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

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Abstract

The post-acclimatization stage is a critical period for Lase banana (Musa acuminata L.) plants derived from tissue culture, as they must adapt to open-field environmental conditions. The application of photosynthetic bacteria (PSB) and chitosan has the potential to enhance plant growth and development, as well as improve the tolerance of banana plants during the post-acclimatization stage. The primary objective of this study was to obtain Lase banana seedlings from tissue culture with optimal field growth through the application of PSB and chitosan. The experiment was conducted using a split-plot design in a field setting, with the main plots representing PSB concentrations (10, 20, and 30 mL/L) and the subplots representing chitosan concentrations (10, 15, and 20 mL/L). Data were analyzed using ANOVA at the 5% significance level and further tested using Duncan's Multiple Range Test (DMRT) at the 5% level. The results showed a significant interaction between PSB at 20 mL/L and chitosan at 15 mL/L for several parameters, including root number and length, plant fresh weight, and total chlorophyll content of Lase banana plants.

INTRODUCTION

Banana (Musa acuminata L.) is one of Indonesia's leading tropical fruits, widely favored by people of all ages. One of the popular varieties is the Lase banana. Bananas have high economic value and are rich in nutrients beneficial to human health (Lubis, 2021). The post-acclimatization stage represents a critical period in the propagation of plants through tissue culture, as plants are vulnerable to environmental stress that affects their growth. During this stage, plants must adapt from the shaded conditions of the nursery to the more extreme open-field environment, characterized by changes in temperature, humidity, and light intensity. The success of this phase greatly determines the subsequent growth and productivity of banana plants.

One potential approach to overcoming these challenges is the application of photosynthetic bacteria as a liquid organic fertilizer and chitosan as a biostimulant or plant growth regulator. These substances are known to enhance plant growth and development as well as mitigate the effects of environmental stress. At present, one of the major issues faced by farmers in Indonesia is their dependency on chemical fertilizers, which has negative impacts on both the environment and plants. Excessive use of chemical fertilizers hardens and acidifies the soil, causes the death of beneficial soil microorganisms, and makes the soil dependent on external fertilizer inputs. Furthermore, crops become more susceptible to diseases, and chemical residues tend to accumulate in the soil. This ongoing dependency on chemical inputs perpetuates environmental degradation, making it increasingly difficult to reduce chemical fertilizer use (Kurnianingrum, 2021). To reduce this dependency, it is necessary to increase soil organic matter to maintain crop productivity. One promising alternative is the use of photosynthetic bacteria, which can serve as a nutrient source for beneficial microbes and plants. The application of PSB represents an environmentally friendly agricultural input that supports sustainable farming systems (Dobrin et al., 2020).

Several previous studies have demonstrated the positive effects of photosynthetic bacteria and chitosan on various crops. Batubara et al. (2021) reported that photosynthetic bacteria can fix atmospheric nitrogen, making it available for plant use, particularly in chlorophyll formation. Qomariah and Mawardi (2024) further explained that PSB application on cucumber plants significantly increased photosynthetic activity, resulting in higher photosynthate production and improved root growth. Similarly, Manukoto et al. (2024) found that chitosan application on stevia plants stimulated root growth and development during the early growth stage, thereby enhancing nutrient absorption. Nurhasanah et al. (2024) also reported that the auxin content in chitosan promotes root elongation and cell division in potato plantlets. In banana plants, Gustia and Wulandari (2022) demonstrated that chitosan application triggered gibberellin hormone synthesis signals, stimulating the vegetative growth of Kepok banana seedlings. Additionally, Bani et al. (2022) showed that chitosan application increased nitrogen and potassium content in Dendrobium orchids during acclimatization, contributing to enhanced chloroplast formation and photosynthetic rates.

Photosynthetic bacteria function by enhancing the plant’s ability to absorb nutrients more efficiently. These bacteria contain approximately 60% protein, including all essential amino acids, as well as vitamins and minerals such as B1, B2, B5, B12, folic acid, vitamin C, vitamin D, and vitamin E. They act as bio-supplements that can reduce the need for chemical fertilizers and, indirectly, production costs by up to 50%. PSB also stimulate root growth and branching, resulting in a better-developed root system. Moreover, they help strengthen plant tissues, including leaves, flowers, fruits, and bark—making them more resistant to pests and diseases. PSB promote faster growth of roots, leaves, and branches, reduce infections caused by fungi or pathogens, and can effectively suppress root rot diseases (Qomariah & Mawardi, 2024).

Chitosan is a linear polymer derived from the deacetylation of chitin, which can be found in the shells of crustaceans (Kanani et al., 2023). Chitosan acts as a biostimulant that promotes plant growth and development. Previous studies have shown that the application of chitosan can trigger gibberellin hormone synthesis signals, thereby stimulating plant growth and improving the growth performance of banana plants compared to other media compositions (Gustia & Wulandari, 2022). Additionally, chitosan can alleviate environmental stress caused by drought and nutrient deficiency while enhancing plant productivity (Agustini et al., 2020). According to Crini et al. (2019), chitosan exhibits strong antifungal properties due to its chelating ability, possesses bactericidal and bacteriostatic activities, and can activate plant defense responses.

Although research on the individual application of PSB and chitosan has been widely reported, studies on their combined application—particularly in banana plants—remain very limited. Most previous research has focused on the single effects of either PSB or chitosan on various crops such as cucumber, stevia, potato, and orchids, but no studies have specifically examined the synergistic interaction between PSB and chitosan on the growth of Lase banana plants during the post-acclimatization stage. Therefore, this study is expected to provide insights into their potential synergistic effects in improving banana plant growth, productivity, and quality while contributing to the development of environmentally friendly and sustainable agricultural practices.

METHOD

This study is a quantitative experimental research conducted as a field experiment. The study aims to examine the effect of Photosynthetic Bacteria (PSB) and chitosan application on the growth of Lase banana (Musa acuminata L.) plants during the post-acclimatization stage. The experimental design used was a Split Plot Design, with the main plot consisting of Photosynthetic Bacteria concentrations and the subplot consisting of chitosan concentrations.

Research Location

The study was carried out at the experimental garden of the Faculty of Agriculture, UPN "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, Photosynthetic Bacteria , chitosan, vitamin B1, NPK fertilizer, acetic acid, distilled water, furadan, and insecticide.

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

Experimental Design

The study was conducted as a field experiment employing a Split Plot Design, with the primary factor being the concentration of Photosynthetic Bacteria and the secondary factor being the concentration of Chitosan.

The primary factor in the experimental design was the concentration of Photosynthetic Bacteria, 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 further assess differences at the 5% level.

RESULTS AND DISCUSSION

A. Number of Roots

The combination treatment of Photosynthetic Bacteria at a concentration of 20 mL/L and chitosan at 15 mL/L produced a significant interaction that enhanced the number of roots in banana plants. The mean values of root number are presented in Table 1.

Table 1. Number of Roots

Treatment	Concentration of Chitosan			Average
	K1 (10 ml/L)	K2 (15 ml/L)	K3 (20 ml/L)	
PSB Concentration				
P1 (10 ml/L)	17,33 bc	11,33 d	14,00 cd	14,22
P2 (20 ml/L)	17,33 bc	28,33 a	12,67 cd	19,44
P3 (30 ml/L)	19,67 b	14,00 cd	17,33 bc	17,00
Average	18,11	17,89	14,67	(+)

Source: Primary data processed (2025)

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.

The application of Photosynthetic Bacteria is presumed to increase the number of roots in banana plants due to its ability to optimize the photosynthetic process, thereby promoting overall plant growth. This finding is consistent with the study by Batubara et al. (2021), which reported that Photosynthetic Bacteria can fix atmospheric nitrogen, making it available for plant use, particularly in chlorophyll formation. In addition, PSB enhances light capture during the day, which plants cannot fully achieve on their own. Qomariah and Mawardi (2024) further explained that photosynthesis directly influences plant growth, as an increase in photosynthetic activity leads to a higher production of photosynthates, consequently increasing the number of roots.

According to Manukoto et al. (2024), chitosan functions as a biostimulant that stimulates root growth and development during the early stages of plant growth, thereby improving nutrient absorption. Similarly, Nurhasanah et al. (2024) stated that, in addition to enhancing nutrient uptake, the auxin content in chitosan also contributes to increasing root number. Auxin promotes root elongation, growth, and development by enhancing cell division activity. The increase in cell division supports overall plant development, enabling faster root formation from meristematic tissues.

B. Root Length (cm)

The treatment combination of Photosynthetic Bacteria at a concentration of 20 mL/L and chitosan at 15 mL/L produced a significant interaction that enhanced root length in banana plants. The mean values of root length are presented in Table 2.

Table 2. Root Length of Banana Plants (cm)

Treatment	Concentration of Chitosan			Average
	K1 (10 ml/L)	K2 (15 ml/L)	K3 (20 ml/L)	
PSB Concentration				
P1 (10 ml/L)	22,17 bc	24,43 b	28,33 b	24,98
P2 (20 ml/L)	14,63 c	40,73 a	21,67 bc	25,68
P3 (30 ml/L)	20,77 bc	25,00 b	19,50 bc	21,76
Average	19,19	30,06	23,17	(+)

Source: Primary data processed (2025)

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.

The application of Photosynthetic Bacteria is believed to increase root length in banana plants because Photosynthetic Bacteria provides multiple benefits, including stimulating root growth, improving nutrient uptake efficiency, and enhancing light capture for photosynthesis. These synergistic functions of Photosynthetic Bacteria contribute to improved root growth and overall plant development.

According to Manukoto et al. (2024), chitosan functions as a biostimulant that promotes root growth and development during the early growth stage, thereby enhancing nutrient absorption. Similarly, Nurhasanah et al. (2024) reported that, in addition to improving nutrient uptake, the auxin content in chitosan also plays a role in promoting root elongation. Auxin stimulates root elongation, growth, and development by increasing cell division activity. The enhanced rate of cell division supports overall plant growth and accelerates root formation from meristematic tissues.

C. Plant Fresh Weight (kg)

The treatment combination of Photosynthetic Bacteria at a concentration of 20 mL/L and chitosan at 15 mL/L produced a significant interaction that increased the fresh weight of banana plants. The mean values of plant fresh weight are presented in Table 3.

Table 3. Fresh Weight of Banana Plants (kg)

Treatment	Concentration of Chitosan			Average
	K1 (10 ml/L)	K2 (15 ml/L)	K3 (20 ml/L)	
PSB Concentration				
P1 (10 ml/L)	0,32 b	0,29 b	0,28 b	0,30

P2 (20 ml/L)	0,17 b	0,83 a	0,19 b	0,40
P3 (30 ml/L)	0,30 b	0,18 b	0,24 b	0,24
Average	0,26	0,43	0,24	(+)

Source: Primary data processed (2025)

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.

The application of Photosynthetic Bacteria is believed to increase the fresh weight of banana plants due to its role in accelerating the photosynthetic process and providing essential amino acids that contribute to cell division. According to Batubara et al. (2021), photosynthetic bacterial cells contain approximately 60% protein, consisting of all essential amino acids as well as various vitamins and minerals. Among these amino acids, tryptophan acts as a precursor and regulator of growth hormones such as auxins and cytokinins, which play an important role in cell division and elongation processes, including fruit formation.

According to Bani et al. (2022), the application of chitosan can increase the nitrogen and potassium content in plants, which contributes to the enhancement of chloroplast formation. The increase in chloroplasts subsequently raises chlorophyll content, leading to higher photosynthetic rates. The photosynthates produced are then translocated throughout the plant and utilized as an energy source for both vegetative and generative growth (Zulfita et al., 2024). The improvement in the growth and development of vegetative organs such as stems, leaves, and roots consequently increases the plant's fresh weight. Furthermore, Lodan et al. (2023) reported that chitosan enhances water and nutrient absorption, which further contributes to an increase in plant fresh weight.

D. Total Chlorophyll Content (mg/g)

The treatment combination of Photosynthetic Bacteria at a concentration of 20 mL/L and chitosan at 15 mL/L produced a significant interaction that increased the total chlorophyll content in the leaves of banana plants. The mean values of total chlorophyll content are presented in Table 4.

Table 4. Total Chlorophyll Content (mg/g)

Treatment	Concentration of Chitosan			Average
	K1 (10 ml/L)	K2 (15 ml/L)	K3 (20 ml/L)	
PSB Concentration				
P1 (10 ml/L)	0,32 b	0,29 b	0,28 b	0,30
P2 (20 ml/L)	0,17 b	0,83 a	0,19 b	0,40
P3 (30 ml/L)	0,30 b	0,18 b	0,24 b	0,24
Average	0,26	0,43	0,24	(+)

Source: Primary data processed (2025)

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.

This result is presumably related to the relatively high nitrogen content in photosynthetic bacteria, which influences chlorophyll formation. According to Maemunah et al. (2019), nitrogen plays an essential role in chlorophyll synthesis in leaves. Chlorophyll is crucial for photosynthesis as well as for protein and lipid synthesis. This finding aligns with Istina (2016), who stated that nitrogen availability in plants promotes protein formation that enhances the rate of photosynthesis; however, excessive nitrogen can disrupt plant growth.

Chitosan contains both macro- (N, P, K, Mg, S) and micro-nutrients (Fe, Mn, Cu, Zn, B, Mo). Among these nutrients, nitrogen (N), magnesium (Mg), and iron (Fe) are key elements involved in chlorophyll synthesis, acting as building components and catalysts. Magnesium functions as a component in enzyme formation involved in various protein synthesis processes necessary for chlorophyll production. This element is predominantly found in leaves, where it supports chlorophyll availability. Titiaryanti and Hastuti (2022) also noted that the greater the chlorophyll content formed, the higher the photosynthate production.

Iron (Fe) plays an important role in chlorophyll formation and photosynthesis during the vegetative phase by supporting plant height and leaf number through the differentiation of meristematic cells at the growing points. These processes require energy derived from the breakdown of organic compounds produced during photosynthesis. Since chlorophyll is synthesized in the leaves, an increase in leaf number will correspondingly enhance chlorophyll production (Pavlovic et al., 2014).

CONCLUSION

The combination of photosynthetic bacteria at 20 mL/L and chitosan at 15 mL/L was the most effective treatment, significantly increasing the number and length of roots, plant fresh weight, and total chlorophyll content of Lase banana (Musa acuminata L.) plants. This combination is considered the optimal treatment for enhancing growth and vigor during the post-acclimatization stage. Based on these findings, it is recommended that further research be conducted to test the application of this optimal treatment combination on a larger scale, such as in farmer field trials or commercial plantation settings. Future studies should also examine the long-term effects of PSB and chitosan application on the generative growth phase, including flowering time, fruit yield, and fruit quality. Additionally, research exploring the molecular mechanisms underlying the synergistic interaction between PSB and chitosan in promoting plant growth would provide valuable scientific insights. For farmers and agricultural practitioners, the application of 20 mL/L PSB combined with 15 mL/L chitosan is recommended as an environmentally friendly alternative to reduce dependency on chemical fertilizers while maintaining optimal plant growth. It is also suggested that extension programs be developed to disseminate this technology to banana growers, particularly those cultivating tissue-culture-derived plantlets during the critical post-acclimatization period.

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