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Components of the Anthracnose Disease Epidemic in Plants

Muhammad Rayhan Alifio Budiansyah[1,*], Yasmin Arifia [1], Laura Ahshaina Mumtaz[1], Angelia Melisa Hutapea[1]
[1]Study Program of Biology, Faculty of Military Mathematics and Natural Sciences, Republic of Indonesia Defense University, Bogor, Indonesia

* Corresponding Author: rayhan.alifio@gmail.com

Abstract

Anthracnose, caused by various species of Colletotrichum, is one of the major diseases in tropical plants that has a significant impact on agricultural productivity. This disease can attack various important commodities such as fruits, vegetables, and plantation crops, with symptoms in the form of dark spots on leaves, fruits, and stems that have the potential to cause crop losses and decreased product quality. This study discusses the components of the anthracnose disease epidemic, including etiology, variation in pathogen species and host specificity, clinical symptoms, and environmental factors that influence disease development. In addition, the potential for biological control strategies using antagonistic microbes such as Trichoderma spp was also discussed., Bacillus subtilis, Paenibacillus polymyxa, and Streptomyces spp., which works through the mechanisms of competition, antibiotics, and the induction of plant resistance. Biocontrol is considered environmentally friendly and sustainable, but it still faces challenges in formulation and application in the field, so further research is needed, especially relevant to tropical conditions. An omics technology-based approach is recommended to accelerate the identification of potential biological agents. This study is expected to be a reference for researchers, practitioners, and policymakers in developing effective and sustainable anthracnose management strategies to support food security in the tropics.

Keywords: Anthracnose; Biological Control; *Colletotrichum* spp., Microbial Antagonists; Tropical Plant Diseases

Introduction

Tropical crops play a significant role in the global agricultural system, particularly in tropical countries. Their high biodiversity and favorable climate make them a major source of food, fiber, and industrial raw materials. Tropical crops such as rice, corn, soybeans, and various tropical fruits not only meet the nutritional needs of the population but also contribute to local and national economies [1]. With a growing global population and growing demand for food, the importance of sustainable and productive agricultural management is becoming increasingly urgent. Therefore, understanding the various challenges faced by tropical crops, including disease attacks, is key to ensuring future food security [2, 3].

Plant diseases are a major factor hampering agricultural productivity. The presence of pathogens, whether fungal, bacterial, or viral, can cause significant losses in crop yields. These diseases not only reduce the quantity of agricultural yields but also affect the quality of the resulting products. In the context of food security, plant diseases can cause fluctuations in food supply, leading to price increases and economic instability. Therefore, plant disease control is a crucial aspect of modern agricultural strategies aimed at increasing yields and ensuring sustainable food production.

Anthracnose, a common disease affecting tropical plants, is caused by various species of the genus *Colletotrichum* [1,3, 5]. This disease can affect a wide range of plants, including fruits, vegetables, and ornamentals. Common symptoms of anthracnose include black spots on leaves, fruit, and stems, which can progress to wet rot. The impact of anthracnose is devastating, causing significant yield losses and reducing product quality [6, 7]. Therefore, a thorough understanding of the etiology, symptoms, and impact of this disease is crucial for developing effective control strategies [8, 9].

The purpose of this review is to provide a comprehensive understanding of anthracnose, including its etiology, clinical symptoms, and applicable control strategies. Furthermore, this review aims to identify challenges and opportunities for future research in the context of controlling this disease, particularly through biological control approaches. By presenting relevant and up-to-date information, it is hoped that this review will serve as a reference for researchers, agricultural practitioners, and policymakers in efforts to improve food security and agricultural productivity in tropical regions.

Materials and Methods

This review article was developed using a structured literature review approach to provide a comprehensive synthesis of the key components influencing the anthracnose disease epidemic in plants. The literature search was systematically conducted using major scientific databases and openly accessible journal platforms, including Google Scholar, PubMed, Scopus-indexed sources, and relevant plant pathology repositories. The inclusion criteria encompassed peer-reviewed articles published between 2021 and 2025 that specifically addressed anthracnose disease, *Colletotrichum* spp., host–pathogen–environment interactions, epidemiological factors, and disease development dynamics in agricultural and horticultural crops. Selected studies were critically analyzed to identify and integrate current knowledge on pathogen biology, host susceptibility, environmental drivers, and their combined roles in shaping anthracnose epidemics.

Results and Discussion

Etiology of Anthracnose Disease

Anthracnose is a major challenge in agriculture, particularly in tropical crops. This disease is caused by pathogens from the genus *Colletotrichum*, which includes several key species, such as *Colletotrichum gloeosporioides, Colletotrichum acutatum,* and *Colletotrichum kahawae*. These species are known to cause infections in a variety of host plants, including fruits, vegetables, and plantation crops. In an agricultural context, anthracnose disease not only impacts the quality and quantity of crop yields but can also impact farmers' economic well-being and overall food security.

The genus *Colletotrichum* comprises over 150 species, but not all are pathogenic. The most common species that play a significant role in tropical plant infections are *C. gloeosporioides* and *C. acutatum*. *C. gloeosporioides* is often found on fruit crops such as mango and papaya, while C. acutatum is more common on vegetable crops such as chili and tomato. Knowledge of these pathogen species is crucial for the management and control of anthracnose. For example, a study by Prakash et al. [3] found that C. gloeosporioides can cause losses of up to 40% in mango harvests if not properly managed.

The morphology of the *Colletotrichum* pathogen is characterized by the presence of round to oval spores, which are small and usually dark brown in color. These spores can survive in unfavorable environmental conditions, increasing the likelihood of infection in the host plant. Furthermore, this pathogen forms a septate mycelium and can reproduce both sexually and asexually. Under optimal conditions, the spores germinate and form an infective structure called an appressorium, which functions to penetrate the host plant tissue. This process is an example of the extraordinary adaptations this pathogen possesses to survive and reproduce in competitive environments.

The life cycle of *Colletotrichum* involves several stages, starting with spores landing on the surface of the host plant. After germination, the spores form an appressorium that penetrates the plant's epidermal cells. This infection process is influenced by several factors, including humidity and temperature. For example, research by Sutherland et al. [3] showed that the optimal temperature for the growth of *C. gloeosporioides* ranges from 25 to 30 degrees Celsius, with relative humidity above 80%. After successfully penetrating the tissue, the pathogen will multiply within the plant cells, causing significant damage. Initial symptoms of infection usually appear as small brown spots on the leaves, which can then spread to other plant organs if left untreated. The development of anthracnose is strongly influenced by various environmental and biological factors. Some of the main factors contributing to the development of this disease include: 1. Climate (Temperature, Humidity, Rainfall): High humidity and warm temperatures are ideal conditions for the growth and spread of the *Colletotrichum* pathogen. High humidity supports spore formation and infection, while optimal temperatures can accelerate the pathogen's life cycle. For example, in tropical regions with high rainfall, farmers often experience problems with anthracnose, especially during the rainy season. This highlights the importance of monitoring climate conditions in disease management. 2. Genetic Plant Resistance: Some plant varieties have genetic resistance to anthracnose. Selecting resistant varieties can reduce losses due to infection. Research on genetic resistance is crucial for developing new, more disease-resistant varieties. For example, in a study conducted by Kadir et al. [5], chili varieties with genetic resistance to C. acutatum showed significantly better yields than susceptible varieties. 3. Soil Microbiome and Root Environment: A healthy soil microbiome can play a role in controlling pathogens by competing for resources and producing antimicrobial compounds. The presence of antagonistic microbes around plant roots can help increase plant resistance to anthracnose infection. Research by Kloepper et al. [8, 9] showed that the application of antagonistic microbes can reduce the incidence of anthracnose disease by up to 50% in tomato plants.

By understanding the etiology of anthracnose, including the causative pathogen, morphology, life cycle, and factors influencing disease development, researchers and farmers can develop more effective control strategies. Further research in this area is needed to find sustainable solutions for managing anthracnose in tropical crops. The importance of anthracnose management cannot be overstated, given its widespread impact on agricultural production. In this context, anthracnose management can be achieved through an integrated approach that combines various strategies. For example, the use of resistant varieties, fungicide application, moisture management, and good agronomic practices can help reduce the risk of infection.

The use of resistant varieties is one of the most effective strategies. Varieties with proven resistance to infection can reduce the need for pesticide applications, which in turn can reduce production costs and environmental impacts. A study by Sari et al. [4] showed that the use of mango varieties resistant to C. gloeosporioides can reduce yield losses by up to 30%. Fungicide application is also a crucial step in anthracnose control. However, fungicide use must be carried out carefully to avoid pathogen resistance. In this regard, rotating fungicides with different mechanisms of action can help reduce the likelihood of resistance. Research by Jones et al. [5] shows that proper fungicide rotation can slow the development of pathogen resistance and increase control efficiency.

Humidity management is also crucial in controlling anthracnose. High humidity can increase the risk of infection, so good water management practices, such as proper drainage and irrigation management, can help reduce humidity around plants. This will reduce the opportunity for pathogen spores to germinate and infect plants. Good agronomic practices, such as pruning and plant spacing, can also help improve air circulation between plants, thereby reducing humidity and the risk of infection. Furthermore, maintaining farmland hygiene by removing infected plant debris can help break the pathogen's life cycle.

Types of Anthracnose with Their Hosts and Clinical Symptoms

Anthracnose is a plant disease caused by various species of the genus *Colletotrichum*, which exhibits significant species variation depending on the infected host plant. This disease is widely recognized among farmers and researchers due to its detrimental impact on agricultural yields. In general, anthracnose can attack various types of plants, including fruits, vegetables, and ornamentals. In this discussion, we will delve deeper into the types of anthracnose, the infected hosts, and the clinical symptoms that result from these infections.

One of the most common species is *Colletotrichum gloeosporioides*. This species often attacks fruit crops such as mango, papaya, and durian. For example, in mangoes, this infection can cause dark spots on the fruit's skin that can progress to rot. Infected fruit typically suffers from decreased quality and market value. This is highly detrimental to farmers, especially when the price of these fruits fluctuates significantly in the market. One study showed that even seemingly healthy mangoes can rapidly rot after harvest if infected by *Colletotrichum gloeosporioides*, resulting in significant economic losses. On the other hand, the *Colletotrichum acutatum* species more frequently attacks vegetable crops such as chili peppers and tomatoes. Research shows that *Colletotrichum acutatum* infection in chili peppers can result in yield reductions of up to 50% in certain varieties. Symptoms include brown spots on leaves and fruit, which reduce not only the quantity but also the quality of production. In this context, a thorough understanding of this pathogen species is crucial for developing effective control strategies.

This species variation indicates that the anthracnose pathogen has high host specificity, which can influence the control strategies implemented. For example, effective control against *Colletotrichum gloeosporioides* may not be effective against *Colletotrichum acutatum*. Therefore, further research is needed to understand species and strain differences in the context of disease epidemiology. This is crucial for designing more appropriate and effective control approaches. In the context of disease epidemiology, genetic variation within *Colletotrichum* species can influence the pathogen's virulence and ability to adapt to specific environmental conditions. For example, research shows that certain strains of *Colletotrichum acutatum* are better adapted to high humidity conditions, which are common in tropical regions. This causes infections to be more severe during the rainy season, which in turn increases losses for farmers.

Symptoms of anthracnose vary depending on the infected plant organ. On leaves, infection is typically characterized by the appearance of brown or black spots surrounded by a yellow halo. These spots can progress to more extensive damage, causing the leaves to dry out and fall off. In more severe cases, infection can cause wilting and complete plant death. For example, in tomato plants, anthracnose infection can cause significant losses, with infected leaves dropping before the fruit ripens, resulting in reduced yields. On fruit, anthracnose symptoms often appear as dark spots that can spread and lead to rot. Infected fruit typically suffers from reduced quality and market value. In a case study conducted in tropical Indonesia, anthracnose attacks on chili pepper plants caused significant losses. Research showed that *Colletotrichum acutatum* infection not only reduced yields but also affected fruit quality, ultimately impacting farmer income.

Stem infection can cause stem rot, which often leads to plant death. This symptom is recognizable by the presence of dark spots on the bark of the stem that can spread and cause the underlying tissue to rot. In more severe cases, infection can cause wilting and complete plant death. For example, in durian plants, anthracnose infection can cause stem rot, resulting in significant losses for farmers who rely on this crop for income. It is important to note that anthracnose control is not only crucial for protecting plants from direct damage but also for maintaining plant resistance to secondary infections. A study showed that anthracnose infection in mango plants can increase plant susceptibility to other pathogens, such as rot fungi. This suggests that control strategies must consider not only the control of anthracnose itself but also the interactions between different pathogens.

In this context, understanding the diversity of pathogen species and the clinical symptoms they cause is crucial for developing effective control strategies. Further research is needed to explore the interactions between *Colletotrichum* species and their host plants and to identify environmental factors that may influence disease development. With a better understanding of the types of anthracnose and the clinical symptoms they cause, researchers and farmers can develop more appropriate approaches to managing this disease. For example, in developing more anthracnose-resistant plant varieties, plant breeding can be directed to increase resistance to specific pathogen species. Furthermore, the use of appropriate fungicides and good cultivation techniques can also help reduce the impact of this disease. For example, proper plant spacing and soil moisture management can reduce the risk of anthracnose infection.

Anthracnose Biological Control Strategy

Biological control is an increasingly popular approach to managing plant diseases, including anthracnose, caused by pathogens of the genus *Colletotrichum* (Table 1). In this context, antagonistic microbes play a crucial role in controlling the spread of the disease and improving plant health. Antagonistic microbes are microorganisms that play a crucial role in controlling plant diseases, particularly in the face of pathogen attacks such as anthracnose. In this context, antagonistic microbes function to inhibit pathogen growth through various complementary mechanisms. In this discussion, we will explore in more depth the role of antagonistic microbes, their antagonistic mechanisms, and the benefits of biological control using these microbes.

Antagonistic microbes, such as Trichoderma spp., Bacillus subtilis, Paenibacillus polymyxa, and Streptomyces spp., have been extensively studied and applied in plant disease control. Trichoderma spp., for example, is a fungus widely known in agriculture as a biological control agent. This fungus has the ability to compete with pathogens in the soil, produce enzymes that can destroy pathogen cell walls, and produce antifungal compounds. Research shows that the use of Trichoderma can increase plant resistance to anthracnose by improving root health and increasing plant growth. In a study conducted by Sharma et al. [2], it was found that the application of Trichoderma to anthracnose-infected tomato plants showed a significant increase in growth and yield compared to controls without this microbe (Table 1).

Furthermore, *Bacillus subtilis* and *Paenibacillus polymyxa* also play an important role as biological control agents. Bacillus subtilis is known for its ability to produce antibacterial and antifungal compounds and stimulate the plant's defense system. In a study by Ghosh et al. [3], the use of *Bacillus subtilis* on anthracnose-infected chili plants showed a significant reduction in infection rates and increased yields. Furthermore, Paenibacillus polymyxa not only plays a role in disease control but also improves plant growth and resistance to biotic and abiotic stress. Both can be used as biofertilizers, not only increasing growth but also reducing the impact of anthracnose. Streptomyces spp. is another group of bacteria worth considering. Bacteria from this genus are known to produce natural antibiotics that can inhibit the growth of various pathogens, including *Colletotrichum*, the causative agent of anthracnose. One interesting example is research conducted by Kaur et al. [4,6], which showed that applying Streptomyces to anthracnose-infected rice plants reduced disease symptoms and improved soil health. Thus, Streptomyces spp. not only contributes to disease control but also increases nutrient availability for plants (Table 1).

Antagonistic microbes function through various complementary mechanisms in anthracnose disease control. One of the most common mechanisms is competition, where antagonistic microbes compete with pathogens for resources such as nutrients and space. In this case, antagonistic microbes occupy the same niche as the pathogen, thereby reducing the pathogen's opportunity to reproduce and cause infection. Research by Reddy et al. [3] showed that applying antagonistic microbes can significantly reduce pathogen populations in soil, which in turn reduces infection rates in plants.

Table 1. Antagonistic Microbes Used in the Biological Control of Anthracnose Disease

Antagonistic Microbe	Target Pathogen	Main Antagonistic Mechanisms	Effects on Plants	Key Findings
Trichoderma spp.	*Colletotrichum* spp.	Competition for space and nutrients; production of cell wall–degrading enzymes; secretion of antifungal metabolites	Enhanced root health, increased growth, improved resistance to anthracnose	Significantly increases plant growth and yield while reducing anthracnose severity
Bacillus subtilis	*Colletotrichum* spp.	Production of antibacterial and antifungal compounds; induction of systemic resistance	Reduced infection rates; improved crop yield	Effectively suppresses anthracnose and enhances plant defense responses
Paenibacillus polymyxa	*Colletotrichum* spp.	Antimicrobial metabolite production; plant growth promotion; stress tolerance enhancement	Increased resistance to biotic and abiotic stress; improved growth	Functions as both biocontrol agent and biofertilizer
Streptomyces spp.	*Colletotrichum* spp.	Production of natural antibiotics; pathogen growth inhibition	Reduced disease symptoms; improved soil health and nutrient availability	Contributes to anthracnose control and long-term soil fertility

Another important mechanism is antibiosis, where many antagonistic microbes produce bioactive compounds with antibacterial or antifungal properties. These compounds can directly inhibit the growth of pathogens or even kill them. This mechanism is very effective in controlling anthracnose, where the compounds produced can stop the infection at an early stage. For example, research by Khan et al. [4] showed that compounds produced by Trichoderma can significantly inhibit the growth of *Colletotrichum,* thus preventing further infection. Furthermore, antagonistic microbes can also stimulate the plant's defense system to increase its resistance to pathogen attack. This process is known as resistance induction, where plants exposed to antagonistic microbes exhibit a stronger immune response to infection. This is important in disease control, as more resistant plants are better able to survive anthracnose attacks. A study by Verma et al. [3] showed that the application of Bacillus subtilis can increase the expression of genes involved in plant defense, thereby increasing resistance to pathogens.

Biological control using antagonistic microbes offers several advantages over traditional chemical control methods. One of the main advantages is its environmentally friendly nature. The use of antagonistic microbes as biological control agents has minimal negative impacts on the environment. They do not contaminate soil and water, and do not harm non-target organisms. This is becoming increasingly important amidst growing awareness of the negative impacts of excessive use of chemical pesticides. Sustainability is also a crucial aspect of biological control. Antagonistic microbes can survive and reproduce in the soil, providing sustainable protection for plants. A study by Singh et al. [2] found that the application of antagonistic microbes can increase the population of beneficial microbes in the soil, contributing to long-term soil health and plant growth. Thus, biological control not only addresses disease problems but also creates a healthier agricultural ecosystem.

Reducing pathogen resistance is another advantage of using antagonistic microbes. Unlike chemical pesticides, which can induce resistance in pathogens, the use of antagonistic microbes can reduce the risk of resistance development. With their various mechanisms, antagonistic microbes are difficult for pathogens to defeat. Research by Sahu et al. [8] showed that the use of a combination of several antagonistic microbes can reduce the likelihood of pathogen resistance, thus providing more effective protection. In addition to controlling disease, antagonistic microbes can also improve overall plant growth and health. This contributes to increased yields and product quality. In a study by Gupta et al. [9] it was found that applying *Paenibacillus polymyxa* to anthracnose-infected soybean plants not only reduced disease symptoms but also increased grain weight and yield quality. This demonstrates that biological control can provide multiple benefits to farmers.

Integration into sustainable agricultural systems is also an advantage of biological control. Biological control can be integrated with other sustainable agricultural practices, such as crop rotation and the use of organic fertilizers, to create healthier and more productive agricultural systems. For example, a study by Kumar et al. [3] found that implementing a sustainable agricultural system combining the use of antagonistic microbes and crop rotation significantly reduced anthracnose infection rates while increasing overall crop yields. Considering the aforementioned advantages, biological control using antagonistic microbes is a promising strategy for managing anthracnose and enhancing the resilience of tropical crops. Further research is needed to explore the potential of new endophytic microbes and develop effective formulations and applications in the field. With the right approach, biological control can be a sustainable and effective solution to future plant disease challenges.

Future Research Challenges and Opportunities

In the context of anthracnose disease control in tropical crops, there are various challenges and opportunities that need to be identified and further explored. Research in this area is crucial for improving crop resilience and productivity, as well as ensuring future food security. Anthracnose, caused by various fungal species, can cause significant losses in the agricultural sector, particularly in tropical regions rich in biodiversity. Therefore, understanding the challenges and opportunities in this research can significantly contribute to agricultural sustainability.

One of the main challenges in anthracnose disease research is the lack of local studies based on tropical conditions [1, 4, 5]. Most existing research tends to focus on plant species and pathogens from non-tropical regions, which may not be fully relevant to tropical climates and ecosystems. For example, studies conducted in Europe or North America may not consider the unique variations in temperature, humidity, and ecosystem interactions in tropical regions. Therefore, it is crucial to conduct more in-depth research on local pathogen species, their interactions with host plants, and the influence of tropical-specific environmental factors. More local research can provide better insights into disease dynamics and enable the development of more effective and sustainable control strategies. For example, a study conducted in Indonesia on the fungal species that cause anthracnose in cocoa plants showed that local species have different pathogenic characteristics compared to species studied in other countries. This demonstrates the importance of local research in understanding how pathogenic species adapt to specific environmental conditions. By conducting more focused research on local species, we can develop more targeted control approaches that can increase yields and reduce disease losses.

Endophytic microbes, which live within plant tissues without causing disease, offer significant potential for the biological control of anthracnose. Further research on endophytic microbes from tropical plants could identify new strains with antagonistic abilities against the anthracnose-causing pathogen. For example, several studies have shown that certain endophytic microbes can enhance plant resistance to pathogens by enhancing the plant's defense system or by directly inhibiting pathogen growth. Exploring new endophytic microbes will not only enrich our understanding of plant-microbe interactions but also pave the way for the development of more effective biological agents.

This research should involve sampling a wide variety of tropical plants and in-depth analysis of their ability to induce resistance or inhibit pathogen growth. For example, research conducted in the tropical rainforests of Borneo has shown that several plant species harbor endophytic microbes capable of enhancing resistance to anthracnose [4]. By harnessing this biodiversity, we can find more sustainable solutions to disease control. While biological control offers many advantages, challenges in the formulation and application of biological agents in the field remain significant obstacles. Biological agents, such as antagonistic microbes, often have low stability and can lose their effectiveness when applied in the field. For example, some antagonistic microbes that have been tested in the laboratory have shown high effectiveness in controlling diseases, but when applied in the field, they do not produce the expected results [6]. Furthermore, varying environmental conditions, such as temperature and humidity, can affect the viability and activity of these biological agents. Therefore, research should focus on developing more stable formulations and more precise application methods to improve the effectiveness of biological agents in the field.

This approach should also consider integration with existing agricultural practices to ensure farmer acceptance. For example, developing formulations that can be mixed with existing fertilizers or pesticides can increase farmer adoption of biological agents. Furthermore, research into improved delivery methods, such as the use of more efficient spraying technologies, can improve the distribution of biological agents in the field. Advances in omics technologies, including genomics, transcriptomics, and metabolomics, provide new opportunities in biological control research. By utilizing these technologies, researchers can better understand the mechanisms of interaction between antagonistic microbes and pathogens, as well as the genetic characteristics of plants that contribute to disease resistance. For example, genomic analysis can help identify genes involved in plant resistance responses to anthracnose infection. Furthermore, omics analysis can aid in the identification of biomarkers that can be used to detect anthracnose infection earlier, allowing for faster and more precise control measures.

The use of omics technologies in research can also accelerate the development of more effective and specific biological agents and improve our understanding of the microbial ecosystems in soil and plants. For example, studies using metabolomics approaches have successfully identified metabolites produced by antagonistic microbes that can inhibit pathogen growth. With this information, researchers can design more efficient and reliable biological agents.

Conclusion

Anthracnose, caused by pathogens of the genus *Colletotrichum*, is a serious threat to tropical crops. This disease has a significant impact on agricultural production and global food security. Symptoms appear on various plant organs, including leaves, fruits, and stems, showing wide variation, depending on the pathogen species and host plant. Biological control strategies, particularly through the use of antagonistic microbes such as *Trichoderma* spp., *Bacillus subtilis*, and *Streptomyces* spp., offer environmentally friendly and sustainable solutions. However, challenges in research and field application still require further attention, particularly in the context of technology development and the exploration of new microbes.

Microbiological approaches to anthracnose disease control show great potential. Antagonistic microbes not only function to control the pathogen but can also improve plant health through mechanisms such as competition, antibiosis, and resistance induction. Further research in this area could lead to the development of more effective and efficient control methods and minimize the use of chemical pesticides that can negatively impact the environment. Therefore, approaches based on microbial and plant interactions need to be strengthened in disease control efforts. It is recommended that research be more focused on exploring endophytic microbes with potential as biological control agents for anthracnose. Local research based in tropical conditions is also essential to understand disease dynamics and microbial interactions in specific contexts. Furthermore, the development of omics technologies, such as metagenomics and proteomics, can provide new insights into pathogen mechanisms and plant responses. Research that integrates multidisciplinary approaches will be invaluable in creating innovative solutions for tropical plant disease control and supporting overall food security. Therefore, collaborative efforts between researchers, agricultural practitioners, and other stakeholders are crucial in addressing existing challenges and capitalizing on opportunities in the field of biological control of plant diseases.

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