QUALITY OF SHALLOT WASTE LIQUID ORGANIC FERTILIZER AND ITS EFFECT ON RED LETTUCE

KUALITAS PUPUK ORGANIK CAIR BAWANG MERAH DAN EFEKNYA TERHADAP PERTUMBUHAN DAN HASIL SELADA MERAH

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ABSTRACT

Converting organic waste into liquid organic fertilizer (LOF) can reduce reliance on inorganic fertilizers and improve soil quality and the productivity of leafy vegetables, including red lettuce. The study aimed to 1) determine the chemical and microbiological properties of LOF from shallot waste (LOF-Shallot) and 2) analyze the growth and yield of red lettuce cv Arista after applying various concentrations of LOF-Shallot. The LOF-Shallot was produced using a fermentation method enriched with decomposer microbes. The field experiment was set up using a Randomized Block Design, with five LOF-Shallot concentrations (0, 30, 60, 90, and 120%), then applied 4 times every 7-day period. The research was conducted at the Chemistry Laboratory of UICM, Bandung City, and the experimental field in Cimenyan village, Bandung Regency, from June to September 2024 The results of the LOF-Shallot waste analysis contained total N 0.12%, P 0.16%, K 0.07%, Cu 3.14 ppm, Fe 151.77 ppm, and Zn 492.4 ppm. Beneficial soil microbes such as *Azotobacter* sp., *Bacillus* sp., and phosphate-solubilizing bacteria at 10^7–10^8 CFU mL^{-1} were detected in the LOF-Shallot waste. The total bacterial population in the LOF-Shallot was about 10^8 CFU mL^{-1}, while the total fungal count was low, fewer than 10^2 CFU mL^{-1}. The results of field experiments showed that the higher concentration of LOF-Shallot applied (up to 90%), the greater the effect on all observed variables. The application of 90% LOF-Shallot concentration had the best effect on shoot height, leaf count, and shoot fresh weight.

Keywords: Beneficial soil microbes, Fertilizer quality, LOF-Shallot waste, Red lettuce.

ABSTRAK

Konversi limbah organik menjadi pupuk organik cair (POC) dapat mengurangi ketergantungan pada pupuk anorganik serta meningkatkan kualitas tanah dan produktivitas sayuran berdaun, termasuk selada merah. Penelitian ini bertujuan untuk 1) menkaji sifat kimia dan mikrobiologis POC Bawang Merah dan 2) menganalisis pertumbuhan serta hasil panen selada merah varietas Arista setelah pemberian berbagai konsentrasi POC-Bawang Merah. Pupuk organik cair dari limbah bawang merah diproduksi menggunakan metode fermentasi yang diperkaya dengan mikroba pengurai. Percobaan lapangan disusun menggunakan Rancangan Acak Kelompok,

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dengan lima konsentrasi POC-Bawang Merah (0, 30, 60, 90, dan 120%) yang diberikan empat kali setiap 7 hari, mulai hari ke 3 sampai dengan hari ke 24 setelah tanam. Penelitian telah dilaksanakan di Laboratorium Kimia UICM, Kota Bandung dan lahan percobaan di desa Cimenyan, Kabupaten Bandung dari Juni sampai September 2024 Hasil percobaan laboratorium menunjukkan bahwa POC-Bawang Merah mengandung 0,12% N total; 0,16% P; 0,07% K; 3,14 ppm Cu; 151,77 ppm Fe; dan 492,4 ppm Zn. POC ini mengandung bakteri potensial, yaitu *Azotobacter* sp. dan *Bacillus* sp., serta bakteri pelarut fosfat sebanyak 10^7–10^8 CFU mL^{-1}. Total populasi bakteri dalam POC-Bawang Merah sekitar 10^8 CFU mL^{-1}, sedangkan jumlah total jamur rendah, yaitu kurang dari 10^2 CFU mL^{-1}. Hasil percobaan lapangan menunjukkan bahwa semakin tinggi konsentrasi POC-Bawang Merah yang diaplikasikan (hingga 90%), semakin besar pengaruhnya terhadap semua variabel yang diamati. Aplikasi konsentrasi POC-Bawang Merah 90% berpengaruh terbaik terhadap tinggi tajuk, jumlah daun, dan berat segar tajuk.

Kata kunci: Bakteri penyubur tanah, Kualitas pupuk, Limbah Bawang merah, Pupuk Organik Cair, Selada merah.

INTRODUCTION

Fertilization plays a vital role in vegetable farming. Because inorganic fertilizers are expensive, organic fertilizers are needed to lessen dependence on them. Liquid organic fertilizer (LOF) can be recommended to boost plant growth; it is also essential for improving soil health and biodiversity. This fertilizer is usually made through the enzymatic breakdown of waste, enriched with activator bacteria and organic materials like molasses, which serve as nutrients for decomposer microbes (Amrullah et al., 2021; Leksono et al., 2024; Priyadi et al., 2023). Creating LOF from a mix of different base ingredients yields a more complete nutrient profile compared to using only similar organic materials (Haryanta et al., 2022) .

Distinctive physicochemical properties, including a dark brown color, fermentation aroma, and high emulsification capacity, characterize the effective decomposition of organic matter into LOF. Generally, LOF contains macronutrients and micronutrients that are readily absorbed by plant roots (Leksono et al., 2024). Organic waste processed into LOF was found to contain macronutrients such as 3.7% nitrogen and 1.8% sulfur, along with micronutrients like Fe, in a balanced composition (Kuncaka et al., 2021) It also contains 0.05% phosphorus, 0.34% potassium, 0.26% calcium, and 0.04% magnesium (Ranasinghe et al., 2019). The fermentation process influences the quality of the LOF (Achmad & Mansyur, 2021; Haryanta et al., 2022; Sarah et al., 2023), while the type of added bio-activator impacts the specific nutrients produced and their levels (Raden et al., 2017; Said et al., 2024). LOF also contains beneficial microbes, including those involved in the nitrogen and phosphorus nutrient cycles. In LOF derived from vegetable and fruit waste, 10-40% of several microbial types are beneficial for plant growth and development, such as *Rhizobhium, Bradyrhizobium, Mesorhizobium*, *Pseudomonas*, *Bacillus*, and *Azotobacter* (Allouzi et al., 2022; Arora & Mishra, 2016). This data shows that each researcher found different types and levels of nutrients and beneficial microbes in the LOF. The occurrence of these differences is thought to be due to differences in the LOF-Shallot fermentation formula and differences in the application of LOF-Shallot to the plants that are the objects of research.

The amount of shallot waste (*Allium cepa* L.) in Indonesia is increasing each year due to high consumption and increased production. Shallot production in West Java, Indonesia, increased by 8.15% in 2022-2023, partly due to a larger harvest area and higher plant productivity (Sholihah, 2023). The rise in consumption also leads to increased shallot waste, thus causing soil and water pollution, facilitating the pest cycle for plants, and increasing greenhouse gas emissions. Coverting shallot waste into LOF (LOF-Shallot) is a smart step to recycle natural materials and reduce environmental pollution (Sari et al., 2022).

Several researchers have developed LOF-Shallot (Banu, 2020; Haryanta et al., 2022), but information on its physical, chemical, and microbiological characteristics, as well as its effects on plant growth and yield, remains limited. According to Adam et al. (2019) LOF-Shallot promotes the growth and development of vegetable plants because onion peels contain growth hormones that stimulate root growth in chrysanthemums (Fadhil et al., 2018). LOF-Shallot increases leaf number, plant height, and fresh weight of Pakchoy plants when applied at a concentration of 20% (Putri et al., 2022). The application of LOF-Shallot at a dose of 250 ml L^{-1} is the optimal concentration for increasing stem diameter, growth, and fresh weight of *Brassica* plants (Sofyan, 2021).

In Indonesia's vegetable production centers, particularly in West Java, cultivation of red lettuce (*Lactuca sativa* L. var. crispa) remains lower than that of green lettuce, even though red lettuce has a higher economic value than green lettuce. In Bandung, the price of red lettuce for 250 g ranges from Rp 17,500.00 to Rp 20,000.00 while the price of green lettuce for 500 g ranges from Rp 4,000.00 to Rp 5,000.00. Farmers' limited knowledge of how to process shallot waste into LOF and the effectiveness of LOF-Shallot in increasing crop production needs to be supported by research, therefore research results are needed that can increase the growth and yield of red lettuce This study aims to 1) determine the chemical and microbiological characteristics of LOF-Shallot waste and 2) analyze the growth and yield of Arista variety red lettuce plants after applying LOF-Shallot at various concentrations.

MATERIALS AND METHODS

The research was conducted from June to September 2024. To achieve the first objective of study, the research was carried out in the Chemistry Laboratory of the Faculty of Agriculture, Insan Cendekia Mandiri University (UICM), located in the Bandung city. Meanwhile, to achieve the second objective of the study, a field experiment was conducted in Cimenyan village, Cimenyan District, Bandung regency, West Java. The site was located at an altitude of 1,200 meters above sea level and primarily has Regosol soil. During the research, has been measured the average daily temperature ranges from 23°C to 30°C and a relative air humidity of 60-65%.

Production of Shallot Waste Liquid Organic Fertilizer (LOF-Shallot)

The basic ingredients of LOF-Shallot include the roots, bark, and waste leaves, all chopped into 1-3 cm pieces. Shallot waste comes from leftover harvests on farmers' land in Cimenyan village, Cimenyan District, Bandung Regency, on Regosol with loam soil at an altitude of 1,200 meters above sea level.

LOF-Shallot was prepared by diluting 1 Liter of molasses in 10 Liters of distilled water, inoculating with 1 Liter of agricultural EM-4 activator, and stirring thoroughly in a 15-liter plastic bucket. A total of 3 kg of chopped base material was mixed into the production solution, stirred well, tightly covered (Figure 1), and stored in the laboratory at 23-26 °C away from direct sunlight. After one week, the lid was opened, the mixture stirred well, and then resealed for 30 days. Stirring was performed weekly. The 10:3:1:1 formulation (water: vegetable + fruit waste: EM-4 activator: molasses) with a fermentation time of 30 days is one of the best formulations ever used by the UICM Faculty of Agriculture in the Horticultural Post-Harvest Technology practicum material.

Figure 1. Production stages of Shallot Liquid Organic Fertilizer (LOF-Shallot)

The observed LOF-Shallot quality was assessed based on visual characteristics, including colour, sediment percentage, aroma, and viscosity**.** Macronutrient and micronutrient content, pH, and EC were analyzed approximately according to (AOAC INTERNATIONAL, 2023), while bacterial and fungal populations were counted using the specific media followed by the serial dilution plate method (Reynolds, 2005).

The microbial population was counted by enumerating colonies grown in the specific media, using the calculation methods of previous researchers (Sonia & Atmaja, 2019; Sha et al., 2020; Mardyansah & Trimulyono, 2021; Wulandari et al., 2020), with repetition two times.

Soniari & Atmaja (2019) conducted a microbial count of *Azobacter* sp. using N-free Ashby's mannitol agar; Sha et al. (2020) conducted a microbial count of *Bacillus* sp. using tryptic soy agar; Mardyansah & Trimulyono (2021) conducted a microbial count of Phosphate-solubilizing bacteria (PSB) using Pikovskaya agar; Wulandari et al. (2020) conducted a total bacterial and fungal count of nutrient agar and potato dextrose agar, respectively. LOF-Shallot was stored in the Chemistry Laboratory, Faculty of Agriculture UICM, at room temperature

(25-26°C) and not exposed to direct sunlight. The analysis results are presented in the Tables.

Field Experiment

The study used a Randomized Block Design (RBD) to evaluate five LOF-Shallot concentration treatments. These treatments were P0 (0%), P1 (30%), P2 (60%), P3 (90%), and P4 (120%). A ready-to-apply LOF-Shallot solution was prepared using the dilution method from Indrawati et al. (2023), with the standard formula C = m/V, where C is the concentration, m is the mass of the solute, and V is the total volume of the solution, expressed as a percentage (%). For example, to prepare a C (ready-to-use LOF-Shallot) solution at 120%, dissolve 120 mL of LOF-Shallot in 100 mL of deionized water. Each treatment was replicated four times, with a 7-day interval between applications.

Seeds of the red lettuce cultivar Arista were sown in trays filled with soil and manure and placed in the nursery for 14 days. The experimental area was tilled with a hoe, and plots measuring 60 x 330 cm were prepared, with a bed height of 25 cm. Chicken manure, at a rate of 10 tons per hectare (equivalent to 20 kg plot^{-1}), was incorporated into the soil of each plot. Before the experiment, the soil had high organic carbon, moderate total nitrogen, very low P_2O_5, low K_2O, low exchangeable K and Na, medium cation exchange capacity, and a pH of 6.3. The soil N, P, and pH were analyzed after the experiment, but were limited for the soil treated with 120% of LOF. The chicken manure was provided by the Faculty of Agriculture UICM, with total nitrogen of 1.07%, P_2O_5 of 0.22%, and K_2O of 1.10%.

Each plot was covered with plastic mulch, and holes were made at a 30 x 30 cm spacing. The 14-day-old seedlings were planted in each hole. LOF-Shallot was applied by soil drenching, four times weekly from 3 days after planting (DAP) to 24 DAP, with 100 mL plant^{-1} at 3 and 10 DAP and 150 mL plant^{-1} at 17 and 24 DAP. The plants were harvested on 29 DAP.

Plant height and leaf number were measured at 8, 15, 22, and 29 DAP, while plant and root fresh weights were measured at 29 DAP. At harvest, the shoots and roots of individual plants were separated and weighed. All data were subjected to analysis of variance, followed by Duncan's test at a 5% significance level, using SPSS version 21. Results for the measured parameters are presented as a histogram (shoot height and leaf count) and tables (fresh weights of plant shoots and roots).

RESULTS AND DISCUSSION

Quality of Liquid Organic Fertilizer

The visual properties, as well as the chemical and microbiological properties of the LOF-Shallot are presented in Tables 1 and 2. Based on Table 1 LOF-Shallot waste resulting from 30 days of fermentation. The process of making LOF-Shallot is one of the biorefinery activities, namely an effort to produce renewable energy sources from the fermentation of organic agricultural waste (Artola et al., 2024) with pH value as one of the benchmarks. The results of laboratory tests obtained a pH LOF-Shallot value of 4.2 and this meets the requirements of SNI 77633:2018 with a value ranging from 4-9.

Table 1. Physical and chemical characteristics of LOF-Shallot

Characteristics of LOF-Shallot[1]	Macronutrients[2]	Level (%)	Micronutrients[2]	Level (ppm)
Color : dark brown	C-organic	2.22	Iron	151.77
Sediment : 10 %	Phosphorus	0.16	Copper	3.14
pH : 4.2	Potassium	0.07	Zinc	492.48
Odor : alcohol/tapai	Nitrogen Total	0.12		
Viscosity : 5,605 mPa	C/N ratio	18.50		
EC : 9,152				

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Reduced pH after fermentation indicated that indigenous and exogenous microbes in LOF were able to ferment specific carbohydrates, producing organic acids. The LOF contained P-solubilizing bacteria (Table 2.) that are suggested to produce organic acid prior to solubilizing inorganic P to available P (Kishore et al., 2015). Moreover, *Bacillus* that in LOF is reported to perform the organic acid secretion (Cheng et al., 2017).

Overall, the organic C content and total macronutrients N, P, and K are below the standard (< 2%). The key factors determining the C, N, P, and K content in liquid organic fertilizer are the type and nutrient profile of the organic raw material, fermentation duration, and bioactivator enrichment. The results of laboratory tests in this experiment on shallot waste were rich in fiber but the C-organic value 2.22%, total N 0,12% and C/N ratio value 18.50 this value is low, because the minimum LOF standard C-organic is 10% and total N 0.5% (Decree of the Minister of Agriculture of the Republic of Indonesia Number: 261/KPTS/SR.310/M/4/2019.2019).

However, the C/N value indicator <20 is a condition indicated that microbes have sufficient N value to decompose C, and N will be released into the soil and can be used by plants, especially in the vegetative phase. The experiment used only shallot biomass and did not add organic matter with high N, such as cow manure or legumes, that could raise the N content of row composting materials. However, the data obtained as presented in Table 1 has partially fulfilled, especially micronutrient values, the requirements as LOF according to Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/KPTS/SR.310/M/4/2019.

Table 2. Microbial composition inside LOF-Shallot

Types of microbial populations	Microbial populations (CFU mL^{-1})
Nitrogen-fixing *Azotobacter* sp.	14.4×10^7
Bacillus sp.	71.3×10^8
Phosphate-solubilizing bacteria (PSB)	11.8×10^7
Total Bacteria	52×10^8
Total Fungi	$< 10^2$

[3]Laboratory of Soil Biology, Faculty of Agriculture, Padjadjaran University.

The levels of Iron (Fe), Copper (Cu), and Zink (Zn), meet the minimum required standards (< 500 ppm) that support the availability of plant nutrients. Iron is critical for photosynthesis, as Fe is an essential element in chloroplasts, along with N (Li et al., 2021). Copper acts as an enzyme cofactor in many biochemical pathways, including photosynthesis, respiration, and antioxidant systems (Xu et al., 2024). The high level of the element Zn benefits plants by inducing enzymatic activity and protein synthesis, boosting the biostimulator effect on root structure alteration, and ensuring crop quality, thereby supporting sustainable agriculture (Saleem et al., 2022).

Table 2 shows that LOF-Shallot contains several potential microbes, including nitrogen-fixing *Azotobacter* sp., *Bacillus* sp., and phosphate-solubilizing bacteria (PSB). Nitrogen-fixing microbes detected in LOF-Shallot totaled 72.7 x 10^8 CFU mL^{-1}. Soil microbiologists have previously agreed that free living nitrogen-fixing microbes, play a role in increasing soil fertility by providing available N (Ayiti & Babalola, 2022). The PSB in LOF was 11.8 x 10^7 CFU mL^{-1}; the presence of PSB in LOF would be essential as it converts insoluble inorganic P into soluble P in soil (Allouzi et al., 2022). Both processes promote plant growth and yield in an environmentally friendly way (Kalayu, 2019; Pane et al., 2022). The total bacterial and fungal populations in LOF-Shallot were 52 × 10^8 CFU mL^{-1} and 11.8 × 10^7 CFU mL^{-1}, respectively (Table 3), indicating that high bacterial colonization may occur in the soil around red lettuce roots after LOF application. Therefore, microbes detected in LOF-Shallot were beneficial in improving the growth and production of red lettuce plants.

Table 3. Fresh weight of the shoot and roots of red lettuce plants given various concentrations LOF-Shallot at 29 DAP

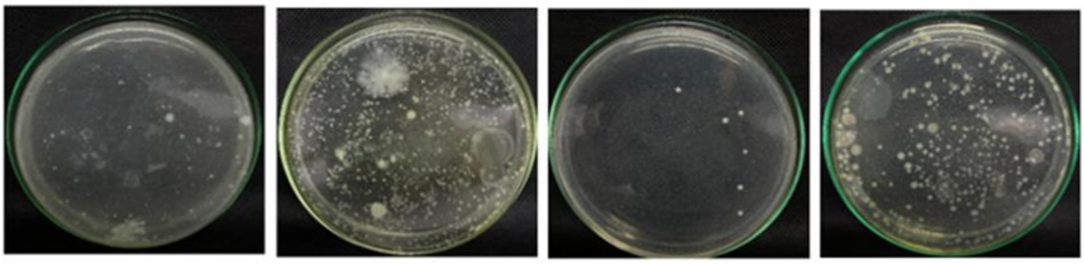
Treatment LOF-Shallot (%)	Shoot fresh weight (g)	Roots fresh weight (g)
P0: 0	30.75 ± 0.82 a	2.44 ± 0.15 a
P1: 30	31.44 ± 0.51 ab	2.47 ± 0.17 a
P2: 60	32.06 ± 0.59 b	2.57 ± 0.18 b
P3: 90	33.26 ± 0.57 c	2.70 ± 0.09 c
P4: 120	33.90 ± 0.64 c	2.66 ± 0.12 c

Information: The same letter in the same column after the number indicates no different treatment on the Duncann test 95% confidence rate

Soil microbes, especially bacteria and fungi, play an essential role in the nutrient cycle and in the decomposition of organic matter, both of which can provide essential nutrients of N, P, and K for plant growth. The presence of Nitogen-fixing bacteria (NFB) in LOF would provide available N for plant. Approximately; 78% of N_2 in the atmosphere is inert and cannot be assimilated by plants. Only N-fixing bacteria can enzymatically convert N2 to NH3, which is then converted to NH4+ and enzymatically incorporated into nitrification in aerobic soil to form NO3-; both inorganic N forms are available to plants (Ayiti & Babalola, 2022).

The microbial profile of LOF-Shallot is quite diverse and aligns with the idea of Nosheen et al. (2021): biofertilizers containing multiple strains of microbes, such as algae, bacteria, and fungi, are more effective at increasing plant growth and soil nutrition. The colony morphology of this specific microbial population in LOF-Shallot waste is shown in Figure 2.

The *Azotobacter* and *Bacillus* are supposed to contribute to the synthesis of phytohormones that regulate plant growth, development, and alleviate environmental stress. Hindersah et al. (2020), confirmed that beneficial *Bacillus* including *B. megaterium* and *B. subtilis* as well as *Azotobacter* (*A. chroococcum* and *A. vinelandii*) produce phytohormone IAA, exopolysaccharide, cytokinin (Cks), and gibberellins (GAs).



Azotobacter, sp.	**_Bacillus_ sp.**	**P-solubz bacteria**	**Total bacteria**
$14.4x10^{7}$(Dilution 10^{-7})	$71.3x10^{8}$(Dilution 10^{-7})	$71.3x10^{8}$ (Dilution 10^{-7})	$52x10^{8}$(Dilution 10^{-9})

Figure 2. The number of bacterial populations in specific media and total bacteria contained in LOF-Shallot waste

Growth and Yield of Red Lettuce

Analysis of variance confirmed that the LOF-Shallot concentration influenced the plant height and leaf number of red lettuce grown in Regosol soil at all observation dates (Figures 3 and 4). At 8 and 15 DAP, the shoot height of lettuce treated with 60%-120% LOF was higher than that of the control and 30% LOF. However, at 22 and 29 DAP, the height and leaf number of plants with 90% and 120% LOF were superior to those of the control and the other LOF concentrations. At harvest time, lettuce shoot height and leaf number were 2.5% and 2.8% higher than the control, respectively.

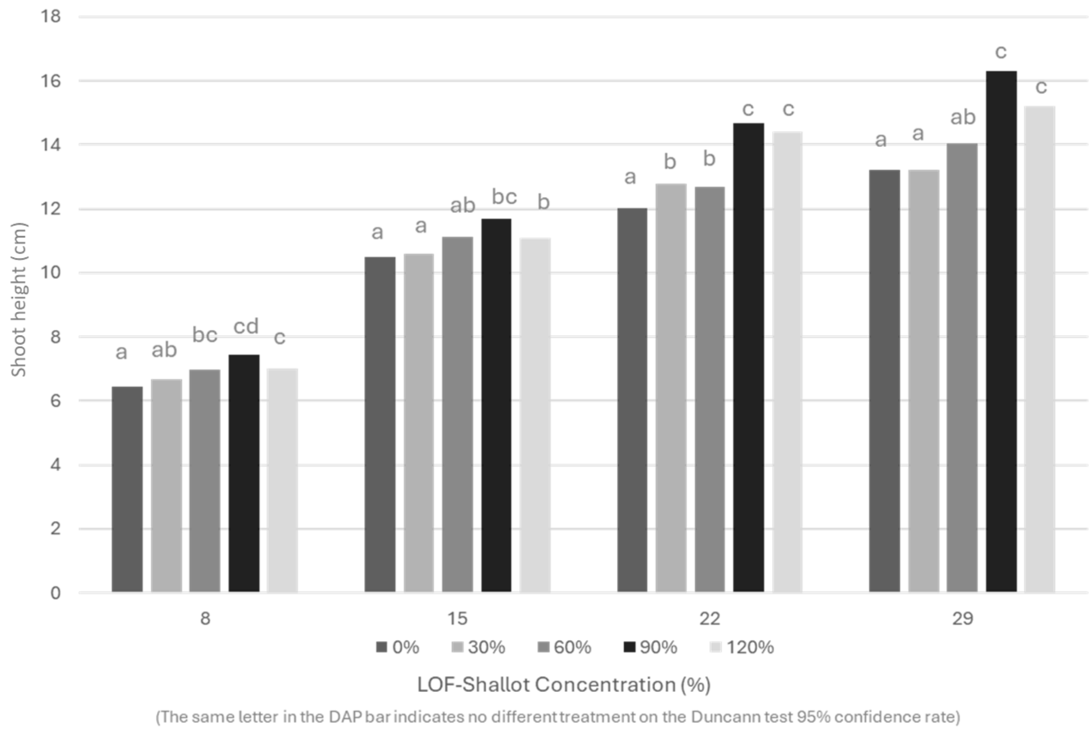


Figure 3. The shoot height of red lettuce plant at the observation day to 8, 15, 22, 29 DAP.

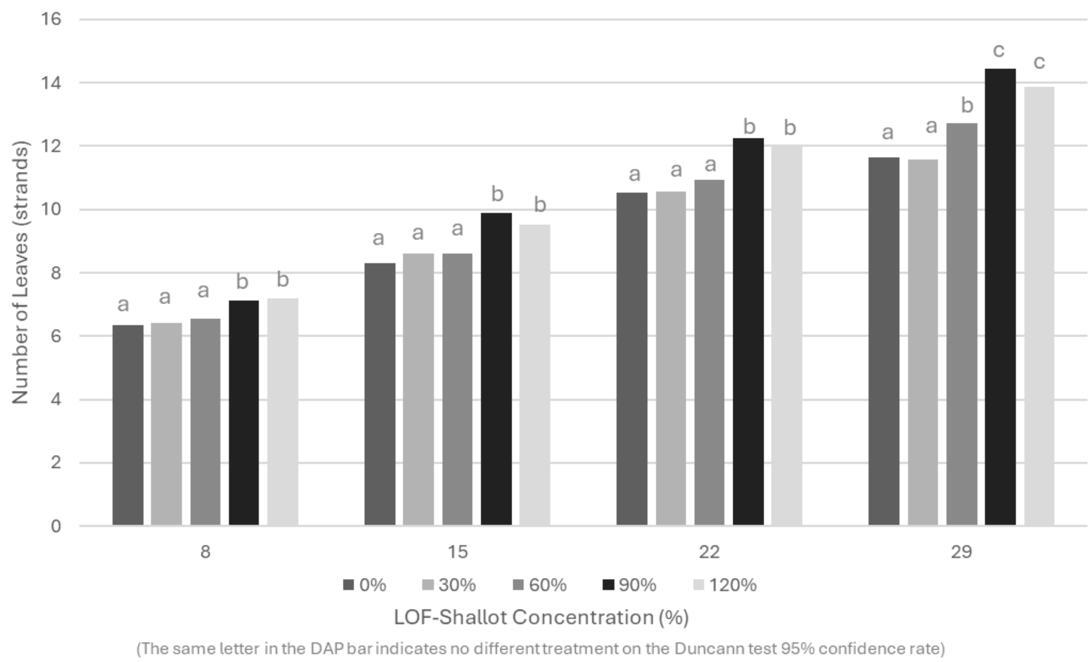


Figure 4. The number total of red lettuce leaves at the observation day to 8, 15, 22, 29 DAP

Statistical analysis showed that the plant biomass at harvest was significantly affected by LOF concentration (Table 3). The results were consistent with plant growth: 90% and 120% of LOF resulted in higher shoot and root fresh weight. Shoot weight is a more essential trait than root weight, since it is the edible and economic part of lettuce. In this field experiment, shoot weight increased by approximately 10% after 90% and 120% LOF application. The root biomass increase at higher LOF concentrations suggests that LOF contained phytohormones excreted by *Azotobacter* and *Bacillus* (Cheng et al., 2017). Nonetheless, further research is required to study the phytohormone composition in LOF. Figure 5 shows that the largest lettuce shoot was in plants with after 90% and 120% of LOF. It is suggested that 90% of LOF is sufficient to boost the yield. Visually, plants treated with any concentration of LOF have dark red in color compared to the control. This shows that excessive concentration of LOF (120%) can be toxic to plants.

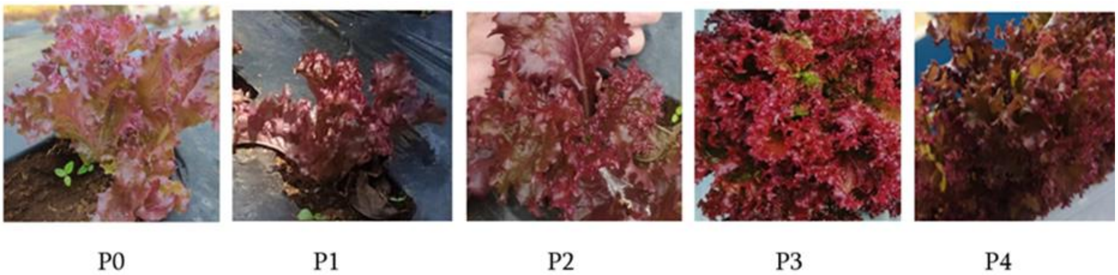


Figure 5. Morphology of red lettuce shoots with and without LOF-shallot treatment at 29 DAP (P0 = 0%, P1 = 30%, P2 = 60%, P3 = 90%, and P4 = 120%)

During the experiment, the inorganic fertilizer was not applied to all treatments. Indeed, plants uptake nutrients from soil, chicken manure, and LOF for treated plants. The manure contained N, P, and K, and additional LOF will provide more nutrients. Thus, LOF-Shallot increased lettuce growth and yield by enhancing nutrient availability, as the microbes in LOF-Shallot significantly supplied N, P, and phytohormones.

Vegetative growth of all leafy vegetables is determined mainly by total N and its availability in soil. LOF-Shallot contained 0.12% N, and at the 120% rate, LOF-Shallot contained more N, so lettuce growth and yield increased after LOF-Shallot treatment. Nitrogen is essential for protein synthesis, cell division, and the development of cells and tissues (Kamer & Khatab, 2021). Phosphorus is an important nutrient in regulating physiological responses and providing energy (Lambers, 2022) and anthocyanin pigment synthesis (Jyothi et al., 2022). The anthocyanin pigment involved in red lettuce development during this study is believed to result from the dissolution of organic phosphorus (P), a process facilitated by the enzyme flavonone-3-hydroxylase during mineralization (Jyothi et al., 2022).

Research on vegetable crops, especially leafy vegetables, generally indicates a need for relatively high P, as P helps roots absorb nutrients and water, activate vegetative growth, and improve yield quality (Jyothi et al., 2022). Fitriatin et al. (2025) reported that the addition of 3 t ha^{-1} of bioameliorants increased available P. This experiment, the addition of LOF-Shallot at 120% concentration was able to increase the available P levels, that’s available soil P it still at a low level. According to Raimi et al. (2017) the effectiveness of phosphate-solubilizing bacteria depends on the soil's buffer capacity and the carbon and nitrogen sources contained therein.

The results of the experiment align with the growth and yield increases observed for red lettuce grown in polybags in greenhouses following specific LOF application (Supyandi & Rahmi, 2023), even though productivity remains below its genetic potential. The high levels of Zn in LOF-Shallot, which may enhance lettuce growth, are consistent with the positive effects of a high Zn dose on the number of leaves, seeds, and seed weight per plant in mung bean (Indriyani et al., 2021).

Despite the higher shoot and root biomass of plants treated with 90% and 120% LOF (Table 3), 60% LOF has already significantly improved both parameters compared to the control. The high LOF-Shallot concentration was required for red lettuce because the soil had previously had low P_2O_5 (1.08 ppm) and K_2O (12.92 ppm). After the experiment, soil treated with 120% LOF (P4) showed increases in available P and total N, which were 0.02% and 0.09% higher than before the experiment, respectively**.** The pH in that soil increased to 6.7, indicating a 0.4-unit increase compared to before treatment. It is suggested that LOF-Shallot waste has a direct positive effect on improving N and P status, and acidity that fits with the plant requirement.

Based on data in Table 3, the predicted productivity of red lettuce received 90 and 120% LOF ranges from 4.1 t ha^{-1} to 4.2 t ha^{-1}. This yield is in line with the productivity of leafy vegetables of the mustard family, namely 4.1 t ha^{-1} with standard cultivation techniques inorganic fertilizwer in Bandung Regency (Basis Data Statistik Pertanian Prov Jawa Barat, 2024). The results of this study support previous scientific reports that the use of microbes through the application of liquid organic fertilizer can reduce dependence on chemical fertilizers and serve as an environmentally-friendly method (Arora & Mishra, 2016; Hindersah et al., 2020; Nosheen et al., 2021).

In the current experiment, chicken manure amendment to Regosol soil with low N, P, and K can provide a slight increase in nutrient levels and improve soil physical properties. Moreover, organic matter enhanced the proliferation of heterotrophic beneficial microbes, including *Azotobacter*, *Bacillus*, and P-solubilizer bacteria supplied by LOF. Low N and P soil levels boost *Azotobacter* to fix N and *Bacillus* to solubilize P, providing both nutrients for lettuce. The impact of organic fertilizer in this experiment aligns with the report by Kamer & Khatab (2021) which found increased mustard greens (*Spinacia oleracea* L.) yield after organic matter amendment alongside reduced chemical fertilizer use. So, a high dose of LOF is needed for better plant growth and yield. The way to reduce LOF concentration is to improve the LOF production process to achieve better quality. It includes mixing the shallot substrate with lower-C/N organic matter or manure, inoculating with decomposer microbes, and extending the fermentation duration. Moreover, the LOF-Shallot field experiment in different leafy vegetables will demonstrate its global effectiveness in increasing vegetable production.

CONCLUSION

1. The presence of macro- and micronutrients and beneficial microbes showed that the LOF-Shallot was the appropriate source of nutrients for crop cultivation. The detected nutrient characteristics of LOF-Shallot are N 0.12%, P 0.16%, K 0.07%, Cu 2.14 ppm, Fe 151.77 ppm, and Zn 492.48 ppm. The

microbial population in LOF-Shallot ranges from 10^7-10^8 CFU mL^{-1} including phosphate-solubilizing bacteria, Nitrogen-fixing *Azotobacter* sp., and *Bacillus* sp., while there are only 10^2 CFU mL^{-1} of fungi.
2. The field experiment showed that the growth and yield of red lettuce plants of the Arista variety were enhanced after treatment with LOF-Shallot at concentrations of 60, 90, and 120%. However, the yield differences between the 60 and 90% treatments were 5.7%, while those between 90 and 120% were 3.7%.

Further research suggests using a 90% LOF-Shallot concentration. It is recommended to make a LOF-Shallot formulation by adding organic materials containing high N, for example cow manure or legume waste.

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