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Growth and production response of cowpea (*Vigna unguiculata* L.) to the application of bamboo root PGPR

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Abstract. The utilization of *Plant Growth Promoting Rhizobacteria* (PGPR) derived from bamboo roots represents an effective approach to enhance the growth and yield of cowpea (*Vigna unguiculata* L.). PGPR has been reported to improve nutrient availability, stimulate root development, and increase nutrient uptake efficiency in cowpea plants. This research was conducted to evaluate the influence of bamboo root-based PGPR on the growth and production performance of cowpea. The experiment employed a non-factorial randomized block design (RBD) with six levels of PGPR concentration: 0 (control), 10, 20, 30, 40, and 50 mL per liter of water. Observed parameters included Plant Length, leaf number, number of pods per plant, seed dry weight per plant, 100-seed dry weight, and chlorophyll content. The findings revealed that bamboo root PGPR application significantly affected several growth parameters of cowpea. The treatment with 30 mL/L water concentration produced the most favorable outcomes, leading to notable increases in plant length, leaf number, pod formation, and seed dry weight. Therefore, applying bamboo root PGPR at a concentration of 30 mL/L water is considered the optimal dosage to promote optimal growth and yield in cowpea cultivation.

1. Introduction

Indonesia possesses a wide diversity of local agricultural products, such as leguminous crops which one of them is the cowpea. Tempeh, a well-known traditional fermented food that is recognized for its high nutritional value and health benefits, can be produced from various legumes, including cowpeas (*Vigna unguiculata* L.) [1]. In every 100 grams of cowpea seeds, the nutritional profile includes roughly 1,420 kJ of energy. Key components per serving are 22 g protein, 51 g carbohydrates, 10 g water, and 1.4 g fat. The seeds are also a good source of vitamins (3.7 g) and minerals like calcium (104 mg), in addition to other beneficial bioactive substances. [2].

Key microorganisms that support plant growth are known as PGPR (Plant Growth Promoting Rhizobacteria). Examples of these beneficial bacteria include *Pseudomonas fluorescens* and *Bacillus polymyxa*. In contrast to chemical fertilizers, organic fertilizers contribute to fulfilling plant nutrient requirements in an environmentally friendly manner. They supply essential



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elements such as carbon, hydrogen, and oxygen, along with other nutrients that are crucial for plant development, making them a vital component of sustainable plant nutrition systems [3].

PGPR has progressively become more acknowledged in the worldwide agricultural practices, to the point that this method presents a viable substitute or supportive measure when compared to standard farming techniques. Its capacity to elevate agricultural output and simultaneously curtail ecological repercussions positions it as a viable approach to address forthcoming farming obstacles. As investigations progress and evolve, creating more potent PGPR variants and refining methods of administration is projected to amplify their effect on environmentally friendly farming practices. In essence, the generation of PGPR is critically important for unlocking the full capacity of advantageous soil microorganisms and improving crop output and excellence. The mechanism behind PGPR's effectiveness is its synthesis of various compounds that encourage plant development. These vital compounds are indole-3-acetic acid (IAA), ACC deaminase, siderophores, chitinase, glucanase, and biotin. Research indicates that using PGPR has a constructive impact on indicators related to plant development and output [5].

PGPR is a liquid fertilizer produced by engineering dead plants and other organic materials, primarily bamboo roots. This process involves utilizing minerals or microbes to increase the soil's nutrients and organic matter, improving its physical, chemical, and biological properties [6]. Our research aims to investigate whether PGPR fertilizer from bamboo root could stimulate the growth and production of Cowpea plants. Our findings offer a pathway to elevate agricultural output for sustainable cowpea crop production, curtail ecological repercussions, and utilize capacity of advantageous soil microorganisms, ensuring a more sustainable and resilient future for farming.

2. Materials and methods

The study was conducted in Medan Selayang, Medan City, North Sumatra, Indonesia, located at an altitude of about 25 meters above sea level. The exact geographical position, measured by GPS, is 3° 33' 13.2" North Latitude and 98° 38' 52.9" East Longitude. The experiment was conducted from June to August 2025. The materials and equipment used in this study included bamboo root-based PGPR, 10 kg Polybags, Urea, TSP, and KCl fertilizers, cowpea (*Vigna unguiculata* L.) var. Albina IPB seeds, a digital scale, reference books, and a camera.

The experimental design used in this study was a non-factorial randomized block design (RBD) consisting of one treatment factor with four replications. The treatment factor was the concentration of PGPR application (P), which consisted of six levels: P0 = no PGPR application (control), P1 = PGPR 10 mL/L water, P2 = PGPR 20 mL/L water, P3 = PGPR 30 mL/L water, P4 = PGPR 40 mL/L water, and P5 = PGPR 50 mL/L water. In total, there were 24 combinations of experimental treatments.

Making PGPR (*Plant Growth Promoting Rhizobacteria*) Culture. Making PGPR culture uses fresh bamboo roots. 200 g of roots are taken, washed clean, then soaked in 1 L of cooled boiled water. Then the bamboo roots are put into a container filled with water and tightly closed. Culture is carried out for 3 days, and observed every day. If there are bubbles, it means there are bacteria (PGPR has been successfully cultured). Then carry out the culture. **Making PGPR (Plant Growth Promoting Rhizobacteria) Culture.** Making PGPR requires ingredients, namely 800 g of brown sugar, 400 g of shrimp paste, 2 kg of bran, and 15 L of water, which are boiled together until boiling

while stirring so that the ingredients do not easily settle, then let it cool, and then the culture is filtered. The filtered results are mixed with 200 ml of PGPR culture and put into a tightly closed container (jar), and fermented for 7-14 days [7]. Following the detection of a noteworthy difference through the analysis of variance (ANOVA), the Duncan's Multiple Range Test (DMRT) is employed for a more detailed examination, with a significance threshold of 5%, to evaluate the averages of the various treatments.

3. Results and discussion

3.1 Plant Length

Our data show that the application of Bamboo Root PGPR (Table 1) significantly affected the length of cowpea plants at various concentrations. Treatment P3 (PGPR 30 mL/L water) showed the best results at all observation stages, with Plant Length at 9 WAP reaching 214.55 cm. Treatment P5 (PGPR 50 mL/L water) showed lower results than P3, with Plant Length at 9 WAP of 158.50 cm, indicating that too high a concentration can cause a decrease in the effectiveness of PGPR on plant growth.

Table 1. Length of cowpea plants aged 2-5 and 9 weeks after planting with bamboo root PGPR.

Treatment	Plant Length				
	2 WAP	3 WAP	4 WAP	5 WAP	9 WAP
P0 (Control)	9.45	13.72	21.70 ^b	29.70 ^b	148.53 ^d
P1(PGPR10 mL/L water)	8.80	13.47	29.10 ^{ab}	37.10 ^{ab}	153.34 ^{cd}
P2(PGPR 20 mL/L water)	9.44	15.06	38.65 ^a	46.65 ^a	198.35 ^b
P3(PGPR 30 mL/L water)	9.33	15.35	40.90 ^a	48.90 ^a	214.55 ^a
P4(PGPR 40 mL/L water)	9.36	13.88	37.85 ^a	45.85 ^a	196.10 ^b
P5(PGPR 50 mL/L water)	9.58	13.13	30.93 ^{ab}	38.88 ^{ab}	158.50 ^c

Description: Within each column, values that share a letter indicate no statistically significant difference, as determined by Duncan's Multiple Range Test (DMRT) at a significance level of 5% ($\alpha = 0.05$).

The relationship between the concentration of Bamboo Root PGPR and plant length of Cowpea plants can be seen in Figure 1.

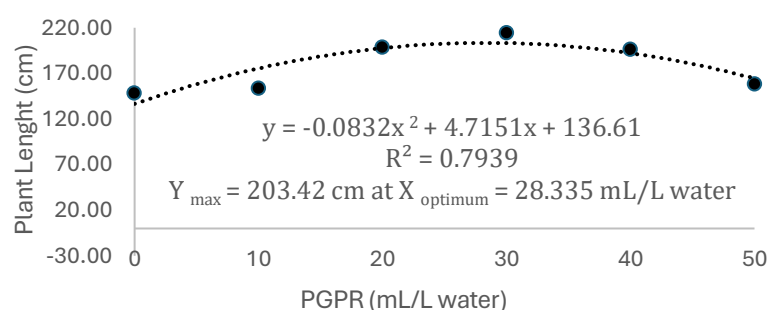


Figure 1. Graph of cowpea plant length in response to bamboo roots *plant growth promoting rhizobacteria* (PGPR) application.

The cowpea plant length measurements from the research showed that the most effective results occurred when PGPR was applied at a concentration of 30 mL/L of water, acting as the key origin of biofertilizer strains. This process enhanced the quality of the soil and promoted agriculture that can be sustained over time by lowering the necessity for synthetic fertilizers or

pest control chemicals. Using PGPR allowed for environmentally conscious farming methods [8]. Excessive application of PGPR can trigger competition between bacteria and microbes for nutrients, which impacts the microbes' nutritional needs. As a result, these microbes will function less optimally, thus having a less than optimal effect on plants [9].

3.2 Number of leaves

Our findings regarding to the crop growth indicated by the number of leaves in cowpea plant is presented in Table 2.

Table 2. Cowpea leaf and chlorophyll analysis (2-5 WAP) with bamboo root PGPR.

Treatment	Number of Leaves				Chlorophyll Contentmg/L.....
	2 WAP	3 WAP	4 WAP	5 WAP	
	strands.....				
P0 (Control)	1.81	5.13 ^d	10.38 ^c	16.94 ^d	47.40
P1(PGPR10 mL/L water)	1.88	7.00 ^c	11.31 ^c	18.75 ^c	56.13
P2(PGPR 20 mL/L water)	1.94	8.38 ^b	14.94 ^b	21.06 ^b	38.64
P3(PGPR 30 mL/L water)	1.94	9.81 ^a	17.00 ^a	24.06 ^a	50.55
P4(PGPR 40 mL/L water)	1.88	7.88 ^{bc}	16.00 ^{ab}	22.19 ^b	55.98
P5(PGPR 50 mL/L water)	1.94	7.38 ^{bc}	15.25 ^b	17.06 ^d	59.29

Description: Within each column, values that share a letter indicate no statistically significant difference, as determined by Duncan's Multiple Range Test (DMRT) at a significance level of 5% ($\alpha = 0.05$).

The results found that using Bamboo Root PGPR substantially boosted the leaf count of cowpea plants, regardless of the concentration level applied. Treatment P3 (PGPR 30 mL/L water) demonstrated the best results across all observation stages, with a total of 24.06 leaves at 5 WAP. Treatment P5 (PGPR 50 mL/L water) showed lower results compared to P3, with a number at 5 WAP of 17.06 strands.

The relationship between the concentration of Bamboo Root PGPR and the number of leaves of Cowpea plants aged 5 weeks after planting can be seen in Figure 2 below.

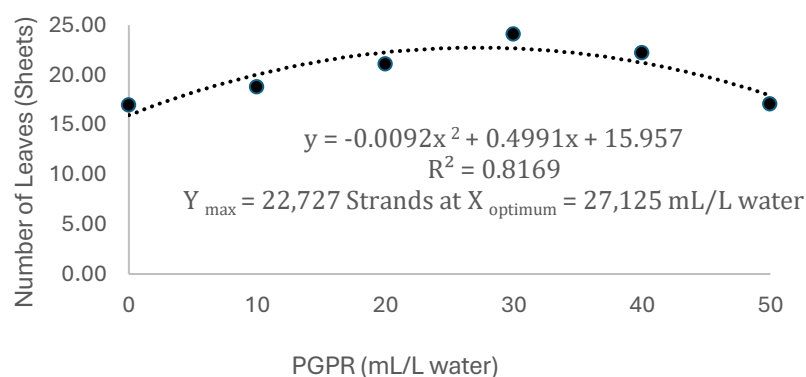


Figure 2. Graph of the number of cowpea leaves in response to bamboo roots *plant growth promoting rhizobacteria* (PGPR) application.

3.3 Chlorophyll Content

Our findings presented in Table 2 above shows that the highest chlorophyll content was found in P5 (PGPR 50 mL/L water) at 59.29%, followed by P1 (56.13%) and P4 (55.98%). The data

suggests that substantial quantities of PGPR have the potential to boost the photosynthetic effectiveness of plants. This enhancement is achieved through improved nutrient accessibility and heightened microbial processes occurring within the soil. However, treatment P2 (38.64 mg/L) produced lower-than-average results, possibly due to unsuitable environmental conditions or other disturbances.

Although there was no significant difference, the highest chlorophyll content was found at a concentration of 50 mL/L. High chlorophyll content indicates photosynthetic efficiency, although higher PGPR concentrations do not always correlate linearly with improvements in other parameters. Nitrogen availability affects photosynthesis. The relationship between chlorophyll and nitrogen is very close and mutually supportive. Nitrogen plays a vital role in chlorophyll formation, while chlorophyll determines a plant's ability to utilize light energy to produce organic matter. The balance between these two factors is crucial for optimal plant growth and yield. This is supported by [14], which states that nitrogen availability affects photosynthesis.

3.4 Crop production

The highest number of pods was found in 30 mL/L water (39.69 pods), significantly different from the other treatments. This indicates that a PGPR concentration of 30 mL/L significantly increased pod number, possibly due to the stimulation of flower and pod formation. The control yielded the lowest number of pods (19.31), highlighting the importance of PGPR use in increasing yields.

Our findings depicted in Table 3 shows that the highest seed weight was achieved in treatment 30 mL/L water (69.42 g), significantly different from the control (34.05 g). PGPR at this concentration likely enhanced seed filling by improving nutrient availability. Conversely, a higher PGPR concentration 50 mL/L water yielded lower yields, indicating an optimal limit to its use. Moreover, it shows that the dry weight of 100 seeds was relatively similar across all treatments, with an average of approximately 15.87 g, indicating that PGPR application had no significant effect on this parameter. This suggests that seed quality and genetics have a greater influence on the dry weight of 100 seeds than the PGPR treatment.

Table 3. Effect of bamboo root PGPR on cowpea pod production and seed weight

Treatment	Number of Pods per Plant Pod.....	Seed Dry Weight per Plant g.....	Dry Weight of 100 Seedsg.....
P0 (Control)	19.31 ^e	34.05 ^d	14.58
P1 (PGPR 10 mL/L water)	23.63 ^d	35.26 ^d	15.57
P2(PGPR 20 mL/L water)	28.63 ^b	49.06 ^c	15.79
P3(PGPR 30 mL/L water)	39.69 ^a	69.42 ^a	16.48
P4(PGPR 40 mL/L water)	32.88 ^b	55.36 ^b	16.27
P5(PGPR 50 mL/L water)	23.06 ^e	38.12 ^d	16.52

Description: Within each column, values that share a letter indicate no statistically significant difference, as determined by Duncan's Multiple Range Test (DMRT) at a significance level of 5% ($\alpha = 0.05$).

The relationship between the concentration of Bamboo Root PGPR and the number of pods per cowpea plant can be seen in Figure 3 below.

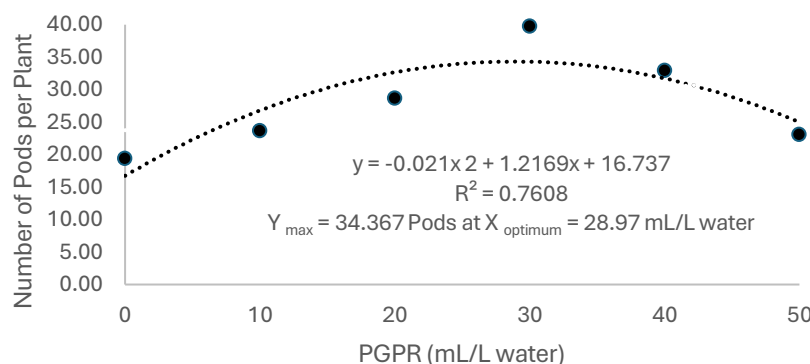


Figure 3. Graph of the number of pods per plant in response to bamboo roots *plant growth promoting Rhizobacteria* (PGPR) application

The relationship between the concentration of Bamboo Root PGPR and the seed weight of Cowpea plants is illustrated in Figure 4 below.

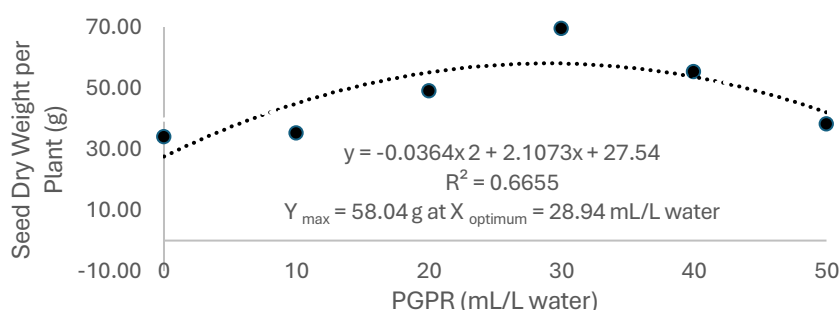


Figure 4. Graph of seed dry weight per plant of cowpea in response to bamboo roots *plant growth promoting Rhizobacteria* (PGPR) application.

Introducing organic materials can have a roundabout positive effect on the chemical characteristics of soil, impacting the quantity of organic carbon, the ability of the soil to exchange cations, and the amount of acidity present. Supplying plants with PGPR not only makes the soil's construction and steadiness better, it also gets the microbes in the soil more active, lets more air into the soil, and builds up the soil's skill at holding onto water so plants can use it [10].

PGPR is said to optimize nitrogen uptake during the vegetative phase. Furthermore, according to [11], leaf number will increase if nutrient needs are met. Research [12] indicates that PGPRs benefit plants by generating enzymes, byproducts, phytohormones, or similar substances, helping plants flourish through diverse processes. A common method involves promoting plant growth by enhancing plant nutrients, synthesizing phytohormones, or altering the stability of plant hormones.

Previous research [13] indicated that Plant Growth Promoting Rhizobacteria (PGPR) is a term used to describe rhizobacteria present in PGPR that possess diverse capabilities connected to the overall growth and well-being of plants. PGPR enhance the development of plants using a variety of methods, which can be categorized as either direct or indirect. These bacteria offer advantages

such as enhanced accessibility of nutrients, generation of phytohormones, improved growth of shoots and roots, defense against numerous plant pathogens, and a decrease in the occurrence of diseases. Thus, plant nutrient needs are met thanks to the presence of PGPR bacteria.

4. Conclusion

The Bamboo Root PGPR concentration of 30 ml/L of water it has proven to be most effective in promoting vegetative growth and optimum productivity in cowpea plants, compared to other treatments. Significant increases were seen in Cowpea Plant Length, leaf number, pod number per plant, and seed dry weight per plant.

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