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Effect of Pseudomonas fluorescens Bacteria on Sow and Pocket Fertilization Methods in Ultisol Soil Planting Media on Phaseolus radiatus L. Plant Growth

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ABSTRACT

Pseudomonas fluorescens is one type of Pseudomonas bacteria that is good for plants. This bacterium is included in a group of bacteria that promote plant growth (PGPR). Pseudomonas fluorescens can play an active role in plants, which can increase plant resistance to disease, this is because it can produce an antibiotic called phenazine and an aerobic, gram negative, and ubiquitous organism found in agricultural soils and can adapt well to grow and develop in the Rhizosphere. Ultisol soil is a type of soil where the level of soil fertility is low, so it is very rarely used, one of the elements of phosphorus (P) becomes inward for Phaseolus radiatus L. plants so that inorganic fertilization methods are needed in spurring its growth. This study aims to determine the ability of Pseudomonas fluorescens bacteria as phosphate solvents in Phaseolus radiatus L. plants and effective fertilization methods for plant growth. The results showed that the ability of Pseudomonas fluorescens bacteria could make the growth of Phaseolus radiatus L. become better and more fertile and had a real effect on the dose given high in all research parameters.

Keywords: Phosphorus, Pseudomonas Fluorescens, Ultisol, Phaseolus Radiatus

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INTRODUCTION

Phaseolus radiates L. plants are plants that include legumes (*Fabaceae*) and have many benefits in life. The content of *Phaseolus radiates* L. plants has many benefits, which can cure beriberi, anaemia, haemorrhoids, liver disorders and other diseases (Indraswari *et al*., 2020). *Phaseolus radiates* L. plants are also a very important and much-loved vegetable protein producer, in addition, *Phaseolus radiatus* L. seeds contain vitamin B1 which can prevent beriberi disease (Phoelman, 1991 *in* Nur *et al*., 2018). Ultisol soil is one type of soil which has a low percentage of nutrients, as well as low organic matter (BO) content. The low level of acidity in Ultisol soils averages <4.50, high aluminium (Al) saturation, and this causes low availability of nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), and molybdenum (Mo) (Prasetyo and Suriadikarta, 2006 *in* Cindy *et al*., 2024). Magnesium (Mg) deficiency that occurs in plants grown in magnesium (Mg) deficient soil will occur, which has a Ca:Mg ratio of 7:1.

Most humid soils with large textures and calcitic lime cause Ca and Mg deficiency and eventually cause severe Mg deficiency (Lubis, 2020). Ultisol soil is a type of soil where the level of soil fertility is low, so it is very rarely used, one of the elements of phosphorus (P) becomes a constraint for *Phaseolus radiatus* L. plants so that inorganic fertilization methods are needed in spurring their growth. Some bacteria can play a role in stimulating plant growth either directly or indirectly. *Pseudomonas fluorescens* is one type of *Pseudomonas* bacteria that is good for plants. This bacterium is included in a group of bacteria that spur plant growth promoting rhizobachteria (PGPR).

Pseudomonas fluorescens can play an active role in plants, which can increase plant resistance to disease, this is because it can produce an antibiotic called phenazine and is an aerobic, gram negative, and ubiquitous organism found in agricultural soils and can adapt well to grow and develop in the *Rhizosphere* (Bloemberg and Lugtenberg, 2001). The fertilization method must follow the 4Ts of fertilization, namely the right type, the right dose, the right time and the right method. The sow fertilizer method is the application of fertilizer on top of the soil or spread over the soil surface. While the benam or pocket fertilization method is the application of fertilizer by giving a hole in the ground, then inserting the fertilizer, this is more effective because the fertilizer does not evaporate and is not washed by watering water (Slamet, 2019 *in* Lubis, 2023).

In the sowing fertilization method, it has been widely practiced by farmers in fertilising plants. while the benam or pocket fertilization method is rarely done in horticultural agricultural crops, because it is less effective for time management, but it is very effective on plants because plants directly absorb nutrients when fertilizers are wetted by water and exposed to plant roots. Pocket fertilization methods have been done but in the plantation sector only, the agricultural sector has not (Lubis, 2023). In this study, the analysis of sowing and pocket fertilization methods with *Pseudomonas fluorescens* bacterial isolates was tested on the growth of *Phaseolus radiatus* L. plants on Ultisol planting media.

METHOD

This study was conducted in the nursery garden of the Soil Management Field Laboratory, Institut Teknologi Sawit Indonesia, Medan. Soil samples were taken from an oil palm nursery, Tanjung Morawa, North Sumatera, river sand as media mix, and compound inorganic fertilizer (N.P.K+Mg+Ca) 16.16.16+0.5+6.

In this study, the *Phaseolus radiatus* L. seedlings used were the Vima 1 variety. *Phaseolus radiatus* L. *var*. Vima 1 seedlings were planted in polybags at the age of 2 weeks. This research was conducted for 2 months. In this study, using a factorial randomised group design (RGD) with 3 repetitions, which consisted of 2 treatment factors, namely the treatment of *Pseudomonas fluorescens* bacteria and the treatment of fertilization methods. Factor 1 consisted of *Pseudomonas fluorescens* bacteria (B) treatment with a dose of 100 ml.polybag^{-1}.month^{-1}. Factor 2 consisted of fertilization methods, namely Sow (S) and Pocket (P) consisting of doses of 5 g.polybag^{-1} and 10 g.polybag^{-1}, where S_1 = 5 g.polybag^{-1}, S_2 = 10 g.polybag^{-1}, and P_1 = 5 g.polybag^{-1}, P_2 = 10 g.polybag^{-1}.

Soil analysis and experiments were conducted at the Soil Laboratory, Indonesian Oil Palm Research Institute (IOPRI or PPKS) Medan, and the Soil, Plant, Fertilizer and Water Laboratory at the Institute for Agricultural Technology (IAT or BPTP) Johor, Medan, North Sumatera. The parameters and indicators observed were Plant Vegetative Analysis namely Plant Height (cm), Number of Branches (twigs), Root Length (cm), Plant and Soil Nutrient P Uptake Analysis namely Plant Nutrient P Uptake (g.plant^{-1}), P_2O_5-Soil Available (ppm P), P_2O_5-Total (%) soil, and Initial and Final Soil Chemical Analysis namely pH (H_2O) Soil, C-Organic content Soil (%), P_2O_5-avl P-Bray I (ppm P) Soil, N-Total (%) Soil, K_2O-Potential Ex. HCl 25% (me.100 g^{-1}), Soil Texture (%), Aluminium Saturation (%), Al-dd (me.100 g^{-1}), Ca-dd (me.100 g^{-1}), K-dd (me.100 g^{-1}), Mg-dd (me.100 g^{-1}), MnO Ex. HCl 25% (%), Soil CEC (me.100 g^{-1}).

RESULTS AND DISCUSSION

Initial Soil Analysis – Ultisol Soil

From the initial soil analysis on Ultisol soil, the results obtained from the soil laboratory can be seen in Table 1 as follows:

Table 1. Preliminary Analysis Results - Ultisol Soil

Texture	Methods of Analysis	Units	Results	Description
✓ Sand	Hydrometer	%	17.00	*Dusty Clay*
✓ Dust			44.00	
✓ Clay			52.00	
C-Organic	Spectrofotometry	%	1.80	l
N-Total	Kjedhal	%	0.28	l
P_2O_5-avl (P-Bray I)	Spectrofotometry	ppm P	5.00	l
K_2O Potential Ex. HCl 25%	AAS	me.100 g^{-1}	0.30	l
MnO Ex. HCl 25%	Spectrofotometry	%	0.27	h
CEC	Volumetry	me.100 g^{-1}	3.78	vl
pH H_2O	Elektrometry	-------	4.10	*Sour*
Al Saturation	Titrimetry	%	0	nm
Al-dd		me.100 g^{-1}	0	nm
Ca-dd	AAS	me.100 g^{-1}	4.39	l
K-dd			0.21	l
Mg-dd			0.70	l

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

In the laboratory research results, seen from the results of the initial analysis of Ultisol soil, that in the soil texture the results are dusty clay, the results of the sand fraction are lower than the dust and clay fractions. Sand fraction is 17.00%, compared to dust fraction 44.00%, clay fraction 52.00%. And this shows that Ultisol soil has a lot of clay content.

In the soil nutrient analysis, it was found that soil macro-nutrients were analysed as low in the soil. Likewise, low organic matter resulted in low organic carbon, with a C-Organic result of 1.80%. Manganese was found to be high, with 0.27% analysed. Cation Exchange Capacity (CEC) was very low with an analysed result of 3.78 me.100 g^{-1} soil. Soil acidity (pH) in Ultisol soil has the status of acid criteria with an analysed value of 4.10.

In the analysis of Aluminium saturation, the analysis results are not measurable, as well as in aluminium exchangeable, the analysis results are not measurable. From both analyses of aluminium levels, both saturated aluminium levels or aluminium saturation and exchangeable aluminium, the results were not analysed and the results were not measurable. This indicates that there is no aluminium saturated and left in the soil, so that Ultisol soil is not toxic to plants and Ultisol soil does not contain aluminium and aluminium-bound nutrient levels, so it is suitable for agricultural cultivation planting media (Lubis, 2023).

The results of the analysis of exchangeable calcium soil (Ca-dd), exchangeable potassium soil (K-dd) and exchangeable magnesium soil (Mg-dd) get low analysis results. Where the analysis level of exchangeable potassium is 0.21 me.100 g^{-1} soil with low criteria, while exchangeable calcium has a result of 4.39 me.100 g^{-1} soil. This can happen because Ultisol soil has high manganese oxide, so that potassium and calcium nutrients can be exchanged with higher nutrient levels, or this can be related to the availability of nutrients strongly related to nutrient H^+ ions or pH in the soil (Lubis, 2023).

Low levels of calcium (Ca) and magnesium (Mg) nutrients that can be exchanged, so that the levels of these nutrients are more difficult to be absorbed by plants so that they are easily washed away by water or low levels of potassium and magnesium needed and can be exchanged to be less available due to the presence of higher nutrients, and related to the physical properties of the soil, Ultisol soil, still contains high levels of clay so that calcium and magnesium are slowly available to plants (Leiwakabessy *et al.*, 2002 *in* Hasibuan, 2023).

Final Soil Analysis – Ultisol Soil

From the initial soil analysis on Ultisol soil, the results obtained from the soil laboratory can be seen in Table 2 as follows:

Table 2. Final Analysis Results - Ultisol Soil

Texture	Methods of Analysis	Units	Results	Description
✓ Sand	Hydrometer	%	19.20	*Dusty Clay*
✓ Dust			40.10	
✓ Clay			39.70	
C-Organic	Spectrofotometry	%	4.00	m
N-Total	Kjedhal	%	0.58	h
P_2O_5-avl (P-Bray I)	Spectrofotometry	ppm P	12.10	h
K_2O Potential Ex. HCl 25%	AAS	me.100 g^{-1}	1.05	h
MnO Ex. HCl 25%	Spectrofotometry	%	0.17	m
CEC	Volumetry	me.100 g^{-1}	23.40	m
pH H_2O	Elektrometry	------	5.60	*Slightly Sour*
Al Saturation	Titrimetry	%	0	nm
Al-dd		me.100 g^{-1}	0	nm
Ca-dd	AAS	me.100 g^{-1}	6.00	m
K-dd			0.42	m
Mg-dd			0.88	l

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

In Table 2, it can be seen the results of the final soil analysis on Ultisol soil. The results of soil analysis seen from the texture of Ultisol soil, that the results of the dusty clay criteria remain, where the sand fraction has increased by 19.20% from the initial 17.00%, so the average is 2.2% increase due to the addition of compound fertilizer. The dust fraction decreased where the final result was 40.10% which was originally 44.00%, thus experiencing a 3.9% decrease in the dust fraction. The clay fraction resulted in 39.70%, which was initially 52.00%. So that the analysis results decreased by 12.30%. This proves that the role of *Pseudomonas fluorescens* bacteria and compound inorganic fertilizer 16.16.16+0.5+6 can make the Ultisol soil fraction which is clumpy dense and clayey when wet into a little clay (Lubis, 2023).

The results of soil chemical analysis on soil C-Organic content have a level of 4.00% which has increased. Likewise, the macro nutrients of Nitrogen, Phosphorus, and Potassium increased with the role of the addition of compound fertilizer N.P.K+Mg+Ca 16.16.16+0.5+6 and *Pseudomonas fluorescens* bacteria in the soil. The increase in phosphorus nutrients in the soil that can be utilised by plants is due to the *Pseudomonas fluorescens* bacteria isolating the roots of *Phaseolus radiatus* L. plants where there is a well-developed rhizosphere in the soil. The statement of Muthiah *et al*. (2023) states that *Pseudomonas fluorescens* can play an active role in plants, which can increase plant resistance to disease, this is because it can produce an antibiotic called phenazine and an aerobic, gram negative, and ubiquitous organism found in agricultural soils and can adapt well to grow and develop in the *Rhizosphere*.

On exchangeable aluminium and aluminium saturation, resulting in unmeasured values, on calcium, magnesium, and potassium nutrients resulting in nutrient increases, so that nutrients that are low in the soil become available in the soil (Lubis *et al*., 2023).

Analysis of Plant and Soil Nutrient P Uptake

Analysis of Plant and Soil Nutrient P Uptake is a study aimed at evaluating the ability of plants to absorb phosphorus (P) from the soil and the availability of phosphorus in the soil-plant system. Phosphorus is an essential macronutrient that plays a vital role in photosynthesis, energy (ATP) production, root growth, flowering, and seed formation. This analysis generally involves measuring the levels of available phosphorus in the soil (e.g., using the Bray I, Olsen, or Mehlich methods) and the phosphorus content in plant tissues through laboratory analysis using spectrophotometry or ICP (Inductively Coupled Plasma). The results of the analysis provide an overview of phosphorus uptake efficiency, nutrient adequacy, and the potential for phosphorus deficiency or fixation in the soil. This information is crucial for proper fertilization planning, increasing plant productivity, and managing soil fertility sustainably. From soil analysis on plant and soil P nutrient uptake, the results of analysis from the soil laboratory can be seen in Table 3 as follows:

Table 3. Analysis of Plant and Soil Nutrient P Uptake

Soil and Plant P Nutrient Analysis					
Treatment	**Plant P Nutrient Uptake (g.plant^{-1})**	**P_2O_5 Available Soil**	**Description (ppm P)**	**Total Soil P_2O_5**	**Description (%)**
S_1B_1	0.18 a	5.60	l	0.08	h
S_2B_1	0.22 b	5.73	l	0.09	h
P_1B_1	0.21 b	5.74	l	0.10	h
P_2B_1	0.26 c	6.10	l	0.14	h

Description: Criteria for Planting Media, h = High, l = Low, m = Medium, sl = Slightly Low, vl = Very Low, vh = Very High, nm = Not Measurable

From the results of the analysis of soil and plant P uptake, produced in Table 3, where the results of the analysis of P nutrient uptake in plants that the greatest in the treatment of pocket fertilization method with a dose of 10 g.polybag^{-1} and the application of *Pseudomonas fluorescens* bacteria at a dose of 100 ml.polybag^{-1}.month^{-1}. This indicates that *Pseudomonas fluorescens* bacteria have isolated the roots of *Phaseolus radiatus* L. plants so that they form a *rhizosphere* in the roots of plants, and so that phosphorus can be available to plants and increase the uptake of P nutrients from *Pseudomonas fluorescens* bacteria and P nutrients are more available to plants in the soil. *Pseudomonas fluorescens* formulated by the fertilization method will be able and easy to absorb the nutrients given in the soil which is very poor in these nutrients so that it will be available for plant growth (Cindy *et al*., 2024; Lubis, 2023).

In the analysis of Soil Available Phosphorus, it was found that it had low levels of phosphorus nutrients and, and it turns out that when viewed in Table 3, *Pseudomonas fluorescens* bacteria isolating the roots of *Phaseolus radiatus* L. plants were higher than the other treatments, namely

6.10 ppm P. This indicates that the ability of microbial phosphate solubilisers in *Pseudomonas fluorescens* is very much determined on the media where the microbes live, and their ability to dissolve phosphate depends on the type of soil as well.

In the analysis of Total Soil Phosphorus, seen in Table 3, the results are high criteria in the treatment of sowing fertilization method and pocket in the application of *Pseudomonas fluorescens* bacteria. That way, the treatment of pocket fertilization method with a high dose of 10 $g.polybag^{-1}$ and the application of *Pseudomonas fluorescens* bacteria at a dose of 100 $ml.polybag^{-1}.month^{-1}$ became the highest treatment of 0.14% in Total Soil P in all treatments on *Phaseolus radiatus* L. plants.

Vegetative Analysis of Plants

From the analysis of vegetative plant growth, the results of analysis from the field can be seen in Table 4 as follows:

Table 4. Vegetative Analysis of *Phaseolus radiatus* L. Plants

Treatment	Vegetative Analysis of *Phaseolus radiatus* L. Plants		
	Plant Height (cm)	Number of Breaches (twigs)	Root Length (cm)
S_1B_1	51.70 a	12.33 a	23.88 a
S_2B_1	53.15 b	14.80 b	25.77 b
P_1B_1	55.78 c	13.70 b	26.83 b
P_2B_1	59.77 d	14.92 b	28.31 c

Description: Number followed by the same index in the same row or colomn showed no the significant difference according to the DMRT test (*Duncan's Multiple Range Test*) 95% confidence level (α = 0,05)

In the observation results in Table 4, it can be seen that in the growth of plant height, the treatment of sow fertilization method with a dose of 5 $g.polybag^{-1}$ is significantly different from the fertilizer dose of 10 $g.polybag^{-1}$, as well as the pocket fertilization method with a dose of 5 $g.polybag^{-1}$ is significantly different from the dose of 10 $g.polybag^{-1}$. and the growth shows only 2 months of planting in Ultisol soil, can make plant growth fertile and good with the help of *Pseudomonas fluorescens* bacteria. This is due to the role of bacteria that help isolate the addition of P into the roots of plants and help increase soil fertility and porosity and help in improving soil structure and texture, as well as the right fertilizer nutrients given, macro-nutrient fertilizers N.P.K+Mg+Ca 16.16.16+0.5+6 are highly utilised by plants in their growth. This is in accordance with the opinion of Murbandono (2014) *in* Mayawi *et al*. (2022) that, soil microorganisms are able to increase soil binding capacity to water, facilitate plant root growth, due to improving and increasing soil porosity, soil pores and soil fertility.

Analysis of observations of the number of branches or twigs is significantly different from the application of sowing method fertilizer at a dose of 5 g.polybag^{-1} compared to other treatments. Although not significantly different, but from the analysis there was a change in the addition of productive branches from *Phaseolus radiatus* L. plants. This is thought to be due to the role of *Pseudomonas fluorescens* bacteria or microbes in the soil, thus contributing nutrients to support the growth of *Phaseolus radiatus* L. plants and influencing the growth of plant productive branches. This is in accordance with the opinion of Rosmawaty *et al*. (2018) *in* Mayawi *et al*. (2022) that, microorganisms are able to provide nutrients into plants to support plant growth and can have an influence on plant branch growth.

The observation of root length of *Phaseolus radiatus* L. showed that it was significantly different from all treatments. The highest root length was the treatment of pocket fertilization method with a dose of 10 g.polybag^{-1} and the application of *Pseudomonas fluorescens* bacteria 100 ml.polybag^{-1}.month^{-1} being the highest root length with a result of 28.31 cm. This is because the *Pseudomonas fluorescens* banteri has isolated the roots of *Phaseolus radiatus* L. plants with the Rhizosphere attached to the roots of plants and provides p nutrients to plants, and the method of pocket fertilization method is also very good because the nutrients are directly exposed to the roots and utilised by plants in their growth and the application of sowing and pucket fertilizer does not forget to be directly watered by water so that it is quickly dissolved into the soil. According to the opinion of Muthiah *et al*. (2023) that, *Rhizobacteria* from *Pseudomonas fluorescens* is a trigger for plant root growth so that plant roots will experience elongation and this bacterium is able to adapt both in the soil and plant roots and grow in the *Rhizosphere*.

CONCLUSION

Based on the results of research conducted in testing the growth of *Phaseolus radiatus* L. plants with sowing and pocket fertilization methods and the application of *Pseudomonas fluorescens* bacteria, it has increased and the plants are fertile and the increase in growth is good and has increased. The results of *Duncan's Multiple Range Test* analysis showed a significant effect of bacterial application and fertilization method on plant growth.

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