

Effectiveness Testing of Liquid Organic Fertilizer from *Rhizophora apiculata* Extract, NPK, and Manure on the Growth of Water Spinach (*Ipomoea reptans* Poir)

Faiq Firjatul Falaz*, I Gusti Putu Arya Darmayoga, Sabina Na'ma Aisa, Chelsy Aulia Zahra, Reinhart Yehezkiel William Hutabarat, Esti Harpeni

Marine Science Study Program, Department of Fisheries and Marine, Faculty of Agriculture, Universitas Lampung
Jl. Prof.Dr.Sumantri Brojonegoro No.1 Bandar Lampung, 35145, Telp +62 721 701609. Faks +62 721 702767, Indonesia.

Corresponding author*
faiqfirjatulfalaz0802@gmail.com

Manuscript received: 05 March 2026. Revision accepted: 10 June 2026, Published: 06 July 2026.

Abstract

This study evaluates the effectiveness of Liquid Organic Fertilizer (LOF) based on *Rhizophora apiculata* mangrove extract compared to NPK and goat manure on the growth of water spinach (*Ipomoea reptans* Poir) in Lampung Province. The experiment was arranged using a Randomized Complete Block Design (RCBD). Laboratory results showed that mangrove LOF contains significant macro-nutrients, specifically Potassium (2,551.83 mg/kg) and Magnesium (1,657.42 mg/kg), and is safe as heavy metals (Pb and Cd) were not detected. During observation, the LOF exhibited dynamic chemical properties with a pH decrease from 5,32 to 4,59 due to microbial decomposition. Analysis of variance indicated that fertilizer treatments had a highly significant effect on plant height ($F(2,4) = 569,902$). Tukey's HSD test confirmed that mangrove LOF produced the highest plants (23,1 cm), significantly outperforming NPK (20,2 cm) and goat manure (19,07 cm). Mangrove LOF produced superior visual quality with deep green leaves, attributed to Magnesium as the core of chlorophyll. Thus, *R. apiculata*-based LOF is an effective and sustainable alternative for vegetable production.

Keywords: *Rhizophora apiculata*; Liquid organic fertilizer; *Ipomoea reptans*; Sustainable agriculture.

INTRODUCTION

Water spinach (*Ipomoea reptans* Poir.) is a highly popular horticultural crop in Indonesia, including Lampung Province, due to its crisp texture and rich nutritional profile, containing essential vitamins A, B, C, and iron (Muchalim et al., 2021). In Lampung, water spinach has become a leading vegetable commodity with demand steadily increasing alongside population growth and rising health awareness among urban communities in Bandar Lampung regarding healthy food consumption. However, the expansion of water spinach production in this region is often hindered by soil conditions dominated by Ultisols. The acidic nature of Lampung's soil, coupled with low organic matter content, necessitates stable nutritional inputs to maintain nutrient availability for plants (Nuryani et al., 2020).

The use of manure, specifically goat manure—given its significant population in Lampung's livestock centers like East Lampung is known to provide a significant positive impact on the growth of water spinach by improving the physical properties of marginal lands (Walangitan et al., 2021). Furthermore, for vegetable farmers in Central Lampung, the integration of organic

and NPK fertilizers remains a primary strategy to meet macro-nutrient requirements instantly, stimulating rapid vegetative growth to meet harvest cycle targets (Muchalim et al., 2021).

Sustainable fertilization innovations based on Lampung's local potential are now exploring the utilization of mangrove vegetation along the East and West coasts of Lampung, specifically the *Rhizophora apiculata* species. *R. apiculata* leaf extract has been proven to contain bioactive compounds such as saponins, tannins, and phenolics, which possess strong antioxidant and antibacterial activities (Dewanto et al., 2021). The utilization of abundant mangrove biomass on the Lampung coast as an additive in the production of Liquid Organic Fertilizer (LOF) has the potential to enhance the nutritional quality of fertilizers in providing essential nutrients (Fadilah et al., 2022). The use of LOF is considered highly applicable for urban farming models in Lampung because its nutrients are more easily absorbed by plants through leaf stomata compared to solid fertilizers (Idris, 2020).

Although the potential of each fertilizer type has been studied individually, comparative effectiveness testing between *Rhizophora apiculata* extract LOF, NPK

fertilizer, and goat manure on water spinach growth under specific soil conditions in Lampung remains very limited. Therefore, this study aims to test the effectiveness of these three nutrient types in increasing the vegetative growth parameters of water spinach on Ultisol soil, providing efficient and sustainable local resource-based fertilization recommendations for farmers in Lampung Province.

MATERIALS AND METHODS

Study area

This research was conducted at the Department of Fisheries and Marine, Faculty of Agriculture, Universitas

Lampung, from September 8 to December 9, 2025, covering the stages of extraction, fermentation, filtration, and laboratory testing. The equipment utilized in this study included scissors, a grinder, filters, an analytical balance, digital calipers, a ruler, jerrycans, an autoclave, Erlenmeyer flasks, a camera, stationery, plastic pots, and filter paper. Meanwhile, the materials used consisted of mangrove leaves (*Rhizophora apiculata*), molasses, EM4, freshwater, NPK fertilizer, animal manure, rockwool, water spinach seeds (*Ipomoea reptans Poir*), and soil.

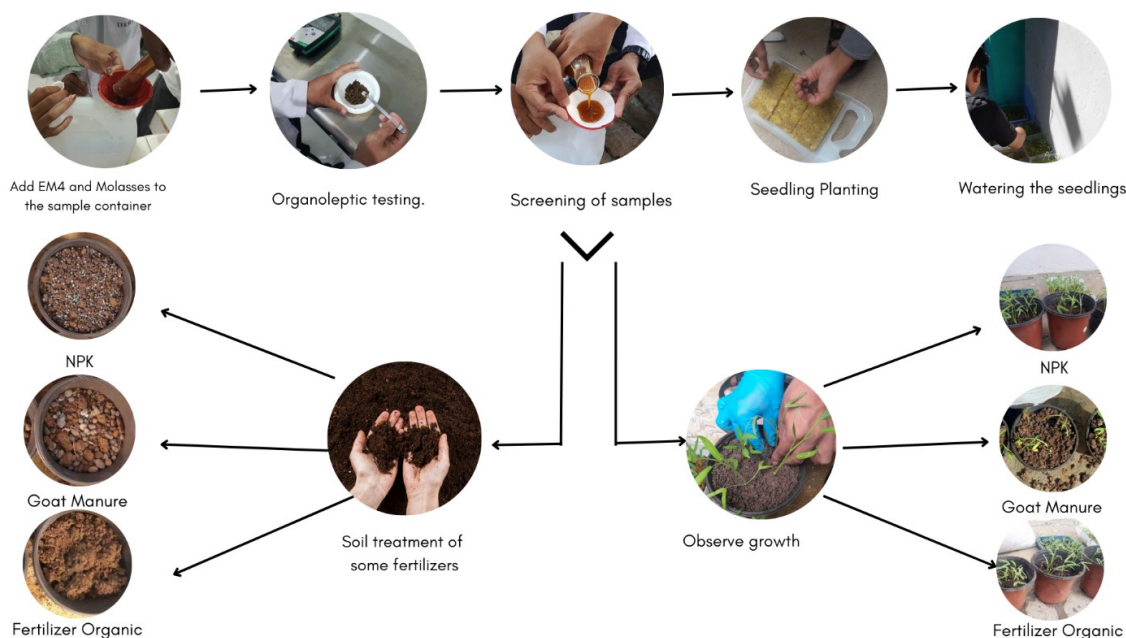


Figure 1. Experimental Research Procedure.

Procedures

This study was conducted as a field experiment using a Factorial Randomized Block Design (RBD) involving three factors. The first factor was the application of NPK fertilizer at a dosage of 1 g/pot. The second factor consisted of goat manure treatment with a soil-to-manure ratio of 2:1. The third factor was the application of liquid organic fertilizer at a dosage of 50 ml/pot.

Liquid Organic Fertilizer (LOF) Production

The production of liquid organic fertilizer (LOF) was carried out using *Rhizophora apiculata* mangrove leaves, which were collected from the Petengoran Mangrove Tourism Area. The leaves were sun-dried, crushed into powder, and subsequently fermented. The fermentation process involved mixing 250 g of mangrove leaf powder, 50 ml of molasses, 20 ml of Effective Microorganisms-4 (EM4), and 680 ml of sterile water in a jerrycan for a 14-

day incubation period. Throughout the fermentation process, the pH level was monitored periodically.

Generally, the production of liquid organic fertilizer (LOF) requires a duration of 5 to 10 days. Latifah, Rahayu, and Winarsih (2012) reported that thermophilic fungi, which facilitate the decomposition of organic matter, typically emerge within this timeframe. This decomposition process occurs gradually, transforming complex organic substances into colloidal liquids enriched with iron, calcium, and nitrogen, thereby producing high-quality fertilizer.

Seeding and Nursery Preparation

Seeding was conducted using rockwool blocks, where a total of 48 water spinach (*Ipomoea reptans Poir*) seeds were sown. The seeds were watered twice daily, in the morning and evening. After a one-week observation period, the seedlings exhibited optimal growth,

characterized by the emergence of 2–3 true leaves. Subsequently, the seedlings were transplanted into pots containing a growth medium composed of soil, liquid organic fertilizer (LOF), NPK fertilizer, and goat manure.

Planting Media Preparation

The planting media used in this experiment was a mixture of soil, NPK fertilizer, liquid organic fertilizer, and goat manure in a 2:1 ratio. The mixture was then thoroughly mixed. The thoroughly mixed media was placed into nine pots, with three treatments being conducted in this experiment.

Transplanting and Plant Establishment

Water spinach (*Ipomoea reptans Poir*) seedlings were transplanted into pots by creating planting holes in the growth medium. The seedlings, along with the soil adhering to the root systems, were carefully lifted and placed upright into the holes. The surrounding medium was then gently compacted, and additional soil was added to ensure the holes were completely filled. Each pot was planted with five healthy, uniform seedlings, free from pests and diseases, which had already developed 2–3 true leaves. The experiment was conducted with three replicates (3 pots per treatment)

Experimental Treatments

In this study, three distinct treatments were evaluated: goat manure, NPK fertilizer, and liquid organic fertilizer (LOF). Each treatment was applied by thoroughly mixing the respective fertilizer with the soil medium within the pots. The experiment was conducted using three treatment groups to assess their effects on plant growth.

Plant Maintenance

The maintenance of water spinach (*Ipomoea reptans Poir*) was carried out systematically through irrigation and weed management. Irrigation was performed twice daily, in the morning and evening, with the water volume adjusted according to the moisture levels of the growth medium, particularly during the initial growth phase. Manual weeding was conducted to prevent nutrient competition and eliminate potential habitats for pests and diseases. This process involved removing weeds around the plants and was executed routinely on a weekly basis, coinciding with the data collection schedule, whenever spontaneous vegetation was detected.

Harvesting and Post-Harvest Handling

Harvesting was conducted at 21 days after transplanting (DAT) by uprooting the entire plant, including the root system. To maintain post-harvest freshness, the water spinach was kept in a shaded area or by submerging the roots in clean water. Subsequently, the harvested plants were cleaned to remove any adhering soil and debris from the plant surfaces.

RESULTS AND DISCUSSION

Nutritional Characteristics and Potential of Mangrove-Based Liquid Organic Fertilizer (LOF)

Table 1 Nutrient Content of the Liquid Organic Fertilizer

Nutrient Element	Concentration mg/L
N	483.333
P	79.000
K	2,551.83
Mg	1,657.42
Pb	ND
Cd	ND

The analytical results revealed a significant concentration of Magnesium, reaching 1,657.42 mg/kg. Furthermore, heavy metal parameters, specifically Lead (Pb) and Cadmium (Cd), were Not Detected (ND), indicating that the samples are free from these specific metallic contaminants.

pH measurement

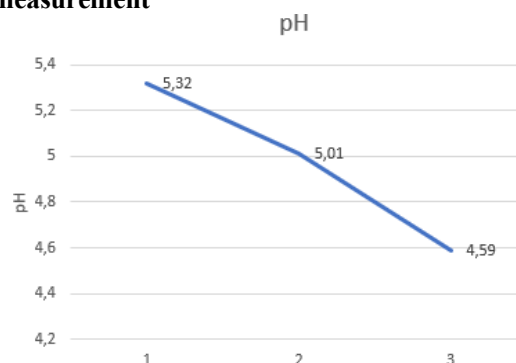


Figure 2. Changes in pH Levels

pH measurement of the planting media was conducted in triplicate throughout the study period. The results indicated a gradual decrease in pH values, as illustrated in Figure 2. The initial pH was recorded at 5.32, which subsequently declined to 5.01 during the second observation, reaching its lowest point at 4.59 by the third observation.

Vegetative Growth in Terms of Plant Height (*Ipomoea reptans Poir*)

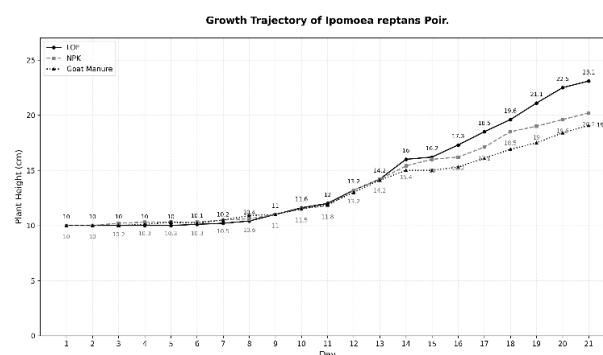


Figure 3. Plant Height Growth of Water Spinach (*Ipomoea reptans Poir*.)

Analysis of Randomized Block Design (RBD)

Table 2. Post Hoc Tukey.

Variable	Mean	Notation
Goat Manure	19,067	a
NPK	20,200	b
POC	23,100	c

Discussion

Based on the laboratory analysis, the Liquid Organic Fertilizer (LOF) derived from *Rhizophora apiculata* extract contains macronutrients consisting of Nitrogen (N) at 483.33 mg/L (0.048%), Phosphorus (P) at 79 mg/L (0.0079%), and Potassium (K) at 2,551.83 mg/L (0.25%). When compared to the minimum macronutrient threshold (N+P+K) of 2% required by Minister of Agriculture Regulation No. 261/2019, the nutrient concentration of this LOF is technically below the standard for commercial organic fertilizers. However, such low concentrations are common in pure mangrove extracts that have not undergone chemical fortification. Interestingly, the Magnesium (Mg) content reached 1,657.42 mg/L (0.16%). This high Mg concentration is highly beneficial for leafy vegetables like water spinach (*Ipomoea reptans*) because Mg serves as the central atom of chlorophyll, which is crucial for optimizing the rate of photosynthesis.

Environmental safety is a primary advantage of this LOF, as heavy metals such as Lead (Pb) and Cadmium (Cd) were "Not Detected" (ND). This aligns with findings by Dewanto et al. (2021), stating that *R. apiculata* possesses a chemical defense system naturally free from hazardous contaminants when harvested from a protected environment. The ND status ensures that the resulting water spinach is safe for human consumption, adhering to SNI 7387:2009 standards and BPOM regulations regarding maximum heavy metal limits in food.

The application of LOF showed a significant influence on the vegetative growth of water spinach compared to other treatments. Data indicates that the average height of water spinach treated with LOF reached 23.10 cm by Day 21. This result is significantly higher than the treatments using NPK (20.20 cm) and goat manure (19.07 cm). Although the macronutrient levels in the LOF were lower than NPK, its effectiveness in promoting plant height is likely due to the presence of secondary metabolites. *R. apiculata* extract is reported to be dominated by inositol (75.6%), which acts as a biostimulant that triggers cell division in the apical meristem of the stem.

The enhancement of water spinach growth through the consistent application of LOF was experimentally verified using a Randomized Block Design (RBD). Based on the Analysis of Variance (ANOVA), the

fertilizer treatments significantly influenced plant height. An F-value (2, 4) of 569.902 indicates that the effectiveness of the treatment on plant growth is highly dependent on the variation in plant response.

The Tukey's HSD (Honestly Significant Difference) test further confirmed these findings. It was observed that the LOF treatment resulted in a significantly higher average plant height of 23.10 cm compared to NPK (20.20 cm) and goat manure (19.07 cm). These three treatments were statistically distinct, with LOF placed in the highest group based on different alphabetical notations (a, b, c). The nutritional formulation and chemical environment of *Rhizophora apiculata* LOF provided higher fertilization efficiency than conventional practices. This biological and chemical superiority stems from the synergy between its pH levels, which enhance nutrient solubility, and its substantial magnesium and potassium content.

The study recorded a gradual decrease in media pH from 5.32 to 4.59. According to Sutedjo (2010) and Subba Rao (2017), mature liquid organic fertilizers with slightly acidic pH levels accelerate nutrient mineralization and improve ion transport to the root zone. This mechanism allows the water spinach to achieve better nutrient utilization, leading to the substantial development in plant height demonstrated by the RBD and HSD test results. This acidic condition, while increasing nutrient availability, also reflects the active decomposition of organic matter into beneficial organic acids.

CONCLUSIONS

Liquid Organic Fertilizer (LOF) from *Rhizophora apiculata* extract is highly effective in enhancing the vegetative growth of water spinach (*Ipomoea reptans* Poir). Laboratory analysis confirmed that the mangrove-based LOF contains essential macro-nutrients, particularly Potassium (2,551.83 mg/L) and Magnesium (1,657.42 mg/L), while remaining safe from heavy metal contaminants as Lead (Pb) and Cadmium (Cd) were not detected. During the observation period, a gradual decrease in the planting medium's pH was recorded, declining from 5.32 to 4.59, which indicates active nutrient mineralization. Statistical analysis via ANOVA revealed that the fertilizer treatments had a highly significant effect on plant height, with an F-value (2,4) of 569.902. Furthermore, Tukey's HSD test confirmed that the mangrove LOF produced the highest average plant height (23.1 cm), significantly outperforming both NPK (20.2 cm) and goat manure (19.07 cm). Consequently, *R. apiculata*-based LOF serves as an efficient and sustainable fertilization alternative for vegetable production, especially in the specific soil conditions of Lampung Province.

Acknowledgements: The authors wish to express their deepest gratitude to the supervising lecturers for their invaluable guidance, support, and the knowledge shared throughout the development and completion of this research.

Authors' Contributions: Falaz F.F., Darmayoga I.G.P.A., Aisa S.N., Zahra C.A., and Hutabarat, R.Y.W. designed the study and performed laboratory analyses. Falaz F.F., and Hutabarat, R.Y.W., performed statistical analysis of the data obtained from the study. Aisa S.N., Zahra C.A., and Darmayoga I.G.P.A., conducted the literature survey and drafted the manuscript for publication. Harpeni, E., contributed. All co-authors read the manuscript and provided necessary input before the final version was approved for publication.

Funding: The authors declare that no external funding was received for this research.

Competing Interests: The authors declare that there are no competing interests regarding the publication of this research.

REFERENCES

- Decree of the Minister of Agriculture Number 261/KPTS/SR.310/M/4/2019 concerning Minimum Technical Requirements for Organic Fertilizers, Biofertilizers, and Soil Improvers
- Dewanto, D. K., Hermawan, R., Muliadin, M., Riyadi, P. H., Aisiah, S., & Tanod, W. A. (2021). Profil GC-MS dari ekstrak daun *Rhizophora apiculata* dari pesisir Teluk Tomini, Sulawesi Tengah dengan aktivitas antibakteri dan antioksidan. *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, 14(1), 30-42.
- Fadilah, R., Kismorodati, W., & Syafruddin. (2022). Pengaruh penambahan daun mangrove *rhizophora apiculata* dalam pembuatan pupuk organik cair (poc) sebagai alternatif pupuk dalam budidaya udang. *Jurnal Pendidikan Teknologi Pertanian*, 8 (1), 99-110.
- Idris, M. (2020). Pengaruh pemberian kompos dan pupuk organik cair terhadap pertumbuhan vegetatif tanaman kangkung darat (*Ipomoea reptans* poir). Skripsi.
- Latifah, R. N. N. (2012). Pemanfaatan sampah organik sebagai bahan pupuk cair untuk pertumbuhan tanaman bayam merah (*Alternanthera ficooides*). *LenteraBio: Berkala Ilmiah Biologi*, 1(3), 139-144.
- Muchalim, S., Ernawati, N. M. L., & Sutresna, I. W. (2021). Pengaruh pupuk organik dan pupuk npk terhadap pertumbuhan dan hasil tanaman kangkung darat (*Ipomea reptans* poir). *Fakultas Pertanian, Universitas Mataram*.
- Nuryani, W., Hanudin, H., & Budiarto, K. (2020). Aplikasi dan efektivitas pupuk hayati dalam upaya perbaikan mutu produksi, produktivitas dan pengendalian serangan layu fusarium pada bawang merah. *Jurnal Agro*, 7(1), 52-70.
- Subba Rao, N. S. (2017). *Biofertilizers in Agriculture and Forestry*. Oxford & IBH Publishing. Sutedjo, M. M. (2010). *Pupuk dan Cara Pemupukan*. Jakarta: Rineka Cipta.
- Walangitan, F. S., Supit, J. M., & Kawulus, R. I. (2021). Pengaruh pemberian pupuk kandang kambing terhadap pertumbuhan tanaman kangkung darat (*Ipomoea reptans*) pada tanah marginal. In *Cocos*, 13 (2).

THIS PAGE INTENTIONALLY LEFT BLANK