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Effectiveness of Bacillus nigr Liquid Organic Fertilizer on Early Growth Parameters of Coconut Plants

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ABSTRACT

The coconut palm (Cocos nucifera) is an economically and culturally significant crop widely cultivated in tropical regions, particularly in Indonesia. However, coconut productivity remains suboptimal due to aging plantations and poor soil conditions. To address this, biofertilizers such as Bacillus nigr have been proposed as sustainable alternatives to chemical fertilizers. This study aimed to evaluate the effect of Bacillus nigr-based liquid organic fertilizer (POC) on the early growth parameters of coconut plants aged 9 to 12 months. Conducted in Deli Serdang, North Sumatra, the experiment involved 38 coconut seedlings divided equally into treatment (POC) and control groups. Data on stem height were collected and analyzed using a T-test. The results demonstrated a statistically significant difference ($p < 0.05$) in stem height between the POC-treated and untreated plants, with notable growth advantages observed in the control group at 11 and 12 months. However, POC treatment showed promising effects at earlier growth stages (9–10 months). These findings suggest that Bacillus nigr-based POC may influence early vegetative growth, but long-term benefits and dosage optimization require further investigation. This study contributes to the growing body of knowledge on the role of microbial biofertilizers in sustainable coconut cultivation and offers insights for enhancing early-stage coconut growth using environmentally friendly agricultural practices.

Keyword : Bacillus nigr; biofertilizer; Cocos nucifera; organic liquid fertilizer; plant growth.

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1. INTRODUCTION

The coconut palm (Cocos nucifera) is a versatile palm tree known as the “tree of life” or “Kalpavriksha.” It provides a variety of products, including coconut oil, milk, and dried coconut, which are in high demand globally. Major producers, including Indonesia, India, and the Philippines, benefit economically from its cultivation. The tree has medicinal benefits and supports livelihoods, with its parts used for food, handicrafts, and construction.(Henrietta et al., 2022).

Coconut trees are cultivated in more than 90 countries, with significant concentrations in Asia and the Pacific region. Indonesia, the Philippines, and India are the leading producers. Indonesia is the world's largest coconut producer, contributing 30% of global production with 18 million tons in 2012. Coconut trees thrive in tropical climates, require minimal maintenance, and adapt well to various soil types. Approximately 11.8 million hectares are planted with coconut trees in Indonesia, which, together with the Philippines and India, account for 75% of global production. (de Freitas Barros, 2021; Pham, 2016). It can reach heights of up to 25 meters and has more than 300 ecotypes, with two main varieties: Typica (giant) and Nana (dwarf).(de Freitas Barros, 2021). Coconut cultivation in Indonesia covers approximately 3.7 million hectares, but productivity remains low at 1.1 tons of copra per hectare per year. This low yield is mainly due to more than 50% of coconut trees being over 50 years old and the common monoculture planting system (Benhdard, 2015).

Coconut tree growth is influenced by land characteristics, with peatlands showing lower sustainability than coastal areas. Key factors affecting growth include ecological aspects such as fertilizer and pesticide use, socio-cultural factors such as family involvement, economic factors such as coconut selling systems,

and technological considerations such as optimal planting distance and seed quality. (Vaulina et al., 2024).

Soil quality, including factors such as pH, organic carbon content, and cation exchange capacity, plays an important role in determining the suitability of land for coconut growth. Improving soil quality through the use of cover crops and balanced fertilization can increase coconut productivity. (Irawan et al., 2022). The application of fertilizers significantly influences the growth and productivity of coconut trees. Fertilization strategies, including the use of mineral, organic, and specialized fertilizers, have been proven to enhance coconut yields by improving soil nutrient content and plant health. The effectiveness of these fertilizers varies depending on their type, combination, application method, and the specific environmental conditions of the coconut plantation. Mineral fertilizers, particularly phosphorus (P) and potassium (K), have been shown to significantly increase coconut yields.
In a study conducted in Pará, Brazil, P and K fertilization increased the number of coconuts per plant and the weight of fresh albumen per hectare. The recommended application rate is 54 kg/ha/year of P_2O_5 and 96 kg/ha/year of K_2O from the sixth year of planting (Lins et al., 2022). Zinc, an important micronutrient, improves growth attributes and photosynthetic performance in dwarf green coconut seedlings. Optimal zinc doses increase leaf area, height, and dry mass, improving overall plant vigor (Moraes et al., 2023). The use of manure and integrated fertilizers improves the physical and chemical properties of the soil, such as pH and organic carbon content, which leads to increased coconut yields. The application of recommended fertilizer doses together with organic amendments such as neem cake and vermicompost is highly effective (Pawar et al., 2024).
Bacillus species are generally known for their ability to enhance plant growth, improve soil health, and reduce dependence on chemical fertilizers. These bacteria promote plant growth by fixing nitrogen, solubilizing phosphorus, and producing growth-promoting substances such as phytohormones and antibiotics. The use of Bacillus-based biofertilizers has been extensively studied and applied in various agricultural settings, demonstrating significant potential in improving crop yields and soil quality. Bacillus species, including Bacillus subtilis and Bacillus amyloquefaciens, have been shown to enhance plant growth by increasing root mass and improving nutrient uptake. In a study on corn, treatment with Bacillus strains resulted in increased root mass and dry matter yield, demonstrating their potential as a viable alternative to chemical fertilizers.(la Paz et al., 2022). The application of Bacillus biofertilizer can significantly improve the physicochemical and biological characteristics of soil. For example, Bacillus strains used in kitchen waste composting have been proven to improve soil quality and inhibit plant diseases.(Zhanyuan et al., 2020).
Bacillus nigr is a type of bacteria that has the ability to facilitate phosphate dissolution and improve soil structure, thereby increasing the availability of nutrients for plants. This bacterium also plays a role in stimulating root growth and overall plant biomass formation. Several studies have demonstrated the effectiveness of Bacillus in supporting the growth of horticultural and food crops; however, research on the specific effects of POC Bacillus nigr on coconut plants remains limited.
In the context of early coconut tree growth, the 9- to 12-month age phase is a critical period for root system and stem development, which will determine long-term productivity. Therefore, agronomic interventions such as POC application need to be systematically evaluated to determine their effects on coconut vegetative growth during this phase.
This study aims to determine the differences in coconut tree growth between those treated and untreated with liquid organic fertilizer based on Bacillus nigr at 9, 10, 11, and 12 months of age. Through an experimental approach and data analysis using the t-test, this study is expected to provide scientific contributions in supporting the use of biofertilizers as part of sustainable agricultural systems, particularly for coconut as a commodity.

2. RESEARCH METHOD

A. Location and Time of Research

This research will be carried out in CV Tiungmas Agrolestari, Pantai Cermin District, Deli Serdang Regency, North Sumatra Province. This research will be carried out in June – August 2024.

B. Population and Sample

This study used 38 plant samples, with 19 cases and 19 controls.

C. Research Tools and Materials

The tools used in this study are polybags, padlocks, hoes, hand sprayers, scales, and cameras. The materials used in this study were coconut seeds, and POC.

D. Data Collection Techniques

This study uses the Non-Factorial Group Random Design (RAK) method consisting of 1 factor and 5 treatments so that there are 20 units of research experiments. The factors studied consist of:

H0 = Control
H1 = POC

E. Data Analysis

The data from the research results were analyzed with a T-test to see the difference in growth in coconut plants.

3. RESULTS AND DISCUSSION

A. Result

Usia	Tinggi batang		Sig
	Case	Control	
9	1.2	2.0	
10	5.5	8.2	
10	3.6	8.5	
10	5.0	8.5	
10	1.0	6.0	
10	1.4	3.5	0.021
10	3.0	5.0	
10	4.3	5.7	
11	6.2	5.4	
11	3.5	5.0	
11	5.6	6.5	
11	11.0	13.5	
11	5.0	8.5	
11	4.0	7.0	
11	6.2	4.2	
11	7.4	5.6	
12	15.0	11.0	
12	5.7	9.0	
12	12.0	9.8	

Based on the data above, it is known that there is a difference in tree height with a p value <0.05 (0.021).

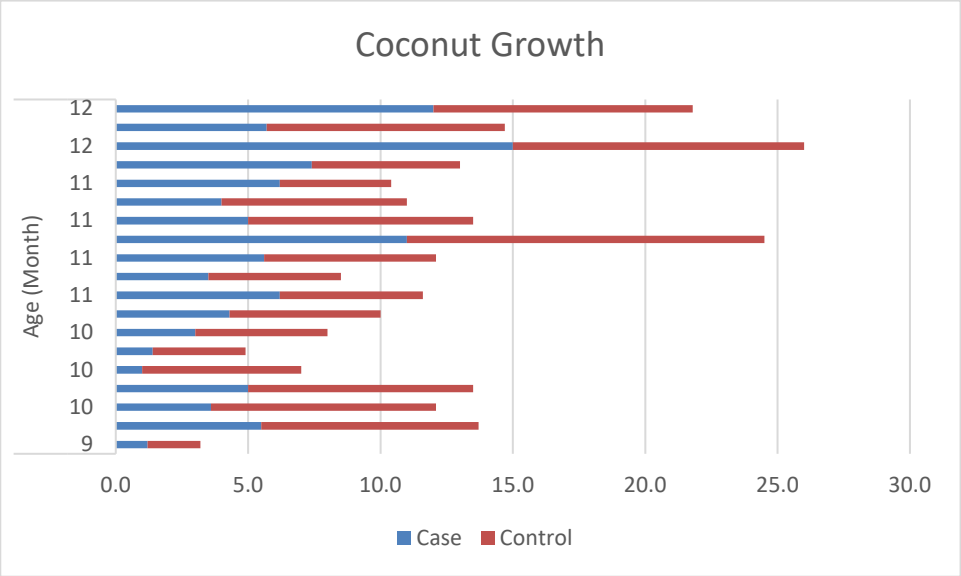

Figure 1. Coconut growth in the case and control groups

The graph shows that at 9 to 10 months of age, coconut growth in the Case group was generally higher or equivalent to that in the Control group. This indicates that at a young age, the treatment or intervention applied to the Case group likely had a positive effect on plant growth. However, this pattern changed significantly at 11 and 12 months, where growth in the Control group experienced a much higher surge compared to the Case group, especially at 11 months, which showed the highest overall growth.

B. Discussion

Bacillus species, particularly Bacillus megaterium, have gained considerable attention in agricultural and ecological research due to their significant role in promoting plant growth and enhancing soil fertility. One of the primary mechanisms through which Bacillus spp. exert their beneficial effects is the solubilization of phosphorus, a macronutrient that is essential for various physiological processes in plants, including root development, energy transfer (ATP synthesis), and nucleic acid formation. In many soils, phosphorus exists in forms that are insoluble and thus unavailable to plants. However, Bacillus species can secrete organic acids and phosphatases that convert these insoluble forms into soluble phosphorus, thereby making the nutrient accessible to plants (Shalaby, 2023). This microbial mechanism is particularly valuable in problematic soils, such as saline or acidic environments, where nutrient availability is inherently restricted. In such conditions, the presence of Bacillus spp. has been linked to increased availability of not only phosphorus but also potassium—another critical macronutrient that contributes to robust tree trunk development, photosynthetic efficiency, and resistance to biotic and abiotic stressors (Setiawati et al., 2022). By facilitating the availability of these key nutrients, *Bacillus* spp. play a vital role in supporting plant physiological performance and structural growth, especially in long-cycle crops such as fruit trees and coconut palms. In addition to nutrient solubilization, Bacillus-based bio-fertilizers contribute significantly to the ecological balance and biological health of soil systems. Their application improves the diversity and density of soil microbial communities by enriching populations of beneficial microorganisms. These microbes enhance nutrient cycling processes, assist in the breakdown of organic matter, and suppress harmful soil-borne pathogens through competitive exclusion or the production of antimicrobial compounds. The result is a healthier rhizosphere environment that supports plant growth and increases the resilience of crops to various environmental stressors, including drought, salinity, and pathogen attacks (Ma et al., 2025).

Moreover, the incorporation of Bacillus spp. into agricultural systems aligns with the principles of sustainable farming. By improving the natural fertility of the soil and reducing dependency on chemical inputs, such as synthetic fertilizers and pesticides, the use of Bacillus-based bio-fertilizers helps minimize environmental degradation. This includes reducing the risk of soil compaction, nutrient leaching, groundwater contamination, and greenhouse gas emissions—issues commonly associated with intensive chemical fertilizer use (Ramírez-Pool et al., 2024; Wu et al., 2025).

Importantly, recent studies have highlighted the practical applications of Bacillus spp. in real agricultural settings. For example, Bacillus cereus has been shown to significantly improve the growth of coconut seedlings even when chemical fertilizers such as nitrogen, phosphorus, and potassium (NPK) are reduced by 50%. This finding underscores the potential of Bacillus spp. to maintain or even enhance crop productivity while reducing reliance on synthetic fertilizers, thus offering a promising pathway toward more sustainable and eco-friendly agriculture (Cardoso et al., 2021).

CONCLUSION

This study shows that the application of liquid organic fertilizer (POC) based on Bacillus nigr affects the initial growth parameters of coconut plants, particularly at the 9–10 month age stage, where treated plants showed comparable or higher stem growth compared to the control group. However, at 11 and 12 months, stem growth in the control group significantly exceeded that of the treated group, as indicated by a p value < 0.05.

These findings indicate that Bacillus nigr LPO can support the early vegetative growth of coconut plants, but its long-term effectiveness appears to be lower than that of the untreated group. This underscores the need for further research to evaluate optimal dosage, application duration, and its impact on subsequent growth phases and crop yields. Overall, this study contributes to the development of sustainable agricultural systems using environmentally friendly biofertilizers, particularly for high-value economic crops like coconut.

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