JURNAL MEDIA AKADEMIK (JMA)
Vol.4, No.3 Maret 2026
e-ISSN: 3031-5220; DOI: 10.62281, Hal XX-XX
PT. Media Akademik Publisher
AHU-084213.AH.01.30.Tahun 2023

THE ROLE OF *AZOTOBACTER CHROOCOCCUM* AND *AZOTOBACTER PASPALI* BACTERIA IN *BROADCAST* FERTILIZATION METHODS IN ULTISOL PLANTING MEDIA ON THE GROWTH OF *PHASEOLUS RADIATUS* (L.) FABACEAE. PLANTS

Oleh:

Sartika Pakpahan[1]
Erwin Junaidi Lubis[2]

Universitas Darwan Ali
Alamat: JL. Batu Berlian No. 10, Mentawa Baru Hulu, Kec. Mentawa Baru Ketapang Kabupaten Kotawaringin Timur, Kalimantan Tengah (74321)
Korespondensi Penulis: sartika@unda.ac.id, erwinjunaidilubis@unda.ac.id

Abstract. Azotobacter bacteria are a type of bacteria that can capture nitrogen from the air and convert it into nutrients that can be absorbed by plants. This process is called nitrogen fixation, which is an important nutrient in plant growth. Azotobacter chroococcum and Azotobacter paspali bacteria are very useful for soil fertility. These bacteria maintain the balance of microbes in the soil and improve the physical properties of the soil, one of which is soil structure. With the addition of these bacteria to Ultisol soil, the Ultisol soil becomes more fertile and better due to the addition of plant fertilization using the Broadcast method, and the soil will be better at storing water and nutrients in the soil for the growth of Phaseolus radiatus (L.) Fabaceae. plants. In this study, the application of Azotobacter chroococcum and Azotobacter paspali bacteria formulated with the Broadcast fertilization method at a rate of 10 g.polybag-1 was the best treatment for the growth of Phaseolus radiatus (L.) Fabaceae. plants.

Keywords: Azotobacter chroococcum, Azotobacter paspali, Broadcast, Phaseolus radiatus, Ultisol

Received January 22, 2026; Revised February 05, 2026; March 03, 2026
*Corresponding author: *sartika@unda.ac.id*

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Abstrak. *Bakteri Azotobacter merupakan salah satu jenis bakteri yang mampu menangkap nitrogen dari udara serta mengubahnya menjadi zat hara yang dapat diterima oleh tanaman. Pada hal ini, proses disebut dengan fiksasi nitrogen yang dimana merupakan unsur hara penting dalam pertumbuhan tanaman. Bakteri Azotobacter chroococcum dan bakteri Azotobacter paspali menjadi bakteri yang sangat berguna bagi kesuburan tanah serta bakteri ini menjaga keseimbangan mikroba di dalam tanah serta memperbaiki sifat fisik tanah salah satunya pada struktur tanah. Dengan adanya pemberian bakteri ini di media tanah Ultisol, maka tanah Ultisol menjadi tanah yang subur serta lebih baik dikarenakan adanya penambahan pemupukan tanaman dengan metode Broadcast dan tanah akan menjadi lebih baik dalam hal menyimpan air serta hara nutrisi di dalam tanah untuk pertumbuhan tanaman Phaseolus radiatus (L.) Fabaceae. Dalam penelitian ini, pengaplikasian bakteri Azotobacter chroococcum dan Azotobacter paspali di formulasikan dengan metode pemupukan Broadcast pada taraf 10 g.polibag^{-1} menjadi perlakuan terbaik bagi pertumbuhan tanaman Phaseolus radiatus (L.) Fabaceae.*

Kata Kunci: *Azotobacter chroococcum*, *Azotobacter paspali*, *Broadcast*, *Phaseolus radiatus*, Ultisol

INTRODUCTION

Phaseolus radiatus (L.) Fabaceae. This is a type of bean plant in agriculture that belongs to the Legume family (Fabaceae) and also has great benefits in life. The compounds found in *Phaseolus radiatus* (L.) Fabaceae. have significant benefits, one of which is for health, namely curing anaemia, liver disorders, beriberi, and others (Indraswati *et al*., 2018 *in* Lubis & Hariyanto, 2026).

Ultisol soil is a type of young soil with a brownish-yellow or reddish-yellow colour that has not yet fully developed. Inceptisol soil has a very weak soil profile, characterised by a cambic horizon (change in colour or structure) but without significant clay accumulation. However, the colour of Inceptisol soil is generally brown or grey, has

loose properties, and is very suitable for rice and secondary crop farming with the addition of organic fertilizer.

Ultisol soil is a material on the earth's surface that is formed from the process of soil formation (*pedogenesis*) over a very long period of time, so that the formation process takes a very long time. The formation process is controlled by five factors, namely parent material, climate, topography, vegetation, and time. Of these five factors, the most influential are climate and vegetation.

The physical properties of Ultisol soil are environmental factors that greatly influence water availability, soil air, and directly affect plant nutrition (Harahap *et al*., *in* Oktapiani *et al*., 2024).

One of the supporting factors in crop productivity that is very important to know is the physical properties of the soil. Although Ultisol soil has favourable chemical properties, if the physical properties of the soil are not taken into account, good crop production will not be achieved.

On Ultisol soils, the percentage of Ultisol soil types is the lowest, with low to very low organic matter content, Inceptisol soil acidity (pH) with an average level of <4.50, and high aluminium (Al) content. This results in low availability of nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S) and molybdenum (Mo) is low or very low (Cindi *et al*., 2024 *in* Lubis *et al*., 2023).

Ultisol soil has a coarse texture and is moist, causing Ca and Mg deficiencies and exacerbating Mg deficiencies over time (Lubis, 2020).

In the study by Hastomo *et al*. (2010), it was found that the effective application of *Azotobacter* bacteria in increasing crop productivity was capable and very good for plants in terms of production. Research experiments continued to be carried out on soil conditions that were given compost fertilizer from animal manure. In addition, nitrogen fertilizer could also be applied to determine the role of *Azotobacter* bacteria in the application of chemical fertilizers.

In previous studies by Scolofsky & Wyss (1961) and Sartaj (2016), it was shown that polybags inoculated with the bacteria *Azotobacter chroococcum* and *Azotobacter paspali* produced the highest seed weight when inoculated with bacteria compared to those without bacteria. In addition, the growth of plants fertilised with animal manure compost was better and without sterilisation.

The fertilization method must follow the 4T of fertilization, namely the right type, the right dose, the right time and the right method. The *Broadcast* fertilizer method is the application of fertilizer on top of the soil or spread over the soil surface. (Slamet, 2019 *in* Lubis, 2023).

In the sowing fertilization method, it has been widely practiced by farmers in fertilizing plants. while the *Broadcast* 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 (Lubis, 2023).

RESEARCH METHOD

This research was conducted over a period of 3 months, from Januari 2024 to April 2024. 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.) Fabaceae. 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 3 months. In this study, using a factorial randomised group design (RGD) with 3 repetitions, which consisted of 2 treatment factors, namely the treatment of *Azotobacter chroococcum* and *Azotobacter paspali* bacteria and the treatment of fertilization methods. Factor 1 consisted of *Azotobacter chroococcum* and *Azotobacter paspali* bacteria (A) treatment with a dose of 100 ml.polybag^{-1}.month^{-1}. Factor 2 consisted of fertilization methods, namely *Broadcast* (B) consisting of doses of B_1 = 2,5 g.polybag^{-1}, B_2 = 5 g.polyba^{-1}, B_3 = 7,5 g.polybag^{-1}, B_4 = 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), 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}).

RESULT 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	%	15.20	*Dusty Clay*
✓ Dust			44.10	
✓ Clay			32.20	
C-Organic	Spectrofotometry	%	1.70	l
N-Total	Kjedhal	%	0.29	l
P_2O_5-avl (P-Bray I)	Spectrofotometry	ppm P	5.10	l
K_2O Potential Ex. HCl 25%	AAS	me.100 g^{-1}	0.80	l
MnO Ex. HCl 25%	Spectrofotometry	%	0.26	h
CEC	Volumetry	me.100 g^{-1}	3.68	vl
pH H_2O	Elektrometry	-------	4.00	*Sour*
Al Saturation	Titrimetry	%	0	nm
Al-dd		me.100 g^{-1}	0	nm
Ca-dd	AAS	me.100 g^{-1}	4.19	l
K-dd			0.20	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

Laboratory research results, based on preliminary analysis of Ultisol soil, show that the texture of Ultisol soil is dusty clay. The sand fraction is lower than the silt and clay fractions. The analysis results show that the sand fraction is 15.20%, compared to the silt fraction of 44.10% and the clay fraction of 32.20%. This indicates that Ultisol soil contains a high clay content.

In the analysis of soil element levels in Ultisol soil, it was found that the soil's macro-nutrient content was low. Similarly, the low organic matter content resulted in low organic carbon content, with an organic carbon result of 1.70%. Manganese nutrient levels were found to be high, with an analysis result of 0.26%. The cation exchange capacity (CEC) content was very low, with an analysis result of 3.68 me.100 g^{-1} soil. The soil acidity (pH) of Ultisol soil was acidic, with an analysis value of 4.00.

In aluminium saturation analysis, the results cannot be measured, nor can they be measured in exchangeable aluminium analysis. From both aluminium level analyses, both saturated aluminium and aluminium saturation levels, as well as exchangeable aluminium, the results are not analysed and cannot be measured. This indicates that there is no saturated aluminium remaining in the soil, so Ultisol soil is not toxic to plants and Ultisol soil does not contain aluminium nutrients and bound aluminium, making it suitable as a growing medium for agricultural cultivation (Lubis, 2023).

The levels of exchangeable calcium (Ca) and magnesium (Mg) are low, making it more difficult for plants to absorb these nutrients, which are also easily washed away by water. In addition, the required and exchangeable levels of potassium and magnesium are also less available due to the presence of other nutrients in high concentrations, as well as the physical properties of the soil. Ultisol soil still contains high levels of clay, so 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	%	19.50	*Dusty Clay*
✓ Dust			40.70	
✓ Clay			30.30	
C-Organic	Spectrofotometry	%	4.00	m
N-Total	Kjedhal	%	0.60	h
P_2O_5-avl (P-Bray I)	Spectrofotometry	ppm P	12.40	h
K_2O Potential Ex. HCl 25%	AAS	me.100 g^{-1}	1.10	h
MnO Ex. HCl 25%	Spectrofotometry	%	0.20	m
CEC	Volumetry	me.100 g^{-1}	24.20	m
pH H_2O	Elektrometry	------	5.70	*Slightly Sour*
Al Saturation	Titrimetry	%	0	nm
Al-dd		me.100 g^{-1}	0	nm
Ca-dd	AAS	me.100 g^{-1}	6.05	m
K-dd			0.52	m
Mg-dd			0.89	l

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 Table 2, it can be concluded that the final soil analysis results for Ultisol soil, based on the texture of Ultisol soil, show that the dusty clay criteria still apply, where the sand fraction increased by 19.50% from the initial value of 15.20%, resulting in an average increase of 4.3% due to the addition of compost fertilizer.

The dust fraction decreased to 44.10% from the original 40.70%, resulting in a 3.4% decrease in the dust fraction. The clay fraction became 32.20% from the original

30.30%. Thus, the analysis results decreased by 1.9%. This proves that the role of *Azotobacter chroococcum* and *Azotobacter paspali* bacteria and 16.16.16+0.5+6 composite inorganic fertilizer can change the soil fraction in dense, clumpy, and clayey Ultisol soil when wet to slightly clayey (Indraswari *et al*., 2020; Lubis, 2023).

The results of soil chemical analysis of soil organic carbon (C-Organic) content in Ultisol soil show an increase of 4.00%. Similarly, macro nutrients such as nitrogen, phosphorus, and potassium increased due to the addition of compound fertilizer using the *Broadcast* N.P.K+Mg+Ca 16.16.16+0.5+6 method and the presence of *Azotobacter chroococcum* and *Azotobacter paspali* bacteria in the soil. The increase in phosphorus content in the soil that can be utilised by plants is due to the *Azotobacter chroococcum* and *Azotobacter paspali* bacteria being able to isolate the roots of *Phaseolus radiatus* (L.) Fabaceae. plants, as well as the presence of a well-developed rhizosphere in the roots of plants in Ultisol soil.

Muthiah *et al*. (2023) *in* Lubis (2026) that, stated that *Azotobacter chroococcum* and *Azotobacter paspali* bacteria can play an active role in plants, which can increase plant resistance to disease. This is because these bacteria can produce an antibiotic called phenazine and are aerobic organisms, as well as being widely distributed in agricultural soil.

Vegetative Analysis of Plants

From the analysis of vegetative plant growth, the results of analysis from the field can be seen in Table 3 as follows:

Table 3. Vegetative Analysis of *Phaseolus radiatus* (L.) Fabaceae. Plants

Treatment	Vegetative Analysis of *Phaseolus radiatus* (L.) Fabaceae. Plants		
	Plant Height (cm)	Number of Breaches (twigs)	Root Length (cm)

AB_1	51.00 a	12.60 a	23.60 a
AB_2	54.25 b	14.80 b	25.89 b
AB_3	56.88 c	17.70 c	29.83 c
AB_4	59.79 d	18.92 c	31.31 d

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 3, it can be seen that in plant height growth, the *Broadcast* fertilization method treatment with a dose of 10 g.polybag^{-1} was significantly different from the fertilizer dose of 7.5 g.polybag^{-1}. Growth in *Phaseolus radiatus* (L.) Fabaceae. plants occurred only in the 3-month growth period in Ultisol soil media, and could make plant growth more fertile and better, as well as produce better yields with the help of *Azotobacter chroococcum* and *Azotobacter paspali* bacteria. This is due to the role of *Azotobacter* bacteria in helping to provide nutrients to Ultisol soil and helping to isolate P addition to plant roots, as well as helping to improve Ultisol soil fertility, increase soil porosity, and improve other physical properties of the soil. Furthermore, fertilizer nutrients applied to Ultisol soil using the appropriate *Broadcast* method will have a positive impact on the soil. This aligns with Murbandono (2014) opinion in Mayawi *et al*. (2022) that soil microbes can provide and increase soil water-holding capacity, as well as maximise plant root growth, by improving soil porosity, soil pores, and soil fertility.

Observations on the number of branches or twigs showed differences between fertilizer dose treatments in the *Broadcast* method. Although there was no significant difference between the 10 g.polybag^{-1} dose treatment and the 7.5 g.polybag^{-1} dose treatment in the *Broadcast* fertilization method, analysis showed changes in the addition of productive branches in *Phaseolus radiatus* (L.) Fabaceae. plants. This is thought to be due to the active role of the bacteria *Azotobacter chroococcum* and *Azotobacter paspali*, which absorb nitrogen from outside, resulting in faster leaf growth due to elongation and increased branch growth. This is further enhanced by the role of potassium nutrients in adding to and anchoring branch growth, thereby providing nutrients to support the growth of *Phaseolus radiatus* (L.) Fabaceae. plants and influencing the growth of productive

branches. This is in line with the opinion of Rosmawaty *et al*. (2021) *in* Mayawi *et al*. (2022) that soil microorganisms are able to provide nutrients to plants to support the growth of *Phaseolus radiatus* (L.) Fabaceae. and can influence the growth of other young plant branches.

Observations of root length in *Phaseolus radiatus* (L.) Fabaceae. plants showed that root length increased significantly. The longest roots were obtained in the treatment using the *Broadcast* fertilization method with a dose of 10 g.polybag^{-1} and formulated with *Azotobacter chroococcum* and *Azotobacter paspali* bacteria at a dose of 100 ml.polybag^{-1}. This is because *Azotobacter chroococcum* and *Azotobacter paspali* bacteria have isolated the roots of *Phaseolus radiatus* (L.) Fabaceae. plants by providing rhizosphere isolates attached to the plant roots and providing nutrients for the plants, and the application of the *Broadcast* fertilization method has been directly absorbed by the plant roots without any leaching or evaporation into the air. According to Muthiah *et al*. (2023), the role of *Azotobacter chroococcum* and *Azotobacter paspali* bacteria is to trigger plant root growth, resulting in the elongation of *Phaseolus radiatus* (L.) Fabaceae. plant roots. *Azotobacter chroococcum* and *Azotobacter paspali* bacteria are able to adapt well in the soil and plant roots and grow in the rhizosphere of plant roots.

CONCLUSION

Based on the results of research conducted on the application of Azotobacter chroococcum and Azotobacter paspali bacteria on the growth of Phaseolus radiatus (L.) Fabaceae. plants using the Broadcast fertilization method. The application of fertilization using the Broadcast system and the application of Azotobacter chroococcum and Azotobacter paspali bacterial formulations have increased the growth of Phaseolus radiatus (L.) Fabaceae. plants, and this increase in growth is significant. In this case, the role of Azotobacter chroococcum and Azotobacter paspali bacteria can make Ultisol soil, which initially had nutrient deficiencies or was nutrient-poor, now available in the soil,

as well as providing assistance with chemical fertilization using the Broadcast system method.

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