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Potential Rhizobacteria of Red Chili Plant as Candidate Biocontrol Agent to Inhibiting Seedborne Pathogen and Its Effects for Growth and Results of Eggplant (*Solanum melongena* L.)

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Abstract: *This study aims to determine the inhibition of rhizobacteria on the growth of seed-borne pathogenic colonies by eggplant seeds in vitro, how the mechanism of action of rhizobacteria in biocontrol agents and rhizobacteria that plant growth promoters, the effect of pre-planting seed treatment using rhizobacteria on vegetative growth and the results of two varieties of eggplant in the field (the role of PGPR). The research was conducted at the Seed Science and Technology Laboratory, Experimental Garden at Faculty of Agriculture, Syiah Kuala University, Banda Aceh, and the Biology Laboratory, Faculty of Teacher Training and Education, Syiah Kuala University. The study took place from July 2018 to March 2019. Rhizobacterial inhibition of the growth of seedborne pathogenic colonies in vitro using a completely non factorial randomized design, the experiment was repeated three times. Experiments effect of seed treatment with rhizobacteria for growth and yield of eggplant in the field using factorial complete random design, namely Torino and Mustang F1 varieties and rhizobacteria. The experiment was repeated three times. Variables observed were height and stem diameter of plants aged 15, 20, 45 and 60 days after planting, number of fruit production per plant (total 4 times harvest), fruit diameter and fruit weight consumption per plant (total 4 times harvest). The results of physiological characterization of rhizobacterial isolates obtained six isolates that have a very high inhibitory ability (Inhibitory Power > 75%) to the growth of pathogenic colonies F. oxysporum ie P. dimuta, B. bodius, B. laterophorus, B. laterophorus, B. larvae, and B. stearothermophillus isolates. All rhizobacterial isolates produced IAA growth regulators, six isolates had phosphate-dissolving abilities, and six isolates produced HCN compounds. Eggplant plants derived from Mustang F1 varieties are superior to Torino varieties, both on growth and yield of plants. Eggplant seed treatment before planting using rhizobacteria effectively increases the growth and yield of eggplant. Rhizobacteri isolate of P. capaca, P. dimuta, and B. larvae are better isolates than the results of this study.*

Keywords: *Eggplant, Isolates, Pathogens, Rhizobacteria, Seeds*

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I. Introduction

Eggplant (*Solanum melongena* L.) is a plant native to the tropics. This plant originally came from the Asian continent namely India and Burma. Areas of the spread of eggplant initially in several countries (regions) include the Caribbean, Malaysia, West Africa, Central Africa, East Africa and South America. This plant spreads throughout the world, both countries with hot climates (tropical) and temperate (sub-tropical) (Firmanto, 2011).

Eggplant is a type of fruit vegetable that contains quite high nutrition, especially the content of vitamin A and phosphorus. This eggplant commodity is quite potential to be developed as a contributor to the diversity of nutritious vegetable ingredients for the population. According to Sunarjono (2013), that every 100g of eggplant contains 26 calories, 1g of protein, 0.2 g of charcoal hydrate, 25IU of vitamin A, 0.04 g of vitamin B and 5 g of vitamin C. In addition, eggplants also have medicinal properties because contains alkaloids, solanin and solasodin. This supports the potential of eggplant to be cultivated.

Eggplant market potential can also be seen in terms of prices that are affordable by all levels of society so as to open greater opportunities for market and farmer uptake. Therefore, demand for eggplant commodities will continue to increase along with population growth and increasing public awareness of health.

According to the Central Statistics Agency (2013), the productivity of eggplant plants in Indonesia in 2012 which was 518,827 tons ha-1 has increased since 1997 and began to decline in 2012 by 1.43%. This is partly due to the limited area of eggplant cultivation and the use of poor quality seeds. Seed is one of the main components for sustainable agricultural productivity. As many as 90% of food plants are derived from seeds

(Schwinn, 1994). Seed quality can determine the economic value of crop production. This is greatly influenced by the health conditions of the seeds that are free from disease attacks. Diseases in plants in the field can be carried away and be transmitted through seeds.

The presence of seed-borne pathogens both inside and on the surface of the seeds will thwart the process of germination and growth of seedlings in the field or cause epidemics of disease due to transmission of disease-causing pathogens from seeds to plants. The use of high quality and pathogen free seeds and seed protection through seed treatment is one of the strategies to control various diseases in eggplant plants. Therefore, the availability of pathogen free seeds is absolutely necessary. One of the efforts to eliminate seed-borne pathogens and disease events, pre-treatment of seeds is very much needed (Maude 1996; Brandl, 2001).

Treatment of seeds using biological agents (biological seed treatment agents) is an alternative as a substitute for fungicides with active chemical synthesis in the treatment of seeds. Biological seed treatment is the treatment of seeds carried out by using one or more organisms that benefit genes or products such as metabolites which reduce the negative influence of pathogens on plants and increase positive effects on plants (Cook and Baker 1983; Junaid *et al*., 2013). Biological control of pathogens in the form of a reduction in total or partial pathogen populations by other organisms naturally occurs continuously in nature (Agrios, 1997).

Besides its role as an antagonistic agent, rhizobacteria which are symbiotic with plant root systems, apparently also play a role as a plant growth promoter or Plant growth promoting rhizobacteria (PGPR). Increased plant growth by rhizobacteria promoting plant growth can occur through biofertilization, phytostimulation and biocontrol. Indole acetic acid is an active form of the auxin hormone found in plants and plays a role in increasing growth and yield. The function of the hormone indole acetic acid for plants, among others, increases cell development, stimulates the formation of new roots, stimulates growth, stimulates flowering and increases enzyme activity (Arshad and Frankenberger, 1993). Generally plants are not able to produce growth regulators in sufficient quantities for their growth and development. Some rhizobacteric strains that promote plant growth are able to synthesize growth regulators from percusors (basic ingredients) found in root exudates and from organic matter (plant and animal residues). Depending on the concentration, these active compounds can increase or inhibit plant growth.

As far as the literature references are searched, information has not been obtained whether rhizobacteria isolates from red chili plants can inhibit the growth of pathogenic colonies carried by eggplant seeds, which act as candidates for biocontrol agents. Likewise, information on whether rhizobacteria isolates from red chili plants are also capable of acting as a growth promoters for eggplant plants is not yet known.

In connection with the role of the rhizobacteria on growth and yield of plants, especially eggplant plants, both through the mechanism of controlling pathogens that cause disease and its role as a plant growth promoter, it is necessary to isolate rhizobacteria that are able to play a role in both functions that can be applied through seed treatment.

The purpose of this study was to determine the ability of rhizobacterial isolates from red chilli plants to inhibit the growth of pathogenic Fusarium oxysporum colonies in eggplant plants in vitro (the role of rhizobacteria as biocontrol agents) and the effect of seed treatment using rhizobacteria that stimulate plant growth on seedling growth and growth as well as in vitro eggplant plants in the field.

II. Research Methods

The research was conducted at the Seed Science and Technology Laboratory, Experimental Garden at Faculty of Agriculture, Syiah Kuala University, Banda Aceh, and the Biology Laboratory, Faculty of Teacher Training and Education, Syiah Kuala University. The study took place from July 2018 to March 2019.

Detection, Identification and Isolation of Pathogenic *F. oxysporum* from Eggplant

Pathogenic isolate of *F.oxysporum* is obtained by isolation directly from eggplant which is attacked by disease in the field. Eggplant shows symptoms of *F.oxysporum* attacks such as plants withering and wet root rot skin. The attack in the nursery is marked by the seedlings suddenly falling and withering then die.

The isolation process is carried out by means of diseased plant tissue being sterilized with ethanol 96% for 10 seconds, then rinsed with sterile water 3 times, then cut with a boundary between diseased and healthy plants with a size of 4 x 100 mm (50% of the tissue is still fresh and 50% brown). Then soaked with 1.0% chlorox for 1 minute then washed with distilled water 3 times then placed in a petri dish containing PDA media. Furthermore, the petri dish is sealed and incubated at 23-25 ^{0} C with Near Ultra Violet (NUV) irradiation. After 2 days of incubation, an observation is started, if it has shown that *F.oxysporum* appears immediately removed and purified and then stored for use in further research.

Rhizobacterial Isolation of Antagonistic Biocontrol Agent Candidates for *F.oxysporum* from the Rhizosphere Area Healthy Chili Plants

Rhizobacteria isolates used in this experiment were rhizobacterial isolates from the Laboratory of Seed Science and Technology, Department of Agrotechnology, Faculty of Agriculture, Syiah Kuala University, type of isolate and its bacterial name: 1. *Acitinobacillus suis*, 2. *Actinotobachter* sp, 3. *Azotobacter* sp, 4. *Necercia* sp, 5. *Psedomonas capacia*, 6. *Bacillus megaterium*, 7. *Psedomonas dimuta*, 8. *Bacillus bodius*, 9. *Bacillus laterophorus*, 10. *Bacillus larvae*, 11. *Bacillus alvei.*

Physiological Characterization and Working Mechanisms of Rhizobacteria as Plant Growth Promoters

Rhizobacterial isolates used in this experiment were isolates obtained from the results of previous experiments. To determine the ability of rhizobacteria as a candidate for Plant Growth Promoting Rhizobacteria (PGPR) or rhizobacteria that plant growth promoters of each rhizobacterial isolate in this experiment, their ability to evaluate the production of acetic acid (IAA), and the ability to dissolve phosphate (P) and its effect on increasing the germination process of rhizobacteria in this experiment were evaluated vegetative growth and crop yield.

Production of Indole Acetic Acid (IAA) by Rhizobacteria Isolates

The ability of each rhizobacterial isolate of *Bacillus* sp., *Pseudomonas* sp. and *Serratia* sp. to produce IAA was analyzed by the method of Glickman and Dessaux (1995). *Pseudomonas* sp. grown for 24 hours in liquid King's B medium while *Bacillus* sp. and *Serratia* sp. in nutrient broth. To stimulate auxin synthesis, 0.5 g / 1 aminotriptofan acid was added to each media. Bacterial culture was centrifuged at 10000 rpm for 10 minutes, then the supernatant was separated from bacterial deposits, filtered with a 0.2 µm nitrocellulose membrane, and analyzed with IAA content. IAA content in bacterial culture filtrate was detected using 12 g / 1 $FeCl_3$ reagent in 7.9 M H_2SO_4. FeCl3 reagents (1 ml) and bacterial culture filtrate (1 ml) were added to the eppendorf tube (volume 2 ml), and the mixture was incubated in a dark room at 26 °C for 30 minutes. After the incubation period, the absorbance value of the mixture was read by a spectrophotometer at a wavelength of 550 nm. Standard curves based on absorbance values of pure IAA solutions with concentrations of 0, 6.25, 12.5, 25, 50, 75, 100, 150, and 200 µ / ml were used to calculate IAA content in bacterial culture filtrate.

The Ability to Dissolve Phosphate

The medium used to determine the ability of the agent to dissolve phosphate is the Dicalsium phosphate (DCP) medium which is insoluble. For medium preparation, 20 g agar, 10 g glucose, 5 g NH_4Cl, 1 g NaCl and 1 g $MgSO_4$ are put into 1000 ml of sterile water and autoclaved at 120 °C for 20 minutes. Then the medium is added by 10% $CaCl_2$ and Na_2 (PO_4) 3 solution. The pH of the medium is adjusted to 7.2 with 5 N KOH. Then the media was poured into petridish and made four holes with cork borer and filled with 0.2 ml of bacterial suspension, then incubated for 3 days at 28 °C. The ability of bacteria to dissolve phosphate is shown by the presence of halo around the hole that contains a bacterial suspension (Goldstein, 1986).

Siderophore Compound Analysis

The bacterial biocontrol agent to be used is grown on a liquid medium with low iron (FeCB) content. The composition of the medium used consisted of 20 g sucrose, 2 g/L asparagine, 1 g K_2HPO_4, 0.5 g $MgSO_4.7H_2O$ in 1 liter of distilled water with a pH of 7.0. This bacterial suspension was incubated at 27 ^{0} C for 24 hours. Furthermore, the suspension was centrifuged at 11000 rpm for 30 minutes. The supernatant was filtered with 0.2 µm membrane of nitrocellulose membrane. For analysis, 3 ml of the supernatant was added with 1 ml of 0.01 M FeCB as a limited source of iron compounds, as a comparison 3 ml of supernatant was used without FeCB added. Siderophore detection was carried out using a spectrophotometer at wavelengths of 350, 380, 410, 470 and 500 nm.

The Ability of an Agent to Produce Hydrogen Cyanide (HCN)

Determination of the formation of hydrogensianide by bacterial biocontrol agents is carried out according to the procedure described by Bakker and Schippers (1987) in Munif (2001). The material used as a medium is 4.4 g glycine, 2 g picric acid, 8 g sodium carbonate, 15 g agar, 30 g TSB, 1000 ml sterile water and sterile filter paper pieces (1x1 cm). Glycine, TSB and agar were put into 1000 ml of sterile water and then autoclaved and poured into petridish. Furthermore, a solution was made to detect HCN (CDS) consisting of 2 g of picric acid and 8 g of sodium carbonate dissolved in 200 ml of sterile water. Sterile filter paper pieces are put into a CDS solution. Bacteria are scratched on the glycine medium, then filter paper pieces are placed in the middle of the petridish lid. Furthermore, incubation was carried out at 24 °C for 4 days. During incubation, bacteria that produce HCN will cause filter paper discoloration from yellow to light brown (slight HCN), brown (medium HCN) and brick red (large HCN).

Seed Treatment using Rhizobacteria Plant Growth Promoters and Effect on Growth and Production of Eggplant in the Field

Experiments on the effect of seed treatment with rhizobacterial candidates for plant growth promoters used a randomized block design in a factorial. Data were analyzed using ANOVA, which will be followed by a difference test between treatments with Duncan's multiple range test (DMRT) at $\alpha = 0.05$. The varieties used consist of 2 varieties, namely Mustang F1 and Torino Varieties. The rhizobacteria treatment consisted of 8 isolates, namely: Control, *Azotobacter* sp., *B. Megaterium*, *P. dimuta*, *B. alvei*, *Flavobacterium* sp., *B. coagulans*, *B. firmus*, and *B. pilymixa*. In comparison also planted seeds that were not treated with rhizobacteria as a control. Each treatment was repeated twice so that overall there were 32 experimental units. Each experimental unit was used 5 sample plants, thus there were 160 plants.

III. Result and Discussion

The results of analysis of variance (F-test) even numbered attachments showed that the ability of various rhizobacterial isolates that stimulate plant growth significantly affected the physiological characteristics observed based on the inhibitory variables on the growth of *F. oxyporum* pathogen colonies and IAA content (µ / ml filtrate). While other physiological characteristics, namely the ability of rhizobacteria to dissolve phosphate, the production of siderophore compounds and the production of HCN compounds were observed on a qualitative basis. From Table 1 it is shown that differences in rhizobacterial isolates significantly affect their ability to inhibit the growth of pathogenic colonies of *F.oxyporum* in vitro. The physiological character variable values of the rhizobacteria isolates that were tested for plant growth are presented in Table 1.

Table 1. Inhibition Various Rhizobacterial Isolates to Growth of *Fusarium oxysporum* Pathogen Colony. In Vitro and Ability to Produce IAA in Media containing Tripino, Amino Acid, Phosphate Dissolving, Siderophore Production and HCN Compound Production

Rhizobacteria Group	Capability Parameters of Various Rhizobacteria Isolates				
	Inhibitory Power (%)	IAA Content (µ/ml filtrate)**	Phosphate Solvents *	Siderophore Production (Abs λ 550 nm)	HCN Production **
A. suis	3.77 e	6.61 de	-	0.000	+
Actinotorbacter sp.	3.77 e	5.58 ef	+	0.037	+
Azotobacter sp.INA8	3.77 e	7.23 cd	+	0.194	++
Necercia sp.	12.77 d	5.62 ef	+	0.116	++
P. capacia	3.77 e	5.94 ef	+	0.136	+
B. megaterium	3.77 e	14.27 b	-	0.137	+
P. dimuta	64.96 c	3.83 g	+	0.157	++
B. bodius	76.40 b	7.87 c	+	0.176	+++
B. laterophorus	75.62 b	13.71 b	-	0.119	+++
B. larvae	75.51 b	6.61 de	+	1.654	+++
B. alvei	77.07 b	5.50 ef	+	0.159	+++
Flavobacterium sp.	3.77 e	3.97 g	+	0.144	+++
B. coagulans	3.77 e	20.26 a	+	0.077	+
B. firmus	3.77 e	4.08 g	+	0.000	+
B. pilymixa	3.77 e	6.47 def	+	0.000	+
B. lichiniformis	3.77 e	5.39 ef	-	0.015	+
B.stearothermophillus	84.07 a	3.79 g	-	0.027	+++

DMRT 0,05

Description : Inhibitory power, very high inhibitory activity (++++ => 75%), high inhibitory activity (+++ = 61-75%), moderate inhibitory activity (++ = 51-60%), low inhibitory activity (+ = <50%) and no inhibitory activity (-).* for the activity of phosphate solvents: + positive reaction, in the form of halo, - negative reaction, not in the form of halo. ** Figures in columns with the same letter are not significantly different based on the DMRT test at $\alpha = 0.05$. ** for HCN production: filter paper color, +++ brick red, ++ dark brown, + light octlat, and - yellow.

The results showed that there were indications that the difference in effectiveness of rhizobacterial inhibition of the test pathogenic fungus (*F. oxysporum*) was related to the ability of rhizobacterial isolates to secrete cyanide acid compounds (HCN). In addition, it is suspected that the rhizobacteria group which has a high ability to inhibit the pathogenic *F. oxysporum* from the results of this study also produces extracellular enzymes, especially proteases and cellulases. One characteristic of the ability of rhizobacteria that acts as a

biocontrol agent is the ability to produce antimicrobial compounds such as HCN. The results of the analysis of the ability to produce HCN antimicrobial compounds turned out that all rhizobacterial isolates that were evaluated had very high inhibitory activity (Inhibitory Power > 75%) on the growth of test pathogen colonies in this study turned out to secrete HCN antimicrobial compounds.

Volatile HCN compounds are the result of secondary metabolism which is generally produced by *P. fluorescens* bacteria and is toxic to plant pathogens. From the results of this study, in addition to rhizobacteria from the *Pseudomonas* spp. group, rhizobacteria from the *Bacillus* spp. group, apparently also produce HCN and are inhibiting the growth of the pathogenic fungus *F. oxysporum*. The results of previous studies also reported that HCN produced by *Pseudomonas* spp. rhizobacteria inhibited the growth of *P. capsici*. Rhizobacteria which show their ability to secrete protease and cellulase enzymes and also produce HCN, have more than 60% effective inhibition. The results of this study indicate that the effectiveness of rhizobacterial inhibition of pathogens involves many mechanisms. As previously report, antagonism between rhizobacteria and pathogenic fungi not only through the mechanism of parasitism but can also occur through the mechanism of antibiosis, competition, and induction of endurance.

The antagonistic nature of biocontrol agent candidate isolates can occur partly because the rhizobacterial group of candidates for biocontrol agents produces enzymes that are able to degrade antimicrobial compounds secreted by pathogens. Several studies have proven that extracellular enzymes (proteases) produced by *P. fluorescens* degrade antimicrobial compounds produced by *P. agglomerans* so that the combination of these agents becomes less effective (Anderson *et al*., 2004). The results showed that the antagonism of biocontrol agents was generally carried out through inhibition of pathogens by the production of antimicrobial compounds (antibiosis), competition for carbon, nitrogen and iron through the production of siderophores, competition for colonization of infection sites, inactivation of spore germination factors, degradation of pathogenic factors such as toxin and parasitism which can involve the production of cell wall degradation enzymes, such as chitinase, and ß-1,3 glucanase which can lyse pathogenic cell walls (Whipps, 2000; Linderman, 2003).

It is known that siderophore is an iron chelating compound secreted by microorganisms in response to iron deficiency (Fe). The results of this study proved that most of the rhizobacterial isolates tested produced siderophore compounds, especially rhizobacteria isolates which had very high inhibitory ability. Siderophore compounds are produced by rhizobacterial microorganisms and fungi that have the ability to chew iron, especially in conditions where Fe is deficient. Siderophore production is one of the rhizobacterial mechanisms in suppressing pathogens through the competition of Fe nutrients, so that microorganisms that do not produce siderophore compounds will not get Fe for their growth (Kazempour, 2004).

One of the characteristics of the rhizobacteria group that acts as a candidate for rhizobacteria that promoters plant growth is related to its ability to produce IAA, dissolve phosphate, and induce systemic resistance. From the results of this study it was proven that some rhizobacterial isolates in addition to producing siderophore compounds, HCN also produces growth regulators especially IAA and has the ability to dissolve phosphates. The results of the study prove that in the plant root system there are many species of rhizobacteria that are able to stimulate plant growth through the production of growth regulators and increase the ability to induce plant resistance to soil borne pathogens (Mhatrea *et al*., 2019). Rhizobacterial species belonging to the PGPR group also involve the ability to induce systemic resistance against various pathogens that attack plants (Liu *et al*., 1995; Chen *et al*., 2000; Sangeetha *et al*., 2010). From the results of this study it is also known that there are some rhizobacterial isolates in addition to acting as candidates for biocontrol agents also acting as rhizobacterial candidates for plant growth promoters.

Effect of Varieties on Growth and Yield of Eggplant Observed by Growth and Yield of Plants

The results of the analysis of variance (F test) showed that the eggplant varieties used had a significant effect on crop yields. Whereas on plant growth variables it turns out that varieties do not have a significant effect both on plant height and stem diameter. Varieties have a significant effect on the diameter and weight variables. The average value of plant growth variables and yields are presented in Tables 2 and 3.

Table 2. Average Height and Stem Diameter of Eggplant in Each Variety at Age 15, 30, 45 and 60 Days After Planting

Varieties	Plant Height (cm)				Stem Diameter (mm)			
	15 days after planting	30 days after planting	45 days after planting	60 days after planting	15 days after planting	30 days after planting	45 days after planting	60 days after planting
Torino	32.350a	44.808a	65.963a	87.527a	6.387a	8.365a	10.066a	11.679a
Mustang	31.329a	43.529a	64.699a	84.883b	6.620a	8.381a	9.788a	11.661a
DNMRT 0,05								

Description: Numbers followed by the same letters in the same column are not significantly different at the 0.05 test level (DNMRT)

Table 2 shows that eggplant vegetative growth observed at 15, 30, 45 and 60 days after planting did not show a significant difference between the two varieties tested, both based on plant height and stem diameter. From Table 2 it can also be seen that overall the Torino Variety produces higher plant height tends to be higher than Mustang Variety. While for the diameter of the stem it turns out that the Mustang Variety is relatively larger than the Torino variety.

Table 3. Average Number of Fruits, Fruit Length, Diameter of Fruit, and Fruit Weight of Eggplant in Each Variety

Varieties	Number of Fruits	Fruit Length (cm)	Diameter of Fruit (mm)	Fruit Weight (g)
Torino	28.167 a	18.726 a	57.342 b	601.564 b
Mustang	29.806 a	18.966 a	59.868 a	628.817 a

DNMRT 0,05

Description : Numbers followed by the same letter in the same column are not significantly different at the 0.05 test level (DMRT)

In observing the observed crop yield variables based on the number of fruits, fruit length, fruit diameter and fruit weight per plant the results are different due to differences in the variety used. From Table 3 it can be seen that the Mustang Varieties produce a higher number, length, diameter and weight of eggplant fruit than the Torino variety. Although statistically is only obtained in diameter and weight variables per plant.

From the results of this study it was shown that the different varieties of eggplant produced different differences in growth and production rates of the two varieties. The Mustang hybrid eggplant variety was superior to the Torino variety. The results of observations on production based on weight and diameter of the fruit are also Mustang varieties superior to Torino varieties. The weight and diameter of the eggplant fruit production of Mustang varieties is statistically significantly higher than the diameter and weight of eggplant fruit production of the Torino variety.

The differences in the growth and production characteristics of the two eggplant plant varieties that were tested were related to the genetic characteristics of the two varieties. In theory, genes are trait-carrying substances that are passed on from the parent to the next generation. Genes determine the metabolic ability of living things that greatly affect the growth and development of these plants. Plants that have good growing genes will grow and develop quickly according to the period. Other results showed that different varieties influenced the phenotypes of each sorghum variety. Growth and yield on sorghum plants are largely determined by their genetic makeup. Sorghum plants will have different appearance of plants which are determined by the genes contained in each seed of sorghum plants of different varieties (Rahmawati, 2013). Individual's phenotype (appearance and way of functioning) is the result of genotype interactions (natural inheritance) and the environment. Although the specific nature of a particular phenotype cannot be determined forever by genotypic or environmental differences, there is a possibility that phenotypic differences between separated individuals are caused by environmental differences or the differences between the two. Some of the results of the research that have been carried out in relation to differences in varieties obtained results found that the varieties affect the growth and yield of red chili plants. The results of research on soybean plants also showed that the varieties had a significant effect on plant production parameters such as the number of productive branches, canopy dry weight, root dry weight, number of pods per plant, number of pods contained per plant, dry weight of seeds per sample and weight of 100 grains (Satwiko *et al*., 2013).

Effect of Rhizobacteria Treatment of Plant Growth Promoters on Growth and Yield of Eggplant Plants Observed Based on Plant Growth and Yield

The results of the analysis of variance (F-test) showed that rhizobacterial treatment of plant growth promoters given to eggplant seed treatment before planting had a significant effect on plant height variables at 45 and 60 days after planting. Whereas the diameter of the stem of the rhizobacteria stem only affected the age of 45 days after planting. In the parameters of crop yields, rhizobacterial treatment significantly affected the fruit number, fruit diameter and fruit weight. The fruit length variable was not significantly affected by rhizobacteria treatment.

From Table 4 it can be seen that the growth of eggplant height is different due to the treatment of seeds before planting using different rhizobacteria isolates. Plant height at 30 and 45 days after planting was significantly higher in plants derived from seeds treated with *P. dimuta* rhizobacterial isolates both at 30 and 45 days after planting compared to seed without treatment. The results also show that when compared with seed treatment using other rhizobacterial isolates, there was no statistical difference.

Table 4. Average Eggplant Height for Age 10, 20, and 30 Days After Planting with Seed Treatment using Rhizobacteria to Plant Growth Promoters

Rhizobacteria Treatment	Eggplant Height (cm)			
	15 days after planting	30 days after planting	45 days after planting	60 days after planting
Control	32.700 a	42.633 b	62.878 b	86.683a
A.suis	30.043 a	43.717 b	65.167 ab	83.817a
Actinotobachter sp	32.517 a	43.633 b	65.533 ab	87.433a
Azotobacter sp	32.833 a	44.217 ab	66.367 ab	84.450a
B.stearo chermopillus.	30.817 a	43.533 b	64.633 b	87.067a
Necercia sp	32.767 a	45.400 ab	66.183 ab	86.133a
P. capacia	31.833 a	44.350 ab	65.183 ab	86.717a
B. megaterium	31.523 a	46.317 ab	66.967 ab	85.350a
P. dimuta	31.943 a	47.967 a	69.367 a	86.450a
B. bodius	33.533 a	43.583 b	65.000 ab	88.317a
B. laterophorus	29.900 a	42.343 b	63.100 b	85.333a
B. larvae	31.667 a	42.333 b	63.600 b	86.717a

DNMRT 0,05

Description: Numbers followed by the same letters in the same column are not significantly different at the 0.05 test level (DNMRT)

From Table 5 it can be seen that the stem diameter of eggplant plants at the age of 15, 30, 45 and 60 days after planting the value is different because of the difference in rhizobacterial isolates used in the treatment of seeds before planting. Eggplant stem diameters are relatively higher in plants derived from seed treated using rhizobacteria *Actinotobachter* sp, *Azotobacter* sp, *Necercia* sp, *P. dimuta*, *B. bodius* and *B. laterophorus*. While the stem diameter of eggplant plants at the age of 15, 30 and 60 days after planting does not differ due to differences in rhizobacterial isolates used in the treatment of seeds before planting.

Table 5. Average Stem Diameter of Eggplant Age, 15, 30, 45 and 60 Days After Planting Results of Seed Treatment Using Rhizobacteria Plant Growth Promoters

Rhizobacteria Treatment	Stem Diameter (mm)			
	15 days after planting	30 days after planting	45 days after planting	60 days after planting
Control	6.466 a	8.453 a	9.740 ab	11.833 a
A.suis	6.446 a	8.473 a	9.275 b	11.066 a
Actinotobachter sp	6.808 a	8.688 a	10.325 ab	12.131 a
Azotobacter sp	6.640 a	8.370 a	10.066 ab	11.873 a
B.stearo chermopillus.	6.361 a	7.816 a	9.363 ab	11.456 a
Necercia sp	6.183 a	8.055 a	10.208 ab	11.963 a
P. capacia	6.471 a	8.351 a	9.760 ab	11.358 a
B. megaterium	6.640 a	8.705 a	9.521 ab	11.531 a
P. dimuta	6.283 a	8.055 a	10.275 ab	11.920 a
B. bodius	6.370 a	8.196 a	11.088 a	11.420 a
B. laterophorus	6.756 a	8.760 a	10.246 ab	11.943 a
B. larvae	6.695 a	8.561 a	9.255 b	11.550 a

DNMRT 0,05

Description: Numbers followed by the same letters in the same column are not significantly different at the 0.05 test level (DNMRT)

The results of this study can be concluded that the rhizobacteria used in seed pre-germination treatment shows its role as rhizobacteria that stimulate plant growth, both in the seedling growth phase, vegetative growth of plants and in the reproductive phase. Theoretically the level of production of a plant is very dependent on how its vegetative growth conditions. The role of rhizobacteria that stimulates plant growth in the seedling and vegetative growth phases in this study also plays a role in the reproductive phase of plants. Rhizobacteria that are effective in the reproductive phase are also thought to be related to the ability of rhizobacteria as rhizobacteria that promote plant growth. One of the characteristics of rhizobacteria that acts as a candidate for plant growth promoters rhizobacteria is the ability to produce growth regulators (auxin, gibberellins, and cytokines), nitrogen fixation and the ability to dissolve phosphates and induction of systemic resistance to

disease. As stated earlier, the rhizobacteria have acted as a trigger for plant growth since the process of seedling growth, and vegetative growth of plants.

Increased vegetative growth of red chili plants that received pre-crop seed treatment with rhizobacteria that promoters plant growth is thought to be closely related to the role of the rhizobacteria as plant growth promoting rhizobacteria (PGPR). This is as shown in the results of the analysis of the ability of rhizobacteria on IAA production and the ability to dissolve phosphate beforehand. Seed treatment with PGPR rhizobacteria plays an important role, especially beneficial in the process of seed germination under stressful environmental conditions (Bennett, 2002).

The ability of rhizobacteria classified as plant growth-promoting rhizobacteria is closely related to the ability of rhizobacteria to produce IAA growth hormones, fix N from the air and dissolve phosphate (Egamberdiyeva, 2008). Thus the positive impact is suspected to also affect the reproductive phase. The ability to fix nitrogen, dissolve phosphate, and produce growth hormones (gibberellins, auxins, and cytokines) has been widely reported as a rhizobacterial mechanism in its role as an agent for promoting plant growth and production (Egamberdiyeva 2008).

The average number of fruit, length, diameter, and weight of eggplant by seed treatment before planting using various rhizobacterial isolates that promote plant growth are presented in Table 6.

Table 6. Average Number of Fruits, Fruit Length, Diameter of Fruit, and Fruit Weight of Eggplant by Pre-Germination Seed Treatment Using Rhizobacteria Plant Growth Promoters

Rhizobacteria Treatment	Peubah Produksi			
	Number of Fruits	Fruit Length (cm)	Diameter of Fruit (mm)	Fruit Weight (g)
Control	16.333 e	17.770 a	52.508 b	570.450 cd
A.suis	30.833 bc	17.698 a	54.108 b	556.720 d
Actinotobachter sp	22.500 de	18.748 a	59.103 a	591.104 bcd
Azotobacter sp	19.000 e	19.297 a	61.425 a	605.980 abc
B.stearo chermopillus.	33.500 bc	18.738 a	60.648 a	631.061 ab
Necercia sp	26.500 cd	18.782 a	59.769 a	616.591 ab
P. capacia	44.500 a	19.213 a	60.398 a	632.641 ab
B. megaterium	32.500 bc	19.360 a	58.737 a	628.521 ab
P. dimuta	32.667 bc	19.967 a	60.932 a	630.283 ab
B. bodius	18.000 e	18.948 a	61.253 a	624.032 ab
B. laterophorus	33.500 bc	19.449 a	60.255 a	650.101 a
B. larvae	38.000 ab	18.595 a	54.136 b	644.762 a
DNMRT 0,05				

Description: Numbers followed by the same letters in the same column are not significantly different at the 0.05 test level (DNMRT)

From Table 6 it can be seen that the number of eggplant fruit is significantly higher in plants derived from seed yields treated using *P. capacia* rhizobacteria isolates and followed by plants whose seeds are treated with *B. larvae* rhizobacteria treated. While the diameter of the fruit treated before planting using all rhizobacterial isolates produced a larger diameter than the control except for plants whose seeds used *A. suis* and *B. larvae*. From the results of this study it can be concluded that based on the best number of isolates for seed treatment are isolates of *P. capacia* and *B. larvae*. While based on the diameter of fruit the isolate *Azotobacter* sp. and *B. bodius*. Meanwhile based on fruit weight, better isolate is used by *B. laterophorus* and *B. larvae* rhizobacterial isolates.

The results of the measurement of reproductive parameters due to pre-planting seed treatment using PGPR rhizobacteria in general can be explained that the treatment of pre-planting seed using various rhizobacterial species shows that of the 10 species of rhizobacteria that were tested there were 8 species of rhizobacteria that significantly increased the number of eggplant plants compared to seeds that were not get treatment namely *A. suis*, *B. stearo chermopillus*, *Necercia* sp, *P. capacia*, *P. dimuta*, *B. laterophorus*, *Actinotobachter* sp and *B. larvae* isolate. While the fruit diameter variable also contained 8 isolates that effectively increased fruit diameter, namely rhizobacteria isolate *B. stearo chermopillus*, *Necercia* sp, *P. capacia*, *P. dimuta*, *B. laterophorus*, *Actinotobachter* sp, *B. bodius* and *Azotobacter* sp. Whereas for fruit weight consumption per plant there were also 8 rhizobacterial isolates that were effective in increasing fruit weight, namely *B. stearo chermopillus*, *Necercia* sp, *P. capacia*, *P. dimuta*, *B. laterophorus*, *B. larvae*, *B. megaterium* and *Actinotobachter* sp.

Increased yield (number of fruits, diameter and weight of fruit consumed per planting) due to pre-planting seed treatment with plant growth promoters rhizobacteria is a cumulative effect of improving plant

growth due to treatment with the rhizobacteria. As previously explained, that the rhizobacteria group has the ability to act as rhizobacteria that stimulate plant growth as evidenced in the analysis of its physiological characteristics, which have the ability to produce IAA growth regulators and dissolve phosphates.

Based on the results of this study it can be concluded that seed treatment with rhizobacteria can increase the growth and yield of chili plants (Safuan, 2013). The results of seed treatment before plants using PGPR rhizobacteria on tomatoes, chili and eggplant plants using *Bacillus cereus* (MTCC 8297), *Pseudomonas rhodesiae* (MTCC 8299) and *Pseudomonas rhodesiae* (MTCC 8300) effectively increase root weight, leaf formation, fruit formation faster and weight of plant biomass (Kalita *et al*., 2015). Taufik *et al*., (2005), showed that the PGPR treatment of *Bacillus substilis* and *B. stearothermopillus* on chili seeds could inhibit disease events and reduce the effect of CMV infection and Chili vein mottle virus (ChiVMV). *Pseudomonas fluorescens* P60 has three mechanisms in controlling *Fusarium* wilt, namely affected resistance, antibiosis, and "Plant Growth Promoting Rhizobacteria" (PGPR).

IV. Conclusion

Based on the results of the study can be concluded as follows:

1. The results of physiological characterization of rhizobacterial isolates obtained five isolates which have a very high inhibitory ability (inhibitory > 75%) against the growth of pathogenic colonies of *F. oxysporum* that is *P. dimuta*, *B. bodius*, *B. laterophorus*, *B. larvae*, and *B. stearothermophillus*. All rhizobacterial isolates produce IAA growth regulators, six isolates have phosphate-dissolving capabilities, and six isolates produce HCN compounds.
2. Eggplant from the Mustang variety is superior to the Torino variety, both in terms of growth and yield.
3. Eggplant seed treatment before planting using rhizobacteria effectively increases the growth and yield of eggplant. Rhizobacteri isolate of *P. capaca*, *P. dimuta*, and *B. larvae* are better isolates than the results of this study.

References

[1] Firmanto B.H. 2011. Success in Organizing Eggplant Organic. Angkasa, Bandung.
[2] Sunarjono, Hendro. 2013. Planting 36 Types of Vegetables. Penebar Swadaya, Jakarta.
[3] Central Statistics Agency. 2013. Production and Productivity Data of tomatoes by province in 2007-2011. Data statistik-/produksi-produktivitas tomat/pdf/htm. Accessed June 25, 2016.
[4] Schwinn, F. 1994. Seed Treatment-a panacea for plant protection Seed Treatment: Progress and Prospects. BCPC Publication.Monograph 57, 3.Rertrieved: September 9, 2014 from http://www.amazon.com/gp/?.
[5] Maude RB. 1996. Seedborne Diseases and Their Control, Priciples and Practice. CAB International. Wallingford, UK. p245.
[6] Brandle F. 2001. Seed Treatment : Evolving to Achieve Crop Genetict Potential. In: Biddle, A.J. (ed) Seed Treatment : Callenges & Opportunities. BCPC Symposium Proceedings, 76.p: 3-17.
[7] Cook RJ, Baker KF. 1983. The nature and practice of biological control of plant pathogens. The American Phytopathological Society, St.Paul, MN, USA.
[8] Junaid JM, Dar AN, Ahmad Bhat T, Hussain Bhat A, dan Ahmad Bhat M. 2013. Commercial Biocontrol Agents and Their Mechanism of Action in the Management of Plant Pathogens. International Journal of Modern Plant & Animal Sciences, 2013, 1 (2): 39-57.
[9] Agrios GN. 1997. Plant Pathology, 4 th ed. Academic Press, New York USA. p 634.and determination of total anthocyanin and degradation index for cranberries. J. Food Sci. 33:72.
[10] Arshad, M. and W.T. Frankenberger, Jr. 1993.Microbial production of plant growth regulators. p. 307-347. *In* F.B. Meeting, Jr. (Ed.). Soil Microbial Ecology. Applications in Agricultural and Environmental Management. Marcel Dekker, Inc. New York.
[11] Goldstein, AH. 1986. Bacterial solubilization of mineral phosphates. Historical perspective and future prrospects.Amer J AlternatAgric I: 51–57.
[12] Anderson, T.H., K.H. Domsch, and W. Gams. 1993. Compendium of Soil Fungi vol. I. IHW-Verlag, Regensburg. 806 p.
[13] Whipps JM. 2001. Microbial interaction and biocontrol in the rhizosphere. Plant Pathology and Microbiology Departement, Horticulture Research International, Wellesbourne, Warwick CV35 9EF, UK.
[14] Linderman RG. 2003. Biological control options for *Phytophthora* species. bowersjo@ba.ars.usda.gov. [12 November 2005].
[15] Kazempour, MN. 2004. Biological control of rhizobacteria solani the causal agent of rice sheath blight by antagonis bacteria in green house and field condition. J. Plant Pathol. 3:88-96.
[16] Mhatrea, P.H., C. Karthikb, K. Kadirvelub, K.L. Divyaa, E.P. Venkatasalama, S. Srinivasanc, G. Ramkumard, C. Saranyae, R. Shanmuganathan. 2019. Plant growth promoting rhizobacteria (PGPR): A potential alternative tool for nematodes biocontrol. Biocatalysis and Agricultural Biotechnology. 17:119-128.
[17] Liu L, Kloepper JW, Tuzun S (1995). Induction systemic resistance cucumber against, *Fusarium* wilt as plant growth promoting rhizobacteria. Phytopathology 85:695-698.
[18] Chen C, Belanger RR, Benhamou N, Paulitz TC (2000). Defense enzymes induced in cucumber roots by treatment with plant-growth promoting rhizobacteria (PGPR). Physiol. Mol. Plant Pathol. 56:13-23.
[19] Sangeetha G, Thangavelu R, Usha Rani S, Muthukumar A, Udayakumar R (2010). Induction of systemic resistance by mixtures of antagonist bacteria for the management of crown rot complex on banana. Acta Physiol. Plant.
[20] Rahmawati, A. 2013. Response of some sorghum genotypes (*Sorghum bicolor* [L.] Moench) to the intercropping system with cassava (*Manihot esculenta* Crantz). Thesis. Faculty of Agriculture, University of Lampung. Bandar Lampung.
[21] Satwiko, T., Lahay, R.S., Sengli, B. Damanik, J. 2013. Growth Response and Production of Several Soybean Varieties (*Glycine Max* L.) Against Comparison of Fertilizer Composition. Agroecotechnology Online Journal, 1 (4):1413-1423.
[22] Egamberdiyeva, D. 2008. Effect of rhizobacterial treatment on seeds and plants as well as phosphate fertilization on the growth of hybrid female corn parent plants. Thesis. Bogor Agricultural University Postgraduate Program. Bogor.

[23] Safuan, L.O. 2013. Seed Treatment with Rhizobacteria Improves Seed Quality and Yield Chili (*Capsicum annuum* L.). Agron. Indonesia 40 (2): 125 – 131.
[24] Kalita, M., M. Bharadwaz, T. Dey, K. Gogoi, P. Dowarah, B. G. Unni, D. Ozah, I. Saikia. 2015. Developing novel bacterial based bioformulation having PGPR properties for enhanced production of agricultural crops Indian Journal of Experimental Biology, 53:56-60.
[25] Taufik, M., S.H. Hidayat, G. Suastika, S.M. Sumaraw, dan S. Sujiprihati. 2005. Kajian Plant Growth Promoting Rhiziobacteria sebagai agens proteksi Cucumber mosaic virus dan Chilli veinal mottle virus pada cabai. *Hayati*, 12 (4): 139-144.

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