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Respon Pertumbuhan dan Produksi Kacang Hijau (*Vigna radiata* L) dengan Aplikasi Mikoriza dan *Penicillium* sp pada Lahan Sawah

Growth and Production Response of Mung Beans (Vigna radiata L) with Mycorrhizal and Penicillium sp Applications on Paddy Fields

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ABSTRACT

This study aimed to evaluate the effect of mycorrhiza and Penicillium sp on the growth and production of mung beans in paddy field. The design of this experimental research was a factorial Randomized Block Design (RBD) with 2 factors and 3 replications. The first factor was the dosage of mycorrhizaconsisting of 0 g/plant; 5 g/plant; 10 g/plant; and 15 g/plant. The second factor was the type of Phosphate solubilizing microbes consisting of without Penicillium sp; Penicillium sp from Mursala island (20 ml/plant); Penicillium sp collection taken from soil biology laboratory of faculty of agriculture USU (20 ml/plant). The results showed that the dosage of Mycorrhiza and Penicillium sp were not significantly affected the height of mung bean plants, however it significantly affected the population of Penicillium sp. The application of 15 g Mycorrhiza with Penicillium sp from Mursala was the best treatment for the growth of mung bean plants at 4 weeks after planting (42.98 cm) and the interaction of Mycorrhiza15 g/plant and Penicillium sp Mursala produced the best seeds/plant of 16.76 g/plant

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***Keywords** :Mycorrhiza, Mung beans, Penicillium sp, Paddy field.*

ABSTRAK

Tujuan dari penelitian ini adalah untuk mengevaluasi pengaruh mikoriza dan *Penicillium* sp terhadap pertumbuhan dan produksi kacang hijau di lahan sawah. Desain penelitian eksperimental ini adalah Rancangan Acak Kelompok (RAK) factorial dengan 2 faktor dan 3 ulangan. Faktor pertama adalah dosis mikoriza terdiri dari: 0 g/tanaman; 5 g/tanaman; 10 g/tanaman; 15 g/tanaman. Faktor kedua adalah jenis mikroba pelarut fosfat yang terdiri dari: tanpa *Penicillium* sp; *Penicillium* sp dari pulau Mursala (20 ml/tanaman dan Penicillium sp dari koleksi laboratorium biologi tanah pertanian USU (20 ml/tanaman). Hasil penelitian menunjukkan bahwa dosis mikoriza dan *Penicillium* sp tidak berpengaruh signifikan terhadap tinggi tanaman kacang hijau, namun signifikan mempengaruhi populasi *Penicillium* sp. Aplikasi mikoriza 15 g dengan *Penicillium* sp dari Mursala adalah perlakuan terbaik untuk pertumbuhan tanaman kacang hijau pada 4 minggu setelah tanam (42,98 cm) dan interaksi mikoriza 15 g/tanaman dan *Penicillium* sp Mursala menghasilkan biji terbaik yaitu 16,76 g / tanaman.

Kata kunci: Mikoriza, Kacang hijau, *Penicillium* sp, Lahan Sawah

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INTRODUCTION

The third legume demanded by Indonesian people is mung bean *(Vigna radiata* L). Mung beans are rich with nutrients and are recommended for consumption for breast feeding mothers. According to Badan Pusat Statistik (2016), national data of mung bean decreased production from 2011-2015 were 341.342 tons, 284.257 tons, 204.670 tons, 244.589 tons and 271.463 tons respectedly, while mung bean production in 2019 was projected to reach 309.400 tons. Efforts to meet the needs of domestic mung beans can be done by increasing production through extensification (increasing the planted area) and intensification (cultivation techniques).

Paddy fields are targeted space for the extensification program of legume plants. Phosphate availability is a major problem at tropical soils including paddy field soil. This element binds easily with Al and Fe in acid soils and with Ca in alkaline soils, as well as absorption by colloidal clay. This condition results in low P fertilization efficiency.

According to Syawal, F et al. (2017), paddy field soils in Beringin District, Deli Serdang Regency have been degraded marked by soil organic matter which is classified as very low, hence to increase the productivity of paddy field soils in Beringin District it is suggested to used organic fertilizer as much as 38.70 tons / ha until 77.40 tons / ha until the soil organic matter content reaches 3%. According to De data *et al* (1990), only 15-20% of the dosage of fertilization applied on paddy field soil could be absorbed. Shen *et al* (2004) also stated that P fertilizer was more frequently used for paddy field soil to improve the harvest results, yet its efficiency was quite low at approximately 10-20% of applied fertilizer. Compost application can improve soil structure. In addition compost can increase water holding capacity, microorganism activity in soil and soil nutrient availability. The pattern of integration between plants and livestock or often referred to as integrated farming is very supportive in the supply of organic fertilizer on agricultural land until the soil organic matter content reaches 3% (Syawal et al. 2017).

P nutrient has an important role to improve plant production because it is required in any plant metabolism activity. According to Doberman and Fairhust (2000), phosphor is an essential constituent nutrient of ATP (adenosine triphosphate) which is directly used in storage process and energy transfer, or in any activity related to the metabolism process of plants.

One of environmentally friendly alternatives to solve that problem is by applying free-living soil microbes and symbiotic microbes that are able to dissolve P. Mycorizal fungi have a specific ability to increase P uptake in marginal soils, in which P nutrient availability is very low, whereas phosphate solvent microbes can dissolve producing organic acids and organic acid phosphatase enzymes to form chelates with Al and Fe cations hence phosphates bound to Al and Fe are released, become available and can be absorbed by plants (Whitelaw, 2000; Susanti et al. 2019).

The interaction between tillage and mycorrhizal inoculation has no significant effect on soil pH, C-organic, P-available, Organic Matters and Total Soil Microbes. Harahap (2019) stated that the effect of mycorrhizal inoculation did not significantly affect the physical properties and P-available soil. P fertilizers are applied regularly, sometimes in enormous amount; meanwhile yield is low. According to Adiningsih (2004), the results of the analysis showed that the amount of P uptake at harvest period is quite small and the phosphate uptake by rice plants in irrigated land is only 15-20% and in dry land only 10-15% of the applied fertilizer dosage, while the rest remains in the soil as residue in the form of compound P. This study aimed to evaluate growth and production response of mung bean (*Vigna radiata* L.) through application of mycorriza and *penicillium* sp.

MATERIALS AND METHODS

Experimental Design

The experiment was conducted at Pasar II Tanjung Sari Paddy Field, Medan, Sumatera Utara and at Laboratory of Biology, Agriculture Faculty, University of Sumatera Utara (USU), from September 2018 to January 2019. The mung bean seeds variety used was VIMA-I. Microbes used were inoculants *Penicillium* sp from faculty of agriculture USU, and *Penicillium* sp from Mursala island, mycorrhiza (71 spore), chemical fertilizers (Urea (0.5 g/plant), SP36 (0.25 g/plant and KCl (1 g/plant).

The experiment used was a Factorial Random Block Design with 2 factors with 3 replications. The first factor was mycorrhiza consisting of: 0 g/plant; 5 g/plant; 10 g/plant; 15 g/plant. The second factor was types of *Penicillium* sp inoculants consisting of: without *Penicillium* sp; *Penicillium* sp. Mursala (20 ml/plant); and *Penicillium* sp. USU (20 ml/plant). Data obtained were analyzed statistically using Analysis of Variance (ANOVA) and followed by Duncan's multiple range test at the level of 5%.

Isolation of Phosphate Solubilizing Microbes

Ten (10) grams of soil were put into 250 ml of Erlenmeyer flask which was filled with 90 ml of sterilized physiological solution (dilution 10^1) and shaken by a shaker for 30 minutes. The dilution was made in series, 1 ml was taken from 10^1 dilution which was put into a test tube filled with 9 ml of sterilized physiological solution (10^2 dilution) and mixed on a rotary mixer until it becomes homogeneous. Then 1 ml was taken from 10^2 dilution using a straw which was put into a test tube filled with 9 ml of sterilized physiological solution (10^3 dilution), this similar treatment was repeated consecutively until 10^5 dilution. After that, 1 ml of 10^3dilution was put into a petri dish that had been sterilized and treated similarly at 10^4 and 10^5 dilution. Then 12 ml of Pikovskayas Medium was poured (at a temperature of 45-50°C) into the petri dish which had been filled with 1 ml of soil suspension and left to harden. After the media got hardened, the petri dish was incubated in an incubator. Then, what was growing on the media was observed. The presence of phosphate solubilizing microbes was indicated by the formation of holozone surrounding the colony. This colony was later purified and separated.

Mycorrhiza Calculation

Isolation of mychorrhiza was applied using wet filtration technique by filtering 10 g of soil from Mursala Island using stratified filter (2 mm, 0.5 mm, 0.25 mm, 0.106 mm,and 0.063 mm). A filtrate was taken at 4th and 5th filtration. The filtrate was diluted with water and then 20 ml of it was taken and mixed with 50% sugar solution until it was 45 ml; it was then let stand for one night. After that, the solution was poured into a petri dish and observed under a stereoscope.

Cultivation, Fertilation, Application of Mycorrhiza and *Penicillium* sp.

Mung bean seeds with VIMA-I variety was planted by planting them into 2 cm depth holes made in the soil with 3 seeds/hole which was then covered by soil again. Mychorrhizal inocullant was applied simultaneously when it was planted as near as possible with the planted seeds in accordance with treatment (5 g, 10 g and 15 g). *Penicillium* sp. was applied when the plant was a week old around its root (rhizosfer plant) with determined treatment (0 ml dan 20 ml).

RESULTS AND DISCUSSION

Plant Height

The application of Mycorrhiza, *Penicillium* and their interaction had no significant effect on plant height in each observation week statistically. The results on plant height at the second week, third week, and fourth week after planting showed at

Table 1. The highest plant height was found at treatment 15 g Mycorrhiza with *Penicillium* sp from Mursala island 17.89 cm; 27.58 cm and 42.98 cm at 2,3 and 4 weeks after planting respectively. The lowest plant height was found in the treatment without Mycorrhiza and *Penicillium* sp 15.31 cm; 20.93 cm and 36.66 cm for 2, 3, and 4 weeks after planting respectively.

Degree of Mycorrhizal Infection

The results of observations of mycorrhizal infection at 2 WAA (Week After Application), 4 WAA, 6 WAA and 8 WAA showed that mycorrhizal application in 2 WAA, 4 WAA, 6 WAA and 8 WAA significantly affected the degree of mycorrhizal infection in the roots of mung bean plants (Table 2). In 2 WAA, 6 WAA and 8 MSA, the highest degree of infection was found in the application of 15g mycorrhiza, respectively 22.50%, 54.44% and 57.22% and significantly different from all other treatments. At 4 WAA the highest degree of mycorrhizal infection was also found in the mycorrhizal application 15 g which is 43.89%, but not significantly different in mycorrhizal application of 5 g and 10 g with 26.11% and 35% respectively.

Population of *Penicillium* sp.

The results of the research demonstrated that the highest population of *Penicillium* sp in the second weeks after application was found in *Penicillium* sp. USU (19.38 x 10^7 CFU/ ml). The significant interaction between the applications of mychorrhiza and *Penicillium* sp was discovered in the fourth week after the application (table 3). The highest average population of *Penicillium* sp was found in the application of mychorrhiza (15g) with *Penicillium* sp. Mursala (38.7 × 10^7 CFU/ ml) whereas the lowest average populationwas demonstrated by the application without mychorrhizal application.

Table 1. The Mung bean Height at 2, 3, 4 Weeks After Planting (WAP) affected by Application of Mycorrhiza and *Penicillium* sp. in Paddy Field

WAP	Treatments	Without *Penicillium*	*Penicillium* sp. Mursala	*Penicillium* sp. USU	Mean
		----------------------------	cm	---------------------------	
2	Without Mycorrhiza	15.31	16.65	16.25	16.07
	Mycorrhiza (5 g)	15.47	16.72	16.49	16.23
	Mycorrhizl (10 g)	15.75	17.04	16.93	16.57
	Mycorrhial (15 g)	16.09	17.89	17.09	17.02
	Mean	15.66	17.07	16.69	
3	Without Mycorrhiza	20.93	24.23	24.23	23.13
	Mycorrhiza (5 g)	23.77	25.60	24.58	24.65
	Mycorrhiza (10 g)	24.22	24.63	26.61	25.16
	Mycorrhiza (15 g)	24.20	27.58	27.21	26.33
	Mean	23.28	25.51	25.66	
4	Without Mycorrhiza	36.66	37.75	37.90	37.44
	Mycorrhiza (5 g)	37.29	39.90	39.87	39.02
	Mycorrhiza (10 g)	37.37	39.59	39.74	38.90
	Mycorrhiza (15 g)	37.38	42.98	42.42	40.93
	Mean	37.18	40.06	39.98	

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Table 2.Average Degree of Mycorrhizal Infection in 2 WAA, 4 WAA, 6 WAA and 8 WAA by Application of Mycorrhiza and *Penicillium* sp. in Paddy Field.

WAA	Treatments	Without *Penicillium*	*Penicillium* sp. Mursala	*Penicillium* sp. USU	Mean
		----------------------------------%------------------------------			
2	Without Mycorrhiza	10,00	11,67	11,67	11,11 c
	Mycorrhiza(5 g)	21,67	26,67	20,00	22,78b
	Mycorrhiza (10 g)	25,00	25,00	25,00	25,00ab
	Mycorrhiza (15 g)	35,00	30,00	31.67	31,11 a
	Mean	22,08	23,33	22,08	
4	Without Mycorrhiza	16.17	25,00	21,67	21,11 b
	Mycorrhiza (5 g)	21,67	25,00	31,67	26,11ab
	Mycorrhiza (10 g)	40,00	33,33	31,67	35,00 a
	Mycorrhiza (15 g)	45,00	43,33	43,33	43.89 a
	Mean	30,83	31,67	32,08	
6	Without Mycorrhiza	25,00	31,67	28,33	28,33 d
	Mycorrhiza (5 g)	33,33	38,33	41,67	37,78 c
	Mycorrhiza (10 g)	50,00	46,67	43,33	46,67 b
	Mycorrhiza (15 g)	51,67	55,00	56,67	54,44 a
	Mean	40,00	42,92	42,50	
8	Without Mycorrhiza	28,33	31,67	33,33	31.11 d
	Mycorrhiza (5 g)	38,33	41,67	45,00	41,67 c
	Mycorrhiza (10 g)	50,55	50,00	46,67	48,89 b
	Mycorrhiza (15 g)	55,00	58,33	58,33	57,22 a
	Mean	42,92	45,42	45,83	

Description: The number followed by the same notation on the same row, same coloum and same WAA indicates that it is not different significantly according to Duncan Multiple Range test at the 5% level.

Seed Weight per Plant

The observations results of seed weight per plant showed that the interaction and each treatment of mycorrhiza and phosphate solubilizing microbes can increase the weight of seeds per plant compared to the ones without treatment. The highest average weight of seeds per plant on mycorrhiza application was obtained from the application of mycorrhizal 15 g/plant that is 13.58 g/plant and significantly different from other treatments, whereas in phosphate microbial applications *Penicillium* sp Mursala 20 mL showed the highest results of 15.50 g/plant. The interaction of mycorrhizal 15 g/plant and *Penicillium* sp Mursala 20 ml showed the highest yield of 16.76 g/plant (table 4).

DISCUSSION

The application of *Penicillium* sp was able to increase the growth of mung beans in paddy field because *Penicillium* sp is able to dissolve P nutrients by producing organic acids which can chelate metal ions that bind phosphate ions hence the phosphate can be absorbed by plants. This is in accordance with Wakelin *et al* (2007) statement that microbial inoculants such as *Penicillium* sp are generally able to increase P by inorganic P dissolution.

The population of *Penicillium* sp. Mursala was higher than *Penicillium* sp USU. It occurred due to the adaptability of *Penicillium* sp Mursala in mung bean plantation on paddy field area was better than *Penicillium* sp. USU (213 x 10^7 CFU/ml). It also occured since the initial population of *Penicillium* sp. Mursala (272 x 10^7 CFU/ml) was also higher than *Penicillium* sp. USU (213 x 10^7 CFU/ml). In addition, *Penicillium* sp. could grow rapidly if it was placed in an appropriate condition. Paddy soil is the kind of soil with pH desired by fungi that is 6.2 (neutral). A study by Sembiring and Fauzi (2017) also stated that phosphate solubilizing fungi such as *Penicillium* sp in rhizosphere of potato plant was able to grow well in Andisol soil because it provided a good condition for the growth of *Penicillium* sp.

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Table 3. Population of *Penicillium* sp in Mung Bean Rhizosphere in Second Week and Fourth Week After Application (WAA) affected by Application of Mycorrhiza and *Penicillium* sp in Paddy field.

WAA	Treatments	Without *Penicillium*	*Penicillium* sp. Mursala	*Penicillium* sp. USU	Mean
		--------------------x 10^7 CFU/ml----------------------			
2	Without Mycorrhiza	0	18.17	20.17	12.78
	Mycorrhiza (5 g)	0	17.00	15.67	10.89
	Mycorrhiza (10 g)	0	20.17	19.83	13.33
	Mycorrhiza (15 g)	0	17.00	21.83	12.94
	Mean	0c	18.08b	19.38a	
4	Without Mycorrhiza	0g	31.00c	18.33ef	16.44
	Mycorrhiza (5 g)	0g	20,67e	16.67f	12.44
	Mycorrhiza (10 g)	0g	35.00b	20.33ef	18.44
	Mycorrhiza(15 g)	0g	38.67a	25.67e	21.44
	Mean	0	31.33	20.25	

Description:The number followed by the same notation on the same row, same coloum and same WAA indicates that it is not different significantly according to Duncan Multiple Range test at the 5% level.

Table 4.Average Seed Weight per Plant by the Application of Mycorrhiza and *Penicillium* sp in Paddy fileds

Treatments	Without *Penicillium*	*Penicillium* sp. Mursala	*Penicillium* sp. USU	Mean
	------------------------g/plant---------------------			
Without Mycorrhiza	8,24 d	14,44 b	13,52 b	12,07
Mycorrhiza (5 g)	9,12 d	15,52 ab	13,18 b	12,61
Mycorrhiza (10 g)	10,81 c	15,29 ab	13,01 b	13,04
Mycorrhiza (15 g)	10,87 c	16,76 a	13,11 b	13,58
Mean	9,76	15,50	13,20	

Description: The number followed by the same notation on the same row, same coloum and same WAA indicates that it is not different significantly according to Duncan Multiple Range test at the 5% level.

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Hasanuddin and Bambang (2004) stated that phosphate solubilising microbes could remove organic acids which would then bind the elements that bound unavailable phosphorus. Organic acids such as citric acids, glutamates, succinates and glyoxylates released by phosphate solubilising microbes will chelate Fe, Al, Ca, and Mg hence the phosphorus that is strongly bound becomes soluble and available, thus the plant will get the nutrients needed for plant development. According to Illmer and Schinner (1992), the mechanism of chemical phosphate dissolution is the main phosphate dissolution mechanism carried out by microorganisms. These microorganisms excrete a number of low molecular weight organic acids such as oxalate, succinate, tartrate, citrate, lactate, α-ketoglutaric, acetate, formate, propionate, glycolic, glutamate, glyoxylate, malate, and fumarate.

Budiman (2004) stated that the availability of sufficient nutrients at the time of growth causes plant metabolism to be more active hence the process of elongation of cell division and differentiation will be better which will ultimately encourage fruit weight to increase. The availability of element P causes photosynthesis allocated to the fruit becomes large hence the size of the fruit is larger. The photosynthesis process of other important compounds for growth will also increase so as to produce high assimilation

The application of mycorrhiza at a dose of 15 g combined with *Penicillium* sp Mursala increases the highest height of mung bean plants compared to the control treatment. It is due to the ability of mycorrhiza to encourage the root growth, thus more nutrients are absorbed by plants. Fitriatin (2009) stated that absorption capacity of mychorrhizal plants could be increased directly through external hypha braid, and indirectly due to the physiological changes in roots. This braid widened the further absorption surface area to find nutrients and water which were relatively out of reach by the root system.

Mycorrhizal infection is known to increase plant growth due to an increase in nutrient uptake. This is consistent with the literature of Sitrianingsih (2010), which stated that the uptake of nitrogen, phosphorus, and potassium is limited by the level of diffusion of each element in the soil. However, the presence of mycorrhiza can increase nutrient uptake through diffusion of nutrients from the soil to the roots because the absorption area by mycorrhizal hyphae is wider, thereby increasing the plant growth.

Soil P solubility is obtained through the release of phosphate enzymes produced by mycorrhiza. Increased plant growth due to symbiosis between plant roots and mycorrhiza is found to be greater in P sources that are difficult to dissolve compared to P sources that are easy to dissolve. The availability of P nutrients in the soil which is one of the essential nutrients is needed by plants, especially in the early reproductive (generative) development of plants (Sastrahidayat, 2011).

The P element stimulates flowering, fertilization, seed formation and root growth. If the plant lacks of P, the plant will grow stunted, the tissue becomes weak and susceptible to disease pests, and unable to produce optimally. Suratmin et al (2017) stated that P functions as a constituent of fats and protein, the P nutrient is the nucleus of cells and can accelerate physiological processes.

The availability of nutrients will affect the process of cell elongation and division which will encourage the development of plants to increase plant production. Husin (2000) suggested that mycorrhizal fungi with external hyphae can increase the absorption of immobilized elements in the soil such as elements P, Co, and Zn, hence the needs of plant nutrient can be met. In addition, mycorrhizal fungi can also increase the production of growth hormones such as auxin, cytokinins and gibberellins for its host plants. Sastrahidayat (2011) also stated that the application of mycorrhiza can also help plants to get water due to mycorrhizal infections found in the roots of plants. It can meet the needs of plants in the development of mung bean seeds hence mung bean plants can produce optimally.

CONCLUTION

Dose of mycorrhizae and Penicillium sp did not significantly influence the height of mung bean plants, but significantly affected the population of Penicillium sp. The application of 15 g mycorrhiza with Penicillium sp from Mursala was the best treatment for the growth of mung bean plants at 4 weeks after planting (42.98 cm) and the interaction of mycorrhizal 15 g / plant and Penicillium sp Mursala produced the best seeds, 16.76 g / plant.

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