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The Effects of *PGPR Type* and Application Intervals on The Growth and Yield of Cucumbers (*Cucumis Sativus* L.)

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Abstract
This study aimed to determine the effects of PGPR type and application interval on the growth and yield of cucumber plants. The study was conducted from October 26 to December 15, 2025, in Menjing Village, Jenawi Subdistrict, Karanganyar Regency, on Latosol soil at an elevation of 510 meters above sea level. This study employed a factorial design with a Randomized Complete Block Design (RCBD), consisting of two treatment factors and three replications. The first treatment factor was the type of PGPR (M), comprising three types (M1 = bamboo roots, M2 = mimosa pudica roots, and M3 = a mixture of bamboo and mimosa pudica roots). The second treatment factor, the PGPR application interval (P), consisted of three levels (I1 = 4 days, I2 = 8 days, and I3 = 12 days). The interaction between the type of PGPR treatment and the application interval had no significant effect on all observed parameters, with the best results observed in the combination of bamboo root PGPR treatment with a 4-day application interval (M1I1). The highest fruit weight of 11.61 kg/plot (60.48 tons/ha) was obtained in the M1I1 treatment combination (bamboo root PGPR applied at 4-day intervals). The lowest fruit weight of 8.19 kg/plot (42.64 tons/ha) was obtained in the M2I3 treatment combination (PGPR from mimosa roots applied at 12-day intervals).

Keywords: application interval; PGPR; plant growth; rhizobacteria

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Introduction

The cucumber plant (Cucumis sativus L) is a fruit vegetable widely consumed fresh by the Indonesian people. According to (1), cucumbers are generally served in fresh preparations, such as pickles, pickled vegetables, salads, and raw vegetable dishes. They are consumed as a refreshing beverage in the form of juice. Cucumbers are used as raw materials in cosmetics to make cleansing creams and body scrubs. Cucumbers contain saponins, proteins, fats, calcium, phosphorus, iron, sulfur, and vitamins A, B1, and C. Raw cucumbers help reduce body heat and boost stamina. Cucumbers are rich in bioactive compounds like phenolics, flavonoids, and cucurbitacins, which contribute to their antioxidant, anti-inflammatory, and other health-promoting properties (2).

According to (3), cucumbers have significant potential for development to meet the growing needs of the population in the coming years. Given the potential of ment|imun fruit, its development holds very promising business opportunities. Mango production in Indonesia reached 450,687 tons in 2022. People around the world are becoming aware of the dangers posed by the use of chemicals in agriculture. Currently, technologies have been developed that are relatively safe for the environment, such as the use of PGPR. PGPR (Plant Growth-Promoting Rhizobacteria) are bacteria that promote plant growth. The bacteria found in PGPR are a type of bacteria that typically live in plant roots. These microorganisms live in colonies around plant roots, which can stimulate plant growth and increase plant resistance to pathogenic fungi. In addition, PGPR bacteria are capable of fixing free nitrogen from the environment, a process known as nitrogen fixation. Free nitrogen is converted into ammonia and then transferred to the plant (4). Nitrogen fixed by PGPR is transferred to plants, promoting root and shoot growth, chlorophyll production, and overall plant health (5).

Plant Growth-Promoting Rhizobacteria are important and recognized as beneficial for the agricultural sector. PGPR can serve as a solution to reduce dependence on synthetic chemical fertilizers, thereby helping to sustain agricultural growth and supporting the global vision regarding development, protection, and conservation of the environment, which has already been damaged by the application of synthetic chemical fertilizers. Plant Growth-Promoting Rhizobacteria are a type of living bacteria. These microorganisms colonize and envelop plant roots. Microorganisms enhance nutrient availability by fixing nitrogen, solubilizing phosphorus, and mobilizing other essential nutrients like sulfur and potassium, making them accessible to plants (6,7,8). The research focuses on the effects of PGPR type and application intervals on the growth and yield of cucumbers (Cucumis sativus L.)

Materials and Methods

The research was conducted from October 26 to December 15, 2025, in Menjing Village, Jenawi Subdistrict, Karanganyar Regency, on Latosol soil at an elevation of 510 meters above sea level. The research was conducted using a factorial method with a Randomized Complete Block Design (RCBD) as the basic pattern, consisting of 2 treatment factors and repeated 3 times. The PGPR type treatment factor (M) consists of 3 treatment types: M1 = bamboo root PGPR, M2 = sensitive plant root PGPR, and M3 = mixed bamboo and sensitive plant root PGPR. Treatment factor PGPR application interval (I), consisting of 3 treatment levels (I1 = PGPR application interval of 4 days, I2 = PGPR application interval of 8 days, and I3 = PGPR application interval of 12 days).

Cucumber propagation: Cucumber seeds are sown in 10x10 cm polybags filled with a growing medium consisting of a mixture of soil, sand, and manure in a 1:1:1 ratio. Each polybag is planted with 1 cucumber seed. Seven-day-old cucumber seedlings are planted in the afternoon. Sample plants in each research plot are selected randomly, with 3 plants per plot. Sample plants are marked with bamboo stakes and numbered. Staking is performed when the plants are 7 days old; stakes made from bamboo strips are then driven into the ground next to the plants, 5 cm from the base of the plant, positioned at an angle into the bed so that it crosses the tip of the stake of the plant in front of it. At each crossing point, a bamboo rod is placed to connect one crossing to the next along the bed. After that, tie them with raffia string at the |intersections of the stems to make them more sturdy. PGPR is applied by pouring it into the soil in the plant's root zone at intervals according to the treatment protocol, with a concentration of 20 ml/L of water and a volume of 250 ml per plant. The fertilizers used are manure and Phonska fertilizer. Manure is applied during soil preparation by mixing it evenly into the soil in each plot at a rate of 20 tons per hectare. Phonska fertilizer is applied twice at a rate of 200 kg per hectare. The first application is made at planting, using half the recommended dose. The second application is carried out when the plants are 15 days old, using half the dose, by placing the fertilizer next to the plants at a distance of 10 cm. Irrigation is performed by channeling water through irrigation channels between the blocks and plots. Irrigation is carried out once a week. Weeding is performed once a week manually by pulling out weeds growing around the plants. Harvesting is conducted 30 days after transplanting, with a 3-day interval. Harvesting criteria: fruits are bright green in color, straight in shape, and free of defects. The observed parameters include: plant height (cm), fresh weight of bunches (g), dry weight of bunches (g), number of fruits per plant, fruit weight per plant (g), and fruit weight per plot (kg). The data were statistically analyzed using analysis of variance (ANOVA) at significance levels of 5% and 1%. If significant differences were found, the Duncan Multiple Range Test (DMRT) was then conducted at the 5% level.

Results and Discussion

Table 1 shows a summary of the results of the analysis of variance and Duncan's multiple range test (5%) for the effects of treatment type and PGPR application interval on plant height, fresh shoot weight, dry shoot weight, number of fruits per plant, fruit weight per plant, and fruit weight per plot.

Table 1. Resume treatment, PGPR-type treatment, and Interval between PGPR applications

Variable	Treatment	I1	I2	I3	Total
Plant height (cm)	M1	128.40	123.26	118.87	123.51 b
	M2	119.01	112.86	108.58	113.48 a
	M3	123.79	118.56	112.06	118.13 ab
	Total	**123.73 b**	**118.23 ab**	**113.17 a**	
Fresh biomass (g)	M1	683.20	633.32	588.92	635.15 c
	M2	574.60	510.92	431.38	505.63 a
	M3	624.13	576.29	519.43	573.28 b
	Total	**627.31 c**	**573.71 b**	**513.25 a**	
Dry biomass (g)	M1	136.91	130.51	123.51*	130.13 b
	M2	123.75	117.60	110.60	117.32 a
	M3	129.17	124.10	118.04	123.77 ab
	Total	**129.94 b**	**124.07 ab**	**117.20 a**	
Number of fruits per plant	M1	5.33	4.44	5.00	5.07 c
	M2	5.00	4.11	4.44	4.00 a*
	M3	4.89	3.44	4.00	4.48 b
	Total	**4.93 c**	**4.52 b**	**4.11 a**	
Fruit weight per plant (g)	M1	1645.82	1480.78	1633.86	1602.51 c
	M2	1604.30	1383.40	1446.63	1334.09 a*
	M3	1557.41	1138.08	1343.81	1474.77 b
	Total	**1586.82 c**	**1478.11 b**	**1346.43 a**	
Fruit weight per plot (kg)	M1	11.61	10.61	11.59	11.33 c
	M2	11.34	9.93	10.28	9.58 a*
	M3	11.03	8.19	9.57	10.48 b
	Total	**11.27 c**	**10.52 b**	**9.60 a**	

Plant Height

The results presented in Table X show that the highest plant height was obtained in treatment M1 (123.51 cm), which differed significantly from M2 but was not significantly different from M3. The lowest plant height was recorded in treatment M2 (113.48 cm), while treatment M3 (118.13 cm) showed an intermediate response and did not differ significantly from either M1 or M2.

The superior performance of M1 indicates that PGPR derived from bamboo roots was more effective in promoting cucumber plant growth than PGPR derived from the other sources. Bamboo root-associated PGPR are known to establish mutualistic interactions with plant roots, enhancing nutrient uptake and stimulating plant growth through the production of plant growth-promoting substances and improved nutrient availability in the rhizosphere (10). In contrast, PGPR derived from sensitive plant roots showed a lower ability to stimulate plant growth, resulting in the shortest plants. Nevertheless, sensitive plant roots harbor beneficial rhizosphere microorganisms, including *Azotobacter* and *Bacillus* spp., which contribute to phosphate and potassium solubilization and may improve nutrient availability under suitable conditions (9).

Regarding the application interval, treatment I1 produced the highest plant height (123.73 cm), which differed significantly from I3 but was not significantly different from I2. The lowest plant height was observed in I3 (113.17 cm), while I2 resulted in an intermediate value of 118.23 cm and did not differ significantly from either I1 or I3.

The results indicate that the frequency of PGPR application influenced cucumber plant height. More frequent application at 4-day intervals (I1) likely maintained a higher population of beneficial rhizobacteria in the rhizosphere, thereby improving nutrient availability and uptake, particularly nitrogen. PGPR are known to enhance nitrogen fixation and increase soil nitrogen availability, which supports vegetative growth and contributes to greater plant height (11). Consequently, the 4-day application interval provided more favorable conditions for cucumber growth than the 8-day or 12-day intervals.

Fresh Weight of Bunches

According to the results of Duncan's multiple range test shown in Table 1, the highest fresh weight of bunches was obtained in treatment M1 (635.15 g), which differed significantly from M2 and M3. The lowest fresh weight of bunches was observed in treatment M2 (505.63 g), which also differed significantly from M3 (573.28 g). The application of PGPR derived from sensitive plant roots (M2) resulted in a lower fresh weight of bunches than PGPR derived from bamboo roots (M1) and the combination of bamboo and sensitive plant roots (M3). PGPR from bamboo roots was able to produce more bacterial colonies, thereby stimulating host plant growth. In contrast, the mixed PGPR from bamboo and sensitive plant roots may have contained bacterial populations that were not fully synergistic, resulting in lower fresh weight production than PGPR from bamboo roots alone.

According to (12), PGPR can form colonies in the rhizosphere and directly promote plant growth by improving the availability of nitrogen, phosphorus, and other mineral nutrients, thereby enhancing the development of vegetative organs such as leaves, stems, and roots and increasing fresh biomass.

Table 1 also shows that the highest fresh weight of bunches was recorded in treatment I1 (627.31 g), which differed significantly from I2 and I3. The lowest fresh weight was obtained in treatment I3 (513.25 g), which differed significantly from I2 (573.71 g). The 12-day application interval (I3) produced the lowest fresh weight because the amount of PGPR available to support cucumber growth was relatively limited, resulting in reduced plant development. According to (13), PGPR are beneficial microorganisms capable of enhancing plant growth and yield, and reduced vegetative growth may consequently decrease fresh biomass production.

The highest fresh weight was obtained when PGPR was applied every 4 days (I1). More frequent application likely increased the population of beneficial microorganisms available for plant uptake and activity in the rhizosphere. According to (14), PGPR enhances nitrogen fixation and improves the availability of other nutrients that are essential during the vegetative growth phase.

PGPR are a group of beneficial bacteria that actively colonize the rhizosphere and play an important role in promoting plant growth and improving soil fertility (15). Enhanced vegetative growth, including increased development of leaves, stems, and roots, ultimately contributes to greater fresh biomass accumulation.

Dry weight of the bales

Table 1 shows that the highest dry weight was obtained in treatment M1 (130.13 g), which differed significantly from M2 but was not significantly different from M3. The lowest dry weight was observed in treatment M2 (117.32 g), which did not differ significantly from M3 (123.77 g). The application of PGPR derived from *Mimosa pudica* roots (M2) resulted in the lowest plant dry weight, indicating its relatively low ability to enhance nitrogen fixation. According to (3), nitrogen deficiency causes slow, weak, and stunted plant growth. In addition, leaves become pale green to yellow, resulting in reduced dry matter accumulation.

In contrast, the application of PGPR derived from bamboo roots (M1) produced the highest dry weight. Bamboo root PGPR can enhance nitrogen fixation and improve the photosynthetic process, leading to greater biomass accumulation. According to (16), plant dry weight is strongly influenced by photosynthetic activity, with higher photosynthetic rates contributing to increased dry matter production. Furthermore, bamboo root PGPR significantly improves nitrogen availability and uptake through root-associated bacteria, stimulating vegetative growth, increasing chlorophyll content, and supporting nitrogen metabolism, which ultimately increases plant dry weight.

The table also shows that the highest dry weight was obtained in treatment I1 (129.94 g), which differed significantly from I3 but was not significantly different from I2. The lowest dry weight was recorded in treatment I3 (117.20 g), which did not differ significantly from I2 (124.07 g).

The application of PGPR at 4-day intervals (I1) produced the highest dry weight, whereas extending the application interval to 8 days (I2) and 12 days (I3) resulted in a gradual reduction in dry weight. The interval of PGPR application is closely related to the amount of beneficial microorganisms available to the plants. PGPR application aims to increase the population of beneficial bacteria in the rhizosphere, thereby enhancing nutrient uptake (17). Increasing the number of active bacteria around the roots provides multiple benefits to plants, including improved mineral availability and enhanced nitrogen acquisition, which ultimately contribute to greater dry matter accumulation (18).

Number of fruits per plant

Table 1 shows that the highest number of fruits per plant was obtained in treatment M1 (5.07), which differed significantly from M2 and M3. The lowest number of fruits per plant was observed in treatment M2 (4.00), which differed significantly from M3 (4.48). The application of PGPR derived from *Mimosa pudica* roots (M2) resulted in a lower number of fruits per plant. However, the combination of PGPR from bamboo roots and *Mimosa pudica* roots (M3) increased the number of fruits produced. PGPR derived from *Mimosa pudica* roots is presumed to have a relatively lower ability to enhance phosphorus availability. PGPR application can accelerate the flowering process because *Rhizobium* bacteria help plants absorb and meet their nutrient requirements. At the same time, PGPR also functions to solubilize and increase the availability of phosphorus (P) in the soil (19).

The application of PGPR derived from bamboo roots (M1) produced the highest number of fruits per plant. Bamboo root PGPR contains beneficial microorganisms that can enhance the uptake of phosphorus as well as nitrogen (15). Phosphorus plays an important role in increasing the percentage of flowers that develop into fruits, thereby contributing to higher fruit production.

The table also shows that the highest number of fruits per plant was obtained in treatment I1 (4.93), which differed significantly from I2 and I3. The lowest number of fruits per plant was observed in treatment I3 (4.11), which differed significantly from I2 (4.52). Application of PGPR at 4-day intervals (I1) resulted in the highest fruit production, whereas extending the application interval to 8 days (I2) and 12 days (I3) reduced the number of fruits produced. This result suggests that more frequent PGPR application allows greater availability and absorption of beneficial microorganisms by the plants. Therefore, the application interval is closely related to the effectiveness of PGPR in supporting plant growth and productivity.

According to (12), PGPR consists of various beneficial bacteria that, when applied at an appropriate concentration, can promote plant growth through both direct and indirect mechanisms. One of its direct effects is improving nutrient availability and facilitating nutrient uptake, particularly phosphorus, which plays a critical role in flower and fruit development and ultimately increases the number of fruits produced.

Fruit weight per plant

The results of Duncan's multiple range test presented in Table 1 show that the highest fruit weight per plant was obtained in treatment M1 (1602.51 g), which differed significantly from M2 and M3. The lowest fruit weight per plant was observed in treatment M2 (1334.09 g), which differed significantly from M3 (1474.77 g). The application of PGPR derived from *Mimosa pudica* roots (M2) resulted in a lower fruit weight per plant than both the mixed PGPR of bamboo and *Mimosa pudica* roots (M3) and the PGPR derived from bamboo roots (M1). PGPR application introduces beneficial bacteria that colonize the rhizosphere and promote plant growth. PGPR from bamboo roots contains a greater abundance of bacteria capable of fixing atmospheric nitrogen and stimulating root development, thereby improving nutrient uptake efficiency (20).

According to (21), PGPR bacteria can fix atmospheric N_2, making nitrogen more available to plants. Nitrogen is an essential component for chlorophyll formation, and increased chlorophyll content enhances the photosynthetic process. During the reproductive stage, a large proportion of photosynthates is translocated to developing fruits. Therefore, the application of PGPR derived from bamboo roots resulted in the highest fruit weight per plant.

The highest fruit weight per plant was also recorded in treatment I1 (1586.82 g), which differed significantly from I2 and I3. The lowest fruit weight per plant was obtained in treatment I3 (1346.43 g), which differed significantly from I2 (1478.11 g). As the PGPR application interval increased from 4 days (I1) to 8 days (I2) and 12 days (I3), fruit weight per plant gradually decreased. This finding indicates that the effectiveness of PGPR is closely associated with the frequency of application and the amount of beneficial microorganisms available for plant uptake.

Nitrogen availability in the soil also plays a critical role in determining plant productivity. Nitrogen is one of the primary macronutrients required for plant growth and is essential for chlorophyll synthesis, which supports photosynthesis. Nitrogen deficiency disrupts plant growth and development and ultimately reduces crop yield because insufficient chlorophyll limits photosynthetic activity (22). Reduced photosynthetic production leads to lower accumulation of assimilates in the fruit, resulting in decreased fruit weight per plant.

Fruit weight per plot

The results of Duncan's multiple range test, presented in Table 1, show that the highest fruit weight per plot was obtained in treatment M1 (11.33 kg), which differed significantly from M2 and M3. The lowest fruit weight per plot was recorded in treatment M2 (9.58 kg), which also differed significantly from M3 (10.48 kg).

The application of PGPR derived from *Mimosa pudica* roots (M2) resulted in the lowest fruit weight per plot. This may be attributed to the relatively lower nutrient-fixing capacity of the bacterial population associated with *Mimosa pudica* roots. In contrast, the application of PGPR derived from bamboo roots (M1) produced the highest fruit weight per plot because it was more effective in stimulating root growth and improving nutrient uptake efficiency (23). Adequate nutrient availability is essential for plant growth, and enhanced vegetative development ultimately contributes to increased fruit yield per plot.

Table 1 also shows that the highest fruit weight per plot was obtained in treatment I1 (11.27 kg), which differed significantly from I2 and I3. The lowest fruit weight per plot was observed in treatment I3 (9.60 kg), which differed significantly from I2 (10.52 kg). The application of PGPR at 12-day intervals (I3) resulted in the lowest fruit weight per plot, presumably because the reduced frequency of application limited the availability of beneficial microorganisms in the rhizosphere and consequently inhibited plant growth. In contrast, PGPR application every 4 days (I1) produced the highest fruit weight per plot. PGPR bacteria are capable of fixing atmospheric nitrogen through biological nitrogen fixation, converting free nitrogen into ammonia that can subsequently be utilized by plants (24).

More frequent PGPR application at 4-day intervals likely increased the population of beneficial bacteria available for root colonization. The presence of these microorganisms in the rhizosphere plays an important role in improving plant physiological processes and promoting growth (25). Enhanced physiological activities, particularly photosynthesis, increase the production of assimilates, a portion of which is translocated and stored in the fruits, thereby increasing fruit weight per plot.

Conclusions

Based on the results of the study titled *"The Effect of PGPR Types and Application Intervals on the Growth and Yield of Cucumber (Cucumis sativus L.) Plants"*, it can be concluded that the type of PGPR significantly affected plant height and dry weight, and had a highly significant effect on fresh weight, number of fruits per plant, fruit weight per plant, and fruit weight per plot, with the best performance observed in the bamboo root PGPR (M1) treatment. The PGPR application interval also significantly influenced plant height and dry weight, and had a highly significant effect on fresh weight, number of fruits per plant, fruit weight per plant, and fruit weight per plot, with the most effective interval being every 4 days (I1). However, there was no significant interaction between PGPR type and application interval on all observed parameters. The highest yield was obtained from the combination of bamboo root PGPR applied at 4-day intervals (M1I1), which produced the highest fruit weight of 11.61 kg per plot (60.48 t ha^{-1}). In contrast, the lowest yield was obtained from the M2I3 treatment (PGPR from *Mimosa pudica* roots applied at 12-day intervals), with 8.19 kg per plot (42.64 t ha^{-1}).

References

[1] Sarumaha I. Growth and production of cucumber (*Cucumis sativus* L.) using tea waste bokashi and mycorrhiza application. Medan: University of Medan Area; 2017. [Indonesian]

[2] Bauleth MZ, Sheehama J, Natascha C, Ahmad C, Makhaba M, Sharma R, et al. Phytochemicals from cucumber (*Cucumis sativus*) by-products. In: Ramadan MF, editor. Bioactive phytochemicals in by-products from bulb, flower, and fruit vegetables. Cham: Springer; 2025. doi:10.1007/978-3-031-77399-0_9.

[3] Tanari Y, Pangli M. Growth response of cucumber (*Cucumis sativus* L.) plants to guano fertilizer application. Poso: Universitas Sintuwu Maroso; 2024. [Indonesian]

[4] Sriyana. PGPR: roles, preparation, and application in plants. Department of Agriculture and Food Services; 2018. [Indonesian]

[5] Li H, Qiu Y, Yao T, Ma Y, Zhang H, Yang X. Effects of PGPR microbial inoculants on the growth and soil properties of *Avena sativa*, *Medicago*

sativa, and *Cucumis sativus* seedlings. Soil Tillage Res. 2020;199:104577. doi:10.1016/j.still.2020.104577.

[6] Rakhmatova M, Khusanov T, Kushiev K, Tekebayeva Z, Wang Z, Temirbekova A, et al. Harnessing nitrogen-fixing and phosphate-mobilizing bacteria for sustainable agriculture. Microorganisms. 2026;14:803. doi:10.3390/microorganisms14040803.

[7] Sharma P, Tripathi S, Srivastava A, Soni R, Singh SP. Microbes enhance assimilation and utilization of minerals, promoting plant health and production. In: Kumar A, Meena VK, Abhilash PC, editors. Microbial resource technologies for sustainable development. Elsevier; 2022. p. 407–418. doi:10.1016/B978-0-323-90590-9.00008-0.

[8] Arıkan Ş, İpek M, Pırlak L, Eşitken A. Physiological and molecular mechanisms in improving salinity stress tolerance by beneficial microorganisms in plants. In: Kumar M, Kumar V, Prasad R, editors. Microbial management of plant stresses: current trends, applications, and challenges. Elsevier; 2021. p. 13–43. doi:10.1016/B978-0-323-85193-0.00006-1.

[9] Nopriyanti M, Rianto F, Wasi'an. Quality of liquid organic fertilizer based on *Mimosa pudica* fermented with several bioactivators. J Partner. 2020;25(2):1403–1414. [Indonesian]

[10] Fadli I, Auliah MR, Aliyah M. Effect of PGPR application interval on growth and yield of bitter melon (*Momordica charantia* L.). Mandar: Universitas Al Asyariah; 2018. [Indonesian]

[11] Sianturi MF, Suryanto S. Study on concentration and application time of PGPR in sweet corn (*Zea mays* var. saccharata). Malang: Universitas Brawijaya; 2021. [Indonesian]

[12] Sihotang F, Wijayanti S, Kristalisasi EN. Effect of type and concentration of PGPR on oil palm seedling growth. Yogyakarta: INSTIPER; 2023. [Indonesian]

[13] Baihaqi AF, Yamika WS, Aini N. Effect of seed soaking duration and PGPR concentration on cucumber growth. Malang: Universitas Brawijaya; 2018. [Indonesian]

[14] Sari RP, Sudiarso S. Effect of PGPR and cattle manure on sweet corn growth and yield. J Crop Prod. 2019;7(4):738–747.

[15] Karmila, Marlina M, Mustafa. Effect of gibberellic acid and bamboo root PGPR on cucumber growth. Kolaka: Universitas Sembilanbelas November; 2023. [Indonesian]

[16] Kesuma P, Salamah Z. Growth of spinach (*Amaranthus tricolor* L.) using compost made from Siam weed leaves. Bioedukatika. 2013;1(1):1–9. [Indonesian]

[17] Ridwansyah A, Wibowo NI. Growth response of cucumber (*Cucumis sativus* L.) to plant growth-promoting rhizobacteria. Agroscience. 2016;6(2):78–87. [Indonesian]

[18] Arfandi. Effect of PGPR on soybean growth. Maros: Universitas Muslim Maros; 2019. [Indonesian]

[19] Dewanti ASR, Umarie I, Wijaya I. Effect of phosphate fertilizer dose and PGPR on edamame soybean growth. Jember: Universitas Muhammadiyah Jember; 2021. [Indonesian]

[20] Oktaviani E, Sholihah SM. Effect of PGPR on kailan growth in a vertical farming system. J Akbar Juara. 2018;3(1):63–70. [Indonesian]

[21] Purniawati DW, Nizar A, Rahmi A. Effect of concentration and interval of PGPR application on kailan growth. Malang: Polytechnic of Agricultural Development; 2021. [Indonesian]

[22] Sartini D, Campagna R, Lucarini G, Pompei V, Salvolini E, Mattioli-Belmonte M, et al. Differential immunohistochemical expression of paraoxonase-2 in actinic keratosis and squamous cell carcinoma. Hum Cell. 2021;34(6):1929–1931.

[23] Yulistiana E, Widowati H, Sutanto A. Bamboo root PGPR improves plant growth. J Biolova. 2020;1(1):1–7. [Indonesian]

[24] Goswami D, Dhandhukia P, Thakker JN. Expanding the horizons for the use of *Paenibacillus* species as PGPR for sustainable agriculture. In: Islam M, Rahman M, Pandey P, Jha C, Aeron A, editors. Bacilli and agrobiotechnology. Springer; 2016. p. 1–18. doi:10.1007/978-3-319-44409-3_12.

[25] Istiqomah N, Adriani F, Rodina N. Nutrient content of water hyacinth compost with different PGPR treatments. Rawa Sains. 2018;8(1):1–10. [Indonesian]