The effectiveness of the interval of liquid organic fertilizer application of goat urine and different planting media on the growth and yield of goat asiatica (*Centella asiatica* L.)

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Abstract. The medicinal plant Centella asiatica L. (gotu kola) is widely known for its benefits and high economic potential with demand for simplicia reaching 126 tons/year, so efficient and environmentally friendly cultivation innovations are needed. Optimal production of this plant requires the availability of balanced nutrients and a growing medium that supports growth. This study aims to analyze the effect of the frequency of application of liquid organic fertilizer (LOF) of goat urine along with a combination of growing media on the growth and productivity of gotu kola. The study was conducted at the Green House of the Plant Laboratory of Jember State Polytechnic. The design used was a two-factor factorial RAL, namely (1) a combination of growing media (soil: rice husk charcoal: cow manure) with a ratio of 1:1:1, 1:2:1, and 1:1:2, and (2) the interval of goat urine LOF application with treatments every 4, 7, and 14 days. Each treatment was repeated three times. Based on the analysis of variance, the two treatment factors separately did not show a significant effect on all growth parameters or yield of pegagan plants, but the interaction of the two significantly affected the number of leaves in the 8th week with the best treatment P0I1 (1:1:1, interval of 4 days) producing an average of 6.92 leaves. The conclusion of this study is that the use of a combination of 1:1:1 media with a LOF interval of 4 days can increase leaf growth, although in general there is no significant difference in other parameters. The implications of this study indicate the need for an assessment of the appropriate LOF concentration to maximize the growth and production of sustainable pegagan.

1. Introduction

The medicinal plant Gotu Kola (*Centella asiatica* L.) is widely known for its benefits and high economic potential, and is widely used as a raw material for the herbal medicine industry and traditional medicine. This plant has quite a wide range of properties, including accelerating wound healing, treating leprosy, and boosting the immune system through its active compounds such as asiaticoside [1]. Gotu kola contains bioactive compounds that play a role in stimulating the immune

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system, so it has long been used to treat various diseases. Demand for this plant in the market is high due to its wide range of benefits. As one of the 50 national priority medicinal plants, gotu kola has a demand for 126 tons of simple herbs per year, ranking 13th out of 152 types of simple herbs used in the herbal medicine industry. This high demand is in line with increasing public awareness of health and the high cost of medical care [2].

The prospects for pegagan cultivation are quite promising, but productivity remains low due to the dominant use of inorganic fertilizers. Long-term use of chemical fertilizers has the potential to reduce soil quality, cause land degradation, and increase pressure on agricultural production costs [3]. The application of organic fertilizers can be a solution to improve the physical, chemical, and biological quality of soil, while reducing the use of synthetic fertilizers. The use of organic fertilizers also supports the development of soil microbes, which play a vital role in decomposition and in increasing nutrient availability for plants. High dependence on inorganic fertilizers not only increases production costs but also has the potential to gradually degrade soil quality due to soil structure degradation and the accumulation of chemical residues [4]. Therefore, the application of organic fertilizers is expected to be a sustainable strategy for maintaining soil health while supporting plant productivity.

As a growing medium, the growing medium needs to provide mechanical support for the roots and ensure the availability of nutrients that support plant growth. The type of growing medium, whether used alone or in combination, directly impacts aeration, water retention, and nutrient availability for plant growth. Water efficiency in growing media can be improved by adding manure, which improves porosity and increases the soil's water retention capacity. This change in soil properties not only maintains water availability for plants but also reduces soil density, allowing roots and tubers to develop optimally [5] . Combining several types of growing media is expected to create the most suitable growing environment for cultivated plants. Furthermore, the addition of liquid organic fertilizer (LOF) made from goat urine is a potential nutrient source because it contains high concentrations of nitrogen, which plays a role in chlorophyll formation and enhances vegetative growth [6]. The advantages of LOF include easy absorption, improved soil quality, and its environmentally friendly nature. Its effectiveness is highly dependent on the correct concentration and administration interval, as it affects the availability and utilization of nutrients by plants [7].

Based on this, this study aims to analyze the effects of the frequency of application of liquid organic fertilizer (LOF) made from goat urine, combined with a combination of growing media, on the growth and productivity of gotu kola. The results are expected to serve as guidelines for sustainable gotu kola cultivation practices, prioritizing the use of more environmentally friendly organic fertilizers.

2. Materials and Methods

The research took place in the Greenhouse of the Jember State Polytechnic Plant Laboratory, located on Jalan Mastrip, Dusun Krajan Timur, Sumbersari District, Jember Regency, East Java, at an altitude of 89 meters above sea level. Data obtained during the research were then processed and analyzed after all field activities were completed.

This research used analytical scales, hoes, watering cans, scissors, nameplates, polybags, measuring tape, knives, stationery, and rulers. The materials used included burnt rice husks, liquid organic fertilizer (LOF) made from goat urine, various types of planting media, gotu kola seeds, solid cow manure, and topsoil.

This study was designed using a factorial Completely Randomized Design (CRD). The planting media combination factor (soil: rice husk charcoal: cow manure) consisted of three treatments: P0 (1:1:1), P1 (1:2:1), and P2 (1:1:2). The goat urine LOF administration interval factor also consists of three levels, namely I0 (once every 7 days), I1 (once every 4 days), and I2 (once every 14 days). From these two factors, 9 treatment combinations were obtained with 3 replications, so the number of experimental units was 27. Each treatment unit consisted of 2 polybags, so the total observation units were 54, with each polybag containing 2 plants. Thus, the total number of plants in this study reached 108.

2.1 Growing Media Preparation

The planting media were prepared by mixing soil, rice husk charcoal, and cow manure according to three ratios: P0 (1:1:1), P1 (1:2:1), and P2 (1:1:2), following the method of [8]. The mixture was moistened before being placed into 25 × 25 cm polybags to achieve uniform humidity.

2.2 Seedling Preparation

Gotu kola (*Centella asiatica* L.) plantlets were collected from the cultivation area behind Politeknik Negeri Jember. The shoots were transplanted into seed trays and maintained for 14 days to allow uniform root development before field transplantation.

2.3 Transplanting Procedure

Transplanting was conducted in the late afternoon to minimize heat stress. Two seedlings were planted in each polybag by inserting them into prepared holes and covering them with planting media. The soil around the roots was gently compacted by hand to remove air gaps, followed by watering to maintain moisture.

2.4 Plant Maintenance

1. Irrigation. Watering was performed once or twice daily depending on media moisture, using a watering can directed at the plant base.
2. Replanting. Dead or weak seedlings were replaced within one week after planting to ensure uniform stand density.
3. Weeding. Manual weeding was carried out whenever weeds appeared, preventing nutrient competition and enhancing soil aeration.
4. Fertilization. Liquid organic fertilizer (LOF) derived from goat urine at 90 ml L^{-1} [9] was applied by drenching 250 ml $polybag^{-1}$ beginning one week after transplanting. Application intervals were I_0 = 7 days, I_1 = 4 days, and I_2 = 14 days, following [10]. In addition, NPK Mutiara fertilizer was applied uniformly at 7 g L^{-1} every 7 days across all treatments.

2.5 Harvesting

Harvesting was performed at 10 weeks after transplanting (WAT)**.** The polybag media were loosened, and plants were carefully removed. Roots were separated from shoots and stolons, and both fresh total biomass and root weight were measured immediately.

2.6 Harvesting

Lettuce harvesting can be done when the plants are 6 WAP (the week after planting) or around 42 - 45 days after planting. Harvest criteria for plants lettuce is already quite large in size with a sufficient number of leaves and it hasn't flowered yet.

2.7 Observation Parameters

Observed parameters or variables include:

a. Number of Leaves. Counted on each mother plant every 2 weeks starting at 2 WAT.
b. Longest Stolon Length. Measured from the mother plant to the stolon tip every 2 weeks from 2 WAT.
c. Number of Stolons. Counted per mother plant at 2-week intervals from 2 WAT.
d. Number of Shoots. Counted every 4 weeks starting at 4 WAT.

e. Longest Petiole Length. Measured from base to tip every 4 weeks from 4 WAT.
f. Plant Fresh Weight. Measured at harvest using a digital scale.
g. Root Weight. Roots cleaned and weighed using an analytical balance after harvest.
h. Leaf Chlorophyll Content. Measured at 9 WAT using a Chlorophyll Meter on three
i. leaves per sample.

The research data were then processed using Analysis of Variance (ANOVA). If a significant treatment effect was found, the test was continued using the Least Significant Difference (LSD) method at a 5% confidence level.

3. Results and Discussion

3.1 Result

Based on the results of the analysis of variance, the combination of planting media (P) and the interval of goat urine LOF administration (I) did not have a significant effect on all growth parameters and yield of pegagan, including the number of stolons, number of tillers, stolon length, leaf stalk length, total plant weight, root weight, and leaf chlorophyll content. However, the interaction between the two factors (P×I) was proven to have a significant effect on the number of leaves at 8 weeks after planting (Table 1). Further DMRT tests at the 5% level indicated that the combination of P0I1, P1I0, and P2I2 produced the highest average number of leaves compared to other treatments.

Table 1. Data from the recapitulation of the analysis of variance

No.	Observation Variables	Diversity Source		
		P	**I**	**P x I**
1.	Number of leaves 2 WAP (strands)	ns	ns	ns
2.	Number of leaves 4 WAP (strands)	ns	ns	ns
3.	Number of leaves 6 WAP (strands)	ns	ns	ns
4.	Number of leaves 8 WAP (strands)	ns	ns	*
5.	Number of stolons WAP	ns	ns	ns
6.	Number of stolons 4 WAP	ns	ns	ns
7.	Number of stolons 6 WAP	ns	ns	ns
8.	Number of stolons 8 WAP	ns	ns	ns
9.	Number of offspring 4 WAP	ns	ns	ns
10.	Number of offspring 8 WAP	ns	ns	ns
11.	Stolon length 2 WAP (cm)	ns	ns	ns
12.	Stolon length 4 WAP (cm)	ns	ns	ns
13.	Stolon length 6 WAP (cm)	ns	ns	ns
14.	Stolon length 8 WAP (cm)	ns	ns	ns
15.	Stem length 4 WAP (cm)	ns	ns	ns
16.	Stem length 8 WAP (cm)	ns	ns	ns
17.	Plant weight (g)	ns	ns	ns
18.	Root weight (g)	ns	ns	ns
19.	Chlorophyll Content	ns	ns	ns

Description: P = Combination of Planting Media, I = Interval of Goat Urine LOF Administration, PxI = Interaction of Combination of Planting Media and Interval of Goat Urine LOF

Administration, Ns = No Significant Effect, (*), Significant Effect, (**) = Very Significant Effect

According to Table 1, the DMRT follow-up test analysis at the 5% level shows that the P0I1, P1I0, and P2I2 treatments, as a result of the interaction of the planting medium with the goat urine LOF application interval, produced a higher number of leaves at 8 weeks of age compared to the other treatments. This indicates that the right combination of planting medium and LOF application frequency contributes to optimal leaf growth.

Table 2. Results of the DMRT Test of the Interaction of the Combination of Planting Media and Goat Urine LOF Interval on the Number of Leaves in Week 8

Combination of Planting Media	Goat Urine LOF Interval		
	I0	**I1**	**I2**
P0	5,74 a B	6,92 a A	5,21 b B
P1	6,18 a A	4,77 b B	5,74 a B
P2	5,44 a B	4,68 b B	6,75 a A

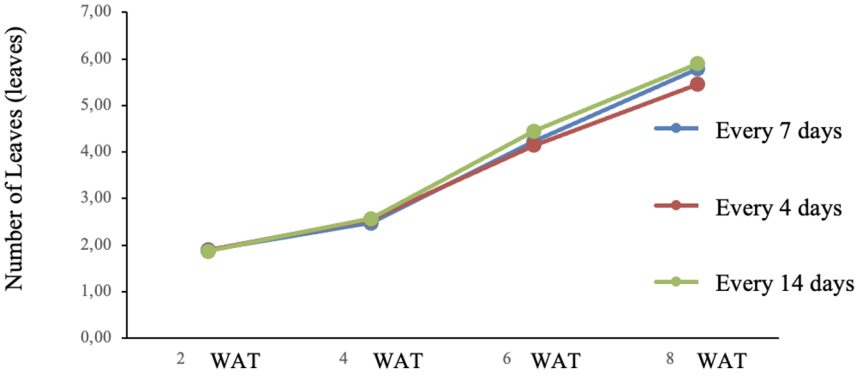
Description: P0 = combination of soil, rice husk charcoal, and cow manure planting media with a ratio of 1:1:1; P1 = combination of 1:2:1 planting media; and P2 = combination of 1:1:2 planting media. Meanwhile, the intervals for administering goat urine LOF consist of I0 = once every 7 days, I1 = once every 4 days, and I2 = once every 14 days. The average value followed by the same lowercase letter in the same row indicates no significant difference based on the DMRT test at the 5% level. Similarly, the average value followed by the same capital letter in the same column is not significantly different in the DMRT test at the 5% level.

ANOVA analysis showed a significant interaction effect between the growing media and the goat urine LOF application interval on the number of leaves in week 8. The P0I1 treatment recorded the highest number of leaves with an average of 6.92 leaves, significantly different from the P0I2, P1I1, and P2I1 treatments (Table 2). These results indicate that the right combination of treatments can have a positive effect on the growth of the number of pegagan leaves.

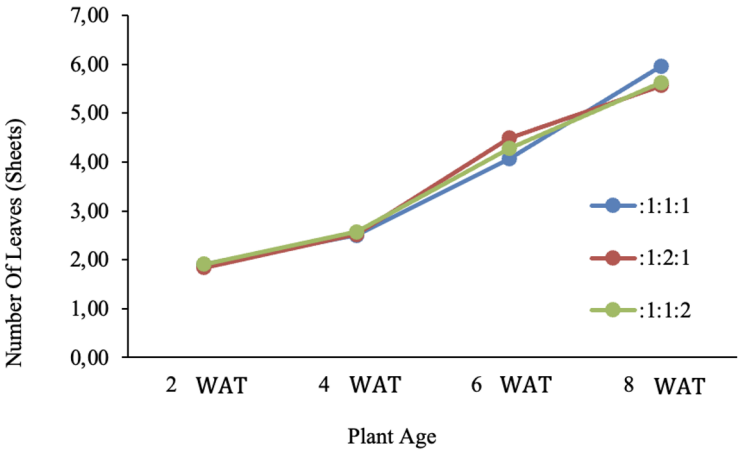
3.2 Discussion

Based on the analysis, the combination of growing media and the interval between goat urine LOF applications showed no statistically significant differences in any of the research parameters. However, both showed a trend toward different results at each level. This difference in trend remains important to analyze, as the plant's physiological response to media conditions and liquid nutrient application plays a role in determining gotu kola productivity. The analysis of leaf number in weeks 2, 4, and 6 showed that neither the growing medium nor the interval of goat urine LOF application had a significant effect. This indicates that in the early stages of growth, the treatment had not significantly impacted the development of the number of pegagan leaves, as the plant still relied on energy reserves and basic environmental conditions, resulting in a suboptimal response to the treatment. However, in week 8, a significant interaction occurred between the growing medium and the interval of goat urine LOF application. The best results were obtained with the P0I1 combination (1:1:1 medium with a fertilization interval of every 4 days) with an average number of leaves of 6.92. A balanced growing medium maintained stable aeration, humidity, and nutrient availability, resulting in more efficient nutrient absorption from the LOF. While more frequent fertilizer application intervals ensured a steady supply of nitrogen and natural growth regulators (auxins, cytokinins) to support new leaf formation. Nitrogen is an essential element in the formation of

proteins, amino acids, and chlorophyll, so its supply significantly determines the number of leaves formed [11]. Goat urine LOF not only contains high nitrogen but also growth hormones that accelerate cell division and leaf tissue differentiation [6].



(a)



(b)

Fig. 1. (a) Average Number of Gotu Kola Leaves at Various LOF Administration Intervals , (b)Average Number of Leaves of Gotu Kola Plants in Various Planting Media Compositions, WAT: Week after treatment

In contrast, the combination of P1I1 and P2I1 resulted in a lower number of leaves despite the same fertilization frequency, because the unbalanced media quality reduced the effectiveness of the liquid fertilizer. In media with dominant rice husk charcoal (P1), nutrients were easily leached due to excessive porosity, while in media rich in manure (P2), excess moisture caused anaerobic conditions around the roots, thus inhibiting nutrient absorption. The media structure significantly determines the ability of plants to utilize liquid organic fertilizer, because media that is too porous or too dense reduces the efficiency of nutrient absorption [12]. This finding supports the report of [13], which states that vegetative plant growth will be optimal when there is synergy between media conditions that support rooting and the appropriate fertilizer frequency. As a result, photosynthesis increases, cell division is more active, and the number of leaves is greater. Therefore, the P0I1 treatment can be recommended as the best combination to increase the number of gotu kola leaves

during the vegetative phase.

The number of stolons was higher in the P1 (1:2:1) treatment and the I2 fertilizer application interval. The higher proportion of rice husk charcoal in the P1 medium increased soil porosity and improved air circulation around the roots, allowing stolons to grow and spread more easily. Stolons are important organs in gotu kola because they provide the source of new shoots. According to [5], rice husk charcoal has the ability to retain moisture while reducing soil density, which facilitates the development of creeping organs. The 14-day fertilizer application interval also supported stolon growth because the plants had sufficient time to accumulate photosynthates and distribute them to the lateral organs. This aligns with the findings of [14] who stated that the effectiveness of liquid organic fertilizer is strongly influenced by the balance between nutrient supply and the medium's ability to store them. Therefore, the higher number of stolons in P1I2 reflects the combination of porous media conditions with efficient nutrient supply.

Stolon length tended to be better in the P0 and I2 treatments. Balanced media (P0) provides even nutritional support between macro and micronutrients, as well as more stable humidity, allowing stolons to elongate consistently. Fertilization intervals of every 14 days (I2) allow sufficient time for plants to utilize nutrients, allowing energy generated from photosynthesis to be allocated to organ elongation. Research by [15] shows that adequate nitrogen and phosphorus promote the growth of creeping vegetative organs through the mechanisms of cell division and elongation. These results indicate that adjusting the media composition and fertilization interval plays a role in strengthening stolon development, which is an indicator of gotu kola plant vigor.

The highest number of tillers was found in P2 media (1:1:2) and the I2 interval. The higher proportion of cow manure in P2 media enriches the nitrogen, phosphorus, and potassium content, which plays a significant role in the formation of new shoots from stolons. Nitrogen supports the formation of vegetative tissue, phosphorus plays a role in the production of energy (ATP) for shoot growth, while potassium aids the distribution of photosynthates to new organs [11]. A looser fertilization interval (I2) supports this process by maintaining more stable nutrient availability. Applying liquid organic fertilizer at appropriate intervals can increase the number of lateral shoots because the plant has sufficient time to accumulate energy reserves before being re-supplied with nutrients.

The relationship between the effect of liquid organic fertilizer concentration and fresh shoot weight showed significantly different results. The average fresh shoot weight results from applying liquid organic fertilizer with a concentration of 4 cc (N2) was higher than a concentration of 6 cc (N3), namely 103.36 gr (N2) and 97.56 gr (N3). The relationship between the effect of liquid organic fertilizer concentration and fresh root weight was also the same, showing significantly different results. The results of the average fresh weight of roots when applying liquid organic fertilizer with a concentration of 4 cc (N2) is higher than a concentration of 6 cc (N3). The value for (N2) is 31.67 gr and for (N3) it is 27.33 gr. Just like observing the fresh weight of the shoot, the highest average fresh weight of the roots also resulted in a concentration of 0 cc (N1), which was 36.44 gr.

(a)

(b)

Fig. 2. (a) Weighing Gotu Kola, (b) Goat Urine LOF Fertilization Process

Furthermore, leaf stalk length, chlorophyll content, plant fresh weight, and root weight of gotu kola did not show significant differences due to the growing media treatment or goat urine LOF administration interval, but the emerging trend pattern remains physiologically important. Leaf stalk length tends to be longer in balanced media with more frequent administration intervals (I1), which

is likely related to the continuous availability of nutrients and the cytokinin content in goat urine which can stimulate cell division and elongation. On the other hand, chlorophyll content and plant fresh weight are relatively higher in balanced media with less frequent intervals (I2), reflecting that the stable availability of nitrogen from manure supports chlorophyll synthesis and increased photosynthetic capacity, resulting in more optimal plant biomass accumulation [16]. Meanwhile, root weight is greater in media with a higher proportion of rice husk charcoal (P1) and weekly intervals (I0), because the porous media improves aeration and lateral root development, thereby increasing nutrient absorption efficiency [17]. Thus, although it does not produce a statistically significant difference, the tendency of these four parameters shows that a balanced combination of planting media and the correct arrangement of liquid fertilizer intervals still contribute to the quality of the vegetative growth of pegagan, both in the leaves and the root system.

4. Conclusion

Based on the research results, it can be concluded that:

1. The combination of planting media did not significantly affect all variables, but a balanced medium of soil, rice husk charcoal, and cow manure in a 1:1:1 ratio (P0) tended to show the best results.
2. The goat urine fertilizer application interval did not significantly affect all variables, with the best trend occurring at a 14-day interval (I2).
3. There was a significant interaction in the number of leaves at 8 weeks after planting, with the best results obtained with the 1:1:1 planting media combination and a goat urine fertilizer application interval of every 4 days (P0I1).

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