



RESEARCH ARTICLE

Interactive effects of bamboo root-derived plant growth-promoting rhizobacteria and pruning intensity on mini hybrid cucumber productivity

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Abstract

The mini cucumber (*Cucumis sativus* L.) variety was characterised by a crunchy texture and low seed content, making it well-suited for lowland cultivation. Mini cucumbers typically produce short, capsule-shaped fruits. This study investigated the effects of plant growth-promoting rhizobacteria (PGPR) dosage and different pruning strategies on the growth and yield of mini hybrid cucumbers. The experiment was arranged in a factorial randomised complete block design (RCBD) with 2 factors. The first factor consisted of four PGPR dosages derived from bamboo roots, namely 0, 20, 40 and 60 mL L⁻¹. The second factor comprised four pruning treatments: no pruning, main stem pruning, pruning of three lateral branches and pruning of five lateral branches. The results demonstrated that both PGPR application and pruning significantly affected vegetative and generative growth parameters of mini hybrid cucumbers. Application of PGPR at 60 mL L⁻¹ significantly increased plant height by 26.11 %, leaf number by 30.00 % and fruit weight per plant by 44.04 % compared to the control. Meanwhile, pruning of three lateral branches significantly increased plant height by 24.90 %, fruit diameter by 13.22 %, fruit length by 28.50 % and total fruit yield per hectare by 47.36 % relative to the control. These findings indicate that appropriate PGPR application combined with strategic pruning practices can substantially enhance the growth and productivity of mini hybrid cucumbers.

Keywords: bamboo root-derived plant growth-promoting rhizobacteria; *Cucumis sativus*; mini cucumber; pruning intensity

Introduction

Mini cucumbers (*Cucumis sativus* L.) are a horticultural commodity with high economic value and are widely favoured by consumers (1). Demand for cucumbers is increasing due to population growth and the popularity of contemporary culinary trends that incorporate cucumbers as a primary side dish. Cucumber production in Central Java in 2023 was 28017 tonnes, in 2022 it was 24602 tonnes and in 2021 it was 28270 tonnes (2). Current production levels remain below 2021 peak, so efforts to increase cucumber production, including mini cucumbers, are needed. One way to increase yields is by applying plant growth-promoting rhizobacteria (PGPR), which can regulate plant physiological activities through the production of phytohormones such as cytokinin, auxin and gibberellin (3). Rhizobacteria could actively synthesise plant hormones from the PGPR addition to the soil (4).

The use of PGPR as biological fertiliser and biocontrol agent is a potential strategy one way to increase the production of mini cucumbers. The PGPR as a biological agent can improve soil fertility. The PGPR used is made from bamboo roots. Bamboo roots contain *Pseudomonas fluorescens* and *Bacillus polymixa* as producers of enzymes and indole acetic acid (IAA) phytohormones, thereby enhancing plant growth (5). These species designations are based

on prior literature characterising bamboo-root-derived PGPR, the microbial composition of the specific inoculum used in the present study was not independently confirmed through microbial identification or viable cell counts. The PGPR can help reduce the input of synthetic fertilisers by farmers. However, the optimal dosage of PGPR from bamboo roots for mini cucumber plants has not been fully explored, necessitating further investigation. The PGPR can play a role in accelerating flowering (6). Generally, male flowers form earlier than female flowers, so mini cucumber plants have an unbalanced flower ratio of 10 : 1. Therefore, flowering induction is necessary for mini cucumber plants.

One management strategy in cucumber cultivation to induce flowering is pruning. Pruning the shoots can increase the number of female flowers on cucumbers (7). An increase in the number of female flowers means an increase in the potential for flowers to be pollinated. Tip pruning involves removing the apical bud to inhibit apical buds so that growth is focused on generative development and lateral buds. Pruning stimulates lateral shoot growth, slows plant aging, increases production, stimulates rooting and changes soil microbial diversity (8). These lateral shoots are stimulated by pruning the apical part for better production.

Research on the treatment of biological agents and branch pruning did not have a significant effect on chili production (9), but research on mini cucumbers needs to be tested. Based on this, this study will examine the interaction between PGPR application and pruning, as well as their effects on cucumber cultivation. This study aims to evaluate the individual and interactive effects of varying PGPR dosages and pruning types on the growth and yield of mini cucumbers, ultimately providing an evidence-based reference to optimise cultivation and increase production.

Materials and Methods

The study was conducted in Rahayu Village, Padureso Subdistrict, Kebumen Regency, Indonesia (Fig. 1), at an elevation ranging from 175 to 210 m above sea level. During the four-month experimental period, the mean air temperature at the study site ranged from 21 to 32.8°C for 4 months. The experimental unit was defined as an individual plot assigned to each combination of bamboo root-derived plant growth promoting rhizobacteria (PGPR) treatment and pruning intensity. The experiment consisted of 2 treatments arranged in a factorial randomised complete block design with 3 replications. The first factor was the application of various doses of PGPR, namely P0 (control), P1 (20 mL L⁻¹ of water), P2 (40 mL L⁻¹ of water) and P3 (60 mL L⁻¹ of water). The second factor was the type of shoot pruning, namely T0 (no pruning), T1 (pruning of the main stem shoots), T2 (pruning of 3 lateral branches) and T3 (pruning of

5 lateral branches). Each plot contained 21 cucumber plants, resulting in a total experimental population of 756 plants. The representative image shown on Fig. 2. To minimise border effects, plants located at the outer rows of each plot were excluded from data collection. A total of 180 representative plants per plot were selected for analysis using a systematic sampling approach. The research was conducted starting from the production of PGPR from bamboo roots, seedling, land preparation, planting, maintenance, PGPR application and pruning, harvesting and observation.

Soil analysis prior to planting in the Rahayu village area showed high potassium and phosphorus content, but low total nitrogen content. The planting medium had a neutral pH. The PGPR from bamboo roots has potential capability to fix free nitrogen in the air (10), thereby increased the nitrogen content in the planting medium, thus, could overcome soil nutrient properties problems.

Experimental apparatus and materials included hoes, measuring tapes, dibble stick (tugal), hand sprayers, stakes, ropes, scissors, measuring cups, scales, writing instruments and cell phones. The ingredients for preparing PGPR starter culture were 200 g of bamboo roots and 2 L of non-chlorinated water (well or distilled). The method of preparation is to soak the bamboo roots along with the soil around the roots in the prepared water. The soaking process takes at least 2 days and 2 nights.

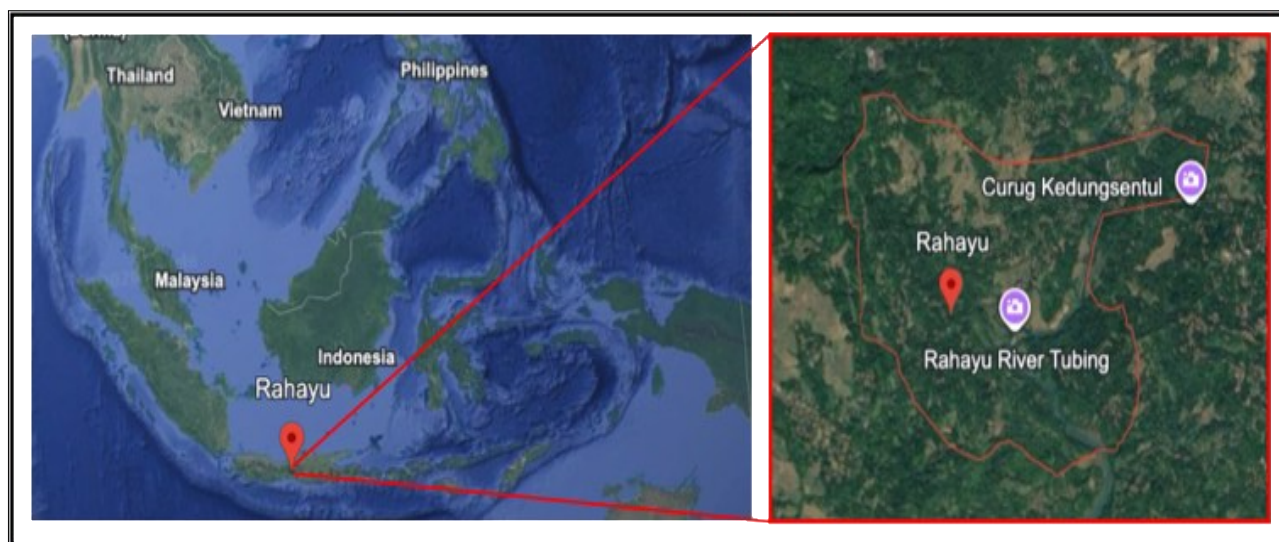


Fig. 1. Location map of Rahayu village, Padureso subdistrict, Kebumen regency, Indonesia.



Fig. 2. Representatives image of mini cucumber plant sample and fruit.

The ingredients used to make PGPR were 100 g of granulated sugar, 2 kg of fine bran, 10 g of shrimp paste, 1 g of lime water, 250 g of flavouring, 10 L of well water or rainwater and 2 L of PGPR starter culture or seeds. The PGPR preparation was conducted by first combining shrimp paste, bran, sugar, flavouring and water in a pot, followed by heating the mixture to boiling while stirring periodically to ensure homogeneity. The boiled solution was then transferred into a storage drum and filtered using gauze to remove solid residues. After filtration, the drum was tightly sealed and allowed to cool to room temperature. Once cooled, PGPR inoculum derived from bamboo roots was added to the solution through a filtering process to prevent root debris from entering the medium. The drum was subsequently resealed and the mixture underwent anaerobic fermentation for 15 days, with periodic stirring performed carefully to minimise the risk of contamination by undesirable microorganisms.

The PGPR inoculum was considered ready for application based on the presence of characteristic indicators of successful fermentation, including a fresh fermented odour, a cloudy brown liquid appearance, a near-neutral pH and the formation of a thin white biofilm on the surface of the solution. These are indirect, sensory-based indicators of fermentation activity; no microbial identification, viable cell enumeration (CFU mL⁻¹), or molecular confirmation of the rhizobacterial taxa present in the inoculum was performed in this study. The PGPR application was conducted during routine crop maintenance by soil drenching at 7 and 21 days after planting (DAP). Pruning treatments were applied by removing lateral branches according to treatment levels: pruning of three lateral branches was performed by cutting nodes 1–3, while pruning of five lateral branches involved cutting nodes 1–5. All pruning treatments were implemented simultaneously prior to the onset of the generative phase, at 21 days after planting (DAP). Plant observations included measurements of plant height, number of leaves, days to 50 % flowering, number of fruits per plant, fruit diameter, fruit length, fruit weight per plant and total fruit yield per hectare. The collected data were statistically analysed using analysis of variance (ANOVA) via IBM SPSS Statistics 21.0 Desktop. When significant differences were detected at the ≤ 0.05 significance level, treatment means were subsequently compared using the least significant difference (LSD) test.

Results and Discussion

Interaction analysis of PGPR application and pruning

The ANOVA revealed that PGPR dosage significantly affected plant height, leaf number, fruit length, fruit weight per plant and fruit weight per hectare. In contrast, pruning treatments significantly

influenced plant height, leaf number, fruit diameter, fruit length, fruit weight per plant and fruit weight per hectare. Both treatments had no significant effect on flowering age and number of fruit per plant. No significant interaction between PGPR dosage and pruning treatments was detected for any growth or yield parameter evaluated in mini cucumber plants (Table 1).

Bamboo root-derived PGPR enhances root development, thereby improving water and nutrient uptake efficiency by the plant root system(11). In contrast, pruning disrupted apical dominance, regulates main stem elongation and reduced the formation of excessive lateral branches and non-productive fruits(12), which in turn promoted more efficient assimilate translocation into lateral shoots and developing fruits. While PGPR application primarily improved nutrient acquisition, pruning functions to regulate assimilate partitioning within the plant. Because these two management practices act through distinct physiological mechanisms nutrient uptake versus assimilate distribution they operate independently without synergistic or antagonistic interactions under the conditions of this study. Consequently, the absence of interaction observed in this study suggested an additive effect, in which each treatment contributed positively to plant growth and yield without directly influencing the effectiveness of the others.

Effect of plant growth-promoting rhizobacteria dosage

Based on the LSD test, PGPR dosage had a significant effect on plant height, leaf number, fruit length, fruit weight per plants and fruit weight per hectare of mini cucumber plants. The highest PGPR dosage (60 mL L⁻¹; P3) resulted in the most significant growth, with an average plant height of 9.66 cm, leaf number of 3.25 and fruit weight of 77.91 g per plant (Table 2). Application of PGPR at this dosage likely provided an optimal rhizobacterial population in the rhizosphere, enabling effective root colonisation and enhanced metabolic activity. The PGPR were known to synthesise phytohormones, particularly indole-3-acetic acid (IAA), which promoted cell elongation and stem growth, thereby increasing plant height. Additionally, IAA production stimulated lateral shoot development and floral initiation, contributing to increased leaf formation and improved yield components(13). Higher PGPR dosages may further enhanced the production of growth-promoting hormones such as auxins and gibberellins, resulting in improved vegetative growth and fruit development. These findings were consistent with previous studies(14), which reported that increasing PGPR dosage enhanced plant growth due to greater bacterial colonisation and modulation of endogenous phytohormone concentrations.

Table 1. Analysis of variance (ANOVA) results

No	Observation variable	PGPR dose	Type of top pruning	Interaction of PGPR dose and pruning type
1	Plant height (PH)	**	**	ns
2	Number of leaves (NL)	**	ns	ns
3	50 % flowering age (FA)	ns	ns	ns
4	Number of fruits per plant (NFP)	ns	ns	ns
5	Fruit diameter (FD)	ns	**	ns
6	Fruit length (FL)	*	**	ns
7	Fruit weight per plant (FWP)	**	*	ns
8	Fruit weight per hectare (FWH)	*	**	ns

* : significant; **: very significant; ns: non significant; PGPR: plant growth-promoting rhizobacteria.

Table 2. The effect of PGPR dosage on the average growth and yield of mini hybrid cucumber

Sl. No.	PGPR dose (mL.L ⁻¹ of water)	PH (cm)	NL (leaves)	FA (days after plant)	NFP (fruits.plant ⁻¹)	FD (cm)	FL (cm)	FWP (g.plant ⁻¹)	FWH (kg.ha ⁻¹)
1	P0	7.66 ^a ± 0.37	2.50 ^a ± 1.45	24.42 ± 0.88	1.42 ± 2.79	4.18 ± 5.01	7.78 ± 3.73	44.04 ^a ± 2.66	7.41 ± 3.68
2	P1	8.16 ^{abc} ± 2.31	3.00 ^b ± 1.56	24.50 ± 0.59	1.17 ± 3.42	4.37 ± 4.27	8.50 ± 0.59	49.41 ^{ab} ± 6.33	8.91 ± 4.57
3	P2	7.81 ^{ab} ± 1.67	3.08 ^{bc} ± 0.89	25.83 ± 1.47	1.25 ± 2.77	4.17 ± 2.56	8.13 ± 1.25	52.65 ^{abc} ± 1.34	11.30 ± 5.41
4	P3	9.66 ^d ± 1.32	3.25 ^{bcd} ± 1.78	24.58 ± 2.83	1.42 ± 3.09	4.40 ± 3.62	9.66 ± 4.75	77.91 ^d ± 0.88	12.40 ± 2.48

PH: plant height; NL: number of leaves; FA: flowering age; NFP: number of fruits per plant; FD: fruit diameter; FL: fruit length; FWP: fruit weight per plant; FWH: fruit weight per hectare; PGPR: plant growth-promoting rhizobacteria. The mean values followed by the same letter are not significantly different at $p < 0.05$ according to the least significant difference (LSD) test.

In addition to plant height, leaf number and fruit weight per plant, PGPR dosage also significantly affected fruit length and fruit weight per hectare, although at a lower significance level ($p < 0.005$) compared with plant height, leaf number and fruit weight per plant ($p = 0.001$). This pattern suggests that the effect of PGPR is expressed most strongly at the level of individual plant growth and development, while its influence on land-scale productivity (fruit weight per hectare) is comparatively more moderate, likely because yield per hectare is also shaped by plant population density and spatial uniformity across experimental plots, factors not directly controlled by PGPR application (15). Nevertheless, the increase in fruit length under higher PGPR dosage is consistent with enhanced auxin and gibberellin production, which promotes cell elongation not only in vegetative tissues but also in developing fruit (16).

Environmental conditions were characterised by limited water availability due to the dry season and the location was far from water sources. Plants used adaptive mechanisms such as plant growth-rhizobacteria interactions with plant roots to mitigate drought stress (17). The PGPR application mitigated the adverse impacts of drought stress through a different mechanism. The root system adapted as an adaptive feature to ensure the plant's water needs were met (18). Thus, under drought conditions, a larger and deeper root system could increase plant yield. Based on the data in Table 2, PGPR application had a positive impact on plant growth and yield, except for the number of fruits per plant and fruit diameter.

Bamboo-root-derived PGPR has been reported in the literature to contain *Azospirillum* bacteria, although the specific microbial composition of the inoculum used in the present study was not independently verified. *Azospirillum* was a genus of rhizobacteria that colonise soil rhizosphere. *Azospirillum* spp.

increased plant resistance to drought stress. *Azospirillum* could overcome low nitrogen availability prior to PGPR application. *Azospirillum* spp. binded free nitrogen in the air and converted it into ammonia (19), thereby increased nitrogen availability and allow nitrogen uptake by plants.

Influence of different pruning types

Based on the results of the 5 % LSD test at 5 % probability level follow-up test, pruning treatments significantly affected plant height, fruit diameter, fruit length and fruit yield per hectare of mini cucumber. The most favourable results were obtained from pruning three lateral branches (T2), which produced a plant height of 9.73cm, a fruit diameter of 4.54cm, a fruit length of 9.74cm and a total fruit yield of 13.69kg/ha⁻¹. Pruning three lateral branches created more optimal growth conditions compared with more intensive pruning treatments. In this treatment, selective removal of lateral branches limited excessive vegetative growth while maintaining a sufficient leaf area to support maximum photosynthetic activity. As a result, a greater proportion of photosynthates was allocated to shoot development and fruit filling (20). Cucumber production requires a balance between source organs (leaves) and sink organs (fruits) and pruning three lateral branches provided adequate sites for fruit formation without causing excessive competition for nutrients. This finding was consistent with the results presented in Table 3, which showed that pruning three lateral branches significantly increased fruit yield per hectare. In addition, fruits produced under this pruning regime tended to be larger, denser and of higher quality due to improved assimilate availability (21). Previous studies reported that fruit development on central lateral branches was associated with greater average fruit weight, supporting the results of the present study (22).

Table 3. Effect of type of top pruning on the average growth and yield of mini hybrid cucumber

Sl. No	Type of top pruning	PH (cm)	NL (leaves)	FA (days after plant)	NFP (fruits.plant ⁻¹)	FD (cm)	FL (cm)	FWP (g.plant ⁻¹)	FWH (kg.ha ⁻¹)
1	T0	7.79 ^{ab} ± 1.46	2.83 ^a ± 3.64	23.92 ^a ± 5.36	1.33 ^a ± 0.77	4.01 ^a ± 5.38	7.58 ^a ± 5.51	45.56 ^a ± 0.55	9.29 ^{abc} ± 0.66
2	T1	7.68 ^a ± 1.63	2.92 ^a ± 4.31	24.92 ^a ± 7.48	1.42 ^a ± 0.85	4.34 ^{abc} ± 4.26	8.39 ^{abc} ± 2.63	49.41 ^{ab} ± 1.62	8.92 ^{ab} ± 3.88
3	T2	9.73 ^d ± 2.53	3.08 ^a ± 5.37	25.25 ^a ± 6.68	1.25 ^a ± 1.48	4.54 ^{bcd} ± 3.64	9.74 ^{cd} ± 6.31	73.38 ^d ± 2.95	13.69 ^d ± 2.73
4	T3	8.09 ^{abc} ± 4.39	2.00 ^a ± 6.46	25.25 ^a ± 4.75	1.25 ^a ± 2.57	4.23 ^{ab} ± 5.66	8.37 ^{ab} ± 0.53	55.66 ^c ± 0.37	8.13 ^a ± 1.46

PH: plant height; NL: number of leaves; FA: flowering age; NFP: number of fruits per plant; FD: fruit diameter; FL: fruit length; FWP: fruit weight per plant; FWH: fruit weight per hectare. Values are presented as mean ± standard deviation (SD). Means within a column followed by different lowercase letters differ significantly at $p \leq 0.05$ according to the least significant difference (LSD) test.

Conclusion

This study demonstrated that the application of plant growth-promoting rhizobacteria (PGPR) significantly enhanced the growth and yield of mini hybrid cucumber. Among the tested treatments, the highest PGPR dosage of 60mLL⁻¹ (P3) produced the most favourable results, significantly increasing plant height (9.66cm), number of leaves (3.25 leaves) and fruit weight per plant (77.91g plants⁻¹). The increase in growth and productivity at higher PGPR dosages was attributed to improved root colonisation and enhanced synthesis of growth-promoting phytohormones, which collectively stimulate vegetative development and yield formation. Pruning treatments also significantly influenced crop performance, with pruning of three lateral branches (T2) resulting in the highest plant height (9.73cm), fruit diameter (4.54cm), fruit length (9.74cm) and fruit yield per hectare (13.69kg ha⁻¹). This pruning strategy optimised the balance between vegetative growth and reproductive development, promoting female flower induction and improved assimilate allocation to fruit growth. However, no significant interaction was observed between PGPR dosage and pruning treatments, indicating that both practices independently affect different plant organs and physiological processes. In conclusion, the findings suggest that the integrated application of an optimal PGPR dosage and moderate pruning could effectively improve mini hybrid cucumber growth and yield through additive, rather than interactive, effects.

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Authors' contributions

TW conducted the research. AR participated in the study design, coordinated the research and performed the statistical analyses. AR, DFS and A drafted the first version of the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

References

- Kartikasari ON, Koesriharti. Response of three varieties of cucumber (*Cucumis sativus* L.) to the application of the growth regulator gibberellin (GA3). *J Prod Tan*. 2016;4(6):425–30.
- Badan Pusat Statistik. Produksi tanaman sayuran. Jakarta: Badan Pusat Statistik; 2024.
- Coskun N, Pirlak L. Effect of plant growth promoting rhizobacteria (PGPR) on branching and growing of apple sapling. *Erwerbs Obstbau*. 2017;59:309–13. <https://doi.org/10.1007/s10341-017-0326-x>
- Windiastruti E, Ramadhan MH, Manik VT, Kurniati F, Sunarya Y. Response of *Cucumis sativus* L. growth and harvest to variations in soaking time and plant growth promoting rhizobacteria concentration. *J Biol Trop*. 2023;23(3):164–72.
- Mulyawan R, Indriyati LT, Widiastuti H, Sabiham S. Testing the activity of laccase and cellulase on peat lignocellulose with various moisture contents. *J Ilmu Pertan Indo*. 2019;24(1):20–7. <https://doi.org/10.18343/jipi.24.1.20>
- Amalia S, Faizah. Application of ethephon to improve flower and fruit formation in cucumbers (*Cucumis sativus* L.) [thesis]. Bogor: IPB University; 2014.
- Hidayatullah R, Munandar DE, Usmedi, Khozin MN. The effect of pruning time and gibberellin hormone (GA3) concentration on cucumber growth and productivity (*Cucumis sativus* L.). *Agrium*. 2024;27(2):191–200.
- Zhang Q, Wang Y, Chen Y, Zhang Y, Chen M, Zou J, et al. Effects of pruning on growth, rhizosphere soil physicochemical indexes and bacterial community structure of tea tree and their interaction. *Agriculture*. 2023;13:1972. <https://doi.org/10.3390/agriculture13101972>
- Sukri MZ, Rohman HF, Firgiyanto R. The effect of biofertilizer application and shoot pruning on the production of chili plants on sandy media. *IOP Conf Ser Earth Environ Sci*. 2022;980:012012. <https://doi.org/10.1088/1755-1315/980/1/012012>
- Flores CAR, Siringan MAT, San Diego MACVR. Multiple plant growth-promoting activities exhibited by root-associated bacteria isolated from bamboo and corn. *Int J Microbiol*. 2025;2025:6374935. <https://doi.org/10.1155/ijm/6374935>
- Strirejeki DI, Maghfoer MD, Herlina N. PGPR and Dekamon applications and topping to increase bean plant productivity (*Phaseolus vulgaris* L.) upright type. *J Prod Tan*. 2015;3(4):302–10.
- Sitawati, Sintawati MB, Fajriani S. Effectiveness of plant growth promoting rhizobacteria (PGPR) and NPK fertilizer on the growth and flowering of aster ericoides (*Symphotrichum ericoides*). *J Hort Indo*. 2022;13(2):64–71. <https://doi.org/10.29244/jhi.13.2.64-71>
- Nie J, Li Z, Zhang Y, Zhang D, Xu S, He N, et al. Plant pruning affects photosynthesis and photoassimilate partitioning in relation to the yield formation of field-grown cotton. *Ind Crops Prod*. 2021;173:114087. <https://doi.org/10.1016/j.indcrop.2021.114087>
- Baid RS, Ilahude Z, Purnomo SH. The effect of coconut water liquid organic fertilizer and plant growth promoting rhizobacteria from bamboo roots on the growth of cocoa seedlings (*Theobroma cacao* L.). *J Agroteknotropika*. 2022;11(1):33–41.
- Xu C, Li R, Song W, Wu T, Sun S, Han T, et al. High density and uniform plant distribution improve soybean yield by regulating population uniformity and canopy light interception. *Agronomy*. 2021;11(9):1880. <https://doi.org/10.3390/agronomy11091880>
- Gosai S, Adhikari S, Khanai S, Poudel PB. Effects of plant growth regulators on growth, flowering, fruiting and fruit yield of cucumber (*Cucumis sativus* L.): A review. *Arch Agric Environ Sci*. 2020;5(3):268–74. <https://doi.org/10.26832/24566632.2020.050306>
- El-Saadony MT, Saad AM, Mohammed DM, Fahmy MA, Elesawi IE, Ahmed AE, et al. Drought-tolerant plant growth-promoting rhizobacteria alleviate drought stress and enhance soil health for sustainable agriculture: A comprehensive review. *Plant Stress*. 2024;14:100632. <https://doi.org/10.1016/j.stress.2024.100632>
- Chieb M, Gachomo EW. The role of plant growth promoting rhizobacteria in plant drought stress responses. *BMC Plant Biol*. 2023;23. <https://doi.org/10.1186/s12870-023-04403-8>
- Giri BR, Chattaraj S, Rath S, Pattnaik MM, Mitra D, Thatoi H. Unveiling the molecular mechanism of *Azospirillum* in plant growth promotion. *Bacteria*. 2025;4:36. <https://doi.org/10.3390/bacteria4030036>

20. Gomasta J, Sarker BC, Haque MA, Anwari A, Mondal S, Uddin MS. Pruning techniques affect flowering, fruiting, yield and fruit biochemical traits in guava under transitory sub-tropical conditions. *Heliyon*. 2024;10(9):e30064. <https://doi.org/10.1016/j.heliyon.2024.e30064>
21. Santika M, Bintoro M. The effect of foliar fertilizer application and shoot pruning on cucumber seed production and quality (*Cucumis sativus* L.). *Agropross Nat Conf Proc Agric*. 2022;6:563–71. <https://doi.org/10.25047/agropross.2022.327>
22. Wee WC, Lai KS, Kong CL, Yap WS. Impact of within-row plant spacing and fixed fruit setting on yield and quality of rockmelon fruit cultivated by drip irrigation in a greenhouse. *Hortic Sci Technol*. 2017;36(2):172–82. <https://doi.org/10.12972/kjhst.20180018>

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