

The Growth and Yield of Potato (*Solanum tuberosum* L.) with Application of Indigenous Rhizobacteria and Coumarin

TRI ISTIFANI OKTAVIANA¹, ZULFADLY SYARIF², YULMIRA YANTI³ and WARNITA WARNITA^{*2}

¹Postgraduate Program, Department of Agronomy, Faculty of Agriculture, Andalas University Padang 25163, West Sumatra, Indonesia.

²Department of Agronomy, Faculty of Agriculture, Andalas University. Padang 25163, West Sumatra, Indonesia.

³Department of Plant Protection, Faculty of Agriculture, Andalas University. Limau Manih, Padang 25163, West Sumatra, Indonesia.

*Corresponding author email id: warnita@agr.unand.ac.id

Abstract – This research was conducted in Nagari Selayo Tanang Hill Sileh, Lembang Jaya, Solok, West Sumatra. The purpose of this study was to determine (1) the best combination of indigenous rhizobacterial isolates and coumarin, (2) the rhizobacterial best individual isolates and (3) the best concentration of coumarin for the growth and yield of potato plants. A completely randomized factorial (4x3) design with three replicates was used. The first factor was the rhizobacterial isolates (A2.1b2, A3.1a5, or B1.2a1) and the second factor was coumarin at concentrations of 75, 100 and 125 milligrams per liter. The Data were Analyzed using analysis of variance and further tested with Duncan's New Multiple Range Test at the 5% level. The combination of an indigenous rhizobacterial isolate and coumarin influenced the net assimilation rate and plant growth rate. Plant height, leaf area index, net assimilation rate, root length, the root / canopy ratio and tuber weight were not influenced by indigenous rhizobacteria. Coumarin at the concentration of 125 milligrams per liter gave the best results for plant height, net assimilation rate, tuber growth rate, tuber number and tuber weight.

Keywords – Potato, Rhizobacteria, Coumarin, Growth, Yield.

I. INTRODUCTION

The need for potatoes is increasing each year in line with population growth and development of industries in need of raw materials potatoes. Indonesia potato production in 2016 as many as 1,213,038 tons with a productivity of 18.23 tons / ha. West Sumatra potato production in 2016 as many as 50 583 tons with a productivity of 19.49 tons / ha [1].

According Yulimasni and Hayani [2] productivity is still relatively low compared to the potential outcome of 30.0 tons / ha. The low yield is not only caused by the use of seeds of low quality and varieties that produce low, but also due to the techniques of farming or cultivating less good, less precise control of pests and diseases, lack of knowledge of farmers on methods of proper fertilization, and the state a less supportive environment [3].

One aspect of cultivation technology that can be proposed is the use of rhizobacteria who acted as Plant Growth Promoting Rhizobacteria (PGPR). The use rhizobacteria as biological agents that stimulate plant growth and increase crop yields predicted it would be an interesting study that continues to grow in the field of agriculture in the future [4].

Mardiah, *et. al.*, [5] states that rhizobacteria used capable of acting as a driver of growth of plants, both in the phase of germination, seedling growth and the reproductive phase of the plant. The experiment Yanti *et al* [6] found that B. cereus strain JN233 have the best ability to promote growth rate, increase yields and suppress *R. Syzygii* subsp. *indonesiensis*, by mechanisms of PGPR attributes by producing IAA, solubilize phosphate, producing siderophore and Cyanide acid (HCN). In the next experiment Yanti *et al* [7] B. pseudomycoides and B. ant rachis used as PGPR or biocontrol agents of plant pathogens as newfound novel species of PGPR from Bacillus genera.

Growth response is increased when PGPR applied in combination, PGPR has the ability to produce IAA, gibberellins and cytokines and can bind the N₂ from the air and can dissolve the phosphate (P) in the soil. Activity of various hormones can increase plant growth. In addition to the use of rhizobacteria, optimal tuber formation in potato plants can be obtained from the application of growth regulators. Plant growth regulators required for the formation of tubers as an initiator or a driving force in the growth of plants.

Growth retardants are often used in the process include the tubers coumarin [8]. Mechanism of action of inhibiting the activity of coumarin is gibberellin role in elongation and cell division, so that the growth is focused on the bottom of the plant by increasing food reserves in the bulb. Effect of coumarin on plant growth and development is determined by various factors, one factor that plays a role is the magnitude of the concentrations used. The exact concentration in plants will lead to growth and development.

The purpose of this study is to investigate the interaction between Isolates of Rhizobacteria indigenous and use of coumarin on the growth and yield of potato, rhizobacteria isolates indigenous know best and best coumarin concentration on growth and yield of potato crop.

II. MATERIAL AND METHODS

The research was conducted on community lands with altitude of 1062 meters above sea level which is housed in Nagari Salayo Tanang Sileh Hill, District Lembang Jaya, Solok regency. Research in the form of completely randomized design (CRD) factorial with two factors and

three replications, so consists of 36 units of the experiment. Each of the experimental unit consisted of 49 plants with a spacing of 40 cm x 30 cm which is divided into a destructive plots and plots the results.

Factor I = Isolates of Rhizobacteria indigenus.

A1 = Without rhizobacteria

A2 = A2.1b2

A3 = A3.1a5

A4 = B1.2a1

Factor II = Concentration of coumarin.

C1 = 75 mg / l

C2 = 100 mg / l

C3 = 125 mg / l

Data were analyzed using the F test and mean comparisons of Duncan's test New Multiple Range Test (DNMRT) at 5 % level.

III. RESULTS AND DISCUSSION

A. Leaf Area Index (\overline{LAI})

The development of the leaves always follow the growth of plant height. In the treatment without giving rhizobacteria provide a response similar to the provision of B1.2a1 isolates, whereas for the other two isolates assigned the result of lower or less good for the development of leaf area index.

Table 1. Leaf area index (\overline{LAI})

Isolates of Rhizobacteria	Coumarin concentration (mg/l)			Average
	75	100	125	
	Without	1.05	0.74	
A2.1b2	0.51	0.57	0.67	0.58
A3.1a5	0.64	0.58	0.58	0.60
B1.2a1	0.74	0.61	0.79	0.71
Average	0.73	0.62	0.61	

KK = 5.98%

Description : The numbers on the same row and column are not significantly different at 5 % level F test.

The values obtained \overline{LAI} ranged from 0.43 to 1.05. It can be said that this value is low. Result of research Basuki *et al* cit Aripin *et al* [9] report productivity of 10 potato varieties range from 11-27 tons per hectare, has \overline{LAI} 1.26 - 3.93, which is equivalent to the leaf area of 2650-8253 cm², increased leaf area index allows for a better photosynthesis process resulting in a higher assimilates for plant growth.

In the treatment of coumarin, an increased concentration of coumarin show results in accordance with the expected results or in accordance with the mechanism of action of coumarin which inhibit the vegetative growth of the plants. Fathonah and Sugiyarto [10] states that the IAA and GA treatment tallest, leaf area at least. This shows that the treatment plant responses on exogenous hormones are inhibiting the growth of leaf area.

Differences in treatment accorded influence can also be associated with PGPR capabilities as a provider of growth hormone for growth and crop production. Root inoculation with PGPR significantly increase growth and yield, but the growth response varies between different strains

rhizobacteria. In general, the growth response increases when applied in combination PGPR strains [11].

High net assimilation rate by using growth retardants coumarin this signifies that work as expected. Coumarin serves to inhibit the growth of crop plants so that the rate of entry into the generative phase to be quick or otherwise accelerate the growth process that occurs. Fathonah and Sugiyarto [10] states that the dry weight of plants depends on the speed capabilities of cells - these cells to divide, enlarged and elongated. Speed active cells may be affected by growth hormones such as auxin and cytokine endogenous expected to accelerate the growth process.

B. Net Assimilation Rate

Correspondingly, the use of coumarin with a concentration of 125 mg / l causes an increase in the value of net assimilation rate - average. High coumarin concentrations can affect the hormone balance, so the higher the concentration of coumarin then the tuber weight is increased because of the inhibition of growth and flow of energy to the process of tuber formation [12].

Table 2. The rate of assimilation Net (\overline{LAB})

Isolates of Rhizobacteria	Coumarin concentration (mg/l)		
	75	100	125
	-mg/cm ² /day-		
Without	1.04 b	1.72 b	3.38 a
	AB	B	A
A2.1b2	0.56 a	1.10 a	0.92 a
	B	B	B
A3.1a5	1.40 b	2.94 a	1.39 b
	AB	A	C
B1.2a1	1.67 a	1.50 a	1.61 a
	A	B	B

KK = 11:35%

Description: The numbers followed by different small letters on the same line and the numbers - a number followed by different capital letters in the same column DNMRT significantly different at 5% level.

Best interaction of growth rates in the treatment of these plants are rhizobacteria A3.1a.5 with coumarin administration of 100 mg / l at 7 - 8 WAP. This indicates that administration of coumarin and the exact concentration well and optimal effect on all aspects of plant growth.

C. The Rate of Growing Plants (\overline{RGP})

Auxin (Indol-3 acetic acid, abbreviated IAA) is one fitohormon produced by soil microbes that are important for regulating plant growth and development. Most of the growth promoting bacteria (PGPR) associated on the plant root can synthesize IAA. Ability in the synthesis of auxin (IAA), gibberellins (gas) and cytokines increased in plants associated with PGPR, establishing symbiosis with rhizosphere microbial or when attacked by pathogens [13].

Verma further research [14] PGPR beneficial effects both directly and indirectly on plant growth promoters and plant protection from pathogens. Increased plant growth rate is affected by the total dry weight of plants produced per unit time.

Table 3. The rate of Growing Plants (\overline{RGP}).

Isolates of Rhizobacteria	Coumarin concentration (mg/l)		
	75	100	125
	- mg/cm ² /day-		
Without	1.01 c	1.55 b	2.01 a
	B	B	A
A2.1b2	0.47 b	0.70 ab	0.95 a
	C	D	C
A3.1a5	1.76 b	2.51 a	1.02 c
	A	A	C
B1.2a1	1.89 a	1,05 c	1.51 b
	A	C	B

KK= 15.35%

Description: The numbers followed by different small letters on the same line and the numbers - a number followed by different capital letters in the same column DNMRT significantly different at level 5%.

D. Growth Rate of Tubers (\overline{GRT})

Although not significantly different statistically, the highest growth rate tuber found in isolates giving rhizobacteria B1.2a1 i.e. 1,83 mg/day, PGPR can improve plant growth, improve the survival rate and produce phytohormones that regulate growth and plant resistance to stress. Root inoculation with PGPR is significant can promote the growth and yield growth but the response varies between different rhizobacteria strains [15].

Table 4. Tuber growth rate \overline{RGT} (transformation $\sqrt{X} + 1$).

Isolates of Rhizobacteria	Coumarin concentration (mg/l)			Average
	75	100	125	
	-mg/day-			
Without	1.69	0.46	1.14	1.09
A2.1b2	0.88	0.33	2.88	1.36
A3.1a5	1.65	0.61	1.21	1.15
B1.2a1	1.77	2,22	1.52	1.83
Average	1.49	0.90	1.68	

KK = 4:16%

Description: The numbers on the same row and column are not significantly different at 5 % level F test.

Closely RGT related to leaf area and more significant with the increasing age of the plant, especially in the phase of filling the bulbs, because at that phase Stover growth continues. Arifah [16] states of the vast surface MKA leaf photosynthesis that occurs can be more effective and fotosintat produced can be more and the subsequent effect on crop yields. Thus, it takes assimilate optimal. Fotosintat needs of plants increasing in accordance with increasing age. After that, the relationship is negative because the leaf area decreased, the leaves begin to experience aging, while charging the bulbs still in progress towards the hardening process.

E. The Plant Height

In theory, plant height with the addition of rhizobacteria will be higher than coumarin. Although the expected results are lower plant height when coumarin is added compared to the addition of rhizobacteria.

Table 5. Plant height.

Isolates of Rhizobacteria	Coumarin concentration (mg/l)			Average
	75	100	125	
	-cm-			
Without	43.68	42.63	47.07	44.46 a
A2.1b2	39,00	36.54	44.19	39.91 b
A3.1a5	35.83	35.72	36.55	36.03 b
B1.2a1	33.29	37.49	40.58	37.12 b
Average	37.95 B	38.09 B	42.09 A	

KK = 9.87%

Description: The numbers followed by different small letters on the same line and the numbers - a number followed by different capital letters in the same column DNMRT significantly different at 5% level.

Treatment Isolates of Rhizobacteria indigenous without giving responded plant height higher than that of Isolates of Rhizobacteria. Rhizobacteria isolates seem that provision has yet to show its role as a driver of growth on potato.

In its growth and development, generally plants are not able to produce IAA in sufficient quantities. Some strains rhizobacteria plant growth promoter capable of synthesizing IAA from basic materials found in root exudates or from organic materials.

Depending on the concentration, the active compounds can enhance or inhibit the growth of plants [5].

Furthermore, the use of retardants can cause some changes. One of them is a long road to be reduced, causing lower plant height. The lower height of this plant by administering coumarin can be seen by comparison with descriptions of potato variety Granola. Plant height of potato Granola variety have generally ranged around 60-70 cm.

Activity retardants in inhibiting stem elongation of plants associated with the work of plant hormones. Rimando [17] states that the chemical compounds contained in retardant cause uncontrolled size and height of the plant through three mechanisms: turn off the terminal bud stem (inhibits the activity of meristematic), inhibits the elongation of the apical segment without disrupting the meristematic activity and reduce apical dominance.

F. Roots Shoot Ratio

The ratio of the root header was conducted to compare the growth that occurred between the underground section and above the ground. The roots of the plant itself has a role to absorb nutrients from the soil around the plant, both the water and nutrients needed by the roots to translocated to other places in the plant canopy. The root header ratios contained in the treatment without giving rhizobacteria. That is, with the high value of the ratio of the root header obtained without giving rhizobacteria explained that the balance between the nutrients are absorbed by the roots with the translocated to other organs in the header section.

The balance between the nutrients derived from soil is also supported by other environmental factors, namely the process of photosynthesis that produces fotosintat and caused increased growth of plants included in the headline rate of roots. Dry matter translocation fotosintat crop a picture around the plant so that the rate of plant growth is determined by the maximum fotosintesis rate [19].

Table 6. Roots shoot ratio.

Isolates of Rhizobacteria	Coumarin concentration (mg/l)			Average
	75	100	125	
Without	2.98	2.99	4.66	3.54
A2.1b2	2.92	2.48	2.75	2.71
A3.1a5	2.73	3.07	2.70	2.83
B1.2a1	3.33	2.51	3.48	3.10
Average	2.99	2.76	3.39	
KK = 30.89%				

Description: The numbers on the same row and column are not significantly different at 5 % level F test.

Dodd *et al.*, [20] states that rhizobacteria allegedly capable of producing hormones that can stimulate plant growth and lateral root growth so that the maximum absorption of nutrient elements and the photosynthetic process can also work well. The process of photosynthesis to produce fotosintat thus also increasing plant growth and the effect on the ratio of the root header.

G. Number of Tubers per Plant

The number of tubers formed with regard to the rate of plant growth, net assimilation rate and leaf area index of the plant itself. Leaf area index showed no significantly different results as well as the number of tubers per plant. With a small leaf surface area, the photosynthesis that occurs less effective and fotosintat resulting in fewer here in after influence on crops. This is because the process of tuber closely related to the growth of activity above the ground. To some extent, the increase in leaf area is always followed by the addition of tuber weight by volume of the growing environment. The larger growing environmental volumes will result in fewer tubers but with larger tuber sizes, compared to the larger number of tubers with smaller tuber sizes in plants with small growing environmental volumes [13].

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Table 7. Number of Potato Tuber,

Isolates of Rhizobacteria	Coumarin concentration (mg/l)			Average
	75	100	125	
-fruit-				
Without	4.00	4.00	4.93	4.24
A2.1b2	4.00	4.00	4.67	4.22

Isolates of Rhizobacteria	Coumarin concentration (mg/l)			Average
	75	100	125	
A3.1a5	5.00	3.00	3.87	4.11
B1.2a1	3.13	5.33	4.53	4.33
Average	4.00	4.18	4.50	
KK = 23.29%				

Description: The numbers on the same row and column are not significantly different at 5 % level F test.

Hasni *et al.*, [23] states that it is because coumarin as retardant function to inhibit the vegetative growth. With the inhibition of vegetative growth it will increase the accumulation of assimilates in the leaves that induces the formation of tubers. Tuber formation is strongly influenced by the process of photosynthesis in plants. Previous research Arifah [16] of the vast surface of the leaf photosynthesis that occurs can be more effective and fotosintat produced can be more and the subsequent effect on crop yields because tubers process is closely connected with the activity of plant growth above the ground.

H. Weight of Tubers per Plant

From these two treatment factors singly, the weight of potatoes per plant was highest in the treatment without giving rizobakteri as many as 124.54 grams. This indicates that by not gave rizobakteri on potato plant is to get the highest weight in this study.. Arifah [13] mentioned that to a certain extent, the increase in leaf area is always followed by the addition of tuber weight by volume grow larger environment. The more leaf surface area, the photosynthesis that occurs can be more and the subsequent effect on crop yields.

Table 8. Weight of tubers per plant.

Isolates of Rhizobacteria	Coumarin concentration (mg/l)			Average
	75	100	125	
- g -				
Without	115.82	107.43	150.39	124.54 a
A2.1b2	98.12	69.91	108.51	92.18 b
A3.1a5	96.52	78.15	96.49	90.38 b
B1.2a1	67.94	103.07	125.06	98.69 ab
Average	94.60 B	89.64 B	120.11 A	
KK = 26.56%				

Description: The numbers followed by different small letters on the same line and the numbers - a number followed by different capital letters in the same column DNMRT significantly different at 5%. level

Tuber weight by administering coumarin coumarin highest in administration with the highest concentration 125 mg / l as many as 120.11 grams, then the administration of 75 mg / l as much as 94.60 grams and the last in administering 100 mg / l coumarin as many as 89, 64 grams. Coumarin high concentration can affect hormonal balance, so the higher the concentration of coumarin given the tuber weight increased. This is due to a period of growth becomes stunted and cause drainage of energy results to tubers [12]. The high weight of tuber with high concentrations of

coumarin administration is in accordance with the objectives expected from this study in which the administration of coumarin vegetative growth rate is expected to be blocked. Hasni *et. al.* [23] mentioned by the inhibition of vegetative growth it will increase the accumulation of assimilates in the dun that induces the formation of tubers.

In addition tuber production itself is also related to the assimilation rate and the rate of plant growth. Where the value of the rate of growth of low crop cause the value of the rate of growth of tubers is low; thus producing tubers with low production. The size of the potato tuber large is not an indication that the compound content of organic matter in the ground, such as carbohydrates, proteins and lipids as well as organic compounds other than products of metabolism are also great, but it could be possible that it contains a large water so that the weight of tubers produced no significant difference among the treatments [18].

IV. CONCLUSION

Based on research that has been done can be concluded that:

- 1) The interaction between Isolates of Rhizobacteria indigenous and coumarin affect net assimilation rate and growth rate of the potato crop.
- 2) Plant height, leaf area index, net assimilation rate, root length, the ratio of the canopy root and tuber weight was not affected by the administration of Isolates of Rhizobacteria indigenous.
- 3) Addition coumarin with a concentration of 125 mg / l gives good results on plant height, net assimilation rate, the rate of growth of tubers, roots canopy ratio, the number of tubers and tuber weight.

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