

Enhancing the Growth and Yield of Lembah Palu Shallot Variety (*Allium wakegi* Araki) Using *Azotobacter* sp.

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Abstract: Nitrogen is the main component of protein, relatively unavailable to plants even though nitrogen molecules account for 80 percent of the total elements in the atmosphere. *Azotobacter* bacteria can play a role in increasing soil fertility and are capable of fixing free nitrogen from the air. This study aims to examine the optimal concentration of *Azotobacter* sp. bacteria for shallot plants of the Lembah Palu variety to support growth and production. This research was conducted at the Agronomy Laboratory and Screen House of the Academic Garden, Faculty of Agriculture, Tadulako University, Palu, from August 2024 to July 2025. The experiment was arranged using a Completely Randomized Design (CRD) consisting of five treatments with three replications. The treatments included control (without *Azotobacter* sp.), 100 ml *Azotobacter* sp., 1:5 (17 ml *Azotobacter* sp. + 83 ml water), 1:10 (9 ml *Azotobacter* sp. + 91 ml water), and 1:15 (6 ml *Azotobacter* sp. + 94 ml water). The results showed that the application of *Azotobacter* sp. did not significantly affect most growth and yield parameters. Significant effects were only observed on root volume and total soluble solids. The treatment with 100 ml *Azotobacter* sp. produced the highest root volume (4.00 ml) and total soluble solids (16.20 °Brix) compared to the other treatments. These findings indicate that the application of *Azotobacter* sp. mainly influenced root development and soluble solid content rather than overall plant growth and yield of Lembah Palu shallots.

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INTRODUCTION

Nitrogen (N) is a major component of proteins and is relatively unavailable to plants, even though nitrogen constitutes 80 percent of the total elements in the atmosphere. Generally, nitrogen present in the atmosphere is chemically "inert" and cannot be directly utilized by plants (Tando, 2019). Therefore, to help plants obtain sufficient nitrogen, nitrogen fixation is required, which can be facilitated by bacteria, one of which is *Azotobacter* sp.

Azotobacter sp. is one of the living organisms with the potential to increase the available nitrogen content in the soil because it can fix nitrogen from the air at a higher rate than other free-living nitrogen-fixing microbes. *Azotobacter* bacteria play a significant role in improving soil fertility by fixing atmospheric nitrogen (N) and converting it into ammonium (NH₄⁺), which is easily absorbed by plants and is an essential nutrient for plant growth (Eka, 2021).

This study uses shallot plants as test subjects because the application of *Azotobacter* sp. bacteria in shallot cultivation is still relatively limited. According to Febriati and Rahayu, (2020), the application of *Azotobacter* bacteria can enhance plant growth by providing nitrogen and plant growth regulators. Therefore, the application of *Azotobacter* sp. to Lembah Palu variety shallots is expected to improve plant growth and yield.

However, studies examining the application of *Azotobacter* sp. specifically on shallot cultivation, particularly the Lembah Palu variety, are still limited. Most previous studies have focused on other crops or on general biofertilizer applications, leaving a gap in understanding the optimal concentration of *Azotobacter* sp. for improving the growth and yield of this economically important local variety.

The Lembah Palu shallot variety is a type of shallot known as a raw material for the fried shallot industry. This type of shallot has become a "local brand" of Palu City. One of the unique characteristics of this shallot, which distinguishes it from other shallot varieties, is its firm texture, which results in crispy and savory fried shallots with an aroma that remains unchanged even when stored for long periods in a sealed container (Irwan et al., 2024).

According to research by (Sudewi dan Indriani, 2017), the demand for local Palu shallot raw materials has been increasing every year due to the growing fried shallot industry. Currently, there are 36 fried shallot industries scattered around Palu City and its surroundings, processing local Palu shallots into fried shallots. However, the fried shallot industry experienced a decline in production due to a shortage of shallot supplies as raw materials.

Therefore, this study aims to evaluate the optimal concentration of *Azotobacter* sp. application to enhance the growth and yield of Lembah Palu shallots. This study is expected to provide scientific information regarding the effective use of *Azotobacter* sp. as a biofertilizer in shallot cultivation and contribute to the development of sustainable agricultural practices.

METHODS

Research Procedure

This study was conducted in a greenhouse at the Academic Garden, Faculty of Agriculture, Tadulako University, Palu, from August 2024 to July 2025. The experiment was arranged using a Completely Randomized Design (CRD) consisting of five treatments with three replications. Each experimental unit consisted of one polybag planted with one shallot bulb. The treatments consisted of different concentrations of *Azotobacter* sp., namely: 0:1 (control, without *Azotobacter* sp.), 1:0 (100 ml *Azotobacter* sp.), 1:5 (17 ml *Azotobacter* sp. + 83 ml water), 1:10 (9 ml *Azotobacter* sp. + 91 ml water), and 1:15 (6 ml *Azotobacter* sp. + 94 ml water).

1. Site Preparation

The cultivation site used in this study was a greenhouse, which was first checked and sanitized to ensure it was ready for use.

2. Seed Preparation

The shallot seeds used for planting were mature, approximately 1.5 to 2 months after harvest. The tips of the shallots were cut to stimulate even growth of the bulbs, promote the development of side bulbs, and encourage the formation of new shoots. The seeds were planted after the cut ends had dried, to prevent any potential rotting or disease attacks at the cut site, which could interfere with plant growth.

3. Growing Medium Preparation

The growing medium used was soil. Polybags with a diameter of 35 x 35 cm were used, with each polybag containing 5 kg of soil. The soil used as the growing medium was topsoil collected from the experimental field area and sieved to remove debris and stones before being placed into the polybags.

4. Planting

Planting was done by making a hole in the center of each polybag, 2-3 cm deep, and planting one shallot bulb in each polybag.

5. Azotobacter Bacteria Application

The bacteria were applied when the plants were 2 weeks old (2 MST), by dissolving the bacteria in water according to the treatment specifications. The *Azotobacter* sp. inoculum used in this study was obtained from the Agronomy Laboratory, Faculty of Agriculture, Tadulako University. The solution was applied by making small holes around the plants and pouring 100 ml of the solution into each hole.

6. Maintenance

Maintenance included watering the plants in the morning and afternoon, adjusted according to soil conditions. Weeding was done manually by removing any unwanted weeds or grasses that grew in the polybags, as these could interfere with the growth of the shallots.

7. Harvesting

Harvesting was carried out when the plants were 55-60 days after planting (HST). The shallot plants were considered ready for harvest when the leaves began to wilt, dry, and turn yellow, and the bulbs were fully formed and slightly protruding from the soil surface. Harvesting was done by carefully uprooting the plants to ensure no bulbs were left behind or damaged. The bulbs were then cleaned of any dirt.

Observation Parameters

1. Plant Height (cm)

Height measurements were taken using a ruler, from the base of the stem to the tip of the

longest leaf. Measurements were recorded at 2, 4, 6, and 8 weeks after planting (MST).

2. Number of Leaves (leaves)

The number of fully grown leaves was counted. Measurements were recorded at 2, 4, 6, and 8 weeks after planting (MST).

3. Number of Offshoots

The number of offshoots formed in each clump was counted and observed at 6 MST.

4. Number of Bulbs per Clump

The number of bulbs produced in each clump was counted and observed during harvesting.

5. Bulb Diameter (mm)

The diameter of the bulbs produced was measured using a digital caliper.

6. Fresh Bulb Weight per Clump (grams)

The weight of the shallot bulbs (after separating the bulbs from the leaves) was measured during harvesting.

7. Bulb Hardness (Newton/cm)

Bulb hardness was measured using a penetrometer. First, the shallot bulbs were cleaned of dirt, and then the penetrometer was pressed into the bulb with constant speed and pressure.

8. Dry Bulb Weight (grams)

The shallot bulbs were cut into several pieces, placed in an envelope, and then dried in an oven for 48 hours at 70°C.

9. Root Volume (ml)

Root volume was measured by placing the plant's roots into a measuring cylinder filled with water. The volume of water displaced by the roots was recorded as the root volume.

10. Total Soluble Solids (°Brix).

This was measured using a hand refractometer. Thin slices of the shallot bulb were cut, making it easier to crush with a mortar. A few drops of water from the crushed bulb were placed on the refractometer's glass surface. The reading of total soluble solids was noted from the lens of the refractometer in units of °Brix, with the result indicated by the blue-colored scale.

11. Data Analysis

The data collected were analyzed using an analysis of variance (ANOVA). The ANOVA was performed based on the Completely Randomized Design (CRD) to evaluate the effect of different concentrations of *Azotobacter* sp. on the observed parameters. If significant differences were found, further testing was conducted using the Honest Significant Difference (HSD) test at the 5% level and Duncan's multiple range test. These statistical tests were used to determine the significance of differences among treatments. If the HSD test did not show any significant effects, Duncan's test was used to accurately observe the significant impacts of the treatments.

RESULT AND DISCUSSION

Plant Height

The analysis of variance (ANOVA) showed that the application of *Azotobacter* sp. bacteria did not significantly affect the height of the shallot plants at 2-8 weeks after planting (WAP), as shown in Figure 1. The results from Figure 1 indicate that all treatments with *Azotobacter* sp. bacteria did not differ substantially from the control treatment (no *Azotobacter* sp. bacteria). However, the treatment with a 1:0 concentration (100 ml *Azotobacter* sp. + no water) tended to have a positive effect on plant height compared to the other treatments. The 1:0 treatment resulted in a plant height of 34.66 cm.

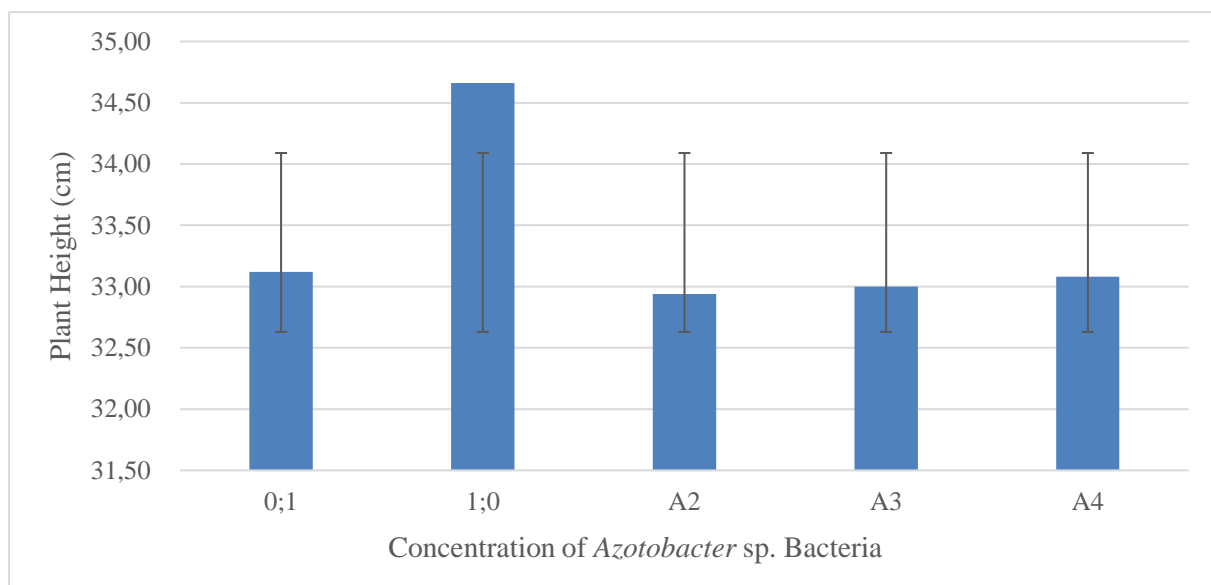


Figure 1. Average Plant Height (cm) of Lembah Palu Shallots at 8 WAP with *Azotobacter* sp. Bacteria Application

Number of Leaves (leaves)

The analysis of variance (ANOVA) showed that the application of *Azotobacter* sp. bacteria did not significantly affect the number of leaves of the shallot plants at 2-8 WAP, as shown in Figure 2. The results from Figure 2 show that the application of *Azotobacter* sp. did not substantially differ from the control treatment. However, the treatment with a 1:5 concentration (17 ml *Azotobacter* sp. + 83 ml water) tended to have a better effect on the number of leaves, with an average of 24.20 leaves. This treatment was not significantly different from the 1:0 treatment (100 ml *Azotobacter* sp. + no water).

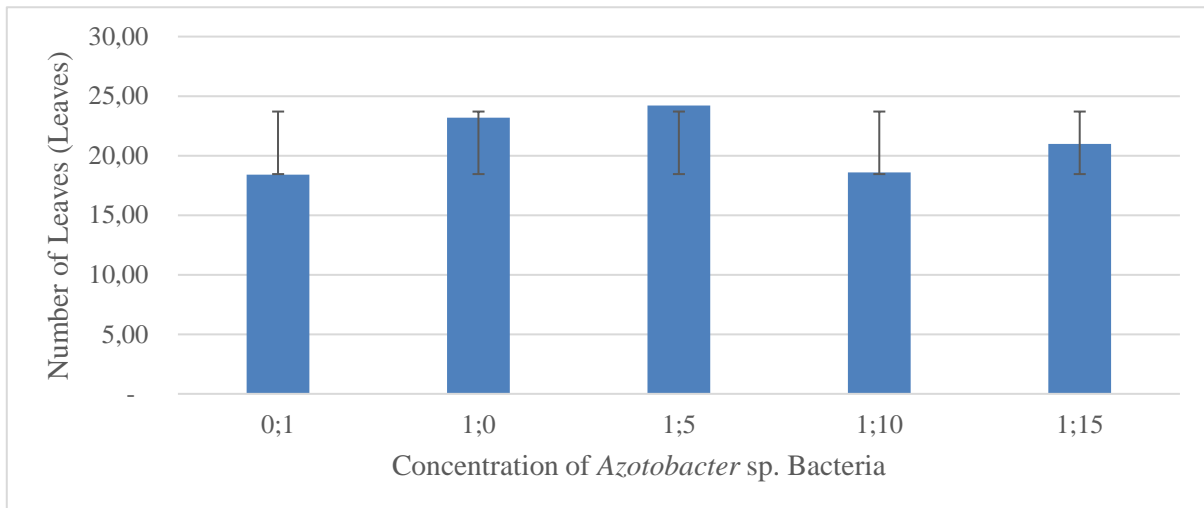


Figure 2. Average Number of Leaves (leaves) of Lembah Palu Shallots at 8 WAP with *Azotobacter* sp. Bacteria Application

Number of Offshoots (bulbs)

The analysis of variance (ANOVA) showed that the application of *Azotobacter* sp. bacteria did not significantly affect the number of offshoots (bulbs) at 6 WAP, as shown in Figure 3. The results from Figure 3 indicate that the application of *Azotobacter* sp. did not differ significantly from the control treatment. However, the treatment with a 1:5 concentration (17 ml *Azotobacter* sp. + 83 ml water) tended to show better growth compared to the other treatments.

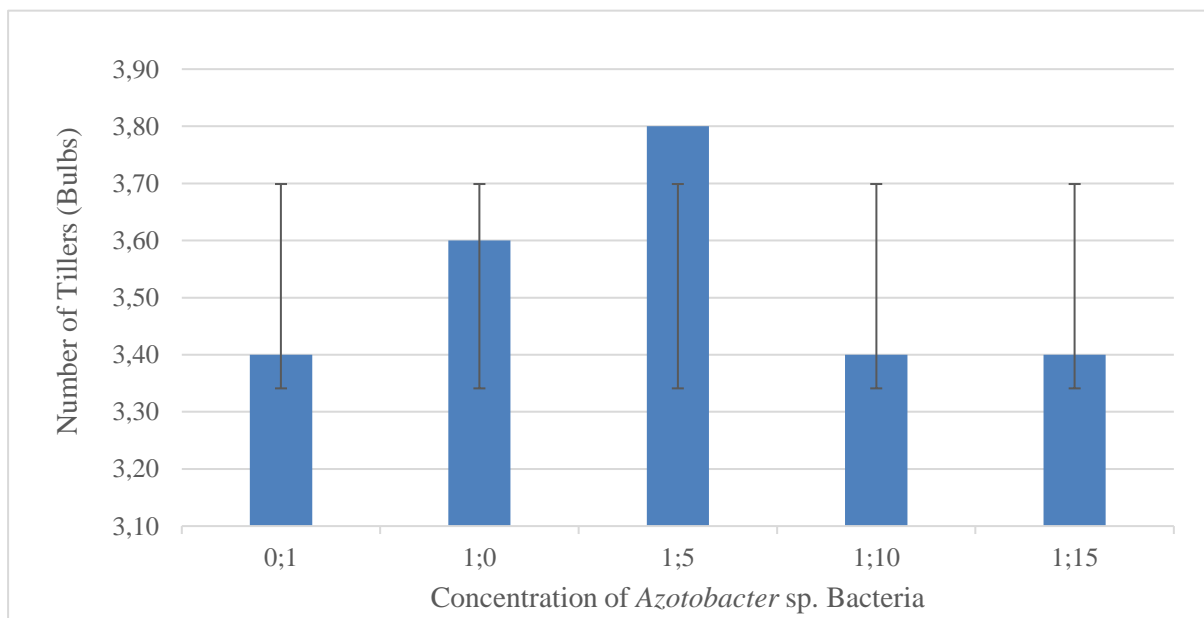


Figure 3. Average Number of Offshoots (bulbs) of Lembah Palu Shallots at 6 WAP with *Azotobacter* sp. Bacteria Application

Number of Bulbs per Clump

The analysis of variance (ANOVA) showed that the application of *Azotobacter* sp. bacteria

did not significantly affect the number of bulbs per clump, as shown in Figure 4. The results from Figure 4 indicate that the application of *Azotobacter* sp. did not substantially differ from the control treatment. However, the treatment with a 1:5 concentration (17 ml *Azotobacter* sp. + 83 ml water) tended to result in better growth compared to other treatments. The 1:0 concentration (100 ml *Azotobacter* sp.) resulted in an average of 4.00 g, which was not significantly different from the 1:5 treatment (17 ml *Azotobacter* sp. + 83 ml water), which had an average of 4.80 g.

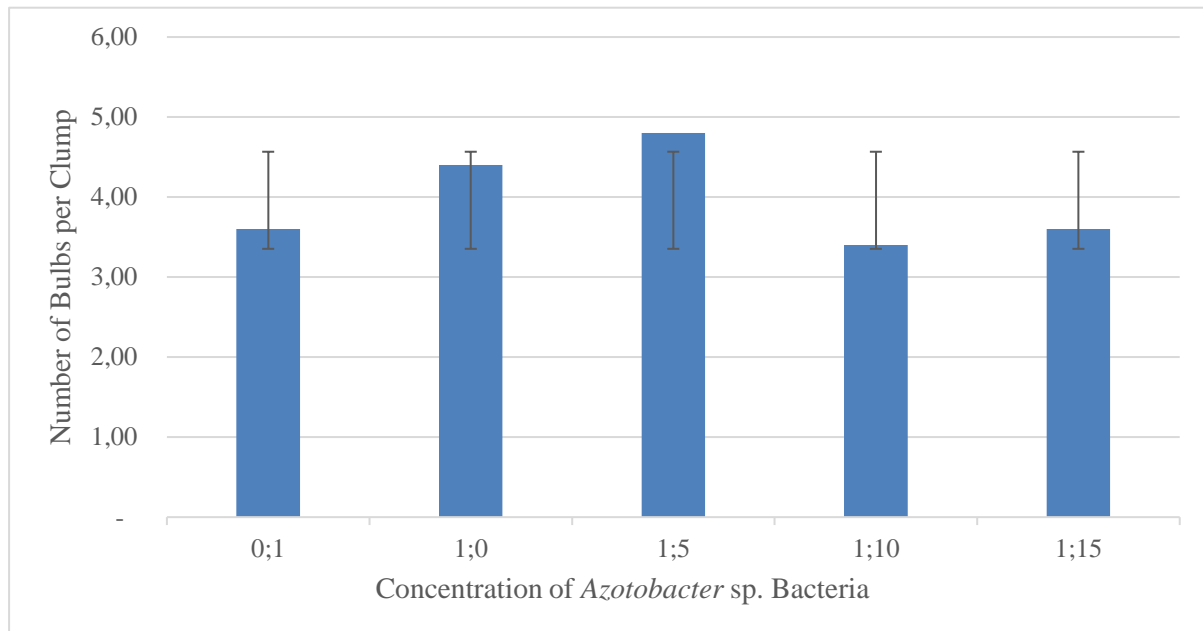


Figure 4. Average Number of Bulbs per Clump of Lembah Palu Shallots with *Azotobacter* sp. Bacteria Application

Bulb Diameter (mm)

The analysis of variance (ANOVA) showed that the application of *Azotobacter* sp. bacteria did not significantly affect the diameter of the shallot bulbs, as shown in Figure 5. The results from Figure 5 indicate that the application of *Azotobacter* sp. did not differ significantly from the control treatment. However, the treatment with a 1:15 concentration (6 ml *Azotobacter* sp. + 94 ml water) showed a slight increase in bulb diameter (18.78 mm) compared to the other treatments. The 1:0 treatment (100 ml *Azotobacter* sp. + no water) resulted in a bulb diameter of 18.32 mm, which was not significantly different from the control (18.30 mm).

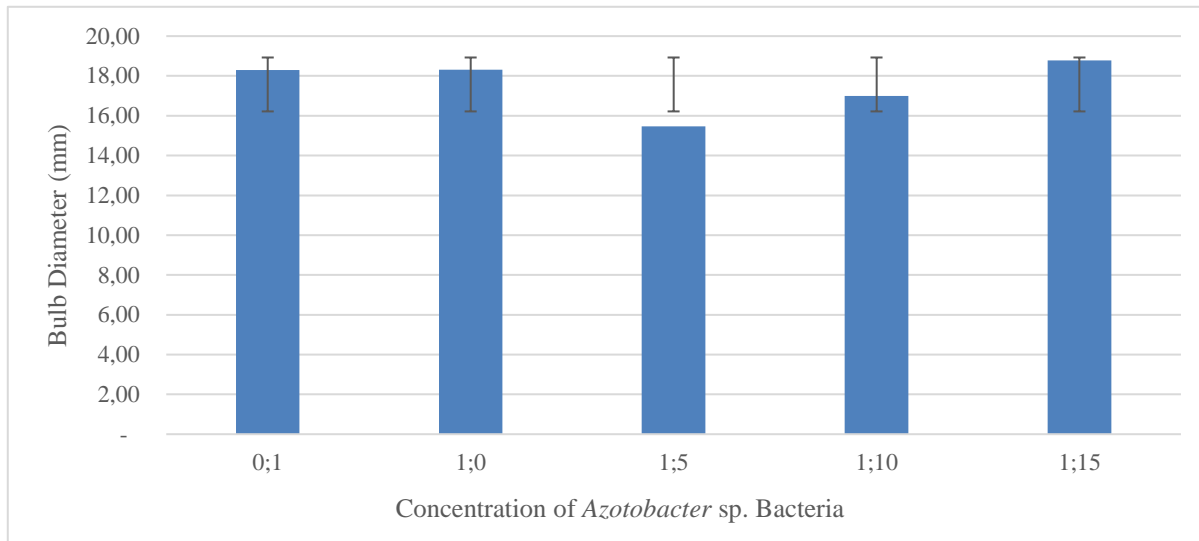


Figure 5. Average Bulb Diameter (mm) of Lembah Palu Shallots with *Azotobacter* sp. Bacteria Application

Fresh Bulb Weight (grams)

The analysis of variance (ANOVA) showed that the application of *Azotobacter* sp. bacteria did not significantly affect the fresh weight of the shallot bulbs, as shown in Figure 6. The results from Figure 6 indicate that the application of *Azotobacter* sp. did not have a significant impact compared to the control treatment. However, the treatment with a 1:5 concentration (17 ml *Azotobacter* sp. + 83 ml water) tended to result in better growth, with an average fresh bulb weight of 24.10 g. The 1:0 treatment (100 ml *Azotobacter* sp. + no water) had an average of 23.72 g, which was similar to the 1:15 treatment (6 ml *Azotobacter* sp. + 94 ml water) at 23.64 g. Meanwhile, the 1:10 treatment (9 ml *Azotobacter* sp. + 91 ml water) had the lowest fresh bulb weight.

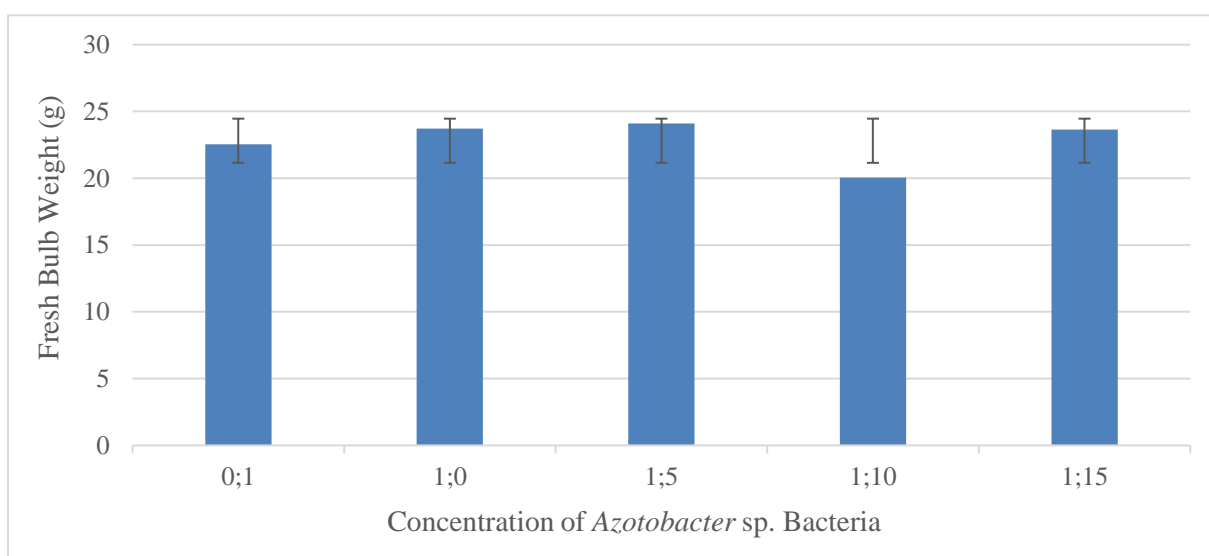


Figure 6. Average Fresh Bulb Weight (grams) of Lembah Palu Shallots with *Azotobacter* sp. Bacteria Application

Bulb Hardness (Newton/cm)

The analysis of variance (ANOVA) showed that the application of *Azotobacter* sp. bacteria did not significantly affect the bulb hardness of the shallots, as shown in Figure 7. The results from Figure 7 indicate that the application of *Azotobacter* sp. did not have a significant effect on the bulb hardness of Lembah Palu shallots. However, the treatment with a 1:0 concentration (100 ml *Azotobacter* sp. + no water) tended to result in better hardness, with an average of 11.24 N/cm.

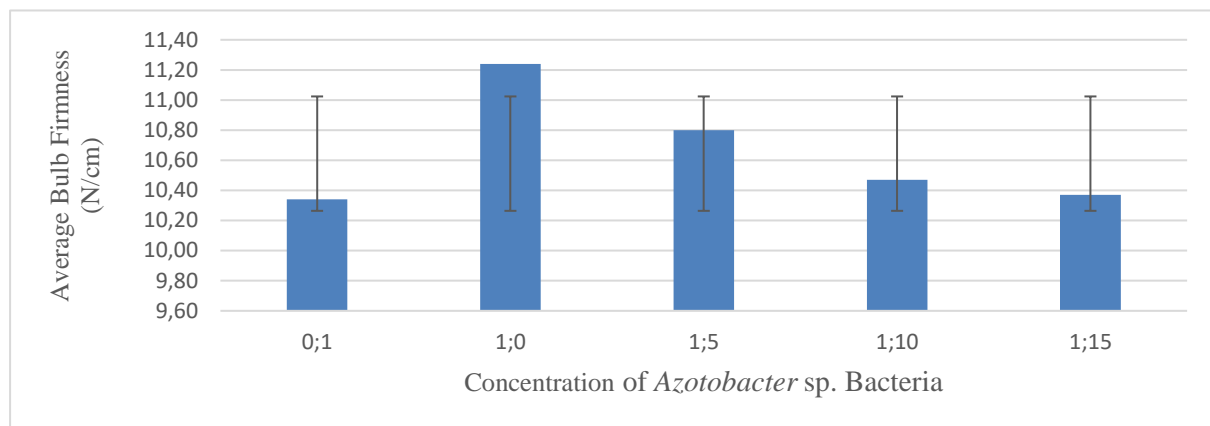


Figure 7. Average Bulb Hardness (N/cm) of Lembah Palu Shallots with *Azotobacter* sp. Bacteria Application

Dry Bulb Weight (grams)

The analysis of variance (ANOVA) showed that the application of *Azotobacter* sp. bacteria did not significantly affect the dry weight of the shallot bulbs, as shown in Figure 8. The results from Figure 8 indicate that the application of *Azotobacter* sp. did not significantly differ from the control treatment. However, the treatment with a 1:0 concentration (100 ml *Azotobacter* sp. + no water) tended to have a better effect compared to other treatments. The 1:5 treatment (17 ml *Azotobacter* sp. + 83 ml water) and the 1:15 treatment (6 ml *Azotobacter* sp. + 94 ml water) showed similar average dry bulb weights to the control. Meanwhile, the 1:10 treatment (9 ml *Azotobacter* sp. + 91 ml water) had the lowest average dry bulb weight of 5.18 g.

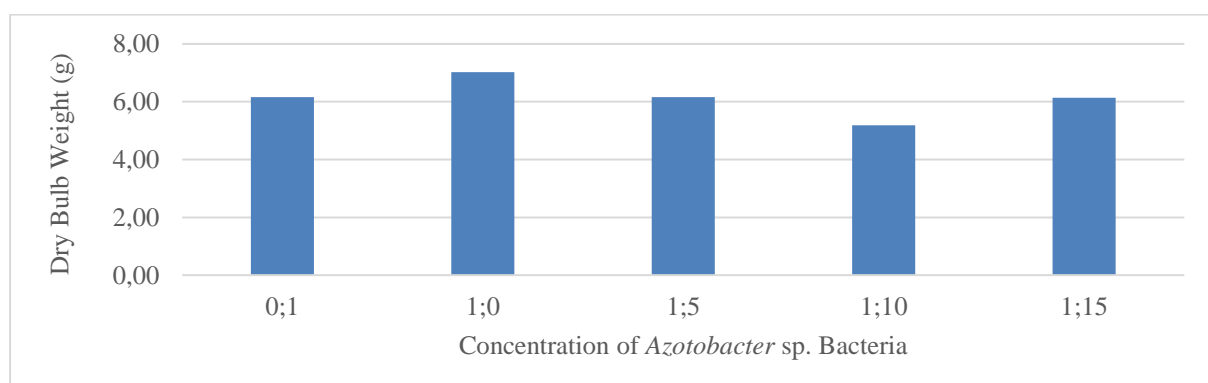


Figure 8. Average Dry Bulb Weight (grams) of Lembah Palu Shallots with *Azotobacter* sp. Bacteria Application

Root Volume (ml)

The analysis of variance (ANOVA) showed that the application of *Azotobacter* sp. bacteria significantly affected the root volume of Lembah Palu shallots, as shown in Table 1.

Table 1. Average Root Volume (ml) of Lembah Palu Shallots with *Azotobacter* sp. Bacteria Application

Treatment	Average Volume (ml)
0:1 (Control: No <i>Azotobacter</i> sp. bacteria)	2.20 ^a
1:0 (100 ml <i>Azotobacter</i> sp.)	4.00 ^b
1:5 (17 ml <i>Azotobacter</i> sp. + 83 ml water)	3.20 ^{ab}
1:10 (9 ml <i>Azotobacter</i> sp. + 91 ml water)	2.80 ^a
1:15 (6 ml <i>Azotobacter</i> sp. + 94 ml water)	2.60 ^a

Note: Values followed by the same letter in the same column are not significantly different according to Duncan's multiple range test.

The results from Table 1 show that the application of 100 ml *Azotobacter* sp. bacteria resulted in the highest average root volume (4.00 ml). This treatment was significantly different from the control, the 1:15 treatment, and the 1:10 treatment, but was not significantly different from the 1:5 treatment (17 ml *Azotobacter* sp. + 83 ml water).

Total Soluble Solids (°Brix)

The analysis of variance (ANOVA) showed that the application of *Azotobacter* sp. bacteria significantly affected the total soluble solids of Lembah Palu shallots, as shown in Table 2.

Table 2. Average Total Soluble Solids (°Brix) of Lembah Palu Shallots with *Azotobacter* sp. Bacteria Application

Treatment	Average °Brix
0:1 (Control: No <i>Azotobacter</i> sp. bacteria)	11.20 ^a
1:0 (100 ml <i>Azotobacter</i> sp.)	16.20 ^c
1:5 (17 ml <i>Azotobacter</i> sp. + 83 ml water)	13.60 ^b
1:10 (9 ml <i>Azotobacter</i> sp. + 91 ml water)	12.80 ^{ab}
1:15 (6 ml <i>Azotobacter</i> sp. + 94 ml water)	11.20 ^a

Note: Values followed by the same letter in the same column are not significantly different according to Duncan's multiple range test.

The results from Table 2 indicate that the application of 100 ml *Azotobacter* sp. bacteria resulted in the highest total soluble solids value (16.20 °Brix). This was significantly different from the control and the 1:15 treatment (6 ml *Azotobacter* sp. + 94 ml water), but not significantly different from the 1:10 treatment (9 ml *Azotobacter* sp. + 91 ml water).

Discussion

The various applications of *Azotobacter* sp. bacteria at different concentrations—100 ml *Azotobacter* sp., 1:5 concentration (17 ml *Azotobacter* sp. + 83 ml water), 1:10 concentration (9 ml *Azotobacter* sp. + 91 ml water), and 1:15 concentration (6 ml *Azotobacter* sp. + 94 ml water)—did not significantly affect parameters such as plant height, number of leaves, number of offshoots, number of bulbs per clump, bulb diameter, fresh bulb weight, bulb hardness, and fresh bulb weight. However, parameters such as root volume and total soluble solids showed significant effects. This suggests that the application of *Azotobacter* sp. bacteria can have a positive impact on the growth of Lembah Palu shallot variety.

The lack of significant effects from *Azotobacter* sp. bacteria is suspected to be due to the bacterial concentration applied to the shallot plants not reaching the optimal level needed to affect growth and yield. However, the application of *Azotobacter* sp. did show some effect, though not significant. According to Nandha & Setiawati, (2018) *Azotobacter* sp. plays a crucial role in plant growth processes, acting as a nitrogen fixer and producing phytohormones that support plant growth.

The lack of significant effects from *Azotobacter* sp. bacteria on the growth of the shallot plants is also likely influenced by the high rainfall during the research period. The planting was conducted during the rainy season, which may have hindered the development of *Azotobacter* sp. as a bio-fertilizer. Marhama *et al.*, (2023) stated that nitrogen-fixing and phosphorus-solubilizing bacteria develop better under water-deficient conditions.

In addition to the bacteria not developing well under high rainfall, the rainy season also had an impact on the growth of the shallot plants, particularly the bulb development. Saputri & Lapanjang, (2022) suggested that shallots planted in low and cold temperatures could experience inhibited growth, with plants failing to produce bulbs. Maemunah, (2010) further added that shallots planted at temperatures below 22°C can have inhibited bulb formation, often resulting in no bulb formation at all.

The results of the study showed that the application of 100 ml *Azotobacter* sp. tended to have a positive effect on plant height, bulb hardness, dry bulb weight, and had a significant effect on root volume and total soluble solids. This suggests that the application of *Azotobacter* sp. as a nitrogen fixer influenced plant growth.

According to (Maknuna dan Soeparjono, 2023), the application of *Azotobacter* bacteria is considered more effective in increasing plant height because *Azotobacter* can absorb and provide nitrogen nutrients more quickly and in greater amounts. Additionally, *Azotobacter* produces hormones that help the growth process of plants. The activity of *Azotobacter* bacteria produces IAA and gibberellins, which are beneficial for plant height development. IAA and gibberellins help accelerate cell division and stem elongation in plants.

The application of *Azotobacter* sp. bacteria also influenced total soluble solids. High total soluble solids indicate that the bulbs have good quality, with high sugar content, nutritional value, and longer shelf life. Lismawati *et al.*, (2023) stated that the higher the total soluble solids, the better the quality of the shallots. A higher total soluble solids value indicates that the shallots

have a stronger flavor, and the higher the value, the better the quality of the shallots.

Based on the study results, the application of *Azotobacter* sp. at a concentration of 1:5 (17 ml *Azotobacter* sp. + 83 ml water) showed a better effect on the growth of the number of leaves, number of offshoots, number of bulbs per clump, and fresh bulb weight. This indicates that the application of *Azotobacter* sp. can provide nutrients to the plants, although it has not yet achieved the desired growth and yield.

The data obtained from the study showed that the number of leaves reached an average of 24.20 leaves, which is still lower than the expected range for Lembah Palu shallot plants, where the typical leaf count ranges between 20 and 40 leaves.

According to Herwanda *et al.*, (2017), leaves are an important growth indicator and support data for explaining the growth processes occurring in plants. The number of leaves in a plant is important because the more leaves there are, the higher the photosynthate content, which supports the growth and development of the plant.

The number of leaves also correlates with the number of offshoots. The number of offshoots produced in this study significantly affected the number of bulbs in the plants. Tandi *et al.*, (2015) stated that the more offshoots there are, the more bulbs are produced. The increasing number of leaves also improves the plant's ability to perform photosynthesis optimally.

The increase in the number of bulbs and leaves during this growth phase affects the fresh bulb weight. This increase occurs due to the photosynthates produced during photosynthesis, which encourages optimal bulb development. Saskia *et al.*, (2024) noted that the fresh weight of plants indicates the amount of water and organic material in the plant's tissues or organs. As the plant grows, the number of leaves, leaf fresh weight, and the number of bulbs produced will increase, affecting the overall fresh weight of the plant

The results of the study showed that the application of *Azotobacter* sp. at a concentration of 1:15 (6 ml *Azotobacter* sp. + 94 ml water) tended to have a better effect on bulb diameter growth. The size of the bulbs used during planting can influence the bulb diameter. The bulbs used were categorized by size into small, medium, and large. Larger bulbs have a better effect on the bulb diameter parameter.

According to Susilawati *et al.*, (2023), larger bulbs contain more food reserves, making them better supported for growth compared to smaller bulbs.

CONCLUSION

Based on the results of data analysis, it can be concluded that the application of 100 ml of *Azotobacter* sp. bacteria showed the most significant effect on root volume and total soluble solids of Lembah Palu shallots. The treatment produced the highest root volume and °Brix value compared to the other treatments, indicating that the application of *Azotobacter* sp. can influence certain physiological aspects of plant growth and bulb quality. However, the application of *Azotobacter* sp. did not show statistically significant effects on several other observed parameters, including plant height, number of leaves, number of offshoots, number of bulbs per clump, bulb diameter, fresh bulb weight, bulb hardness, and dry bulb weight.

These findings indicate that the application of *Azotobacter* sp. in this study had a more

pronounced effect on root development and soluble solid content rather than on overall vegetative growth and yield components of the Lembah Palu shallot variety. Nevertheless, the tendency of several growth parameters to show higher values under certain treatments suggests that *Azotobacter* sp. has potential as a biofertilizer in shallot cultivation, although its effectiveness may depend on appropriate application conditions and concentrations.

Recommendations

The author recommends that future research include the assessment of nitrogen content in the growing medium, both before and after planting. This is important because *Azotobacter* sp. is a nitrogen-fixing bacterium, and such measurements can help distinguish the impact of the bacteria application.

DAFTAR PUSTAKA

- Eka P, D. (2021). *pengaruh pemberian biochar tongkol jagung dengan mikroba azotobacter dan actinomycetes terhadap pertumbuhan generatif tanaman kakao*. 2(4), 1147–1152.
- Febriati, N., & Rahayu, Y. (2020). The Effect of Biochar and Nitrogen Stimulating Bacteria (*Rhizobium* & *Azotobacter* sp.) on the Growth of Soybean (*Glycine max*) in Calcarouse Soil. *Lentera Bio*, 8(1), 62–66.
- Herwanda, R., Murdiono, W. E., Jurusan, K., Pertanian, B., & Pertanian, F. (2017). THE APPLICATION OF NITROGEN AND FOLIAR FERTILIZER TO GROWTH AND YIELD OF SHALLOTS (*Allium cepa* L. var. *ascalonicum*). *Jurnal Produksi Tanaman*, 5(1), 46–53.
- Irwan, Basri, Z., & Maemunah. (2024). Pengaruh Lama Perendaman Dan Konsentrasi Kalium Nitrat Terhadap Mutu Benih Bawang Merah Varietas Lembah Palu (*Allium Wakegi* Araki). *J. Agrotekbis*, 12(1), 133–141.
- Lismawati, Mahfudz, & Maemunah. (2023). Meningkatkan Hasil Bawang Merah (*Allium aggregatum* L.) Dengan Pupuk Organik cair Eco Farming. *J. Agrotekbis*, 11(6)(6), 1425–1435.
- Maemunah, M. (2010). Viabilitas dan vigor benih bawang merah pada beberapa varietas setelah penyimpanan. *Agroland*, 17(1), 18–22.
- Maknuna, L. L., & Soeparjono, S. (2023). Pengaruh Aplikasi Bakteri *Azotobacter* sp . dan Dosis Pupuk Kotoran Kambing terhadap Serapan Nitrogen , Pertumbuhan dan Hasil Tanaman Jagung (*Zea mays* L .) The Effect of *Azotobacter* sp . Bacteria Application and the Dose of Goat Manure Fertilizer on Nitro. *Pengaruh Aplikasi Bakteri Azotobacter Sp. Dan Dosis Pupuk Kotoran Kambing Terhadap Serapan Nitrogen, Pertumbuhan Dan Hasil Tanaman Jagung (Zea Mays L., 11*.(No. 2 Juli 2023), 112–131.
- Marhama, H., Triharyanto, E., Theresia, M., & Budiastuti, S. (2023). Hayati Di Luar Musim Tanam Analysis of Growth and Yield of Shallot With Biofertilizer in Off-Seasons. *Jurnal AGRO*, 10(May), 320–333.
- Nandha Afrilandha, & Setiawati, M. R. (2018). The Effect of Inorganic Nutrients and Biofertilizer on The Population of *Azotobacter* sp., Chlorophyll Content, Nitrogen Uptakes, and Yield of Tomatoes Plants in Hydroponic. *Agriin*, 22(1), 66–75.
- Saputri, H. A., & Lapanjang, I. (2022). Pengaruh Pemberian Mikoriza Terhadap Pertumbuhan Dan Hasil Tanaman Bawang Merah Varietas Lembah Palu. *Jurnal Agrotekbis*, 10(1), 64–72.
- Saskia, N., Firnia, D., Utama, P., & Sodiq, A. H. (2024). Efektivitas Rhizobakteria dan Pupuk Kotoran Kambing pada Pertumbuhan dan Hasil Tanaman Bawang Merah (*Allium ascalonicum* L.). *JIA (Jurnal Ilmiah Agribisnis): Jurnal Agribisnis Dan Ilmu Sosial Ekonomi Pertanian*, 9(3), 215–226. <https://doi.org/10.37149/jia.v9i3.1145>
- Sudewi, S., & Indriani, L. B. (2017). Pengaruh Pemberian Pupuk Kandang dan Cendawan Mikoriza Arbuskula terhadap Pertumbuhan dan Hasil Bawang Merah Lokal Palu. *Jurnal Agropet*, 14(1), 20–30.

- Susilawati, S., Sodikin, E., Sulaiman, F., & Irmawati, I. (2023). Pengaruh Ukuran Umbi Terhadap Pertumbuhan Awal Tiga Varietas Bawang Merah (*Allium ascalonicum* L.). *Optimalisasi Pengelolaan Lahan Suboptimal Untuk Pertanian Berkelanjutan Dalam Menghadapi Tantangan Perubahan Iklim Global*, 6051, 151-162.
- Tandi, O. G., Paulus, J., & Pinaria, A. (2015). PERTUMBUHAN DAN PRODUKSI BAWANG MERAH (*Allium ascalonicum* L.) BERBASIS APLIKASI BIOURINE SAPI. *Eugenia*, 21(3), 142-150. <https://doi.org/10.35791/eug.21.3.2015.9704>
- Tando, E. (2019). Upaya efisiensi dan peningkatan ketersediaan nitrogen dalam tanah serta serapan nitrogen pada tanaman padi sawah (*Oryza sativa* L.). *Buana Sains*, 18(2), 171-180.