The Effect of Gamal Leaf (*Gliricidia sepium (Jacq.) Kunth ex Walp*)-based Liquid Organic Fertilizer on The Vegetative Growth of Lettuce (*Lactuca sativa* L.)

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Abstract

The growth of lettuce depends on the interaction of growth and environmental conditions. Improper crop maintenance may cause low yield of lettuce production. Application of liquid organic fertilizer could be performed as a strategy in crop maintenance. This study aimed to determine the effect and concentration of gamal leaf (*Gliricidia sepium* (Jacq.) Kunth ex Walp)-based liquid organic fertilizer (LOF) on the vegetative growth of green lettuce plants (*Lactuca sativa* L.). The research method used a non-factorial Randomised Group Design (RGD), with treatments consisted of P0 (control), P1 (20% gamal leaves-based LOF), P2 (40% gamal leaves-based LOF), and P3 (60% gamal leaves-based LOF). The results showed that Gamal leaves-based liquid organic fertilizer (LOF) that is produced in this research might still contain less macronutrients C, N, P and K that is stated by SNI 7763: 2018 (2-6%), but its application on lettuce as tested plants could still support their growth. Dose of P1 (20%) was the best to support lettuce growth in the form of increased plant height and leaf area index. Dose of P2 (40%) was abble to maintain showed minimum decrease on lettuce total chlorophylls content. Application of dose of P2 (40%) on lettuce growth medium supportes highest uptake of N while the application of dose of P3 (60%) showed highest uptake of P.

Keywords: liquid organic fertilizer, gamal leaves, lettuce plants, vegetative growth

Introduction

Lettuce (*Lactuca sativa* L.) is a plant belonging to the Asteraceae family. This plant is a horticultural commodity that has quite good prospects and commercial value. The increasing population of Indonesia and the increasing awareness of the population's nutritional needs have led to a demand for vegetables. Lettuce plants in Indonesia are planted from the lowlands to the highlands, taking into account the selection of varieties that are suitable for the place where they grow. This plant is a seasonal vegetable originating from West Asia and America (Afsari *et al*., 2020). Raw lettuce contains calcium, phosphorus, iron, vitamin A, vitamin B and vitamin C and is very beneficial for body health (Ahmed *et al*., 2020)

Lettuce leaves are rich in antioxidants such as beta-carotene, folate and lutein which are effective in protecting the body from cancer. Its natural fiber content can maintain the health of digestive organs (Raras *et al*., 2018). According to data from Central Bureau of Statistics Indonesia (2021) lettuce production in 2021 reached 55,710 tons/ha, and decreased to 47,920 tons/ha in 2022. Several reason can be pointed out as the cause of the decline such as reduction in plantation area, bad plant varieties, insufficient nutrients in the soil, and a climate that is not suitable for plant growth.

Biologically, organic fertilizer is the most important energy provider for the activity of soil microorganisms. Providing organic fertilizer stimulates the proliferation of microorganisms and increases nutrients for plants (Fauziah *et al*., 2022). One of the plants that can be used as the material of organic fertilizer preparation, especially liquid organic fertilizer (LOF) is Gamal (*Gliricidia sepium (Jacq.) Kunth ex Walp*).

Gamal is a plant belonging to Leguminosae family which its leaves can be used as a raw material of LOF preparation. During their growth, Gamal has a capability

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to absorb and fix N elements from its surroundings (Suparman *et al*., 2022). Gamal plants contain various nutrients which are high enough for plant growth. Gamal leaves contain 3.15% N, 0.22% P, 2.65% K, 1.35% Ca and 0.41% Mg so its biomass is used to improve the physical and chemical properties of soil (Widya *et al*., 2021).

According to Sumaryani *et al.,* (2018) application of Gamal leaf-based LOF in concentration of 40% increased number of leaves and stem height of Tomato plants. Meanwhile, according to Peni *et al*., (2021) concentration of 30% Gamal leaves-based LOF supported the growth of mustard greens.

The aim of this research was to determine the effect and concentration of Gamal leaves (*Gliricidia sepium (Jacq.) Kunth ex Walp*)-based LOF on the vegetative growth of green lettuce plants (*Lactuca sativa* L.).

Materials And Methods

Place and Time of Experiment

This research was conducted from December 2022 to February 2023 in Rumah Berastagi Village, Karo Regency, North Sumatra. Measurement of leaf chlorophyll levels, N and P nutrient uptake, and soil analysis were carried out in the laboratory of the Faculty of Agriculture, University of North Sumatra.

The materials used in this research were lettuce seeds, liquid organic fertilizer (LOF) prepared from gamal leaves, EM4 (*Effective Microorganisms*) as microbes inoculum, white sugar water and coconut water. All research materials were purchased from agricultural stores in Karo Regency, North Sumatra. The tools used in this experiments are a hoe, knife, meter, bucket, gembor, stationery, ruler, camera, pH, thermohydrogrometer and UV-Vis spectrophotometer.

Research Design

This research used a non-factorial Randomized Group Design (RGD) experiment, the treatment was the administration of gamal leaves-based LOF with 4 treatments (Table 1).

Table 1.Treatment and Replicate used in the Experiment

Treatment	Replicates
P0: No application of LOF from gamal leaves (control)	3
P1: 20% LOF from gamal leaves = (200 ml + 800 ml water)	3
P2: 40% LOF from gamal leaves = (400 ml + 600 ml water)	3
P3: 60% LOF from gamal leaves = (600 ml + 400 ml water)	3
Total	**12**

Components of this experiment is summarized as follows: 4 number of treatment, triplicates per treatment, 12 research plots, plot size of 1 m x 2m, space between plant was 50 cm x 60 cm, 6 sample plants per plot, total 72 plants used in this study, spacing between research plots was 30 cm, and spacing between replicates : 30 cm

Measured Parameters of Experiment

Experiment data was collected 2 weeks after planting lettuce at intervals of 2 week after planting(WAP) until the last measurement at week 4. Parameter of lettuce growth and its related data that were measured consisted of plant height (cm), leaf area index (cm), leaf chlorophyll levels, N and P uptake, initial and final soil analysis.

Plant height was measured from the base of the plant stem to the highest growing point of the plant observed using a meter. Data collection of plant height was carried out once a week for 4 weeks.

Leaf area index (LAI) observations were carried out at 2 WAP and 4 WAP. Data of LAI was obtained from the comparison of total leaf area with total area. According to Susi (2018) the formula used was:

$$\text{LAI} = \frac{\text{Total leaf area}}{\text{Area}}$$

Data collection of the amount of leaf chlorophyll were carried out of 2 WAP and 4 WAP. Measurement of N and P nutrient uptake were carried out at 1 WAP and 4 WAP.

Initial and final soil analysis were carried out at the Agricultural Laboratory of University of North Sumatra.

Production of Gamal leaves (Gliricidia sepium (Jacq.) Kunth ex Walp)-based Liquid Organic Fertilizer (LOF)

Approximately 10 kg of young Gamal leaves were collected and washed.Leaves were finely sliced, put into a container and filled with 20 liter of water Four liter of coconut water, 1 liter of microbe inoculum (Effective Microorganism (EM4), and 1 kg of white sugar were added to the mixture and stirred well. Mixture was fermented for 14 days before being used as fertilizer tested plant.

Data analysis

The data studied was tested using the Univariate Analysis test ANOVA with the help of the SPSS application and if the variance has a significant effect then the test uses analysis of the mean value using Duncan's test treatment.

Results

Appearance and Nutrient Contents of Gamal leaves-based Liquid Organic Fertilizer (LOF)

The Gamal leaves-based LOF that was produced in this syudy had a brownish green colour and a pungent smell (Figure 1).

Figure 1. Gamal leaves-based liquid organic fertilizer (LOF)

Analysis of macronutrient content of Gamal leaves-based LOF is shown in Table 2.

The level of macronutrient C,N,P, and K had not yet meet the requirement of standard

Table 2. Quality analysis of gamal leaf LOF

Nutrients	Gamal leaf LOF	SNI 7763: 2018
C-Organic (%)	0.19	Min. 2
N-Total (%)	0.10	Min. 2
P (%)	0.03	Min. 2
K (%)	0.20	Min. 2

LOF as stated by SNI 7763: 2018. Low level of macronutrients detected in The Gamal leaves-based LOF is thought to be related to the length of fermentation time required by microorganisms in breaking down organic matter in fertilisers. This is in line with the statement (Utami & Syamsuddin, 2021), which states that the content of nutrients that does not meet SNI 7763: 2018 is due to insufficient time for microorganisms to break down organic matter in compost.

Lettuce Growth Parameters After Application of Gamal leaves-based Liquid Organic Fertilizer (LOF)

Application of Gamal leaves-based LOF on the growth of lettuce was measured on its height, leaf area index, leaf chlorophyll level, and macronutrients N and P uptake.

Direct measurement result of lettuce growth after applied with Gamal leaves-based LOF which consist of plant height and leaf area index is presented in Figure 2 and 3.

Aplication of gamal leaves-based LOF in the final period of research (week 4) showed that the dose of P1 (20% of Gamal leaves-based LOF) was the best dose to support lettuce growth in the form of increased plant height and leaf area index (Figure 2 and 3).

Lettuce leaves content of chlorophyll and its macronutrients nitrogen (N) and phosphor (P) uptake after aplication of Gamal leaves-based LOF are presented in Table 3 and 4.

Concentration of lettuce's leaf total chlorophylls were decreased on weak 4 if compared to week 2 of all tested plants treated with Gamal leaves-based LOF. Lettuce on P2 treatment (40% of Gamal leaves-based LOF) showed minimum decrease on its total chlorophylls level on week 4 compared to other LOF treatments (Table 3).

Uptake of N and P by lettuce at the end of research period tended to occur in different ways. Uptake of N tended to decrease at

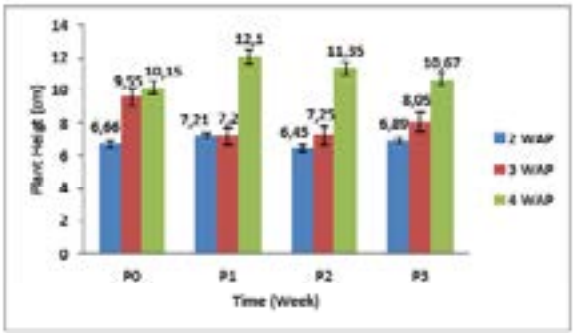

Figure 2. Height of lettuce that was treated with Gamal leaves-LOF on week after planting 2,3, and 4

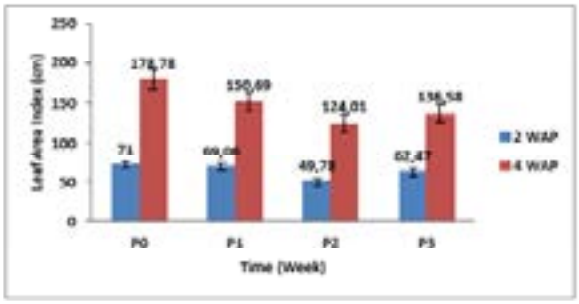

Figure 3. Leaf Area Index of lettuce that was treated with Gamal leaves-LOF on week after planting 2 and 4

week 4 if compared to week 2, while uptake of P tended to be stabilized from week 2 to week 4. This phenomenon were generally observed on all tested lettuce fertilized with Gamal leaves-based LOF. Compared to all treatments of Gamal leaves-based LOF, application of 40% dose (P2) on lettuce growth medium showed highest uptake of N at the end of research period (week 4), while the application of 60% dose (P3) on lettuce growth medium showed highest uptake of P at the end of research (week 4)

Macronutrient Content of Initial and Final Soil

Result of macronutrients content of initial and final (soil condition at the end of research period) soil used as lettuce growth media in this research is presented in Table 5, as well as pH value of soil.

Level of macronutrients N and P, but not K, were lower in final soil compared to initial ones.

These observed result might be cause by the use of those macronutrients by lettuce in order to fullfill their daily need for growth.

Addition of Gamal leaves-based LOF did not exactly increase the level of macronutrients N, P, and K in soil because their preliminary level were already low as detected in LOF. The value of soil pH were decreased as observed in final soil compared to its initial condition.

Table 4. N and P nutrient uptake of lettuce that was treated with Gamal leaves-LOF on week after planting 2 and 4

Treatment	N and P Uptake			
	2 WAP		4 WAP	
	N Total	P	N Total	P
P0	3.9900a	0.21900 a	2.8000 a	0.31333 a
P1	3.3133 a	0.24667 a	0.6367 a	0.23333 a
P2	3.5933 a	0.25033 a	2.3800 a	0.24333 a
P3	3.5467 a	0.20933 a	2.6133 a	2.07667 b

Note: numbers in rows and columns followed by the same letter do not have a significant effect according to Duncan's advanced test at the 5% level.

Table 5. Macronutrient content of initial and final soil used as media

Parameters	Initial Soil Analysis		Final Soil Analysis	
	Result	pH	Result	pH
P	1.1647		0.3523	
K	0.0607	7.00	1.0709	5.1
N	0.4174		0.0509	

Table 3. Leaf chlorophyll content of lettuce that was treated with Gamal leaves-LOF on week after planting 2 and 4

Treatment	Leaf Chlorophyll Content					
	2 WAP			4 WAP		
	Chlorophyll A	Chlorophyll B	Total Chlorophyll	Clorophyll A	Clorophyll B	Total Clorophyll
P0	0.71333 ab	1.7267a	17.2433 a	0.85200 a	1.73100 ab	14.4433 a
P1	0.60467 a	1.5383a	17.2433 a	0.75633 a	1.50133 ab	12.2433 a
P2	0.77300 a	1.7513a	17.2433 a	0.76367 a	1.89467b	15.6533 a
P3	0.56233 a	1.3923a	11.8300 a	0.58433 a	1.32867 a	11.3867 a

Note: numbers in rows and columns followed by the same letter do not have a significant effect according to Duncan's advanced test at the 5% level.

Discussion

Gamal leaves-based liquid organic fertilizer (LOF) that is produced in this research might still contain less macronutrients C, N, P and K, but its application on lettuce as tested plants could still support their growth.

After 4 week of planting, it was observed that bioparameters of lettuce, such as plant height and leaf area, were increased.

Aplication of 20% of gamal leaves-based LOF (P1) was the best dose to support increased plant height (Figure 2). Plant will use available macronutrients such as C, N, P and K from its growth medium as raw material for their metabolism. Growth of lettuce in this reesearch was influenced by the avilibility of macronutrients in its media. Plant height increase, including lettuce, is supported by the uptake of nutrients P and K from the growth medium, which are necessary for carrying out the physiological and metabolic processes of the plant.

Result of Oviyanti *et al*. (2016) mentioned that the higher the concentration of LOF made from Gamal leaves, the better the plant condition will be without interfering with plant growth and metabolic processes. Furthermore, studies by Triadiawarman (2019) on mustard and Milla (2023) on papaya stated that the use of gamal leaves-based LOF affects the increase of those plants height. Our result showed that the lowest dose of gamal leaves-based LOF (20%) was already capable to support increase of lettuce height. It is then asumed that the low dose of LOF is sufficient to support vegetative growth of plant insluding lettuce.

Aplication of 20% of gamal leaves-based LOF (P1) was also better to support the increased of lettuce leaf area compared to other doses (Figure 3). Growth of lettuce leaf area in this research was calculated and stated in the form of leaf area index (LAI).

The size of the leaves greatly influences plant metabolism, especially the photosynthesis process. Macronutrients that is contained in soil and fertilizer playimportant role to stimulate plant growth, including increasing on leaf area.

Liquid organic fertilizer (LOF) made from gamal leaves is known to have a high enough nitrogen content to provide enough elements during plant growth, so the photosynthesis process is active so that cell division, elongation and differentiation go well. The results of photosynthesis that are converted during respiration will produce energy for cell division and enlargement activities which causes the process of leaf growth to become longer and wider (Milla, 2023).

According to Oviyanti *et al* (2016), the presence of nitrogen in gamal leaves-based LOF can accelerate the photosynthesis process and cause the formation of leaf organs to occur faster. Plants that do not receive appropiate N nutrient for their daily needs will be stunted in growth and produce smaller leaves, whereas plants that receive sufficient N will be taller and have wider leaves. Another research from Qoniah (2019) mentioned that the use of LOF made from Gamal leaves had a real effect on lettuce leaves. The increase in leaf width and area is due to the meristem capability to proliferate and produce a number of new cells. Growth of leaf is influenced by hormones to regulate growth, water for the turgidity of leaf tissue cells, as well as the amount of nutrients N, P and K.

As observed in the high increased of lettuce height that is applied with low dose of gamal leaves-based LOF (P1), similar effect of this low dose is noted on lettuce LAI increase. Both of these result may support the idea tha application of low dose of gamal leaves-based LOF is sufficient in contributing on plant growth, inculding lettuce.

Total chlorophyll content of lettuce leaves measured in this research show that its concentration was decreased on weak 4 if compared to week 2 of all tested plants treated with Gamal leaves-based LOF. Lettuce on P2 treatment (40% of Gamal leaves-based LOF) showed minimum decrease on its total chlorophylls content on week 4 compared to other LOF treatments (Table 3).

Application of organic fertilizer that is made from gamal leaves had an effect on the amount of chlorophyll in lettuce leaves. This effect is dependent on one main factor namely nitrogen (N). Macronutrient N is a nutrient needed by plants, one of which is

in the formation of chlorophyll. Plants that lack of N will show chlorosis on its leaves.

A research conducted by Efendi (2022) mentioned that application of LOF made from gamal leaves had a significant effect on the increased amount of chlorophyll in mustard plant leaves. As presented in Table 3, our result showed that total chlorophylls content of all lettuce that were treated with Gamal leaves-based LOF show a decrease at the end of research period (week 4). Between those LOF treatments, the dose of P2 (40% of Gamal leaves-based LOF) showed minimum decrease on its total chlorophylls content on week 4. The decrease of chlorophylls content of lettuce leaves in this research might be cause by aging of the plant. Shi (2019) mentioned that the descrease of chlorophylls content may also dependent on plant stages of growth. After a peak of growth, chlorophyll content will gradually decreased and tended to be flat. The decrease of chlorophylls content may relate to plant respon to its surrounding environmental factors that cause stress condition (Liang *et al*, 2017).

During its life span, plant needs to provide material for its metabolism by absorbing nutrients from its surrounding. Plant needs of macroinutrients such as C,N,P,K were provide by its initial growth medium or gained after the enrichment with fertilizer. In this research, lettuce absorbed macronutrient from its medium that is already enriched by the application of Gamal leaves-based LOF. Uptake of N and P by lettuce at the end of research period tended to occur in different ways. As observed, Uptake of N tended to decrease at the end of research period, while uptake of P tended to be stabilized during research period. These results may indicated that lettuce needs for N is higher than its need on P. Nitrogen plays important role in the growth of lettuce, especially for supporting the growth of it leaves.

Between all treatments of Gamal leaves-based LOF on lettuce, application of 40% dose (P2) on lettuce growth medium showed highest uptake of N at the end of research period (week 4), while the application of 60% dose (P3) on lettuce growth medium showed highest uptake of P at the end of research (week 4).

Based on our result on the comparation of initial and final soil macronutrients level (Table 5), the concentration of N and P, but not K, were lower in final soil compared to the initial one. Decrease of N and P in soil that was used as lettuce growth medium could be caused by the use of those macronutrients by lettuce in order to fullfill their daily need for growth. According to Tando, (2019), nitrogen in plants has an important role in encouraging plant growth through increasing the number of tillers, developing leaf area, and protein synthesis. Plants that lack nitrogen elements in the soil will cause the leaves to turn yellowish and start from the tip and then spread to the middle of the leaf blade. Furthermore, as mentioned by Rianditya and Hartatik (2020), phosphor (P) in plants plays role in conserving and transferring energy in the form of ADP and ATP, and fulfilling the need of P will increase chlorophylls biosynthesis.

Our gamal leaves-based LOF was detected to have 0.19% organic carbon (C-organic), 0.10% nitrogen, 0.03% phosphor (P), and 0,20% kalium (K). Those macronutrients concentration does not yet meet the standards of LOF as stated in SNI 7763: 2018 (2-6%). Several effort could be done to increase the quality of LOF, such as addition of organic materials that are rich of N, P, K or refining the fermentation process to endorse better decomposition of complex organic material to their simple components.

Conclusion

Gamal leaves-based liquid organic fertilizer (LOF) that is produced in this research might still contain less macronutrients C, N, P and K that is stated by SNI 7763: 2018 (2-6%), but its application on lettuce as tested plants could still support their growth. Aplication of dose P1 (20%) of gamal leaves-based LOF was the best to support lettuce growth in the form of increased plant height and leaf area index. Total chlorophylls content of all lettuce's leaf treated with Gamal leaves-based liquid organic fertilizer (LOF) were

decreased at the end of research period, but lettuce treated with dose of 40% (P2) showed minimum decrease on its total chlorophylls

Uptake of N tended to decrease at the end of research period, while uptake of P tended to be stabilized during research period. Compared to all treatments of Gamal leaves-based LOF, application of 40% dose (P2) on lettuce growth medium showed highest uptake of N at the end of research period, while the application of 60% dose (P3) on lettuce growth medium showed highest uptake of P at the end of research.

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