



The Effect of the Composition of Planting Media and the Concentration of Plant Growth-Promoting Rhizobacteria (PGPR) on the Growth and Yield of Bird's Eye Chili (*Capsicum frutescens* L.)

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Abstract: Chili pepper (*Capsicum frutescens* L.) is a high-value horticultural commodity, but its productivity is often hampered by the excessive use of chemical fertilizers. This study aims to evaluate the effect of planting medium composition and plant growth-promoting rhizobacteria (PGPR) concentration on the growth and yield of chili pepper. The study was conducted from May to August 2025 at the Kedungrejo Seed Garden, Madiun Regency, using a factorial Randomized Block Design (RAK) with two factors: planting medium (soil, soil + compost, soil + manure, and soil + compost + manure) and PGPR concentration (0, 8, 16, and 24 ml/L), each replicated three times. Significant interactions were found between planting medium and PGPR on plant height, number of leaves, and fruit weight. The combination of soil + manure with PGPR at doses of 8 and 16 ml/L produced the highest values for fruit weight (up to 2.99 g) and number of leaves (44). Soil and manure alone also increased root weight and fruit number while accelerating flowering. PGPR at a dose of 16 ml/L significantly increased shoot dry weight and shortened the harvest period. This study demonstrates that combining organic media with PGPR can sustainably increase chili productivity.

Keywords: Chili pepper; Crop yield; PGPR concentration; Planting media composition

Introduction

Chili peppers (*Capsicum frutescens* L.) are a horticultural commodity with high economic value. Their nutritional content includes calories, protein, fat, carbohydrates, calcium, vitamins (A, B1, and C), and capsaicin, which imparts a distinctive spicy flavor (Sipahutar, 2022). Demand for chili peppers in Indonesia shows an increasing trend every year, but production tends to fluctuate. This condition is primarily due to farmers' limited knowledge of cultivation techniques, particularly fertilizer management (Sajar & Setiawan, 2024).

Excessive use of chemical fertilizers not only increases production costs but also negatively impacts soil health, including decreased fertility, disrupted microbial balance, and reduced nutrient uptake efficiency. These impacts ultimately hamper chili pepper productivity. Therefore, alternative, environmentally friendly cultivation technologies are needed that can improve the physical, chemical, and biological properties of the soil through the addition of organic matter while increasing nutrient availability with the help of Plant Growth - Promoting Rhizobacteria (PGPR) (Ishartati et al., 2022). The combination of organic media with PGPR is seen as an integrated approach to

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support plant growth and increase yields sustainably (Hadi et al., 2023).

Planting media plays a crucial role as a support, nutrient provider, and site for root growth. The addition of organic materials such as compost and manure has been shown to improve soil structure, increase cation exchange capacity, and enrich soil microorganisms (Tarihoran et al., 2019). Meanwhile, PGPR is a group of beneficial bacteria in the rhizosphere that can enhance plant growth through nitrogen fixation, phosphate solubilization, and the production of growth hormones such as IAA (Widawati et al., 2015).

Several previous studies have demonstrated the role of organic media and PGPR separately in increasing plant productivity. Hawari et al. (2021) reported that the use of soil media combined with manure can increase the growth and yield of several horticultural crops. Meanwhile, research by Herliya et al. (2024) showed that the application of PGPR at a concentration of 16 ml/L effectively accelerated the generative phase and increased yields. Furthermore, research by Murti et al. (2024) found that the best combination for cayenne pepper (*Capsicum frutescens* L.) was achieved at a PGPR concentration of 16 ml/L with a soil: compost (1:1) growing medium. This treatment resulted in the highest shoot dry weight of 148.52 g and the longest root length reaching 42.50 cm. These findings confirm that the integration of organic media with PGPR can provide optimal growth results for cayenne pepper (Hadi et al., 2023).

Based on this description, this study aims to evaluate the effect of combinations of various organic growing media compositions and PGPR concentrations on the growth and yield of cayenne pepper. The results are expected to provide a scientific basis and technical recommendations for developing more productive and environmentally friendly cayenne pepper cultivation.

Method

This research was conducted from May to August 2025 at the Kedungrejo Seed Garden, Pilangkenceng District, Madiun Regency, East Java Province. The research location is in a tropical climate with an altitude of 63 m above sea level, an average daily temperature of 24–32°C, and relative humidity ranging from 51–84%. The materials used included Dewata F1 hybrid chili seeds, soil, compost, manure, inorganic fertilizers (NPK 16:16:16, urea, SP-36, KCl), the PGPR isolate *Pseudomonas* sp. SKNG-03, chemical pesticides (Agrimec, Pegasus, and Alike), and supporting materials such as labels, envelopes, and distilled water. The equipment used included polybags, a digital scale, a measuring cylinder, a sprayer, a bucket, a ruler, stakes, and a camera for documentation.

The experimental design used was a factorial Randomized Block Design (RBD) with two factors and three replications. The first factor was the planting medium composition (M), which consisted of four levels: M0 = soil (control), M1 = soil + compost (1:1), M2 = soil + manure (1:1), and M3 = soil + compost + manure (1:1:1). The second factor was the PGPR concentration (P), which consisted of four levels: P0 = no PGPR, P1 = 8 ml/L, P2 = 16 ml/L, and P3 = 24 ml/L. The combination of these two factors resulted in 16 treatments, each replicated three times, resulting in 48 experimental units. Each experimental unit consisted of nine plants, with three plants randomly selected as observation samples.

The research began with sowing chili seeds until they were ready to be transferred to polybags containing the appropriate growing medium. PGPR was applied at the appropriate concentration level at transplanting and repeated periodically throughout the growing period. Plant maintenance included watering, weeding, staking, follow-up fertilization, and pest and disease control. Harvesting was carried out when the cayenne peppers reached their optimal maturity. Observed parameters included vegetative growth, generative growth, and yield. Data were analyzed using ANOVA, and if a significant effect was found, Duncan's Multiple Range Test (DMRT) was applied at the 5% level (Vauzia et al., 2023).

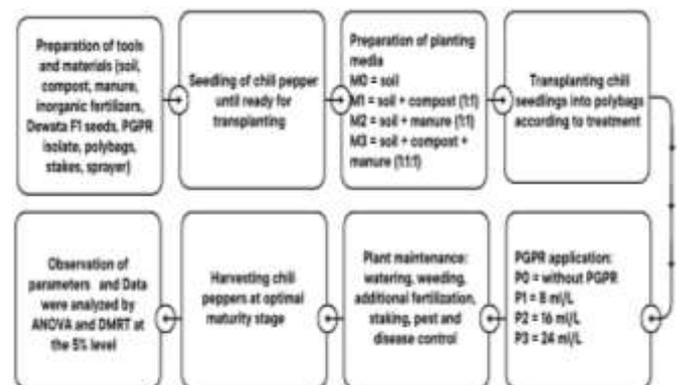


Figure 1. Research implementation flowchart

Results and Discussion

Plant Height

ANOVA revealed a significant interaction between growing media composition and PGPR concentration on chili pepper (*Capsicum frutescens* L.) height at 7 DAP, but not at later stages. Growing media composition alone significantly affected plant height at 7, 14, 21, 35, and 42 DAP, with mean values shown in Table 1.

Table 1 shows that the growing medium composition significantly increased plant height at 14 and 21 days after planting (DAP), with the highest

growth in the soil + manure medium (16.81 cm and 21.39 cm, respectively). No significant effect was observed at 28–42 days after planting from either the growing media or the PGPR concentration. The superior growth in the soil + manure medium was due to the higher nitrogen content, which encouraged stem elongation and leaf

formation (Lingga & Marsono, 2013). Similar results were also reported by (Meida et al., 2024), who found that the combination of chicken manure and inorganic fertilizer increased chili plant height by increasing nitrogen availability and improving soil structure, which supports optimal nutrient absorption.

Table 1. Average Plant Height (cm) of Chili Pepper Plants Due to Planting Media Composition and PGPR Concentration Treatments at 14 – 42 HST

Planting media composition & Concentration PGPR	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Soil	13.28 a	17.83 a	21.69	25.53	30.81
Soil+Compost	15.58 b	19.61 ab	22.94	26.94	32.11
Soil+Manure	16.81 b	21.39 b	24.00	28.06	32.86
Soil + Compost + Manure	13.64 ab	17.94 a	21.47	25.56	30.75
BNJ 5%	1.89	2.55	tn	tn	tn
0 ml/L	14.19	18.22	22.06	25.92	31.11
8 ml/L	15.08	19.53	22.47	26.31	31.50
16 ml/L	15.08	19.83	23.17	27.39	32.19
24 ml/L	14.94	19.19	22.42	26.47	31.72
BNJ 5%	tn	tn	tn	tn	tn

Description: The average number followed by the same letter in each treatment and the same column indicates no significant difference in the 5% BNJ test; tn: Not Real

Meanwhile, the single PGPR concentration treatment on plant height at 14–42 days after planting (DAP) had no significant effect. This indicates that plant height growth is more influenced by genetic factors and basic environmental conditions than by the PGPR treatment. Physiologically, PGPR plays a crucial role in supporting plant growth through several mechanisms, namely nitrogen fixation, phosphate solubilization, and the production of phytohormones such as auxins, gibberellins, and cytokinins (Amanda et al., 2024). According to Hyder et al. (2020), *Pseudomonas* and *Bacillus* bacteria from the rhizosphere of chili peppers produce IAA and siderophores, which enhance root growth and plant resistance to pathogens. However, their effect on stem elongation is relatively small due to their dominant activity in the roots.

However, these roles are more dominant in supporting root development, increasing nutrient uptake efficiency, and accelerating the transition from the vegetative to the generative phase. This was also explained by Kazerooni et al. (2021), who found that *Bacillus amyloliquefaciens* in *Capsicum annuum* plants increased ACC-deaminase enzyme activity, chlorophyll levels, and growth hormone balance, thus improving plant adaptation to stress, but not always significantly increasing stem height.

Therefore, the effect of PGPR on plant height is not always apparent. Chili plant height is generally more influenced by genetic factors that determine stem growth potential. Although PGPR can increase nutrient availability, the energy produced by the plant is diverted more to support the formation of other vegetative organs, such as leaves, or to prepare for the generative

phase (flowering and fruiting), rather than to increase stem height. This finding is supported by the results of Hyder et al. (2020), which showed that increased PGPR activity was more significant for leaf biomass and flowering than for stem growth. This is consistent with the findings of Sini et al. (2024) that plant responses to PGPR inoculation were more significant for leaf number, flowering time, and fruit production than for plant height.

Number of Leaves

ANOVA results indicated that the interaction between planting media composition and PGPR concentration significantly affected the number of cayenne pepper (*Capsicum frutescens* L.) leaves at 14–42 days after planting, but not at 7 days. Planting media composition alone showed a significant effect at 7 days. The mean leaf numbers for each treatment combination are presented in Table 2.

Table 2 shows that the combination of growing media composition and PGPR concentration had a significant interaction effect on the number of leaves of chili pepper (*Capsicum frutescens* L.) plants at 14, 21, 28, 35, and 42 days after planting (DAP). The highest average number of leaves was observed in the treatment combination of soil + farmyard manure with 16 ml/L PGPR concentration, which produced 24.11 leaves at 14 DAP, 37.44 leaves at 21 DAP, 39.78 leaves at 28 DAP, 39.56 leaves at 35 DAP, and 44.44 leaves at 42 DAP. In contrast, the lowest number of leaves was found in the treatment combination of soil + farmyard manure with 0 ml/L PGPR inoculation, yielding 9.00 leaves at 14

DAP, 16.78 leaves at 21 DAP, 22.78 leaves at 28 DAP, 23.89 leaves at 35 DAP, and 30.22 leaves at 42 DAP.

Table 2. Average Number of Chili Leaves Due to Combination of Planting Media Composition and PGPR Concentration Treatments at 14, 21, 28, 35, and 42 HST

Age (DAP)	Planting Media Composition	Concentration PGPR (ml/L)			
		0 ml/L	8 ml/L	16 ml/L	24 ml/L
14	Soil	10.2 ab	11.11 ab	9.00 a	9.33 ab
	Soil+Compost	10.67 ab	19.67 bc	16.89 b	21.22 bc
	Soil+Manure	15.44 ab	17.56 bc	24.11 c	19.33 bc
	Soil + Compost + Manure	16.11 b	13.56 ab	12.78 ab	14.00 ab
	BNJ 5%				7.07
21	Soil	21.22 ab	19.22 ab	16.78 a	18.67 ab
	Soil+Compost	20.33 ab	31.33 bc	29.00 bc	32.78 bc
	Soil+Manure	28.00 b	30.11 b	37.44 c	30.11 bc
	Soil + Compost + Manure	27.00 b	24.33 ab	24.56 ab	25.22 ab
	BNJ 5%				9.82
28	Soil	24.11 ab	22.67 ab	20.78 a	22.78 ab
	Soil+Compost	23.89 ab	32.44 bc	30.78 b	34.11 bc
	Soil+Manure	30.00 b	32.33 bc	39.78 c	32.22 bc
	Soil + Compost + Manure	29.22 ab	27.00 ab	27.11 ab	27.78 ab
	BNJ 5%			8,69	
35	Soil	27.56 ab	25.78 ab	23.89 a	25.22 ab
	Soil+Compost	27.11 ab	34.56 b	32.44 b	35.56 b
	Soil+Manure	32.22 b	34.89 b	39.56 b	34.22 b
	Soil + Compost + Manure	31.22 ab	29.44 ab	29.56 ab	29.67 b
	BNJ 5%				8.26
42	Soil	33.89 ab	33.33 ab	30.22 a	31.89 ab
	Soil+Compost	32.56 ab	39.33 ab	38.00 b	40.89 b
	Soil+Manure	38.00 b	40.67 b	44.33 b	39.89 b
	Soil + Compost + Manure	36.00 b	35.22 b	36.00 b	35.33 b
	BNJ 5%				7.71

Description: The average number followed by the same letter in each combination and observation period shows no significant difference in the 5% BNJ test.

The combination of soil, manure, and PGPR has been shown to significantly impact plant growth, particularly in increasing leaf number. This is because each nutrient complements the other. Manure contains nitrogen and organic matter, which are essential for leaf and stem growth. Nitrogen helps the formation of chlorophyll and protein, enabling plants to photosynthesize and grow well (Tong et al., 2024). Similar results were also reported by Purnamasari et al. (2025), who found that the combination of chicken manure and bamboo root PGPR increased leaf number and accelerated the vegetative growth of cayenne peppers.

Age of Flower Emergence

The analysis of variance revealed that the combination of growing media composition and PGPR concentration showed no significant interaction effect on the flowering time of cayenne pepper (*Capsicum frutescens* L.). However, each single factor—growing

media composition and PGPR concentration—significantly affected the flowering time. The mean flowering time of cayenne pepper under these treatments is presented in Table.

Table 3. Average Age of Flower Emergence of Chili Pepper Plants Due to Planting Media Composition and PGPR Concentration Treatments

Planting media composition & Concentration PGPR	
Soil	42.67 b
Soil+Compost	38.61 a
Soil+Manure	36.89 a
Soil + Compost + Manure	40.67 ab
BNJ 5%	3.62
0 ml/L	42.06 b
8 ml/L	39.28 ab
16 ml/L	37.72 a
24 ml/L	39.53 ab
BNJ 5%	3.62

Description: The average number followed by the same letter in each treatment shows no significant difference in the 5% BNJ test.

Table 3 shows that the single factor of growth medium composition significantly affected the flowering time of cayenne pepper (*Capsicum frutescens* L.), with the best average value of 36.89 days after planting observed in the soil + manure treatment and the worst average value of 42.67 days after planting observed in the soil-only (control) treatment. This difference indicates the important role of organic matter in improving the physical, chemical, and biological properties of the soil (Arifin et al., 2024). Pure soil media are generally nutrient-poor, less friable, and have limited aeration and drainage, which slows vegetative growth and delays flowering (Sutedjo & Kartasapoetra, 2010). The addition of compost improves soil structure, increases cation exchange capacity, and gradually supplies macro- and micronutrients. The soil + manure medium produced the best results because the manure decomposes more quickly, providing sufficient nitrogen, phosphorus, and potassium. Nitrogen supports vegetative growth, allowing plants to reach optimal conditions for flowering more quickly, while potassium plays a role in flower formation and the translocation of assimilates to the generative organs. Thus, balanced nutrient availability in the soil and manure media accelerates the plant's transition from the vegetative to the generative phase (Sumarna & Rushiana, 2023).

The single factor, PGPR concentration, significantly affected the flowering time of cayenne pepper plants, with the best average value being 37.72 days after planting at a concentration of 16 ml/L, and the worst average flowering time being 42.06 days after planting at a control PGPR concentration of 0 ml/L. This is because the 16 ml/L concentration has been shown to increase PGPR activity in mobilizing nutrients in a balanced manner, thus supporting accelerated flowering. Meanwhile, at lower concentrations (0 and 8 ml/L), PGPR activity in producing hormones and increasing nutrient availability was relatively suboptimal. Consequently, plants took longer to enter the generative phase. Conversely, at higher concentrations (24 ml/L), excessive microbial numbers could actually compete with plant roots for oxygen and nutrients in the root zone. Research shows that a PGPR dose of 10–15 ml/L significantly increases plant height, leaf number, and chili yield (Santika et al., 2023). Furthermore, PGPR plays a role in nitrogen fixation, phosphorus solubilization, and the production of phytohormones such as auxins, gibberellins, and cytokinins, which accelerate flowering (Raza et al., 2021).

Harvest Age

The results of the analysis of variance showed that the combination of planting media composition and PGPR concentration treatments did not have a significant interaction on the harvest age of cayenne pepper (*Capsicum frutescens* L.) plants. The single treatment of planting media composition had no significant effect, while the single treatment of PGPR concentration had a significant effect on the harvest age of cayenne pepper plants (Appendix Table 16). The average results of cayenne pepper harvest age in the planting media composition and PGPR concentration treatments are presented in Table 4.

Table 4. Average Harvest Age of Chili Pepper Plants Due to Planting Media Composition and PGPR Concentration Treatment

Planting media composition & Concentration PGPR	
Soil	68.36
Soil+Compost	68.08
Soil+Manure	67.44
Soil + Compost + Manure	68.39
BNJ 5%	tn
0 ml/L	70.00 b
8 ml/L	67.47 a
16 ml/L	67.22 a
24 ml/L	67.58 a
BNJ 5%	3.49

Description: The average number followed by the same letter in each treatment shows no significant difference in the 5% BNJ test; tn: Not Real.

Table 4 shows that the single factor of growing media composition had no significant effect on the harvesting time of cayenne pepper (*Capsicum frutescens* L.). This indicates that growing media is not the main determinant of harvest time, which is primarily influenced by plant genetic factors and environmental conditions. In contrast, the single factor of PGPR concentration significantly affected harvest time, with the best mean value of 67.22 DAP observed at 16 ml/L PGPR, while the longest harvest time of 70.00 DAP was recorded at 0 ml/L PGPR.

This finding is consistent with Wulandari et al. (2018), who reported that PGPR at an optimal dose can accelerate harvest time by enhancing phytohormone production and improving plant physiology, while excessively high doses are less efficient than the optimum. Similar findings were also reported by Novian Zeni et al. (2023), who demonstrated that PGPR at 10–15 ml/L significantly improved growth and yield of chili, thereby contributing to earlier harvesting. Moreover, the role of root distribution and nutrient uptake efficiency, which is strongly affected by environmental conditions, is also a key factor influencing harvest time in chili cultivation (Iemaaniah

et al., 2023), In addition, microbial consortia, including PGPR groups, have been shown to support plant generative development and improve yield quality by supplying nutrients and phytohormones that accelerate maturity (Aksarah et al., 2024).

Root Dry Weight

The results of the analysis of variance (ANOVA) showed that the combination of planting media composition and PGPR concentration treatments did not provide a significant interaction on the dry weight of cayenne pepper (*Capsicum frutescens* L.) roots. The single treatment of planting media composition and PGPR concentration each had a significant effect on the dry weight of cayenne pepper root plants. The average value of dry weight of plant roots due to planting media composition and PGPR inoculation concentration is presented in Table 5.

Table 5. Average Dry Weight of Roots of Chili Pepper Plants Due to Planting Media Composition and PGPR Concentration Treatments

Planting media composition & Concentration PGPR	
Soil	4.41 a
Soil+Compost	5.17 ab
Soil+Manure	5.69 b
Soil + Compost + Manure	4.78 ab
BNJ 5%	0.95
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0 ml/L	4.43 a
8 ml/L	5.02 ab
16 ml/L	5.66 b
24 ml/L	4.95 ab
BNJ 5%	0.95

Description: The average number followed by the same letter in each treatment shows no significant difference in the 5% BNJ test.

Table 5 shows that the growing media composition had a significant effect on the root dry weight of cayenne pepper (*Capsicum frutescens* L.) plants, with the highest mean root weight of 5.69 g observed in the soil + farmyard manure treatment and the lowest mean of 4.41 g in the soil-only (control) treatment. This result is attributed to the role of organic material mixtures in improving and supporting the growing medium. Farmyard manure, as a component of the growing medium, provides essential macronutrients (N, P, and K) that enhance root growth and the development of root hairs, ultimately contributing to higher root dry weight (Havlin, 2014). Healthy root growth is strongly influenced by several factors, particularly phosphorus, which promotes cell division and elongation in the root meristem and increases ATP synthesis, an essential energy source for new tissue formation.

The single factor of PGPR inoculation concentration showed the highest value at 16 ml/L, with a mean root

dry weight of 5.66 g, which was significantly different from the control (0 ml/L) at 4.43 g, but not significantly different from the 8 ml/L and 24 ml/L treatments. This effect is attributed to indole-3-acetic acid (IAA) produced by rhizobacteria, which enhances lateral root development and root hair formation, thereby promoting longer and more branched roots that contribute to increased root dry weight. IAA biosynthesis in the soil can be stimulated by natural tryptophan released from root exudates, which is converted into IAA by microbes (Kholida & Enny, 2015). The 16 ml/L PGPR inoculation concentration proved to optimize its population within the roots, thereby maximizing its ability to increase root dry weight.

Plant Dry Weight

The results of the analysis of variance (ANOVA) showed that the combination of planting media composition and PGPR inoculation concentration did not provide a significant interaction on the dry weight of cayenne pepper (*Capsicum frutescens* L.) stems. The single treatment of planting media composition had no significant effect, while the single treatment of PGPR concentration had a significant effect on the dry weight of cayenne pepper stems. The average value of dry weight of plant stalks due to planting media composition and PGPR inoculation concentration is presented in Table 6.

Table 6. Average Dry Weight of Slabs (g) of Chili Pepper Plants Due to Planting Media Composition and PGPR Concentration Treatments

Dry Weight of Slabs (g)	
Soil	65.54
Soil+Compost	66.62
Soil+Manure	67.17
Soil+Compost+Manure	69.14
BNJ 5%	tn
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0 ml/L	64.10 a
8 ml/L	64.62 ab
16 ml/L	72.94 b
24 ml/L	66.80 ab
BNJ 5%	6.81

Description: The average number followed by the same letter in each treatment shows no significant difference in the 5% BNJ test; tn: Not Real.

Table 6 shows that the single treatment of planting media composition did not have a significant effect, but the soil-only manure planting media composition treatment provided the highest average value of 67.17 g and the soil planting media composition (control) provided the lowest average value of 65.54 g. This indicates that all planting media used were able to provide relatively similar nutrients and physical

conditions so that the vegetative growth of the plants was balanced.

This indicates that all growing media used were able to provide relatively equal nutrients and physical conditions so that the vegetative growth of the plants was balanced (Shyam & Narzary, 2024). The highest single treatment of PGPR inoculation concentration was 16 ml/L with a value of 72.94 g, which was significantly different from the average value of PGPR inoculation concentration of 0 ml/L (control) of 64.10 g. The PGPR inoculation concentration of 16 ml/L was not significantly different from the PGPR inoculation treatments of 8 and 24 ml/L. This is due to the effectiveness of bacterial colonization which is highly dependent on the dose. At low concentrations, bacterial colonies have not yet sufficiently dominated the rhizosphere, while at too high concentrations, competition between microbes or even toxic effects can occur in plants (Zhang et al., 2023). Listiani (2020) reported that the optimal PGPR concentration ranges from 10^7 - 10^8 CFU/mL, which can significantly increase chili biomass. The results of other studies also show that the application of PGPR consortium is able to improve fruit quality and improve soil chemical properties through changes in the microbial community in the rhizosphere (Zhang et al., 2023).

Total Number of Fruits

ANOVA results showed no significant interaction between planting media composition and PGPR concentration on the total number of cayenne pepper (*Capsicum frutescens* L.) fruits per plant. However, each factor individually had a significant effect, with mean values presented in Table 7.

Table 7. Average Total Number of Fruits per Chili Pepper Plant Due to Planting Media Composition and PGPR Concentration Treatments

Total Number of Fruits	
Soil	72.22 a
Soil+Compost	81.00 ab
Soil+Manure	86.94 b
Soil+Compost+Manure	81.03 ab
BNJ 5%	7.03
0 ml/L	76.47 a
8 ml/L	82.50 ab
16 ml/L	80.86 ab
24 ml/L	86.36 b
BNJ 5%	7.03

Description: The average number followed by the same letter in each treatment shows no significant difference in the 5% BNJ test.

Table 7 shows that the single treatment of soil + manure planting media composition had a significant effect compared with the soil planting media

composition (control), with the highest average value of 86.94 and the lowest average value of 77.22. This is because the composition of soil + manure provides macronutrients N, P, K which are available more quickly and in greater quantities compared to soil + compost. Nitrogen plays a role in supporting good vegetative growth, phosphorus helps flower formation, and potassium accelerates the formation and filling of fruit so that the number of fruits formed is greater. In addition, manure is also able to increase the activity of soil microbes that can dissolve phosphate and increase the availability of essential nutrients (Waskito et al., 2018).

The highest single treatment of PGPR inoculation concentration was 24 ml/L with a value of 86.36 which was significantly different from the average value of 0 ml/L PGPR inoculation concentration (control) which was 76.47 and the PGPR inoculation concentration of 24 ml/L was not significantly different from the PGPR inoculation treatments of 8 and 16 ml/L. This indicates that a concentration of 24 ml/L is the optimal dose in supporting the process of flowering, fruiting, and the success of fruit ripening to harvest. Physiologically, PGPR acts as a plant growth stimulating agent through the mechanism of hormone production (auxin, cytokinin, and gibberellin), phosphate solubilization, increased nitrogen absorption, and improvement of the root system (Aini et al., 2023). At a concentration of 24 ml/L, the number of microorganisms applied was greater, so that physiological activity around the rhizosphere increased. Furthermore, at lower concentrations (8 and 16 ml/L), plants still benefited from PGPR, but bacterial colonization in the rhizosphere was not optimal, resulting in a less than optimal effect on fruit formation. Meanwhile, in the treatment without PGPR (0 ml/L), the flowering and fruiting processes depended solely on the natural nutrient conditions of the growing medium, resulting in fewer fruits than in the optimal PGPR treatment.

Fruit Weight per Fruit

The results of the analysis of variance (ANOVA) showed that the combination of planting media composition and PGPR concentration treatments had an interaction on the weight per fruit of cayenne pepper (*Capsicum frutescens* L.) plants. A single treatment of planting media composition had an effect on the weight per fruit of cayenne pepper plants, while a single treatment of PGPR inoculation concentration had no effect on the weight per fruit of cayenne pepper plants. The average value of fruit weight per plant due to the combination of planting media composition and PGPR inoculation concentration is presented in Table 8.

Table 8 shows that the combination treatment between the composition of the planting medium and

the concentration of PGPR had a significant interaction on the fruit weight per cayenne pepper plant. The highest average fruit weight per cayenne pepper plant was in the combination treatment of the composition of the soil planting medium + manure with 8 ml/L of PGPR concentration, namely 2.99 g. Meanwhile, the lowest fruit weight per cayenne pepper plant was in the combination of the composition of the soil planting medium with 0 ml/L of PGPR concentration (control), namely 2.57 g.

The increase in chili fruit weight does not occur by chance, but rather results from a complex interaction between nutrient availability, the structure of the growing medium, and the activity of beneficial

microorganisms in the root zone. In this study, the combination of soil and manure in the growing medium, combined with the application of PGPR, was shown to have a significant synergistic effect on increasing fruit weight. The addition of manure as organic matter plays a crucial role in improving soil structure, increasing the soil's capacity to hold air and nutrients, and creating a more supportive environment for soil microbial life. This finding aligns with research by Vejan et al. (2016), which showed that organic matter such as manure can increase cation exchange capacity (CEC), improve soil porosity, and provide an ideal habitat for beneficial microorganisms in the rhizosphere.

Table 8. Average Weight per Fruit (g) of Chili Pepper Plants Due to Planting Media Composition and PGPR Concentration Treatments

Planting media composition	Concentration PGPR			
	0 ml/L	8 ml/L	16 ml/L	24 ml/L
Soil	2.57 a	2.59 a	2.65 ab	2.64 ab
Soil+Compost	2.68 ab	2.73 b	2.78 bc	2.75 bc
Soil+Manure	2.86 c	2.99 d	2.84 c	2.80 bc
Soil + Compost + Manure	2.86 c	2.81 bc	2.79 bc	2.84 c
BNJ 5%				0.11

Description: The average number followed by the same letter in the treatment combination shows no significant difference in the 5% BNJ test.

This healthy growing medium indirectly supports the activity of PGPR (Plant Growth Promoting Rhizobacteria), which plays a crucial role in increasing plant productivity. Microbes such as *Pseudomonas* sp. have the ability to synthesize plant growth hormones, such as IAA, cytokinins, and gibberellins, which promote cell division and concentration. In addition, PGPR also solubilizes phosphate in the soil, binds nitrogen from the air, and produces the enzyme ACC-deaminase, which helps mitigate stress caused by ethylene accumulation, especially during the fruit-setting phase (Hawardi & Yudiawati, 2021). However, the success of PGPR depends on a growing environment rich in organic matter. Without adequate substrate, PGPR effectiveness will decline due to the lack of energy and growth space necessary for microbial colonization and metabolism.

Interestingly, the results of this study showed that a PGPR concentration of 8 ml/L resulted in the highest fruit weight (2.99 g), compared to higher concentrations of 16 ml/L and 24 ml/L. This phenomenon suggests a balance point in PGPR application, where the microbial population is at a scale that matches the plant's physiological capacity to absorb and respond to the metabolites produced. When PGPR concentrations are too high, the accumulation of hormones or metabolites can disrupt the plant's hormonal balance, trigger excessive vegetative growth, or even lead to detrimental

intermicrobial competition. These findings are supported by those of Dhiman et al. (2023) in the journal *Horticulturae*, which stated that moderate doses of PGPR were more effective in supporting generative growth and photosynthetic efficiency, compared to high doses, which tended to have the opposite effect.

Further support for this research was also found in a study by Mahmud et al. (2018) published in the *Agroteknotropika* Journal. They reported that the combination of manure and PGPR significantly increased fruit weight and the number of cayenne peppers compared to untreated media. This research was supported by Kurniawati et al. (2023) in the *Journal Tropical Biology*, which found that applying chicken manure and PGPR to bamboo roots not only increased yields but also improved root structure and nutrient uptake efficiency. These similar results suggest that the use of PGPR will be more effective when combined with organic matter that supports activity and survival in the root zone.

Conclusion

Based on the research results, it can be concluded that the combination of planting media and PGPR concentration significantly affected the growth and yield of cayenne pepper (*Capsicum frutescens* L.). The combination of soil + manure planting media with PGPR

concentrations of 8 ml/L and 16 ml/L respectively produced the best results in terms of fruit weight per fruit, which was 2.99 g, and the number of leaves was 44 leaves. Individually, soil + manure planting media increased the dry weight of the roots (5.69 g), the total number of fruits per plant (86.94 fruits), and accelerated the emergence of flowers (36.89 days after planting). PGPR at a concentration of 16 ml/L showed the best effect on shoot dry weight (72.94 g) and accelerated the harvest time (67.22 DAP).

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Author Contributions

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Conflicts of Interest

The author declares that there is no conflict of interest related to this research. This research was conducted independently and was not influenced by personal interests, professional relationships, or financial affiliations. All decisions made during the research and writing process were made objectively and with scientific integrity.

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