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Effect of Plant Growth Promoting Rhizobacteria in Cultivation of Tomato (*Lycopersicum esculentum* Mill.)

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Abstract. The effect of Plant Growth Promoting Rhizobacteria (PGPR) in tomato plants can impact plant growth and production with the relationship between bacteria and plant roots. This research aimed to decide the benefits and impacts of PGPR on the development and production of tomato plants. The research was conducted within the Research facility of Seed Science and Innovation of Agrotechnology Consider Program of Syiah Kuala University, Exploratory Plant of Staff of Horticulture, Syiah Kuala University from February 2023 to December 2023. This study used 2 designs, namely the Complete Randomized Design and Randomized Group Design of factorial pattern. Non-factorial RAL uses 1 factor studied, namely rhizobacterial isolates (R) consisting of one control treatment and five kinds of isolates. Factorial RACT was used to treat two tomato varieties consisting of Servo (V1) and Gammara (V2). Subsequently, 2x6 medications were obtained, each treatment was rehashed 3 times, hence 12 treatment combinations and 36 exploratory units were obtained, whereas each test unit utilized 3 plant tests so that there were 108 plants in add up to. If the results of the F test show significant influence, then the analysis continues with further testing using DMRT (Duncan Multiple Range Test) test at the 5% level. The results of the consider, that the arrangement of rhizobacteria as PGPR in tomato plant development does not have a noteworthy impact. The utilization of Servo and Gammara tomato plant assortments has a critical impact on tomato plant development.

Keywords: PGPR; rhizobacteria; tomato

INTRODUCTION

Tomato (*Lycopersicum esculentum* Mill.) is a plant from Solanaceae family and is the second most important fruit or vegetable crop after the potato (*Solanum tuberosum* L.). Tomatoes contain numerous health-promoting compounds counting vitamins, carotenoids, and phenolic compounds. In expansion to its financial and dietary significance, tomatoes have ended up showing the need for plump natural product improvement (Quinet *et al*., 2019). Tomato production in Indonesia in 2022 reached 1.17 million tonnes, an increase of 4.88% (54.34 thousand tons) from 2021. Tomato consumption by the household sector in 2022 is reached 687.98 thousand tons, an increase of 1.48% (10.01 thousand tons) from 2021. As for household participation in tomato consumption was 42.92%.(BPS, 2022).

In Indonesia, tomato consumption is estimated to increase by 5.01% in 2021, while production is estimated to only increase by 1.95%. Problems in tomato cultivation are caused by insufficient quality of growth and yield of tomatoes due to disease or environmental conditions and inadequate land. Tomato crops are at risk around the world due to biotic and abiotic stresses that have caused noteworthy diminishments in abdicate and efficiency. One reason is that tomatoes have about 200 species of plant pathogens, counting organisms, microscopic organisms, nematodes, viruses, and others that contaminate plants at all stages of improvement (Stout *et al*., 2018).

Endeavors that can be made to extend tomato plant generation are by utilizing PGPR. PGPR for brief, may be a heterogeneous bunch of microscopic organisms found within the rhizosphere on the root surface and related with roots and can upgrade plant development through a few instruments called plant growth-promoting rhizobacteria (PGPR). Zuluaga *et al*. (2021) detailed that *Pseudomonas* sp. altogether expanded the dry biomass of tomato roots and shoots and balanced the work of the rhizosphere microbiome.

The use of PGPR in plants can have an impact on plant growth and production with the association between bacteria and roots.

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Harahap (2018) found that rhizobacterial treatment can increase the development and decrease parameters of soybean plants such as the number of units, the number of seeds per plant, and the absorption potential surrender. The comes about of Yagmur & and Gunes (2021) detailed that the application of distinctive PGPRs had a critical impact on the abdicate and quality of tomato plants on natural cultivating. PGPR microbes *Bacillus megaterium* M-3, *Paenibacillus polymxa*, *Burkholderia cepacia, Azospirillum improve the delivery of goods* expanded item surrender and had positive impacts on quality parameters.

Besides the use of PGPR, variety is one of the factors that must be considered in the cultivation of tomato plants. The use of high-quality and disease-resistant varieties has been proven in various previous studies. Dunan (2018) detailed that the utilization of Gammara tomato assortments had an impact on plant tallness, number of clears out, natural product weight per plant, weight per fruit, and tomato fruit distance across. Servo F1 tomato plants give great development and giving surrender in terms of plant stature, number of clears out, number of fruits per plant and add up to fruit weight per plant (Kahar, 2021).

There is an influence between the treatment of varieties and the provision of PGPR on the observation variable of fertile book leaf area in soybean plants. The treatment of varieties gives different results. The Grobogan variety gave higher yields than the Dena 1 variety. The arrangement of PGPR can increase the growth of plant stature, number of leaves, leaf area, fertile book, number of blossoms, number of cases and surrender of soybean plants compared to without PGPR (Indah & Titiek, 2018) (Indah and Titiek, 2018). Asfin (2017) reported the application of PGPR on Tymoti and Mutia varieties produced a better response than the treatment without PGPR application. Both varieties gave the same growth and yield at various PGPR concentrations.

METHODS

The research was conducted within the Research facility of Seed Science and Innovation of Agrotechnology Consider Program of Syiah Kuala University, Exploratory Plant of Staff of Horticulture, Syiah Kuala University and other laboratories as needed in the implementation of this research. The research took place from February 2023 to December 2023.

The devices utilized in this investigate are autoclave, laminar air flow cabinet, expository adjust, miniaturized scale pipette, petridish, spectrophotometer, broiler, binocular magnifying lens, brooding chamber, bunsen light, test tube, erlenmeyer, measuring container, ose needle, tweezers, development rack, culturing hardware and other hardware required in this inquire about .The materials used in this research are tomato seeds of Servo and Gammara varieties, isolates of rhizobacteria *Bacillus furmus*, *Bacillus polymixa*, *Azotobacter sp*., *Actinotobacter sp.*, *Bacillus bodius*, 96% alcohol, 2% sodium hypochlorite solution, distilled water, spirtus, soil, manure, TSA (tryptic soy agar) media, King'B media, polybags, pesticides and other materials needed in this research.

The rhizobacterial isolates utilized in this research were bacterial separates from the collection of the Seed Science and Innovation Research facility of Syiah Kuala University, namely *Bacillus furmus*, *Bacillus polymixa, Azotobacter sp., Actinotobacter sp.,* and *Bacillus bodius*. The rhizobacteria isolates were grown in solid tryptic soy agar or King's B then incubated for 48 hours. The developing bacterial colonies were suspended in sterile refined water until they came to a populace thickness of 109 cfu/ml comparable to absorbance values of OD6oo=0.164 mm and OD600=0. mm employing a spectrophotometer. Tomato seeds were cleaned for three minutes with 96% alcohol at that point washed three times with sterile refined water and dried for one hour in a laminar air flow cabinet. Another, the seeds were splashed for 24 hours in a

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suspension of each rhizobacterial isolate(50 ml) at 26°C. After treatment, the seeds were once more dried in a laminar air flow cabinet and prepared for utilize. Another, the seeds were sown.

The planting medium used was a mixture of soil and organic fertilizer in a ratio of 2:1. Planting media was prepared by putting the mixture of soil and manure into 5 liter polybags. Planting media was made into 108 polybags. Planting was done in the afternoon. Tomato seedlings that were ± 3 weeks old after sowing were transferred to polybags by pulling the plants out of the seedling polybags and planting them in polybags with a planting hole depth of ± 10 cm. The planted seedlings were watered to field capacity.

This study used 2 designs, namely the Complete Randomized Design of non-factorial pattern and Randomized Group Design of factorial pattern. Non-factorial RAL uses 1 factor studied, namely rhizobacterial isolates (R) consisting of one control treatment and five kinds of isolates, namely *Bacillus furmus* (R1), *Bacillus polymixa* (R2), *Azotobacter* sp. (R3), *Actinotobacter* sp. (R4), and *Bacillus bodius* (R5). Factorial RACT was used in the treatment of two tomato varieties consisting of Servo (V1) and Gammara (V2), presented in **Table 1**. Subsequently, 2x6 medications were obtained, each treatment was rehashed 3 times, hence 12 treatment combinations and 36 exploratory units were obtained, whereas each test unit utilized 3 plant tests so that there were 108 plants.

Table 1. Arrangement of treatment combinations of Rhizobacteria isolates and tomato varieties

No.	Treatment combinations	Varieties	Rhizobacteria isolates
1	V_1R_0	Servo	without Isolate (control)
2	V_1R_1	Servo	*Bacillus furmus*
3	V_1R_2	Servo	*Bacillus polymixa*
4	V_1R_3	Servo	*Azotobacter sp.*
5	V_1R_4	Servo	*Actinotobacter sp.*
6	V_1R_5	Servo	*Bacillus bodius*
7	V_2R_0	Gammara	without Isolate (control)
8	V_2R_1	Gammara	*Bacillus furmus*
9	V_2R_2	Gammara	*Bacillus polymixa*
10	V_2R_3	Gammara	*Azotobacter sp.*
11	V_2R_4	Gammara	*Actinotobacter sp.*
12	V_2R_5	Gammara	*Bacillus bodius*

To decide the impact of treatment variables on the growth and yield of tomatoes tried with change or Fisher (F) test at 0.05 level of opportunity. If the results of the F test showed a significant effect, the analysis continued with further tests using the Duncan New Multiple Range Test test at the 5% level. Observations of growth include plant height, stem diameter, total of leaves, total of bunches per plant, and total of fruits per bunch.

RESULTS AND DISCUSSION

Effect of Rhizobacteria on Tomato Plant Growth

Table 2 shows that the rhizobacteria treatment did not have a significant effect on the parameters plant height 15 DAP, meaning that the differences observed between the treatment and control groups were not statistically strong enough to be considered different. This result may be due to several factors, such as high natural variability of the plants, insufficient sample size, or insufficient rhizobacterial efficacy to produce significant changes in the observed variables. average height of tomato plants at the age of 15 DAP inclined to be higher in the rhizobacterial treatment of *Azotobacter* sp. (R3) which was 29.13 cm although

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statistically not significantly different from other rhizobacterial treatments. At the age of 30 DAP after giving rhizobacteria also did not have a statistically significant effect At the age of 30 DAP, the average height of tomato plants inclined to be higher in the treatment of rhizobacteria *B. polymixa* (R2) but statistically also not significantly different from other rhizobacterial treatments. Rooting bacteria have great potential to facilitate plant growth and productivity in a variety of ways. *Azotobacter* sp. is known to have the capability to support plant growth under environmentally stressful conditions. The bacteria are able to produce 1-aminocyclopropane-1-carboxylate (ACC) deaminase which inhibits ethylene formation when plants are stressed (Zarei *et al*., 2020).

Table 2. Average of plant height, stem diameter, number of leaves due to rhizobacterial rhizobacteria treatment at the age of 15 and 30 day after planting (DAP)

Rizobacteria	Plant height (cm)		Stem diameter (mm)		Total of leaves	
	15 DAP	30 DAP	15 DAP	30 DAP	15 DAP	30 DAP
Control	26.54	47.24	5.47	7.84	11.00	17.72
Bacillus furmus	26.94	47.03	5.28	7.60	10.94	16.72
Bacillus polymixa	28.24	48.22	5.50	7.79	10.94	17.67
Azotobacter sp.	29.13	46.85	5.60	8.04	11.17	18.00
Actinotobacter sp.	26.91	45.94	5.39	7.52	11.33	16.39
Bacillus bodius	27.00	45.72	5.39	7.97	11.00	17.50

Based on **Table 2**, the data shows that the provision of rhizobacteria did not have a significant effect on the stem diameter of tomato plants at the age of 15 and 30 DAP after conducting a variance analysis. This shows that the use of rhizobacteria has no effect on increasing the stem diameter of tomato plants.The average stem diameter of tomato plants aged 15 DAP tended to be higher in the rhizobacteria *Azotobacter* sp. (R3) which was 5.60 cm although statistically it was not significantly different from other rhizobacteria treatments.

The same thing also happened, the average diameter of tomato plants aged 30 DAP tended to be higher in the treatment of the rhizobacteria *Azotobacter* sp. (R3) was 8.04 cm and was not significantly different from other rhizobacteria treatments. As is known, the use of PGPR can have an impact on plant growth and production. This is in line with research by Gau *et al* (2021) which stated that the application of *Bacillus subtilis* bacteria to shallots was able to produce the highest number of bacteria in leaves, number of stems, number of tubers, diameter of tubers, and wet weight of tubers.

The average total of leaves of tomato plants at 15 DAP due to rhizobacterial rhizobacteria treatment tends to be higher in *Actinotobacter* sp (R4), which is 11.33 strands, although statistically not significantly different from other rhizobacterial treatments. At the age of 30 DAP, the average number of leaves of tomato plants tended to be higher found in rhizobacteria *Azotobacter* sp. (R3) which was 18.00 strands but statistically not significantly different from other rhizobacterial treatments.

It is suspected that rhizobacteria are less able to increase plant growth due to environmental factors and also the lack of availability of nutrients such as nitrogen nutrients that plants need. Sofyan *et al* (2022) stated that the effect of PGPR provides an effective role. One of its roles is being able to help in the formation of nitrogen and also the effect of PGPR to produce cytokinin compounds in leaf formation.With the fulfillment of nutrition needed by plants, the total of chili branches will be more. Many factors influence the effect of PGPR application; type of crop, soil moisture,

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aeration, soil pH, presence of organic fertilizer, temperature and abundance of other soil microflora (Mahmood *et al*,2023).

Based on the ANOVA test (**Table 3**), the use of rhizobacteria had no significant effect on the total number of bunches of tomato plants. Table 3 shows that in the treatment using rhizobacteria, the average number of bunches of tomato plants tends to be higher in the treatment without rhizobacteria (R0), although these results are not statistically different from other rhizobacterial treatments. As for the average number of fruits per bunch, the value tended to be higher in the *Bacillus furmus* rhizobacteria treatment (R1) at 2.72 but not significantly different from the *Actinotobacter* sp rhizobacteria (R4) at 2.32 and *Bacillus polymixa* (R2) at 2.27.

Table 3. Average number of bunches per plant, and total of fruits per bunch due to rhizobacterial

Rhizobacteria	Total of bunches	Total of Fruits per Bunch
Control	7.33	2.04 a
Bacillus furmus	5.17	2.72 b
Bacillus polymixa	6.00	2.27 ab
Azotobacter sp.	6.44	2.22 a
Actinotobacter sp.	5.94	2.32 ab
Bacillus bodius	6.11	2.08 a

Notes: Each number followed by the same letter is not significantly different based on the duncan new multiple range test (DMRT) at the 5% level.

Inoculation with bacterial isolates was not as it were inc only the development of an increment but an imperative impact on the securing of plant supplements. In line with the inquiry of Dani et al (2022), the arrangement of PGPR is able to fortify the development of plant root frameworks and repress hurtful bacterial organisms and is able to optimize the retention and utilization of supplements and the vegetative stage. Abdicate components such as the number of tubers per clump, the number of tillers per clump, tuber breadth, normal damp weight and normal dry weight of tubers per clump, can be influenced by the arrangement of PGPR. A few analysts have moreover detailed expanded plant growth due to PGPR inoculation on diverse natural product crops. Sorghum inoculated with PGPR expanded leaf water potential beneath field conditions. The solid sinking force of the inoculated roots actuated an increment in the photosynthetic assets of soybeans (Purwantisari et al., 2019).

Table 4 shows that the average height of tomato plants in the treatment of varieties at the age of 15 DAP is higher in variety V1 (Servo F1) with a value of 29.61 cm which is statistically give significantly different from the treatment of variety V2 (Gammara) with a value of 25.31 cm. At the age of 30 DAP, the higher average plant height was also found in the treatment of variety V1 (Servo) which was 48.37 cm and significantly different from variety V2 (Gammara) which was 45.30 cm.

Each variety has different adaptability depending on the environmental conditions where it grows. This adaptability can provide good or unfavorable growth in plants. In addition, plants of different varieties have growth that tends to be different even though they are planted in the same soil. This is in line with Fiqa *et al*. (2020) which states that each plant variety is different in adapting to the environment and is also influenced by plant genetic factors. Plants continue to grow at all times which shows that cell division and enlargement have occurred and this growth is strongly influenced by physiological and genetic environmental factors.

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Effect of Variety on Tomato Plant Growth

Table 4 also shows that the average stem diameter of tomato plants in the treatment of varieties at the age of 15 DAP is higher in the Servo Variety (V1), which is 5.57 cm, statistically significantly different from the Gammara Variety (V2), which is 5.31 cm (Table 4) . At the age of 30 DAP, the average stem diameter of tomato plants was higher in the Servo Variety (V1), which was 7.78 cm although statistically not significantly different from the Gammara Variety (V2). The effect of plant variety on stem diameter can vary depending on several factors, including variety genetics, growth conditions, and environmental factors. The advantages shown by each variety are thought to be related to the differences in responses shown by the plants, especially in terms of growth such as number of leaves, stem diameter, flowering time, harvest time, pod diameter (Elena & Surya, 2022). In addition to genetic factors, stem diameter is also influenced by environmental factors, such as sunlight, which affects the growth and yield of a plant (Yustiningsih, 2021).

Table 4. Average plant height, stem diameter, number of leaves some varieties at the age of 15 and 30 days after planting (DAP)

Variety	Plant height (cm)		Stem diameter (mm)		Total of leaves	
	15 DAP	30 DAP	15 DAP	30 DAP	15 DAP	30 DAP
Servo	29.61 b	48.37 b	29.61 b	48.37 b	29.61 b	48.37 b
Gammara	25.31 a	45.30 a	25.31 a	45.30 a	25.31 a	45.30 a

Notes: Each number followed by the same letter is not significantly different based on the duncan multiple range test (DMRT) at the 5% level.

The average number of leaves at the age of 15 DAP is higher in the Servo Variety (V1), which is 12.59 strands, statistically significantly different from the Gammara Variety (V2), which is 9.54 strands. At the age of 30 DAP the same thing also happened, namely the average number of leaf strands was higher in the Servo Variety (V1) which was 20.22 strands, which was statistically significantly different from the Gammara Variety (V2) which was 14.44 strands (Table 4). Each plant variety has a different growth response because each variety has its own advantages and is also influenced by the genetic response to the place of growth, each plant variety shows a different genotype response to its environmental conditions. Well-adapted varieties, in case these varieties are composed of total of genotypes that have the capacity to adjust to contrasts in environmental conditions (Aisyawati *et al*, 2021).

Table 5. Average number of bunches per plant, and number of fruits per bunch due some varieties of tomato plants

Variety	Total of bunches	Total of Fruits per Bunch
Servo	7.39 b	1.59 a
Gammara	4.94 a	2.96 b

Notes: Each number followed by the same letter is not significantly different based on the DMRT test at the 5% level.

Table 5 shows that the average number of fruit bunches in the 15 DAP treatment varieties tended to be higher in the Servo Variety (V1), which was 7.39 fruits. Meanwhile, the average number of fruits per bunch for the Gammara Variety (V2) was higher, which was 2.96 fruits . Availability of nutrients can affect the growth and yield of tomato plants. The increase in the number of fruit is related to adequate nutritional needs for generative growth. The generative growth of plants will really require high levels of

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nutrients to meet the nutritional needs needed in the generative phase (Assadiyah *et al, 2023)*. Other factors that can influence are the ability of the genotype of each variety to form heavier or more fruit as well as the ability to utilize the photosynthetic light received (Khumairot, 2014).

CONCLUSION

Based on the study results, it can be concluded that the utilization of Servo and Gammara tomato plant varieties has a noteworthy impact on tomato plant development, and the arrangement of rhizobacteria as PGPR in tomato plant development does not have a noteworthy impact.

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