INTERNATIONAL CONFERENCE PROCEEDINGS
UNIVERSITAS ISLAM BALITAR BLITAR
Empowering Education and Society through Digital Transformation
Volume 1 (2025)

Response of Plant Growth-Promoting Rhizobacteria and Biochar on Growth and Yield of Domba Peanut Variety

Muhamad Rifa'i[1], Jeka Widiatmanta [2], Army Dita Serdani [3], Tri Kurniastuti[4]

[1,2,3,4] Agrotechnology Study Program, Faculty of Agriculture and Animal Husbandry, Balitar Islamic University, JL. Imam Bonjol No. 16, JL. Majapahit No. 2 – 4, Sananwetan, Sananwetan District, Blitar City, East Java, Indonesia

Keywords:
Peanuts, PGPR, Biochar, 100-Seed Weight

***Correspondence Address:**
muhamad.rifai7770808@gmail.com

Abstract: This experiment aims to determine the appropriate ratio of Plant Growth Promoting Rhizobacteria (PGPR) and biochar to improve the growth and yield of peanut plants (Arachis hypogaea L.) Domba variety. The study used a Randomized Block Design in a factorial arrangement with two factors and three replications. The first factor was PGPR concentration: P1 (10 ml/L), P2 (15 ml/L), and P3 (20 ml/L). The second factor was biochar dose: B1 (control), B2 (3 tons/ha or 18 g/polybag), and B3 (6 tons/ha or 36 g/polybag). Observed variables included plant height, number of primary branches, number of pods per plant, fruit weight per plant, and weight of 100 seeds. Data were analyzed using ANOVA, and significant differences were further tested with Duncan's test at the 5% level. The experiment was conducted in Tingal Village, Garum District, Blitar Regency, East Java, from December 2024 to March 2025. Results showed that the best treatment combination was P3B3 (PGPR 20 ml/L + biochar 6 tons/ha), which improved both growth and yield from the vegetative to generative phases of peanut plants.

INTRODUCTION

Peanuts (*Arachis hypogaea* L.) are a high-value food crop and one of Indonesia's main sources of protein in its diet. Along with Indonesia's growing population, public awareness of nutritional needs, and demands from the food and feed industries, the demand for peanuts is increasing every year. The need for peanuts, both for food and industry, continues to increase over time. Meanwhile, because domestic production is still insufficient to meet this demand, peanuts are still needed to be imported from neighboring countries. Between 2015 and 2019, peanut consumption increased while production and harvested area decreased, at a rate of -8.7% and -7.4% per year, respectively, forcing Indonesia to import approximately 266,000 tons of dry peanuts annually (Rahmanianna, 2021).

Peanut yields per hectare have not reached their potential. This is due to declining soil fertility resulting from the continued use of chemical fertilizers and uneven adoption of agricultural technology at the farm level. The increasing practice of applying chemical fertilizers damages the soil (hard clumps) and reduces yields. Nutrient availability, especially nitrogen, is crucial for healthy peanut plant growth and production. With the help of root nodules, plants can produce their own nitrogen through a symbiosis with bacteria found in the root zone. One approach to increasing bacterial numbers is by using Plant Growth Promoting Rhizobacteria (PGPR), which are soil or root zone bacteria. These bacteria contribute to soil fertility and plant development. (Aprianti, 2018).

According to (Jannah M, 2022) Through its mechanism, which can improve the dissolution of bound P, and produce the plant hormone indole acetic acid, PGPR can increase plant growth. N, Application as a biofertilizer is a biotechnology effort that aims to increase agricultural yields. PGPR Because it is a biostimulant that promotes growth by producing and regulating the concentration of different growth regulating compounds, making essential nutrients available, and functioning as a soil pathogen controller (bioprotective), PGPR can improve plant development. The results of research (Marom & Rizal, 2017) show that administering PGPR with a concentration of 12.5 ml/L can increase plant height and yield of peanut plants.

One innovation for improving soil physical quality is the use of biochar soil conditioner. Biochar is a carbon-rich material produced by the pyrolysis of biomass, such as wood, manure, branches, and leaves, under high temperatures and low oxygen conditions. It is used in agriculture as a soil amendment. Applying biochar to soil can improve its physical, chemical, and biological characteristics, such as increased porosity, water retention capacity, soil aggregation, pH, cation exchange capacity, soil organic carbon, nutrient retention and availability, and increased microbial, meso, and macrofauna life (Evizal R and Prastiwi, 2023).

In an effort to increase the growth and yield of local varieties of peanut plants, it is necessary to conduct research on the effect of providing Plant Growth Promoting Rizobacteria (PGPR) and Biochar Doses in order to find the optimum combination of PGPR and biochar treatments.

RESEARCH METHODS

Place and Time

The research was conducted in Tingal Village, Garum District, Blitar Regency, with coordinates 08*09'36" South Latitude 112*23'18" East Longitude, an altitude of 130 meters above sea level. The average temperature was 23 degrees Celsius. Humidity was 38 percent in December 2024 – March 2025.

Tools and materials

Materials used: Rice husk charcoal, organic fertilizer, Decis insecticide, Amistar fungicide, PGPR, seeds, polybags. Meanwhile, tools: scissors, raffia rope, calipers, hose, stationery, ruler, paranet edges, plastic bags (for sample containers), sprayer, bucket, knife, shovel, hoe, research label, trowel, digital scales.

Method

The research was conducted using a Randomized Block Design arranged in a factorial manner with two (2) factors.

The first factor: PGPR concentration is symbolized by the letter P and consists of 3 treatment levels:

P1: PGPR concentration 10 ml/L

P2: PGPR concentration 15 ml/L

P3: PGPR concentration 20 ml/L

The second factor: Biochar dosage, marked B, consists of three levels:

B1: Control

B2: Dosage 3 tons/ha (equivalent to 18 grams/polybag)

B3: Dosage 6 tons/ha (equivalent to 36 grams/polybag)

Each treatment was repeated three times, resulting in 27 experimental units. Each experimental unit consisted of five polybags, each containing one plant. Five polybags were sampled, resulting in a total of 135 plants. The table above shows the three levels of PGPR concentration and three levels of Biochar dosage, resulting in nine treatment combinations.

Data analysis

The collected data will be evaluated through analysis of variance. The results will be analyzed using the F-test with a 5% error rate. If significant differences are found, further testing will be carried out using Duncan's Multiple Range Test with a 5% error rate.

RESULTS AND DISCUSSION

Plant Height

Based on the results of the analysis of variance (ANOVA) with a level of 5% on the height of the Lamb variety peanut plants with the provision of PGPR (P) and Biochar (B) showed a significantly different interaction at the observation age (15 HST, 30 HST, 45 HST and 60 HST) but there was no significant interaction at the age of 75 HST).

In this study, the administration of PGPR and Biochar had a significant effect on the growth and yield of peanut varieties of sheep. The parameter of plant height (cm) showed a significant interaction between the treatment combinations. The best average was at the age of 30 HST recorded in the treatment of PGPR concentration of 10 ml/L with a dose of 6 tons/ha (equivalent to 36 grams/polybag) (P1B3) with a height of 13.4 cm, statistically not significantly different from other treatments. The P1B3 treatment is a combination treatment of PGPR 10 ml/L + Biochar dose of 6 tons/ha (equivalent to 36 grams/polybag) which produced an average plant height of 13.4 cm. These results indicate that PGPR at low concentrations induces growth hormone production without causing physiological stress, while soil under natural conditions with added biochar already has sufficient basic fertility to support initial growth. This is consistent with research conducted by (Marom & Rizal, 2017) that PGPR at low concentrations is sufficient to increase plant height without the need for additional organic fertilizer.

Table 1. Average height of peanut plants (cm) in the combination of PGPR (P) and Biochar (B) treatments at the ages of 15, 30, 45, 60, and 75 HST.

Combination Treatment	Average Plant Height (cm)				
	15 HST	30 HST	45 HST	60 HST	75 HST
P1B1	5,8a	13,4ef	31e	32,7ab	37,8a

P1B2	6,6a	11,5b	24,8ab	33,2ab	32,7a
P1B3	7,6b	13,4f	24,5ab	34,6b	33,2a
P2B1	6a	12,3cd	24,6ab	33,6ab	32a
P2B2	6,3a	11,8bc	22,5a	29,1a	32,1a
P2B3	6,6a	12,6de	29,7de	34,3b	33,2a
P3B1	7,6b	13,3ef	26,8bc	30,3ab	33a
P3B2	6,1a	10,4a	28,4cd	33,8b	34,5a
P3B3	7,6b	11,3b	24,4ab	31,2ab	33,1a

Description: The average number followed by the same letter in the same column shows an insignificant difference according to *Duncan's Multiple Range Test* at a level of 5%.

Number of Primary Branches

Based on the results of the analysis of variance (ANOVA) with a level of 5% on the primary branches of the lamb variety peanut treated with PGPR (P) with Biochar (B), there was a significantly different interaction at the age of 45 HST and 60 HST, but there was no significant interaction at the age of 30 HST.

The best average was found in treatments P1B2 (PGPR 10 ml/L + Biochar 3 tons/ha), P2B2 (PGPR 15 ml/L + Biochar 3 tons/ha) and P3B1 (PGPR 20 ml/L + Biochar control) which produced the same average of 5 branches at 60 days after planting. This was significantly different from the other treatments. In the P3B1 treatment with 20ml/L PGPR with control biochar supports the role of biochar in vegetative growth, because the microbes in PGPR are able to develop more dominantly and effectively in accelerating plant growth. This is in accordance with research conducted by (Marom & Rizal, 2017) which stated that PGPR at a concentration of 12.5-20 ml/L is very effective in increasing vegetative parameters including the number of primary branches due to increased hormones and nitrogen absorption. So it can be concluded that the provision of PGPR and biochar at moderate concentrations provides optimal conditions for plants in maximizing primary branch growth through the provision of hormones and increasing the efficiency of nutrient utilization.

Table 2. Average primary branches of peanuts (cm) in the combination of PGPR (P) and Biochar (B) treatments at 30, 45, and 60 HST.

Combination Treatment	Number of Branches			
	30 HST	45 HST	60 HST	
P1B1	2,2a	3,2a	3,3a	

P1B2	1,8a	4bc	5c	
P1B3	2a	4bc	4abc	
P2B1	2,1a	3,9bc	4,6bc	
P2B2	1,6a	3,5ab	5c	
P2B3	1,9a	4c	4,3abc	
P3B1	1,8a	3,8bc	5c	
P3B2	1,8a	3a	4,2abc	
P3B3	1,6a	3a	3,8ab	

Description: The average number followed by the same letter in the same column shows no significant difference according to *Duncan's Multiple Range Test* at 5% level.

Number of Plant Pods

Based on the results of the analysis of variance (ANOVA) at the 5% level in observing the number of pods of the Lamb variety of peanut plants in the PGPR (P) treatment with Biochar (B), there was a significant interaction.

The pod number parameter showed a significantly different interaction between the other treatments. The best average was found in treatment P3B1 (PGPR 20 ml/L + Biochar control), which produced an average of 22.13 pods per plant and was significantly different from the other treatments. This could be due to the ability of PGPR at a high dose to increase nitrogen availability through biological fixation and increase the formation of hormones that encourage pod development. With biochar control, PGPR at a high dose was able to work more dominantly, which could be caused by microorganisms not encountering other organic materials for root growth. These results are supported by research (Dwi Anjardita, 2018) which stated that PGPR can significantly increase the number of pods in entisol soil, especially when used in the early growth phase. The study also stated that the addition of excessive organic fertilizer does not always increase the number of pods if biological nitrogen fixation is optimal. Thus, treatment P3B1 confirms that the application of high doses of PGPR with biochar control can influence the pod growth process efficiently.

Table 3. Average number of peanut pods (cm) of the Lamb variety in the PGPR (P) treatment with Biochar (B).

Combination Treatment	Number of Plant Pods
P1B1	21,13cd
P1B2	19,93abc
P1B3	18,66a
P2B1	19,98abc
P2B2	18,66a
P2B3	18,93ab
P3B1	22,13c
P3B2	19ab
P3B3	19,93abc

Description: The average number followed by the same letter in the same column shows no significant difference according to Duncan's multiple range test at a level of 5%.

Fruit Weight Per Plant

Based on the results of the analysis of variance (ANOVA) with a level of 5% in observations of fruit weight per plant in the lamb variety peanut treated with PGPR (P) and Biochar (B), it shows that there is a significantly different interaction effect.

Fruit weight per plant is crucial for evaluating peanut productivity because it directly reflects nutrient uptake efficiency, pod formation, and seed filling success during the generative phase. The results showed the highest average yield in the P3B3 treatment (PGPR 20 ml/L + Biochar 6 tons/ha), with a value of 65.74, significantly different from the other treatments. This indicates that the combination treatment with the highest dose of PGPR and Biochar effectively increased yields. This could be due to PGPR's ability to support nutrient uptake, such as nitrogen, phosphorus, and potassium, and stimulate growth hormone production. Furthermore, high doses of biochar can improve soil structure, increase water retention, and increase cation exchange capacity, making nutrients more available sustainably during the formation phase. This finding is also supported by research (Dedy Prasetyo, 2022) that found the combination of PGPR and biochar significantly increased fruit weight.

Table 4. Average fruit weight per peanut plant of the Lamb variety in the combination treatment of PGPR (P) with Biochar (B).

Combination Treatment	Fruit Weight Per Plant
P1B1	52,13bc
P1B2	53,36bc
P1B3	51,84bc
P2B1	42,57a
P2B2	47,48ab
P2B3	54,4c
P3B1	61,73cd
P3B2	58,03de
P3B3	65,74e

Description: The average number followed by the same letter in the same column shows no significant difference according to *Duncan's multiple range test* at a level of 5%.

Weight 100 Seeds

Based on the results of the analysis of variance (ANOVA) with a 5% level on the observation of the weight of 100 seeds in the lamb variety peanut treated with PGPR (P) with Biochar (B), it shows that there is a significantly different interaction effect.

Table 5. Average weight of 100 peanut seeds of the Lamb variety in the PGPR (P) and Biochar (B) treatments.

Combination Treatment	Weight 100 Seeds
P1B1	32,23a
P1B2	32,28a
P1B3	32,22a
P2B1	32,12a
P2B2	31,84a
P2B3	33,42c
P3B1	32,84b
P3B2	34,27d
P3B3	35,52e

Description: The average number followed by the same letter in the same column shows no significant difference according to *Duncan's Multiple Range Test* at a level of 5%.

The 100-seed weight parameter is an indicator of the quality of peanut crop harvests, especially related to seed filling efficiency and seed maturity level. In this study, the best average was found in the P3B3 treatment (PGPR 20 ml/L+Biochar 6 tons/ha) with a value of 35.52 and was significantly different from other treatments. This increase in seed weight explains that the correct concentration of PGPR and biochar dosage can increase peanut production, allegedly because the addition of PGPR and the correct dosage of biochar will increase the number of good bacteria because biochar in the soil can loosen the soil, so that bacteria can grow well, so that growth will be good, with good plant growth then the plant will produce well. This is in accordance with the research results (Ventin & Sudiarso, 2020) that the bacteria found in PGPR are able to increase plants in the absorption of nutrients N, P, and K. In addition, PGPR bacteria also play a role as hormone producers, binding N2 from the air and producing indole acetic acid (IAA) which can prevent the process of shedding plant organs so that plant growth results are better.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Based on the results of research that has been conducted on "The Response of Plant Growth Promoting Rhizobacteria (PGPR) and Biochar to the Growth and Yield of Peanut (Arachis hypogaea L.) Variates Domba", the following conclusions were obtained:

1. PGPR concentration treatment significantly affected the growth and yield of peanut (Arachis hypogaea L.) plants. PGPR increased plant height, number of primary branches, number of pods, fruit weight per plant, and weight of 100 seeds. A concentration of 20 ml/L yielded better results than other concentrations.
2. Biochar treatment also significantly impacted the growth and yield of peanut (*Arachis hypogeaea* L.) plants. A dose of 6 tons/Ha significantly

increased the number of branches, the weight of each plant, and the weight of 100 seeds compared to other doses.

3. The best treatment combination is P3B3 which is PGPR 20 ml/L + biochar 6 tons/Ha, because it is able to produce the best weight of 100 seeds and is very different compared to other treatment.

Recommendations

1. The use of PGPR was carried out at a concentration of 20 ml/L with 6 tons/ha of biochar to increase the yield and quality of the Lamb variety of peanut plants.
2. Further research is needed in the field to test the effectiveness of the best treatment in different soil and climate conditions.
3. The combination of PGPR and Biochar can also be tested on other peanut varieties or other legume plants to see the consistency of its effect on growth and yields.

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