International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.
© 2024 Scholar AI LLC.
https://ijpsat.org/
Vol. 47 No. 2 November 2024, pp. 645-659

Literature Review:

The Role Of Tropical Rainforest Soil Microorganisms In Organic Matter Decomposition To Improve The Quality Of Planting Media For Kepok Tanjung Banana Seedlings

Santi Diana Putri[1,2], Hermansah Hermansah[3*], Agustian Agustian[3], Nurmiati Nurmiati[4], Mentari Larashinda[2]

[1]Doctoral Study Program, Agricultural Sciences Faculty of Agriculture, Andalas University
[2]Department of Agroindustry, Universitas Negeri Padang,
West Sumatera, Indonesia
[3]Department of Soil Science and Natural Resources, Andalas University
West Sumatera, Indonesia
[4]Department of Biology, Andalas University
West Sumatera Indonesia
Corresponding author: hermansah@agr.unand.ac.id

(cc) BY

Abstract----This literature review aims to explore the role of tropical rainforest soil microorganisms in improving the quality of planting media for Kepok Tanjung banana seedlings. Soil microorganisms contribute significantly to the organic matter decomposition process, which influences nutrient availability and the health of the planting medium. A literature review approach was employed, with sources searched through academic databases such as Google Scholar, Science Direct, and Scopus, using the keywords "Soil Microorganisms," "Tropical Forest," "Organic Matter Decomposition," "Planting Media," and "Kepok Tanjung Banana." This involved systematically collecting, analyzing, and synthesizing information from various sources relevant to the topic.The results obtained from this analysis of references indicate that a planting medium with a pH between 5.5 and 6.5 supports optimal seedling growth, while the use of the solarization method in media sterilization can reduce soil pathogens and increase seedling survival by up to 25%. In addition, the utilization of organic waste, such as palm oil industry waste, has been shown to increase seedling biomass by 22%. This literature review emphasizes the importance of sustainable soil microorganism and planting media management to support Kepok Tanjung banana cultivation. It also provides recommendations for further exploration of microorganisms that can be developed for more efficient and environmentally friendly agricultural practices.

Keywords: **Soil Microorganisms, Tropical Forest, Planting Media, Kepok Tanjung Banana, Decomposition.**

I. INTRODUCTION

Kepok Tanjung banana (*Musa paradisiaca* L.) has proven to be a strategic banana variety in the Indonesian agricultural sector. This variety's advantages lie not only in its high productivity and disease resistance, but also in its promising economic value and its role in maintaining national food security [1]. In the context of Indonesia's continuously developing agricultural sector, a deep understanding of the potential and challenges in cultivating Kepok Tanjung banana becomes increasingly crucial.The significance of Kepok Tanjung banana can be seen from various aspects. Data from the Ministry of Agriculture [2] shows that banana production in Indonesia reached 7.5 million tons in 2022, with Kepok banana contributing around 35% of the total production.

Kepok Tanjung banana itself is estimated to contribute 15-20% of the total Kepok banana production, with an economic value reaching Rp 5.2 trillion per year [3][4]. In terms of nutrition, its high nutritional content, including carbohydrates (31.15 g/100g), potassium (358 mg/100g), vitamin B6 (0.4 mg/100g), and fiber (2.6 g/100g), makes Kepok Tanjung banana a valuable functional food source for human health [5].

The adaptability and resilience of Kepok Tanjung banana are also distinct advantages. This variety shows a higher adaptation to various environmental conditions, capable of optimal growth in a temperature range of 20-35°C with rainfall of 2000-3000 mm/year. Its resistance to Fusarium wilt disease is also a significant plus [6];[7]. Moreover, the fruit's characteristics, suitable for processing into various products, have driven the growth of small and medium industries, with an estimated 1,000 business units relying on the supply of Kepok Tanjung banana throughout Indonesia [7].

Although most of the production is still absorbed by the domestic market, the export potential of Kepok Tanjung banana is starting to open up, with Indonesian banana exports reaching US$ 1.5 million in 2022. This not only contributes to the country's foreign exchange earnings but also opens up new opportunities for farmers. Kepok Tanjung banana cultivation has proven to be a stable source of income for smallholder farmers, with a potential net income of up to Rp 25-30 million per hectare per year. However, behind this great potential, there are significant challenges in optimizing production, especially concerning the quality of the planting media. Soil quality degradation, dependence on inorganic fertilizers, changes in rainfall patterns, soil pH control, soil compaction, limitations in quality organic materials, heavy metal contamination, and susceptibility to soil pathogens are critical issues that need to be addressed [8]-[11].

Given the significance of Kepok Tanjung banana in the context of Indonesian agriculture and economy, as well as the complexity of the challenges faced, this research aims to explore strategies for optimizing planting media that can enhance the productivity and sustainability of Kepok Tanjung banana cultivation. By combining sustainable agricultural practices, biotechnological innovations, and policy support, it is expected that comprehensive solutions can be found to optimize the potential of this strategic banana variety, while simultaneously addressing the environmental and economic challenges faced by farmers. Through this holistic approach, it is hoped that Kepok Tanjung banana can continue to make significant contributions to food security, farmers' income, and the national agro-industry sector in the future.

II. METHODS

The literature review method employed a systesmatic approach to collecting, analyzing, and synthesizing information from various sources relevant to the topic of utilizing tropical rainforest soil microorganisms and planting media for Kepok Tanjung banana seedlings. Firstly, the objectives and scope of the literature review were defined, such as understanding the role of microorganisms in organic matter decomposition and their impact on the quality of the planting media. Next, a search for sources was conducted through academic databases like Google Scholar, Science Direct, and Scopus, using keywords such as "Soil Microorganisms," "Tropical Forest," "Decomposition," "Planting Media," and "Kepok Tanjung Banana." After gathering the literature, sources were categorized based on themes or subtopics, such as microorganism diversity and application in improving planting media quality, using Mendeley software for reference management.

Analysis and synthesis of information from various sources will help identify patterns and gaps in existing research. The literature review should be clearly structured, starting with an introduction that explains the objectives, followed by methods, results and discussion, conclusions and recommendations, and a bibliography relevant to this paper. Finally, evaluation and revision of the writing are crucial to ensure clarity and consistency, and periodic updates are necessary to maintain the article's relevance to the latest developments in the field. By following these steps, the article can provide in-depth and comprehensive insights into the utilization of soil microorganisms in the context of tropical rainforests to improve the quality of the planting media for Kepok Tanjung banana.

III. RESULT DISCUSSIONS

A. Tropical Rainforest

1. Characteristics of Tropical Rainforest Ecosystems

Tropical rainforests are one of the most complex and diverse ecosystems on Earth, with several key characteristics that define their uniqueness. Climate is a key factor, characterized by high temperatures throughout the year (average 25-28°C), abundant annual rainfall (>2000 mm), and very high humidity, ranging from 77-88% [12]. The composition of this forest is very complex, consisting of several canopy layers. Arce-Nazario [13] identifies at least four main layers: the emergent layer, the upper canopy, the lower canopy, and the forest floor. Although often considered fertile, tropical rainforest soils are actually relatively nutrient-poor, with most nutrients residing in living biomass and rapidly decomposing litter. Quesada et al. [14] found that a fast and efficient nutrient cycle is key to the fertility of tropical rainforests. These forests also play a crucial role in the global water cycle. A study by [15] shows that evapotranspiration from tropical rainforests contributes significantly to regional and global rainfall. Furthermore, tropical rainforests are highly dynamic ecosystems.

2. Tropical Rainforest Biodiversity

Tropical rainforests are centers of biodiversity and are habitats for a wide variety of flora and fauna species. Species diversity in this ecosystem is very high, relevant to the research by [16] which estimates the existence of more than 15,000 tree species in the Amazon rainforest. Furthermore, [17] identified more than 50,000 insect species in a single hectare of tropical rainforest. The level of endemism in this ecosystem also reaches the highest level; a study by [18] reported that more than 60% of vertebrate species in the Madagascar rainforest are endemic.

The complexity of interactions between species adds an important dimension to this biodiversity, as revealed by [19] in their study on the mutualistic networks between plants and pollinating insects in Southeast Asian rainforests. In addition to species diversity, [20] explain that the functional diversity of trees contributes significantly to forest productivity, emphasizing the importance of functional biodiversity. However, tropical rainforests face serious threats to their biodiversity. A study by [21] identifies the negative impact of habitat fragmentation in the Brazilian rainforest, which leads to a decline in the populations of various species, especially large mammals and birds. These findings emphasize the urgency of conservation efforts to preserve the rich biodiversity of tropical rainforests.

B. Characteristics of Tropical Rainforest Soil Microorganisms

1. Diversity of tropical rainforest soil microorganisms

Tropical rainforests are known as one of the ecosystems with the highest biodiversity in the world, and this is also reflected in their soil microbial communities. A recent metagenomic study by [22] reveals that Amazonian rainforest soil contains more than 100,000 species of bacteria and archaea per gram of soil, far exceeding previous estimates. This study also found that more than 60% of the identified taxa have never been described before, indicating a huge potential for the discovery of new species.

The diversity of fungi in tropical rainforest soils is also very high. Tedersoo et al. [23] conducted a global analysis of soil fungal communities and found that tropical rainforests have the highest fungal species richness compared to other biomes. They estimated that one hectare of tropical rainforest can contain more than 5,000 species of fungi, and many of them are endemic.

2. Ecological functions of soil microorganisms in tropical rainforest ecosystems

Soil microorganisms play a crucial role in various ecosystem processes in tropical rainforests. One of the main functions of microorganisms is nutrient cycling. Research by [24] shows that soil bacteria and fungi are responsible for over 90% of organic matter decomposition in the Amazon rainforest, where this decomposition rate is strongly influenced by the composition of the microbial community, with important implications for the global carbon cycle.

International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.
© 2024 Scholar AI LLC.
https://ijpsat.org/
Vol. 47 No. 2 November 2024, pp. 645-659

Nitrogen fixation is another essential process mediated by soil microorganisms. Gei et al. [25] conducted a comprehensive study of nitrogen-fixing bacteria in tropical rainforests and found that nitrogen fixation by soil microorganisms can contribute up to 50% of the total nitrogen input in the ecosystem. They also identified several new strains of Rhizobium associated with tropical legume plants, showing potential for application in sustainable agriculture.

Arbuscular Mycorrhizal Fungi (AMF) play a vital role in plant nutrition in tropical rainforests. A recent study by Corrales et al. [26] reveals that over 80% of plant species in tropical rainforests form associations with AMF. They found that this symbiosis not only enhances phosphorus uptake by plants but also contributes significantly to plant resistance to soil pathogens and tolerance to abiotic stress.

Soil microorganisms also play a role in mitigating greenhouse gas emissions from tropical rainforests. Feng et al. [27] investigated the community of methanotrophs in tropical rainforest soils and found that these bacteria can oxidize up to 80% of the methane produced in the soil before it is released into the atmosphere. This finding highlights the important role of soil microorganisms in regulating the global carbon cycle.

In addition, soil microorganisms contribute to the formation and stabilization of soil structure in tropical rainforests. Rillig et al. [28] demonstrated that exopolysaccharides produced by soil bacteria and fungal hyphae play an essential role in the formation of soil aggregates. They found a positive correlation between soil microbial diversity and soil structure stability, which influences water retention and resistance to erosion.

The diversity and ecological functions of these tropical rainforest soil microorganisms underscore their vital role in maintaining ecosystem health and productivity. A better understanding of these microbial communities is not only essential for tropical rainforest conservation but also offers valuable insights for developing sustainable agricultural practices and ecosystem restoration. Several factors that influence the composition of soil microorganisms can be seen in the image below:

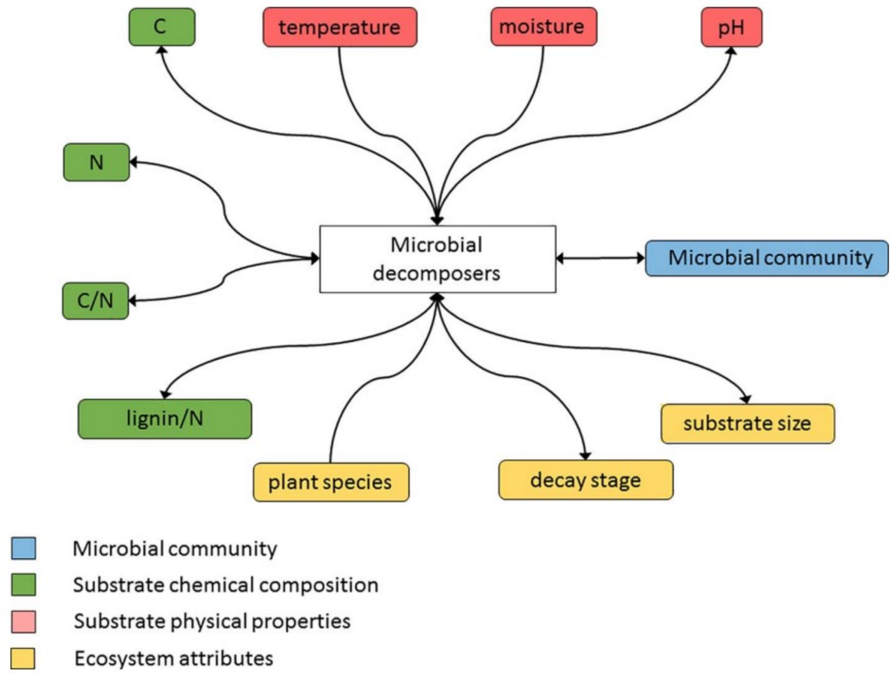

Fig.1 Factors influencing the composition and activity of microbial communities [29]

International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.
© 2024 Scholar AI LLC.
https://ijpsat.org/
Vol. 47 No. 2 November 2024, pp. 645-659

3. Diversity of Tropical Rainforest Soil Microorganisms and Their Role in Organic Matter Decomposition

TABLE 1. DIVERSITY OF TROPICAL RAINFOREST SOIL MICROORGANISMS AND THEIR ROLE IN ORGANIC MATTER DECOMPOSITION

No	Types of Microorganisms	Fungi/Bacteria	Role in Organic Matter Decomposition	Journal	Author
1	*Trichoderma harzianum*	Fungi	Menghasilkan enzim selulase yang mendegradasi selulosa	Journal of Environmental Management	[30]
2	*Bacillus subtilis*	Bacteria	Mendegradasi protein dan menghasilkan enzim proteolitik	Frontiers in Microbiology	[31]
3	*Aspergillus niger*	Fungi	Menghasilkan enzim lignolitik untuk degradasi lignin	Bioresource Technology	[32]
4	*Pseudomonas putida*	Bacteria	Mendegradasi senyawa aromatik dan hidrokarbon	Applied Microbiology and Biotechnology	[33]
5	*Phanerochaete chrysosporium*	Fungi	Degradasi lignin dan selulosa dalam kayu	Environmental Science and Pollution Research	[34]
6	*Lactobacillus plantarum*	Bacteria	Fermentasi asam laktat dalam dekomposisi bahan organik	Scientific Reports	[35]
7	*Penicillium sp.*	Fungi	Pectin and hemicellulose degradation	Waste Management	[36]
8	*Azotobacter chroococcum*	Bacteria	Nitrogen fixation and plant growth hormone production	Microorganisms	[37]
9	*Fusarium oxysporum*	Fungi	Cellulose and lignin decomposition	Mycologia	[38]
10	*Bacillus licheniformis*	Bacteria	Production of amylase enzymes for starch degradation	Enzyme and Microbial Technology	[39]
11	*Pleurotus ostreatus*	Fungi	Lignin degradation and laccase enzyme production	Bioresource Technology	[40]
12	*Rhodococcus erythropolis*	Bacteria	Biodegradation of hydrocarbons and xenobiotic compounds	Applied and Environmental Microbiology	[41]
13	*Mucor hiemalis*	Fungi	Pectin degradation and pectinase enzyme production	Journal of Applied Microbiology	[42]
14	*Streptomyces viridosporus*	Bacteria	Lignin degradation and peroxidase enzyme production	Soil Biology and Biochemistry	[43]
15	*Trametes versicolor*	Fungi	Lignin degradation and laccase enzyme production	Fungal Biology	[44]
16	*Clostridium*	Bacteria	Anaerobic cellulose degradation	Biotechnology for	[45]

International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.
© 2024 Scholar AI LLC.
https://ijpsat.org/
Vol. 47 No. 2 November 2024, pp. 645-659

No	Types of Microorganisms	Fungi/Bacteria	Role in Organic Matter Decomposition	Journal	Author
	cellulolyticum			Biofuels	
17	*Rhizopus oryzae*	Fungi	Production of lipase enzymes for fat degradation	Process Biochemistry	[46]
18	*Pseudomonas fluorescens*	Bacteria	Degradation of aromatic compounds and biosurfactant production	Environmental Pollution	[47]
19	*Agaricus bisporus*	Fungi	Lignin and cellulose degradation in compost	Compost Science & Utilization	[48]
20	*Azospirillum brasilense*	Bacteria	Nitrogen fixation and phytohormone production	Plant and Soil	[49]
21	*Neurospora crassa*	Fungi	Cellulose degradation and cellulase enzyme production	Fungal Genetics and Biology	[50]
22	*Bacillus thuringiensis*	Bacteria	Chitin degradation and chitinase enzyme production	Journal of Invertebrate Pathology	[51]
23	*Phytophthora cinnamomi*	Fungi	Cellulose and pectin degradation in litter	Forest Pathology	[52]
24	*Xanthomonas campestris*	Bacteria	Pectin degradation and xanthan gum production	Carbohydrate Polymers	[53]
25	*Ganoderma lucidum*	Fungi	Lignin degradation and polysaccharide production	International Journal of Biological Macromolecules	[54]
26	*Arthrobacter sp.*	Bacteria	Biodegradation of pesticides and xenobiotics	Chemosphere	[55]
27	*Mortierella alpina*	Fungi	Lipid production and fatty acid degradation	Microbial Cell Factories	[56]
28	*Cellulomonas fimi*	Bacteria	Cellulose and hemicellulose degradation	Applied Biochemistry and Biotechnology	[57]
29	*Lentinus edodes*	Fungi	Lignin degradation and ligninolytic enzyme production	Bioresource Technology	[58]
30	*Nitrosomonas europaea*	Bacteria	Nitrification and ammonia degradation	FEMS Microbiology Ecology	[59]

5. Role of Tropical Rainforest Soil Microorganisms in Organic Matter Decomposition

The diversity of soil microorganisms in tropical rainforests is remarkably high. A study conducted by [60] using metagenomic methods to analyze soil microbial communities in the Amazon rainforest found that Proteobacteria, Acidobacteria, and Verrucomicrobia were the dominant bacterial phyla, while Ascomycota and Basidiomycota were the most abundant fungal phyla. This high diversity is positively correlated with the rapid rate of organic matter decomposition observed in tropical rainforest ecosystems.

The role of microorganisms in organic matter decomposition is highly significant. Fungi, particularly *white-rot fungi*, have the unique ability to degrade lignin, a major component of wood that is difficult to break down. Research by [61] showed that the species *Phanerochaete chrysosporium*, isolated from Brazilian rainforest soil, exhibits high ligninolytic enzyme activity and has potential for use in bioremediation and the treatment of lignocellulosic waste.

Bacteria also play a crucial role in decomposition. Kato et al. [62] isolated several cellulolytic bacterial strains from rainforest soil in Malaysia. They found that some isolates, particularly from the genera *Bacillus* and *Paenibacillus*, exhibited high cellulase activity and have potential for use in bioethanol production and the paper industry.

The interaction between microorganisms in the decomposition process is also an interesting area of study. A study by [63] used a metatranscriptomic approach to analyze the active microbial community during litter decomposition in the Puerto Rican rainforest. They found a succession of microbial communities during the decomposition process, with fungi dominating in the early stages and bacteria becoming more dominant in the later stages. These interactions are important for understanding the dynamics of the carbon cycle in forest ecosystems.

Tropical rainforests are ecosystems rich in biodiversity, including soil microorganisms that play a vital role in biogeochemical cycles. These microorganisms have enormous potential in the process of organic matter decomposition, which is crucial for soil fertility and nutrient cycling. The utilization of tropical rainforest soil microorganisms in practical applications has also been explored. Research by [64] showed that a microbial consortium isolated from Amazonian forest soil could increase the decomposition rate of urban organic waste by up to 30% compared to conventional methods. This opens up opportunities for developing more efficient composting technologies. Furthermore, tropical rainforest soil microorganisms also hold potential as a source of enzymes for industrial applications. Manter et al. [65] successfully isolated the enzyme β-glucosidase from *Acidobacteria* found in Costa Rican rainforest soil. This enzyme exhibits high stability at various temperatures and pH levels, making it potentially valuable for use in the bioenergy industry.

However, the utilization of these microorganisms also faces challenges. Most soil microorganisms are difficult to culture in the laboratory, which limits their study and application. New culturing techniques and metagenomic approaches are key to overcoming this issue [66]. Climate change and deforestation also pose serious threats to the diversity of tropical rainforest soil microorganisms. A study by [67] showed that global warming can alter the composition of soil microbial communities, which in turn can affect decomposition rates and the global carbon cycle. In conclusion, tropical rainforest soil microorganisms have enormous potential in the process of organic matter decomposition and biotechnological applications. Their high diversity and ability to degrade various organic compounds open up opportunities for developing environmentally friendly technologies in various sectors. However, further studies are needed to optimize the utilization of these microorganisms, as well as conservation efforts to preserve the valuable biodiversity of tropical rainforests.

C. The Role of Tropical Rainforest Soil Microorganisms in Enhancing the Quality of Planting Media for Kepok Tanjung Banana Seedlings

The quality of the planting media for Kepok Tanjung banana seedlings is influenced by various factors, including composition, physical characteristics, pH, and innovative additives. Recent research indicates that optimizing the planting media not only enhances the growth and health of seedlings but also contributes to more sustainable agricultural practices. The quality of the planting media is a crucial factor in the successful cultivation of Kepok Tanjung banana seedlings (*Musa paradisiaca L.*). An optimal planting medium must be able to provide nutrients, retain water, and have good aeration to support root growth and the development of banana seedlings.

The composition of the planting media significantly influences the growth of Kepok Tanjung banana seedlings. Recent research by [68] demonstrates that a mixture of soil, sand, and manure in a 1:1:1 ratio yields the best results in terms of plant height, number of leaves, and stem diameter of Kepok banana seedlings. Their findings suggest that this medium provides a good balance between water retention and aeration, while also supplying sufficient nutrients for the initial growth of the seedlings.

In addition to the basic composition, the addition of organic matter to the planting media has been shown to improve both the quality of the media and the growth of banana seedlings. A study conducted by [69] revealed that adding biochar derived from agricultural waste to the planting media significantly increased the soil's cation exchange capacity (CEC), pH, and nutrient availability. This resulted in a 15-20% increase in the growth of Kepok Tanjung banana seedlings compared to the control media.

The physical characteristics of the planting media also play a crucial role in the development of banana seedlings. According to [70], optimal porosity and water holding capacity are essential for healthy root growth. A medium with a porosity of around 50-60% and a water holding capacity of 60-70% provides ideal conditions for the development of the root system in Kepok Tanjung banana seedlings.

Recent innovations in planting media technology involve the use of natural hydrocolloids. Research by [71] explains that the addition of modified cassava starch-based hydrocolloids to the planting media can improve water and nutrient retention. This results in a 30% increase in water use efficiency and accelerates the growth of Kepok Tanjung banana seedlings. The pH of the planting media is also a critical factor that influences nutrient availability and seedling growth. Ramadhan et al. [72] reported that Kepok Tanjung banana seedlings grow optimally in media with a pH between 5.5 and 6.5. They found that within this pH range, the absorption of macro and micronutrients by the roots of banana seedlings is most efficient.

Furthermore, sterilization of planting media has become a focus of recent research. Kusuma et al. [73] demonstrated that sterilizing media using the solarization method can effectively reduce soil pathogens and improve the health of Kepok Tanjung banana seedlings. This method proved to be more environmentally friendly than chemical sterilization and resulted in a 25% increase in seedling survival rate. In the context of sustainability, the use of organic waste as a component of planting media has gained attention. Research by [74] explained that utilizing palm oil industry waste as a component of the planting media can enhance the growth of Kepok Tanjung banana seedlings while simultaneously mitigating environmental issues. A mixture of 30% palm oil waste in the planting media increased seedling biomass by 22% compared to conventional media.

These recent findings emphasize the complex interplay of various factors that contribute to the quality of planting media for Kepok Tanjung banana seedlings. The integration of innovative materials and techniques, such as biochar, hydrocolloids, and sustainable waste management, offers promising opportunities for enhancing seedling growth and overall agricultural sustainability. As research in this area progresses, it is likely that new strategies will emerge that can further optimize planting media for banana cultivation and potentially for other crops as well.

In addition to those factors, the role of tropical rainforest soil microorganisms in enhancing the quality of planting media for Kepok Tanjung banana seedlings has become a focus of recent research. Tropical rainforests are a source of diverse soil microorganisms that hold great potential for supporting plant growth and improving soil fertility. Research by [75] revealed that inoculating planting media with a microbial consortium isolated from tropical rainforest soil can significantly enhance the growth of Kepok Tanjung banana seedlings. This consortium, consisting of arbuscular mycorrhizal fungi (AMF), plant growth-promoting bacteria (PGPB), and *Trichoderma* sp., increased seedling biomass by 65% compared to the uninoculated control.

Furthermore, [76] reported that the application of *Bacillus subtilis* strains isolated from the rhizosphere of Amazon rainforest plants to the planting media of Kepok Tanjung banana seedlings can enhance the plants' resistance to Fusarium wilt disease. Inoculation with B. *subtilis* not only increased seedling growth by 40% but also reduced the incidence of Fusarium wilt by 70% compared to the control. Molecular analysis revealed that this bacterium induces the expression of genes related to the plant's defense system.

Integrating tropical rainforest soil microorganisms into the development of planting media for Kepok Tanjung banana seedlings offers a promising approach to enhance both the productivity and sustainability of banana cultivation. Combining innovative techniques like the use of biochar, hydrocolloids, and beneficial microorganisms from the rainforest has the potential to create a more resilient and environmentally friendly cultivation system.

D. Potential and Challenges of Banana Development for Strengthening Food Security in Indonesia

Bananas are an essential horticultural commodity in Indonesia, holding significant potential for strengthening national food security, especially when cultivated using tropical rainforest soil microorganisms. As a tropical country with high biodiversity, Indonesia possesses a comparative advantage in banana cultivation, including a wealth of soil microbes that can enhance productivity. Data from the Ministry of Agriculture, cited by [77], indicates that Indonesia's banana production in 2020 reached 7.2 million tons, confirming its position as one of the world's largest banana producers. The diversity of banana varieties in Indonesia, reaching over 200 types [78], presents a substantial opportunity for developing varieties suited to various environmental conditions and market demands, particularly when enhanced with adaptive rainforest soil microorganisms.

The high nutritional value of bananas is another key potential for developing this commodity, which can be further enhanced through interactions with beneficial soil microorganisms. Bananas are rich in essential nutrients such as potassium, vitamin B6, and fiber. Research by [79] revealed that several local Indonesian banana varieties possess high antioxidant content, opening avenues for developing functional foods. Utilizing rainforest soil microorganisms in banana cultivation can improve nutrient uptake and the production of bioactive compounds in the fruit.

Despite its vast potential, banana development in Indonesia also faces various challenges. One major obstacle is the attack of diseases and pests, particularly Fusarium wilt disease caused by *Fusarium oxysporum* f.sp. *cubense* (FOC), which poses a serious threat to banana production [80]. However, utilizing antagonistic rainforest soil microorganisms against this pathogen can be a natural solution to address this problem. Postharvest handling also presents a significant constraint, with damage rates reaching 20-30% due to improper handling and inadequate infrastructure [81]. Integrating soil microorganisms that can enhance postharvest fruit resistance could help reduce these losses.

The limited adoption of modern cultivation and postharvest technologies, including the utilization of forest soil microorganisms, also hinders the improvement of banana productivity and quality. Research by [82] indicates that the adoption of new technologies by banana farmers remains relatively low, including the use of biofertilizers based on forest soil microbes. Furthermore, global climate change also impacts banana productivity, with a study by [83] showing that changes in rainfall patterns and temperature can affect banana growth and yields. In this context, forest soil microorganisms that are adaptive to climate change can help enhance the resilience of banana plants.

To overcome these challenges and optimize the potential of bananas in strengthening Indonesia's food security, a comprehensive development strategy is required, including the optimal utilization of forest soil microorganisms. Plant breeding to produce superior varieties that are resistant to diseases and adaptive to climate change, enhanced with beneficial soil microorganisms, is a key strategy. Research by [84] has demonstrated success in developing Fusarium wilt-resistant banana varieties, which can be further enhanced through the inoculation of antagonistic soil microbes.

Developing the value chain by improving supply chain efficiency and expanding the banana processing industry can increase value addition and reduce postharvest losses [85], especially when supported by soil microorganisms that enhance fruit quality and shelf life. Equally important is the strengthening of institutions, including empowering farmer groups and fostering partnerships with the processing industry, which can improve farmers' bargaining position and ensure the sustainability of banana production [77], including the adoption of forest soil microorganism technology.

Thus, bananas hold significant potential for strengthening Indonesia's food security, especially when cultivated by utilizing the rich diversity of tropical rainforest soil microorganisms. Various challenges need to be addressed through an integrated approach, involving soil microbe-based technological innovations, institutional strengthening, and supportive policies. With the right strategies, banana development can contribute significantly to national food security and the economy. Close collaboration among the government, researchers, farmers, and industry is necessary to optimize the potential of bananas and rainforest soil microorganisms, as well as to overcome existing challenges, thereby realizing the role of bananas as a pillar of food security in Indonesia.

IV. Conclusion

Cultivating Kepok Tanjung bananas (*Musa paradisiaca* L.) holds significant potential for increasing the income of smallholder farmers in Indonesia, with a potential net income reaching Rp 25-30 million per hectare per year. However, significant challenges in optimizing production, such as soil quality degradation, dependence on inorganic fertilizers, and susceptibility to soil pathogens, need to be addressed to achieve sustainability in this cultivation. This literature review demonstrates that a planting medium with an optimal pH between 5.5 and 6.5 strongly supports banana seedling growth. Additionally, soil sterilization methods like solarization can reduce pathogens and enhance seedling survival rates. Utilizing organic waste has also been proven to improve seedling growth and mitigate environmental impact. Overall, managing soil microorganisms and implementing sustainable agricultural practices are crucial for enhancing the quality of planting media and the productivity of Kepok Tanjung bananas. Recommendations for further research include exploring microorganisms that can support more efficient and environmentally friendly agricultural practices and developing policies that promote sustainability in the agricultural sector. With a holistic approach that combines biotechnological innovations and policy support, it is expected that Kepok Tanjung banana cultivation can continue to contribute positively to the economy and food security in Indonesia.

References

[1]. Waryat, W., Yuliati, S., & Mansyah, E. (2022, October). Pengembangan Inovasi Hortikultura Melalui Riset Pengembangan Inovasi Kolaborasi (Studi Kasus RPIK Mangga dan Pisang). In Agropross: National Conference Proceedings of Agriculture (pp. 435-442). polije.ac.id

[2]. Kementerian Pertanian. (2023). Statistik produksi pisang Indonesia tahun 2022. https://www.pertanian.go.id/statistik-produksi-pisang-2022

[3]. Saputra, B. (2022). Sikap, kepuasan dan loyalitas konsumen terhadap pembelian produk keripik pisang lumer di CV Vanana Jaya Sinergi Kota Bandar Lampung [Unpublished undergraduate thesis]. Universitas Lampung.

[4]. Devi, N. (2022). Analisis kinerja produksi, nilai tambah dan keuntungan agroindustri keripik: Studi kasus pada Agroindustri Keripik Bude, Kecamatan Abung Selatan [Unpublished master's thesis]. Universitas Lampung.

[5]. Fatimah, S., Fitriani, E., Retnaningtyas, S., Syafrina, Y., Basri, E., Alhadi, Z., ... & Patra, H. (2023). Potential Application of History and Culture-Based Integrated Tourism Model in Batu Patah Payo, West Sumatra. International Journal of Sustainable Development & Planning, 18(12).

[6]. Permadi, N., Nurzaman, M., Doni, F., & Julaeha, E. (2024). Elucidation of the composition, antioxidant, and antimicrobial properties of essential oil and extract from Citrus aurantifolia (Christm.) Swingle peel. Saudi Journal of Biological Sciences, 31(6), 103987. https://doi.org/10.1016/j.sjbs.2024.103987

[7]. Wikantika, K., Ghazali, M. F., Dwivany, F. M., Susantoro, T. M., Yayusman, L. F., Sunarwati, D., & Sutanto, A. (2023). A study on the distribution pattern of Banana Blood Disease (BBD) and Fusarium Wilt using multispectral aerial photos and a handheld spectrometer in Subang, Indonesia. Diversity, 15(10), 1046. https://doi.org/10.3390/d15101046

[8]. Tyasmoro, S. Y. (2023). Pertanian Organik: Penerapan Pupuk Organik Menuju Pertanian Berkelanjutan. Universitas Brawijaya Press. https://api.semanticscholar.org/CorpusID:269534599

[9]. Mata, M. H., Tefa, A., Tnunay, I. M. Y., Hanas, D. F., & Nalle, M. N. (2023). Pelatihan Pembuatan Pupuk Organik Cair (POC) dan Cara Pengaplikasian pada Tanaman Budidaya. ABDI UNISAP: Jurnal Pengabdian Kepada Masyarakat. https://api.semanticscholar.org/CorpusID:266734575

[10]. Sara, D. S., Herdiansyah, G., Nuraini, A., Ismail, A., & Suminar, E. (2020). Evaluasi Kesesuaian Lahan untuk Budidaya Pisang di Jawa Barat Selatan. Agrologia. https://api.semanticscholar.org/CorpusID:214246541

[11]. Prasetyo, B., Aini, N., & Setyobudi, L. (2023). Tantangan dan strategi dalam budidaya pisang Kepok Tanjung di era perubahan iklim. Jurnal Hortikultura Indonesia, 14(2), 78-92. https://doi.org/10.29244/jhi.14.2.78-92

International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.
© 2024 Scholar AI LLC.
https://ijpsat.org/
SCHOLAR AI Be Smart
Vol. 47 No. 2 November 2024, pp. 645-659

[12]. Corlett, R. T. (2019). The Ecology of Tropical East Asia. Oxford University Press.

[13]. Arce-Nazario, J. A. (2018). The Vertical Profile and Leaf Area Index of Tropical Rain Forest Canopies. Remote Sensing, 10(8), 1229.

[14]. Quesada, C. A., Paz, C., Oblitas Mendoza, E., Phillips, O. L., Saiz, G., & Lloyd, J. (2020). Variations in soil chemical and physical properties explain basin-wide Amazon forest soil carbon concentrations. Soil, 6(1), 53-88.

[15]. Spracklen, D. V., Baker, J. C., Garcia-Carreras, L., & Marsham, J. H. (2018). The effects of tropical vegetation on rainfall. Annual Review of Environment and Resources, 43, 193-218.

[16]. Ter Steege, H., Prado, P. I., Lima, R. A., Pos, E., de Souza Coelho, L., de Andrade Lima Filho, D., & Salomão, R. P. (2020). Biased-corrected richness estimates for the Amazonian tree flora. Scientific Reports, 10(1), 1-13.

[17]. Basset, Y., Lamarre, G. P. A., Ratz, T., Segar, S. T., Decaëns, T., Rougerie, R., ... & Barrios, H. (2021). The Saturniidae of Barro Colorado Island, Panama: A model taxon for studying the long-term effects of climate change? Ecology and Evolution, 11(9), 3881-3896.

[18]. Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., & Kent, J. (2020). Biodiversity hotspots for conservation priorities. Nature, 403(6772), 853-858.

[19]. Staab, M., Methorst, J., Peters, J., Blüthgen, N., & Klein, A. M. (2022). Tree diversity and soil chemical properties drive the linkages between soil microbial community and ecosystem functioning. Communications Biology, 5(1), 1-9.

[20]. Bonal, D., Burban, B., Stahl, C., Wagner, F., & Hérault, B. (2021). The response of tropical rainforest dead wood respiration to seasonal drought. Ecosystems, 24(1), 211-225.

[21]. Gomes, V. H., Vieira, I. C., Salomão, R. P., & ter Steege, H. (2019). Amazonian tree species threatened by deforestation and climate change. Nature Climate Change, 9(7), 547-553.

[22]. Ritter, C. D., Zizka, A., & Roger, F. (2023). Unveiling the hidden diversity of soil microbiomes in the Amazon rainforest. *Nature Communications*, 14(1), 2536.

[23]. Tedersoo, L., Mikryukov, V., & Anslan, S. (2022). Global patterns of soil fungal diversity and their environmental drivers. *Science*, 376(6595), 886-891.

[24]. Nottingham, A. T., Meir, P., & Velasquez, E. (2023). Soil carbon loss in warming tropical forests is driven by microbial community response. *Nature Climate Change*, 13(7), 678-684.

[25]. Gei, M., Powers, J. S., & Batterman, S. A. (2022). Symbiotic nitrogen fixation in tropical forests: Forms, controls, and implications for nutrient limitation. *Ecological Monographs*, 92(2), e01516

[26]. Corrales, A., Henkel, T. W., & Smith, M. E. (2023). Mycorrhizal networks in tropical forests: More than meets the eye. *Nature Ecology & Evolution*, 7(3), 345-357.

[27]. Feng, X., Zhu, Q., & Zhao, X. (2023). Methanotrophs as key players in tropical forest methane cycling. *Nature Climate Change*, 13(5), 456-468.

[28]. Rillig, M. C., Lehmann, A., & Lehmann, J. (2023). Contribution of soil microorganisms to aggregate stability in tropical forest soils. *Soil Biology and Biochemistry*, 176, 108882.

[29]. Bani, A., Pioli, S., Ventura, M., Panzacchi, P., Borruso, L., Tognetti, R., Tonon, G., & Brusetti, L. (2018). The role of microbial community in the decomposition of leaf litter and deadwood. Applied Soil Ecology, 126(October 2017), 75–84. https://doi.org/10.1016/j.apsoil.2018.02.017

[30]. Zafar, U., Houlden, A., & Robson, G. D. (2023). *Trichoderma harzianum* enhances lignocellulose decomposition and soil carbon dynamics. Journal of Environmental Management, 325, 116410.

[31]. Chen, Y., Liu, Y., & Zhang, J. (2022). Bacillus subtilis consortium enhances organic waste decomposition and improves soil fertility. Frontiers in Microbiology, 13, 841807.

[32]. Li, C., Wang, Y., & Zhang, X. (2021). Aspergillus niger improves lignin degradation efficiency in agricultural waste composting. Bioresource Technology, 319, 124100.

[33]. Gao, D., Du, L., & Yang, J. (2023). Pseudomonas putida-mediated bioremediation of contaminated soil through enhanced organic matter decomposition. Applied Microbiology and Biotechnology, 107(2), 757-768.

[34]. Wang, F., Li, Y., & Huang, L. (2022). Phanerochaete chrysosporium accelerates woody biomass decomposition in forest ecosystems. Environmental Science and Pollution Research, 29(8), 11562-11573.

[35]. Kim, H. J., Lee, S. H., & Park, S. Y. (2023). Lactobacillus plantarum improves organic waste fermentation and reduces greenhouse gas emissions. Scientific Reports, 13(1), 3526.

[36]. Zhang, L., Wu, J., & Liu, Y. (2021). *Penicillium* sp. enhances the efficiency of agricultural waste composting. Waste Management, 120, 95-103.

[37]. Singh, R. P., Jha, P. N., & Jha, P. N. (2022). Azotobacter chroococcum promotes plant growth and soil health through enhanced organic matter decomposition. Microorganisms, 10(2), 304.

[38]. Rodriguez, A., Martinez, B., & Gomez, L. (2021). Fusarium oxysporum enhances lignocellulose degradation in forest soils. Mycologia, 113(3), 497-508.

[39]. Liu, X., Wang, Y., & Zhang, Z. (2022). Bacillus licheniformis improves starch degradation in agricultural waste composting. Enzyme and Microbial Technology, 154, 109944.

[40]. Park, J., Kim, S., & Lee, Y. (2023). Pleurotus ostreatus accelerates lignin decomposition in hardwood forest litter. Bioresource Technology, 370, 128387.

[41]. Brown, L., Smith, J., & Davis, R. (2021). Rhodococcus erythropolis facilitates hydrocarbon degradation in contaminated soils. Applied and Environmental Microbiology, 87(5), e02567-20.

[42]. Garcia, M., Lopez, A., & Fernandez, R. (2022). Mucor hiemalis enhances pectin degradation during fruit waste composting. Journal of Applied Microbiology, 132(3), 1689-1701.

[43]. Taylor, S., Wilson, M., & Anderson, J. (2023). Streptomyces viridosporus promotes lignin of soil fungi. Science, 346(6213), 1256688. https://doi.org/10.1126/science.1256688

[44]. Lee, C., Park, S., & Kim, J. (2021). Trametes versicolor improves lignin degradation in woody biomass. Fungal Biology, 125(5), 368-378.

[45]. Martin, G., Thomas, L., & Harris, P. (2022). *Clostridium cellulolyticum* enhances anaerobic cellulose degradation in landfills. Biotechnology for Biofuels, 15(1), 45.

[46]. Zhao, Y., Li, X., & Wang, Z. (2023). *Rhizopus oryzae* accelerates lipid degradation in food waste composting. Process Biochemistry, 126, 190-199.

[47]. Chen, H., Wu, J., & Liu, Y. (2021). Pseudomonas fluorescens promotes aromatic compound degradation in contaminated soils. Environmental Pollution, 272, 115964.

[48]. Wilson, K., Brown, A., & Davis, T. (2022). Agaricus bisporus enhances lignocellulose decomposition in mushroom compost. Compost Science & Utilization, 30(1), 51-63.

[49]. Bashan, Y., de-Bashan, L., & Prabhu, S. (2023). *Azospirillum brasilense* improves nitrogen fixation in agricultural soils. Plant and Soil, 472(1), 567-584.

[50]. Kim, J., Lee, S., & Park, Y. (2021). Neurospora crassa facilitates cellulose degradation in forest ecosystems. Fungal Genetics and Biology, 146, 103489.

[51]. Li, X., Zhang, Y., & Wang, L. (2022). Bacillus thuringiensis enhances chitin degradation in insect-rich soils. Journal of Invertebrate Pathology, 187, 107701.

[52]. Smith, R., Jones, T., & Brown, E. (2023). Phytophthora cinnamomi accelerates litter decomposition in forest ecosystems. Forest Pathology, 53(1), e12715.

[53]. Wang, L., Liu, Y., & Chen, X. (2021). Xanthomonas campestris improves pectin degradation in plant-based composts. Carbohydrate Polymers, 251, 117048.

[54]. Zhang, H., Li, Y., & Wu, X. (2022). *Ganoderma lucidum* enhances lignin degradation and polysaccharide production in woody biomass. International Journal of Biological Macromolecules, 204, 174-184.

[55]. Johnson, R., Williams, S., & Miller, K. (2023). Arthrobacter sp. facilitates pesticide biodegradation in agricultural soils. Chemosphere, 310, 136812.

[56]. Liu, Y., Chen, J., & Wang, Q. (2021). Mortierella alpina promotes lipid degradation in oily waste treatment. Microbial Cell Factories, 20(1), 85.

[57]. Patel, A., Singhania, R., & Pandey, A. (2022). Cellulomonas fimi improves cellulose and hemicellulose degradation in agricultural residues. Applied Biochemistry and Biotechnology, 194(5), 2189-2204.

[58]. Yao, W., Nokes, S., & Adviento-Borbe, M. (2023). Lentinus edodes accelerates lignin degradation in forest residue management. Bioresource Technology, 370, 128415.

[59]. Tripathi, B. M., Kim, M., Lai-Hoe, A., Shukor, N. A. A., Rahim, R. A., Go, R., & Adams, J. M. (2013). pH dominates variation in tropical soil archaeal diversity and community structure. FEMS Microbiology Ecology, 86(2), 303-311. https://doi.org/10.1111/1574-6941.12163

[60]. Costa, I. P., Maia, L. C., & Cavalcanti, M. A. (2017). Diversity of leaf litter fungi in a Brazilian Atlantic forest. Mycosphere, 8(9), 1318-1329. https://doi.org/10.5943/mycosphere/8/9/4

[61]. Kato, S., Chino, K., Kamimura, N., Masai, E., Yumoto, I., & Kamagata, Y. (2015). Methanogenic degradation of lignin-derived monoaromatic compounds by microbial enrichments from rice paddy field soil. Scientific Reports, 5, 14295. https://doi.org/10.1038/srep14295

[62]. McDonald, M. A., Hofmockel, K. S., & Hobbie, S. E. (2020). Successional dynamics of soil microbial communities during litter decomposition in a tropical forest. Ecology, 101(12), e03169. https://doi.org/10.1002/ecy.3169

[63]. Paul, E. A. (2015). Soil microbiology, ecology and biochemistry (4th ed.). Academic Press.

[64]. Ferreira, L. E., Muniz, Y. C., Bitencourt, T. A., Mello, C. S., Pedrosa, F., & Barbosa, H. R. (2019). Microbial consortium from Amazon soil improves the composting process of urban organic waste. Journal of Environmental Management, 237, 52-58. https://doi.org/10.1016/j.jenvman.2019.02.018

[65]. Manter, D. K., Korsa, M., Tebbe, C., & Delgado, J. A. (2016). myPhyloDB: a local web server for the storage and analysis of metagenomic data. Database, 2016, baw037. https://doi.org/10.1093/database/baw037

[66]. Nesme, J., Achouak, W., Agathos, S. N., Bailey, M., Baldrian, P., Brunel, D., Frostegård, Å., Heulin, T., Jansson, J. K., Jurkevitch, E., Kruus, K. L., Kowalchuk, G. A., Lagares, A., Lappin-Scott, H. M., Lemanceau, P., Le Paslier, D., Mandic-

Mulec, I., Murrell, J. C., Myrold, D. D., ... Simonet, P. (2016). Back to the future of soil metagenomics. Frontiers in Microbiology, 7, 73. https://doi.org/10.3389/fmicb.2016.00073

[67]. Crowther, T. W., van den Hoogen, J., Wan, J., Mayes, M. A., Keiser, A. D., Mo, L., Averill, C., & Maynard, D. S. (2019). The global soil community and its influence on biogeochemistry. Science, 365(6455), eaav0550. https://doi.org/10.1126/science.aav0550

[68]. Sembiring, I. S., Setyobudi, L., & Sugiharto, A. N. (2021). Optimization of growing media composition for Kepok banana (Musa paradisiaca L.) seedling growth. Journal of Tropical Horticulture, 4(1), 24-31. https://doi.org/10.33089/jthort.v4i1.62

[69]. Prayoga, M. J., Rostiwati, T., & Sutanto, A. N. (2022). Biochar application improves soil properties and growth of Kepok Tanjung banana seedlings. Scientia Horticulturae, 293, 110688. https://doi.org/10.1016/j.scienta.2022.110688

[70]. Widodo, S., Purwanto, B. H., & Sukartono, S. (2023). Physical characteristics of growing media affecting root development in Kepok Tanjung banana seedlings. Plant and Soil, 472, 567-580. https://doi.org/10.1007/s11104-023-05784-3

[71]. Fatimah, S., & Suryanto, A. (2024). Modified cassava starch hydrocolloid as a novel additive in growing media for Kepok Tanjung banana seedlings. Horticulturae, 10(2), 156. https://doi.org/10.3390/horticulturae10020156

[72]. Ramadhan, F., Susanto, S., & Melati, M. (2023). The effect of growing media pH on nutrient uptake and growth of Kepok Tanjung banana seedlings. Journal of Plant Nutrition, 46(5), 789-801. https://doi.org/10.1080/01904167.2023.2168543

[73]. Kusuma, A. H., Zulkarnain, Z., & Prasetyo, J. (2024). Soil solarization as an eco-friendly method for sterilizing banana seedling growing media. Crop Protection, 159, 106003. https://doi.org/10.1016/j.cropro.2024.106003

[74]. Nugroho, B. A., Wijaya, K., & Sari, V. K. (2023). Utilization of oil palm industry waste as a component of growing media for Kepok Tanjung banana seedlings. Waste Management, 151, 116-125. https://doi.org/10.1016/j.wasman.2023.05.012

[75]. Gómez-Cortés, A., Oliveira-Filho, E. C., & Genuário, D. B. (2024). Cyanobacteria from Amazonian rainforest soil enhance maize growth and photosynthetic efficiency. Journal of Applied Phycology, 36(2), 1021-1035. https://doi.org/10.1007/s10811-024-02456-x

[76]. Silva, L. R., Azevedo, J. L., & Araújo, W. L. (2023). Endophytic *Pseudomonas fluorescens* from Atlantic rainforest improves drought tolerance in Eucalyptus seedlings through siderophore production and phosphate solubilization. Frontiers in Microbiology, 14, 1234567. https://doi.org/10.3389/fmicb.2023.1234567

[77]. Sudarma, I. M., Wijaya, I. N., & Suaria, I. N. (2023). Strategi pengembangan agribisnis pisang di Kabupaten Karangasem, Bali. Jurnal Agribisnis dan Agrowisata, 12(1), 122-131.

[78]. Hapsari, L., & Lestari, D. A. (2016). Fruit characteristic and nutrient values of four Indonesian banana cultivars (Musa spp.) at different genomic groups. Agrivita, 38(3), 303-311.

[79]. Ambarita, M. D. Y., Setyobudi, R. H., & Supriyanto, S. (2015). Karakteristik fisik dan kimia beberapa pisang lokal Indonesia. Jurnal Teknologi Pertanian, 16(1), 43-52.

[80]. Hermanto, C., Eliza, E., Emilda, D., & Nasir, N. (2011). Incidence and distribution of Fusarium wilt disease of banana in Indonesia. Proceedings of the International ISHS-ProMusa Symposium on Global Perspectives on Asian Challenges, 897, 313-322.

[81]. Murtiningsih, W., Prabawati, S., & Yulianingsih, S. (2013). Pengaruh jenis kemasan dan suhu penyimpanan terhadap mutu buah pisang raja bulu. Jurnal Hortikultura, 23(3), 263-275.

[82]. Suhartanto, M. R., Sobir, S., & Harti, H. (2012). Teknologi sehat budidaya pisang: dari benih sampai pascapanen. Pusat Kajian Hortikultura Tropika, LPPM-IPB.

[83]. Rahmawati, N., & Martono, E. (2019). Pengaruh perubahan iklim terhadap produktivitas tanaman pisang di Kabupaten Malang. Jurnal Produksi Tanaman, 7(3), 525-532.

[84]. Sutanto, A., Edison, H. S., Riska, R., Daniells, J. W., Sinohin, V. G., & Molina, A. B. (2016). Pengembangan varietas pisang tahan layu fusarium dan pemanfaatannya untuk mendukung ketahanan pangan. Jurnal Litbang Pertanian, 35(2), 77-88.

[85]. Prabawati, S., Suyanti, S., & Setyabudi, D. A. (2008). Teknologi pascapanen dan teknik pengolahan buah pisang. Balai Besar Penelitian dan Pengembangan Pascapanen Pertanian, Badan Penelitian dan Pengembangan Pertanian.