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The Effectivity of Indigenous Rhizobacteria and Manure on the Yield of Red Potato (Solanum tuberosum L.)

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Abstract

Potatoes are one of the world's five food crops in the form of tubers and have many benefits. One type of potato developed in Indonesia is red potatoes because they have a high nutritional content and are more resistant to plant pest organisms. An experiment was conducted in Nagari Selayo Tanang Bukit Sileh, Lembang Jaya, Solok, West Sumatra, Indonesia from May to August 2017. The effect of three indigenous rizobacteria isolate (A2.1b2, A3.1a5 and B1.2a2) and three types of manure, both individually and in combination, on the yield of red potatoes was studied. A two way factorial experiment with a completely randomized design and three replicates was used. Cattle, chicken and quail manure were applied at a dose of 30 tons per hectare. Data were analyzed by analysis of variance and comparison of mean using the Honestly Significant Difference test at the 5% level. There was no interaction between rizobacterial isolates and manure on the yield of red potatoes. All isolates gave similar results with respect to plant yields, but isolates A2.1b2 give the best yields. Chicken manure increased fresh weight of tubers by 11.73 ton per hectare compared to quail and cattle manure.

Keywords: crossing, effluent, fowl, nutrient, PGPR

1. Introduction

Potatoes (*Solanum tuberosum* L.), one of the world's important tuber commodities that have various advantages. Potatoes have long been cultivated as a major food source that has a wide variety of properties. Cultivated potatoes are usually a type of white and yellow potato that is later susceptible to plant-disrupting organisms. The recent use of potatoes not only as a source of nutritious food, but also as a raw material for the food industry, cosmetics and medicine. It has been the focus of substantial studies due to its use both as a staple food crop and as a source of potentially significant compound. Potatoes have been found to be a highly nutritious vegetable. Starch is the main component of potatoes, but they also contain small amounts of protein and alkaline salts. They are also rich in vitamin c, b-complex vitamins, and beneficial levels of the minerals iron, calcium, manganese, magnesium and phosphorus. Many of the nutrients in potatoes are found in their skin, so more benefits have been attributed to eating them whole as opposed to peeled (Umadevi, et al., 2013).

One type of potato developed in Indonesia is red potatoes. Red potatoes have a high nutritional value and are important in the fresh market (Pardo, et al., 2000). Red potatoes have a relatively high content of fiber, vitamins, iron, and protein. Red potatoes also contain anthocyanin compounds as antioxidants in the body. It has various advantages, but the production of red potatoes is still limited in some areas, such as the Dieng Mountains (Central Java), Bengkulu and Solok Regency (West Sumatra) with successive productions: 30 tons per hectare, 40-5-tons per hectare and 15 tons per hectare (Ferizal, 2013). Red potatoes rank second in vegetable commodities with a land area of 1,462 hectares (Department of Agriculture, Fisheries and Plantations of Solok Regency, 2013). Therefore, it is necessary to strive to increase the productivity of red potatoes, among others, by using rizobakteria which acts as a plant growth booster or PGPR (plant growth promoting rhizobacteria) and manure to provide nutrients needed by plants during the growth and development phase.

The results of Maunuksela research (2004), some rhizobacteria groups are as biological agents that have the ability to spur plant growth. This rhizobacteria comes from the bacillus spp., Pseudomonas fluorescens and Serratia spp., groups that have been reported to be able to produce growing hormones such as acetic indol acid (IAA). Kloepper, et al. (2004); Saharan and Nehra (2011) stated that PGPR rizobacteria are very aggressive in colonizing the rootage which can act as biofertilizers, biopesticides and bioprotectants. Organic fertilizers will release plant nutrients completely (N, P, K, Ca, Mg, S and micro nutrients) with an indeterminate and relatively small amount during the mineralization process, in addition to the addition of organic fertilizers can improve the soil structure so that the soil becomes light to treat and easily penetrated roots, can increase the water holding capacity so that the ability of the soil to provide water becomes more (Roesmarkam and Yowono, 2002). This study aims to find out the effectiveness of rizobakteria indigenus and some types of manure against red potato yields as well as to find out the types of rizobakteria isolates and manure that effectively support the results of red potato plants.

2. Materials and Methods

The research was conducted from May to August 2017 in Lembang Jaya Districk, Solok Regency, West Sumatra province with Lat: -0º58'31", Lon: 100º43'31", 219º at an altitude of 1383.5 m in andosol soil type with pH 6. Rainfall during the research was moderate (177 mm per month) with an average temperature of 18 (min 12.17, max 26.1). The variety of red potato tuber was PING 06 were obtained from Balai Penelitian Tanaman Sayuran (Balitsa). The study used 2 factors design in Completely Randomized Design (CRD). The first factor was kind of indigenous rhizobacteria isolates (without isolate, A2.1b2, A3.1a5 and B1.2a1). The isolates were the collection and characterization result of Department of Agronomy, Faculty of Agriculture, Andalas University. The second factor was type of manure with 30 tons dose per hectare (chicken manure, quail manure and cattle manure). The manure was given at 1 weeks before planting; rhizobacteria application with submerge with rhizobacteria suspension for 15 minutes and drying before planting. The variable observed were shoot root ratio, number of tuber per plot, tuber fresh weight per plot and tuber classification. Data was analyzed by F test in 5% and followed by Honestly Significant Different/HSD.

3. Results and Discussion

A. Shoot Root Ratio

The results of the analysis of data with the F test at 5% showed that there was no interaction between the two treatments to the shoot root ratio and each treatment of the type of rizobacteria isolate and manure has no effect on the shoot root ratio. The average shoot root ratio of red potato at 9 WAP can be seen in Table 1.

The results of the data analysis with the F 5% test showed that there was no interaction between the two treatments to the shoot root ratio, as well as each type of rizobacteria isolate and manure treatment had no effect on the shoot root ratio. The average shoot root ratio of red potato plants at 9 WAP can be seen in Table 1. The shoot root ratio of red potatoes to the rizobacteria isolates and manure applications gives almost the same shoot root ratio value. The average shoot root ratio ranges from 3.21 to 4.43. The shoot root ratio is an important factor in plant growth that reflects the ability in nutrient absorption as well as metabolic processes that occur in plants.

Table 1. Shoot Root Ratio of red potato at 9 WAP with the application of indigenous rhizobacteria and manure

Indigenous rhizobacteria	Manure (30 tons per hectare)			Average
	Cattle	Chicken	Quail	
Without isolate	4.45	5.22	3.21	4.30
A2.1b2	3.74	3.41	5.19	4.11
A3.1a5	2.71	3.98	2.93	3.21
B1.2a2	3.21	5.11	3.46	3.93
Average	3.53	4.43	3.70	

The shoot root ratio value indicates the root's ability to absorb water and nutrients that are translocated to the plant header to support plant growth and development. An increase in root weight followed by an increase in header weight leads to an insignificant shoot root ratio (Efendi, 2014). In addition, the presence of water and the ability of roots to absorb and translocate asimilat also determines the growth and development of plants. The magnitude of the shoot root ratio is related to the ability of water absorbion by plants that increases as one of the mechanisms to maintain a high water potential at a time when plants are experiencing water shortages (Palupi and Dedywiryanto, 2008).

Solichatun, et al. (2005) stated that the shoot root ratio can be a clue to growth related to the availability of water and nutrients, especially nitrogen in the soil. Lack of water that inhibits the growth of shoot and roots, has a relatively greater influence on the growth of the header. Title growth is encouraged when there is a lot of nitrogen (N) and water. While root growth is more encouraged when nitrogen and water factors are limited. Differences in the response of plant parts in absorbing available nutrients cause growth differences between the shoot and root parts of the plant. This will affect the biomass of the plant. The development and morphogenesis of plants is the result of division, enlargement and differentiation of cells. This growth process leads to the accumulation of dry weight (Gardner, et al., 1991).

The shoot root ratio is used to determine the ability of plants to maintain functional balance in a stable environment. The shoot root ratio is plastic, its value will increase under conditions of availability of water, nitrogen, oxygen, and low temperature. This happens because in plants that experience inflammation will allocate most of the results of photosynthesis to storage organs. The allometry of header growth and root growth (commonly expressed as the shoot root ratio) have physiological importance. The shoot root ratio can describe one type of tolerance to drought. The shoot root ratio is controlled by both genetic and environmental factors (Gardner, et al., 1991). Growth is essentially a balance between the acquisition of carbon in photosynthesis and its production in respiration. In conditions of silence (e.g. drought), the balance will undergo changes that can result in disruptions in growth (Solichatun, et al., 2005)

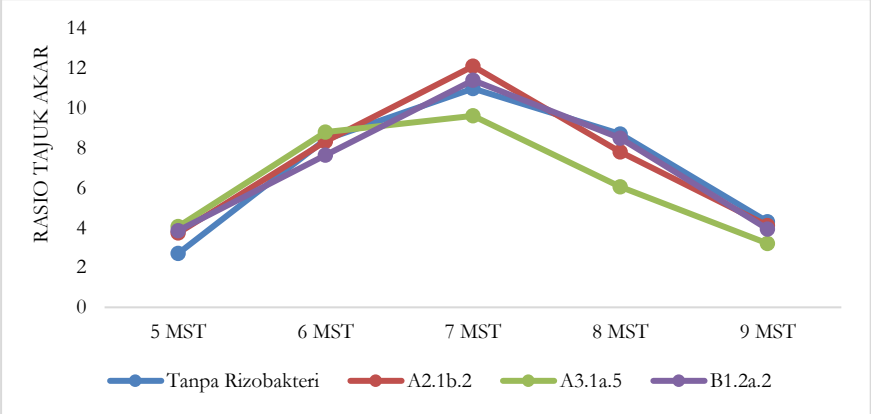

Fig 1. The development of shoot root ratio from 5 WAP to 9 WAP according indigenous rhizobacteria

Figure 1 shows that the shoot root ratio of 5 WAP in rizobacteriateri isolate treatment A3.1a5 is greater than other treatments and increases to the 7 WAP which indicates the optimal shoot root ratio value in

rizobacteria isolate treatment A2.1b2. At the 8 WAP the shoot root ratio indicates a decrease. The shoot root ratio is related to the rate of net assimilation and the rate of growth of the plant. The high rate of photosynthesis is able to increase plant biomass. The high biomass of plants will affect the growth and development of roots. This leads to a high shoot root ratio in plants. The presence of microbes in plant rooting also helps to promote root growth and development. This will increase the growth and development of the plant, so it will increase the value of the shoot root ratio. Hadda (2010) explained that the application of rizobacteria isolates can increase root development which has an impact on the growth of the header. Egamberdiyeva (2007) states that seed inoculation with rizobacteria Pseudomonas spp. and Bacillus spp. can increase the length of the roots and the height of wheat and ercis beans.

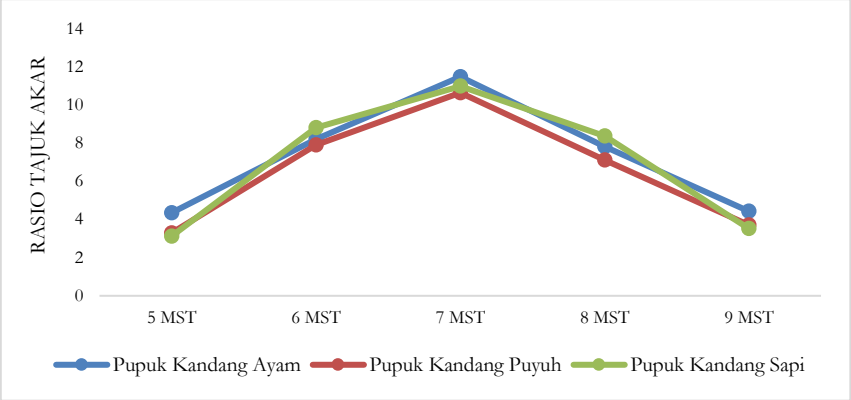

Fig 2. The development of shoot root ratio from 5 WAP to 9 WAP according manure

Figure 2 shows that the shoot root ratio increased of 7 WAP and decreased in the following week. Chicken manure treatment has a greater shoot root ratio value of 9 WAP compared to quail and cattle manure treatment. Observation of the shoot root ratio is intended to see a comparison of the growth distribution between the header part and the root part of the plant. A high shoot root ratio value indicates that the growth of the header is greater than the root growth. Conversely, a low shoot root ratio value indicates that the growth of the header is lower than the root growth. Triastuti (2016), with the provision of organic fertilizers into the soil increases wet weight and dry weight, and automatically increase the shoot root ratio in plants. PGPR applications in plants can modulate root growth and development by producing phytohormones, secondary metabolites and enzymes. The most common thing is the reduced growth of primary roots and the increasing length and number of lateral roots and hair roots (Vacheron, et al., 2013).

B. Number of tuber per plot , Tuber fresh weight per plot and Tuber classification

The results of the analysis of data on the F 5% test showed that at the number of tubers per plot only affected by the treatment of manure, in fresh weight tubers per plot were affected single-handedly by each treatment and no interaction between treatment and each in the tuber classification age 14 WAP can be seen in Table 2.

Table 2. Number of tuber per plot , Tuber fresh weight per plot and Tuber classification of red potato at 14 WAP with the application of indigenous rhizobacteria and manure

Treatment	Number of tuber per plot	Tuber fresh weight per plot	Tuber classification
	---pieces---	---kg---	---pieces---
Indigenous rhizobacteria			
Without isolate	88.00	1.15 a	2.98
A2.1b2	94.22	1.39 b	3.27
A3.1a5	90.77	1.21 b	2.98
B1.2a2	97.33	1.37 b	3.64
Manure (30 tons per hectare)			

Cattle	83.00 A	1.23 A	3.27
Chicken	99.75 B	1.40 B	3.24
Quail	95.00 B	1.22 A	3.10

The results of the analysis of data with the F test at a real level of 5% showed that the number of tubers per plot of red potatoes was only influenced by manure treatment. There is no interaction between rizobacteria isolate and manure treatment. The average number of tubers per plot 14 WAP in Table 2. The number of tubers per plot the treatment of the lowest type of manure in cattle to quail manure is 83.00 to 95.00 pieces and chicken manure 99.75 pieces which produces the highest number of fruits. The number of tubers per plot is an accumulation of the number of soil tubers contained in one map. This causes the higher the number of tubers per plant, the higher the number of tubers per plot. The number of tubers formed is affected by the ability of rizobacteria isolates and manure in accumulating nutrients available for plant growth including in photosynthesis and respiration that will produce asimilat. After the plant enters the development phase, the translocation of the photosynthintate is more focused on the filling of tubers. The number of tubers formed is affected by the ability of stolons to produce tubers. Sumadi (2016), the ability of stolons to form tubers has an impact on the number of tubers produced.

The tuber fresh weight per plot on red potato depends on rizobacteria isolates and the type of manure used in this study. In rizobakteri isolates, the tuber fresh weight per plot tends to be lower than the treatment without rizobakteri isolates to rizobacteriai A3,1a5 isolates which are 1.15 kilograms and 1.21 kilograms in rizobakteri isolate b1.2a2 which is 1.37 kilograms and higher in rizobakteri isolate A2.1b2 which is 1.39 kilograms. Quail manure treatment gives a lower tuber fresh weight per plot of 1.22 kilograms to the type of cattle manure which is 1.23 kilograms and higher in the type of chicken manure which is 1.40 kilograms. Rizobakteri isolate treatment gives better results than without rizobakteri isolate. The ability of rizobacteria in increasing plant growth and development will increase crop yields. In this study it was seen that chicken manure gave the best results on the fresh weight of tubers per map of potato plants. This is due to the high nutrient content in chicken manure can increase plant growth and yield. The production of a plant is the resultant of the process of photosynthesis, decreased aimilat due to respiration, and translocation of dry matter to plant yields (Jumin, 2005).

The presence of rizobacteria applied was able to increase the nutrient uptake provided by chicken coop fertilizer so that crop yields increased. Surtiningsih, et al. (2014) provides results that rizobacteria can increase the growth and productivity of food crops. The response of rizobacteria to each type of plant is different. Joo, et al. (2005), Park, et al. (2009), Bhattacharyya and Jha (2012) which stated that rizobacteria's ability as a plant growth driver is shown by the ability to provide and mobilize the absorption of various nutrients in the soil as well as synthesize and change the concentration of various phytohormones driving plant growth. Sufficient nutrients available will be utilized by plants for development through the process of photosynthesis. Rizobakteri increases the uptake of nutrients thereby increasing the rate of photosynthesis and photosynthetic produced. The results of Murphy's research, et al. (2000) reported that the application of a number of rizobacteria from the Bacillus sp group. able to increase the yield of tomato plants.

The results showed that there was no interaction between the two treatments to the classification of tubers of size ≤ 30 grams, as well as each rizobacteria isolate treatment and the type of manure did not affect the tubers of the size of ≤ 30 grams. The average classification of tubers of ≤ size is 30 grams, in red potato plants age 14 MST can be seen in Table 15. The average bulb size of ≤ 30 grams ranges from 2.98 to 3.67 pieces. In kind of manure, tubers of ≤ size 30 grams lower than the type of quail, chicken and cattle: 1.42 to 1.78 and 1.96 pieces. Size of number of tubers produced is the accumulation of plant photosynthat during its life. But the weight of the resulting tubers does not always have an optimal size. Sumadi, et al. (2016) a larger number of tubers will not necessarily result in a higher weight of tubers per plant as well. A larger number of tubers tends to produce bulbs of smaller size. The number and size of the resulting tubers are in line with the size of the seedling tubers, the number of stems formed and the use of planting distance. The use of large tuber seedlings and narrow planting distances tends to produce small tubers and vice versa (Utomo, et al., 2013). Permadi (2009), the volume of the growing environment smaller will be produced a greater number of tubers but with a smaller size of tubers. In general, large tubers will produce a large number of stems as well. A large number of stems will produce a large number of tubers but with a smaller size.

4. Conclusions

The effectiveness of rizobacteria indigenus and manure on red potatoes can increase the tuber fresh

weight per plot. Application of manure is able to increase the number of tubers per plot.

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