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The Effect of Liquid Organic Fertilizer from Gamal Leaves (*Gliricidia sepium*) on the Growth of Cayenne Pepper (*Capsicum frutescens L.*) as a Natural Substitute for Urea

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ABSTRACT

This study aims to determine the effect of liquid organic fertilizer (LOF) made from gamal leaves (Gliricidia sepium) on the growth of bird's eye chili (Capsicum frutescens L.) as an alternative to natural urea fertilizer. The research is based on the high demand for fertilizers in chili cultivation and the negative impacts of excessive chemical fertilizer use on soil and the environment. Gamal leaves contain essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), which support plant growth. The experiment used various concentrations of gamal leaf LOF applied to chili plants, with observations on plant height, leaf number, and other morphological traits. Results showed that gamal leaf LOF positively affected plant growth, with certain concentrations performing better than the control. This indicates that gamal leaf LOF can serve as an eco-friendly and sustainable alternative to natural urea fertilizer.

Keywords: liquid organic fertilizer, gamal leaves, bird's eye chili, urea alternative, plant growth

1. INTRODUCTION

Indonesia has abundant biological resources. Its fertile soil supports a wide variety of plants due to the country's geographical position along the equator. The tropical climate allows various plant species to thrive. Most Indonesians work as farmers, and agricultural production is relatively high because large areas of land are used for cultivation. Agriculture is a fundamental sector in an agrarian country.[1]

In agriculture, fertilizer use is closely related to optimizing plant growth until harvest to meet food demands. Fertilizer is a material containing one or more nutrients that are applied to plants or growing media to support their maximum development.[2] Naturally, the earth and its atmosphere provide nutrients for plant life, but their availability does not always meet plant needs. Therefore, human intervention through biosphere management such as crop regulation, planting time, location, fertilization, and irrigation is necessary to achieve high and efficient production. Fertilizers function as an additional or substitute source of nutrients essential for plant growth and can also improve soil structure to make it suitable for cultivation.[3]

Fertilizers are classified based on their origin, compounds, nutrient content, physical form, application, and nutrient release method. The increasing use of chemicals in various sectors, including industry, household, and food production, has created the need to understand their chemical properties to ensure safe and beneficial use.[4]

To implement the concept of sustainable agriculture, the use of organic fertilizers is highly encouraged, especially in organic farming systems. Organic farming aims to produce healthy and nutritious crops without using chemical substances.[5] Organic agricultural products are generally preferred by consumers because they are tastier, more attractive, last longer, and are healthier and more nutritious since they contain no chemical residues.[6]

Based on their form, organic fertilizers are divided into solid and liquid types. Solid fertilizers are mostly made from organic materials such as plant residues, animal manure, or human waste in solid form. Liquid organic fertilizers, on the other hand, are solutions containing one or more nutrients needed by plants.[7] The advantages of liquid fertilizers include varied nutrient content, faster absorption because the nutrients are dissolved, and the ability to adjust concentration according to plant needs. Their application is also more uniform.[8]

Liquid organic fertilizers contain nitrogen, which plays a key role in forming proteins, amino acids, and chlorophyll. They also contain micronutrients that act as catalysts in protein synthesis and chlorophyll formation. Several studies have shown that liquid organic fertilizers have a positive impact on plant growth, although the concentration or dosage must be carefully adjusted.[9]

One potential natural material for producing liquid organic fertilizer is gamal leaves (*Gliricidia sepium*). Gamal is a leguminous plant containing high levels of essential nutrients useful for plant growth. Its leaves contain about 3.15% nitrogen (N), 0.22% phosphorus (P), 2.65% potassium (K), 1.35% calcium (Ca), and 0.41% magnesium (Mg).[10]

Based on this, the researcher aims to reduce the use of chemical fertilizers by developing organic fertilizers that can be made from locally available materials. Gamal leaves have great potential to be processed into liquid organic fertilizer because they are abundant, easy to find, and environmentally friendly. In this study, liquid organic fertilizer will be prepared from gamal leaves and tested on vegetable crops or other plants.

2. EXPERIMENTAL

2.1. Chemicals and Equipment

The equipment used in this study included filter paper, a pH meter, measuring cylinders, a funnel, a bucket, a stirring rod, a balance, a blender, a knife, a cutting board, a watering can, and polybags.

The materials used in this study consisted of Gamal leaves (Gliricidia sepium), rice washing water, palm sugar, and EM4 (Effective Microorganisms 4), which served as a liquid bioactivator.

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2.2. Research Procedure

2.2.1 Stage of Liquid Organic Fertilizer (LOF) Preparation

The preparation of liquid organic fertilizer (LOF) from gamal leaves was carried out through several stages. First, the gamal leaves were thoroughly washed and then blended until they formed a smooth pulp. The blended gamal leaves were then filtered to separate the liquid extract from the residue. The obtained gamal leaf residue was mixed with EM4 solution and palm sugar that had been previously dissolved. Next, a small amount of water was added, and the mixture was stirred evenly until homogeneous. After mixing thoroughly, the resulting solution was placed into a closed container for the fermentation process. The container was stored at room temperature for approximately 3–4 weeks to allow the fermentation process to occur properly and produce LOF ready for use.

2.2.2 Stage of LOF Application on Chili Plants

The application of gamal leaf liquid organic fertilizer (LOF) was carried out on chili plants (*Capsicum frutescens L.*) that had been previously planted. At the initial stage, chili seeds were sown until they grew into young seedlings. After the seedlings developed several leaves, they were transplanted into five different polybags.

The first polybag served as a control, in which no gamal leaf LOF was applied, and the plants were watered only with plain water. The second to the fifth polybags were treated with different concentrations of gamal leaf LOF, namely 30 ml/L of water, 60 ml/L of water, 90 ml/L of water, and 130 ml/L of water, respectively. The application of LOF was carried out once a week on a regular basis..

3. RESULTS AND DISCUSSION

3.1. Plant Height

The data collected in this study included measurements of chili plant height (cm), number of leaves (pieces), and leaf width (cm), obtained from each replication (I, II, III, IV, and V) and presented consecutively. The results of the One Way ANOVA statistical analysis for plant height are presented in Table 4.1.

Table 1. Results of Mean Analysis of Chili Plant Height (cm)

Treatment	Days After Planting					Average
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	
P0	4,70	6,50	7,60	9,80	11,15	7,95
P1	6,44	8,10	10,80	13,80	14,66	10,76
P2	7,44	10,27	12,21	15,80	16,40	12,42
P3	7,89	11,85	14,29	17,80	18,80	14,12
P4	9,40	13,85	16,90	20,50	21,45	16,42

Table 4.1 shows the results of the One Way ANOVA test conducted using SPSS 20. Based on the analysis of the plant height parameter for chili plants aged five weeks after planting, there was an increase

from the first to the fifth week. This indicates that the duration of the observation period affected the growth in plant height. The longer the observation time, the higher the plant height obtained.

Based on the mean plant height data in Table 4.1, the highest average chili plant height with the application of Gamal leaf liquid organic fertilizer (LOF) at 7 DAP was found in treatment P4 (9.40 cm), while the lowest was in P0 (5.78 cm). At 14 DAP, the highest mean height was also in P4 (13.85 cm) and the lowest in P0 (6.50 cm). At 21 DAP, the highest mean height was recorded in P4 (16.90 cm) and the lowest in P0 (7.60 cm). At 28 DAP, P4 again showed the highest mean height (20.50 cm), while P0 had the lowest (9.80 cm). Similarly, at 35 DAP, the highest average height was in P4 (21.45 cm) and the lowest in P0 (11.15 cm).

The results of the One Way ANOVA test for plant height in the fourth week showed that the calculated F-value was 74.290, while the critical F-value for $df_1 = 4$ and $df_2 = 20$ at a 5% significance level was 2.87. Since the calculated F-value was greater than the critical value, the Null Hypothesis (H_0) was rejected and the Alternative Hypothesis (H_1) was accepted. This indicates that the application of Gamal leaf extract and water as liquid organic fertilizer had a significant effect on the vegetative growth of chili plants.

To determine which Gamal leaf liquid fertilizer concentration provided the best and most effective results for plant height at 7, 14, 21, 28, and 35 days after planting, a further test using the Least Significant Difference (LSD) at a 5% significance level was conducted, as shown in Table 2.

Table 2. Results of the 5% LSD Test on the Average Height of Chili Plants (cm)

Treatment	Days After Planting				
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP
P0	4,70 a	6,50 a	7,60 a	9,80 a	11,15 a
P1	6,44 bc	8,10 b	10,80 b	13,80 b	14,66 b
P2	7,44 cd	10,27 c	12,21 c	15,80 c	16,40 c
P3	7,89 d	11,85 d	14,29 d	17,80 d	18,80 d
P4	9,40 e	13,85 e	16,90 e	20,50 e	21,45 e

Table 2 presents the results of the One Way ANOVA test analyzed using SPSS 20. The results of this test indicate that plant height from the first week to the fifth week showed a significant effect due to the different concentrations of treatments applied to chili plants. Each treatment applied from the first to the fifth week after planting had a statistically significant influence on plant height. The significance value obtained from the ANOVA test was 0.000. Since the significance value (P) was less than 0.05, it can be concluded that the Gamal leaf liquid organic fertilizer had a significant effect at different dosage levels on the growth of chili plants.

The data in Table 4.2 also show the results of the 5% Least Significant Difference (LSD) test for the mean height of chili plants. In the fifth week, there was a clear difference among the treatments of Gamal leaf liquid organic fertilizer. The application of Gamal leaf liquid fertilizer showed that the highest plant growth occurred in treatment P4 (130 mL/L of water) with an average plant height of 21.45 cm. This result was significantly different from treatment P3 (90 mL/L of water) with a height of 18.80 cm, P2 (60 mL/L of

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water) with a height of 16.40 cm, P1 (30 mL/L of water) with a height of 14.66 cm, and the control treatment P0, which showed the lowest average height of 11.15 cm.

This finding suggests that the treatment with 130 mL/L provided sufficient nutrient intake to meet the growth requirements of chili plants. This result is consistent with the study by Winarti and Rauf (2023), which stated that applying concentrations higher than 130 mL/L can inhibit the growth in plant height. Similarly, Oviyanti et al. (2016) reported that using concentrations that are too low can also inhibit the growth of chili plants, particularly in terms of plant height.

According to Siska (2000) as cited in Oviyanti et al. (2016), nutrient content, particularly nitrogen, plays an important role in stimulating and accelerating plant growth and height development. Nitrogen influences the total nitrogen content in plants, helps activate plant cells, and supports the photosynthesis process, which ultimately affects plant height growth. In addition, Mardianto (2014) stated that the nutrient content, especially nitrogen, can promote and accelerate plant growth and height development. Dhani et al. (2013) also explained that nitrogen is essential for the synthesis of amino acids and proteins, especially at the plant's growth points, thereby accelerating plant growth processes such as cell division and cell elongation, which in turn enhance overall plant growth.

3.2 Number of Leaves

Based on the results of the One Way ANOVA analysis, the mean number of leaves showed that the application of various concentrations of Gamal leaf liquid organic fertilizer (LOF) had a significant effect on the number of leaves of chili plants. The response of chili plants at 7, 14, 21, 28, and 35 days after planting (DAP) is presented in the following table.

Table 3. Results of Mean Analysis of the Number of Leaves (pieces)

Treatment	Days After Planting				
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP
P0	4	5	6	7	9
P1	5	6	7	9	11
P2	5	6	8	9	14
P3	5	7	9	11	16
P4	5	8	10	12	17

Table 3 presents the results of the One Way ANOVA test analyzed using SPSS 20. Based on the mean analysis of the leaf number parameter in chili plants aged five weeks after planting, there was an increase from the first to the fifth week. This indicates that the duration of the research period affected the number of leaves. The longer the observation period, the greater the number of leaves obtained (Table 4.3).

The mean number of leaves in chili plants treated with Gamal leaf liquid organic fertilizer showed the highest average at 7 DAP in treatment P4 (5 leaves) and the lowest in P0 (4 leaves). At 14 DAP, the highest mean number of leaves was found in P4 (8 leaves) and the lowest in P0 (5 leaves). At 21 DAP, the highest mean was P4 (10 leaves) and the lowest was P0 (6 leaves). At 28 DAP, the highest mean was P4 (12 leaves) and the lowest was P0 (7 leaves). At 35 DAP, the highest mean number of leaves was recorded in P4 (17 leaves) and the lowest in P0 (9 leaves).

The results of the One Way ANOVA test for the leaf number parameter in the fourth week showed that the calculated F-value was 17.619, while the critical F-value for $df_1 = 4$ and $df_2 = 20$ at a 5% significance level was 2.87. Since the calculated F-value was greater than the critical value, the null hypothesis (H_0) was rejected and the alternative hypothesis (H_1) was accepted. This indicates that the application of Gamal leaf liquid organic fertilizer significantly affected the vegetative growth of chili plants. To determine the most effective concentration of Gamal leaf liquid fertilizer for increasing the number of leaves at 7, 14, 21, 28, and 35 DAP, a further test using the Least Significant Difference (LSD) at a 5% significance level was conducted, as presented in Table 4.4.

Table 4. Results of the 5% LSD Test on the Average Number of Leaves (pieces)

Treatment	Days After Planting				
	7 DAP	**14 DAP**	**21 DAP**	**28 DAP**	**35 DAP**
P0	4 a	5 a	6 a	7 a	9 a
P1	5 ab	6 ab	7 b	9 b	11 b
P2	5 ab	6 bc	8 bc	9 c	14 bc
P3	5 bc	7 cd	9 cd	11 cd	16 cd
P4	5 c	8 d	10 d	12 d	17 d

Table 4.4 shows the results of the 5% LSD follow-up test using SPSS 20 One Way ANOVA analysis. The results of the test confirmed that the number of leaves from the first to the fifth week was significantly affected by the different concentrations of Gamal leaf liquid fertilizer applied to the chili plants. Based on the fifth-week data analysis, the increase in leaf number showed a significant effect. The significance value obtained from the ANOVA test was 0.000. Since the significance value (P) was less than 0.05, it can be concluded that the Gamal leaf liquid fertilizer had a significant effect on the increase in the number of leaves of chili plants for each treatment concentration.

The 5% LSD test results in Table 4.4 show that the application of Gamal leaf liquid organic fertilizer with different concentrations resulted in an average number of leaves ranging from 9 to 17 at the fifth week. The highest number of leaves was found in treatment P4 (17 leaves), which was not significantly different from treatment P3 (16 leaves). However, it was significantly different from treatment P0 (9 leaves), P1 (11 leaves), and P2 (14 leaves). These results are consistent with the findings of Oviyanti et al. (2016), who reported that the application of Gamal leaf liquid fertilizer at concentrations ranging from 0 mL/L to 120 mL/L produced between 6 and 17 leaves. Similarly, Suparno et al. (2013) found that the application of vermicompost fertilizer (a product of organic material decomposition by earthworms) at doses of 10 to 30 tons per hectare resulted in 7.33 to 10.19 leaves.

According to Lestari (2016), a similar number of leaves indicates that the plants have similar potential for photosynthesis. This is likely because all plants were able to absorb essential nutrients with nearly the same efficiency. Rosmimi (2013) stated that the use of nitrogen fertilizer plays a prominent role in the vegetative parts of plants, particularly leaves and shoots. Rahmah et al. (2014) also explained that an

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abundance of nitrogen promotes rapid growth, including leaf development, thicker and greener stems, and overall enhancement of vegetative growth above ground.

3.3 Leaf Width

Based on the results of the One Way ANOVA analysis, the mean leaf width showed that the application of various concentrations of Gamal leaf liquid organic fertilizer (LOF) had a significant effect on the leaf width of chili plants. The response of chili plants is presented in Table 4.5.

Table 5. Analysis of Mean Leaf Width (cm)

Treatment	Days After Planting				
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP
P0	2,15	2,90	4,10	5,19	5,80
P1	2,90	4,20	6,10	8,10	10,25
P2	3,50	4,49	6,50	8,50	10,70
P3	3,60	4,80	7,15	9,10	11,15
P4	4,49	6,10	8,15	10,20	12,49

Table 5 presents the results of the One Way ANOVA analysis conducted using SPSS 20. Based on the analysis, the leaf width of chili plants at five weeks after planting showed an increase from the first to the fifth week (Table 4.5). The highest mean leaf width was obtained from the application of Gamal leaf liquid organic fertilizer at 7 DAP in treatment P4 (4.49 cm), while the lowest was in P0 (2.15 cm). At 14 DAP, the highest mean leaf width was recorded in P4 (6.10 cm) and the lowest in P0 (2.90 cm). At 21 DAP, the highest mean was in P4 (8.15 cm) and the lowest in P0 (4.10 cm). At 28 DAP, P4 showed the highest mean (10.20 cm), while P0 had the lowest (5.19 cm). At 35 DAP, P4 again produced the highest mean leaf width (12.49 cm), and the lowest was in P0 (5.80 cm).

The One Way ANOVA results for leaf width at the fifth week showed that the calculated F-value was 53.492, while the critical F-value for $df_1 = 4$ and $df_2 = 20$ at a 5% significance level was 2.87. Since the calculated F-value was higher than the critical value, the null hypothesis (H_0) was rejected and the alternative hypothesis (H_1) was accepted. This means that the application of Gamal leaf liquid organic fertilizer had a significant effect on the leaf width of chili plants. To determine the most effective concentration of Gamal leaf liquid fertilizer on leaf width at 7, 14, 21, 28, and 35 DAP, a further test using the 5% Least Significant Difference (LSD) test was conducted, as presented in Table 4.6.

Table 6. Results of the 5% LSD Test on the Average Leaf Width (cm)

Treatment	Days After Planting				
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP
P0	2,15 a	2,90 a	4,10 a	5,19 a	5,80 a
P1	2,90 b	4,20 bc	6,10 bc	8,10 bc	10,25 bc

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P2	3,50 cd	4,49 bc	6,50 bc	8,50 cd	10,70 cd
P3	3,60 d	4,80 c	7,15 d	9,10 d	11,15 d
P4	4,49d	6,10 d	8,15 e	10,20 e	12,49 e

Table 6 shows the results of the 5% LSD follow-up test using the SPSS 20 One Way ANOVA analysis. The test results indicate that leaf width from the first to the fifth week was significantly affected by the different concentrations of Gamal leaf liquid organic fertilizer applied to chili plants. The analysis of five-week-old plants showed that the increase in leaf width was significant. The significance value obtained from the ANOVA test was 0.000. Since the significance value (P) was less than 0.05, it can be concluded that Gamal leaf liquid fertilizer had a significant effect on leaf width growth at each fertilizer concentration.

Table 6 also shows that the application of Gamal leaf liquid organic fertilizer with different concentrations produced mean leaf widths ranging from 5.80 to 12.49 cm. At the fifth week, the largest leaf width was found in treatment P4 (12.49 cm), which was significantly different from all other treatments. The smallest leaf width was recorded in treatment P0 (5.80 cm), followed by P1 (10.25 cm), P2 (10.70 cm), and P3 (11.15 cm). The most effective concentration of Gamal leaf liquid fertilizer on leaf width was observed at the fourth week with a concentration of 130 mL/L (P4 = 12.49 cm).

These results are consistent with the findings of Oviyanti et al. (2016), who reported that Gamal leaf liquid organic fertilizer at a concentration of 120 mL/L influenced the leaf width of mustard plants, resulting in an average width ranging from 6.34 to 9.66 cm. Leaf width supports the photosynthesis process because of the presence of chlorophyll. The results of this study showed an average leaf width of 8 to 10 cm, which differs from the findings of Wahid et al. (2013), who reported that the leaf width of mustard plants treated with Gamal leaf liquid fertilizer ranged from 7 to 9 cm.

4. CONCLUSION

The application of Gamal leaf liquid organic fertilizer (LOF) significantly influenced the vegetative growth of chili plants, including plant height, number of leaves, and leaf width. Higher concentrations of LOF resulted in better plant growth, with treatment P4 (130 mL/L of water) producing the best results.

The nutrient content, especially nitrogen, in Gamal leaves plays a key role in enhancing photosynthesis and cell division. Therefore, Gamal leaf LOF at optimal concentration can be an environmentally friendly organic alternative to improve chili plant growth.

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