



Production of Liquid Organic Fertilizer using Shallot Peels through EM4-assisted Fermentation

Difaa Ali Subhan Abdurrazaq¹, Rizky Fahmi Nugraha²

¹ Department of Agriculture, Faculty of Postgraduate, Universitas Swadaya Gunung Jati, Indonesia

² Department of Agriculture, Faculty of Postgraduate, Universitas Swadaya Gunung Jati, Indonesia

Corresponding Author: Difaa Ali Subhan Abdurrazaq E-mail: difaaali123@gmail.com.

| ABSTRACT

Shallot peels represent a common household organic waste that contains many useful compounds for liquid plant fertilizer by producing a liquid organic fertilizer derived from shallot peels, based on the composition given by Istigfarin and Abror [8]. The liquid fertilizer is prepared using 500 grams of shallot peels, 25 mL of EM4 as a microbial starter, and 34 grams of sugar as a fermentation substrate. The mixture is then fermented for 14–28 days to allow microbial decomposition and nutrient release. The resulting liquid fertilizer, when applied at an optimal concentration, can improve plant growth performance. Ernis et al. [5] have also shown that shallot peel fertilizer contains N, P, K, and organic C elements, as well as micronutrients such as Fe, Mn, and Cu in trace amounts.

| KEYWORDS

EM4, fermentation, liquid organic fertilizer, plant growth, shallot peel

I. INTRODUCTION

Sustainable agriculture in developing countries increasingly emphasizes the utilization of locally available resources, including household organic waste, as an alternative input to reduce dependency on synthetic fertilizers and enhance environmental sustainability. Fertilizers are a way for farmers to increase the fertility and health of the soil and help provide more nutrients for crop growth [12]. Fertilizers can take form as organic fertilizer made from organic material such as compost, or anorganic materials from chemical manufacture. However, organic fertilizer has several advantages compared to anorganic fertilizers, namely being safer to use long term, easy and cheap to produce, and can improve soil quality better than its anorganic counterparts [1]. The application of organic fertilizers derived from household waste has also been reported to be effective in improving plant growth while simultaneously contributing to waste reduction and soil health improvement [4]. Among various organic fertilizer forms, liquid organic fertilizer (POC) is considered highly promising due to its ease of application, rapid nutrient availability, and ability to stimulate soil microbial activity.

The use of Effective Microorganisms-4 (EM4) in the fermentation process has been widely reported to accelerate organic matter decomposition and enhance nutrient solubility, thereby improving fertilizer quality. Fermentation duration and raw material composition play a crucial role in determining the nutrient content, particularly nitrogen (N), phosphorus (P), and potassium (K), of the resulting liquid organic fertilizer [11].

Shallot peels represent a commonly generated household waste with considerable potential as a raw material for liquid organic fertilizer. Chemically, shallot peels contain essential nutrients such as potassium (K), phosphorus (P), magnesium (Mg), and iron (Fe), along with bioactive compounds including allicin [3][7]. Previous studies have demonstrated that liquid organic fertilizer derived from shallot peels can significantly enhance the growth of cayenne pepper plants, with an optimal application concentration of 1.5% [7].

Therefore, it can be hypothesized that shallot peels are viable as the main ingredient of an organic fertilizer that is a sustainable alternative for farmers. This study aims to investigate the fermentation process of shallot peels using EM4, evaluate the nutrient content of the fermented liquid organic fertilizer, and assess its agronomic potential as an environmentally friendly, cost-effective, and practical fertilizer alternative for farmers.

II. METHODOLOGY

This experiment was conducted using a one-factor randomized block design (RAK) to evaluate the effect of various concentrations of liquid organic fertilizer (POC) from shallot skins on chili plant growth. The treatments consisted of seven concentration levels, namely P1 (0.5%), P2 (1%), P3 (1.5%), P4 (2%), P5 (2.5%), P6 (3%), and P7 (3.5%), each diluted in 1 liter of water with the appropriate volume of POC (ranging from 5 ml to 35 ml). Each treatment was repeated three times, resulting in a total of 21 experimental units. POC was prepared using a formulation namely 500 grams of shallot peel, 25 mL of EM4, and 34 grams of sugar as a fermentation substrate, which were mixed in a fermentation container and water was added until all the ingredients were submerged [8]. The mixture was fermented for 14 to 28 days under closed conditions, with stirring on the seventh day to stimulate microbial activity, then filtered to obtain a ready-to-use POC solution.

The growing medium was prepared by mixing topsoil and manure, which was then placed in 25 × 25 cm polybags. Two-week-old chili seedlings were planted in each polybag and used as research sample units. POC application was carried out according to the treatment concentration, where the stock solution was diluted in one liter of water, then applied through a drip method to the root zone with a uniform volume between experimental units. Plant growth observations were carried out periodically on sample plants, including plant height, number of leaves, and other growth indicators according to research needs. The data were analyzed using analysis of variance (ANOVA) based on RAK, and if there was a significant treatment effect, the test was continued with an appropriate discriminant test to find the POC concentration that provided the best growth response.

III. RESULTS AND DISCUSSION

The two papers we have reviewed as the basis of this article provide some useful results. Provided the results of an application of shallot peel LOF on *Capsicum frutescens*' height, root length, leaf count, and wet weight [8][5]. Provided the macro- and micro-nutrient analysis of a shallot peel LOF at different concentrations. Plant height, root length, leaf count, and wet weight represents the fertilizer's effectiveness in aiding plant growth whereas the micro nutrient analysis is used as secondary data to compare the fertilizer's nutrients to the existing standards set [10].

Treatment	Plant Height (cm)					
	11 days	18 days	32 days	39 days	53 days	74 days
P1	11.76	14.56	19.13	23.20 a	28.56 a	54.36 b
P2	9.73	11.60	16.80	21.93 a	25.63 a	36.36 a
P3	10.50	16.10	23.00	25.93 a	30.86 a	48.83ab
P4	11.70	15.86	21.60	27.50 a	31.80 a	41.06ab
P5	10.83	12.56	17.60	21.46 a	24.30 a	42.60ab
P6	11.83	14.53	19.63	23.36 a	25.63 a	51.00ab
P7	11.60	14.20	19.16	23.16 a	26.83 a	45.80ab
HSD	NA	NA	NA	13,61	14,01	16,42

AVERAGES OF SHALLOT PEEL LOF TREATMENT EFFECT ON CAPSICUM FRUTESCENS HEIGHT

Based on the data obtained by Istigfarin and Abror [8], the treatment that produced the greatest plant height was treatment 1 with a dosage of 5 mL/L, resulting in an average final plant height of 54.36 cm. In contrast, the shortest plant height was recorded in treatment 2 with a concentration of 10 mL/L, which resulted in an average final plant height of 36.36 cm.

CAPSICUM FRUTESCENS ROOT LENGTH AT 74 DAYS AFTER PLANTING

Treatment	Root Length (cm)
P1	36.4 b
P2	27.3 ab
P3	37.4 b
P4	23.53 ab
P5	19.6 ab
P6	17.3 a
P7	23.3 ab
HSD 5%	17.99

The root-length data show that treatment P3, with a fertilizer concentration of 15 mL/L, produced the greatest root growth in *Capsicum frutescens*, resulting in an average root length of 37.4 cm at 74 days after planting.

AVERAGES OF SHALLOT PEEL LOF TREATMENT EFFECT ON CAPSICUM FRUTESCENS LEAF COUNT

Treatment	Leaf Count							
	11 days	18 days	25 days	32 days	39 days	46 days	53 days	74 days
P1	5.66	6.33	13.00	11.00	16.33	16.66 ab	19.33 a	90.66 a
P2	6.00	6.00	8.00	13.66	12.00	16.33 ab	25.00 a	54.00 a
P3	5.33	7.33	16.66	9.66	18.66	28.66 b	24.33 a	82.33 a
P4	5.66	7.66	11.00	13.00	19.66	22.66ab	23.33 a	57.66 a
P5	5.00	5.33	11.00	9.00	12.00	11.33 a	14.33 a	48.33 a
P6	6.33	7.00	9.00	12.00	12.33	14.66 ab	19.33 a	94.66 a
P7	6.00	6.33	11.00	12.33	17.00	11.33 a	11.66 a	77.66 a
HSD	NA	NA	NA	NA	NA	17.09	13.52	53.12

The leaf-count data show that there are differences in the number of leaves produced by chili plants across all treatments. Among the seven concentrations of shallot-peel LOF tested, the highest number of leaves was obtained in treatment 6 with a dosage of 30 mL/L, resulting in an average of 94.66 leaves. In contrast, the lowest leaf count was recorded in treatment 5 with a dosage of 25 mL/L, which produced an average of 48.33 leaves.

AVERAGES OF SHALLOT PEEL LOF TREATMENT EFFECT ON CAPSICUM FRUTESCENS WET WEIGHT

Treatment	Wet Weight at 74 Days after Planting (g)
P1	6.26 a
P2	13.90 a
P3	12.30 a
P4	5.26 a
P5	9.60 a
P6	13.06 a
P7	22.73 a
HSD 5%	NA

The wet-weight data show that there are variations in the wet weight of chili plants across all treatments. Among the seven concentrations of shallot-peel LOF tested, the highest plant wet weight was obtained in treatment 7 with

a dosage of 35 mL/L, resulting in a final plant weight of 42.93 g. In contrast, the lowest wet weight was recorded in the treatment using a 20 mL/L dosage.

The data obtained confirm that liquid organic fertilizer derived from shallot peels can enhance plant growth in terms of height, root length, leaf number, and wet biomass [8]. These findings are consistent with the results, who used a similar shallot-peel-based liquid fertilizer and observed improved growth in red lettuce (*Lactuca sativa*) [14]. Also found that a similar liquid fertilizer made using onion juice concentrate, derived from the same species as shallots (*Allium cepa*), can increase the yield of bok choy, lettuce, and radish [15].

However, further research is required to optimize the concentration of LOF during the fermentation process. Not all plants have the same optimal fertilizer concentration, and each fertilizer composition may produce different outcomes. In the study, shallot-peel LOF was tested at concentrations ranging from 0.5% to 3.5% per liter of water. They found that a concentration of 1.5% was the most effective for promoting the growth of *Capsicum frutescens* [8]. This indicates that higher concentrations of LOF do not necessarily yield the best plant growth.

Organic fertilizers also offer environmental benefits compared to inorganic fertilizers, particularly when used continuously [10]. Moreover, liquid organic fertilizer produced from household waste—such as shallot peels—can help reduce the problem of waste accumulation while providing added value to everyday organic waste [6].

SHALLOT PEEL LOF MACRO- AND MICRO-NUTRIENTS ANALYSIS

No	EM4 Concentration (ml)	Macronutrients (%)				Micronutrients (mg/L)		
		N	P	K	Organic C	Fe	Mn	Cu
1	0	0,11	0,07	0,03	0,4	0,02	0,0002	0,004
2	25	0,16	1,44	0,22	2,46	0,02	0,0012	0,0041
3	50	0,27	1,39	0,31	2,64	0,02	0,0014	0,0049
4	100	0,71	1,45	0,36	4,7	0,037	0,0052	0,198

Shows that liquid organic fertilizer made from shallot peels and fermented using 100 mL of EM4 contains macronutrients that meet the standards set [5][2], except for organic C content, which remains below the required standard (9.8%). In terms of micronutrients, the shallot peel liquid fertilizer also meets the applicable standards.

Napitupulu and Winarto [9] state that N, P, and K each play specific roles in plant growth. Nitrogen (N) can stimulate the growth of leaves, stems, and roots, and its deficiency may lead to chlorosis and stunted growth. Phosphorus (P) supports flowering, tuber formation, and seedling root development, especially in short-life-cycle plants. Potassium (K) functions as an enzyme activator and enhances plant resistance to diseases. Micronutrients such as Fe, Mn, and Cu serve as essential cofactors for various plant processes [13].

IV. CONCLUSION

This study demonstrates that liquid organic fertilizer (LOF) derived from shallot peels and fermented with EM4 has significant potential to enhance plant growth performance. The findings compiled from previous studies indicate that shallot peel LOF can improve plant height, leaf count, root length, and biomass when applied at appropriate concentrations. Among the tested treatments, a concentration of 1.5% (15 mL/L) showed the most consistent positive effect on *Capsicum frutescens*, emphasizing that optimal nutrient availability does not always correlate with higher fertilizer concentration.

Nutrient analysis confirms that shallot peel LOF contains essential macronutrients (N, P, K) and micronutrients (Fe, Mn, Cu), meeting most of the standards set by SNI 19-7030-2004, although its organic C content remains below the required threshold. These results highlight the agronomic value of household organic waste as an environmentally friendly and economically feasible input for sustainable agriculture.

However, the research still presents limitations, particularly regarding the narrow concentration range tested and the absence of direct nutrient analysis in the current experimental setup. Future studies should explore a wider concentration range, analyze the chemical properties of the produced LOF, and apply the fertilizer to multiple crop species to determine broader applicability. Furthermore, optimization of fermentation conditions and the use of different bioactivators may reveal potential improvements in nutrient quality and plant response.

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