The growth and the production of potato plant supplemented by plant growth promoting rhizobacteria (PGPR)

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Abstract. Lack of nutrients is the major cause of potato production to decrease and potato plant not to grow well. The objective of the study was to analyze the effect of Plant Growth Promoting Rhizobacteria (PGPR) on the growth and the production of potato. The research was conducted in Kledung Village, Temanggung Regency (1,136 meter above the sea level), in 04 March – 04 June 2018. Randomized Block Design (RBD) with five treatments was applied with five treatments each of which was placed in a different plot and each plot was filled with 40 plant treatments. On the first plot, no treatment was given (P1); the second plot was given chemical fertilizer (P2), the third plot was supplemented with PGPR one dose (P3), the fourth plot was PGPR two dose (P4), and the last was the fifth plot treated with GA hormone (P5). The results showed that there was no significant difference in plant height. The highest potato production was in the group treated with PGPR 1 time was 277.1 g and the lowest was in the P2 group, which was 101.4 gr. PGPR directly increases the availability of nutrients for plants, and increases fertility. So, it, can be concluded that the administration of PGPR one dose is the best dose and increases potato production.

1. Introduction
As the use of long-term anorganik pesticides and fertilizers creates problem for soil fertility that leads to decrease both crop productivity [2] and human health [8], Plant Growth Promoting Rhizobacteria (PGPR) has been introduced to solve this problem. PGPR actively colonizes plant roots as it has three main roles for plants; biofertilizer, biostimulant, and bioprotectant [7].

Several laboratory-scale studies have shown that PGPR is capable of producing phytohormones, increasing symbiotic N2 fixation, and phosphorus absorption (Pérez-Montaño et al., 2014), producing siderophores, antibiotics, enzymes [1] and/or fungicide compounds [11]. Adding PGPR to wheat increases seed germination and Azotobacter inoculation [4]; while, the addition of Rhizobacteria Pseudomonas putida and Pseudomonas fluorescens on canola plants increases the elongation of roots and shoots. In addition, Azospirillin culture significantly affects growth, increases plant biomass, N tissue content, plant
height, leaf size, and root length. Thus, PGPR potentially function as biological fertilizer in an effort to increase the production of agriculture and estate crops.

However, the effect of PGPR on the growth and its correlation to tuber production, especially on potatoes, needs to be further evaluated. The objective of this study was to analyze the impact of PGPR on the growth and production of potato tubers grown on the field.

2. Method
The study was conducted in Kledung Village, Kledung District, Temanggung Regency of Central Java Province from March to June 2018. The altitude of the village is 1,138 meters above the sea level with an average temperature of around 18°C, and approximately 83% of air humidity. The research sample was potato seed (Solanum tuberosum L) of generation G-2 which was nationally certified by the Potato Seed Research Institute in Kledung Village, Temanggung.

A total of 200 potato plants were divided into 5 separated plots in one field (known as block A). Each plot was planted with 40 G-2 potato seeds, then covered by plastic mulch and leaved only a hole with a diameter of 10 cm to grow buds. The distance between two holes (as a stand) was 40 cm apart from another hole.

Each plot was loosened using manure, bokhasti, and Trichoderma. Watering plants and weeding were carried out every day. The administration of herbicides and rodenticides was carried out once a week during the planting period. The first plot is negative control (P1), a plot without being treated at all. The second plot is positive control (P2), a plot treated with chemical/synthetic fertilizer using manufacturer's dosage; while, the third plot (P3) and the fourth plots (P4) were treated with dose of 10 mg/L and 20 mg/L PGPR respectively. In the fifth plot, potato plants were treated in the form of synthetic hormones namely Giberellin (GA) with a recommended dosage.

Observation was started a week after potato seeds were planted, and was conducted once a week to measure plant height (cm), number of plants (stem), and number of leaves (strand). Meanwhile, the observation of the incubation period of leaf blight disease, the number of tubers, tuber diameter, and tuber weight (gr) were measured at the time after harvesting.

The data obtained were analyzed using Analysis of Variants (ANOVA) at a 5% confidence level. If the treatments were significant, the comparison test (Tukey test at 5%) was conducted. To determine the best dosage of PGPR treatment, the groups that have significant differences in the Tukey test results were retested using t test, then, conclusion were taken. Meanwhile, the relationship between the growth and the productivity was analyzed using a one-way correlation test.

3. Result
The application PGPR on potato growth significantly affected productivity (Table 1). The height of potato plants in the treatment group stands was significantly different from the stands of group P1. The result of the analysis showed that the most effective treatment applied in Kledung field was P2 or supplementing PGPR 1x (dose 15 mg/ml). The average height of plant given with PGPR one time was 27.36 cm; while, in that of P1 was only 19.27 cm and the administration of PGPR had no effect on the number of plants and leaves. The production of tubers increased in the PGPR group 1x, which was 173.27% compared to P1.

Table 1. ANOVA analysis of potato on the PGPR different treatment plant growth and crop production

|       | Total Plant | Total Leaves | Plant Height (cm) | Crop Production (gr) | Total Bulb |
|-------|-------------|--------------|-------------------|----------------------|------------|
| P1    | 2,00        | 22,40        | 19.27             | 101,4 a              | 5.4 a      |
| P2    | 3.40        | 28.70        | 27.07             | 243,1bc              | 8.9bc      |
Weekly observations showed that there was an increase in plant height in all treatment groups occurred even though it was not significant (Figure 1). Giving a dose of 10 mg/L PGPR (P3) increased the highest plant height compared to other treatments.

In addition to plant growth, the provision of PGPR was able to increase significantly the yield of potato production. In the potato plant group supplemented with 10 mg/L PGPR dosage, the average number of potato tubers per plant was 10.6 gr. This amount was not significantly different from the group given GA hormone, which was 10.2 gr, but higher than that of P1, which was 5.4 gr and P2, which was 8.9 gr.

|     | 3.10 | 28.80 | 27.36b* | 277.1c* | 10.9bc* |
|-----|------|-------|---------|---------|---------|
| P3  | 3.20 | 29.50 | 26.01b   | 230.3bc  | 7.7ac   |
| P4  | 3.60 | 26.00 | 26.38b   | 167.6ab  | 10.2bc* |
| P5  |      |       |          |         |         |

* indicates significantly different
* represents the best treatment based on t-test analysis
* indicates there is no different on data variant

Figure 1. Growth of the height of potato plants in each treatment group per day
4. Discussion
PGPR significantly increased potato production because the bacteria of *Rhizobium sp*, *Pseudomonas sp*, and *Bacillus sp* in PGPR were able to do symbiosis with potato roots plants [6]. The symbiosis increased mineral absorption resulted in the better growth of the root and later increased the plants growth. The symbiosis of PGPR bacteria with the root surface of the potato plants was able to initiate the formation of hair roots [3] and increased branching causing changes regulation of the root cortex cells. This interaction results in more hair root formation.

The increased number of the roots provided an opportunity for potato plants to increase water absorption as photosynthetic material in the form of sugar into the tuber [4]. In addition, PGPR might also play a role in increasing higher N accumulation. The Higher N incorporation turned out to increase the formation of proteins and enzymes for better physiological activity. The higher N also contributed to the formation of chlorophyll, which consequently increased photosynthesis of activity and sugar production [5].

Meanwhile, *Azospirillum* inoculation proved to increase growth in corn through N2-fixation and increased absorption of mineral nutrients P, K, Ca, and Mg. The increased plant growth due to PGPR inoculation in different fruit plants had also been reported by several researchers. Inoculated sorghum with PGPR improved leaf water potential under field conditions. Strong sink strength of the inoculated roots induced the increase of leaf source of photosynthesis of soybean.

Some PGPR bacteria such as *Azospirillum* (Sp7) potentially synthesized plant hormones that could replace indole acetic acid (IAA) to stimulate root growth in vegetables [9]. In addition, the secretion of auxin, gibberellins, and cytokines by bacteria contributed to the production of potato tubers [3]. In this study, the provision of PGPR was significant to tuber but not to growth. In the research group, the mechanism of increasing production without increasing plant growth was still inconclusive; therefore, further research is needed to clarify the effect of PGPR on the physiology and metabolism of potatoes. Measurement of parameters at the cellular and cellular levels may contribute to explain the mechanisms that work in PGPR interactions with potato plants.

5. Conclusion
The results show that PGPR significantly increases the weight of potato tubers with an average production of 277.1 g. However, the provision of PGPR in field conditions does not have a significant impact on increasing growth.

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