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Pengaruh Perendaman dalam Berbagai Konsentrasi PGPR (*Plant Growth Promoting Rhizobacteria*) terhadap Pertumbuhan Kecambah Biji Kacang Hijau (*Vigna radiata L.*)

The Effect of Soaking in Various Concentration of PGPR (Plant Growth Promoting Rhizobacteria) on The Growth of Mung Bean Seed Sprouts (Vigna radiata L.)

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ABSTRAK

Kacang hijau (Vigna radiata L.) merupakan salah satu tanaman legum penting di Indonesia yang memiliki nilai gizi tinggi, namun produktivitasnya masih relatif rendah. Salah satu upaya untuk meningkatkan pertumbuhan tanaman adalah melalui aplikasi Bakteri Peningkat Pertumbuhan Tanaman (PGPR). Penelitian ini bertujuan untuk mengetahui pengaruh pemberian PGPR terhadap pertumbuhan tanaman kacang hijau. Penelitian ini menggunakan Rancangan Acak Lengkap (CRD) dengan empat perlakuan, yaitu kontrol (0 mL/L), 5 mL/L, 10 mL/L, dan 15 mL/L PGPR, masing-masing dengan tiga ulangan. Parameter yang diamati meliputi tinggi tanaman, jumlah daun, panjang daun, lebar daun, dan panjang akar pada 1–8 hari setelah tanam (DAP). Hasil penelitian menunjukkan bahwa pemberian PGPR berpengaruh terhadap tinggi tanaman, panjang daun, lebar daun, dan panjang akar, namun tidak berpengaruh terhadap jumlah daun. Perlakuan terbaik untuk tinggi tanaman, panjang daun, dan lebar daun diperoleh pada konsentrasi 10 mL/L, sedangkan panjang akar tertinggi diperoleh pada konsentrasi 15 mL/L. Dengan demikian, PGPR telah terbukti meningkatkan pertumbuhan vegetatif awal tanaman kacang hijau. Penelitian lebih lanjut disarankan dengan menggunakan periode pengamatan yang lebih lama dan parameter pertumbuhan dan produksi yang lebih komprehensif.

ABSTRACT

Mung bean (Vigna radiata L.) is one of the important legume plants in Indonesia that has high nutritional value, but its productivity is still relatively low. One effort to increase plant growth is through the application of Plant Growth Promoting Rhizobacteria (PGPR). This study aims to determine the effect of PGPR

administration on the growth of mung bean plants. The study used a Completely Randomized Design (CRD) with four treatments, namely control (0 mL/L), 5 mL/L, 10 mL/L, and 15 mL/L PGPR, each with three replications. The parameters observed included plant height, number of leaves, leaf length, leaf width, and root length for 1–8 days after planting (DAP). The results showed that PGPR administration affected plant height, leaf length, leaf width, and root length, but did not affect the number of leaves. The best treatment for plant height, leaf length, and leaf width was obtained at a concentration of 10 mL/L, while the highest root length was obtained at a concentration of 15 mL/L. Thus, PGPR has been shown to enhance early vegetative growth of mung bean plants. Further research is recommended using longer observation periods and more comprehensive growth and production parameters.

INTRODUCTION

Mung beans (Vigna radiata L.) are one of the most important legume food commodities in Indonesia, after soybeans and peanuts. This commodity has strategic value because it serves as a source of vegetable protein, vitamins, minerals, and is a raw material for various traditional and modern food products (Hinarti, 2025). The relatively high nutritional content of mung beans, particularly protein, complex carbohydrates, dietary fiber, and antioxidants, makes them potentially valuable for supporting food security and improving the nutritional status of the community (Sehrawat et al., 2024). Furthermore, mung beans have a relatively short harvest period, are tolerant of marginal land conditions, and require relatively easy cultivation techniques, thus offering good prospects for development in the agribusiness sector (Sequeros et al., 2021).

Mung bean production in Indonesia still faces various obstacles, resulting in suboptimal productivity levels. According to data from the Central Statistics Agency (BPS), national mung bean production in 2023 was recorded at around 182,000 tons, with an average productivity of 1.2–1.3 tons/ha (Hinarti, 2025). This figure is still relatively low compared to the potential yield of several superior mung bean varieties, which can reach more than 2 tons/ha. This situation indicates that there is still ample opportunity to increase mung bean production and productivity in Indonesia through the implementation of improved cultivation technologies.

Mung bean production areas in Indonesia are spread across several provinces, particularly on the island of Java, which remains the main center of national production. Additionally, other regions such as West Nusa Tenggara, East Nusa Tenggara, South Sulawesi, and West Sumatra also contribute to national mung bean production. Most mung bean cultivation is carried out in paddy fields after the rice harvest or on dry land using simple cultivation systems (Oue & Laban, 2019). However, crop productivity at the farmer level remains relatively low due to various factors, such as limited soil nutrients, suboptimal cultivation management, limited water availability, and pest and disease attacks (Begna, 2020; Id et al., 2021). The main diseases that frequently attack mung bean plants include Cercospora leaf spot, powdery mildew, leaf rust, and viral infections, which can significantly reduce yields (Prakash et al., 2022; Primandani et al., 2025).

Efforts to increase mung bean productivity can be achieved through improved cultivation techniques, one of which is the use of microorganisms that act as plant growth promoters (Yousefi et al., 2025). One technology currently being developed is the use of Plant Growth Promoting Rhizobacteria (PGPR). PGPR is a group of rhizosphere bacteria capable of enhancing plant growth through various mechanisms, such as nitrogen fixation, phosphate solubilization, phytohormone production, siderophore production, and increasing plant resistance to pathogens (Andrade et al., 2023). In addition to functioning as a biofertilizer, PGPR also acts as an environmentally friendly biological control agent, thus supporting sustainable agricultural systems (Bajracharya, 2019).

Several studies have shown that PGPR application can increase the growth and yield of various cultivated plants, such as corn, rice, soybeans, wheat, and horticultural crops (Akinrinlola et al., 2018;

Kobua & Wang, 2025). PGPR use has been reported to increase plant height, root length, leaf number, leaf area, and nutrient uptake efficiency (Ilwati & Ujianto, 2025; Solanum et al., 2023). In mung bean plants, growth parameters such as plant height, root length, leaf number, leaf length, and leaf width are important indicators that determine the plant's ability to photosynthesize and influence yield (Supambri et al., 2026). However, information regarding the effect of PGPR application on mung bean plant growth is still limited, particularly under local cultivation conditions in Indonesia. Therefore, research on the effect of adding PGPR on the growth of mung bean plants (*Vigna radiata* L.) needs to be conducted to obtain scientific information that can support the increase in plant productivity in a sustainable manner.

METHOD

Time and place

This research was conducted from July to August 2025 at the Narmada Agricultural Plant Protection Center (BPTP), West Lombok Regency, West Nusa Tenggara.

Research design

This research is an experimental study using a completely randomized design (CRD) with one factor, namely the concentration of PGPR in mung bean seeds (*Vigna radiata* L.). This design was chosen because the research was conducted under relatively homogeneous conditions, namely using uniform planting media, containers, seeds, and treatments.

Population and research sample

The tools used in this study were plastic as a planting container, basin, bucket, stove, pan, dipper, sieve, stirrer, measuring cup, plastic bottle, ruler, stationery, gallon, and aerator, while the materials used included shrimp paste, granulated sugar, lime, rice washing water, bamboo root soaking water, water, soil, compost, label paper, and mung bean seeds (*Vigna radiata* L.). This study tested the PGPR concentration factor with four treatment levels, namely control (0 mL/L water), K1 (5 mL/L PGPR), K2 (10 mL/L PGPR), and K3 (15 mL/L PGPR), each with three replications to obtain 12 experimental units. The experimental unit was a plastic planting container containing soil and compost media planted with five mung bean seeds in each experimental unit. The independent variable in this study was the PGPR concentration, while the dependent variables included plant height, number of leaves, leaf length, leaf width, and root length. The control variables that were maintained so as not to influence the research results were the uniformity of seed type, homogeneity of planting media, volume of water for irrigation, duration of seed soaking for 30 minutes, observation time of 1–8 DAP, and environmental conditions that were made uniform (Waday et al., 2022).

Research procedure

Preparation of Tools and Materials

In this study, the tools and materials were prepared in advance. Because it was using soil as a medium, the soil used must be homogeneous, as must the mung bean seeds used. The homogeneous soil was then placed in a plastic cup.

PGPR Collection and Cultivation

Soak 100 grams of bamboo roots (as the source) for 4 days in 1 liter of cooled boiled water. The water from soaking the bamboo roots was then filtered and used as a starter/culture for PGPR bacteria (Napoleon et al., 2026).

PGPR Media Preparation

Prepare a container for making the media, add 20 liters of water, and bring to a boil. After that, add 100 grams of granulated sugar, 100 grams of shrimp paste, 1/2 tablespoon of whiting lime, 500 grams of bran, and 1 liter of rice washing water. Stir, let it sit for 15 minutes, and then cool. The cooled solution was then filtered and 10 liters of bacterial culture added. The mixture was then placed in a closed container fitted with an aerator. The mixture was then incubated for 21 days.

PGPR Application

The mung bean seeds were first washed with clean water five times, then soaked in PGPR solutions of varying concentrations: 5 mL/L (K1), 10 mL/L (K2), 15 mL/L (K3), and 1 L of water (Control/K), with three replicates of each treatment. Afterward, the seeds were soaked for 30 minutes. Five seeds were then planted in a growing medium containing compost. Observations were conducted for eight days, watering with 10 mL of water at two-day intervals for each treatment.

Parameter Measurement

Plant Height (cm)

Plant height was measured using a ruler, starting from the soil surface to the growing point. Observations and measurements were conducted from 1 day after planting to 8 days after planting.

Number of Leaves (Leaf Blades).

Observations of the number of leaf blades were conducted on fully opened leaves. Observations and measurements were conducted from 1 day after planting to 8 days after planting.

Leaf Length (cm)

Observations of leaf blade length were conducted on fully opened leaves. Observations and measurements were conducted from 1 day after planting to 8 days after planting.

Leaf Width (cm).

Observations of leaf blade width were conducted on fully opened leaves. Observations and measurements were conducted from 1 day after planting to 8 days after planting.

Root Length Measurement (cm)

Root length was measured at the end of the observation period using a ruler. Data obtained from these parameter measurements will be presented in tables and graphs.

Research data analysis

Data obtained from these parameter measurements will be presented in graphs.

RESULT

To determine the effect of PGPR on the growth of mung bean (*Vigna radiata L.*) plants, plant height was observed for 8 days after planting (DAP) for each treatment. The observation data were then presented in graphical form to facilitate the visualization of plant growth patterns at each PGPR concentration. The graph shows the difference in plant height growth rate between the control treatment and the PGPR treatments at various concentrations.

The Effect of PGPR Addition on Plant Height

Based on the results of observations and graphs of mung bean plant height growth in Figure 1, it can be seen that all treatments experienced an increase in plant height from 1–8 DAP, but the treatment

with the addition of PGPR showed better growth compared to the control. The graph shows a relatively slow growth pattern at 1–2 DAP, then increased rapidly starting from 3–6 DAP in all treatments. The K2 treatment (10 mL/L) produced the highest and most stable growth curve until the end of the observation with a plant height reaching 11.6 cm at 8 DAP, while the control treatment only reached 9.8 cm. The K3 treatment (15 mL/L) showed quite high growth in the middle phase of the observation, but experienced a tendency to stagnate at the end of the observation so that the results were still lower than K2. The graph shows that the administration of PGPR at a concentration of 10 mL/L is the most optimal concentration in increasing the growth of mung bean plants.

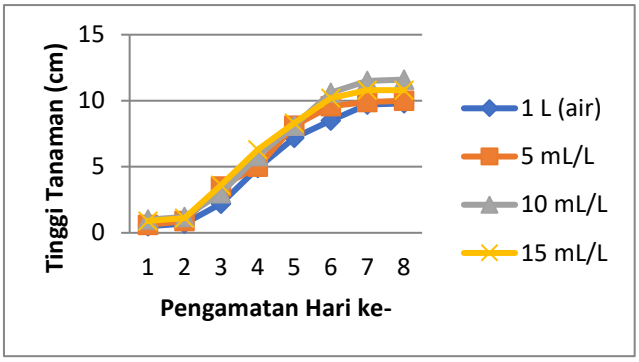

Figure 1. The effect of PGPR addition on plant height

Effect of PGPR Addition on Leaf Length

Based on the observation graph of mung bean (Vigna radiata L.) in Figure 2 leaf length during 1–8 DAP, it can be seen that all treatments experienced an increase in leaf length as the observation time increased. At 1–2 DAP, leaf growth was not yet visible in all treatments, then began to increase at 3 DAP. The PGPR treatment showed higher leaf length growth compared to the control (1 L of water). The K3 treatment (15 mL/L) produced the highest leaf length at the end of the observation, which was around 4.4 cm at 8 DAP, followed by K2 (10 mL/L) at around 4.3 cm, K1 (5 mL/L) at around 4 cm, while the control only reached around 3.7 cm. The graph also shows that the increase in leaf length occurred quite rapidly at 3–5 DAP, then growth began to slow and tended to stabilize at 6–8 DAP. These results indicate that PGPR administration is able to increase the growth of mung bean leaf length, with a concentration of 15 mL/L providing the best growth response compared to other treatments.

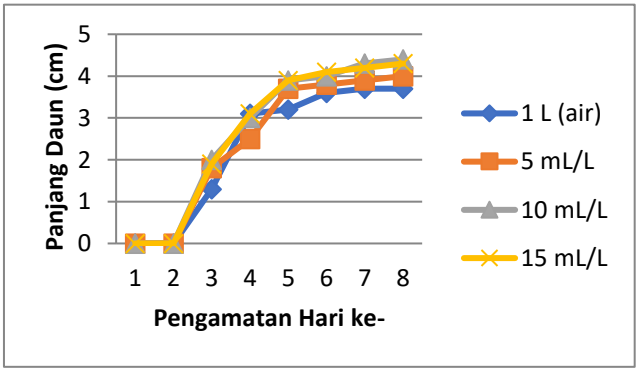

Figure 2. Effect of PGPR Addition on Leaf Length

Effect of PGPR Addition on Leaf Width

Based on the graph of mung bean (*Vigna radiata L.*) in Figure 3 leaf width during 1–8 days after planting, it can be seen that at 1–2 days after planting, there was no growth in leaf width in all treatments, then growth began to appear at 3 days after planting and increased very rapidly until 5 days after planting. In this initial phase, the 10 mL/L and 15 mL/L treatments showed a greater increase in leaf width compared to the control and 5 mL/L treatments, while the control (1 L water) tended to have the lowest value. Entering 5 days after planting, all treatments reached a leaf width of around 1.5 cm, but after that the growth pattern began to differ; the 10 mL/L treatment continued to increase until it became the highest at the end of the observation, which was around 1.8 cm at 7–8 days after planting. The 15 mL/L treatment also showed quite good growth and reached around 1.7 cm at 8 days after planting, while the 5 mL/L treatment tended to stagnate at around 1.5 cm from 5 days after planting until the end of the observation. Meanwhile, the control experienced slower growth, reaching only about 1.5 cm at 8 DAP. Overall, this graph shows that PGPR application can increase mung bean leaf width, with a concentration of 10 mL/L providing the most optimal results compared to other treatments.

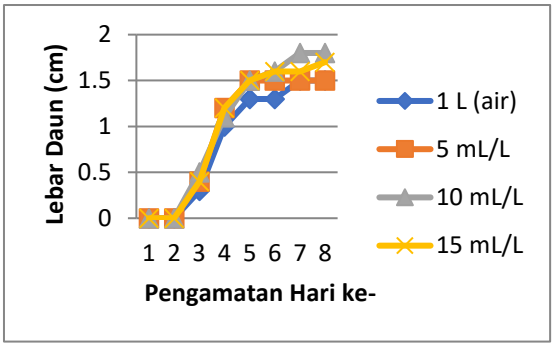

Figure 3. Effect of PGPR Addition on Leaf Width

Effect of PGPR Addition on Leaf Number

Based on the graph of the number of mung bean leaves (*Vigna radiata L.*) in Figure 4 during 1–8 DAP, it can be seen that at 1–2 DAP all treatments still did not show leaf formation, with the number of leaves valued at 0 at all PGPR concentrations and the control. Entering 3 DAP, all treatments experienced an increase to 2 leaves and after that the number of leaves was relatively stable until the end of the observation at 8 DAP without any differences between treatments, both the 1 L water control and PGPR 5 mL/L, 10 mL/L, and 15 mL/L. This pattern indicates that in the early growth phase, the addition of PGPR has not had a different effect on the number of leaves, because all plants tend to form leaves in the same number. Thus, the graph indicates that the variable number of leaves in this study did not show significant variation between treatments, so that the effect of PGPR is more visible in other growth parameters such as plant height, leaf length, and leaf width.

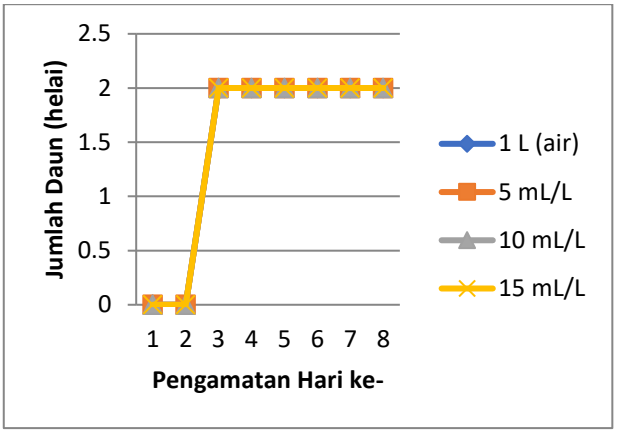

Figure 4. Effect of PGPR Addition on Leaf Number

Effect of PGPR Addition on Root Length

Based on the graph of mung bean root in Figure 5 length on day 8, it can be seen that PGPR administration showed an effect on root growth compared to the control. The 15 mL/L treatment produced the highest root length, which was around 15.2 cm, followed by the 10 mL/L treatment at 14.2 cm, then the 1 L water control at 13.9 cm, while the lowest value was shown by the 5 mL/L treatment at around 13.1 cm. These results indicate that increasing the PGPR concentration tends to be able to stimulate better root growth, especially at a concentration of 15 mL/L which gives the most optimal results. However, at a concentration of 5 mL/L, the lowest root length was obtained, so it can be indicated that the root growth response does not always increase linearly at all concentrations, but is influenced by the suitability of the PGPR dose to the plant's growth needs.

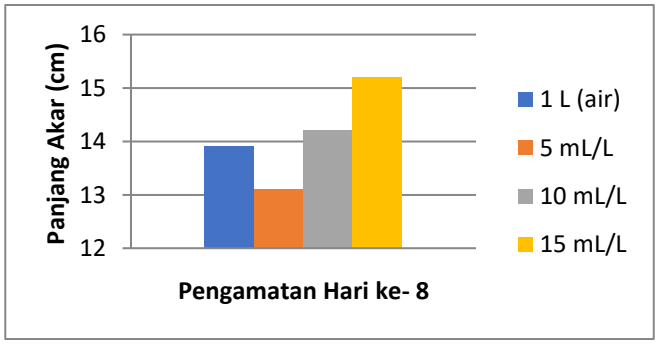

Figure 5. Effect of PGPR Addition on Root Length

DISCUSSION

The application of Plant Growth Promoting Rhizobacteria (PGPR) has been shown to increase the early vegetative growth of mung bean (*Vigna radiata L.*), particularly in terms of plant height, leaf length, leaf width, and root length. This increase is thought to be due to the activity of rhizosphere bacteria, which increase nutrient availability, produce phytohormones, and improve the development of the plant's root system (Yang et al., 2024). Recent research has shown that PGPR can enhance mung bean growth and productivity through phosphate solubilization, siderophore production, and the synthesis of growth hormones such as Indole Acetic Acid (IAA) (Vaghela & Gohel, 2025). Furthermore, bacteria from the *Pseudomonas* spp. and *Bacillus* spp. groups have been reported to increase root length, leaf area, plant biomass, and chlorophyll content in mung bean plants compared to plants without PGPR treatment (Ahmad et al., 2022).

In addion, the results of this study show that PGPR application was able to enhance the early growth of mung bean plants compared with the control treatment using only water without PGPR, as

indicated by the consistent increase in plant height, leaf length, leaf width, and root length. These findings support previous reports that PGPR can act as an effective biostimulant in the early vegetative phase of various crops, including cereals and legumes, by improving growth performance under suboptimal conditions (Yousefi et al., 2025; Andrade et al., 2023). This is in line with the concept that PGPR can facilitate nutrient availability, produce phytohormones, and improve root system development, enabling plants to adapt more rapidly to the growth environment and express better vegetative growth, which is crucial for achieving optimal productivity in mung bean cultivation (Sequeros et al., 2021; Bajracharya, 2019).

In this study, the PGPR treatment at a concentration of 10 mL/L (K2) demonstrated the best results in terms of plant height, leaf length, and leaf width compared to other treatments. Meanwhile, the 15 mL/L treatment (K3) produced the highest root length. These results indicate that PGPR acts as a biostimulant and biofertilizer, optimizing plant vegetative growth by increasing physiological activity and nutrient uptake (Biostimulants, 2024). Other studies have also reported that the application of growth-promoting bacteria-based biofertilizer significantly increased leaf area index, radiation utilization efficiency, and biomass growth in mung bean plants compared to the control (Yousefi et al., 2025).

Moreover, In the present study show that the concentration of 10 mL/L PGPR was identified as the most optimal for increasing plant height, while 10–15 mL/L tended to provide the best response for leaf length and leaf width, and 15 mL/L produced the highest root length. This pattern suggests that plant responses to PGPR can be parameter-specific, indicating that the physiological requirements for shoot and leaf development may differ from those for root growth and stem elongation. Several mechanisms may explain these results, including enhanced production of phytohormones such as auxins and cytokinins by PGPR strains, which can stimulate cell elongation and leaf formation, as well as improved nutrient uptake and rhizosphere interactions that ultimately increase photosynthetic efficiency and biomass accumulation during the early vegetative phase (Andrade et al., 2023; Yousefi et al., 2025).

Overall, the response pattern observed in this study is consistent with previous findings reporting that PGPR application can increase plant height, root length, leaf number, and nutrient uptake efficiency in several crops cultivated under diverse agroecological conditions (Bajracharya, 2019; Andrade et al., 2023). However, empirical evidence on the use of PGPR in mung bean, particularly PGPR derived from bamboo roots and formulated with the media used in this study, is still relatively limited, so the data obtained provide an important contribution to the development of locally adapted biofertilizer technologies in Indonesia (Oue & Laban, 2019; Sehrawat et al., 2024). Considering that mung bean is widely cultivated in paddy fields after rice harvest and on dry lands with limited soil fertility in several regions including West Nusa Tenggara, the application of PGPR has the potential to become a promising approach to sustainably improve mung bean productivity while supporting environmentally friendly agricultural practices (Hinarti, 2025; Sequeros et al., 2021).

However, PGPR application in this study did not affect the number of leaves in mung bean plants, as the number of leaves remained constant until the end of the observation period. This is likely due to the relatively short observation period, which prevented optimal leaf formation. Similar results have been found in several studies, indicating that PGPR exerts a more dominant influence on vegetative growth parameters such as plant height, root length, and leaf area than on leaf number in the early stages of mung bean growth (Zawad et al., 2025).

CONSULACION

Based on the research results, it can be concluded that the administration of Plant Growth Promoting Rhizobacteria (PGPR) affects the vegetative growth of mung bean plants (Vigna radiata L.), especially on the parameters of plant height, leaf length, leaf width, and root length. PGPR treatment with a concentration of 10 mL/L (K2) showed the best results in the parameters of plant height, leaf

length, and leaf width, while the treatment of 15 mL/L (K3) produced the highest root length compared to other treatments and the control. This indicates that PGPR is able to increase plant growth by increasing root activity, nutrient absorption, and growth h ormone production. However, the administration of PGPR did not affect the number of leaves because all treatments showed a relatively similar number of leaves until the end of the observation. Overall, PGPR application proved effective in increasing the initial growth of mung bean plants, with a concentration of 10 mL/L as the most optimal concentration for most growth parameters.

REKOMENDATION

Suggestions derived from the findings of this study are that PGPR application, particularly at concentrations between 10 and 15 mL/L, should be considered as a supporting technology in mung bean cultivation during the early growth phase. Farmers and field practitioners in areas with limited soil fertility are encouraged to gradually test PGPR application under their local conditions to assess the consistency of growth enhancement in different environments, while taking into account existing cultivation practices and resource availability. Furthermore, it is recommended that future research employ longer observation periods covering the generative phase and yield components, so that the influence of PGPR can be evaluated not only in terms of vegetative growth but also in relation to yield quantity and quality of mung bean production.

LIMITATIONS

This study has several limitations that should be considered when interpreting the results. First, observations were conducted only up to 8 days after planting, so the long-term effects of PGPR on the generative phase and final yield of mung bean cannot be fully explained. Second, the experiment was carried out under relatively homogeneous and controlled media and environmental conditions, which may differ from the variable soil properties, microclimate, and management practices typically encountered in farmers' fields; therefore, plant responses observed here may not be entirely replicated under on-farm conditions. Third, the detailed characteristics of the PGPR community used, including species composition, functional traits, and population stability during storage and application, were not comprehensively evaluated, so further studies are needed to ensure the consistency of quality and effectiveness of the PGPR-based biofertilizer being developed.

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