Research article

# Characteristics of Vegetables Following Growth-Promoting Bacteria Applications as an Environmentally Friendly Cultivation Innovation

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**Abstract.**
The focus of this research was to determine how plant growth-promoting rhizobacteria (PGPR) can affect the soil and physical characteristics of Chinese cabbages, tomatoes, and carrots. A two-factor randomized block design was used. The first factor examined was the time spent soaking the seeds in PGPR solution and the alternatives tested were 0, 10, 20, or 30 minutes. The second factor was the PGPR concentration used when watering the plants in the beds and the alternatives tested were 0, 1.25, 2.5, or 3.75 cc/L. The study found that using PGPR had an effect on soil organic matter and NPK levels, plant height, and yields that differed slightly from the characteristics obtained through conventional practices. The texture and brightness of the Chinese cabbages, tomatoes, and carrots were affected by PGPR treatment. The average texture of the Chinese cabbages, tomatoes, and carrots from the PGPR application was 23.46, 22.82, and 34.14 kg m/sec2, respectively, with brightness levels of 40.19, 34.06, and 39.10. The Chinese cabbages, tomatoes, and carrots from conventional farming practices had textures of 27.12, 23.03, and 31.13 kg m/sec2, respectively, and brightness levels of 58.11, 34.16, and 43.04. The texture and brightness level of the Chinese cabbages, tomatoes, and carrots produced by PGPR application were nearly identical to those produced by conventional farming practices.

**Keywords:** plant growth-promoting rhizobacteria, characteristics, Chinese cabbages, tomatoes, and carrots

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## 1. Introduction

Cultivation technology is now more advanced, farmers practice cultivation not only using chemicals, but in combination with natural/organic materials to get better results. Currently, farmers are starting to reduce the use of chemicals in cultivation and are starting to try to use environmentally friendly cultivation technologies. In this study, the cultivation technology innovation used is the application of the use of PGPR to seeds and plants in the field. The physical characteristics of vegetables with PGPR application were compared with the yields of conventional farmers. The application of cultivation without the application of chemicals in the future to be further improved, to get vegetables that are free of chemical residues, healthy and safe for consumption. This research was conducted in Mayungan Village, Baturiti sub-district, Tabanan Regency, where farmers have never used the PGPR application before during the planting period on their land. The vegetables selected for this study represent vegetables derived from leaves, fruits and tubers. Mayungan Village was chosen because it is the center of horticultural development in Bali, as well as the fertile soil and its location in the highlands, suitable for growing the vegetables of Chinese Cabbage (*Brassica rapa* L. *Ssp. Pekinensis*), tomato (*Lycopersicon esculent* Mill.) and carrot (*Daucus carota* L.).

Farmers sometimes face situations of severe losses due to pests and plant diseases, they try to take care to avoid losses. Pesticides are an easy and quick solution to overcome losses in vegetable and fruit cultivation. Pesticides that are permitted together with non-pesticide solutions are evaluated for their suitability in terms of integrated pest management, residues, efficacy, safety of living things and the environment [1]. To overcome the use of chemicals in vegetable cultivation, an environmentally friendly technology known as organic farming is applied. Conversion to organic farming illustrates the process of learning and implementation of agricultural changes towards sustainable and natural ways of farming [2]. The results of the study [3], agricultural land in the highlands of Bedugul Village, Baturiti Subdistrict, Bali which is cultivated with potatoes contains insecticide residues of the profenofos group amounted to 0,02 - 0,043 ppm and potato tubers contain an average residue of 10% of the insecticide residue content in the soil. To overcome the use of chemicals in vegetable cultivation, an environmentally friendly technology known as organic farming is applied. The form of the process varies depending on the local conditions of agricultural land [4].

Beneficial and free-living rhizobacteria are commonly referred to as plant growth rhizobacteria (PGPR). PGPR comes from various genera such as *Azospirillum, Azotobacter, Bacillus, Burkholderia, Corynebacterium, Pseudomonas, Rhizobium, Serratia* and etc, where *Bacillus* and *Pseudomonas spp*. very dominant. The function of PGPR is to synthesize certain compounds, facilitate the absorption of nutrients, and reduce/prevent disease [5]. Farmers have long realized the importance of soil biology, they see the role of rhizobia, mycorrhizae, biological control organisms, and all soil nutrients in maintaining soil quality for crop production. The use of bacteria in cultivation is one of the efforts to reduce the use of chemicals in the cultivation process. One of the bacteria used is *rhizobacteria*, a group of bacteria that colonize plant roots, and increase plant growth and reduce disease or damage caused by insect attacks, known as *Plant Growth Promoting Rhizobacteria* (PGPR). [6]. The application of PGPR continues to increase in agriculture to replace the application of chemicals in aquaculture, its benefits are to produce antibacterials that are effective against pest and disease [7].

Several studies on bacteria previously described are an attempt to reduce the application of chemicals in plant cultivation. The application of environmentally friendly technology with the use of growth-promoting bacteria is something that needs to be done for farmers in Bali, especially all farmers in Mayungan Village, Tabanan, to start using natural ingredients as fertilizers and pesticides towards organic farming. The application of this technology is expected to produce vegetables with almost the same quantity and quality and even better than the results of conventional farmers. The purpose of this research was to know the effect of PGPR application on soil conditions and physical characteristics of Chinese cabbage, tomatoes and carrots produced, then compared with vegetable yields from conventional farmers.

## 2. Methodology

The research was conducted on land in Mayungan Village, Tabanan Regency, while results from conventional farmers were obtained from land in Batunya Village, Tabanan Regency, Bali. Laboratory analysis was carried out at the Udayana University Laboratory, Denpasar, Bali. The research materials were soil, Chinese cabbage, tomatoes and carrots from land in Mayungan Village and Batunya Village, manure from chicken manure, *Plant Growth Promoting Rhizobacteria* (PGPR) and endophytes obtained from the Pest and Disease Laboratory, Faculty of Agriculture, Brawijaya University, Malang. Laboratory materials are silica gel, acetone, hexane, ethanol, iodine, sodium bicarbonate. The analytical equipment used is a measuring cylinder (size 100 ml and 10 ml), pipette scales (Mettler Toledo), texture and color analyzer. The experimental design used was a factorial randomized block design with 2 factors with the first factor namely the length of seeds soaking with PGPR (0, 10, 20, and 30 minutes), while the second factor is the use of PGPR when watering plants in beds (0; 1,25; 2,5 and 3,75 cc/L). The treatments were grouped into 3 groups so that 48 experimental units were obtained. To see the difference between the use of PGPR and the yields of conventional cultivation, an analysis was carried out including the analysis of soil, plant height, number of harvests and grading, texture analysis and brightness level of vegetables [8] [9].

Cultivation of chinese cabbage, tomatoes and carrots [9] includes soil preparation, PGPR treatment, plant maintenance and harvesting. The soil before being used for cultivation is loosened first, by providing fertilizer from chicken manure, at a rate according to the habits of farmers in general. Loose soil is left for 4-7 days, before being used for the cultivation of Chinese cabbage, tomatoes and carrots. The making of beds for vegetable cultivation with a size of 100 x 600 cm. The distance between the beds is 30 cm. The length of the beds according to the length of the garden plot. Seeds were treated with PGPR soaking before planting, after soaking the seeds were drained, then immediately planted in beds for carrot seeds, with a depth of ± 1 cm and covered with soil. Chinese cabbage and tomato seeds are planted in the seedlings first for 5-7 days, then transferred to the beds on the 5-7th day, and planted and then watered until the soil is saturated. Treatment of the seed of Chinese cabbage, tomatoes and carrots amounted to ± ½ cup (250 ml size) or ± 50 g soaked in PGPR solution. PGPR solution was made by mixing 5 ml of PGPR into 1 L of water, placed in a glass (4 cups were made for each treatment), the soaking time treatments namely 0, 10, 20, and 30 minutes. The soaked seeds are drained first, then continue planting according to the condition of the vegetables. Plant age ± 14 days, sprayed with PGPR according to the treatment, namely 0; 1.25; 2.5 and 3.75 cc/L, which were applied to plants in the field according to the experimental plot. Irrigation is carried out intensively when there is no rain and the soil becomes dry. During cultivation, if vegetables are attacked by pests and diseases, the spraying treatment using endophytes is given to overcome them (material from bacteria to treat fungi, carried out when the vegetables are ± 16 days old, only done once), while spraying PGPR is conducted amounted to 2-4 times depending on the attack of pests and plant diseases. Harvesting is done when the vegetables have reached the age of 60 days for Chinese cabbage, 114 days for tomatoes and 118 days for carrots. To see the layout of the experiment, it is presented in Figure 1, while for the experimental field for vegetables with the PGPR application, it can be seen in Figures 2, 3 and 4.

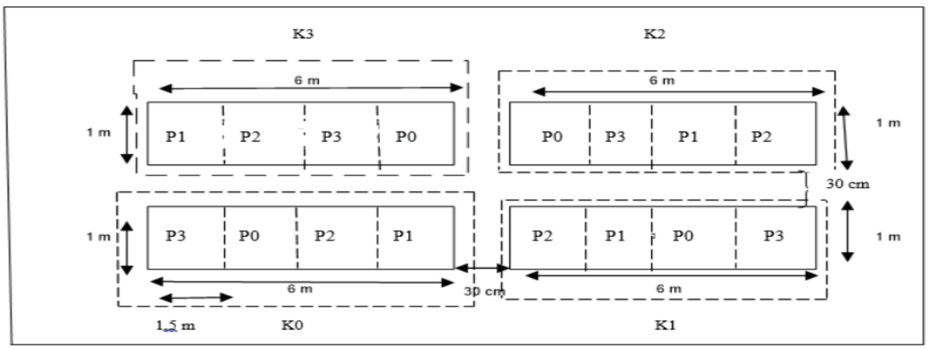


**Figure** 1: the layout of the experiment.

Information :

1. One experimental bed plot measuring 100 x 600 cm, with details of 1 bed containing 4 treatment plots, each treatment plot area is 100 x 150 cm, containing ±16 holes with a distance between rows of 20 cm.

2. One treatment plot, namely the length of time for soaking the seeds with PGPR (P) and the use of PGPR for watering plants aged ± 14 days (K) [9].

**Figure** 2: The experimental field for chinese cabbage with the PGPR application [8].


**Figure** 3: The experimental field for tomatoes with the PGPR application [9].

Observations in this study included: soil analysis (organic matter and elements N, P, K), plant height, number of harvests and vegetable grading, texture analysis (pressed test type, the sensor used was the TA39 probe with a speed of 20 mm/s) and brightness level (sensor attached to vegetables reads numbers on display, color reads brightness level/L*) [9] [10]. Laboratory analysis data (texture and brightness level) using analysis of variance, processing the data using the Minitab17 program [11].

## 3. Results and Discussion

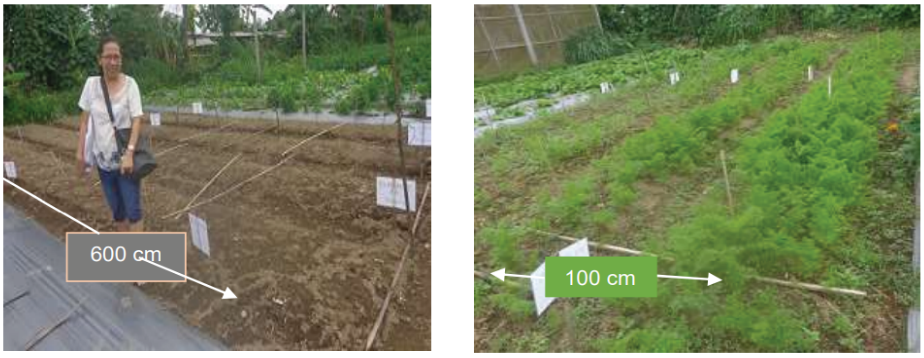


**Figure** 4: The experimental field for carrots with the PGPR application [10].

### 3.1. Soil Condition

The soil where the Chinese cabbage, tomato and carrot were cultivated was previously analyzed to determine the condition of the soil, and used as a comparison with soil that using PGPR. The analysis carried out includes the levels of organic matter and levels of N, P, K. Soil analysis data before and after using PGPR are presented in Table 1.

Table 1: Soil analysis data before and after using PGPR.

| **Application before and after the use of PGPR on soil for cultivation** | **The Levels** | | | | |
|---|---|---|---|---|---|
| | **Organic matter (%)** | **N (%)** | | **P (ppm)** | **K (ppm)** |
| **A. Chinese cabbage (Brassica rapa L. Ssp. Pekinensis),** | | | | | |
| **1. Before** | 2,87 | 0,23 | | 143,79 | 184,24 |
| **2. After** | 3,45 | 0,57 | | 338,54 | 289,15 |
| **B. Tomato (Lycopersicon esculent Mill.)** | | | | | |
| **1. Before** | 3,20 | 0,36 | | 230,99 | 284,87 |
| **2. After** | 4,06 | 0,63 | | 337,74 | 435,19 |
| **C. Carrot (Daucus carota L.)** | | | | | |
| **1. Before** | 3,01 | 0,24 | | 270,11 | 105,34 |
| **2. After** | 4,03 | 0,55 | | 352,86 | 257,34 |

**Source** : processed data [9]

Table 1 shows that after the application of PGPR in the cultivation of Chinese cabbage, tomatoes and carrots, obtained a slight increase in organic matter (BO) and N, P, K levels. This is probably because after the application of PGPR, the bacteria in the soil are more active in absorbing mineral nutrients so that there is a slight increase in the levels of organic matter and N, P, K. The soil around the plant is strongly influenced by roots and involves interactions among the roots, soil and microbes. Research results from Xiao

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Xiao *et al.*[12], *Rhizobacteria* stimulate plant growth through different mechanisms by increasing the absorption of mineral nutrients, stimulating the synthesis of phytohormones and secondary metabolites, suppressing phytopathogens and increasing plant tolerance to environmental stresses. So that the research by Naeima [13], research aimed to isolate and screen IAA-producing bacteria from soil and study the impact of alkalinity and salinity on IAA production and the total antioxidant activity of high IAA-producing strains. The results showed that total antioxidants increased in acidic (pH 5 and pH 6) and alkaline (pH 8) media, and salinity up to 2%. The results of this study as a candidate for isolating IAA-producing bacteria in the field, as an alternative to biological fertilizers. According to Ashrafuzzaman *et al.* [7], the ability of bacteria to solubilize phosphate minerals has been attracted agricultural microbiologists, as they increase the availability of phosphorus and iron for plant growth. PGPR has been shown able to dissolve phosphate and increase phosphate availability in rice which represents a mechanism for the plant growth promoting under field conditions. Simultaneously, the results show that PGPR is able to induce IAA production, phosphorus solubilization, and resistance to pathogens and pests, thereby enhancing plant growth.

## 3.2. Plant Height

Growth of Chinese cabbage, tomatoes and carrots can be seen in Figure 5, where the growth of plants with PGPR application was slightly higher than those without PGPR, only carrots were slightly lower than without PGPR treatment. Plant height was measured during the planting period until harvest, for Chinese cabbage 6 observations were made, tomatoes were observed 11 times and carrots were observed 12 times. The average final height before harvesting of the Chinese cabbage plants with PGPR application namely 44,82 cm and without PGPR 44,67 cm. The final average height before harvesting of tomato plants with PGPR application namely 182,04 cm and without PGPR 163,67 cm. The final average height before harvesting of carrots with PGPR application namely 79,63 cm and without PGPR 85,50 cm. Observations were made by measuring plant height every 7 days, taken from plant samples (chinese cabbage, tomatoes and carrots) at random for each treatment and measured 3 times, then averaged as plant height data.

In Figure 5, it can be seen that the average plant height with PGPR application is slightly higher than without PGPR application. The results of this growth are supported by the research of Diyansah *et al.*[14], observation on the 6th day of *Brassica juncea*L after planting, there were differences in the length of plant roots in each treatment.

The average root length of each treatment namely PF (*P. fluorescens*) 6,625 cm, BS (*B. subtilis*) 7,1 cm, PF + BS (*P. fluorescens* and *B. subtilis*) 5,735 cm, and control (without treatment) 2,95 cm. This shows that PGPR can stimulate the growth of roots and leaves of cabbage plants. PGPR inoculation can improve the growth, germination and harvest of cultivated plants.

Based on the relationship of bacteria summarized in PGPR with plants, bacteria are divided into two groups, namely symbiotic and free rhizobacteria. The mechanism of PGPR stimulating plant growth is classified as direct and indirect, as a growth promotion and biological control agent. Bacterial fertilizers cause a significant increase in plant growth, health and yields [15]. Research by Abdeljalil *et al.*[16], that the rhizosphere soil in tomatoes has a diversity of beneficial bacteria that are promising biocontrol agents, because their metabolic activity can produce lipopeptide antibiotics and antifungals. In addition, the activity of these bacteria produces compounds that promote plant growth which indicate the possibility of showing biofertilization action. Future research will focus on the ability to suppress root and crown rot caused by *R. solani* and increase tomato plant growth.

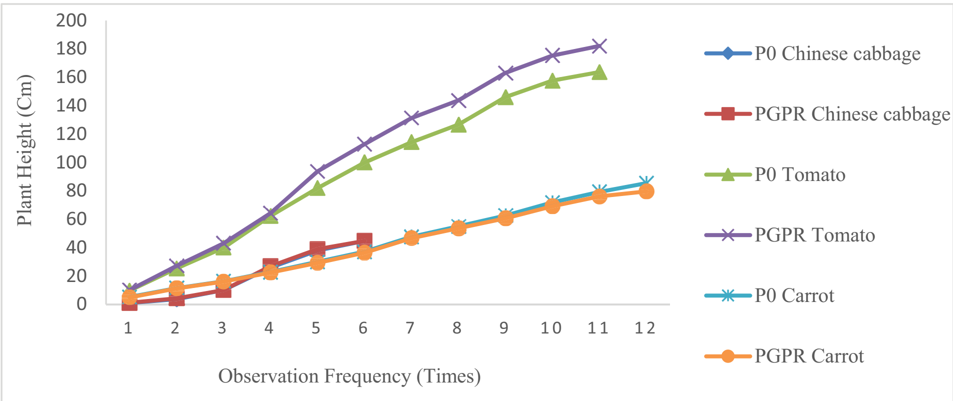


**Figure** 5: Growth of Chinese cabbage, tomato and carrot from planting to harvest.

Information :

1. PGPR = the use of PGPR applications in the cultivation of Chinese cabbage, tomatoes and carrots
2. P0 = without the application of PGPR on the cultivation of Chinese cabbage, tomatoes and carrots

Several studies reported that the use of growth-promoting bacteria increased stem diameter, root weight and plants were more resistant to drought and disease. Several studies have also indicated that the transplantation root weight is increased by PGPR.

The application of PGPR is carried out during nurseries and transferring seedlings to the field, because it can control harmful microorganisms and can increase growth under stress conditions [17].

### 3.3. Harvest Results from PGPR applications and conventional farmers

Harvest results (yields) from the application of PGPR applications on Chinese cabbage, tomatoes and carrots include the number of yields and grading, these yields are compared with yields from conventional farmers or farmers who do not apply PGPR during cultivation. Data on the number of yields and grading of Chinese cabbages, tomatoes and carrots can be presented in Table 2.

TABLE 2: Data on the number of yields and grading of Chinese cabbages, tomatoes and carrots.

| **Harvest commodities from conventional farmers and PGPR applications** | **Data** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Harvest results** | | **Grading** | | | | | | | | |
| | **Good(pc)** | **Damage (pc)** | **Class 1** | | | **Class 2** | | | **Class 3** | | |
| | | | **Weight (g)** | **Long (cm)** | **Wide (cm)** | **Weight (g)** | **Long (cm)** | **Wide (cm)** | **Weight (g)** | **Long (cm)** | **Wide (cm)** |
| **A Chinese cabbages** | | | | | | | | | | | |
| 1. Conventional farmers | 175 | 17 | 856 | 36 | 43 | 525 | 30 | 35 | 305 | 23 | 28 |
| 2. PGPR applications | 166 | 26 | 790 | 40 | 41 | 515 | 32 | 34 | 297 | 24 | 26 |
| **B. Tomatoes** | | | | | | | | | | | |
| 1. Conventional farmers | 1800 | 150 | 72 | 5 | 18 | 53 | 3 | 15 | 37 | 2 | 13 |
| 2. PGPR applications | 1136 | 165 | 64 | 7 | 16 | 39 | 6 | 13 | 25 | 4 | 11 |
| **C. Carrots** | | | | | | | | | | | |
| 1. Conventional farmers | 795 | 175 | 99 | 18 | 14 | 72 | 15 | 12 | 45 | 12 | 10 |
| 2. PGPR applications | 702 | 243 | 105 | 19 | 14 | 60 | 12 | 10 | 33 | 9 | 7 |

**Source** : processed data [9]

In Table 2. the cultivation of Chinese cabbage by soaking the seeds using PGPR treatment and spraying PGPR after planting in the beds, the yield is quite good, the leaves are strong, hard, green and fresh, after the Chinese cabbage begins to form leaf segments, caterpillar pests begin to attack the Chinese cabbage. The leaf segments have a few holes due to caterpillar bites, but not all the leaves are eaten by the caterpillars. The cabbage leaf blades look fresh and dark green for the outermost layer, but the inner leaf blades are light green. Cabbage leaves outside the PGPR application area have fewer pests, because insecticides are given to overcome these pests, cabbage produced by the outer leaf blade is dark green, the inner leaf blade is green, the leaves are quite hard, dense and fresh. The yields produced are supported by the research of Somayeh *et al.*[18] stated that biofertilizers containing rhizobacteria can increase germination and nutrient absorption *of Onobrychis sativa* L. Another aspect of the use of rhizobacteria is the selection of appropriate species from each climate, plant type and environmentaly condition.

Tomato cultivation by soaking the seeds using PGPR and spraying PGPR after planting in the beds, the yields are quite good. The tomato tree grows tall, the leaves are thick and the fruit is quite a lot. During tomato cultivation, spraying of PGPR and combined with endophytes (to control fungi), continues to be carried out ± 5 times, because the tomatoes are attacked by insects, but after the application of organic matter the pests disappear and the tomato plants grow taller. For tomato plants from conventional farmers or farmers without applying the use of PGPR during cultivation in accordance with the treatment of farmers in general, for pest attacks, pesticide spraying is carried out during the tomato planting period. According to Ahmed *et al.*[19], *Rhizobacteria* present in the rhizosphere layer provide many plant nutrients, phytohormones or destroy plant diseases so as to stimulate the development and growth of tomatoes directly or indirectly. PGPR activity causes an increase in the production of high-quality tomatoes, while reducing chemical inputs.

Carrot cultivation with seed soaking treatment using PGPR and spraying PGPR after planting in the beds, the yields are quite good. Carrot plants grow quite tall, the leaves are thick and the tubers are quite large. Research from Melek Ekinci *et al.* [17], the use of PGPR increased stem diameter, root weight and plants can withstand stress conditions such as drought and disease. Several studies have also indicated that transplanted root weight is increased by PGPR. PGPR isolate increased shoot length, root length and dry matter production of shoots and roots of *Arietinum cicer* grafts. In this study, bacterial inoculation increased the nutrient content of the plant. Kundan *et al.* [15] reported that PGPR supports growth by reducing phytopathogens and increasing crop yields. In the future, this is an effort to replace chemical fertilizers and support ecosystems in Indonesia.

This study groups by weight (g), length (cm) and width (cm) of vegetables, then given the level or grading in the form of class, namely class 1 (good vegetables according to the size of weight, length and width observed), class 2 (medium ) and class 3 (small size vegetables). The results of this study will be used as a basis or reference for the distribution of organic vegetables in the market and as a benchmark for prices in the market, so that consumers can determine the choice of buying organic vegetables based on their ability to buy organic products. The grading results based on class 1, 2 and 3 for Chinese cabbages, tomatoes and carrots from the PGPR application and conventional farmers can be seen in Table 2, while the difference between Chinese cabbages, tomatoes and carrots from PGPR application and conventional farmers' results can be seen in Figure 6, 7, and 8.


**Figure** 6: Chinese cabbages from conventional farmers (a) and Chinese cabbages from PGPR application (b).


**Figure** 7: Tomatoes from conventional farmers (c) and tomatoes from PGPR application (d).

## 3.4. Texture and Brightness Level

The results showed that the interaction between duration of soaking the seeds with PGPR and the use of PGPR at the time of watering the plants in the beds had a very significant effect ($P < 0,01$) on the texture and brightness level (L*) of Chinese cabbages. The results showed that the interaction between the length of soaking the seeds with PGPR and the use of PGPR when watering plants in the beds had a significant ($P < 0,05$) effect on texture and no significant effect ($P > 0.05$) on the brightness level (L*) in tomatoes. The results showed that the interaction between the length of soaking the


**Figure** 8: Carrots from conventional farmers (e) and carrots from PGPR application (f).

seeds with PGPR and the use of PGPR when watering plants in the beds had a significant effect (P < 0,05) on the texture and brightness level (L*) in carrots. The average value of texture and brightness level of Chinese cabbage, tomatoes and carrots are presented in Table 3.

In Table 3 it can be seen that the average texture value of Chinese cabbage ranges from 18,05 – 27,42 kg.m/sec$^2$. The treatment of soaking the seeds with PGPR for 30 minutes and without the use of PGPR at the time of watering the plants in the beds namely 27,42 kg.m/sec$^2$, which was significantly different from the treatment of soaking the seeds for 0; 10 minutes and the use of PGPR at the time of watering plants in beds 0; 1,25 cc/L namely 18,5; 18,46 and 19,03 kg.m/sec$^2$. The results of this study indicate that the average texture value of Chinese cabbage which given PGPR treatment, some of the texture values are a little bit hard and crunchy, the rest are harder than cabbage produced by conventional farmers amounted to 27,12 kg.m/sec$^2$. Chinese cabbage has an increase in texture after being given PGPR treatment, the increase ranges from 2-34% of cabbage without PGPR treatment. Soaking the seeds and the use of PGPR solution after planting in the beds, affect the texture of the cabbage yields. Table 3 shows that the average brightness level (L*) of Chinese cabbage ranges from 29,31 to 46,63. The treatment of soaking the seeds with PGPR for 30 minutes and the use of PGPR when watering plants in the beds were 3,75 cc/L, namely 46,63; which is not significantly different from the treatment of soaking for 0; 30 minutes and the use of PGPR at the time of watering plants in the garden is 0; 2,5 cc/L were 45,58 and 45,97, and significantly different from the treatment of soaking the seeds with PGPR for 10 minutes and the use of PGPR when watering plants in the beds as much as 2,5 cc/L which was 29,31. The study showed that the average brightness level (L*) on Chinese cabbage treated with PGPR was less bright (tends to be slightly dim in color, but fresh in appearance) compared to Chinese cabbage produced by conventional farmers of 58,11.

TABLE 3: The average value of texture and brightness level of Chinese cabbages, tomatoes and carrots.

| Chinese cabbages | | | | Tomatoes | | | | Carrots | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T | Texture (kg.m/sec$^2$) 1) | T | Brightness level (L*) 1) | T | Texture (kg.m/sec$^2$) 1) | T | Brightness level (L*) 2) | T | Texture (kg.m/sec$^2$) 2) | T | Brightness level (L*) 1) |
| P3K0 | 27,42 ± 4,48 a | P3K3 | 46,63 ± 3,44 a | P2K0 | 28,43 ± 5,81 a | P3K0 | 35,09 ± 2,31 a | P2K2 | 37,72 ± 9,12 a | P1K0 | 44,12±2,92a |
| P3K2 | 27,14 ± 3,26 ab | P3K2 | 45,97 ± 7,39 a | P2K3 | 26,21 ± 4,53 ab | P1K1 | 34,92 ± 1,40 a | P1K0 | 37,58 ± 9,32 a | P3K3 | 43,91 ±2,91ab |
| P0K2 | 27,08 ± 2,35 ab | P0K0 | 45,58 ± 3,59 a | P0K3 | 25,46 ± 5,63 ab | P2K1 | 34,68 ± 1,15 a | P3K2 | 37,44 ±10,77a | P3K2 | 41,68 ± 3,46 abc |
| P2K1 | 26,71 ± 3,88 abc | P2K1 | 44,39 ± 4,45 ab | P3K1 | 25,35 ± 4,24 ab | P1K0 | 34,61 ± 0,79 a | P0K3 | 37,10 ± 8,55 a | P2K0 | 41,22 ± 2,89 abcd |
| P0K3 | 26,31 ± 5,01 abc | P0K1 | 44,03 ± 2,66 ab | P1K0 | 24,91 ± 2,44 ab | P2K2 | 34,59 ± 3,28 a | P1K1 | 36,75 ± 6,02 a | P1K1 | 40,07 ± 3,09 abcde |
| P3K1 | 24,98 ± 4,78 bc | P1K0 | 41,65 ± 5,03 abc | P1K2 | 24,89 ± 4,63 ab | P3K1 | 34,51 ± 0,75 a | P2K0 | 35,40 ± 7,72 a | P2K2 | 39,63 ± 3,77 bcde |
| P2K0 | 24,56 ± 3,28 bc | P3K0 | 41,37 ± 2,80 abc | P1K3 | 22,71 ± 3,09 ab | P0K1 | 34,32 ± 2,16 a | P0K2 | 35,19 ± 5,92 a | P0K2 | 38,82 ± 3,22 cde |
| P2K2 | 24,05 ± 3,94 bcd | P1K3 | 40,76 ± 3,49 abc | P3K2 | 22,47 ± 2,80 ab | P3K2 | 34,24 ± 2,69 a | P2K3 | 35,16 ± 5,44 a | P3K0 | 38,59 ± 3,19 cde |
| P1K0 | 23,53 ± 3,05bcde | P2K3 | 39,95 ± 2,96 abc | P2K2 | 22,23 ± 3,02 ab | P0K3 | 34,19 ± 0,25 a | P1K2 | 34,71 ± 8,63 a | P3K1 | 38,44 ± 3,27 cde |
| P3K3 | 22,81 ±3,44bcdef | P1K1 | 39,52 ± 3,33 abc | P1K1 | 21,61 ± 2,46 ab | P0K0 | 34,05 ± 2,85 a | P2K1 | 33,34 ±8,12ab | P2K3 | 37,94 ± 3,20 cde |
| P2K3 | 22,54 ±3,17bcdef | P0K3 | 39,42 ± 2,78 abc | P3K0 | 21,19 ± 2,90 ab | P2K3 | 33,83 ± 1,51 a | P3K1 | 32,94 ±6,73ab | P1K3 | 37,84 ± 3,33 cde |
| P1K2 | 21,80 ±3,10 cdef | P3K1 | 39,17 ±3,87abcd | P0K0 | 20,43 ± 2,42 b | P1K3 | 33,44 ± 1,67 a | P0K0 | 32,74 ±8,37ab | P0K1 | 37,24 ± 3,32 de |
| P1K3 | 20,88 ± 2,97 def | P2K2 | 38,81 ±2,76abcd | P3K3 | 20,15 ± 2,42 b | P1K2 | 33,42 ± 0,66 a | P1K3 | 32,62 ±5,38ab | P0K0 | 37,03 ± 3,17 de |
| P0K1 | 19,03 ± 3,17 f | P2K0 | 34,41 ± 7,68 bcd | P0K1 | 19,96 ± 3,50 b | P3K3 | 33,30 ± 1,84 a | P3K3 | 32,28 ±6,25ab | P1K2 | 36,81 ± 2,94 e |
| P1K1 | 18,46 ± 2,99 f | P0K2 | 32,07 ± 4,04 cd | P2K1 | 19,71 ± 2,43 b | P0K2 | 33,20 ± 0,89 a | P3K0 | 29,71 ±5,22ab | P2K1 | 36,39 ± 2,91 e |
| P0K0 | 18,05 ± 2,98 f | P1K2 | 29,31 ± 2,84 d | P0K2 | 19,44 ± 2,95 b | P2K0 | 32,61 ± 0,78 a | P0K1 | 25,51 ± 5,48 b | P0K3 | 35,85 ± 3,42 e |
| CP | 27,12 ± 1,46 | CP | 58,11 ± 6,49 | CP | 23,03 ± 0,90 | CP | 34,16 ± 2,26 | CP | 31,13 ± 5,27 | CP | 43,04±5,21 |

**Source** : processed data [9]

Information :

1) The average grades with different letters showed significantly different results ($P < 0.05$).

2) The average grades by the same letter shows a non-significant difference ($P > 0.05$).

1. T = Treatment, CP = Convensional farmer

2. Soaking time of seeds (P0: without soaking, P1: soaking 10 minutes, P2: soaking 20 minutes, P3: soaking 30 minutes)

3. PGPR concentration for watering (K0: without PGPR concentration, K1: PGPR concentration of 1,25 cc/L, K2: PGPR concentration of 2,5 cc/L, K3: PGPR concentration of 3,75 cc/L).

Table 3 shows that the average value of tomato texture ranges from 19,44 - 28,43 kg.m/sec$^2$. The treatment of soaking the seeds with PGPR for 20 minutes and without the use of PGPR at the time of watering the plants in the beds was namely 28,43 kg.m/sec$^2$, which was significantly different from soaking the seeds with PGPR for 0; 20; 30 and the use of PGPR at the time of watering plants in the beds amounted to 0; 1.25; 2.5; 3.75 cc/L namely 19,44; 19,71; 19,96; 20,15 and 20.43 kg.m/sec$^2$ . The results of this study indicate that the average texture value of tomatoes which is given PGPR treatment, the texture value is almost the same as tomatoes produced by conventional farmers, namely 23,03 kg.m/sec$^2$. For the texture of good tomatoes that were given PGPR treatment with tomatoes produced by conventional farmers, they were almost the same, slightly hard to hard, according to the level of fruit maturity. Tomatoes with PGPR treatment, the color is bright and fresh, the texture is hard but the size is smaller than the tomatoes produced by conventional farmers. Table 3 shows that the average brightness level (L*) of tomatoes ranges from 32,61 – 35,09. The treatment of soaking the seeds with PGPR for 30 minutes and without the use of PGPR at the time of watering plants in the beds was 35,09, which was not significantly different from all treatments using PGPR. The results of this study indicate that the average brightness level (L*) of tomatoes treated with PGPR is almost the same color as tomatoes produced by conventional farmers, namely 34,16.

Table 3 shows that the average value of texture values in carrots ranges from 25,51 to 37.72 kg.m/sec$^2$. The treatment of soaking the seeds with PGPR for 20 minutes and the use of PGPR when watering plants in beds of 2,5 cc/L namely 37,72 kg.m/sec$^2$, which was significantly different from soaking seeds with PGPR and using PGPR when watering plants in beds of 1,25 cc/L namely 25,51 kg.m/sec$^2$. The study indicate that the average texture value of carrots treated with PGPR has a high texture value compared to carrots produced by conventional farmers, namely 31,13 kg.m/sec$^2$. Table 3 shows that the average value of the brightness level (L*) in carrots from 35,85 to 44,12. The treatment of soaking the seeds with PGPR for 10 minutes and without the use of PGPR when watering plants in the beds was 44,12, which was not significantly different from soaking the seeds for 30 minutes and the use of PGPR when watering plants in the beds was 3.75 cc/L, namely 43,91, but significantly different from seed soaking for 0; 10; 20 minutes and the use of PGPR when watering plants in the beds was 1.25; 2.5; 3.75 cc/L that is 35.85; 36.39 and 36.81. The study showed that the average brightness level (L*) of carrots was influenced by seed soaking and PGPR application during cultivation. Carrots treated with PGPR mean brightness level (L*) was still quite low compared to carrots produced by conventional farmers, which was 43,04.

The hardness value indicates the level of freshness of the fruit and vegetables, but the hardness value is said to be good not because the value is high or low, but depends on the condition of the fruit and vegetable [20]. Plant tissue contains more than two-thirds of water so that the difference in texture is determined by the relationship of the components with water. Turgidity is determined by the osmotic force, plays an important role in the texture of fruits and vegetables. The cell walls of plant tissues have varying degrees of elasticity and are mostly permeable to water and to ions and small molecules. The living protoplasmic membrane is semi-permeable, which allows the water flow to remain selective for the transfer of solutes [21]. Fruit can change in texture during the ripening, when ripe it quickly becomes softer. Excessive moisture loss can also affect plant texture. Hardness can be used to assess crop maturity in some leafy and tuber vegetables [22]. Excessive application of nitrogen inhibits the color change from green to yellow and induces a fainter development of redness on the fruit skin. High nitrogen applications can reduce the color of the wine. Nitrogen is also associated with undesirable coloration of endogenous chlorophyll catabolism and post-harvest treatment of citrus [23].

## 4. Conclusion

This study concluded that the application of PGPR use affects soil conditions, plant height and number of harvest results (yield) slightly different from the yield of the conventional farmer. The application of PGPR has an effect on the texture and brightness level of Chinese cabbages, tomatoes and carrots. The average texture of the PGPR application on Chinese cabbage namely 23,46 kg m/sec$^2$ and the brightness level is 40,19, while from conventional farmers namely 27,12 kg m/sec$^2$ and 58,11. The average texture of the application of PGPR on tomatoes is 22,82 kg m/sec$^2$ and the brightness level is 34,06, while from conventional farmers namely 23,03 kg m/sec$^2$ and 34,16. The average texture of the application of PGPR on carrots is 34,14 kg m/sec$^2$ and the brightness level is 39,10, while from conventional farmers namely 31,13 kg m/sec$^2$ and 43,04. Cultivation with PGPR application is an initial step towards environmentally friendly cultivation without the use of chemicals, so that later it produces safe, healthy and quality products.

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