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Increasing the Growth and Yield of Green Bean Plants (*Vigna radiata* L.) by Providing Fly Ash and Organic Materials in Ultisol Soil



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Abstract

Mung bean (*Vigna radiata* L.) is an important source of plant-based protein; however, its production has been declining. Efforts to increase mung bean production can be achieved through land extensification and intensification. Extensification can be implemented by utilizing Ultisol soils, while intensification can be accomplished through the application of fly ash and organic amendments. This study aimed to evaluate the effects of fly ash and organic amendments on the growth and yield of mung bean (*Vigna radiata* L.) grown on Ultisol soil. The experiment was conducted at the experimental field and Soil Laboratory of the Faculty of Agriculture, Riau University, using three fly ash rates and four organic amendments. Data were statistically analyzed using analysis of variance (ANOVA), followed by Duncan's New Multiple Range Test (DNMRT) at the 5% significance level, using SAS software. Observed parameters included the number of filled pods, percentage of filled pods, dry seed weight per plant, root volume, and percentage of effective root nodules. The results showed that fly ash application increased soil pH and organic carbon content while reducing exchangeable aluminum (Al-dd). The application of cattle manure at different fly ash rates significantly increased the number and percentage of filled pods, dry seed weight per plant, root volume, and the percentage of effective root nodules. Fly ash application at rates of 12.5 and 25 g per polybag did not result in significant differences in the number of filled pods, percentage of filled pods, dry seed weight per plant, or root volume compared to the control, but it did significantly increase the percentage of effective root nodules. Overall, applying 25 g of cattle manure per polybag resulted in higher mung bean growth and yield on Ultisol soil than cattle urine or cattle manure bokashi across various fly ash rates.

Keywords: Fly Ash, Mung Bean, Organic Fertilizer, Ultisol

1. Introduction

Green beans (*Vigna radiata* L.) are an important source of vegetable protein, containing 22–26% protein by dry seed weight (Abdul et al., 2025). However, the harvested area of mung beans in Riau decreased from 151 hectares in 2021 to 53 hectares in 2022. This reduction in harvested area led to a decline in mung bean production from 147 tons to 54 tons (Directorate General of Food Crops, 2023). Decreased soil quality, particularly in acidic soils such as Ultisols characterized by low pH, high aluminium saturation, and limited nutrient availability, hinders plant growth. Additionally, the decline in production was exacerbated by reduced harvested area, the use of low-input cultivation technologies, pest and disease

infestations, and economic factors that compelled farmers to switch to more profitable crops. This combination of factors has led to a decline in mung bean productivity year after year. Possible solutions to increase mung bean production include extensification and intensification. Extensification involves utilizing the abundant land in Indonesia, such as Ultisol soils, while intensification involves applying fly ash and organic materials to improve Ultisol soil quality.

According to Subagyo *et al.* (2004), the distribution of Ultisols in Indonesia is approximately 45,794,000 ha, or a quarter of the total area of the Indonesian mainland. Ultisol potential for sustainable agriculture, but has low fertility. According to Prasetyo, BH, & Suriadikarta (2016), Ultisol

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has an acidic pH, low nutrient availability, low KTK and saturation levels, and high Al saturation. Therefore, it is necessary to make efforts to restore fertility in Ultisols by applying ameliorants such as fly ash.

Fly ash can be a potential solution for problem-fertility land as an ameliorant. Faoziah *et al.* (2022) stated that *fly ash* chemically has a pH of H₂O (9.91), Al₂O₃ (5.40%), CaO (3.57%), MgO (2.38%), Na₂O (1.09%), K₂O (0.21%), N-total (1.10%) P₂O₅ (0.10%). According to the research results of Falah *et al.* (2023), fly ash application and chicken manure can increase soil pH, total P, and available P.

Fly ash contains alkaline compounds such as CaO and MgO, which increase soil pH, but also carries metal ions such as Al, which are potentially toxic in acidic soils. Adding organic matter offers a solution because its organic acids can chelate Al, reducing its availability. Previous research has shown that combining fly ash with organic matter can improve soil chemistry by reducing heavy metal concentrations and increasing pH, organic carbon, and microbial activity. (Ginting & Indriyati, 2024). Another study also reported increased plant growth on acidic soils when fly ash was combined with fertiliser. (Hayah *et al.*, 2025). However, previous studies have focused more on other crops, such as peanuts and bok choy, and on contaminated soils rather than on mung beans in Ultisol soil. The novelty of this study lies in testing the interaction between fly ash and three types of organic matter to reduce Al toxicity while increasing growth, effective root nodules, and mung bean yield in Ultisol soil.

Cow urine is thought to be able to reduce Al concentration in Ultisol soil by forming chelate bonds between organic acids and Al. contain uric acid and hippuric acid (Ghume & More, 2022). Besides organic liquid fertiliser, can use organic concentrated fertiliser, like fertiliser per cow.

Cow manure releases organic acids such as acetate, propionate, and butyrate during decomposition (Chesson, 1997). Organic acids form organometallic complexes with metal ions, such as Al. (Haider & Hossain, 2013). Neltriana (2015) stated that cow manure can improve soil structure, increase water-holding capacity, and enhance the activity of soil microorganisms. Sudarsono *et al.* (2013) stated that cow manure has a high fiber content such as cellulose with a C/N of 15.07. This fertiliser also contains macronutrients, including 1.63% N, 0.26% P₂O₅, and 2.80% K₂O. Pen cow has a high C/N, so it needs bokashi fertiliser per cow.

Bokashi cow manure contains organic acids that bind Al at moderate levels. Bokashi cow manure contains dissolved organic matter (MOT), such as humic acid, fulvic acid, and low-molecular-weight organic acids (e.g., acetic acid, lactic acid), which contain carboxyl and hydroxyl groups. These groups are highly reactive to Al³⁺ ions, forming stable and non-toxic organo-Al complexes (Zhang

et al., 2018).

The results of Utami's (2023) research show that bokashi from cow manure can increase pH, available P, organic C, total N, CEC, and available bases, and reduce Al³⁺. These results differ from Agustini (2017), who showed that bokashi from cow manure can increase pH, available P, organic C, total N, CEC, and available bases, and reduce Al³⁺. Cow sheds contain 23.74% water content, 12.80% organic C, 1.53% total N, 8% C/N, 0.78% P₂O₅, and 1.13% K₂O which only report the chemical composition of bokashi without assessing its effects on the soil. Thus, these two previous studies failed to examine how the interaction between organic matter and mineral-based ameliorants can improve Ultisols.

Based on the description above, the provision of fly ash as a soil ameliorant and organic materials as an aluminium complexing agent is expected to improve the chemical characteristics of Ultisol soil, thereby increasing the growth and productivity of mung bean plants (*Vigna radiata* L.). This research aimed to know influence *fly ash* to characteristic chemistry land Ultisol as well as growth and yield plant peanut green (*Vigna radiata* L.) on the ground Ultisol, knowing influence material organic at a dose different *fly ash*, as well as For get dose *fly ash* and materials organic best in increase growth and yield plant peanut green (*Vigna radiata* L.) on the ground Ultisol.

2. Material and Methods

This research was conducted at the UPT Kebun Faculty of Soil Experiments and Laboratory Agriculture, University of Riau, Bina Widya Campus, Km 12.5, Bina Widya Village, Tampan District, Pekanbaru. Location: approximately 0°28' N, 101°22' E (0.474° N, 101.380° E). This research was conducted over three months, from November 2024 to January 2025.

The materials used in this research activity were Vima I variety mung bean seeds (description of Vima I variety mung bean plants can be seen in Appendix 1), Ultisol soil (from Batu Belah Village, Kampar District, Kampar Regency), *fly ash* (from PT. TJK Power Batam City) (can be seen in Figure 1), bokashi cow manure from Sago Farm cattle farm, 10 kg *polybags*, cow urine, cow manure, water, Urea fertiliser, KCl fertilizer, SP-36 fertilizer, 3% carbofuran, insecticide with active ingredient deltamethrin 25 g/l, fungicide with active ingredient mancozeb 80% and chemical materials for laboratory analysis. The tools used in this research were hoes, machetes, stakes, label paper, wood, meters, watering cans, buckets, raffia rope, digital scales, measuring cups, stationery, documentation tools, nets, bench scales, and laboratory equipment.

The study was conducted as an experiment in the form of a factorial design, arranged in a split-plot design with a random complete design (RAL). The main plot is fly ash, and the subplot is organic matter. The main plot is the provision of *fly ash*, consisting of 3 levels, namely, without

fly ash, 2.5 t.ha^{-1} (12.5 g *fly ash* per *polybag*), 5 t.ha^{-1} (25 g *fly ash* per *polybag*), The subplot is the provision of organic matter, consisting of 4 levels, namely, without organic matter, 250 ml.l^{-1} water (9.6 ml per *polybag*) cow urine, 5 t.ha^{-1} (25 g per *polybag*) cow manure, 2 t.ha^{-1} (10 g per *polybag*) bokashi cow manure. There are 12 treatment combinations with three replications, resulting in 36 experimental units. Each experimental unit consists of two *polybags*, resulting in 72 *polybags*. The flow diagram of the research method is shown in Figure 2.



Figure 1. Fly ash in use

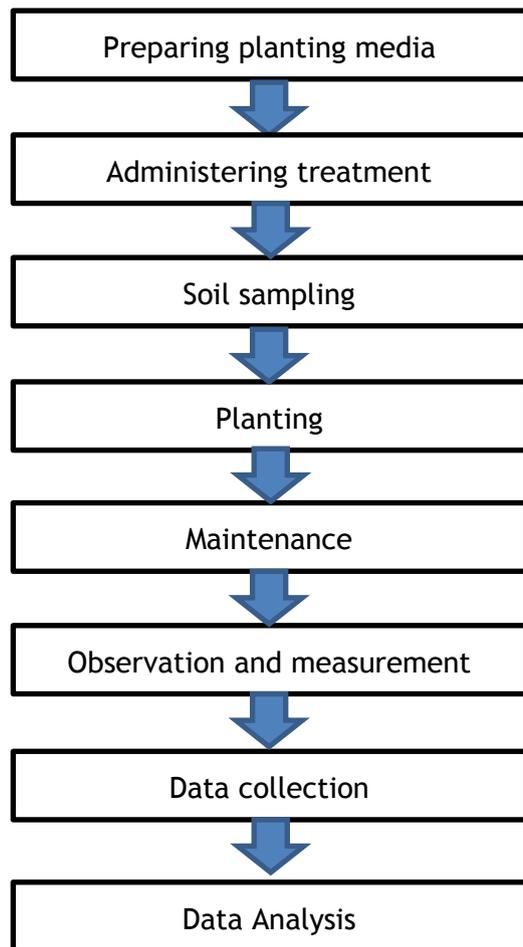


Figure 2. Research method flowchart

Observation parameters consisted of initial soil chemical analysis and soil chemical analysis after *fly ash treatment* (the soil analyzed was composite soil, so the sample used for analysis was only one sample), the number of full pods (pods) was carried out at harvest by counting all full pods, the percentage of full pods (%), dry seed weight per plant (g) by weighing the weight of all dry seeds on each plant, root volume (ml) by measuring the volume of water after inserting the plant roots in a measuring cup, the percentage of effective root nodules (%). The data obtained were analyzed statistically using analysis of variance (ANOVA). Results showing significant and insignificant effects of the treatment were further tested using Duncan's multiple range test (DMRT) at the 5% level. Variance and DMRT data were analysed using SAS version 9.1. Initial soil analysis data and post-treatment data were analysed descriptively.

3. Results and Discussion

3.1. Analysis of initial soil chemistry and soil chemistry after fly ash treatment

Table 1. Analysis results chemistry beginning land Ultisol

Parameter	Results	Category
pH _{H2O}	4.93	Sour
C- organic (%)	1.80	Low
Al-dd (me/100 g)	6.80	-

Table 2. Analysis results of the chemistry land after giving *fly ash*

Parameter	Results	Category
pH_{H2O}		
without <i>fly ash</i>	5.05	Sour
<i>fly ash</i> 12.5 g/medium	5.42	Sour
<i>fly ash</i> 25 g/medium	5.54	Sour
C- organic (%)		
without <i>fly ash</i>	1.73	Low
<i>fly ash</i> 12.5 g/medium	2.09	Currently
<i>fly ash</i> 25 g/medium	2.51	Currently
Al-dd (me/100 g)		
without <i>fly ash</i>	6.76	
<i>fly ash</i> 12.5 g/medium	2.42	-
<i>fly ash</i> 25 g/medium	2.13	-

Table 1 shows soil pH value Ultisol used of 4.93 which includes category sour. pH increases with increasing dose, giving fly ash 5.42 in the treatment with fly ash 12.5 g and 5.54 in the treatment with *fly ash* 25 g. This increase in pH happens because *fly ash* contains alkaline compounds such as CaO, MgO which can neutralize acidity land through hydrolysis that produces OH⁻ ions (Pratama et al., 2022).

Table 2 shows that there is no increase in organic C with increasing *fly ash dosage*. *Fly ash* contains low organic C, so it needs to be combined with organic

materials such as cow urine, cow manure, and bokashi cow manure. The results of research by Kurniawan *et al.* (2014) indicated a decrease in organic C content with increasing fly ash application in the planting medium. Wiskandar (2009) stated that *fly ash* does not contribute much carbon to the soil because its carbon content is very low.

Table 3. Results of soil Al-dd analysis after giving *fly ash* and materials, organic

No	Sample Code	Al-dd value (me/100g)
1	F0B0	6.76
2	F0B1	2.65
3	F0B2	2,1
4	F0B3	2.32
5	F1B0	2.42
6	F1B1	0.72
7	F1B2	0.48
8	F1B3	0.61
9	F2B0	2.13
10	F2B1	0.89
11	F2B2	0.36

Table 2 shows that the Al-dd of Ultisol soil decreased from 6.8 me/100 g to 2.42 me/100 g after 12.5 g of *fly ash* treatment and to 2.13 me/100 g after 25 g of *fly ash* treatment. The decrease in Al is thought to be caused by the increase in soil pH after fly ash treatment. The addition of *fly ash* increases soil OH⁻ ions, allowing them to bind Al-dd to form Al(OH)₃ precipitates, thereby decreasing Al-dd (Fahrunsyah *et al.* 2020).

Table 3 shows that the Al-dd of Ultisol soil decreased after organic matter application. This is because organic matter can bind Al, thereby decreasing Al-dd. A decrease in Al-dd was observed after the application of organic matter, namely cow urine, cow manure, and bokashi cow manure. Cow manure can reduce Al-dd higher than cow urine and bokashi cow manure. This is in line with the research of Pasaribu *et al.* (2018) which showed that the average Al-dd value of Ultisol soil after the application of organic matter ((durian peel compost + chicken manure) and (EFB compost + chicken manure)) was able to reduce the Al-dd level in the soil from the control Al-dd level of 0.59 me/100 to 0.01 me/100.

3.2. Number of full pods

The analysis of variance showed that the interaction between fly ash and organic matter treatments, and the single factor of organic matter, had significant effects, whereas the single factor of fly ash did not affect the number of full pods of mung bean plants in Ultisol soil. The average number of full pods per mung bean plant in Ultisol soil is shown in Table 4.

Cow manure produced the highest number of full-bodied pods compared to bokashi, cow manure, and cow urine. This is due to the organic acids in cow manure, which can bind Al more strongly (Table 3). The research

results of Sari *et al.* (2017) indicated that the treatment supplemented with organic matter and Pfertiliserr had lower Al-dd levels than the treatment supplemented with Pfertiliserr alone. This may be due to organic matter binding Al, thus decreasing the soil Al-dd levels. Furthermore, Al also adsorbs P. Amijaya *et al.* (2015) stated that cow manure increases P availability in the soil through decomposition, which produces CO₂ and organic acids. CO₂ compounds. What is formed will dissolve in water and then form carbonic acid. The carbonic acid produced by this process will release P from Al's absorption, increasing P availability.

Availability of sufficient P nutrients can increase the rate of photosynthesis, so that assimilates produced are partly utilised for growth, and the arrangement of plant organs, like stems, and the rest are stored as proteins and carbohydrates in seed plants (Iswanda, 2018). Research This is in line with the research of Smita *et al.* (2023) which reported that the combination of organic fertilization (RDF + vermicompost + jeevamrut + Rhizobium) produced the number of pods per plant as much as 31.35, pod length 11.05 cm, weight of 100 seeds 45.7 g, and seed productivity reached around 1,242.5 kg ha⁻¹ in mung beans, much higher than the control treatment without organic amendments.

3.3. Percentage of full pods

The analysis of variance showed that the interaction between fly ash and organic matter treatments and the single factor of fly ash had no significant effect, whereas the single factor of organic matter had a significant effect on the percentage of full pods of mung bean plants in Ultisol soil. The average percentage of full pods for mung bean plants in Ultisol soil is shown in Table 5.

Cow manure produced the highest percentage of full-bodied pods compared to bokashi and cow urine, due to the binding of Al by organic acids. The organic acids in cow manure bind Al more strongly, thereby decreasing Al concentration in the soil solution. The binding of Al by organic acids can increase the availability of P in the soil. Mulat (2003) stated that plants with high P availability will produce more full-bodied pods. P is needed by mung bean plants from the beginning of growth until harvest. so that its needs must be met throughout its life, therefore, if seed filling is optimised, the resulting seeds will be more nutritious. Poudel (2025) reported that the application of phosphorus fertilizer significantly increased mung bean yields: the treatment with P resulted in the highest seed production of 1.53 t ha⁻¹, while the plot without P (P₀) only produced 0.79 t ha⁻¹, almost a doubled increase at high P doses compared to control 1. Sianturi (2008) stated that P stimulates the formation of flowers, fruits, and seeds, and can accelerate fruit ripening and make them more fleshy. Fekadu (2025) stated that the application of P₂O₅ 46 kg ha⁻¹ produced the highest 1,000 seed weight of

30.18 g and seed yield of 961.6 kg ha⁻¹, greater than without P (766.7 kg ha⁻¹).

Table 4. Total pod pithy plant peanut green on giving *fly ash* and materials organic matter in the soil Ultisol

Treatment	Amount Pods (pods)	Average
Without <i>fly ash</i> (control)	3.37 ± 0.70 b	
Without material organic (control)	1.50 ± 0.29 e	
Cow urine 9.6 ml per <i>polybag</i>	2.33 ± 0.65 de	
Cow manure 25 g per <i>polybag</i>	7.00 ± 1.21 b	
Bokashi cow manure 10 g per <i>polybag</i>	2.66 ± 0.65 cde	
<i>fly ash</i> 12.5 g per <i>polybag</i>	4.50 ± 0.42 a	
Without material organic (control)	1.83 ± 0.29 e	
Cow urine 9.6 ml per <i>polybag</i>	2.00 ± 0.41 e	
Cow manure 25 g per <i>polybag</i>	10.16 ± 0.41 a	
Bokashi cow manure 10 g per <i>polybag</i>	4.00 ± 0.58 cd	
<i>fly ash</i> 25 g per <i>polybag</i>	4.70 ± 0.62 a	
Without material organic (control)	1.66 ± 0.17 e	
Cow urine 9.6 ml per <i>polybag</i>	2.16 ± 0.29 e	
Cow manure 25 g per <i>polybag</i>	11.16 ± 0.65 a	
Bokashi cow manure 10 g per <i>polybag</i>	4.33 ± 1.4 c	
Average		
Without Material organic (control)	1.50 ± 0.25 c	
Cow urine 9.6 ml per <i>polybag</i>	2.16 ± 0.45 c	
Cow manure 25 g per <i>polybag</i>	9.44 ± 0.76 a	
Bokashi cow manure 10 g per <i>polybag</i>	3.66 ± 0.87 b	

Note: Numbers in the column followed by the same lowercase letter are not different. real according to Duncan at the 5% level

Table 5. Percentage of full pods of mung bean plants when given *fly ash* and organic matter in Ultisol soil

Treatment	Percentage Pod Nutritious (%)	Average
Without <i>fly ash</i> (control)	66.19 ± 0.70 b	
Without material organic (control)	55.55 ± 0.29 ef	
Cow urine 9.6 ml per <i>polybag</i>	65.83 ± 0.65 cd	
Cow manure 25 g per <i>polybag</i>	76.15 ± 1.21 bc	
Bokashi cow manure 10 g per <i>polybag</i>	67.24 ± 0.65 cd	
<i>fly ash</i> 12.5 g per <i>polybag</i>	67.73 ± 0.42 ab	
Without material organic (control)	50.00 ± 0.29 f	
Cow urine 9.6 ml per <i>polybag</i>	60.74 ± 0.41 de	
Cow manure 25 g per <i>polybag</i>	87.13 ± 0.41 a	
Bokashi cow manure 10 g per <i>polybag</i>	73.05 ± 0.58 bc	
<i>fly ash</i> 25 g per <i>polybag</i>	72.12 ± 0.62 a	
Without material organic (control)	53.33 ± 0.17 f	
Cow urine 9.6 ml per <i>polybag</i>	68.25 ± 0.29 bc	
Cow manure 25 g per <i>polybag</i>	88.15 ± 0.65 a	
Bokashi cow manure 10 g per <i>polybag</i>	78.75 ± 1.4 ab	
Average		
Without material organic (control)	52.96 ± 0.25 d	
Cow urine 9.6 ml per <i>polybag</i>	64.94 ± 0.45 c	
Cow manure 25 g per <i>polybag</i>	83.81 ± 0.76 a	
Bokashi cow manure 10 g per <i>polybag</i>	73.01 ± 0.87 b	

Note: Numbers in the column followed by the same lowercase letter are not different. real according to Duncan at the 5% level

3.4. Dry seed weight per plant

The results of the analysis of variance showed that the interaction between *fly ash* and organic matter treatments, and the single factors of *fly ash* and organic matter, had a significant effect on dry seed weight per mung bean plant in Ultisol soil. The results for dry seed weight per mung bean plant in Ultisol soil are shown in Table 6.

Cow manure reduces Al-dd higher than bokashi cow

manure and cow urine (Table 3), thus increasing P availability and producing the highest dry seed weight per plant. Cow manure can form organometallic bonds between organic acids and metals, such as Al, thereby increasing nutrient uptake by mung bean plants. Application of cow manure significantly increases seed weight by providing complete macro- and micro-nutrients and improving the pH and structure of Ultisol soil (Oesman *et al.*, 2024). Haynes

and Mokolobate (2001) stated that the increase in P occurs due to the formation of Al-complex compounds from decomposed organic matter, which can reduce Al-dd content and reduce P adsorption by Al, thereby increasing P availability. This study is in line with the study of Susanti

et al. (2022) who reported that the application of organic matter can reduce Al saturation in acidic soils by 14–22%, which is followed by an increase in available P from 10.4 mg kg⁻¹ to 18.7 mg kg⁻¹.

Table 6. Dry seed weight per mung bean plant when *fly ash* and organic matter are applied in Ultisol soil.

Treatment	Heavy seeds (g)	Average
Without <i>fly ash</i> (control)	1.01 ± 0.70	c
Without material organic (control)	0.52 ± 0.29	f
Cow urine 9.6 ml per <i>polybag</i>	0.80 ± 0.65	ef
Cow manure 25 g per <i>polybag</i>	1.60 ± 1.21	c
Bokashi cow manure 10 g per <i>polybag</i>	1.13 ± 0.65	cd
<i>fly ash</i> 12.5 g per <i>polybag</i>	1.67 ± 0.42	b
Without material organic (control)	0.53 ± 0.29	f
Cow urine 9.6 ml per <i>polybag</i>	0.93 ± 0.41	de
Cow manure 25 g per <i>polybag</i>	3.73 ± 0.41	b
Bokashi cow manure 10 g per <i>polybag</i>	1.48 ± 0.58	cd
<i>fly ash</i> 25 g per <i>polybag</i>	2.68 ± 0.62	a
Without material organic (control)	0.43 ± 0.17	
Cow urine 9.6 ml per <i>polybag</i>	0.82 ± 0.29	ef
Cow manure 25 g per <i>polybag</i>	7.80 ± 0.65	a
Bokashi cow manure 10 g per <i>polybag</i>	1.66 ± 1.4	c
Average		
Without material organic (control)	0.49 ± 0.25	c
Cow urine 9.6 ml per <i>polybag</i>	0.85 ± 0.45	c
Cow manure 25 g per <i>polybag</i>	4.37 ± 0.76	a
Bokashi cow manure 10 g per <i>polybag</i>	1.42 ± 0.87	b

Note: Numbers in the column followed by the same lowercase letter are not different, real according to Duncan at the 5% level.

3.5. Root volume

The results of the analysis of variance showed that the interaction between fly ash and organic matter treatments, and the single factors of fly ash and organic matter, had no significant effect on the root volume of mung bean plants in Ultisol soil. The results for root volume of mung bean plants in Ultisol soil are shown in Table 7.

Cow manure showed the highest root volume, followed by cow urine and bokashi cow manure. Cow manure can bind Al more strongly, as indicated by the large decrease in Al-dd (Table 3). High Al concentrations will inhibit plant root development. According to Rosmarkam and Yuwono (2002), at acidic pH, Al and Fe solubility is high, resulting in abnormal plant growth at very low pH due to unsuitable pH, decreased solubility of several nutrients, and Al and Fe toxicity. Ifansyah (2014) reported that in highly acidic Ultisol soil with a pH of 3.53, the soluble Al content reached 4.70 cmol kg⁻¹ and the soluble Fe content reached 39.35 mg kg⁻¹. After the soil pH increased to 4.19 through the application of amendments, the soluble Al content decreased to 1.90 cmol kg⁻¹ and soluble Fe decreased to 20.07 mg kg⁻¹, so that P availability increased from 0.05 mg kg⁻¹ to 0.12 mg kg⁻¹.

3.6. Percentage of effective root nodules

The analysis of variance showed that the interaction

between fly ash and organic matter treatments was not significant, whereas the single factors of fly ash and organic matter had a significant effect on the percentage of effective root nodules in mung bean plants grown in Ultisol soil. The results for the percentage of effective root nodules in mung bean plants grown in Ultisol soil are shown in Table 8.

Cow manure showed the highest percentage of effective root nodules compared to cow urine and bokashi. Cow manure binds Al more strongly than cow urine and bokashi (Table 3). The treatment of 25 g of *fly ash per polybag* and 25 g of cow manure per *polybag* produced the highest percentage of effective root nodules in mung bean plants. This is because applying fly ash can increase soil pH, and cow manure can bind Al through organic acids. According to Ifansyah *et al.* (2013) and Nakei *et al.* (2022), the population and activity of Rhizobia vary depending on soil conditions. Soil conditions with low acidity can affect Rhizobium activity. Disruption of Rhizobium activity prevents root nodule initiation, leaving many root nodules ineffective at fixing N and leading to stunted plant growth in line with the statement (Sarikaya-Bayram *et al.*, 2015) that the level of soil acidity affects the symbiosis between Rhizobium and host plants, such as the suppression of nodulation factors that can cause a decrease in the production of chemical compounds in root exudates that function as intermediaries for interactions between host

plants and soil microbes.

Table 7. Root volume plant peanut green on giving *fly ash* and materials organic matter in the soil Ultisol

Treatment	Root volume (ml)	Average
Without <i>fly ash</i> (control)		0.97 ± 0.70 a
Without material organic (control)	0.63 ± 0.29 b	
Cow urine 9.6 ml per <i>polybag</i>	1.20 ± 0.65 ab	
Cow manure 25 g per <i>polybag</i>	1.00 ± 1.21 ab	
Bokashi cow manure 10 g per <i>polybag</i>	1.06 ± 0.65 ab	
<i>fly ash</i> 12.5 g per <i>polybag</i>		0.82 ± 0.42 a
Without material organic (control)	0.81 ± 0.29 b	
Cow urine 9.6 ml per <i>polybag</i>	0.70 ± 0.41 b	
Cow manure 25 g per <i>polybag</i>	0.96 ± 0.41 ab	
Bokashi cow manure 10 g per <i>polybag</i>	0.80 ± 0.58 b	
<i>fly ash</i> 25 g per <i>polybag</i>		0.98 ± 0.62 a
Without material organic (control)	0.71 ± 0.17 b	
Cow urine 9.6 ml per <i>polybag</i>	0.78 ± 0.29 b	
Cow manure 25 g per <i>polybag</i>	1.86 ± 0.29 a	
Bokashi cow manure 10 g per <i>polybag</i>	0.56 ± 1.4 b	
Average		
Without material organic (control)	0.72 ± 0.25 b	
Cow urine 9.6 ml per <i>polybag</i>	0.89 ± 0.45 ab	
Cow manure 25 g per <i>polybag</i>	1.27 ± 0.76 a	
Bokashi cow manure 10 g per <i>polybag</i>	0.81 ± 0.87 ab	

Note: Numbers in the column followed by the same lowercase letter are not different. real at the 5% level according to Duncan.

Table 8. Percentage of effective root nodules after application of *fly ash* and organic matter in Ultisol soil

Treatment	Average Percentage nodule root effective (%)
Without <i>fly ash</i> (control)	24.31 ± 0.70 b
Without material organic (control)	21.47 ± 0.29 e
Cow urine 9.6 ml per <i>polybag</i>	24.85 ± 0.65 cd
Cow manure 25 g per <i>polybag</i>	26.02 ± 1.21 bc
Bokashi cow manure 10 g per <i>polybag</i>	24.90 ± 0.65 cd
<i>fly ash</i> 12.5 g per <i>polybag</i>	25.80 ± 0.29 a
Without material organic (control)	23.40 ± 0.29 d
Cow urine 9.6 ml per <i>polybag</i>	25.11 ± 0.41 cd
Cow manure 25 g per <i>polybag</i>	27.82 ± 0.41 ab
Bokashi cow manure 10 g per <i>polybag</i>	26.89 ± 0.58 ab
<i>fly ash</i> 25 g per <i>polybag</i>	26.21 ± 0.62 a
Without material organic (control)	23.86 ± 0.17 d
Cow urine 9.6 ml per <i>polybag</i>	26.46 ± 0.29 ab
Cow manure 25 g per <i>polybag</i>	28.39 ± 0.65 a
Bokashi cow manure 10 g per <i>polybag</i>	26.15 ± 1.4 bc
Average	
Without material organic (control)	22.91 ± 0.25 c
Cow urine 9.6 ml per <i>polybag</i>	25.47 ± 0.45 b
Cow manure 25 g per <i>polybag</i>	27.41 ± 0.76 a
Bokashi cow manure 10 g per <i>polybag</i>	25.98 ± 0.87 b

Note: Numbers in the column followed by the same lowercase letter are not different. real according to Duncan at the 5% level

4. Conclusion

Based on the research conducted, it can be concluded that, the application of 25 g of fly ash per polybag to acidic Ultisol soil significantly increased soil pH and organic carbon while reducing the concentration of added aluminum (Al). The combination of fly ash with organic matter, particularly cow manure, was the most effective in enhancing soil fertility.

Application of fly ash at a dose of 12.5–25 g per polybag, combined with cow manure, increased the number and percentage of full pods, dry seed weight per plant, root volume, and the percentage of effective root nodules in mung bean plants by improving soil pH, reducing aluminum toxicity, and increasing phosphorus availability.

The application of 12.5 to 25 g of fly ash per polybag did not significantly affect certain yield components

compared to the control (no fly ash), but it significantly increased the percentage of effective root nodules. The combination of 25 g of fly ash per polybag with cow manure produced the highest yield.

Cow manure applied at a dose of 25 g per polybag produced the highest growth and yield of mung bean plants grown on Ultisol soil, compared to cow urine and bokashi cow manure applied at various doses with fly ash.

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