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Effects of Liquid Sulfur Fertilizer and Azolla Application on the Growth and Yield of Bird's Eye Chili (Capsicum frutescens L.)

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ABSTRACT

This research was carried out at the UPTD BIH Gedung Johor, Medan Johor, Medan City, starting from December 2023 to March 2024. This research aimed to determine the effect of applying liquid sulfur fertilizer and Azolla on the growth and production of cayenne pepper plants. This research used a factorial randomized block design (RAK) with 2 treatment factors. The first factor is liquid sulfur with the symbol (S) which consists of 3 treatment levels, namely: S0 = without sulfur fertilizer, S1 = 2.5 cc/liter of water, and S2 = 5 cc/liter of water. The second factor is Azolla with the symbol (A) which consists of 4 treatment levels, namely: A0 = Without Azolla, A1 = 20 grams/plant, A2 = 40 grams/plant, A3 = 60 grams/plant. The parameters observed in this study were plant height (cm), stem diameter (mm), flowering age (days), number of branches (branches), number of fruits per plant (fruit), fruit weight per plant (grams), number of per plot (fruit), fruit weight per plot. The results showed that liquid sulfur fertilizer treatment had no significant effect on all parameters. Giving Azolla had a significant effect on plant height at 2 WAP, 4 WAP, and some branches. The interaction between the two has no significant effect on all parameters. The best fruit weight per plant was obtained in the combination of S2A2 treatment (Liquid Sulfur 5 cc/liter of water + Azolla 40 grams/plant), namely 125.35 grams.

Keywords: Liquid Sulfur, Azolla, Cayenne Pepper.

INTRODUCTION

One of the most valuable horticultural plant commodities from the Solanaceae family is the chili plant (Capsicum frutescens L.). Almost all regions of Indonesia consume a lot of chili plants, both as industrial food and domestic food, as well as for export abroad (Nugraha et al., 2023). This versatile horticultural plant, known for its high nutritional content, can be used as a base ingredient for medicines, spices, and sauces (Karim et al., 2016).

Sofiarani et al., (2020) stated that cayenne pepper has a high potential to meet domestic demand and export abroad. The need for cayenne pepper is estimated to increase by 2.65% per year between 2017 and 2021, to meet the needs of industrial raw materials, consumption, and seeds. On the other hand, it is projected that cayenne pepper production will decrease by 0.4% annually between 2017 and 2021. Cayenne pepper has a bright future in terms of meeting domestic consumer demand and exports.

As the population increases the high interest of the community in consuming cayenne pepper causes market demand for cayenne pepper to increase. This encourages farmers to plant continuously without considering environmental aspects, thus reducing the production of cayenne pepper plants (Nugraha et al., 2023). The environmental factors in question are the nutrient content in the soil and soil fertility which is getting lower and lower. Chemical fertilizers that are used excessively for a long time cause the soil to become harder, infertile, and low in nutrients.

To increase the production of cayenne pepper, it is necessary to improve fertilization management. Efforts to increase chili yields can be carried out starting from cultivation to proper and correct post-harvest handling. Fertilization is one of the cultivation methods that play a role in efforts to increase chili plant yields (Asmawati et al., 2020). Fertilization is carried out because the available nutrients are not sufficient for plants to grow and develop. Fertilization can be done by providing macro and micronutrients needed by plants (Fauziah et al., 2018).

Sulfur is one of the important macronutrients that plants need in large quantities. Sulfur is an essential component of various plant proteins, including cysteine, methionine, and cystine amino acids; some hormones, and vitamins, such as biotin and thiamine; and enzymes that break down proteins (Rom et al., 2021). Sulfur nutrients have been added in the last two to three decades, and this is very important in correcting sulfur nutrient deficiencies and increasing crop yields and quality (Rai et al., 2020). In addition, the process of sulfur mineralization into sulfate form (SO4 2-) causes a decrease in pH (Aisyah et al., (2015).

Without the addition of organic fertilizers, the use of inorganic fertilizers for a long period will result in an imbalance of nutrients in the soil, damage the soil structure, and reduce the number of microbiology in the soil. According to Muktamar et al., (2016), organic fertilizer is

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a good choice for providing nutrients to plants because of its high and complete nutrient content. The use of organic fertilizers can improve the physical quality of the soil, soil chemistry, and soil biology as well as nutrients for plant growth and development (Murnita et al., 2021). Azolla is a type of water fern that floats in water and can be found in various regions because it has a wide distribution. Azolla can also bind nitrogen in the atmosphere to provide nitrogen nutrients for plants. (Prayoga et al., 2019).

MATERIALS AND METHODS

This research was conducted in the experimental garden of the UPTD Horticultural Parent Seeds, Gedung Johor, Medan Johor, Medan City, which is located at 25 m above sea level, starting in December 2023 to March 2024.

The materials used in this study were chili pepper seeds of Pelita 8 F1 variety, Liquid Sulfur fertilizer, Azolla, polybags, treatment planks, and topsoil. The tools used included hoes, meters, watering cans, scales, scissors, machetes, scrapers, burlap, parent, plastic rope, cameras, and stationery.

This study used a Factorial Randomized Block Design (RAK) consisting of two treatment factors, each treatment repeated 3 times. The first factor is Liquid Sulfur Fertilizer (S) with 3 levels, namely: S0 = Without Sulfur fertilizer, S1 = 2.5 cc/liter of water S2 = 5 cc/liter of water. The second factor is Azolla Fertilizer (A) with 4 levels, namely: A0 = Without Azolla, A1 = 20 grams/plant, A2 = 40 grams/plant, and A3 = 60 grams/plant.

RESULTS AND DISCUSSION

Plant Height

Table 1. Results of the mean difference test of the Effect of Liquid Sulfur and Azolla Application on Plant Height (cm) at the ages of 2 MST, 4 MST, and 6 MST.

Treatment	Plant Height		
	2 MST	4 MST	6 MST
Liquid Sulfur			
S0	3.63	10.53	25.77

S1	3.99	11.35	27.12
S2	4.05	11.29	26.88
Azolla			
A0	3.83	9.26b	22.94b
A1	3.56	10.93a	25.98a
A2	3.96	12.12a	29.15a
A3	4.22	11.92a	28,28a
Interaction			
S0A0	3.62	8.95	23.53
S0A1	3.22	9.85	23.52
S0A2	3.33	10.5	26.47
S0A3	4.37	12.83	29.57
S1A0	4.22	8.52	20.88
S1A1	3.85	11.75	26.67
S1A2	3.78	12.43	31.08
S1A3	4.1	12.68	29.83
S2A0	3.65	10.3	24.42
S2A1	3.6	11.2	27.75
S2A2	4.77	13.42	29.9
S2A3	4.2	10.23	25.45

Note: The numbers thatfollowed by letters in the same row or column indicate significant differences based on the DMRT test at the 5% level.

The results of the analysis of variance showed that the Liquid Sulfur treatment had no significant effect at the ages of 2 MST, 4 MST, and 6 MST. The Azolla treatment showed no significant effect at the age of 2 MST but had a significant effect at the ages of 4 MST and 6 MST. The interaction showed no significant effect at the ages of 2 MST, 4 MST, and 6 MST. Table 1 shows that the Liquid Sulfur treatment had no significant effect on the height of chili plants at the ages of 2 WAP, 4 WAP, and 6 WAP. In the Liquid Sulfur treatment at the age of

2 WAP, the tallest plant was in the S2 treatment, which was 4.05 cm. At the age of 4 WAP, the tallest plant was in the S1 treatment, which was 11.35 cm. The tallest plant measured at the age of 6 WAP was in the S1 treatment, which was 27.12 cm. This may be influenced by factors such as the lack of maximum fertilizer absorption so it is not significant in influencing plant growth and development because the plants do not receive enough fertilizer or it is not following plant needs. According to Damanik et al., (2011) in Waskita et al., (2022) a fertilizer dose that is too high can damage plant roots and disrupt the balance of nutrients in the soil, while a fertilizer dose that is too low will not affect plant development and yield.

Table 1 shows that Azolla treatment did not significantly affect plant height at 2 MST but significantly affected at 4 MST and 6 MST. At 2 MST, the tallest plant was in the A3 treatment, which was 4.22 cm. At 2 MST, the Azolla treatment showed no significant effect on the height of chili plants. This may be because the plants are still young so the roots and plant tissues are not yet able to absorb nutrients from the soil properly. The roots and plant tissues that are formed in the early growth phase are still in the development stage so the plants are still not able to absorb nutrients from the soil optimally. This is following the opinionJatsiyah et al.,(2020)which states that young plants do not yet have perfect roots so the roots are not yet able to absorb nutrients optimally.

The tallest plant measured at 4 MST was in treatment A2, which was 12.12 cm, which was not significantly different from treatment A3, which was 11.92 cm, and treatment A1, which was 10.93 cm but significantly different from treatment A0, which was 9.26 cm. At 6 MST, the tallest plant was in treatment A2, which was 29.15 cm, which was not significantly different from treatment A3, which was 28.28 cm, and treatment A1, which was 25.98 cm but significantly different from treatment A0, which was 22.94 cm. In the parameter of plant height at 4 MST, the best Azolla treatment was treatment A2 (Azolla 40 grams) with a plant height of 12.12 cm. In the parameter of plant height at 6 MST, the best Azolla treatment was treatment A2 (Azolla 40 grams) with a plant height of 29.15 cm. In the parameter of the number of branches, the best Azolla treatment was treatment A3 (Azolla 60 grams) with the largest number of branches of 12.67 branches. This may be due to the treatment, nutrients are available in the soil in sufficient quantities and plants are also able to absorb nutrients from the soil well. The provision of this treatment increases the availability of nutrients such as N

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and other nutrients in the soil, thereby encouraging the growth and development of cayenne pepper plants, especially in plant height and number of branches. According to Rajak et al., (2016) the N element has a function to encourage the growth and development of plants in general, especially the growth of stems, branches, and leaves.

The interaction of Liquid Sulfur and Azolla had no significant effect on the height of chili plants at 2 MST, 4 MST, and 6 MST. The tallest plant measured at 2 MST was in the S2A2 treatment combination, which was 4.77 cm. At 4 MST, the tallest plant was in the S2A2 treatment combination, which was 13.42 cm. At 6 MST, the tallest plant was in the S1A2 treatment combination, which was 31.08 cm. This is thought to be because one of the treatment factors was more dominant than the other factors. From the results of the study, it can be seen that the Azolla treatment was the best, while the Sulfur fertilizer treatment was covered up and its performance was hampered so that no interaction between treatments could be created. Sutedjo and Kartasapotra (2006) in Mahenda et al., (2023) stated that if one factor has a stronger effect than the other factors, then the influence of the other factors will be covered up and if each factor has very different properties and working characteristics, it will produce a relationship that has no real effect in supporting the growth of a plant.

Number of Branches

Table 2. Results of the mean difference test for the effect of administering liquid sulfur and Azolla on the number of branches of chili plants.

Liquid Sulfur	Azolla				Average
	A0	A1	A2	A3	
S0	10.67	9.50	9.00	13.17	10.58
S1	9.50	10.00	12.00	12.50	11.00
S2	10.67	12.67	12.33	12.33	12.00
Average	10.28b	10.72b	11.11b	12.67a	

Note: The numbers thatfollowed by letters in the same row or column indicate significant differences based on the DMRT test at the 5% level.

Based on the results of the analysis of variance, it can be seen that the Liquid Sulfur treatment did not have a significant effect on the number of chili plant branches. The Azolla treatment showed a significant effect on the number of chili plant branches, but its interaction showed no significant effect on the flowering age of chili plants.

Table 2 shows that the liquid sulfur treatment did not significantly affect the number of chili plant branches. In the Liquid Sulfur treatment, the highest number of branches was in the S2 treatment, which was 12.00 branches. This is thought to be influenced by the low availability of nutrients so that it does not affect plant growth. This nutrient deficiency can be influenced by the application method through leaves where the application of fertilizer through leaves is one way of applying fertilizer that can be done because it is quite effective in increasing nutrient availability and is easily absorbed by plants if done properly. Liquid sulfur applied through leaves by spraying on chili plants may experience evaporation or leaching and not have time to be absorbed by the plants so the nutrients in the sulfur are still not optimal for the growth and development of chili plants. Fertilization through leaves is carried out by paying attention to various conditions and circumstances properly. According to Suryani et al., (2021), the Application of fertilizer through leaves is carried out at the right time to avoid loss of nutrients due to evaporation and leaching so that the nutrients contained can be properly absorbed by the plants.

In Table 2, Treatment Azolla has a significant effect on the number of branches of chili plants. In the Azolla treatment, the highest number of branches was found in the A3 treatment, which was 12.67 branches, which was significantly different from the A2 treatment, which was 11.11 branches, and the A1 treatment, which was 10.72 branches, and the A0 treatment, which was 10.28 branches. This is thought to be caused by the provision of Azolla, which encourages the availability of nutrients in the soil. Azolla is an organic material that is beneficial for plants because Azolla can provide nitrogen nutrients that are needed in large quantities by plants. The ability of Azolla to provide N for plants is because Azolla contains Cyanobacteria which then both carry out mutualistic symbiosis. The symbiosis of both is then named Anabaena azollae. Anabaena azollae can bind free Nitrogen in the air and change it into a form that is available to plants so that it can contribute to the N needs of plants in the soil (Sudjana 2014). Nitrogen is one of the most important nutrients for

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plants to stimulate their growth and development such as height, stem diameter, and number of branches and leaves of the plant. The interaction of Liquid Sulfur and Azolla did not significantly affect the number of branches of chili plants where the highest number of branches was found in the S0A3 treatment combination, namely 13.17 branches. This may be caused by the treatment given not following the needs of the plant. The liquid sulfur applied to the plant was not enough so its interaction with the azolla treatment was not optimal.

Number of fruits per plant

Table 3. Results of the mean difference test for the effect of administering liquid sulfur and Azolla on the number of fruits per chili plant.

Liquid Sulfur	Azolla				Average
	A0	A1	A2	A3	
S0	72.33	70.00	49.33	112.67	76.08
S1	84.17	56.83	83.00	78.17	75.54
S2	85.83	83.83	110.00	75.33	88.75
Average	80.78	70.22	80.78	88.72	

Table 3 shows that the Liquid sulfur and azolla treatments did not significantly affect the number of fruits per chili plant. In the Liquid Sulfur treatment, the highest number of fruits per plant was in the S2 treatment, which was 88.75 fruits. Liquid Sulfur did not significantly affect the number of fruits per chili plant, which is thought to be influenced by nutrients that are not available in sufficient quantities, resulting in less-than-optimal results. This nutrient deficiency may be influenced by the application of liquid sulfur which is only carried out during the vegetative growth period of chili plants so that the existing nutrients are not available in sufficient quantities when the plants enter the generative period. The timing of foliar fertilizer application needs to be considered because it can affect the growth of chili plants. This aims to prevent excess or deficiency of nutrients in plants. According to Suryani et al., (2021), fertilizers given through the leaves must be considered carefully, because a period that is too short between fertilization can result in waste and poison the plants, while a period that is too long between fertilization will reduce the availability of nutrients.

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In the Azolla treatment, the number of fruits per plant was the highest in the A3 treatment, which was 88.72 fruits. This may be due to factors such as the Azolla treatment which was applied only once to the chili plants was not enough to meet the nutrients needed by the plants. In addition to Nitrogen, several other nutrients such as phosphorus and potassium also affect the growth and production of cayenne pepper, especially in the generative phase. However, the availability of these nutrients in azolla is quite low, causing growth in the generative phase to be less than optimal. According to Supriansyah et al., (2021), phosphorus helps plants form and enlarge roots, and maintain a good root system and ripening of fruits and flowers. The interaction of Liquid Sulfur and Azolla did not significantly affect the number of fruits per chili plant where the highest number of fruits per plant was in the S0A3 treatment combination, which was 112.67 fruits. The provision of sulfur and Azolla nutrients does increase the availability of nutrients for plants, but the absorption that is not optimal by plants causes plant growth to be less than optimal.

Fruit weight per plot

Table 4. Results of the mean difference test of the effect of administering liquid sulfur and Azolla on fruit weight per chili plant plot.

Liquid Sulfur	Azolla				Average
	A0	A1	A2	A3	
S0	323.67	253.30	212.37	363.93	288.32
S1	369.33	246.63	370.87	324.53	327.84
S2	317.87	289.63	357.60	291.40	314.13
Average	336.96	263.19	313.61	326.62	

Table 4 shows that the Liquid sulfur and azolla treatments did not significantly affect the fruit weight per plot of chili plants. In the Liquid Sulfur treatment, the highest fruit weight per plot was in the S1 treatment, which was 327.84 grams. This may be influenced by the lack of sulfur nutrients, which causes production results to be less than optimal. Sulfur is a nutrient that plays an important role in chlorophyll and photosynthesis in leaves, so it affects plant

production results. According to Wati et al., (2014), Sulfur plays an important role in plant growth because it forms protein and chlorophyll, both of which play a role in plant growth. If there is a sulfur deficiency, plants will not be able to grow optimally and become stunted and thin with newly grown leaves turning yellow. In addition, sulfur deficiency causes plant defenses against pest attacks to decrease.

In the Azolla treatment, the highest fruit weight per plot was in the A0 treatment, which was 336.96 grams. The Azolla treatment showed no significant effect on the fruit weight of chili plants. Azolla applied to plants had more effect on increasing the growth of the vegetative phase of the plant. Nutrients such as nitrogen contained in azolla are used more in the growth of the vegetative phase of the plant so the available nutrients are not sufficient to help the generative growth of the plant. Lack of nutrients in the soil causes plant growth to be less than optimal.

The interaction of Liquid Sulfur and Azolla did not significantly affect the fruit weight per chili plant where the highest fruit weight per plant was found in the S1A2 treatment combination, namely 370.87 grams. The unreal interaction may be influenced by the lack of nutrients so plant growth is not optimal. Chili plants can grow well if the factors that support growth are available in sufficient quantities and according to needs such as nutrients, water, temperature, and sunlight. This is following the opinion of Irwan et al., (2019) which states that good harvest results can be achieved if the environment that affects growth is favorable and balanced, and plant development can be hampered if one of the factors that affects plant growth is not balanced.

CONCLUSION

1. The application of liquid sulfur fertilizer had no significant effect on all parameters. The best treatment is treatment S2 = 5 cc/liter of water
2. The provision of Azolla significantly affected the parameters of plant height 2 MST, 4 MST, and the number of branches. The best treatment was in treatment A2, which was 40 grams/plant.

3. The interaction of liquid sulfur and azolla administration did not significantly affect all parameters. The best treatment was in the combination of S2A2 (5 cc/liter of water) and (40 grams/plant).

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