Research Paper

Responsibility of PSB (*Photosynthetic Bacteria*) and Chitosan on the Growth of Banana Lase (*Musa acuminata* L.)

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Abstract

Banana (Musa spp.) is a crucial tropical fruit crop, but its cultivation faces significant challenges related to seedling availability and reliance on chemical fertilizers. Tissue culture provides a solution for large-scale seedling production. However, post-acclimatization remains a critical stage due to plant sensitivity to environmental stress. Sustainable alternatives, such as photosynthetic bacteria (PSB) and chitosan, have been suggested to improve growth and reduce chemical input dependency; however, their combined effects on banana remain underexplored. This study aimed to evaluate the influence of PSB and chitosan applications on the post-acclimatization growth of tissue-cultured Lase banana seedlings. A field experiment was conducted using a split-plot design, with PSB concentrations (10, 20, and 30 ml/L) as the main plots and chitosan concentrations (10, 15, and 20 ml/L) as subplots. Growth parameters were measured and analyzed using ANOVA at the 5% significance level, followed by DMRT for mean separation. The results revealed a significant interaction between PSB at 10 ml/L and chitosan at 10 ml/L, which produced the highest values for plant height and leaf number. This indicates that the synergistic application of PSB and chitosan enhances the early establishment of Lase banana seedlings after acclimatization. The findings contribute both practically and academically, demonstrating an effective strategy for reducing dependence on chemical fertilizers while improving seedling vigor and providing new insights into the integration of microbial inoculants and biopolymers in sustainable banana micropropagation.

Keywords: *Banana, Photosynthetic Bacteria, Chitosan*

INTRODUCTION

The economic importance of banana cultivation primarily lies in its fruit, which is valued for its large size and desirable taste. However, farmers face several challenges in banana production. The availability of seedlings in sufficient quantity is limited, production costs are high, the nursery period is prolonged, and the resulting plants are often non-uniform. Moreover, suckers as conventional planting material are highly susceptible to disease. Since seedlings are generally sourced from previously planted parent plants, their quality varies, and the supply remains inadequate. To address these constraints, the provision of high-quality planting material is essential, and tissue culture has emerged as a promising method for large-scale production of uniform and disease-free banana seedlings (Karina, 2022).

In addition to planting material, nutrient management remains a significant obstacle, particularly in Indonesia, where farmers continue to rely heavily on chemical fertilizers. Excessive use of these inputs leads to soil degradation, including compaction, acidification, and the decline of beneficial soil organisms, ultimately resulting in soil dependence on external fertilization. A sustainable alternative is the use of photosynthetic bacteria (PSB) fertilizer, which enhances nitrogen availability and supports plant growth through the process of photosynthesis. PSB is relatively easy to produce using low-cost materials, allowing farmers to reduce production

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expenses while decreasing reliance on synthetic fertilizers. Furthermore, as an organic fertilizer composed of natural microorganisms, PSB offers environmental benefits and greater safety compared to chemical fertilizers (Brahmana et al., 2022).

Another critical challenge arises during the post-acclimatization stage of tissue-cultured banana seedlings, when plants transition from nursery conditions to the harsher environment of open fields. During this stage, fluctuations in temperature, humidity, and light intensity expose plantlets to environmental stress, which strongly influences their survival and subsequent productivity. Chitosan, a linear polymer obtained from the deacetylation of chitin in crustacean shells, has been identified as a potential biostimulant to overcome these challenges (Kanani et al., 2023). Chitosan not only promotes plant growth and development by inducing gibberellin synthesis, but also mitigates abiotic stress factors such as drought and nutrient deficiency, thereby improving plant vigor and yield (Gustia & Wulandari, 2022; Agustini et al., 2020).

Although research on the combined application of PSB and chitosan in banana cultivation remains limited, the integration of these two bio-based inputs is expected to improve growth, productivity, and fruit quality. More importantly, their use aligns with the principles of sustainable agriculture by reducing dependence on chemical fertilizers and promoting environmentally friendly cultivation practices.

LITERATURE REVIEW

Banana (*Musa* spp.) is one of the most diverse tropical fruits in Southeast Asia. Its widespread consumption is primarily attributed to its sweet flavor, soft texture, and affordability. Among the cultivated varieties, the Barangan banana is particularly popular. This cultivar belongs to the triploid group (AAA) derived from *Musa acuminata* L. (Poerba et al., 2018).

Plant tissue culture has become a crucial technique for the mass propagation of banana cultivars, providing a reliable method for producing disease-free and uniform planting material. Within this technique, acclimatization constitutes the final and most critical stage, as it largely determines the success of seedling establishment. This stage involves adapting plantlets from controlled in vitro growth conditions to ex vitro or field environments (Muhklisani et al., 2021).

Failures in tissue culture propagation frequently occur during acclimatization, necessitating careful and intensive management (Gunarta et al., 2023). This phase is considered critical because plantlets are highly vulnerable and susceptible to environmental stress (Faradilla et al., 2021). Problems encountered during acclimatization arise from both internal and external factors. Internally, newly transferred plantlets often exhibit abnormal traits, including excessive succulence, thin cuticles, underdeveloped vascular tissues, and non-functional stomata. Externally, variables including growth medium, temperature, humidity, and light intensity significantly affect acclimatization success (Habibah et al., 2021).

Moreover, acclimatization is widely recognized as the most challenging stage in the in vitro regeneration of plants. In Indonesia, acclimatization failure remains a significant challenge in large-scale tissue culture applications. This stage requires substantial expertise and careful handling, as it involves transitioning plantlets from culture vessels to soil in open environmental conditions. The adjustment of micropropagated seedlings to external environments represents a crucial step in the tissue culture process. Acclimatization also marks the physiological shift of plantlets from a heterotrophic to an autotrophic mode of growth, making it the final and decisive stage of in vitro culture (Slamet, 2020).

The implementation of environmentally friendly agriculture requires practices that minimize the use of chemical fertilizers and pesticides. The application of photosynthetic bacteria (PSB) has been shown to improve plant performance by enhancing flower primordial initiation, increasing the total number of flowers, strengthening disease resistance, reducing the dependence on chemical fertilizers, promoting root development, and increasing tolerance against pests and diseases (Priyono, 2022).

The function of photosynthetic bacteria lies in their ability to enhance the efficiency of nutrient absorption in plants. Photosynthetic bacterial cells consist of approximately 60% protein, comprising all essential amino acids. They are also rich in vitamins and minerals, including B1, B2, B5, and B12, folic acid, vitamin C, vitamin D, and vitamin E. These properties enable photosynthetic bacteria to act as natural supplements or bio-nutrients, thereby reducing the need for chemical fertilizers, lowering production costs by up to 50%, and supporting environmentally sustainable agricultural practices. Furthermore, photosynthetic bacteria stimulate root development and branching, resulting in improved fiber production, and strengthen plant immunity in leaves, flowers, fruits, and bark, thereby enhancing resistance to pests and diseases. They also promote faster growth of roots, leaves, flowers, and branches, reduce fungal or pathogen infections, and help control root rot disease. Plants treated with organic fertilizers containing photosynthetic bacteria (PSB) have also been reported to produce fruits with superior taste quality (Qomariah & Mawardi, 2024).

Chitosan is a linear polymer derived from chitin through a process of deacetylation. Both chitin and chitosan are naturally found in the exoskeletons of crustaceans such as shrimp, crabs, and lobsters (Kanani et al., 2023). Chitosan is considered a chitin derivative with a similar chemical structure, differing mainly in that the majority of its glucopyranose residues are in a deacetylated form, where the amide group at the C2 position of glucosamine is not bound to an acetyl or acetamide group (Nainggolan, 2023).

In agriculture, chitosan has been widely applied as a biodegradable mulch, edible film, biopesticide, food preservative, and plant growth regulator (Faqir et al., 2021). It functions as a biostimulant that promotes plant growth and development, while also alleviating abiotic stresses such as drought and excessive heat. This role is essential for enabling plants to sustain growth under suboptimal environmental conditions (Bani et al., 2022). Moreover, chitosan has been reported to enhance the activity of key defense-related enzymes, including peroxidase, phenylalanine ammonia-lyase, tyrosine ammonia-lyase, and catalase. Additionally, it exhibits antifungal, antiviral, and nematicidal properties. Chitosan can also serve as a carrier agent for controlled-release fertilizers when combined with nutrient formulations, thereby enhancing fertilizer efficiency (Román-Doval et al., 2023).

RESEARCH METHOD

Research Location

The study was carried out at the experimental garden of the Faculty of Agriculture, Universitas Pembangunan Nasional Veteran Yogyakarta.

Research Materials and Tools

Materials used in the study were three-month-old tissue-cultured Lase banana plantlets, goat manure fertilizer, rice husk charcoal, regosol soil, PSB, chitosan, vitamin B1, NPK fertilizer, acetic acid, distilled water, Furadan, and insecticide.

Tools used in the research included stationery, a caliper, a hoe, a measuring tape, a dibbler, a ruler, a sprayer, a scale, a watering can, a measuring glass, and a camera.

Experimental Design

The study was conducted as a field experiment employing a Split-Plot Design, with the primary factor being the concentration of PSB and the secondary factor being the concentration of Chitosan. The primary factor in the experimental design was the concentration of PSB, which included three levels:

P1 = 10 ml/L
P2 = 20 ml/L
P3 = 30 ml/L

The secondary factor in the experimental design was the concentration of Chitosan, which consisted of three levels:

K1 = 10 ml/L
K2 = 15 ml/L
K3 = 20ml/L

Data Analysis

The observational data were analyzed using Analysis of Variance (ANOVA) at a 5% significance level, followed by a Duncan's Multiple Range Test (DMRT) to assess differences at the 5% level further.

FINDINGS AND DISCUSSION

Plant Height

Table 1 shows that the combination treatment of PSB at a concentration of 10 ml/L and chitosan at 10 ml/L produced the tallest plants compared to other treatment combinations. In these two treatments, a synergistic relationship was observed, where each factor influenced the other. Plant height growth is strongly affected by the availability of sufficient nutrients to sustain the plant's metabolic processes. The application of chitosan has been demonstrated to enhance plant growth, as indicated by increased plant height, root length, fruit weight, total fruit weight per plant, and overall yield. Chitosan can also increase the activity of enzymes such as peroxidase, phenylalanine ammonia-lyase, tyrosine ammonia-lyase, and catalase. Additionally, chitosan serves as an antifungal, antiviral, and bionematicide agent. It can also act as a carrier agent that promotes the slow release of fertilizers by incorporating fertilizers with chitosan (Román-Doval et al., 2023).

Table 1. Plant Height (cm)

Treatment	Concentration of Chitosan			Average
	K1 (10 ml/L)	**K2 (15 ml/L)**	**K3 (20 ml/L)**	
PSB Concentration				
P1 (10 ml/L)	141,67 a	106,33 bcd	99,67 bcd	115,89
P2 (20 ml/L)	112,67 bc	110,33 bc	118,67 b	113,89
P3 (30 ml/L)	84,00 de	87,33 cde	65,67 e	79,00
Average	112,78	101,33	94,67	(+)

Notes: Means followed by the same letter in rows and columns indicate no significant difference based on DMRT at 5% level. The sign (+) indicates there is an interaction.

Photosynthetic bacteria (PSB) are autotrophic bacteria capable of photosynthesis. PSB contains pigments called bacteriochlorophyll a or b, which produce red, green, and purple pigments that capture solar energy as fuel for photosynthesis. The benefits of PSB include increasing nitrogen availability for plants, enhancing taste quality, promoting root growth, and strengthening plant resistance against pests and diseases (Suyana et al., 2023). The application of PSB fertilizer serves as a "vitamin" for plants. When combined with chitosan, PSB is beneficial in accelerating and strengthening root development, increasing resistance to pests, and improving the quality of fruits, leaves, and flowers in plants.

Leaf Number

Table 2 shows that the combination treatment of PSB at 10 ml/L and chitosan at 10 ml/L resulted in a higher leaf number compared to other treatment combinations. Several factors, including both genetic and environmental influences, can impact plant growth. One important environmental factor is the availability of nutrients; when nutrients are supplied in sufficient and even amounts, plants can grow optimally.

According to Ibnusina et al. (2022), the number of leaves in plants is influenced by pest attacks, the nutrient content in the growing medium, aeration treatments, and root drainage. An increase in leaf number is considered an indicator that plant nutrient requirements are being met. The increase in leaf blades in plants is thought to be influenced by the high nutrient demand supplied by inorganic fertilizers, which in turn affects the photosynthesis process. The primary nutrient required for photosynthesis is nitrogen (N). This finding is consistent with the results of Zulkifli et al. (2022), who stated that photosynthetic products in plants serve as food reserves and energy sources, thereby promoting cell division and differentiation processes closely related to the development of plant organs, including the number of leaves.

Table 2. Leaves Number (leaves)

Treatment	Concentration of Chitosan			Average
	K1 (10 ml/L)	K2 (15 ml/L)	K3 (20 ml/L)	
PSB Concentration				
P1 (10 ml/L)	11,00 a	6,67 b	6,67 b	8,11
P2 (20 ml/L)	5,33 bc	5,00 c	5,33 bc	4,03
P3 (30 ml/L)	6,67 b	5,67 bc	6,00 bc	6,11
Average	7,60	5,78	6,00	(+)

Notes: Means followed by the same letter in rows and columns indicate no significant difference based on DMRT at 5% level. The sign (+) indicates there is an interaction.

PSB fertilizer works by helping plants utilize the phosphorus present in the soil. Its mechanism begins when the bacteria release organic acids and specific enzymes that can solubilize insoluble phosphate in the soil, converting it into a form that plants can absorb. This process increases phosphorus availability around the plant roots, allowing plants to absorb more nutrients. Adequate phosphorus supply can improve root growth, flowering, and overall yield. Additionally, PSB contributes to overall soil health by enhancing soil structure and promoting the growth of other beneficial soil microorganisms (Brahmana et al., 2022).

This finding is consistent with the results of Gustia and Wulandari (2022), who reported that the addition of chitosan at a concentration of 8 mL/L produced the highest number of leaves by inducing signals that synthesize growth hormones, such as gibberellins, which play a role in cell division and leaf formation. The auxins present in chitosan also play a role in cell division, elongation, and differentiation, thereby enhancing plant growth and development. Nitrogen (N) is one of the main components required in leaf formation. Since chitosan is composed primarily of nitrogen, it plays a crucial role in the synthesis of proteins, chlorophyll, and nucleic acids, all of which support overall plant growth, particularly in stems and leaves (Maluin & Hussein, 2020).

CONCLUSIONS

The combined application of PSB (10 ml/L) and chitosan (10 ml/L) significantly improved plant height and leaf number in Musa acuminata L. during post-acclimatization. This synergy provides a sustainable approach to enhancing banana seedling establishment and reducing reliance on chemical inputs, underscoring the potential of integrating biofertilizers and biopolymers in horticultural production.

This study provides novel empirical evidence of the synergistic role of PSB and chitosan in supporting post-acclimatization growth. The findings contribute to the scientific discourse on environmentally friendly inputs for tissue culture-derived crops.

LIMITATIONS & FURTHER RESEARCH

This study was limited to a single cultivar (*Musa acuminata* L.) and focused primarily on early vegetative traits. Further research should investigate the physiological and biochemical mechanisms underlying the observed synergy, test different banana cultivars and various environmental conditions, and assess the long-term effects on yield and fruit quality. Such studies will strengthen the practical application of PSB–chitosan integration in sustainable banana production systems.

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