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Application of isolates of indigenous rhizobakteria: effect on the growth and yield of potato var. Cingkariang

R Suwinda^{1 (a)}, Warnita², and I Chaniago²

¹Postgraduate student of Department of Agronomy, Faculty of Agriculture, Andalas University, Padang 25163, Indonesia

²Department of Agrotechnology, Faculty of Agriculture, Andalas University, Padang 25163, Indonesia. ^(a)E-mail: rahmisuwinda@yahoo.com

Abstract. Potato var. Cingkariang is originated from Municipality Agam the Province of West Sumatra. This variety has low water content that is good for specific food process such as potato chips and crackers. However, the productivity is low compared to other varieties in Indonesia. Attempts should be made to increase the productivity of potato var. Cingkariang including the introduction of indigenous rhizobacteria to induce better growth and yield. The application of indigenous rhizobacteria is proven to be an easy and environmentally-friendly way to support sustainable agricultural system. This experiment was aimed at determining isolate of rhizobacteria suitable for increasing the growth and yield of potato var. Cingkariang. The experiment was carried out at the experimental station of BPTP Sukarami, Solok from July to November 2018. A completely randomised block design was assigned with three blocks and five treatments as follows: without rhizobacteria, isolate RZ.3.L2.1, isolate RZ.3.L2.2, isolate RZ.3.L2.5, and isolate RZ.1.L2.3. Data were analysed with analysis of variance and mean separation was tested according to HSD 5% level. Results indicated that the isolates did not affect the growth and yield of potato though isolate RZ.3.L2.5 was the best to promote the growth and yield of potato var. Cingkariang.

1. Introduction

Potato is an annual tubers crops and of important source of carbohydrate together with wheat, corn, and rice [1]. Esgar [2] stated that for its potential in carbohydrate, potato may be promoted as an alternative to rice for people in Indonesia. Potato var. Cingkariang is local to West Sumatra and well known for its lower moisture content compared to other varieties. This will benefit for longer shelf life than that of other varieties. However, this variety has low productivity with genetic potential up to 15 ton/ha. Yulimasni and Handani [3] reported lower productivity of potato var. Cingkariang as for 8.58 ton/ha and much lower that of var. Granola, Cipanas, Pink and Merbabu that yielded 19.16 ton/ha, 12.21 ton/ha, 13.2 ton/ha, and 41.58 ton/ha; respectively.

Low quality of potato seeds will result in low plant growth and yield [4] but good quality seeds will produce high yield both in quantity and quality [6]. Most potato farmers in West Sumatra used the 8th generation (G8) of potato seeds which directly lower the yield. Mulyono [5] used G3 of potato seeds and produced as much as 15 ton/ha yield with grade A and B and suitable for being released as Extension Seeds (ES).

Kusniwati [7] stated that plant growth promoting rhizobacteria (PGPR) may stimulate plant growth and development in a very environmentally-friendly way. Moreover, PGPR is easy to find and local-specific and live on/or surrounding the roots forming colony beneficial for the rhizosphere [8] and some act as bio-stimulant [9] to promote enzymatic reaction and some biochemical reactions. The



application of rhizobacteria may also induce the production of some phytohormone and resistance to pathogen [10]. Rhizobacteria may affect the host plants either directly or indirectly. The direct effect resulted from the ability in providing and mobilising or facilitating nutrient uptake by roots, N₂ fixation, and producing plant hormone such as IAA, gibberellins, cytokinins, ethylene, and others. Furthermore, rhizobacteria act indirectly through other biochemical mechanisms such as production of secondary metabolites useful for protection from pathogens, production of siderophores, etc. The study reported here was aimed at determining isolate of indigenous rhizobacteria suitable for increasing the growth and yield of potato var. Cingkariang.

2. Materials and Methods

2.1. Time and place of experiment

This study was conducted from July to November 2018 at the experimental station of BPTP Sukarami, Solok, the Province of West Sumatra with altitude about 850 m above sea level. Isolate of indigenous rhizobacteria were cultured and propagated at the Laboratory of Microbiology, Faculty of Agriculture, Andalas University Padang. INDONESIA.

2.2. Experimental Design

Potato var. Cingkariang was used as target species in this experiment and were grown according to common practices for potato growing. The experimental units were arranged in a completely randomized block design (CRBD) with three blocks and five treatments. Treatments were without rhizobacteria; isolate RZ.3.L2.1; isolate RZ.3.L2.2; isolate RZ.3.L2.5; and isolate RZ.1.L2.3. Data were analyzed with analysis of variance and mean separation using Honestly Significant Difference test (HSD) at 5% level.

2.2.1. Purification and Propagation of Rhizobacteria.

Rhizobacteria isolates were obtained from the collection of Prof. Warnita, at the Laboratory of Microbiology, Faculty of Agriculture, Andalas University. Isolates of rhizobacteria that has been kept was taken out of the microtubes prior to re-culture on NA medium in Petri dishes and were incubated 2x24 hours at ambient temperature. The cultured rhizobacteria was then suspended with sterile distilled water and homogenized by vortex. The population density is determined by comparing the turbidity of a bacterial suspension with a solution of McFarland scale of 8 (density of the bacterial population is estimated 108 cell / ml) [11].

The propagation of rhizobacteria was carried out in two stages: Pre-culture and Main-culture. For pre-culture, 1 colony of rhizobacteria was added to 25 ml of NB medium in a 50-mL-culture bottle and was incubated in a horizontal rotary shaker for 24 hours. Subsequently 1 ml of preculture was transferred into 150 ml NB medium. Both pre- and main-culture were kept for 48 hours in a horizontal rotary shaker with a speed of 150 rpm. The suspension of rhizobacteria from the main culture was then diluted and the population density is determined by adjusting the turbidity equal to McFarland scale solution of 8 (density of the bacterial population is estimated 108 cell / ml [11]).

3. Results and Discussions

3.1. Plant height

Different isolates of rhizobacteria did not affect plant height of potato. Isolates of RZ.3.L2.2 resulted in the lowest plant height of 34.43 cm that is slightly lower than that of control plant without the application of isolate of rhizobacteria at 8 weeks after planting (WAP). Data of plant height is presented in Table 1.

Table 1. Plant height of potato plant cv. Cingkariang at 8 WAP in response to different isolates of rhizobacteria.

| Treatment group | Plant height (cm) | Effectiveness (%) |
|-----------------------|-------------------|-------------------|
| without Rhizobacteria | 40.30 | 0 |
| Isolate RZ.3.L2.2 | 34.43 | -14.56 |
| Isolate RZ.3.L2.1 | 41.94 | 4.06 |
| Isolate RZ.3.L2.5 | 40.03 | -0.67 |
| Isolate RZ.1.L2.3 | 42.29 | 4.94 |

Non significant effect of rhizobacteria in promoting plant height of potato in line with finding reported by [12] who introduced different isolates of rhizobacteria collected from potato growing area at Municipality Agam. However, [13] reported different finding where bacterial isolates promoted the growth of potato as indicated by higher plant height compared to that of control group without the administration of isolates. Different response may indicate host specificity of the indigenous rhizobacteria. Kloepper [14] explained that rhizobacteria may indirectly affect plant growth to suppress the activity of pathogens through their ability to produce metabolite compounds such as antibiotic and siderophores.

3.2. Leaf Area (cm^2)

Potato leaf area varied in response to different isolate of rhizobacteria (Table 2) although the effect was not significant. The lowest leaf area was observed at the treatment of Isolate RZ.3.L2.2 that reduced leaf area of 29.61% compared to control treatment group without rhizobacteria.

Table 2. Leaf area of potato plant cv. Cingkariang at 8 WAP in response to different isolates of rhizobacteria.

| Treatment | Leaf area (cm^2) | Effectiveness (%) |
|-----------------------|----------------------|-------------------|
| Without Rhizobacteria | 444.67 | 0 |
| Isolate RZ.3.L2.2 | 313.00 | -29.61 |
| Isolate RZ.3.L2.1 | 563.67 | 26.76 |
| Isolate RZ.3.L2.5 | 679.67 | 52.70 |
| Isolate RZ.1.L2.3 | 469.00 | 5.47 |

The growth of potato leaf was not affected by the introduction of rhizobacteria. Some isolates except for Isolate RZ.3.L2.2 slightly promoted leaf growth. According to [15] some types of rhizobacteria may facilitate and mobilize nutrient uptake in the soil. They are rhizobium with the ability to fix free nitrogen, phosphate-binding bacteria help plants to adsorb mineral phosphate, and other bacteria that facilitate in providing macro- and micro-elements for plant growth.

Figure 1 demonstrates that leaf area gradually increased from week 4 to week 7. However, the growth of potato leaf area with isolates RZ.3.L2.5 and control treatment increased sharply towards week 8. Some factors affecting leaf growth including temperature, hormone activity, and sun light [16]. Temperature may stimulate the activity of plant hormones and cell division which increase leaf size to reach its maximum. Photosynthesis goes well with optimum sun light and water thus photosynthate is translocated throughout the plants to support growth and development.

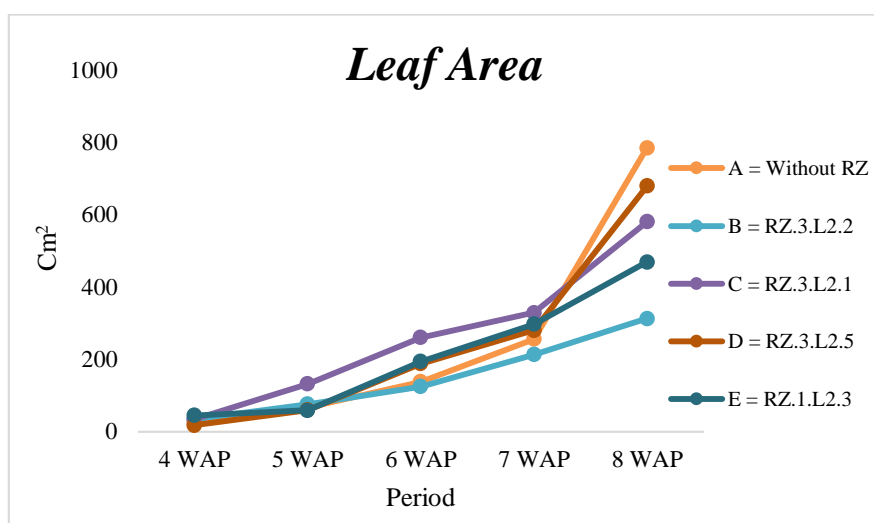


Figure 1. Growth of potato var. Cingkariang leaf area (cm²) resulted from indigenous rhizobacteria isolates applications

3.3. Relative growth rate

Relative growth rate of potato varied in response to rhizobacterial isolates. The introduction of isolate RZ.3.L2.5 increased relative growth rate 46.44% higher than that of control treatment group (Table 3) at 7-8 week of sampling time. In contrast, at the same sampling time, other potato plants responded differently. Reduction in relative growth rate was observed from the other groups of isolate treatments. This showed physiological incompatibility between potato var. Cingkariang and some isolates of rhizobacteria to support growth rate.

Table 3. The relative growth rate of the potato var. Cingkariang in the period 7-8 MST in response to different isolates of indigenous rhizobacteria

| Treatment | Relative Growth Rate (mg / cm ² / week) | Effectiveness (%) |
|-----------------------|---|-------------------|
| without Rhizobacteria | 35.70 | 0 |
| Isolate RZ.3.L2.2 | 9.87 | -72.35 |
| Isolate RZ.3.L2.1 | 7.64 | -78.60 |
| Isolate RZ.3.L2.5 | 52.28 | 46.44 |
| Isolate RZ.1.L2.3 | 5.84 | -83.64 |

Non significant effect of rhizobacteria on the growth of potato is in line with relatively similar growth of leaf area. As an important site for photosynthesis, leaves capture the energy from sun light to form glucose from water and carbon dioxide. Leaf area and leaf area index often be used as main indicator to learn the effectiveness of photosynthesis. High leaf area is not necessarily reflects efficient photosynthesis. High leaf area with low leaf area index may result in lower photosynthetic rate due to low ability in capturing maximum sun light. Leaves sitting under the shade of other leaves cannot photosynthesis effectively and to some extent these leaves become sink instead of source of the photosynthate. This is supported by [17] who stated that the growth rate of the plant will increase with increasing plant leaf area index.

Plant growth is indicated by an increase in size and biomass that is resulted from the total plant dry weight per unit time. Total plant biomass may be considered as a comprehensive unit to form new part of a plant. Relative growth rate is often used to measure the productivity of initial biomass in plant. Moreover, it can be used to determine plant growth at certain period of time specially at the period of early rapid growth.

Figure 2 shows a slight decrease in growth of potato in response to rhizobacteria during the period of week 6-7 after planting then increased towards week 8. Potato growth rate in the isolate RZ.3.L2.5 treatment group increased sharply from week 7 to week 8 of time after planting. According to [18] the relative growth rate has a dual function: to measure plant ability to produce dry matter per leaf unit area for certain period of time and to recover from slow growth rate due to environmental stress.

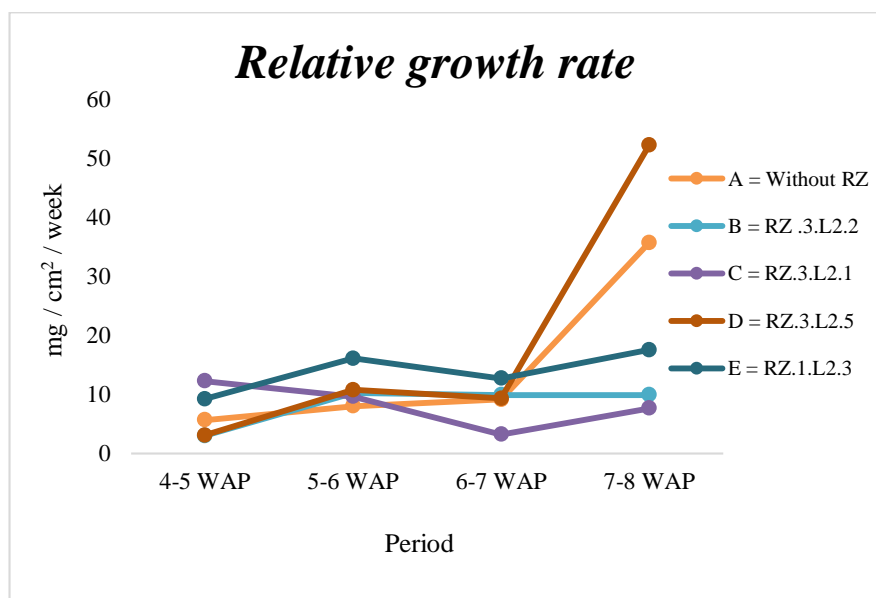


Figure 2. Relative growth rate (mg / cm² / week) of potato var. Cingkariang in response to indigenous rhizobacteria

3.4. Net assimilation rate

Different isolates of indigenous rhizobacteria resulted in different net assimilation rate of potato plants at week 7-8 after planting although the difference was not significant. Isolate RZ.3.L2.5 resulted in the highest assimilation rate that is 21.87% more than that of control treatment group (Table 4). Low net assimilation rate in other isolates of rhizobacteria treatment groups is in accordance with low leaf area and dry matter (Table 2 and 3). Low leaf area indicates low capacity to capture the energy from sunlight used for photosynthesis. Leaves are plant tissue having stomata where CO₂ mainly diffuse to plant prior to photosynthesis.

Table 4. Net assimilation rate of potato var. Cingkariang potato in the period 7-8 WAP at different isolates of rhizobacteria

| Treatment | The rate of assimilation Net (mg / cm ² / week) | Effectiveness (%) |
|-----------------------|--|-------------------|
| without rhizobacteria | 3.93 | 0 |
| Isolate RZ.3.L2.2 | 1.59 | -59.54 |
| Isolate RZ.3.L2.1 | 0.81 | -79.38 |
| Isolate RZ.3.L2.5 | 4.79 | 21.89 |
| Isolate RZ.1.L2.3 | 0.63 | -83.96 |

The production of dry matter in plants is resulted from the amount and position of leaves on the plants. The larger the leaf area the higher the photosynthesis [19]. Figure 3 demonstrates the fluctuation of net assimilation rate of potato plants. Various level of increase in net assimilation rate support the growth of the plants together with enough nutrient uptake and other supporting key elements [12].

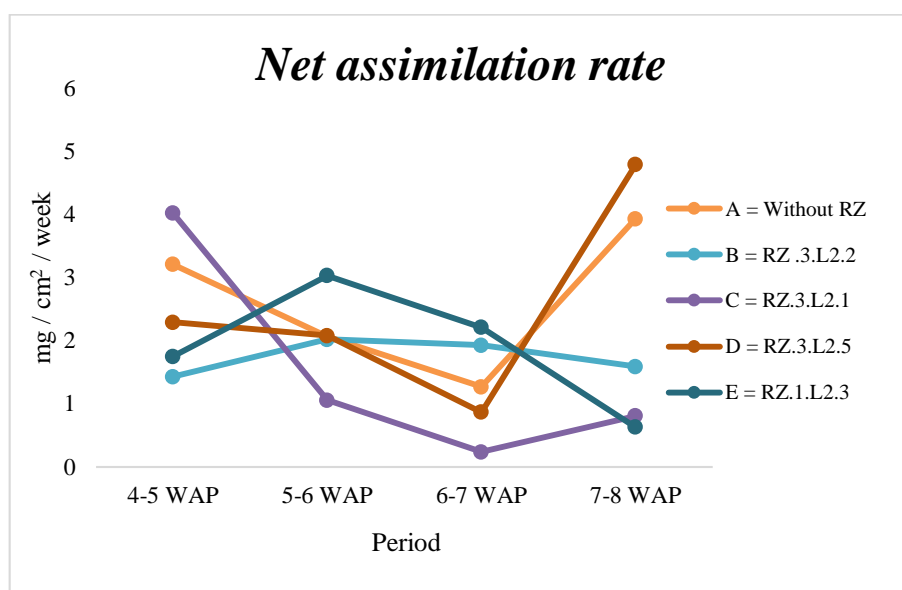


Figure 3. Net assimilation rate (mg / cm² / week) of potato var. Cingkariang in response to isolates of indigenous rhizobacteria

3.5. The number and weight of tubers per plant.

The number and weight of potato tuber per plant was not affected by the introduction of different isolates of rhizobacteria. Although the difference is not significant, potato from the treatment group of isolates RZ.1.L2.3 produced the highest number of tubers with total weight of 100.82 g. (Table 5). However, the effectiveness of rhizobacterial introduction was highest (48.04% higher than that of control treatment group) in the isolate RZ.3.L2.5 treatment group.

Table 5. Number and weight of potato tubers per plant at 8 WAP in response to isolates of indigenous rhizobacteria

| Treatment | Number of tubers per plant (tuber) | Effectiveness (%) | The weight of tubers per plant (g) | Effectiveness (%) |
|-----------------------|------------------------------------|-------------------|------------------------------------|-------------------|
| without rhizobacteria | 3.78 | 0 | 79.69 | 0 |
| Isolate RZ.3.L2.2 | 4.56 | 20.63 | 78.30 | -1.74 |
| Isolate RZ.3.L2.1 | 4.11 | 8.73 | 84.97 | 6.63 |
| Isolate RZ.3.L2.5 | 4.22 | 11.64 | 115.92 | 48.04 |
| Isolate RZ.1.L2.3 | 4.78 | 26.45 | 100.82 | 26.51 |

Rhizobacteria as plant growth promoting agents may indirectly increase plant growth and development through various mechanisms such as increasing resistance to pathogens, mobilising and increasing nutrient uptake, and the production of phytohormones. In addition, rhizobacteria may induce the production of siderophores that are able to adsorb Fe and make it unavailable to phytopathogen. They may produce secondary metabolite such as antibiotic that function as antifungal; other compounds act as lysing-enzyme. Another mechanism that is driven by rhizobacteria is suppressing the growth of pathogenic fungi, and the potential to induce systemic resistance [20].

The mechanism of action of plant growth promoting rhizobacteria may be indicated by the activity of the rhizobacteria to support host plant growth through the production of siderophores that may act as chelating agents for Fe. Antibiotic and HCN are produced by some rhizobacteria and have been related to their function to reduce plant pathogens. Yet, some strains of rhizobacteria have proven to be potential to suppress the effects of pathogen in plants [21].

4. Conclusion

There is no significant effect of some isolates of indigenous rhizobacteria on the growth and yield of potato var. Cingkariang. However, isolate RZ.3.L2.5 demonstrated its ability to induce the growth and development of the potato tested.

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