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RESPONSE OF VEGETATIVE GROWTH OF TOMATO (*Solanum lycopersicum* L. VAR. MIRA) DUE TO PGPR (PLANT GROWTH-PROMOTING RHIZOBACTERIA) COMBINED WITH COMPOST AND NPK FERTILIZER

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Abstract

This study aims to determine the growth response of tomato (Solanum lycopersicum L.) plants after the application of PGPR combined with compost and NPK fertilizer on vegetation. The tested parameters include the plant height, number of leaves, wet and dry weight, and root volume of plants. The method used was a non-factorial trial with five treatments and replications, whereby P0 was a control, P1 was given PGPR, P2 composted fertilizer and PGPR, P3 NPK and PGPR, and P4 was given only NPK. Analysis of Variance (ANOVA) was performed on the data and continued with the Least Significance Different Test (LSD). The results showed no significant difference in the plant height, number of leaves, wet and dry weight of PGPR treatment plants with a combination of compost fertilizer and NPK; hence PGPR was used to compensate for NPK. Although the root volume parameters showed significant differences, which was evident in the application of NPK in combination treatment of PGPR, compost fertilizer, or NPK..

Key words**:** *fertilizer, PGPR, tomato*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a horticultural commodity with high economic value because it is rich in vitamins and minerals [16]. Therefore, they are widely used as a daily side dish, a mixture of cooking spices, processed industrial products, or consumed fresh. Furthermore, the variety of benefits possessed by tomatoes is an attraction for farmers and the community to cultivate for commercial purposes.

The use of fertilizers is one of the efforts that enhance crop production. Fertilization is the addition of plant nutrients into the soil to make it fertile. According to Government Regulation No. 8/2001, fertilizers are classified into inorganic and organic fertilizers [10].

Inorganic fertilizers increase productivity, but continuous use reduces soil quality [5]. According to Kartika et al. [7], organic fertilizers are used to increase the efficiency of using chemicals, hence reducing the impact of environmental pollution due to the use of chemical fertilizers. However, using organic fertilizers alone will not produce optimal crop production. This is because the nutrient content produced by organic and inorganic fertilizers is not equivalent. Therefore, through the help of certain effective microbes, organic fertilizers that are not wholly decomposed are broken down and made useful by plants.

The current developments in biotechnology have boosted public awareness, which promotes the development of more environmentally friendly products, such as biofertilizers. This fertilizer contains live microorganisms that bind or facilitate the availability of certain plant nutrients in the soil [2]. Furthermore, the biofertilizers are Plant Growth-Promoting Rhizobacteria (PGPR) or root bacteria, currently studied and

developed to assist agriculture. PGPR is a rhizosphere bacterium that positively affects plant growth [11]. These bacteria can colonize plant roots to absorb microbial secretions that are beneficial for root growth and prevent pathogen invasion [14].

Various studies have proved PGPR to be a plant growth supporter. However, the use of local rhizosphere bacteria in combination with organic and inorganic fertilizers for the growth of tomatoes has not been reported.

Therefore, this study aims to determine the growth response of tomatoes (*Solanum lycopersicum* L. Var. Mira) due to the application of PGPR combined with compost and NPK on the vegetation. The parameters considered were the growth curve, plant height, number of leaves, wet and dry weight, and plant root volume.

MATERIALS AND METHODS

The study was conducted from November 2019 to January 2020 at the Kalasey Biological Agency Laboratory Greenhouse, the Center for the Protection and Testing of the Quality of Food Crops and Horticulture (BPPMTPH), the Regional Agriculture and Livestock Service North Sulawesi Province, and the Advanced Laboratory. Department of Biology, Faculty of Mathematics and Natural Sciences, Sam Ratulangi University.

This study is a nonfactorial experiment with five treatments and replications. The five treatments were P0 (garden soil as a control), P1 (garden soil plus PGPR), P2 (garden soil plus compost with PGPR), P3 (garden soil plus NPK (5 g) with PGPR), and P4 (garden soil plus NPK (5 g) without PGPR). Each growing medium (polybag) was filled with 5 kg soil at a 4:1 ratio of garden soil to compost for P2 treatment. Every five days, up to 5 mL of PGPR was administered.

The plant height was measured from the soil surface to the tip of the growth point after transplanting into the medium [6]. Data on plant height (cm), number of leaves (strands), wet and dry weight (g), and root volume (mL) were collected on the last day of observation (40 DAP). Wet weight data were collected by gently taking plants from a medium cleansed with running water until all soil was discharged and dried. Furthermore, the root volume was calculated by inserting the roots into a measuring cup with a predetermined volume of water. Hence, the increase in water volume after insertion is the root volume value [8]. Finally, the wet weight of plants was measured by weighing all cleaned plants using an analytical balance, while dry weight was measured by placing the plants which were previously enveloped in an oven at 70°C. After which, it was weighed daily until a constant weight was obtained. Hence, the last constant weight is plant dry weight data [9].

Analysis of Variance (ANOVA) was conducted on the collected data at a 95% confidence level and continued with the Least Significant Difference (LSD) test with a 95% confidence level ($\alpha = 0.05$).

RESULTS AND DISCUSSIONS

Growth Curve

The test results on tomato plants treated with PGPR in combination with compost and NPK reveal a range of growth curves, as shown in Figure 1. Generally, the vegetation pattern was close to the sigmoid curve. However, until the last day of observation, there was no aging phase due to the plant having passed the generative period, namely inflorescence [10].

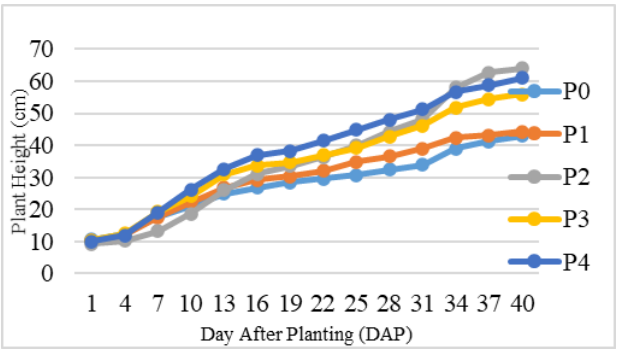

Fig. 1. The growth curve of tomato plants treated with P0 (garden soil as control), P1 (garden soil plus PGPR), P2 (garden soil plus compost with PGPR), P3 (garden soil plus NPK with PGPR), and P4 (garden land plus NPK).

Source: own calculation.

During the 40-day observation period, all treatments demonstrated a logarithmic phase that was estimated to have begun at 4 DAP, as the treatment was performed after the plants were 22 days old. The linear phase began when the growth rate began to slow between 7 and 40 DAP. Furthermore, the ANOVA test on tomato plant height from 1 to 4 DAP showed no difference in height between treatments; hence, PGPR combined with compost and NPK did not affect variations in the growth curve up to 4 DAP. Variations in growth patterns started at 7 DAP until the last day of observation (40 DAP).

Plant Height

Observational data on tomato plant height after 40 DAP received treatment showed that PGPR combined with compost (P2) produced the highest yield with an average value of 64.1 cm, followed by treatment with NPK alone (P4) with an average value of 61.02 cm, a combination of PGPR and NPK (P3) with an average value of 55.88 cm, and treatment with PGPR alone (P1) with an average value of 44.32 cm and the lowest plant height was observed in the control treatment (P0) with an average value of 43.02 cm (Figure 2).

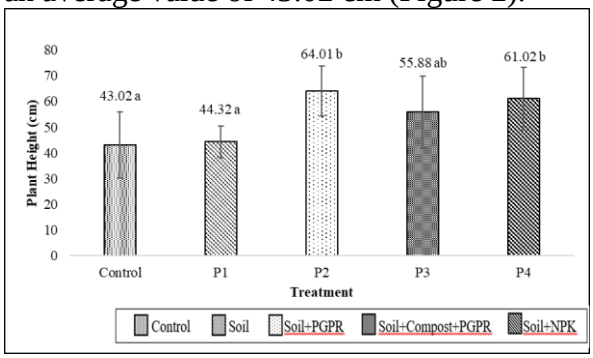

Fig. 2. Tomato plant height after treatment of several combinations of fertilizers on the 40th day of the study.
The numbers, followed by the same letter, do not differ significantly based on the 5% LSD test.
Source: own calculation.

The results of the ANOVA test showed that the treatment had a significant effect on plant height. In addition, statistical analysis of LSD (α 0.05) showed that treatments P3, P4, and P2 were significantly different from treatments P0 and P1.

The combined provision of PGPR with compost replaces synthetic NPK fertilizers. Furthermore, PGPR enhances the absorption of compost nutrients by plants, except compost provides nutrients for the microorganisms contained by PGPR; thus, these fertilizers and compost work synergistically to support plant growth. The administration of PGPR increases plant height. It is shown in Iswati's research, which states that 12.5 ml doses of PGPR have a significant effect on tomato plant height [6].

Number of Leaves

The number of tomato plant leaves observed after 40 DAP obtained the highest value in treatment P2. The average number of leaves was 15.4 strands, followed by P4, P3, and P1, respectively, with 14.2, 9.8, and 7.8 strands. The lowest was observed in treatment P0, which produced 7.4 strands (Figure 3). The Anova test showed that the treatment increased the number of tomato plant leaves. Also, statistical analysis of LSD (α 0.05) showed that treatments P2 and P4 differed from P0 and P1, while each was not significantly different from treatment P3.

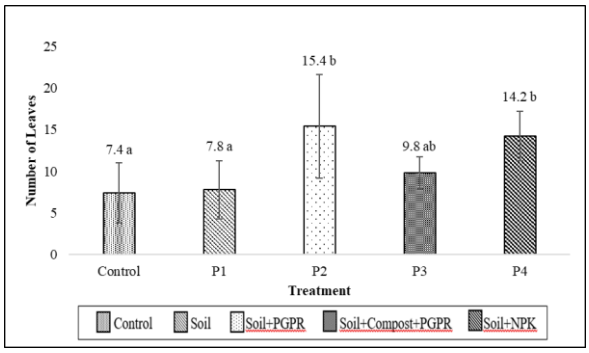

Fig. 3. Number of leaves of tomato plants after treatment of several combinations of fertilizers on the 40th day of the study.
The numbers, followed by the same letter, do not differ significantly based on the 5% LSD test.
Source: own calculation.

Febriani et al. [3] stated that the treatment without PGPR generated the least number of leaves. Iswati's research [6] discovered that the administration of PGPR at a concentration of 7.5 mL affects the number of leaves on tomato plants. There is a difference with the research in which the provision of PGPR without a combination of planting media does not affect the number of leaves. On the other hand, the PGPR and compost fertilizer treatments impacted the number of leaves,

with the highest average number of leaves being 15.4. However, it was not significantly different from the NPK treatment alone (14.2 strands).

Gross weight

These results showed that the highest wet weight was discovered in treatment P4 with an average of 55.54 g, followed by treatment P2 and P3 of 47.59 and 35.01 g. ANOVA was conducted on the wet weight data and continued with a 0.05 LSD test. Figure 4 shows the experimental data on the wet weight of plants. These three treatments were not statistically significantly different. The lowest wet weight was discovered in the control treatment with 15.51 g, followed by PGPR of 16.80 g. There were no significant differences in the combined PGPR and NPK, but it tends to be higher than the control. It is possible to observe significantly different data when the concentration is increased.

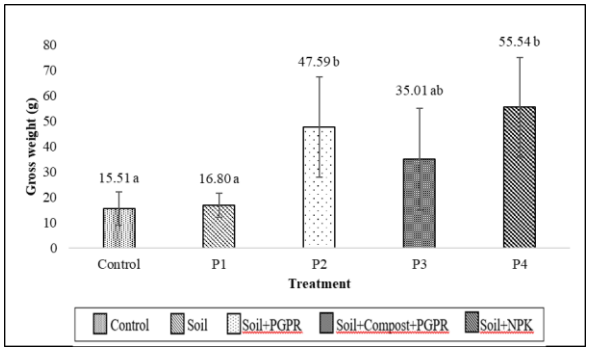

Fig. 4. Gross weight of tomato plants after treatment of several combinations of fertilizers on the 40th day of the study.
The numbers, followed by the same letter, do not differ significantly based on the 5% LSD test.
Source: own calculation.

In general, the application of PGPR when combined with compost compensates for the wet weight yield produced by the administration of NPK. Research conducted by Syamsiah and Rayani [15] states that PGPR application with a concentration of 0.75% affected the fresh weight of chili plants. The wet weight is used as a plant growth parameter because it results from occurring processes in plants. Also, according to Salisbury and Ross [13], it is stated to be the plant's total weight, which shows the results of metabolic activity. Hence, the metabolic activity of plants treated with PGPR increases, especially when combined with compost.

Dry Weight

The lowest average dry weight resulting from PGPR treatment alone was 1.48 g, followed by tomato plants without treatment at 1.58 g. However, the tendency of an increase in dry weight in both treatments was not statistically significant. Furthermore, an increase in the combined treatment of PGPR was not significantly different from PGPR combined with compost. This shows that PGPR application results in a better dry weight when combined with compost or NPK. Meanwhile, the highest weight was obtained in the treatment, with NPK alone being 5.92 g. It was not significantly different from PGPR treatment combined with compost or NPK. This shows that PGPR needs to be combined with compost to achieve a good dry weight. Therefore, its combination with compost replaces NPK fertilizer as a source of plant nutrition.

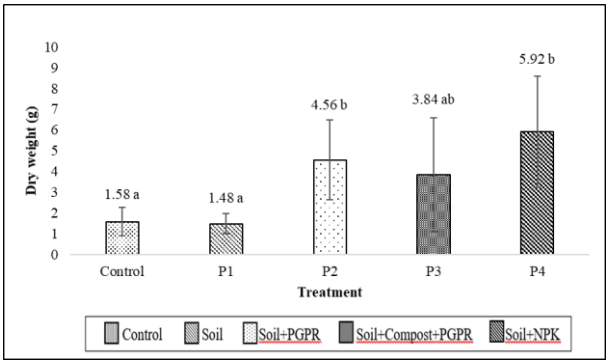

Fig. 5. Dry weight of tomato plants after treatment of several combinations of fertilizers on the 40th day of the study.
The numbers, followed by the same letter, do not differ significantly based on the 5% LSD test.
Source: own calculation.

Plant dry weight illustrates the amount of photosynthate used to perform body metabolism, which determines the high productivity of [1]. In addition, Saharan and Nehra [12] stated that PGPR application to plants replaces chemical fertilizers, pesticides, and hormones that are useful for growth, thereby increasing plant dry weight.

Root Volume

Tomato plants treated with NPK had the highest average root volume of 10.6 mL,

followed by PGPR and NPK treatments with an average root volume of 6.4 mL, while untreated plants produced the lowest root volume (2.6 mL) than those treated with PGPR alone (3.6 mL).

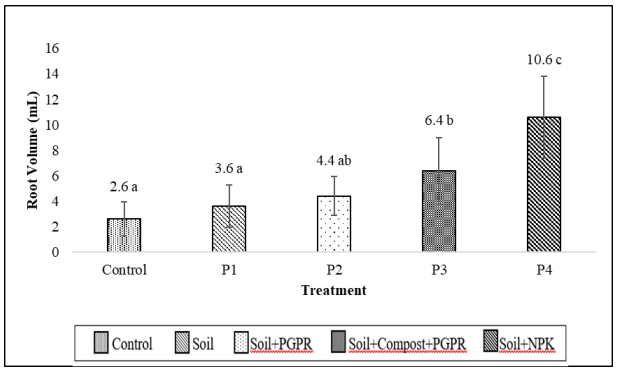

Fig. 6. Root volume of tomato plants after treatment of several combinations of fertilizers on the 40th day of the study.
The numbers, followed by the same letter, do not differ significantly based on the 5% LSD test.
Source: own calculation.

After being analyzed with the LSD 0.05 test, it was observed that the root volume in control was not significantly different from those administered PGPR alone or in combination with compost. This shows that the application of PGPR or its combination with compost has not been able to increase root volume.

However, given the tendency for therapy to increase root volume, it is probable that the PGPR concentration was insufficient. According to Iswati [6], the administered dose of PGPR is directly proportional to the length and number of roots of tomato plants.

The results also showed that NPK treatment as a positive control generated the highest root volume, which implies that the administered dose of PGPR could not compensate for the increase in root volume of tomato plants. Furthermore, there is a possibility of increasing the volume of plant roots due to the low need for water and nutrient absorption. Gardner et al. [4] stated that plants experience greater root growth under water stress conditions than when water needs are met. This is because plant roots are planted vegetative organs that grow and develop correctly when the supporting factors for growth are met.

However, there is a tendency that the use of PGPR increases root volume, although the difference is not significant, especially when combined with compost or NPK fertilizers.

CONCLUSIONS

Based on the research conducted, tomato plants treated with PGPR showed a good growth response with a combination of compost and NPK fertilizers. PGPR administration on the growth pattern is almost close to the sigmoid curve. Furthermore, its treatment combined with compost fertilizer and NPK generated the highest yield on the parameters of plant height and number of leaves.

Furthermore, the combination of PGPR and compost produce indistinguishable results from NPK in terms of wet and dry weight. Finally, the highest root volume was produced by the application of NPK.

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