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The Effect of *Azolla microphylla* Compost and Biocon-NP Biofertilizer on Soybean (*Glycine max* (L.) Merril) Growth in Lapindo Mud Planting Media

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Abstract
This research describes the effect of *Azolla microphylla* compost and Biocon-NP biofertilizer on the growth of soybean plants (*Glycine max* (L.) Merrill) on lapindo mud planting media. This study used an experimental method with a Randomised Group Design involving two factors, *Azolla microphylla* compost with concentrations of 0 grams, 100 grams, 200 grams, and 300 grams and Biocon-NP biofertilizer concentrations of 0 ml, 125 ml, and 150 ml with three replications using vegetative phase observation parameters including plant height, number of leaves, plant wet biomass, root length, and active root nodule biomass. Generative phase parameters included flowering time, number of pods, and pod biomass. Data analysis used Two-Way Analysis of Variance followed by Duncan's test ($p < 0.05$). The results showed that the treatment of *Azolla microphylla* compost 200 grams + Biocon-NP biofertilizer 150 ml gave a significant effect with the highest results in the parameters of the number of leaves, plant wet biomass, root length, wet biomass of active root nodules, number of pods, and pod biomass. This study also showed that applying *Azolla microphylla* compost and Biocon-NP biofertilizer accelerated growth to the generative phase.

Keywords: *Azolla microphylla*; endophytic bacteria; biocon-NP; *Glycine max*, lapindo mud, growth
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INTRODUCTION

Soybean plants (*Glycine max* (L.) Merril) are a legume family of food crop commodities that are a source of vegetable protein and vegetable oil, containing nutrients and bioactive components beneficial for health. Besides being safe for health, the price of vegetable protein is also more affordable than animal protein (Sulan *et al*., 2022). The nutritional value of soya is higher than that of beef and equivalent to cow's milk. Soybeans are also a source of lecithin and vitamin E. The high content of isoflavones and saponins serves as a powerful antioxidant. Ingredients such as fibre, unsaturated fat, and high vitamins and minerals make it a healthy food choice (Vidiatama and Elfis, 2024). Soybean plants are usually cultivated on various types of land such as dry land, rice fields, swamp land, and tidal land (Kurniawan and Ajiningrum, 2020). Land in Indonesia generally has marginal land characteristics. Marginal land is dry land with limited nutrient content. In marginal land agriculture, if planted with annual crops, the productivity tends to be low (Sari *et al*., 2020). One of the marginal lands that can be applied as a planting medium is Lapindo mud.

Lapindo mud is an environmental disaster that occurred in Sidoarjo Regency, in the form of a mudflow originating from petroleum drilling that caused a large underground explosion called an underground blowout during the excavation process (Intakhiya *et al*., 2021). Lapindo mud has a specific gravity of 2.142 gr/cc, so it is classified as an inorganic clay soil type by the theory of soil mechanics 2.1-2.6 gr/cc (Rosanti and Winanti, 2016). Based on Yusuf's (2020) research on lapindo mud, the content of essential macro nutrients in lapindo mud, such as nitrogen (N), is 0.04%, and phosphorus (P) is 3.75 ppm, so the nutrients in lapindo mud are relatively low. Nitrogen acts as a nutrient needed by plants in the form of ammonium ions (NH_4) and nitrate (NO_3), while phosphorus is needed by plants in photosynthesis. Plants need potassium in the process of protein and carbohydrate formation. Improving soil structure and fertility is necessary to maximise agricultural potential, especially for soybean cultivation. Improving soil structure and fertility is necessary to maximise agricultural potential, especially for soybean cultivation (Yunaedi and Perdana, 2023).

Organic matter provides a source of nutrients that support the survival of microbes in the soil. Organic fertilisers do not leave inorganic acid residues in the soil and have a high organic C content. Organic fertilisers available in nature include compost, green manure, manure, and guano. Organic fertilisers are a carrier medium for microorganisms (Gultom *et al*., 2021). *Azolla microphylla* forms a partnership with cyanobacteria named *Anabaena azollae*, which can take nitrogen from the air. This shows that the organic fertilizer from this plant can enhance the soil's chemical properties by breaking down organic materials and providing essential nutrients to plants (Sari *et al*., 2021). Using organic materials like water hyacinth compost, through decomposition and mineralization, can increase the uptake of phosphorus (P) and nitrogen (N) and improve soil structure, which supports better root growth. These changes make the soil more effective at holding water and nutrients, promoting healthier plant growth. As an organic fertilizer, this plant is rich in nitrogen and has low levels of lignin and polyphenols (Mamang *et al*., 2017).

When combined with endophytic microorganisms, organic fertilizer can improve soil quality and speed up plant growth (Kumar *et al*., 2017). Soil microorganisms play a vital role in plant growth and development. These microorganisms are often added to compost as biofertilizers, including bacteria that dissolve phosphorus (P), fix potassium (K), and fix nitrogen (N) (Saraswati and Sumarno, 2018). Biocon-NP is a type of biofertiliser made from endophytic bacteria. It is a microbial inoculum that includes *Azotobacter* sp., *Azospirillum* sp., and *Pseudomonas* sp. These bacteria work together to fix nitrogen, solubilise phosphate, and break down organic matter, which helps plants grow better. Other free-living nitrogen-fixing bacteria like Azospirillum, Azotobacter, and Pseudomonas can also be used on a wide range of plant types (Jalal *et al*., 2022). Based on research by Kurniawati and Rahayu (2022), applying a single treatment of *Azotobacter* sp. significantly increased nitrogen levels in soybean plants.

Azotobacter sp. is a type of nitrogen-fixing bacteria that does not form a partnership with plants.It has a strong ability to fix nitrogen and also helps in dissolving phosphorus, which is important for making nitrogen and phosphorus more available in the soil (Putri and Rahayu, 2019). Nitrogen fixation happens because of an enzyme called nitrogenase. These bacteria also produce plant hormones like indole-3-acetic acid (IAA), extracellular polysaccharides, and cytokinins. These substances help promote the growth of plant roots and the top parts of the plant (Putri and Rahayu, 2019). *Azospirillum* sp. is a soil bacterium that belongs to the rhizobacter group. It lives near plant roots without forming nodules. It provides nitrogen and phosphorus by taking nitrogen from the air. Pseudomonas sp. is another type of bacterium that interacts closely with plant roots. These bacteria have special abilities that help plants grow better and improve soil health (Dorjey *et al*., 2017).

The way nitrogen-fixing bacteria in *Azotobacter* and *Azospirillum* work is different from symbiotic bacteria. They increase their breathing to keep oxygen levels low, which is needed for nitrogen fixation. Even in the presence of oxygen, these bacteria can still fix nitrogen. However, when oxygen levels are high, they can't activate the nitrogenase enzyme. The nitrogen fixation process requires 16 ATP to be broken down into N_2, which uses the enzyme nitrogenase. Reducing N_2 to NH_3 occurs when the nitrogenase enzyme binds the N_2 molecule. The nitrogen fixation process can occur in the anaerobic cycle or requires an oxygen-neutralisation stage by leghemoglobin because the nitrogenase enzyme can be destroyed without direct contact with oxygen. Meanwhile, phosphate dissolution occurs when phosphate-solubilising bacteria produce phosphatase enzymes that can hydrolyse organic phosphate into inorganic phosphate. The bacteria produce several organic acids, such as citric, glutamic, and sucinic acids, to produce complex compounds that can release bound ions into available ions (Asrul *et al*., 2020). Based on research by Noviani and Rahayu (2022), the combined treatment of P. *Fluorescens*, *Azospirillum* sp., and local microorganisms increased the number of pods and pod biomass in soybean plants. Providing organic matter in the soil is essential for improving soil structure. Muyassir *et al*. (2012) stated that adding organic matter can reduce the weight of the soil content, where there is a difference in value due to the process of improving the physical properties of the soil with the presence of decomposers that can break down organic matter. The provision of compost causes an improvement in soil aggregates, so that the soil structure becomes crumbly, and the crumbly soil structure causes a decrease in the weight content of the soil.

This study aims to examine the effect of *Azolla microphylla* compost and Biocon-NP biofertilizer on the growth of soybean plants on lapindo mud planting media, given the limitations of lapindo mud to be used as planting media. It is known that adding *Azolla microphylla* compost can provide plant nutrients, improve soil structure, and thus increase plant growth. In addition, endophytic microorganisms from Biocon-NP biofertilizer containing *Azotobacter*, *Azospirillum*, and *Pseudomonas* bacteria can improve soil quality, increase plant growth, especially the fulfillment of nutrients such as nitrogen and phosphorus.

MATERIALS AND METHODS

The preparation process was carried out by planting *Azolla microphylla* seedlings. The process of planting *Azolla* seedlings was carried out in a 5 x 2 m tarpaulin pond with a height of 0.5m. Water filling in the pond was done until it reached a height of about 15 cm. At the bottom of the pond, soil with a thickness of about 3 cm was added. Nutrients for *Azolla* were given as goat manure, as much as 12.5 kg. The soil and fertiliser were mixed approximately 5 cm thick. The seedlings were spread at a rate of 50-70 grams per square metre (Samah *et al*., 2022).

The composting process begins by taking 16 kg of fresh *Azolla* and weighing it. Then, 800 grams of bran, 15 kg of manure, and 1.6 kg of charcoal are mixed until well combined. Next, a solution of 160 ml of EM4, 16 grams of molasses, and 480 ml of water is sprayed evenly (Shamita *et al*., 2022). Then, the production stage of the biological fertilizer based on endophytic bacteria is carried out by mixing 0.5 kg of instant tiwul, 11 g of instant yeast, 0.5 L of molasses, 50 g of endophytic bacterial inoculum (Biocon-NP) with a density of 1.75 x 10^7 CFU/ml, and 80 L of clean water. These materials are mixed and fermented in a fermenter for one week. The fertiliser is applied in two stages, with 125 ml and 150 ml applied at each stage (Novelia *et al*., 2022).

Planting media preparation was done by mixing lapindo mud and regosol soil with 30% lapindo mud. The regosol soil needed is about 2.1 kg and is added with 0.9 kg of mud obtained from the Lapindo mud embankment in Sidoarjo Regency. Before mixing, the dried lapindo mud was ground until smooth and then filtered to separate the smooth part, which was still in the form of chunks. After that, the media was mixed into polybags measuring 40 x 40 cm—the transfer of soybean seedlings to the planting media when the soybean had four leaves. Planting was done separately by planting two soybean seedlings in each hole with a depth of about 2 cm. After the plants were 2 weeks old, selection was done to select the best plants, so that only one plant was retained per hole, while the other plants were planted back into the soil (Ruseli *et a*l., 2024).

Soybean plant care includes watering, replanting, weeding, and pest control. Watering was done in the morning and evening according to weather conditions to meet the plants' water needs. Observations were made on the parameters of plant height and number of leaves at 15, 30, and 45 Day After Planting (DAP), while on the parameters of root length, plant wet biomass, wet biomass of active root nodules, flowering time, number of pods, and pod biomass at 45 DAP. The data obtained were analysed using two-way ANOVA. This was followed by Duncan's 5% significance test to analyse the differences in each treatment on the growth parameters of soybean plants grown on lapindo mud planting media.

RESULTS

This study was conducted to determine the effect of *Azolla microphylla* compost, Biocon-NP biofertiliser, and their interaction on the growth of soybean plants (*Glycine max* (L.) Merril) on lapindo mud planting media. The concentrations of *Azolla microphylla* compost were 0 grams, 100 grams, 200 grams, and 300 grams. The concentration of Biocon-NP biofertilizer given was 0 ml, 125 ml, and 150 ml. The parameters observed include the observation of vegetative phase growth and generative phase growth. The vegetative phase included plant height, number of leaves, plant wet biomass, and active root nodule biomass. In contrast, the generative phase parameters were observed because several generative phase parameters had appeared before the age of 45 DAP, including flowering time, number of pods, and pod biomass.

Before treating with *Azolla microphylla* compost and Biocon-NP biofertilizer, the environmental conditions of Lapindo mud, such as pH, temperature, humidity, %C, %N, C/N, P2O5, and soil texture, were tested. The results of this testing are in Table 1.

Table 1. Measurement results of environmental conditions and nutrient levels in the Lapindo mud

No.	Parameter	Nutrient Content	Criteria
1.	pH	7.54	Basa
2.	Total N (%)	0.105	Low
3.	C/N	31.24	Very High
4.	P_2O_5 (ppm)	17.87	High
5.	Soil Texture		

No.	Parameter	Nutrient Content	Criteria
	Sand	7%	Dusty Clay
	Dust	43%	
	Clay	50%	

Notes: *) Based on the criteria of the Technical Guidelines for Chemical Analysis of Soil, Plants, Water and Fertilisers (2005).

Based on the results presented in Table 1, the chemical and physical conditions of Lapindo mud show that it does not fulfill the requirements as an optimal growing medium. The pH value of 7.54 indicates that the sludge is alkaline. The total nitrogen content is only 0.105%, which is quite low, showing that there isn't much nitrogen available. The C/N ratio of 31.24 suggests that there's an imbalance between carbon and nitrogen in the sludge. However, the phosphorus content, measured as P_2O_5, is relatively high at 17.87 ppm. In addition, the texture of the mud, made up of 7% sand, 43% dust, and 50% clay, classifies it as dusty clay. This type of texture tends to have low porosity and poor drainage, which can hinder air and water movement in the growing medium. Thus, the characteristics of Lapindo mud in these parameters indicate that this material cannot be used directly as a growing medium.

Table 2. Test results of nutrient content in *azolla microphylla* compost

No.	Parameter	Nutrient Content	Threshold*
1.	C-Organic (%)	16.81	> 5,00 (Very High)
2.	Total N (%)	1.62	> 0,40 (High)
3.	Ratio C/N	10.38	> 10 (Medium)
4.	Organic Matter	28.91	> 27 (Medium)
5.	Total P_2O_5 (ppm)	1.47	> 0,10 (High)
6.	Total K_2O	2.01	> 0,20 (High)
7.	Water Content	24.38	< 50 (Medium)

Notes: *) National Standardisation Agency SNI 1970-30-2004

Based on Table 2 of the test results, *Azolla microphylla* compost has a C-organic content of 16.81%, which is classified as very high. The N-total content reaches 1.62% with high criteria, while the C/N ratio 10.38 is included in the medium category. The organic matter contained reached 28.91% (medium), with a total P_2O_5 content of 1.47 ppm (high) and K_2O of 2.01% (high). The moisture content in the compost was recorded at 24.38%, which is classified in the medium category.

The results of the research on the concentration of *Azolla microphylla* compost and Biocon-NP biofertiliser showed that the interaction between *Azolla microphylla* compost and Biocon-NP biofertiliser had a significant effect on the number of leaves, root length, plant wet biomass, and wet biomass of active root nodules but had no significant effect on plant height (Figure 1). In all vegetative phase parameters, the concentration of *Azolla microphylla* compost 300 grams and Biocon-NP biofertilizer 150 ml showed a significant effect, while in the parameters of plant wet biomass and wet biomass of active root nodules, the concentration of *Azolla microphylla* compost 200 grams and Biocon-NP biofertilizer 150 ml had a significant effect.

On the other hand, interaction between *Azolla microphylla* compost and Biocon-NP biological fertilizer had a significant effect on the growth of soybean plants ; the maximum vegetative phase was reached when the plants were 45 DAP. When the research observations took place, soybean flowers had begun to appear at 19 DAP, indicating the start of the generative phase of soybean plants. The appearance of flowers indicates that soybean plants experience an accelerated transition from the vegetative phase to the generative phase. The generative phase showed that the interaction between *Azolla microphylla* compost and Biocon-NP biofertilizer had a significant effect on the parameters of the number of pods and pod biomass at the concentration of *Azolla microphylla* compost 200 grams and Biocon NP 150 ml, but had no significant effect on the parameter of flowering time (Figure 2).

DISCUSSION

Based on the test results on Lapindo mud planting media before treatment Table 1, the soil on Lapindo mud has a pH of 7.54, which is included in the alkaline category. This condition is due to the range of soil pH in the area, which tends to have an alkaline pH (Yusuf, 2020). This alkaline pH state can affect the availability of specific nutrients and some micronutrients, which become less available to plants. Soil pH levels reflect the concentration of hydrogen ions (H^+) and hydroxide ions (OH-) present in the soil, which affect the ease with which plants can absorb nutrients. Carbonate acts as a pH buffer

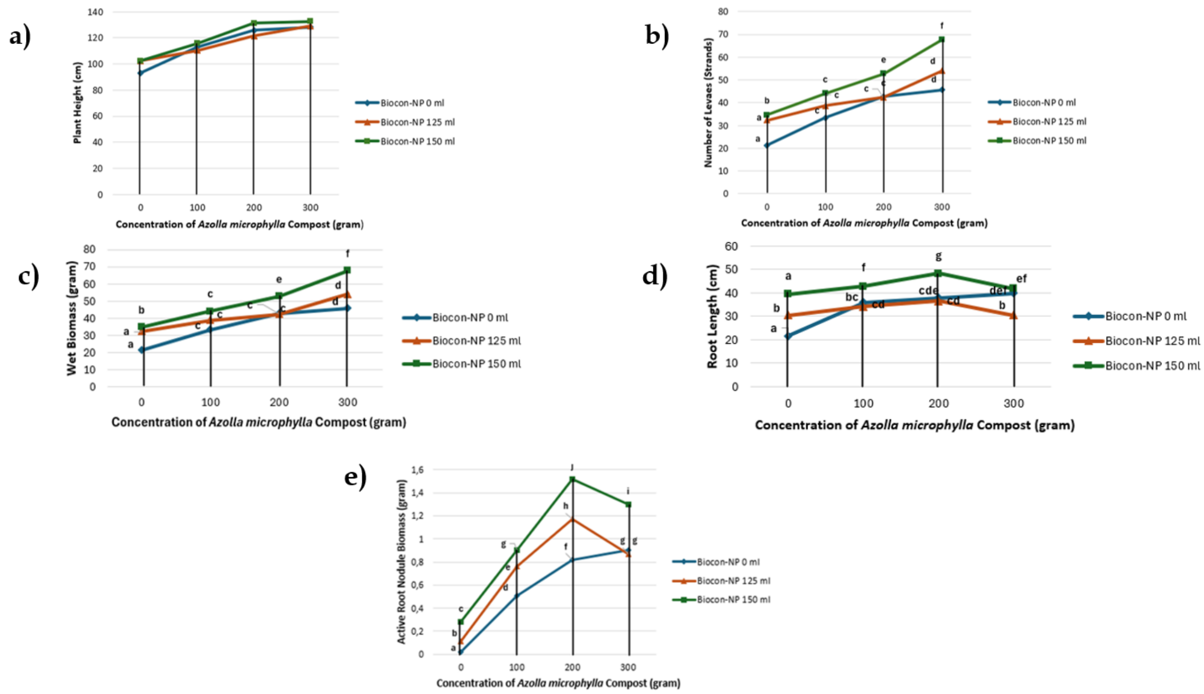

Figure 1. The effect of the combination of *Azolla microphylla* compost and Biocon-NP biofertiliser on a) plant height, b) number of leaves, c) root length, d) plant wet biomass, e) wet biomass of active root nodules (different letter notations indicate significant differences in the results of the Duncan test at the 0.05 significance level).

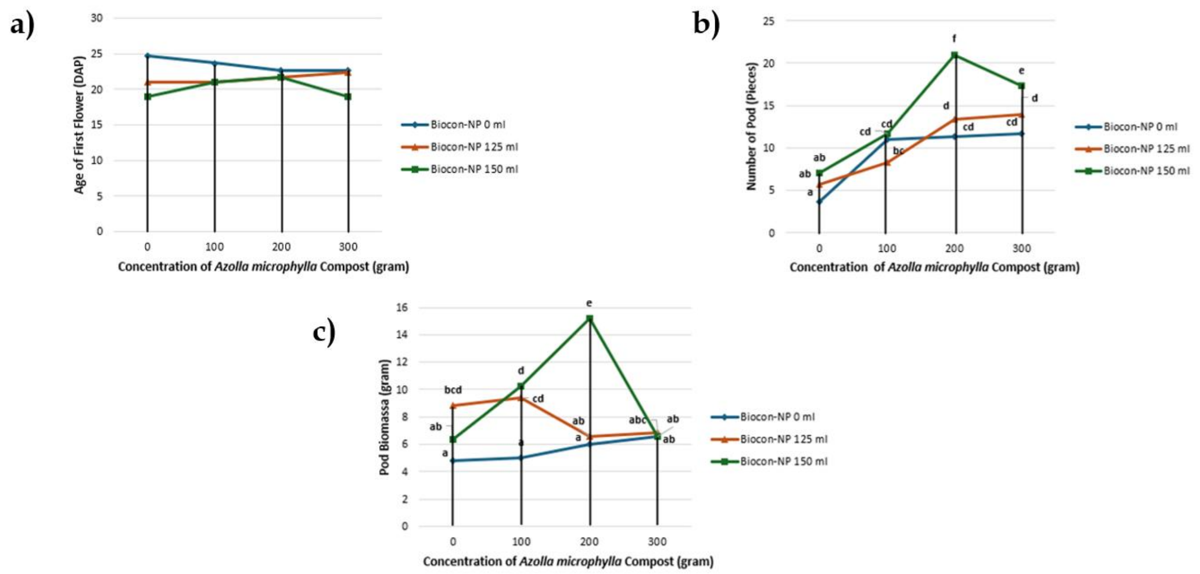

Figure 2. Effect of the combination of *Azolla microphylla* compost and Biocon-NP biofertiliser on a) flowering time, b) number of pods, c) pod biomass (different letter notations indicate significant differences in the results of Duncan's test at the 0.05 significance level).

in the range of 7.5-8.5. The presence of high levels of basic cations can raise the soil pH, which can affect the availability of essential nutrients that plants require (Azurianti *et al.*, 2022). Soil moisture was recorded at 65%, indicating moist soil. The soil C-organic content of 3.28% is in the high category. The increase in C-Organic content in the soil is influenced by the high rate of decomposition of organic matter or the rapid turnover process of organic matter, which ultimately accelerates the availability of nutrients (Yanti & Kusuma, 2021).

Based on the test results on the main nutrient content, the percentage of total N in the soil is only 0.105%, which is in the low category. This imbalance between carbon and nitrogen can slow down the nitrogen mineralisation process. Low levels of N-total in the soil can occur due to the decomposition of organic matter containing nitrogen. In addition, nitrogen is an easily lost element, either through plants' absorption or leaching due to water flow in the soil (Liu G *et al.*, 2025). The element N is an essential nutrient plants need in large quantities, which is needed in plant growth during the vegetative phase, such as roots, stems, and leaves (Saputra *et al*., 2018). The soil C/N ratio reached 31.24, which is classified as very high. The ratio of carbon and nitrogen mass (C/N) can be used to determine the speed of the decomposition process of organic matter and nutrient immobilisation in the soil (Nopsagiarti *et al*., 2020). The C/N ratio value has an inverse correlation with soil nutrient availability, where a low C/N ratio indicates high nutrient availability in the soil (Fitriyani et al, 2023). Based on Table 1, the C/N ratio belongs to the high category, indicating that the decomposition process of organic matter may be slow, as soil microorganisms require additional nitrogen to decompose carbon-rich organic matter.

Using compost as a source of key nutrients for plants, such as nitrogen, phosphorus, and potassium, helps in supplying these elements over time. During the composting process, the amount of soluble nutrients decreases, which means the compost releases nutrients gradually and lasts longer in the soil. Moreover, compost improves soil structure by increasing porosity and the soil's water-holding capacity, leading to better fertility and increased resistance to environmental stressors like drought. Compost also contains beneficial microorganisms that help maintain the soil ecosystem, support nutrient cycling, and reduce the growth of harmful plant pathogens (Siagian *et al*., 2024). Microorganisms involved in the breakdown of organic matter mainly help in breaking down complex substances like lignin and cellulose, which are the main parts of organic material, into simpler forms that plants can take in. According to research by Chavez *et al*. (2021), aerobic bacteria such as *Pseudomonas* and *Bacillus*, as well as fungi like *Trichoderma* and *Aspergillus*, play a significant role in this process, which helps improve soil fertility and the availability of nutrients for plants. However, the activity of these microbes is heavily influenced by environmental conditions, such as temperature, moisture, and soil pH. Compost is rich in humus, which enhances the availability of both macro and micro nutrients needed for root growth and supports microbial activity within the growing medium (Girsang *et al*., 2019).

Based on Table 2, *Azolla microphylla* compost has a total nitrogen content of 1.62%, which falls into the high category as defined by the Technical Guidelines for Chemical Analysis of Soil, Plants, Water and Fertilisers (2005). Lingga and Marsono (2006) explained that nitrogen is vital for the formation of plant vegetative parts like leaves, stems, and roots because it is a key part of amino acids that help with cell division and growth. The nitrogen content in solid organic fertilisers supports cell division in plants, which leads to more growth and more leaves. This improves photosynthesis. In *Azolla* compost, nitrogen sources break down quickly in the soil due to microorganisms, which speeds up the decomposition of organic matter. This process produces nitrogen in the form of ammonia (NH_4^+) and nitrate (NO_3^-), which plants can take up to support healthy vegetative growth (Febriana *et al*., 2018).

Biofertilizers are important for improving nutrient availability, especially nitrogen, in soils affected by Lapindo mud. Using them helps enhance soil quality and plant growth by making it easier for plants to take up nutrients. Liquid biofertilizers usually contain various types of microbes like *Bacillus*, *Azotobacter*, *Azospirillum*, *Rhizobium*, *Streptomyces*, and *Trichoderma* (Widyantoro *et al*., 2019). According to Rahayu (2022), nodules on legume plants that work with hydrocarbon-reducing bacteria like *Rhizobium* and *mycorrhiza* can help increase the survival rate of soybean plants in Lapindo mud-contaminated soil. Among these microbes, *Azotobacter* and *Azospirillum* are known for nitrogen fixation (Lia *et al*., 2022). Data from the Total Plate Count test in Table 3 shows that Biocon-NP liquid biofertiliser has a bacterial count of 1.75 x 10^7CFU/ml, which meets the standards set by SNI 2803-2010 for fertilisers.

From the results of the vegetative phase, using 300 grams of *Azolla microphylla* compost and 150 ml of Biocon-NP biofertiliser produced the best outcomes in terms of plant height, number of leaves, and plant biomass. This combination led to a plant height of 132.67 cm, the highest number of leaves at 67.66 strands, and a plant biomass of 52.43 grams. Using 200 grams of *Azolla microphylla* compost and 150 ml of Biocon-NP biofertiliser gave the best results for root length, reaching 48.26 cm, and active root nodule biomass of 1.52 grams.

Azolla microphylla compost is a good alternative to chemical fertilizers because it provides nitrogen to plants (Hodiyah *et al*., 2023). According to Sumiyanah and Sunkawa (2018), nitrogen is one of the most important components in synthesising proteins, chlorophyll, nucleic acids, and organic compounds. Protein is very important because it helps form many enzymes and parts of the cell structure (Saepuloh *et al*., 2020). When composting happens, there are many changes in the organic materials. Carbohydrates, cellulose, hemicellulose, fats, and waxes break down into carbon dioxide

(CO_2) and water. Proteins, on the other hand, turn into ammonia, carbon dioxide, and water. These breakdown processes create nutrients that plants can take in through their roots (Veronika *et al*., 2019).

According to the FNCA Biofertilizer Project Group (2006), biofertilizers include live microorganisms that can grow in the area around plant roots (rhizosphere) or inside the plant tissues. Bacteria that live around the roots (rhizosphere), known as rhizobacteria, act as *Plant Growth-Promoting Rhizobacteria* (PGPR). These bacteria have two main roles: they can take nitrogen (N_2) from the air and make plant growth hormones like auxin (IAA) and gibberellin. Auxin plays a role in regulating root cell elongation in plants by affecting cell wall flexibility. As a result, water enters through the osmosis process, so the cell is elongated. In addition, auxin also stimulates root and stem growth by stimulating cell elongation (Rusmin, 2011). In Biocon-NP biofertilizer, nitrogen-fixing bacteria such as *Azospirillum* are located around the plant root and develop mainly in the root elongation zone and the base of the root hairs. *Azospirillum* is an aerobic chemoorganotrophic, nonfermentative, vibroid bacterium capable of producing phytohormones, especially auxins (Reis *et al*., 2011). *Azospirillum* sp. can stimulate plant growth through the secretion of phytohormones. These bacteria also produce many chemical compounds, such as auxins, cytokinins, gibberellins, ethylene, and other growth regulators (ZPT), which include abscisic acid (ABA), polyamines like spermidine, spermine, and cadaverine, and nitrogen oxides (Wahyuni and Parmila, 2019).

Auxin hormones help cells grow longer. Also, auxin activates the cambium, which is responsible for making xylem and phloem tissues (Andianingsih *et al*., 2023). Cell elongation happens when water enters the cell through osmosis. This happens because the hydrogen bonds in the cellulose chain in the cell wall are broken. This breaking is caused by certain enzymes that are activated by H+ ions. Auxin hormones make specific proteins in the plant's cell membrane pump H+ ions into the cell wall, which causes the cell to stretch (Taiz & Zeiger, 2012). In roots, auxin works by relaxing or making the cell wall more flexible, which leads to cell elongation. Auxin stimulates specific proteins in the plasma membrane of plant cells to move H^+ ions to the cell wall. H ions activate certain enzymes that break hydrogen bonds in the cellulose molecular chains that make up the cell wall. As a result, cells experience pressure due to increased water absorption through the process of osmosis, which then encourages cell elongation (Putra & Shofi, 2015).

Figure 2 shows that in the generative phase of soybean plants, the application of *Azolla microphylla* compost, Biocon-NP biofertilizer, and their interactions has a significant effect on the number of pods and pod biomass, while having no significant effect on flowering time. The best combination of the number of pods and pod biomass was at the concentration of 200 grams of Azolla microphylla compost and 150 ml of Biocon-NP biofertilizer. However, the flowering phase experienced an accelerated transition from the vegetative phase to the generative phase at 19 DAP during the vegetative phase observation period of 45 DAP maximum.

The early initiation of flowering marks the transition from the vegetative phase to the generative phase. This process also causes plant parts to change from being vegetative (leaves and stems) to reproductive (flowers). This change is linked to how cells differentiate into different parts of the plant. This transition is controlled by three main types of genes: those that control when a plant flowers, genes that identify flower parts, and genes that determine the specific parts of the flower, with gene activity happening gradually (Ihtirahmiddin *et al*., 2024). According to Mahdhar and Ermadani (2021), phosphorus plays an important role during this stage by being part of compounds that act as secondary receptors.This role comes from the activity of enzymes that activate hormones as primary receptors and other compounds that stimulate the expression of floral primordial genes. In addition, phosphorus also stimulates root growth, fruit development, and seed formation (Santi, 2008). Phosphorus (P) plays a vital role in forming nucleic acids, stimulating cell division, and supporting the process of assimilation and respiration in plants (Sari *et al*., 2023).

Azolla microphylla compost and Biocon-NP biofertilizer, as well as their interactions, affected pod biomass parameters. This condition can occur due to the optimal translocation of photosynthates into soybean seeds. Pod biomass formed from photosynthesis in the leaves produces assimilates channelled to other parts of the plant, primarily to support fruit formation or pod filling, by utilising more assimilates than new assimilates (Wardana *et al*., 2024). Research by Bangun *et al*. (2023) revealed that nitrogen (N) in organic fertilizers and *Azotobacter* forms nucleic acids and proteins and supports the photosynthetic process in producing photosynthate. This is in line with the statement of Yoseva *et al*. (2022), which explains that photosynthate from photosynthesis will be distributed to all parts of the plant to support seed development and pod growth. Agustini and Subardja (2023) quoted Sudadi (2003), who stated that plant growth and yield are strongly influenced by environmental factors, especially the temperature around the plant. Soybeans can grow in a temperature range of 21-34ºC, but the ideal temperature for growth is 23-27ºC (Arsyad, 2018, in Agustini and Subardja, 2023).

CONCLUSION

Based on the results of the research that has been done, it can be concluded that the application of *Azolla microphylla* compost and Biocon-NP biofertilizer has a significant effect on the growth of vegetative and generative phases of soybean plants on the parameters of the number of leaves, root length, plant wet biomass, wet biomass of active root nodules, number of pods and pod biomass, but has no significant effect on the parameters of plant height and flowering time. The interaction of *Azolla microphylla* compost treatment and Biocon-NP biofertilizer significantly affected soybean plants when 200 grams of *Azolla microphylla* compost were combined with 150 ml of Biocon-NP biofertilizer. The combination of *Azolla microphylla* compost treatment and Biocon-NP biofertilizer can accelerate the transition from the vegetative phase to the generative phase.

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CONFLICT OF INTEREST

There is no conflict of interest.

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