six key aspects: farmer demographics, disease frequency and severity, yield and income losses, management practices, coping strategies, and perceptions of future risks. Findings aim to guide policymakers, researchers, and local stakeholders in designing targeted, sustainable interventions to strengthen mango production and resilience.

2. LITERATURE REVIEW

2.1. Global importance of mango production

Mango (Mangifera indica L.) is one of the most widely cultivated tropical fruits, vital to global food systems and rural economies. In 2022, worldwide production reached about 58 million metric tons (FAO, 2023), with the industry valued at over USD 60 billion (Diwani, 2024). Demand extends beyond fresh fruit to processed products such as juices, purees, and dried mango. In many tropical regions, smallholder farmers depend on mango for livelihood and income.

2.2. The Philippines

The Philippines ranks among the world's top mango producers, known for the export-quality Carabao variety. From April to June 2023, production was 596,340 metric tons, an 11.4% increase from the previous year (PSA, 2023), with Carabao mangoes accounting for 83% of output. Cultivation spans about 184,000 hectares and contributed PHP 35.52 billion in gross value added in 2020 (Shuck *et al.*, 2023). The industry supports around 2.5 million smallholder farmers. However, persistent challenges pests, fungal diseases, climate variability, and low adoption of improved practices limit productivity. Initiatives such as Good Agricultural Practices (GAP), hot water treatment, and pest management have improved export quality in pilot regions (ACIAR, 2018; Shuck *et al.*, 2023).

2.3. Samal island

Samal Island in Davao del Norte is an emerging hub for Carabao mango production, with about 2,000 hectares under cultivation. Its rich soils, warm climate, and protection from typhoons provide favorable growing conditions (Shuck *et al.*, 2023). Local government initiatives, including the One Town One Product (OTOP) program and a PHP 10-million packing facility, aim to boost export readiness (Edge Davao, 2013). Case studies highlight the benefits of bagging, optimum harvest timing, and hot water treatment, which significantly increased Class A mango yields (Shuck *et al.*, 2023). Yet, issues like anthracnose and limited technical support remain pressing.

2.4. Pathogen causing panicle anthracnose

Panicle anthracnose, caused by fungi in the Colletotrichum gloeosporioides species complex, severely impacts mango yield. Molecular tools such as ITS-PCR and multi-gene sequencing have identified species differences, with implications for fungicide sensitivity and environmental tolerance (Dufour *et al.*, 2023; Kamle & Kumar, 2023).

2.5. Disease management

Effective management combines fungicides with cultural practices. Fungicides such as fluopyram + tebuconazole, mefentrifluconazole–pyraclostrobin, and tebuconazole + trifloxystrobin have shown 60–92% disease control (Vamshika *et al.*, 2021; Wang *et al.*, 2022; IntechOpen, 2023). However, sustainable control requires pruning, sanitation, and spacing to lower humidity and inoculum levels (MedCrave, 2021; Hio *et al.*, 2024). Farmer training and extension programs in the Philippines and elsewhere have proven essential for promoting adoption of integrated disease management practices (Shuck *et al.*, 2023).

2.6. Conceptual framework

This study applies the Input–Process–Output (IPO) model to examine the factors influencing panicle anthracnose and its yield impact in Samal Island mango production. Inputs include farmers' socio-demographics, farm profiles, ecological conditions, disease incidence, and awareness shaped by training programs. The process captures management practices such as fungicide use, pruning, sanitation, and adaptive coping strategies like adjusting harvest or adopting resistant varieties.

Outputs focus on yield per tree, rejected fruits, economic losses, and perceived effectiveness of management strategies.

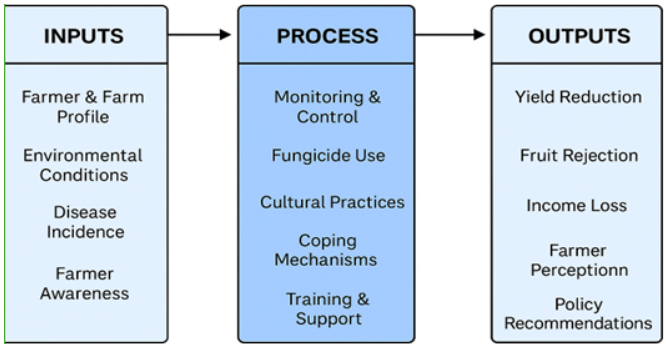

Figure 1. Conceptual framework using the IPO (input–process–output) model for evaluating the influence of panicle anthracnose on mango grower in samal island.

3. METHODOLOGY

This section presents the research methods that are working to attain the study objects. It explained the sources of data, the data gathering tool, and the sample method. Moreover, it discussed the way of the study and the statistical treatment of the met data.

3.1. Research design

This study employs a quantitative research design, specifically using survey questionnaires to collect data (Creswell & Creswell, 2018). This method is well-suited for examining the knowledge, perceptions, and outlooks of mango growers in Samal Island. Compared to purely qualitative approaches, questionnaires allow for systematic measurement while still capturing key insights into participants' challenges and motivations. This is crucial in understanding the lived experiences of mango growers within the local industry. The design also provides flexibility to explore issues encountered at different stages of production. Ultimately, the study seeks to uncover the underlying reasons behind the challenges farmers face, offering a more nuanced understanding of contributing factors.

3.2. Ethical considerations

The investigator strictly adhered to recognized ethical standards and protocols throughout the conduct of the study. All procedures were guided by institutional guidelines, particularly in relation to data handling and respondent confidentiality. Prior to data collection, the survey questionnaire—along with proper citations and supporting documentation—was presented for thorough review and evaluation. The study design was carefully examined to ensure that no harm would come to participants, and that informed consent would be observed. Only after receiving formal approval from the Ethics Committee did the researcher proceed with the distribution of the instrument and continuation of the research process.

3.3. Informed consent

Before data collection, the researcher secured written informed consent from all qualified participants. They were clearly informed about the study's purpose, relevance, and their role in identifying factors affecting farming practices. Explanations were given in simple, understandable terms to ensure full comprehension. Participation was entirely voluntary, and respondents had the right to decline or withdraw at any time without consequence. No pressure or influence was applied. The confidentiality of all responses was strictly maintained, with no identifying information disclosed. The investigator also prioritized members' emotional comfort, concerning their time, limits, and inclination to contribute through the research procedure.

3.4. Vulnerability of research participants

The contributors involved in this study were mango farmers from Samal Island. All respondents were of legal age and mentally accomplished of delivering informed consent, and therefore, were not confidential as part of a vulnerable population. None of the participants were exposed to physical, emotional, or psychological risks during the conduct of the research. The researcher safeguarded that the data collection process was carried out respectfully and at a time convenient to the respondents to avoid any undue burden or stress. Additionally, contribution was entirely voluntary, with the freedom to decline or withdraw at any stage without consequence. The researcher took appropriate measures to protect the privacy and privacy of all information shared by the participants. No identifying details were included in the final report to ensure anonymity. Ethical standards were carefully observed to safeguard the dignity, rights, and well-being of every individual involved in the study.

3.5. Sources of data

The main data sources were the survey questionnaires assumed among the mango growers in Samal Island. Furthermore, the investigator obtained secondary data sources from books, journals, articles and online resources that produce various views, outcomes, and data from the authors to support the study findings.

3.6. Respondents of the study

This study involved 277 small-scale mango farmers from Samal districts, Samal Island, along with key investors in farming, disease organization, and policymaking. Farmers' Associations supported collaboration, knowledge sharing, and resource pooling. Respondents were chosen through stratified random sampling, ensuring comparative representation from each district (Wiley, 2017). The sample size was determined using the Raosoft Sample Size Calculator, based on 417 growers, with a 90% confidence level and 5% margin of error (Raosoft, 2020). This method provided a diverse and representative picture of the farming population, strengthening the validity and dependability of the study's findings.

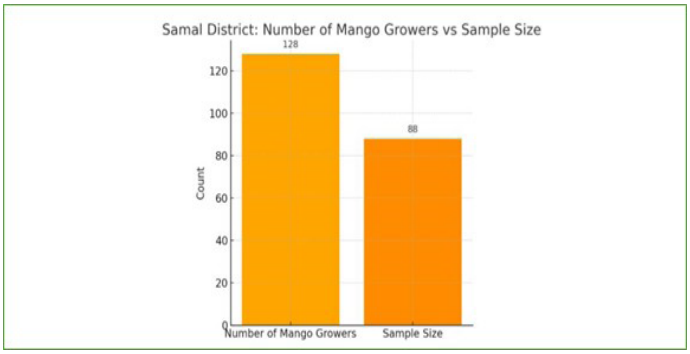

Figure 2. Number of mango farmers and sample size in Samal District.

3.7. Research instrument

This study employed a organized survey questionnaire as the main tool to collect quantitative data from mango growers in Samal Island. The instrument was carefully designed to capture respondents' socio-demographic features, farming practices, consciousness of panicle anthracnose caused by Colletotrichum gloeosporioides, and the disease's economic impact. It consisted of six sections: (1) Demographics and Land Ownership, (2) Panicle Anthracnose Incidence, (3) Yield and Economic Impact, (4) Practices and Awareness, (5) Coping Mechanisms, and (6) Future Outlook. These sections aligned with the study's purposes to provide a complete sympathetic of the disease's effects and guide maintainable organization strategies.

3.8. Data gathering procedure

The researcher followed a series of systematic steps in conducting the study after the research questionnaire had been validated.

3.9. Procedure of the study

Before conducting the study, the researcher obtained an endorsement letter from the Dean, which was used to formally request permission from the Local Chief Executive of DA Samal Island through the City Agriculture Office. After approval, data collection followed approved protocols. A list of beneficiaries was secured to identify respondents, verified with the help of Farmers' Association officers. A researcher-made survey questionnaire, validated by experts including banana growers' leaders, Provincial Agriculture Office staff, researchers, and the advisory committee was used. Permission was sought from association chairpersons, with courtesy visits to explain the study's purpose. Data were gathered through questionnaires and personal interviews.

3.10. Data analysis

After collecting the completed questionnaires, responses were systematically recorded and organized based on each indicator. Descriptive statistical methods, counting frequency and percentage, were applied to interpret the data. These methods helped current the respondents' profiles and review key trends related to the objects of the study.

4. RESULTS AND DISCUSSION

This chapter presents the results and discussion in line with the purposes of the study. Section A delivers an indication of the defendants and farm profile to establish background information. Section B discusses the incidence of panicle anthracnose and its extent of occurrence. Section C highlights the yield and economic impact of the disease on farmers' construction and income. Section D examines organization practices and the level of consciousness among respondents. Section E outlines the coping instruments adopted to address challenges caused by the disease. Finally, Section F explores the future outlook, emphasizing plans for maintainable disease management.

4.1. Respondents and farm profile

This part presents the demographic and farm features of mango growers in Samal District, Samal Island. It highlights defendants' age, gender, educational accomplishment, years of farming experience, and farm size.

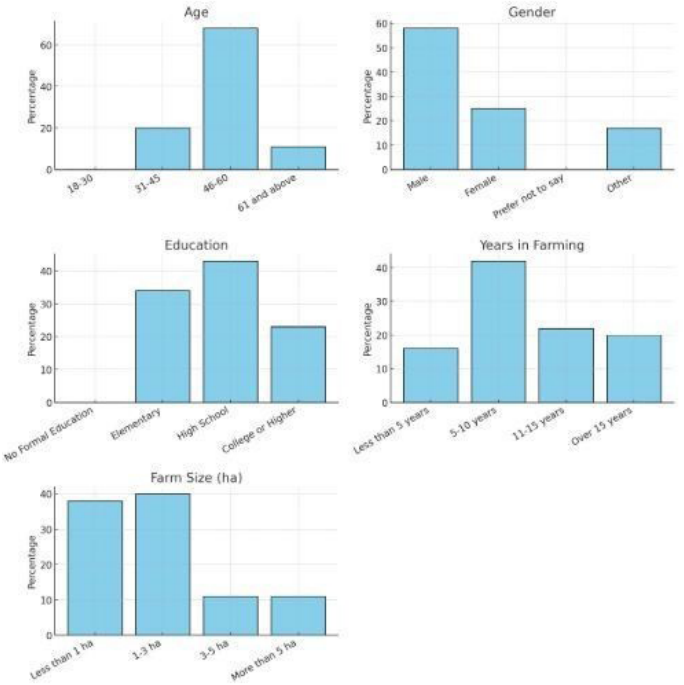

Figure 3. Survey results on the demographic characteristics and farm profiles of mango growers. Responses correspond to the following questions: (Q1) Age group; (Q2) Sex; (Q3) Educational attainment; (Q4) Years of experience in mango farming; and (Q5) Farm size in hectares.

4.2. Age

A majority of respondents (68%) fell within the 46–60 age bracket, while 20% were between 31–45 years old, and only 11% were 61 years and above. These figures reflect a nationwide trend in Philippine agriculture, where farming is increasingly dominated by older generations as younger people often seek employment opportunities outside agriculture. This pattern raises concerns about generational succession and the long-term sustainability of mango production. The limited involvement of younger farmers suggests a gap in innovation and reduced adoption of modern technologies and disease management

practices, which are crucial in addressing persistent problems such as anthracnose and fruit fly infestations. An aging farmer population may therefore pose challenges to productivity growth and resilience in the mango sector.

4.3. Gender

The study additional exposed that mango farming in Samal District is slightly male-dominated, with 58% of respondents being men and 42% women. Men were more likely to be engaged in labor-intensive orchard activities such as pruning, spraying, and harvesting. This aligns with cultural visions of orchard group as physically demanding work usually assigned to men. Nonetheless, women played equally important roles in mango production systems. They were often involved in decision-making, financial management, and post-harvest quality control, mainly in sorting, grading, and marketing of mango fruits. This highlights the complementary nature of male and female contributions and the need to know gender inclusivity in farming development initiatives.

4.4. Educational attainment

Education plays a important role in shaping farmers' awareness, decision-making, and capacity to adopt innovative practices. In Samal District, 43% of accused reported having attained only high school education, while 23% were college graduates or degree holders. The prevalence of growers with limited formal education may make their ability to effectively engage with modern agricultural technologies, Good Agricultural Practices (GAP), and integrated pest management (IPM) strategies. By contrast, growers with higher educational attainment are generally more open to training programs, more knowledgeable about safe pesticide use, and more adaptive to climate-resilient farming practices. The relatively low education levels among many growers thus remain a barrier to progress in disease management and farm productivity.

4.5. Years in mango farming

Farming experience among respondents showed that 42% of mango growers had 5–10 years of experience. This suggests that many are relatively new entrants to mango production, possibly motivated by market opportunities or government support. Farmers in this category may be considered "early intermediates," possessing basic orchard knowledge but lacking advanced expertise in disease forecasting, pest surveillance, and post-harvest handling. While more adaptable than older, highly traditional farmers, they still require support from extension services and peer learning to improve productivity. Farming experience strongly influences decision-making and openness to adopting improved technologies, underscoring the importance of targeted capacity building.

4.6. Farm size

The survey also revealed a diverse distribution of mango farm sizes. Most growers cultivated between 1–3 hectares, while a important portion (38%) achieved orchards larger than 5 hectares. This mix of smallholder and medium-scale systems is characteristic of Philippine agriculture. Smallholders typically rely on mango production as a supplementary income source together with other livelihoods, but their limited landholdings restrict economies of scale. This makes it more hard for them to adopt costly technologies such as drip irrigation, cold storage, or advanced pest and disease control methods. Medium-scale farmers, on the other hand, are better positioned to experiment with new technologies but face challenges in accessing consistent support services and markets.

Overall, the socio-demographic profile of mango growers in Samal District underscores both strengths and susceptibilities. While mango farming remains an significant livelihood for many households, the aging farmer population, limited youth participation, low educational attainment, and limitations of small farm sizes present challenges to the long-term sustainability and transformation of the industry. Critical these issues through beset policies, training, and support facilities is vital to secure the future of mango manufacture in the region.

4.7. Incidence of panicle anthracnose

Panicle anthracnose is a major mycological disease of mango, caused by Colletotrichum species, which meaningfully marks flowering, fruit set, and yield. Its occurrence varies across seasons and orchards, often climaxing during wet conditions. Sympathetic its occurrence provides valuable insights for developing effective, locally adapted organization strategies in mango production systems.

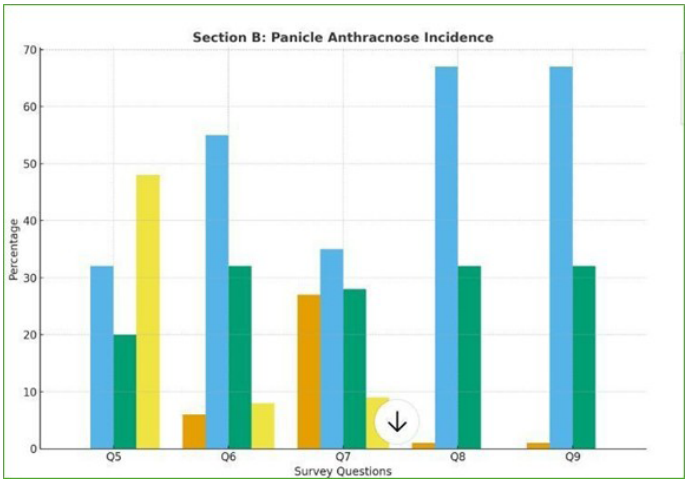

Figure 4. Survey results on the incidence and severity of panicle anthracnose in mango farms. Responses of farmers to the following questions: (Q6) Do you observe panicle anthracnose every cropping season? (Q7) Estimated percentage of your mango trees infected annually? (Q8) Estimated percentage of flower panicles showing anthracnose symptoms per tree? (Q9) When does panicle anthracnose usually occur? (Q10) How severe is anthracnose in your farm during peak season?.

4.8. Panicle anthracnose every cropping season

The study revealed that when asked whether they observed panicle anthracnose every cropping season, 48% of mango farmers in Samal District stated that the disease occurrence depends on environmental conditions. This response highlights farmers' awareness of the strong link between anthracnose incidence and climatic factors such as humidity, rainfall, and

temperature.

Research confirms that panicle anthracnose is highly influenced by weather. High humidity (≥90%), prolonged leaf wetness, and frequent rainfall create favorable conditions for conidial production and dispersal of *Colletotrichum* spp. (Kamle & Kumar, 2023). In the Philippines, incidence peaks during wet months, especially when flowering coincides with rainy periods (Lapitan & Barroga, 2021). Similarly, studies in Mexico and South Asia found that anthracnose severity strongly correlates with seasonal rainfall and canopy microclimate conditions (Martínez Bolaños *et al*., 2022).

4.9. Percentage of your mango trees are infected annually

The survey revealed that most mango farmers in Samal District, Samal Island estimated 11–25% of their mango trees were infected yearly with panicle anthracnose (55% of respondents). Meanwhile, 32% described higher infection levels of 26–50%, indicating that the disease remains a important and recurrent production constraint.

These findings suggest that while most growers information moderate infection levels, a substantial portion face severe disease frequency, which can greatly decrease flowering success, fruit set, and overall yields. Studies have shown that panicle anthracnose can cause up to 60% yield loss under favorable ecological circumstances if unmanaged (Kamle & Kumar, 2023). In Ethiopia, Gebremariam *et al.* (2020) reported disease incidence exceeding 70% during peak seasons, while in Côte d'Ivoire, anthracnose incidence collected between dry and rainy seasons (Ettien *et al*., 2020).

4.10. Percentage of flower panicles showing anthracnose

The survey exposed that 33% of mango growers in Samal District reported that 11–25% of flower panicles per tree showed anthracnose symptoms. This level of infection is physically significant, as it can cause flower blight, abortion, and abridged fruit set even at moderate rates.

Recent local studies settle that *Colletotrichum* species including *C. asianum, C. fructicola*, and *C. theobromicola* are recognized pathogens affecting the Carabao mango diversity in the Philippines (Alvarez *et al*., 2020; Dela Cueva *et al*., 2021). These species affect flowers, leaves, and fruits, foremost to early-stage disease expression. Also, trials at the University of the Philippines Los Baños established that actions using organic acids significantly inhibited *C. gloeosporioides* growth on Carabao mango (Yanos *et al*., 2021). Effective organization during flowering such as timely antifungal application, canopy thinning, and sanitation is therefore critical to prevent panicle-level infection.

4.11. Panicle anthracnose usually occur

The study exposed that 67% of the 88 mango farmers surveyed in Samal District reported panicle anthracnose typically occurs during the wet season. This insight reproduces the strong requirement of the disease on environmental conditions, mainly rainfall and humidity, which fungal spore sprouting and contamination.

Resident studies support this observation. In the Philippines, anthracnose incidence has been shown to peak during months with relative humidity above 90% and recurrent rainfall, conditions that promote the monogenesis and spread of *Colletotrichum* spp. (Lapitan & Barroga, 2021). Similarly, Alvarez *et al.* (2020) complete that *Colletotrichum* asianum and related species causing anthracnose in Carabao mango thrive under high-moisture environments typical of the rainy season. Investigate on fungicide efficacy also stresses that appropriate applications during wet months are crucial to overpowering anthracnose speats in orchards (Yanos *et al*., 2021).

4.12. Anthracnose severity in your farm during peak season

The review further revealed that 67% of the 88 mango farmers in Samal District slow anthracnose severity as mild during the peak season. This discovery commends that while the disease is shared and carefully linked with wet season situations, its severity remains at controllable levels for most growers.

Philippine studies provide similar insights. Lapitan and Barroga (2021) observed that anthracnose incidence increases during the rainy season, but disease severity often varies depending on orchard management practices such as clipping, hygiene, and bagging. Alvarez *et al.* (2020) also reported that *Colletotrichum* asianum contaminations in Carabao mango can remain localized and mild under certain conditions, though they may escalate if conducive weather persists. Also, Yanos *et al.* (2021) emphasized that appropriate preventive events counting fungicide application and alternative treatments like organic acids can help uphold anthracnose severity at low levels, even during peak infection periods.

4.13. Yield and economic impact of the disease on farmers' production and income

Panicle anthracnose expressively reduces mango yield, fruit quality, and marketability, subsequent in substantial economic losses for farmers. Its possessions extend from yield discount and fruit denial to lower trade prices and income disappointment.

The survey of 88 mango growers in samal district, samal Island revealed that average mango yield per tree per season was less than one ton, reflecting productivity challenges common among smallholder systems. This low yield contrasts sharply with the potential of Philippine Carabao mangoes under optimal management and is largely attributed to pest and disease pressures, particularly panicle anthracnose and cecid fly infestation, along with inconsistent adoption of good Agricultural practices.

Yield losses due to anthracnose were significant, with 41% of farmers reporting 11–25% losses, 26% citing 26–50% reductions, and 18% suffering losses exceeding 50%. Only 15% reported minimal losses. These figures align with national studies that document anthracnose-related yield reductions of 20–60%, particularly during wet and humid seasons when disease pressure is highest.

Fruit rejection rates also reflected the disease's burden: 42% of farmers reported 11–25% rejection, while 24% experienced 26–50% rejection of harvested fruits. Anthracnose reduces fruit set at flowering and later undermines marketability through blemishes and decay, severely limiting access to export markets with strict quality standards.

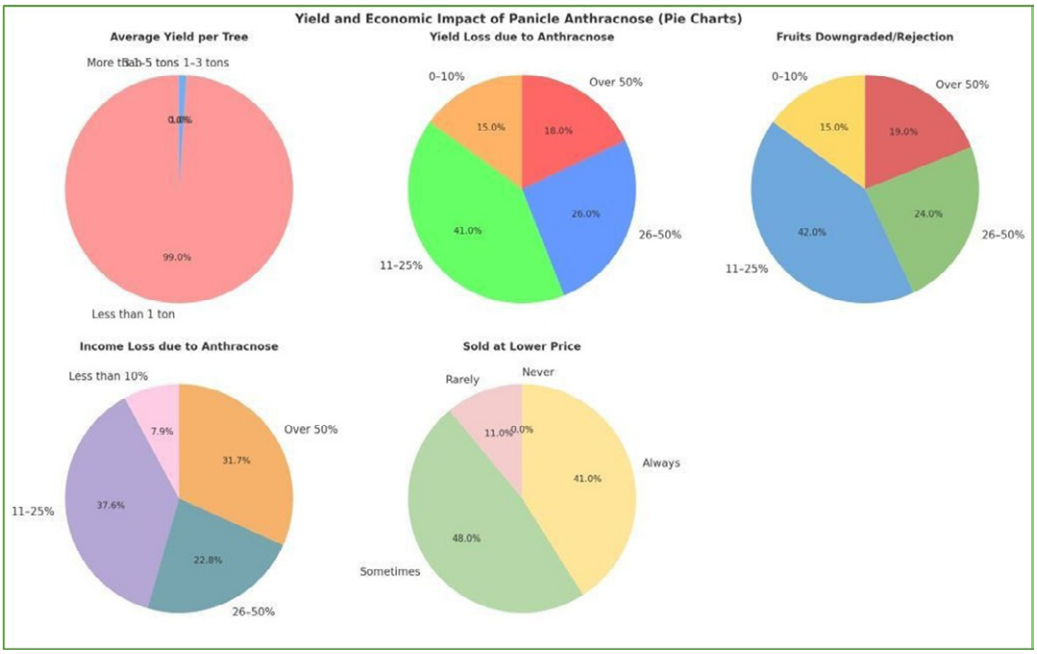

Figure 5. Investigation results on the yield and economic influence of panicle anthracnose in mango farms. Responses correspond to the following questions: (Q11) Average mango yield per tree per season; (Q12) Estimated yield loss due to anthracnose per tree; (Q13) Estimated percentage of fruits per tree rejected due to anthracnose; (Q14) Estimated income loss caused by anthracnose per season; and (Q15) Frequency of selling mangoes at a lower price due to anthracnose.

The disease also imposes heavy financial costs. Income losses of 11–25% were reported by 38% of growers, 23% lost 26–50%, and 32% lost more than half of their seasonal earnings. Additionally, 41% admitted to selling fruits at lower prices due to visible lesions, reducing profitability.

4.14. Management practices and the level of awareness

Organization practices and farmer awareness play a dangerous

Figure 6. Survey results on growers' management does and awareness of panicle anthracnose in mango farms. Responses correspond to the following questions: (Q16) Frequency of fungicide application during the flowering season; (Q17) Effectiveness of current disease management strategies; (Q18) Attendance in training or seminars on

role in controlling mango anthracnose. The efficiency of disease control often depends on farmers' knowledge, access to training, and adoption of proper methods. Kind these factors provides insights into how awareness effects organization plans and yield outcomes in samal district.

4.15. Apply fungicides during flowering season

The survey bare that all mango farmers in Samal District practical fungicides during the flowering season to manage anthracnose. Among the respondents, 28% reported applying antifungals three to four times, while the majority (72%) applied fungicides more than four times within the same period.

These findings suggest a strong need on chemical control as the primary plan for disease management. While frequent fungicide use can reduce anthracnose incidence, it also raises concerns about increased production costs, environmental risks, and the potential growth of fungicide resistance (Lapitan & Barroga, 2021). Similar trends have been documented in other mango-producing regions of the Philippines, where farmers often apply fungicides excessively due to fear of yield losses, regardless of disease forecasting (Yanos *et al.*, 2021). According to Alvarez *et al.* (2020), dependance on chemical control without integrating cultural or biological practices results in unsustainable organization and declining effectiveness over time. The effective used of fungicide like Managing Black Sigatoka in Cavendish Bananas according to Cobrado & Fernandez (2025).

4.16. Fungicides application during flowering season

The study revealed that 72% of respondents applied fungicides more than four times during the flowering season to manage panicle anthracnose. This frequent application reflects the high disease pressure perceived by farmers and their strong reliance on chemical control. However, excessive fungicide use raises production costs and increases the risk of fungicide resistance. Similar trends have been documented in other mango-growing regions of the Philippines, underscoring the need for integrated management approaches that combine chemical, cultural, and postharvest strategies for sustainable disease control (Alvarez *et al.*, 2020; Lapitan & Barroga, 2021; Yanos *et al.*, 2021). Comparable practices are seen in banana disease management, where fungicides such as pyrimethanil, spiroxamine, and mancozeb have been effectively utilized (Cobrado & Fernandez, 2025).

4.17. Efficay of current disease management

The study revealed that 55% of the defendants considered their current management strategies against panicle anthracnose to be very effective, while 45% rated them as only moderately effective. These findings suggest that although farmers recognize some success in their control measures, a significant portion still experiences limitations in fully managing the disease.

Like results have been observed in other mango-producing areas in the Philippines, where reliance on fungicide spraying alone often provides only partial protection due to timing, weather conditions, and pathogen variability (Lapitan & Barroga, 2021). Alvarez *et al.* (2020) also emphasized that the effectiveness of chemical control depends on integrating complementary practices such as sanitation, bagging, and postharvest treatments. Yanos *et al.* (2021) highlighted that combining chemical, cultural, and biological methods under an Integrated Disease Management framework enhances both effectiveness and sustainability.

4.18. Training/seminars on mango disease management

The study revealed that 55% of farmers seldom attended seminars or training on disease management, mainly due to the limited availability of free training programs. This indicates that access to technical support and extension services remains a barrier for many mango growers in Samal District. Former studies highlight that farmer participation in training significantly improves knowledge of proper disease management practices, including correct fungicide use, pruning, and postharvest handling (Lapitan & Barroga, 2021). Alvarez *et al.* (2020) also noted that lack of regular extension services contributes to inconsistent adoption of integrated management strategies. Similarly, Yanos *et al.* (2021) emphasized that farmer education through seminars and field schools strengthens the implementation of sustainable anthracnose control measures.

4.19. Monitor mango trees for anthracnose symptoms

Study exposed that 66% of farmers regularly monitor their mango orchards on a weekly basis for signs of anthracnose infection. This practice reflects farmers' awareness of the importance of early detection in reducing disease impact. Regular monitoring enables timely interventions such as fungicide spraying, pruning, or sanitation to prevent severe outbreaks.

Similar findings were reported by Lapitan and Barroga (2021), who emphasized that common field scouting helps farmers align fungicide applications with actual disease presence, improving efficiency and reducing unnecessary chemical use. Alvarez *et al.* (2020) highlighted that weekly monitoring contributes to the early identification of anthracnose symptoms, which is essential given the latent infection period of *Colletotrichum* species. Yanos *et al.* (2021) further noted that regular monitoring, when integrated with cultural and chemical controls, meaningfully improves overall disease management and fruit quality

4.20. Proper management reduces yield loss

The study showing that all farmers believed proper management has a significant impact on reducing yield loss caused by anthracnose. This observation highlights the farmers' recognition that proactive practices such as timely fungicide spraying, orchard sanitation, and pruning right influence both fruit quality and overall productivity.

Lapitan and Barroga (2021) highlighted that mango yield losses in the Philippines are highly correlated with the level of disease management adopted by farmers. Similarly, Alvarez *et al.* (2020) demonstrated that integrated management strategies substantially reduce anthracnose incidence and improve harvest recovery. Yanos *et al.* (2021) also noted that farmers who implement proper control measures, including both chemical and cultural practices, achieve meaningfully lower postharvest losses compared to those who rely on limited interventions.

4.21. Coping mechanisms adopted to address challenges

Mango farmers in Samal District employ diverse coping

mechanisms to lessen the effects of panicle anthracnose and related challenges. These strategies include adjusting farm practices, adopting modern control measures, collaborating with fellow farmers, and exploring alternative solutions to sustain production, reduce losses, and improve income resilience.

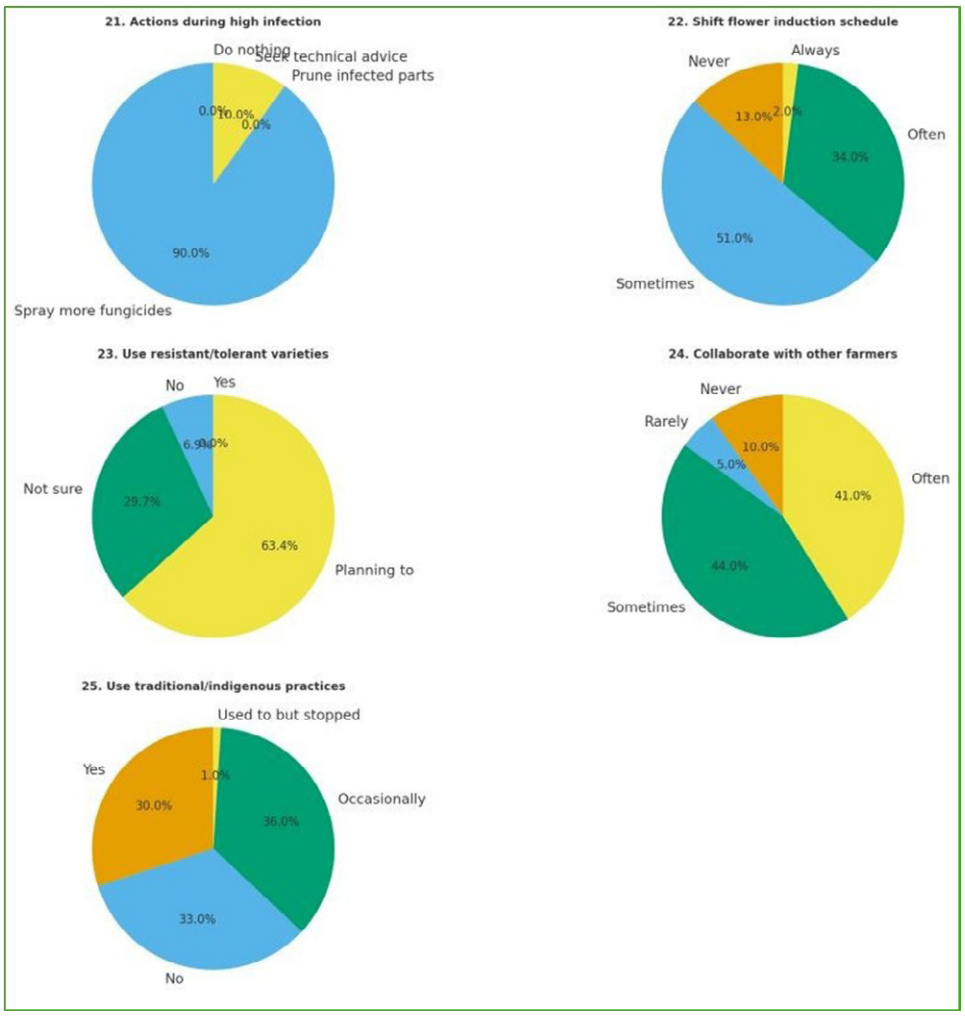

Figure 7. Survey results on the coping mechanisms of mango farmers against panicle anthracnose. Responses correspond to the following questions: (Q21) Actions taken when anthracnose infection is high; (Q22) Adjustment of flower induction schedule to avoid disease outbreaks; (Q23) Use of resistant or tolerant mango varieties; (Q24) Collaboration with other farmers for disease management; and (Q25) Use of traditional or indigenous practices to control anthracnose.

4.22. Anthracnose infection is high

According to this study, 90% of the farmers reported that when anthracnose infection is high, they apply fungicides more frequently than the recommended rate. This finding reflects a reactive approach to disease control, where farmers rely heavily on chemical interventions once symptoms are visible. While this practice may temporarily suppress the disease, it also increases manufacture costs, risks of fungicide resistance, and environmental hazards.

Similar explanations were made by Salvani *et al.* (2021), who found that mango farmers in the Philippines often exceed recommended spray frequencies due to limited access to training and fear of losing yields. Yanos *et al.* (2021) also reported that overreliance on chemical control without proper scheduling or rotation reduces fungicide efficacy and accelerates pathogen resistance. Also, Gimenez *et al.* (2022) emphasized that excessive fungicide use can negatively affect fruit quality and market acceptance, especially in export markets with strict residue limits.

4.23. Induction schedule

This study revealed that 51% of the farmers in Samal District reported occasionally shifting their flower induction schedule to avoid anthracnose outbreaks. This practice reflects a preventive strategy, as timing flower induction during periods of lower humidity and reduced rainfall can minimize disease incidence. By adjusting phenological stages, farmers attempt to escape peak infection periods that favor *Colletotrichum* sporulation and spread.

Similar adaptive strategies have been documented in other

mango-producing regions. According to Lapitan and Barroga (2021), altering flower induction schedules in the Philippines helps reduce exposure of panicles to favorable disease conditions, especially during the rainy season. Hio *et al.* (2024) emphasized that manipulating crop calendars, combined with pruning and canopy management, significantly lowers anthracnose severity in tropical orchards. Likewise, Martínez-Bolaños *et al.* (2022) noted that aligning flowering with drier months improves fruit set and reduces reliance on fungicide sprays.

4.24. Use of resistant or tolerant mango varieties

The study found that 64% of the respondents expressed willingness to adopt resistant or tolerant mango varieties as a strategy to manage anthracnose. This indicates that most farmers recognize the potential of genetic resistance as a cost-effective and sustainable solution, reducing reliance on frequent fungicide sprays. Resistant or tolerant cultivars can provide long-term protection against the disease by minimizing infection rates and severity, especially under favorable conditions for *Colletotrichum* development.

In the Philippines, breeding and selection programs have been exploring varietal tolerance, though the Carabao mango remains the dominant cultivar due to its export value (Lapitan & Barroga, 2021). Studies by Kamle and Kumar (2023) emphasize that resistant varieties are key components of integrated disease management, reducing both production costs and chemical risks. Similarly, Sivaji *et al.* (2024) highlight that farmer adoption of resistant cultivars—combined with cultural practices and judicious fungicide use—offers the most sustainable pathway for anthracnose management in tropical orchards.

4.25. Collaborate with other farmers

This study revealed that 41% of the respondents identified collaboration among farmers as an important strategy in managing anthracnose. Collective action allows growers to synchronize practices such as flower induction, fungicide application, and orchard sanitation, which reduces inoculum sources and disease spread across neighboring farms. Since anthracnose is highly influenced by environmental factors and pathogen dispersal, isolated efforts are often less effective compared to coordinated community-based management.

Collaborative approaches have been successfully applied in other Philippine agricultural systems. According to Salvani *et al.* (2021), farmer cooperatives play a key role in sharing knowledge, pooling resources, and standardizing disease management practices in mango production. Similarly, Florendo *et al.* (2022) emphasized that collective monitoring and synchronized interventions improve pest and disease control efficiency while lowering costs per farmer. International studies also support this approach; Hio *et al.* (2024) found that community-based integrated pest and disease management significantly reduced mango anthracnose incidence in tropical orchards compared to individual efforts.

4.26. Use of traditional or indigenous practices in controlling anthracnose

The survey results indicate that 33% of the respondents reported they no longer use traditional or indigenous practices in controlling anthracnose. This reflects a shift away from community-based or low-input methods—such as ash application, herbal sprays, or cultural rituals—toward chemical-dependent strategies. While modern fungicides often provide faster and more visible results, the abandonment of indigenous knowledge may reduce the diversity of management practices available to farmers.

In the Philippines, indigenous pest and disease control methods have historically included the use of botanical extracts, ash, smoke, and intercropping for microclimate regulation (Rola *et al.*, 2020). These practices, while less effective when used alone, often complemented cultural strategies like pruning, sanitation, and crop rotation. According to Quilloy *et al.* (2021), traditional methods are gradually being replaced as farmers gain access to commercial inputs, though some communities still integrate them to lower costs and minimize chemical use. More recently, Gimenez *et al.* (2022) emphasized that combining indigenous practices with modern integrated disease management (IDM) can strengthen sustainability by reducing chemical dependence and promoting eco-friendly

4.27. Future outlook

The future outlook emphasizes sustainable strategies to address mango anthracnose in Samal District. With farmers recognizing the impacts of climate change, disease pressure, and economic losses, forward-looking approaches—such as resistant varieties, climate-smart practices, stronger government support, and farmer collaboration—are essential to secure long-term productivity and competitiveness.

4.28. Anthracnose incidence increase in the next 5

The study revealed that 50% of the respondents believe anthracnose incidence will increase in the next five years. This perception reflects farmers' awareness of changing environmental conditions such as rising humidity, unpredictable rainfall, and warming temperatures that favor disease development. Similar concerns were noted in Philippine studies linking climate variability with higher anthracnose incidence in fruit crops (Lapitan & Barroga, 2021).

Globally, researchers emphasize that anthracnose is highly responsive to climate change, with projections of increased severity in tropical orchards due to extended wet seasons and warmer microclimates (Ali *et al.*, 2023; Jeevanantham *et al.*, 2024). Farmers' expectations of worsening disease pressure highlight the urgency of developing adaptive management strategies—such as resistant varieties, improved canopy management, and climate-informed fungicide schedules—to secure mango productivity in Samal District.

4.29. Willingness to invest in disease management

The survey revealed that 36% of respondents expressed willingness to invest more in disease management, provided the practices are cost-effective. This reflects farmers' careful balance between managing production costs and protecting yields. Given the high expense of fungicides and inputs, many growers remain hesitant unless assured of profitable returns.

Studies in the Philippines show that mango farmers are cost-sensitive, often reducing or delaying disease control measures

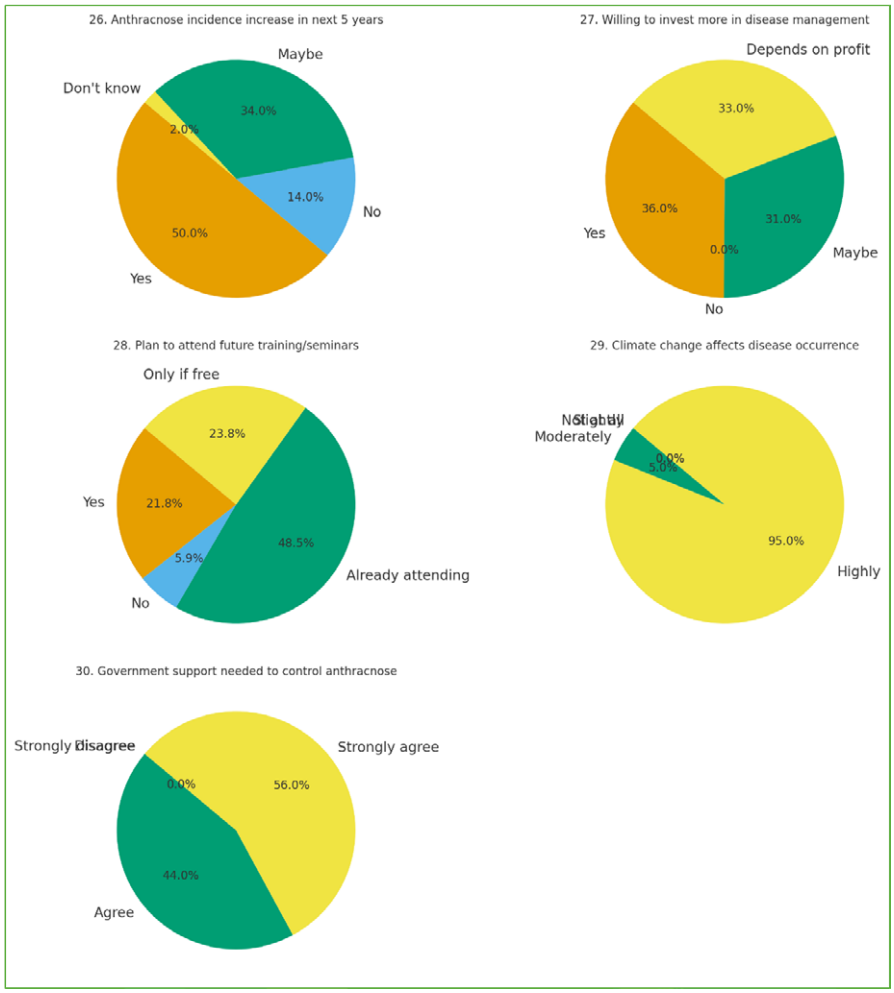

Figure 8. Survey results on farmers' perspectives and future outlook regarding mango panicle anthracnose. Responses correspond to the following questions: (Q26) Expected change in anthracnose incidence over the next five years; (Q27) Willingness to invest more in cost-effective disease management; (Q28) Intention to attend future training or seminars conducted by private companies; (Q29) Perceived influence of climate change on anthracnose occurrence; and (Q30) Belief in the need for government support to control anthracnose.

when input prices rise (Salvani *et al.*, 2021). However, evidence also indicates that when farmers clearly see the benefits of integrated disease management such as reduced yield loss and better market prices they are more open to additional investments (Quilloy *et al.*, 2021). Internationally, Gimenez *et al.* (2022) found that cost-effectiveness and accessibility strongly influence farmers' adoption of sustainable pest management practices.

4.30. Training and seminars on mango diseases

The study revealed that 49% of mango farmers in Samal District currently attend training or seminars on mango diseases. This indicates that nearly half of the growers are already accessing formal learning opportunities to strengthen their knowledge of disease identification and management. Participation in training is vital for improving farmers' capacity to adopt Good Agricultural Practices (GAP) and Integrated Pest Management (IPM).

In the Philippines, farmer participation in agricultural training has been shown to directly improve pest and disease management decisions, leading to reduced chemical misuse and improved fruit quality (Quilloy *et al.*, 2021). Similarly, Salvani *et al.* (2021) reported that mango growers who attended GAP seminars were more likely to implement sanitation, pruning, and proper fungicide application schedules. On a broader scale, Dumayas *et al.* (2023) highlighted that farmer education programs enhance resilience to climate-related disease pressures by increasing awareness of adaptive and sustainable management practices.

However, the fact that more than half of the farmers have not attended trainings suggests a gap in extension outreach and accessibility. Expanding training opportunities through local government units, cooperatives, and research institutions could significantly improve disease management outcomes in Samal Island.

4.31. Climate change and disease occurrence

The study revealed that 95% of mango farmers in Samal District believe that climate change highly affects disease occurrence in mango. Farmers reported observing increased disease

outbreaks, particularly anthracnose, during periods of irregular rainfall, prolonged wet seasons, and higher humidity—conditions favorable for fungal development.

This perception aligns with recent studies in the Philippines showing that climate variability directly influences anthracnose severity and frequency, with warmer temperatures and extreme rainfall events accelerating pathogen spread (Lapitan & Barroga, 2021). Similarly, Ali *et al.* (2023) documented in Pakistan that humidity, rainfall, and wind speed strongly correlated with mango anthracnose incidence. Globally, Jeevanantham *et al.* (2024) highlighted that climate change is expected to intensify polycyclic fungal diseases like anthracnose, increasing yield losses in tropical fruit production systems.

4.32. Farmers' belief on the need for government support

The study found that 56% of mango farmers in Samal District believe government support is necessary to effectively control anthracnose. Farmers emphasized that interventions such as subsidized fungicides, access to resistant varieties, extension services, and postharvest facilities are critical to reducing production losses and improving profitability.

This finding reflects broader trends in Philippine agriculture where smallholder farmers often lack sufficient resources to independently manage crop diseases. Salvani *et al.* (2021) reported that mango growers with limited capital depend heavily on government-led extension and subsidy programs to adopt Good Agricultural Practices (GAP). Similarly, Shuck *et al.* (2023) highlighted that farmer cooperatives and local government initiatives in Davao Region, such as training and packing facility support, significantly improved fruit quality and export readiness. International evidence also supports this, as Hio *et al.* (2024) showed that coordinated government-backed integrated disease management programs in Colombia led to better outcomes than farmer-led efforts alone.

5. CONCLUSION

This section presents the conclusions and recommendations of the study in relation to its itemized objectives. Section A offers an overview of the respondents and their farm profiles to establish essential background information. Section B debates the incidence of panicle anthracnose and the extent of its occurrence in mango orchards. Section C highlights the yield and economic impact of the disease on farmers' production and household income. Section D examines organization practices and the level of awareness among respondents, reflecting their approaches and knowledge gaps in disease control. Section E outlines the coping mechanisms farmers adopt to address the challenges caused by anthracnose. Finally, Section F explores the future outlook, highlighting strategies for integrated and sustainable disease management that can enhance output and resilience of mango farming in Samal District.

This outlines the conclusion of the study serious impact of mango anthracnose on yield and farmer livelihoods, emphasizing the importance of integrated management strategies. By linking disease dynamics with environmental and socioeconomic factors, the findings deliver a basis for sustainable practices that enhance productivity, resilience, and success in mango production systems.

5.1. Respondents and farm profile

The respondents' and farm profile of mango growers in Samal District, Samal Island reveal important demographic and structural characteristics that influence production and disease management. Mango farming is largely managed by middle-aged and older farmers, with 68% aged 46–60 years, while younger growers remain underrepresented, reflecting the nationwide issue of an aging farmer population. Men (58%) are more engaged in orchard operations such as spraying, pruning, and harvesting, whereas women contribute significantly in decision-making, postharvest handling, and financial management. Educational attainment is modest, with 43% completing only high school and 23% attaining college-level education, suggesting gaps in technical knowledge and potential barriers to adopting advanced production and pest management practices. Farming experience shows a mix of tradition and adaptability, with 42% cultivating mango for 5–10 years. Most farms range between 1–3 hectares, while 38% exceed 5 hectares. These realities highlight the need for targeted training, extension services, and farmer support programs to sustain mango farming in the district.

5.2. Incidence of panicle anthracnose

The study confirms that panicle anthracnose is a persistent, climate-sensitive disease threatening mango production in Samal District, Samal Island. Nearly half of farmers (48%) observed that disease occurrence depends on environmental conditions, while 67% reported peak incidence during the wet season, consistent with the pathogen's dependence on humidity, rainfall, and warm temperatures (Kamle & Kumar, 2023; Lapitan & Barroga, 2021). Annually, 55% estimated 11–25% tree infection, and 32% reported higher levels, significantly affecting productivity. Although severity was mostly rated mild, recurring infections reduce flowering and fruit set. These results highlight the need for climate-informed, integrated disease management strategies.

5.3. Yield and economic impact of the disease on farmers' production and income

The findings of this study demonstrate that panicle anthracnose is a major constraint to mango production and farmer income in Samal District, Samal Island. Yields were consistently low, with most farmers reporting less than one ton per tree per season, far below the potential yield of Carabao mango. Yield reductions were directly linked to anthracnose incidence, as 41% of growers reported 11–25% losses, 26% experienced 26–50%, and nearly one-fifth faced losses above 50%. Beyond yield decline, fruit quality was severely affected: 42% of farmers reported 11–25% of fruits rejected due to lesions, while 24% reported higher rejection rates, limiting access to premium and export markets. Income losses mirrored these trends, with 38% losing 11–25% and 32% losing more than half of seasonal earnings. Additionally, 41% were forced to sell fruits at reduced prices. These results emphasize the urgent need for integrated management practices to safeguard yields, fruit quality, and farmer livelihoods.

5.4. Management practices and the level of awareness

Findings from Samal District reveal that mango anthracnose

management relies heavily on chemical control, with all farmers applying fungicides during flowering and 72% spraying more than four times per season. While this reflects strong commitment to disease control, it raises concerns about costs, over-reliance, and potential resistance. Effectiveness was mixed, with 55% rating their strategies very effective and 45% only moderately effective, pointing to gaps in current practices. Awareness was relatively high—66% regularly monitored orchards, and all respondents recognized that proper management reduces yield loss. However, training access remained limited, with only 55% occasionally attending seminars. These findings highlight the need for stronger extension support, farmer education, and adoption of Integrated Disease Management (IDM) to ensure sustainable and cost-effective strategies.

5.5. Coping mechanisms adopted to address challenges

The coping mechanisms of mango farmers in Samal District reveal a mix of adaptive and reactive strategies against panicle anthracnose. Most growers (90%) respond to high infection by increasing fungicide use, a short-term solution that risks resistance, high costs, and environmental harm. Preventive measures, such as shifting flower induction schedules (51%), show awareness of timing practices to reduce disease pressure. Encouragingly, 64% expressed willingness to adopt resistant or tolerant varieties, indicating openness to sustainable alternatives. Collaboration among farmers (41%) highlights opportunities for collective management, though the decline of traditional practices (33% discontinuation) signals a loss of indigenous knowledge. Overall, these findings stress the need for integrated approaches that combine modern technologies, collective action, and locally adapted practices to ensure resilience and sustainability in mango production.

5.6. Future outlook

The future outlook for mango production in Samal District underscores both challenges and opportunities in addressing anthracnose under changing climatic conditions. Half of the farmers anticipated higher incidence within the next five years, attributing this to climate variability, warmer temperatures, and unpredictable rainfall—concerns that align with scientific projections of more severe fungal outbreaks. Encouragingly, 36% expressed willingness to invest in management if cost-effective, while 64% were open to adopting resistant or tolerant varieties, signaling readiness for innovation despite financial and knowledge barriers. Nearly half (49%) had attended training, highlighting the role of capacity-building, though extension services must expand to reach more farmers. Furthermore, 95% acknowledged climate change as a key driver of outbreaks, and 56% stressed the need for government support through subsidies, resistant planting materials, and infrastructure. Ensuring sustainability will require integrating farmer practices with institutional support, strengthening collaboration, and promoting climate-smart approaches to secure long-term productivity and competitiveness.

RECOMMENDATION

The study highlights critical issues shaping mango production in Samal District, Samal Island, particularly the constraints posed by panicle anthracnose. The demographic profile reveals an aging farmer population, modest educational attainment, and predominance of smallholder farms. These realities underscore the need for youth engagement, gender-sensitive approaches, and strengthened extension services to build technical capacity. Training modules and farmer field schools tailored to practical, farmer-friendly learning will help bridge knowledge gaps and encourage adoption of Good Agricultural Practices (GAP).

Results confirm that anthracnose remains widespread, with high seasonal prevalence during the wet season. Farmers reported considerable yield and income losses, alongside fruit quality downgrades, which limit access to premium markets. Management remains heavily dependent on frequent fungicide applications, raising concerns about cost, resistance, and environmental impacts. While growers demonstrate vigilance, integrated approaches combining fungicide use with cultural practices—such as pruning, canopy management, sanitation, and fruit bagging—are urgently needed.

Farmers' coping strategies, including shifting induction schedules and interest in resistant varieties, reflect both adaptability and openness to sustainable solutions. However, limited training access and declining use of traditional practices indicate gaps that require policy and institutional support. Future resilience depends on climate-smart management, improved extension services, and stronger farmer organizations to foster synchronized community interventions. Government assistance in the form of subsidies, planting materials, and market infrastructure is essential. By aligning farmer readiness with institutional support and research innovations, Samal District can enhance productivity, reduce losses, and secure the long-term sustainability of its mango industry.

Implications

The findings of this study have significant implications for mango production, farmer livelihoods, and agricultural policy in Samal District, Samal Island. First, the high incidence of panicle anthracnose underscores the urgent need to strengthen Integrated Disease Management (IDM) strategies that go beyond chemical control. Reliance on frequent fungicide spraying is not sustainable and may lead to resistance, environmental risks, and rising production costs. Second, the demographic profile—characterized by aging farmers, modest educational attainment, and smallholder farm sizes—highlights structural challenges that may hinder the adoption of advanced technologies. This calls for farmer-friendly training programs, youth engagement initiatives, and gender-inclusive interventions to ensure continuity and innovation in mango production. Third, the considerable yield and income losses associated with anthracnose directly threaten farmer livelihoods and regional competitiveness, emphasizing the importance of policy support through subsidies, credit access, and market linkages. Finally, the recognition of climate change as a key driver of anthracnose incidence indicates that future strategies must be climate-smart, integrating forecasting systems, resistant varieties, and adaptive cultural practices. Collectively, these implications point to the need for coordinated action among farmers, government agencies, and research institutions to secure sustainable and profitable mango farming in Samal District.

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