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Cultivation Innovations of Growth Promoting Bacteria and the Characteristics of Several Vegetables

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Abstract— Reducing the use of chemicals in vegetable cultivation is an environmentally friendly cultivation technology that is expected to reduce negative impacts on the environment. One of the efforts to reduce chemicals in cultivation is to use bacteria that live in plant roots as plant growth promoters or biopesticides. This study aims to determine the number of endophytic bacteria from bamboo and leguminosae roots that have the potential as plant growth promoting agents. The making of plant growth-promoting rhizobacteria (PGPR) starter which was carried out in this study used the roots of bamboo, lemongrass and *Mimosa Pudica* Linn. Furthermore, it is applied to vegetable cultivation (Chinese cabbage, tomato, carrot and green mustard/caisim) to determine the physical characteristics of vegetables from the result of PGPR application compared to results from conventional farmers. This study used a factorial randomized block design with 2 factors. The first factor is the plant roots used, while the second factor is the length of the plant roots soaking in water, namely 72, 96, 120 hours. The data from the PGPR starter analysis results are made into a table, then a descriptive discussion is carried out. For vegetable data from the cultivation results using PGPR compared to vegetable from conventional farmer results. Based on laboratory analysis, obtained the total microbes in samples from bamboo roots with a soaking time of 72 hours were higher than the other samples, namely 8.49 x 106 cfu ml^{-1}; pH in samples of PGPR from the roots of *Mimosa Pudica* Linn, bamboo, lemongrass, commercial PGPR (from Central Java farmers) ranged from 3.0 to 6.7; while the total dissolved solids content ranged from 0.2 to 2.6%. Based on the graph of plant growth in the PGPR treatment and with no treatment, there is a slight difference, not much increase or decrease. In tomatoes with PGPR treatment, plant growth was higher than without the use of PGPR, while for Chinese cabbage and caisim the growth was almost the same between PGPR treatment and without PGPR. For carrots, it was seen that with PGPR treatment, plant growth was lower than without PGPR. The results of the analysis of texture, brightness level and total dissolved solids in Chinese cabbage, caisim, tomatoes and carrots with PGPR application, the characteristics are almost the same as the results of conventional farmers. By looking at these results, it is hoped that in the future cultivation innovation by utilizing bacteria around the roots, is one of the environmentally friendly cultivation applications and begins to reduce the use of chemicals in cultivation.

Keywords— Cultivation, characteristics, Plant Growth Promoting Rhizobacteria (PGPR), vegetables

I. Introduction

Agriculture in Bali is currently starting to lead to organic farming. To move forward to organic farming as a whole, there must be a process that is carried out, so then currently it is still semi-organic. Vegetables grown in Balinese agricultural areas still use chemicals application in their cultivation, but some are combined using organic materials in their cultivation. Weather factors and climate conditions in Bali, are the main problems in addition to pests and diseases. Efforts to eradicate pests and diseases that are easy, effective and fast among farmers namely the use of pesticides from the organophosphate group that are widely used today.

To reduce the negative impact on the use of chemicals in agriculture, then environmentally friendly cultivation technology is carried out which is expected could reduce the negative impact on the environment. Efforts that conducted namely to implement organic farming. The process of transitioning to organic farming has great risks, because farmers have to learn about controlling pests biologically without using chemicals, managing nutrient cycles, producing different crops and marketing products. [14].

Plant Growth Promoting Rhizobacteria (PGPR) are *rhizobacteria* that promote plant growth, some bacteria that live around plant roots. These bacteria live in colonies covering plant roots. These bacteria provide benefits in plant physiology and growth processes. PGPR can be a solution to

dependence on synthetic chemical fertilizer products, so that could maintain sustainable agricultural growth and support a global vision of development, protection and preservation of the environment that has already been damaged by the application of synthetic chemicals. The way PGPR works in plant growth, namely increasing nitrogen fixation in legumes, promoting free-living nitrogen-fixing bacteria, increasing the supply of other nutrients, such as phosphorus, sulphur, iron and copper, producing plant hormones, increasing other beneficial bacteria or fungi, controlling fungal, bacterial and insect diseases [16]. PGPR is used as a way to restore soil fertility because some bacteria from the PGPR group are nitrogen-fixing bacteria such as the genus of *Azospirillum, Rhizobium, Azotobacter* and phosphate solubilizing bacteria such as the genus of *Bacillus, Pseudomonas, Arthrobacter, Bacterium, and Mycobacterium* [13]. In the research of Firdu *et al.*[19] showed *Bacillus* and *Serratia* species as potential isolates in showing the best inhibitory activity against *Botrytis fabae* AAUBF-12 together with antagonist and plant growth promoting properties. From the strain of *Bacillus, B. subtilis* AAUB95 showed the best antagonistic properties against *B. fabae* AAUBF-12 by producing plant growth promoting properties and thus could be utilized as a biofungicide both under greenhouse and/or field conditions after several strain tests.

Until nowadays vegetable cultivation spread across agriculture in Bali mostly uses the application of pesticides and chemical fertilizers in their cultivation. To reduce this, efforts are made to utilize bacteria as an alternative for reducing the use of chemicals. Based on the description above, the use of bacteria that live in plant roots can be used as a plant growth promoter or biopesticide. Various studies have shown that the bacteria group of *Bacillus sp., Pseudomonas sp., dan Rhizobium sp.* can be used as a plant growth promoter as well as play a role in controlling plant diseases. This research was conducted as an alternative to reducing the use of chemicals in vegetable cultivation applications. This study aims to determine the number of endophytic bacteria from bamboo roots and leguminoseae that have the potential as plant growth promoting agents, so that the results obtained can be developed as commercial products. The making of PGPR that was carried out in this study used materials available in nature, namely bamboo, lemongrass and Putri malu roots. Furthermore, PGPR starter is made the growing medium that is used in vegetable cultivation applications. The purpose of PGPR application in vegetable cultivation is to determine the physical characteristics of vegetables produced by PGPR applications compared to vegetables produced by conventional farmers.

This study analyzed the treatment of immersion water on plant roots (bamboo, lemongrass and *Mimosa Pudica* Linn) with variations in soaking time (72, 96, 120 hours) the result obtained is called the PGPR starter, wherein the application of cultivation on vegetables, it is continued to develop a growing medium called PGPR. In this study, the vegetables used were Chinese cabbage (*Brassica rapa* L. Ssp. *Pekinensis*), tomato (*Lycopersicon esculentum* Mill.), carrot (*Daucus carota* L.) and caisim (*Brassica rapa* var *parachinensis*), because these vegetables are easy to obtain in traditional markets and supermarkets, affordable prices, easy cultivation and preferred by consumers. In the vegetable cultivation process, conducted the treatment of seeds soaking and PGPR watering during the planting period. This result is one of the environmentally friendly cultivation innovations by using bacteria that live in plant roots as fertilizers and biopesticides, it is hoped that with this application, gradually reduce the use of chemicals in vegetable cultivation.

II. Research Methods

A. Place and Time of Research

This research was conducted on agricultural land in the village of Mayungan, Tabanan and in the village of Renon, Denpasar, Bali. Laboratory analysis was carried out at the Laboratory of the Faculty of Agricultural Technology, Udayana University, Bali, Indonesia and the implementation of this research from December 2020 to December 2021.

B. Experimental Design

This study used a factorial randomized block design with 2 factors. The design of this study was used for the making of PGPR starter. The first factor is the plant roots used, while the second factor is the length of the plant roots soaking in water, namely 72, 96, 120 hours. Each plant root treatment *(Mimosa Pudica* Linn, bamboo and lemongrass) were grouped into 3 groups, so that each root treatment was 9 experimental units. The research design can be seen in Table 1.

C. Research Implementation

114 g of natural ingredients (the root of bamboo, lemongrass and *Mimosa Pudica* Linn), soaked in 750 ml of water, then placed in a bottle (with a lid) and and soaked according to treatment (72, 96 and 120 hours). Every day the solution was shaken manually. The purpose of shaking is to increase the population of microbes, because microbes reproduce by dividing.

The bacteria formed in the bottle are characterized by a sour smelling solution, there is a thin layer on top of the water, when it is shaken, air bubbles emerge from the dough. To increase the number of bacteria, a growth medium is made for this PGPR starter. PGPR bacteria are soil bacteria that have a short life span. Therefore, it is necessary to restore the population every time we will sow the seeds, by making the

growth medium so that it stays alive and the bacterial population increases. The PGPR starter produced will be tested including total microbes, pH and Total Dissolve Solid. After knowing the test results, proceed with making a solution of PGPR (bacterial growth media) to be applied to plants [13].

This result is a PGPR starter that was carried out laboratory analysis first before created the media for microbial growth and used in cultivation applications on vegetables. PGPR solution applied to plants by the seeds soaking treatment with PGPR solution for 20 minutes and watering the PGPR solution during the growth equal to 2.5 cc L^{-1} for Chinese cabbage and caisim, soaking the seeds with PGPR solution for 30 minutes and watering the PGPR solution during the growth as much as 1.25 cc L^{-1} for carrots and soaking the seeds with PGPR solution for 10 minutes and watering the PGPR solution during the growth as much as 1.25 cc L^{-1} for tomatoes. These results are the best results from Triani's research [2]. Data of plant height on caisim with PGPR treatment from the roots of *Mimosa Pudica* Linn and PGPR treatment for products from the Faculty of Agriculture, Brawijaya University for the application of Chinese cabbage, tomato and carrot cultivation, are presented in a graph of plant growth compared to without the use of PGPR.

D. Data Collection

Laboratory analysis that carried out for the PGPR starter made from the roots of *Mimosa Pudica* Linn, bamboo and lemongrass, namely an analysis of total microbes, pH and total dissolved solids (hand refractometer). Analysis of vegetables from PGPR results from the roots of *Mimosa Pudica* Linn, namely in caisim, plant height was calculated (observations were made every 7 days, until harvest), compared to without PGPR treatment, plant height in Chinese cabbage, tomatoes and carrots with PGPR (obtained from the Faculty of Agriculture, Brawijaya University) compared to without PGPR. In addition, conducted the analysis of total dissolved solids (digital TDS), texture (Texture analyzer) and brightness level (Colourmeter) from Chinese cabbage, tomato, carrot, and caisim.

E. Data Analysis

The analysis of the PGPR starter data that was tested included total microbes, pH and total dissolved solids (TDS). The data from the vegetable analysis results (Chinese cabbage, tomatoes, carrots and caisim) were compared with vegetables from conventional farmers. The PGPR starter analysis data obtained is made into a table, while the vegetable analysis data is made into plant growth charts and characteristic data tables. Furthermore, the results of the data are discussed descriptively by linking relevant literature and journals, to obtain research results.

III. Results and Discussion

Total Microbes

Analysis of total microbes on the results of the roots soaking of the *Mimosa Pudica* Linn plant, bamboo roots and lemongrass roots can be seen in Table 2. In Table 2 it can be seen that the total microbes in samples from the roots of the *Mimosa Pudica* Linn plant with soaking time of 96 hours were higher than the other samples. It is possibly because microbes with soaking time of 96 hours have a high activity in increasing the population, so that the increase in growth becomes ± 3 times compared to the soaking time for 72 and 120 hours. Table 2 shows that the total microbes in samples from bamboo roots seen at 72 hours soaked were higher than other samples. Similar to microbial growth in the results of *Mimosa Pudica* Linn roots soaking, in bamboo roots, 72 hours of soaked were higher, this is because microbial activity increases in increasing the population, as well as in samples from lemongrass roots there is also an increase in the 72 hours soaking time. This is also because the microbes that live in the roots of the *Mimosa Pudica* Linn, bamboo and lemongrass plants may have different types and their growth is also different in time, so from the results of the analysis obtained differences in total microbes for each soaking time.

The number of bacteria in Table 1, the results of soaking the roots of *Mimosa Pudica Linn*, bamboo roots and lemongrass roots were higher than the observation results from commercial PGPR products, probably because the results were still pure from root soaked and had not been added to the growing media where the bacterial isolates were soaked in the roots. The bacteria listed in the table are the total bacteria resulting from root immersion directly obtained from the soil where the plant grows, while commercial PGPR is a product that has been added to growth media to retain the bacteria in it.

Figure 1 shows the microbial population and various species from the characteristics of the colonies growing on the media. The number of microbial colonies in petri dishes in PM2, AB1, AS1 and PG treatments looks different. In PM2 the distribution of microbes is quite evenly distributed and in AB1 they are evenly distributed as seen in petri dishes. For AS1 the distribution of microbes looks very even and abundant so it is clearly legible, while for PG it looks like a little distribution of microbes seen in petri dishes. This is related to microbial growth in the treatment of soaking time and different plant roots used so that can be seen the different microbial growth, because the microbes that live in the rhizosphere roots come from diverse genera and are very dominant.

PGPR are a group of beneficial bacteria that actively colonize the rhizosphere and play an important role in increasing root growth which has an impact on plant growth,

yield and soil fertility. PGPR is very much found in the area around plant roots or the rhizosphere, especially the rhizosphere of thorny bamboo (*Bambusa blumeana*). The number of microorganisms contained in rhizosphere PGPR of bamboo shoots makes it difficult to know what types of bacteria are the most dominant and most active in influencing plant growth. The activity of soil microorganisms is influenced by various environmental and plant-related factors (species and age). In the last two decades, various types of PGPR have been recognized to play an important role in enhancing plant growth [10].

The bacteria that provide several benefits to plants are of two general types: those that form a symbiotic relationship and those that live freely in the soil but are often found near or even in plant roots. PGPR is useful for producing a variety of compounds including phytohormones, organic acids and siderophores, for fixing atmospheric nitrogen, for dissolving soil phosphate, for producing antibiotics that suppress destructive rhizobacteria or for demonstrating some other unknown mechanism [22]. Plant growth promoting rhizobacteria are soil bacteria that inhabit the root surface and are directly or indirectly involved in promoting plant growth and development through the production and secretion of various regulatory chemicals around the rhizosphere. Rhizobacteria that are beneficial to plants can reduce global dependence on harmful agricultural chemicals that destabilize agroecosystems. This review highlights the perception of the rhizosphere and plant growth promoting rhizobacteria under current perspectives [1]. Soil is generally a moist environment, rich in reduced carbon that supports broad soil microbial communities. Rhizomicrobiomes are very important to agriculture due to the rich diversity of root exudates and plant cell debris that attracts diverse and unique patterns of microbial colonization [4].

Beneficial and free-living rhizobacteria are commonly referred to as plant growth promoting rhizobacteria (PGPR). It is known that from 33 only 1 to 2% of bacteria promote plant growth in the rhizosphere. PGPR comes from various genera such as *Azospirillum, Azotobacter, Bacillus, Burkholderia, Corynebacterium, Pseudomonas, Rhizobium, Serratia* etc, wherea *Bacillus* and Pseudomonas spp. very dominant. The function of PGPR is to synthesize certain compounds for plants, facilitate the absorption of nutrients from the soil, and reduce or prevent plants from disease [6]. *Bacillus, Burkholderia, Erwinia, Paenibacillus, Pseudomonas, Rhizobium and Serratia* have the ability to dissolve phosphate through the release of organic acids [8].

In Table 1, it can be seen that the pH of the PGPR samples from the roots of *Mimosa Pudica Linn* ranged from 4.38 – 4.91. At bamboo roots the pH ranges from 6.5 – 6.7, while at lemongrass roots the pH ranged around 6.3. The PGPR solution was categorized in the range of 4.5 - 5 was acidic. For commercial PGPR (Central Java farmers' yields) it ranges from 3.0 to 3.2, which is categorized as very acidic. This is probably due to high respiration in the roots of *Mimosa Pudica Linn*, bamboo and lemongrass plant. According to Kurnia (2017) in [12], the classification of soil acidity is different from the classification of other soil chemical properties, because for soil acidity (pH) it is grouped into six categories, namely very acidic for soil pH lower than 4.5; acid for soil pH ranged from 4.5 to 5.5 ; slightly acidic for soil pH ranging from 5.6 to 6.5 ; neutral for soil pH ranging from 6.6 to 7.5 ; slightly alkaline for soil pH ranging from 7.6 to 8.5 ; alkaline for soil pH greater than 8.5. Factors that cause soil acidity namely rainwater, respiration of plant roots and fertilizers applied to the soil.

The total dissolved solids content of all treatments from the roots of *Mimosa Pudica* Linn, bamboo and lemongrass plants ranged 0.2%. This is probably because PGPR from the treatment results of the plant roots are still in the form of PGPR starter or water from the immersion of plant roots, there are no additional media yet. For commercial PGPR (Central Java farmers' result) which is a planting medium, where the media contains sugar as a raw material for microbial growth and development in it. Pantastico [7] stated that the increase in total dissolved solids was due to the breaking of long chains of carbohydrate compounds into soluble sugar compounds. The breakdown of more polysaccharides will result in a decrease in acidity, resulting in an increase in the ratio of total dissolved solids to acid [23].

Plant Height

The graph of vegetable plant growth can be seen in Figure 2. In the graph it can be seen that the growth of vegetables in the PGPR treatment and without treatment, there is a slight difference, not much increase or decrease. Only in tomatoes, it was seen that with PGPR treatment, plant height was slightly higher than without the use of PGPR. For Chinese cabbage and green mustard (caisim) the increase in plant height was almost the same with PGPR treatment and without PGPR. For carrots seen with PGPR treatment, the plant height was not better than the treatment without PGPR. The graph of plant height on Chinese cabbage, tomato, carrot and green mustard (caisim) during the harvest period can be seen in Figure 2.

In Figure 2, it can be seen that Chinese cabbage without PGPR treatment had a final plant height of 43 cm, while Chinese cabbage with PGPR treatment had a final plant height of 44 cm, slightly different. Plant height from the beginning of observation to the end after harvest for Chinese cabbage without and with PGPR treatment, slightly different. Research conducted by Triani et al.[3], the growth of Chinese cabbage (*Brassica rapa* L. Ssp. *pekinensis*) has increased every

observation. Not all Chinese cabbage with the PGPR treatment experienced high growth compared to Chinese cabbage produced by conventional farmers. Observations were made by measuring plant height once every 7 days, taken from samples of mustard plants for each treatment at random and carried out 3 measurements, then averaged as data on mustard plant height for each treatment.

Figure 2 shows that tomatoes without PGPR treatment had a final plant height of 162 cm, while tomatoes with PGPR treatment had a final plant height of 198 cm. There was an increase in plant height in tomatoes with PGPR treatment. In Figure 2, it can be seen that the carrot without PGPR treatment had a final plant height of 83 cm, while the carrot with PGPR treatment had a final plant height of 61 cm.. This is the same with Chinese mustard and caisim, the PGPR treatment is slightly lower than without PGPR treatment. In Figure 2 the final plant height on caisim without PGPR treatment and with PGPR treatment namely 34 and 29 cm.

PGPR enhances nutrient uptake for plants by altering plant hormone levels. There was a change in growth in the root shape by increasing root branching, root mass, root length, and the number of root hairs. This causes the absorption of more nutrients in the soil. The way of PGPR works in plant growth, namely increasing nitrogen fixation in legumes, promoting free-living nitrogen-fixing bacteria, increasing the supply of other nutrients, such as phosphorus, sulphur, iron and copper, producing plant hormones, increasing other beneficial bacteria or fungi, controlling fungal, bacterial and insect diseases [16]. PGPR directly affects plant metabolism by providing nutrients which normally scarce in the rhizosphere, such as nitrogen [9]. The genera member of *Anabaena, Azospirillum, Azotobacter, Bacillus, Clostridium, Klebsiella, Nostoc, Paenibacillus and Rhodobacter* are examples of free-living diazotrophic bacteria that provide nitrogen available to some plants [11]. Various species of *Azospirillum* promote plant growth, especially those with the C4 photosynthetic pathway, through atmospheric nitrogen fixation [5]. According to Khalid et al. [15], demonstrated that *B. subtilis and P. Fluorescens* had the ability to efficiently colonize roots and increase crop yields by increasing plant metabolism. *B. Subtilis and P. Fluorescens* were also reported to be able to produce indole-aceticacid (IAA), which functions as a plant growth stimulant. The intensity of TuMV disease on mustard leaves showed that the application of *P. fluorescens and B. subtilis* and their combination could reduce the intensity of TuMV disease on mustard leaves.

In a study by Tripatmasari et al.[17], on the use of organic fertilizer from cow manure containing several important bacteria in it, reported that the combination of soil, 20 x 103 kg cow manure ha^{-1} (P4), was effective in increasing the growth and yield of clover biomass which was significantly different from other treatments at 32 Days After Planting. This can be seen in the parameters of growth and yield of plant biomass such as stolon length (74.78 cm), number of leaves (160.44), leaf area (1379.28 cm2), root length (23.85 cm), and total fresh weight of 210.830 g. Therefore, it is recommended to use cow manure (organic fertilizer) which is good *Marsilea crenata* Presl. and open up opportunities for wider research. The results of Hariyadi's research [10] reported that the best eggplant yield component was obtained from the addition of guano swallow fertilizer at a dose of 15 t ha^{-1}, which resulted in fruit weight per plant of 541.14 g tan^{-1} and total fruit weight per ha of 12.88 t ha^{-1}. While in the chicken manure treatment, the most optimal dose was 10 t ha^{-1} which can produce eggplant fruit weight per plant of 531.56 g tan^{-1} and 12.66 t ha^{-1} total eggplant fruit weight per ha. Research by WANG et al. [18], biochar combined with PGPR had positive effects on soil microbial community structure, soil enzyme activity, and soil N transformation. The tomato yield in the treatment with biochar combined with PGPR (UBP) was 32.45%, 45.69%, and 10.44% higher than those in the N without PGPR or biochar (U); N and PGPR without biochar (UP); N and biochar without PGPR (UB) treatments, respectively. The nitrogen use efficiency (NUE) in the UBP treatment was 13.63%, 17.66%, and 10.77% higher than those in the U, UP, and UB treatments, respectively. This study showed that biochar combined with PGPR can improve soil microbial community structure and increase the NUE of tomato. Our results suggest that biochar combined with PGPR significantly enhanced the microbial community diversity and enzyme activity in tomato rhizosphere soil, improved the availability of soil N and crop N uptake, and increased dry matter accumulation.

Texture, Brightness Level and Total Dissolved Solids in Vegetables

Based on laboratory analysis obtained the texture value of Chinese cabbage was 18.05, 24.05 and 27.10 kg.msec^{-2} (Table 3). The results of this study indicate that the texture value of Chinese cabbage which given PGPR treatment has a hard and crunchy texture, while Chinese cabbage without PGPR treatment and the results of conventional farmers are rather hard (slightly soft) compared to PGPR treatment. The seeds soaking and the use of PGPR solution after planting in the beds, affect the texture of Chinese cabbage, so that it looks a little different in texture from Chinese cabbage without using PGPR and conventional farmers' results.

Table 3 shows that the caisim texture value was 29.28, 24.98 and 28,30 kg.m sec^{-2}. The results of this study indicate that the texture value of caisim given PGPR treatment has a slightly harder texture compared to caisim without PGPR treatment and the results of conventional farmers. For the value of

tomato texture is 20.40, 21.60 and 23.04 kg.m sec^{-2}. Tomatoes from PGPR treatment are slightly harder than tomatoes produced by conventional farmers. Carrot texture value was 32.73, 32.93 and 31.14 kg.m sec^{-2}. Carrots from the PGPR treatment were rather hard (slightly soft) compared to carrots from conventional farmers. The difference in the texture value of some of these vegetables is the effect of the seeds soaking treatment in PGPR solution and the application of PGPR spraying on the land after planting in the beds.

The hardness value is indicated by the level of freshness of the fruit and vegetables, but the hardness value is said to be good, not due to high or low values, but depending on the condition of the fruit and vegetables [7]. Plant tissue generally contains more than two-thirds of water, the relationship between these components and water is a determinant of texture differences. The state of turgidity, determined by osmotic forces, 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 protoplast membrane is semipermeable, which allows water to flow selectively to transfer dissolved materials [21].

Table 3 shows that the brightness level (L*) in Chinese cabbage was 45.56, 38.80 and 58.12. The results of this study indicate that the average brightness level (L*) of Chinese cabbage given PGPR treatment is less bright (tends to be a bit dim in color, but looks fresh) compared to Chinese cabbage produced by conventional farmers. Chinese cabbage with PGPR treatment does look less bright, the color tends to be light green, less dark, and more yellowish green. At caisim the brightness level (L*) was 33.95, 30.95 and 34.05. It can be seen that the PGPR treatment caisim has a lower brightness level than the caisim from conventional farmers. Caisim from PGPR treatment is green, less bright with fresh appearance.

Table 3 shows the brightness level (L*) of tomatoes was 33.45, 34.90 and 34.17. Tomatoes with PGPR treatment had the same brightness level as tomatoes produced by conventional farmers. This means that the use of PGPR applications during tomato cultivation is sufficient to produce products that are almost the same as the results of conventional farmers. While the brightness level (L*) of carrots was 37.04, 38.45 and 43.05. Carrots from the PGPR treatment were less bright than carrots from conventional farmers. From the brightness level of several vegetables observed, the most influential PGPR treatment namely on tomatoes with a brightness level that was almost the same as tomatoes produced by conventional farmers. So that to produce better yields later, it is likely that the use of PGPR should be repeated frequently during cultivation on land, in order for the resulting product to be better than the production result that uses chemical applications during cultivation.

Fruit and vegetable color pigments and precursors occur mostly in cellular plastic inclusions such as chloroplasts and chromoplasts. These pigments are classified into four main groups which include chlorophyll, carotenoids, lycopene and anthocyanins. Pigments belonging to this group are fat soluble and have colors ranging from yellow, orange 129 to red. Lycopene is red color in tomatoes, watermelon, and apricots. In food processing, this pigment is quite resistant to heat, changes in pH, and water washing because it is easily soluble [21].

Table 3 shows that the total dissolved solids in Chinese cabbage was 1.75, 2.90 dan 2.02 % brix. The results of this study indicate that the total dissolved solids in Chinese cabbage which given PGPR treatment is quite high compared to Chinese cabbage produced by conventional farmers. While the total dissolved solids in caisim is 5.8, 5.7 and 5.3 % brix, the results are almost the same in all treatments. For tomatoes, the total dissolved solids was 2.96, 3.12 and 3.62 % brix, the yield of total dissolved solids in PGPR treatment were almost the same as tomatoes from conventional farmers. Whereas for carrots, of total dissolved solids was 2.77, 3.02 dan 2.10 % brix. Carrots with PGPR treatment had a higher total dissolved solids value than carrots produced by conventional farmers. So for the PGPR treatment which produces total dissolved solids slightly above the yield of conventional farmers, namely Chinese cabbage and carrots. So that the PGPR treatment on vegetables, not all of the characteristics are higher than conventional farmers' yields, for that it must continue to be conducted the repetition of PGPR usage in cultivation so that the yields have physical characteristics that are almost the same or higher than conventional farmers' yields. Dissolved solids are closely related to carbohydrate content in vegetables, where carbohydrates in vegetables and fruits consist of monosaccharides, oligosaccharides and polysaccharides that are soluble in liquid vegetable cells [23].

IV. Conclusion

Based on the analysis of total microbes in samples from bamboo roots with soaking time of 72 hours, it was higher than other samples, namely 8.49 x 106 cfu ml^{-1}; pH in samples of PGPR from the roots of *Mimosa Pudica* Linn, bamboo, lemongrass, commercial PGPR (from Central Java farmers) ranged from 3.0 to 6.7; while the total dissolved solids content ranged from 0.2 to 2.6%. Based on the graph of plant growth in the PGPR treatment and with no treatment, there is a slight difference, not much increase or decrease. In tomatoes with PGPR treatment, plant growth was higher than without the use of PGPR, while for Chinese cabbage and caisim the growth was almost the same between PGPR treatment and without PGPR, meanwhile in carrots, it was seen that with PGPR

treatment, plant growth was lower than without PGPR. Based on the results of the analysis; Chinese cabbage, caisim, tomato and carrot with PGPR application, texture, brightness level, total dissolved solids were almost the same as conventional farmers' yields. The yields of Chinese cabbage, caisim, tomatoes and carrots from the application of PGPR were quite good compared to those without PGPR. The use of growth-promoting bacteria as fertilizers and biopesticides, from now on, its use continues to be increased during cultivation, so that the products produced are better and reduce the use of chemicals in cultivation technology in the future.

RECOMMENDATION

For further research, it is recommended to identify and isolate growth-promoting bacteria on plant roots obtained in the Bali area, as well as analyze the chemical and physical characteristics of vegetables from the yield of growth-promoting bacteria application. By conducting further research, it is hoped that the development of growth-promoting bacteria which is one of the innovations in environmentally friendly cultivation technology, as organic fertilizer or biopesticide, in the future will reduce the use of chemicals so that could produce products that are safe for consumption.

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Table 1. Research design

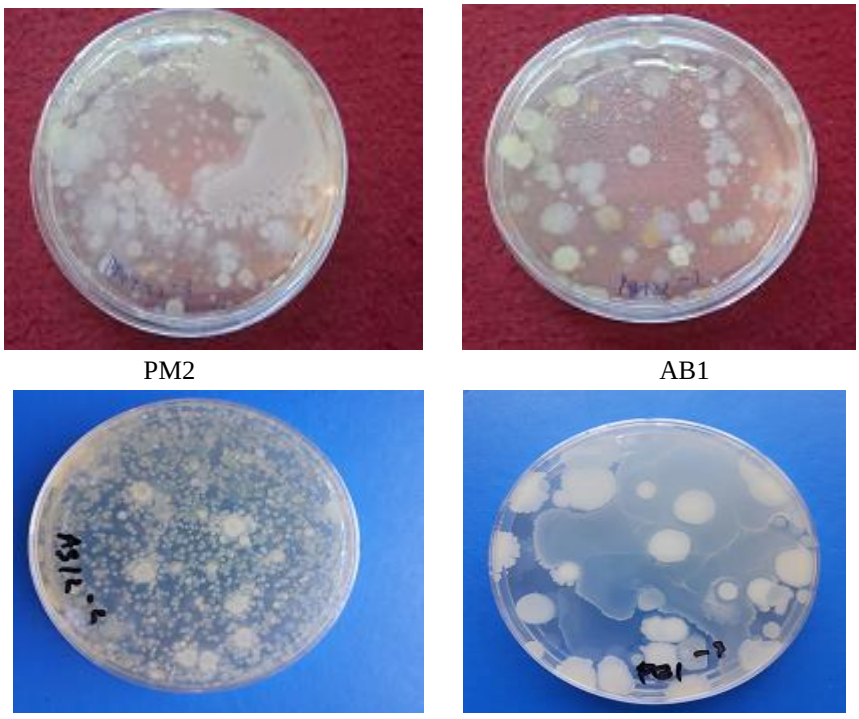
Plant roots	Soaking time (hours)		
	72	96	120
Mimosa pudica Linn (PM)	PM1	PM2	PM3
Bambusa maculata (AB)	AB1	AB2	AB3
Cymbopogon nardus L (AS)	AS1	AS2	AS3

Table 2. The analysis results of total microbes, pH and total dissolved solids

Code	**TPC (cfu ml$^{-1)}$**	**TDS (%)**	**pH**
PM 1	1.71 x 10^6	0.2	4.91
PM 2	4.15 x 10^6	0.2	4.61
PM 3	1.79 x 10^6	0.2	4.38
AB 1	8.49 x 10^6	0.2	6.5
AB 2	3.21 x 10^6	0.2	6.6
AB 3	1.40 x 10^6	0.2	6.7
AS 1	1.45 x 10^6	0.2	6.3
AS 2	0.60 x 10^6	0.2	6.3
AS 3	0.43 x 10^6	0.2	6.3
PG 1	0.19 x 10^6	2.6	3.2
PG 2	0.26 x 10^6	2.0	3.0

Source: data processed (2021).

Information: PM 1, 2, 3 (PGPR from *Mimosa pudica* Linn root with soaking time for 72, 96, 120 hours)
AB 1, 2, 3 (PGPR from bamboo roots with soaking time for 72, 96, 120 hours)
AS 1, 2, 3 (PGPR from lemongrass root with soaking time for 72, 96, 120 hours)
PG 1, 2 (PGPR produced by farmers in Central Java).



PM2 AB1

AS1 PG

Figure 1. Distribution of total microbes in petri dishes in PM2, AB1, AS1 and PG treatments

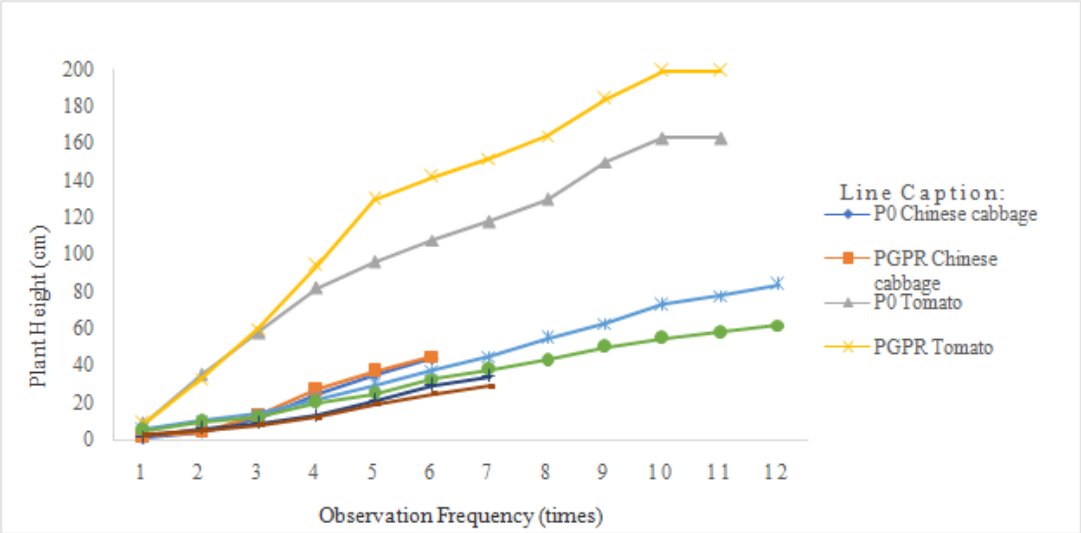


Figure 2. Growth of Chinese cabbage, tomato, carrot and caisim from planting to harvest

Information :

1) PGPR = the use of PGPR applications in the cultivation of Chinese cabbage, tomato, carrot and caisim
2) P0 = without the application of PGPR on the cultivation of Chinese cabbage, tomato, carrot and caisim

Table 3. Texture, brightness level and total solids in Chinese cabbage, green mustard, carrots and tomatoes from cultivation applications without PGPR, with PGPR and from conventional farmers

Commodity (treatment)	Texture (kg m sec^{-2})	Brightness Level (L*)	TDS (% brix)
1. Chinese cabbage			
Control (without PGPR)	18.05	45.56	1.75
With PGPR	24.05	38.80	2.90
Conventional farmers	27.10	58.12	2.02
2. Green mustard			
Control (without PGPR)	29.28	33.95	5.8
With PGPR (*Mimosa Pudica* Linn root)	24.98	30.95	5.7
Conventional farmers	28.30	34.05	5.3
3. Tomatoes			
Control (without PGPR)	20.40	33.45	2.96
With PGPR	21.60	34.90	3.12
Conventional farmers	23.04	34.17	3.62
4. Carrots			
Control (without PGPR)	32.73	37.04	2.77
With PGPR	32.93	38.45	3.02
Conventional farmers	31.14	43.05	2.10

Source: data processed (2021).