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Research article

Characteristics of Liquid Organic Fertilizer Made from Milkfish Viscera (*Chanos chanos Forsskal*) at Differents Long Time Fermentation

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Abstract

Fish viscera contains nutrients consisting of protein, lipid, and minerals that can be used to stimulate plant growth. Milkfish visceral waste is one type of material that can be used as organic fertilizer. The aim of this research was determining the effect of different fermentation times on the liquid organic fertilizer derived from milkfish viscera waste on the growth rate of purple eggplant (*Solanum melongena*). Samples of milkfish viscera were reduced in size using a blender. The milkfish viscera were cooked to a temperature of 100°C was done to sterilize microbes. Homogenization was also carried out with the addition of water (1:2), 5% molasses, and *Trichoderma* sp. at a concentration of 100 g/L. The fermentation process was conducted for 7 days, 10 days, 13 days, and 16 days, respectively. ANOVA analysis and Tukey's test revealed that different fermentation durations resulted in significant differences in pH, yield, c-organic, nitrogen, potassium, plant wet weight, root length, plant height, number of leaves, leaf width and stem diameter but did not significantly differ in phosphorus. A duration of 16 days yielded the highest values for pH (5.80), c-organic (4.46%), nitrogen (0.34%), phosphorus (0.06%), potassium (0.59%), plant wet weight (58.67 grams), root length (36.50 cm), plant height (25.67 cm), number of leaves (10.00), leaf width (15.07 cm), and stem diameter (8 .00 mm).

Keywords: Eggplant, liquid organic fertilizer, milkfish viscera, *Trichoderma* sp.

1. Introduction

The development of the fishing industry is currently increasing rapidly because it is supported by the large potential of fisheries resources in Indonesia. In the fish processing industry and household use of fish, many parts of the fish are discarded, such as the head, tail fins, bones, and viscera, which ultimately causes waste. According to data from the Ministry of Maritime Affairs and Fisheries in 2019, Indonesian fisheries production resulted in 30%–40% waste, or up to 8.6 million tons, and around 2 million tons of this waste is discarded as unused waste [1]. Because the potential for fish waste is very large, it can lead to a decline in environmental quality since it can cause foul odors and disturb the environment.

Soft-boned milkfish is a famous traditional food icon from Semarang, Central Java, Indonesia. Based on data from the Semarang City Central Statistics Agency in 2019, the amount of processed milkfish products in the city of Semarang reached 3,000 tons per year [2]. The increasing production of soft-boned milkfish results in more milkfish viscera waste being produced. So far, milkfish viscera have not been utilized optimally, even though fish viscera have quite high nutritional contents, such as ash (0.24%), fat (20.40%), and protein

(14.89%) [3]. Hence, milkfish viscera have the potential to be used as liquid organic fertilizer [4]. Furthermore, fish waste contains many nutrients, namely N (nitrogen), P (phosphorus), and K (potassium), which are components of liquid organic fertilizer [5].

Liquid organic fertilizer is a solution obtained from the decomposition of organic materials. The Central Bureau of Statistics (BPS) Agricultural Census 2019 reported that the pattern of fertilizer use by rice farmers in Indonesia is almost dominated by inorganic fertilizers. Farmers who use inorganic fertilizers account for 86.41%, while those who use balanced fertilizers (organic and inorganic) account for 13.5%, and those who utilize organic fertilizers account for only 0.07% [6]. Excessive use of inorganic fertilizers can kill various living organisms, including microbes that are very beneficial for improving soil fertility, and can cause the extinction of animal populations that are predators of insect pests [7]. Agricultural technology that guarantees food safety is organic agricultural technology, namely the use of technology derived from nature, such as the use of liquid organic fertilizer. Based on Muhammad and Madaniyah (2015), the use of organic fertilizer produces fresh vegetable products that can increase plant resistance while ensuring that the products are safe for consumer consumption [8].

The liquid organic fertilizer fermentation process is generally carried out for 30 days [9]. The long fermentation time can be accelerated by using Trichoderma sp. as a bioactivator and by providing molasses as a source of nutrition. Trichoderma sp. is a group of fungi that plays a role as a decomposer of organic material in the production of liquid organic fertilizer [10]. Apart from being a decomposer, Trichoderma sp. also has the ability to protect plants from attacks by soil-borne pathogens and to enhance plant growth [11]. Various organic compounds in liquid organic fertilizer produced by Trichoderma sp. play a role in stimulating growth, accelerating the flowering process, increasing the biosynthesis of biochemical compounds, inhibiting pathogens, and increasing the production of secondary metabolite compounds [12]. The aim of this research was to determine the effect of different fermentation times of liquid organic fertilizer made from milkfish viscera waste on the growth rate of purple eggplant (*Solanum melongena*).

2. Materials and Methods

2.1 Raw Material Preparation

The fresh viscera (without a rotten odor) were cleaned of blood and dirt attached to the fish stomach by washing the fish viscera, then the fish viscera were mashed using a blender [4]. After mashing, the fish viscera were cooked at a temperature of 100 °C to sterilize the microbes contained in them. After the fish viscera had cooled, water was added at a ratio of fish viscera to water of 2:1 until a uniform slurry was formed. The purpose of adding water to the fish viscera was to produce organic fertilizer with a normal pH level.

2.2 Microbial Preparation

Solated mold Trichoderma sp. Was cultured on Potato Dextrose Agar (PDA) media dissolved with aquadest. The media was then heated on a hot plate until it boiled and then poured into a petri dish. The tools and media used were sterilized using an autoclave at 121°C with a pressure of 1 atm for 15 minutes. After sterilized the Trichoderma sp. was inoculated into the PDA medium for 7 days. The culture of Trichoderma sp. reactivated with solid media, namely 100 grams of ground corn. The material of ground corn that has been given Trichoderma sp culture. Left for 7 days for the fungal growth process [13].

2.3 Process for Making Liquid Organic Fertilizer

The viscera slurry already obtained in liquid form was homogenized by adding 5% molasses and Trichoderma sp. at 100 g/L. The fertilizer formulation was placed into jerry cans for the fermentation process. The processing was carried out aerobically with a closed circulation system using an aerator. Closed circulation was implemented to prevent contamination by pathogenic bacteria from the open air. The fermentation duration of the liquid organic fertilizer was based on the treatments in this research, namely 7 days (A), 10 days (B), 13 days (C), and 16 days (D).

Tests on the growth rate of purple eggplant (Solanum melongena)—including plant wet weight, root length, plant height, number of leaves, leaf width, and stem diameter—were conducted at the plantation land of the Agricultural Technology Research Institute, Central Java.

The materials used in this research included milkfish viscera obtained from UD. Putri Laut, Semarang City, Central Java; Trichoderma sp. fungal isolates in slanted agar form obtained from BPTPHP (Food Crop Protection, Horticulture, and Plantation Center) Ungaran, Central Java; and liquid molasses obtained from Bu Maya Flower Shop, Semarang City, Central Java.

The equipment used consisted of a destructor (Pyrex, Indonesia), distillator (Pyrex, Indonesia), set of distillation tubes (Pyrex, Indonesia), visible spectrophotometer (Spectrophotometer 721, China), flame photometer (Shimadzu, Japan), pH meter (TDS-3, China), autoclave (GEA 18L, Indonesia), and incubator (Memmert, Germany)..

2.4 pH

The pH test procedure was carried out using a pH meter [14]. Liquid samples were measured with the pH meter, which had been previously calibrated using buffer solutions with pH 4.0 and pH 7.0. The pH value was recorded after the scale needle reached a constant position.

2.5 Yield

The yield of liquid organic fertilizer was determined by calculating the ratio of the final weight (B) of the product produced to the initial weight of the material used (A). The resulting yield value indicates the effectiveness of the fermentation process or the decomposition of organic material in the liquid organic fertilizer. The yield of liquid organic fertilizer was calculated using the following formula:

$$\text{Yield} = B/A \times 100\%$$

2.6 C- Organic

The test procedure refers to the Walkley and Black method [16], in which the sample was digested using 1 $NK_3Cr_2O_7$ and concentrated H_2SO_4, then diluted with distilled water. The digested and diluted sample was then cooled, and after cooling, the volume was adjusted exactly to the 100 ml mark. The next step was measuring the sample using a spectrophotometer at a wavelength of 561 nm. The calculation of the C-organic concentration of the liquid organic fertilizer is as follows:

C-Organic content (%) = ppm curve x 100/mg sample x 100ml/1000ml x correction factor

2.7 Nitrogen

Nitrogen testing was carried out through digestion, distillation, and titration. The organic N and $N\text{-}NH_4$ contained in the sample were digested with a mixture of sulfuric acid and selenium to form ammonium sulfate, then distilled by adding excess base, and finally the distillate was titrated. Nitrogen in the form of nitrate was extracted with water, then reduced using Devarda's alloy, distilled, and finally titrated.

2.8 Phosphorus

The P_2O_5 was carried out using concentrated HNO_3 and concentrated HClO heated at high temperatures. The clear extract was taken and added with distilled water, 2N HNO_3 and Vanadate solution then left for 30 minutes and observed on a spectrophotometer at a wavelength of 650 nm, where

$$77 = (a + bx) \times \text{dilution}$$

$$P_2O_5\ (\%) = P \times 2.2914 \text{ where}$$

a = mL of titrant examples and blanks, bx = normality solution standard HNO_3

a = weight equivalent Phosphor, 2.2914 = conversion to %

2.9 Potassium

Potassium concentration measurements were carried out based on the Flamephotometry method [16]. K_2O measurements were carried out using concentrated HNO_3 and concentrated HClO heated at high temperatures. Then the clear extract was taken and added with distilled water, HNO_3 2N, vanadate solution, then observed on a flamephotometer and compared with the standard solution (0; 5; 10; 15; 20 ppm).

K (%) = ppm curve x ml 1000 mL extract −1 x 100 mg sample −1 x dilution factor x correction factor

2.10 Planting and Fertilizing

Seedlings plant eggplant purple (*Solanum melongena*) which has obtained from Plant Depot Decorate SAE Agrofarm moved to in panting media polybag. The planting media used was husk rice and land with ratio 1:1. Planting media mixture was three of the four fully entered into the poly bag with size 30 cm x 30 cm. Planting done with method put seeds eggplant purple to part middle poly bag with amount one plants on each poly bag. The fertilization process is done with method give fertilizer organic liquid from waste milkfish viscera in each treatment with method watering at the roots. Before application to plants, liquid organic fertilizer is diluted 10 times first. Liquid organic fertilizer was sprinkled on purple eggplant plants every 2 days in the afternoon for 1 month to see the effectiveness of the liquid organic fertilizer. Based on Maryani et al. [16], liquid organic fertilizer can be obtained in approximately 10-15 days of fermentation. Liquid organic fertilizer can be transferred to a prepared container, then water is added in a ratio of 1:10. Liquid organic fertilizer ready used as fertilizer.

2.11 Test the Growth Rate of Purple Eggplant Plants

Gross weight plants were counted with method weigh plants (grams) without through a drying process moreover formerly [17, 18]. Root length (cm) was done by cleaning the plant roots from adhering dirt and then measuring the length using a ruler from the base of the root to the tip of the root. Plant height (cm) was measured using a ruler from the base of the stem to the tip of the leaf starting at 7 days, 14 days, 21 days, and 28 days. The number of leaves (strands) was carried out at the same time as the plant height, namely 7 days, 14 days, 21 days and 28 days. Leaf width (cm) was measured using a ruler on all plants from side to side on the widest leaf following the radius of the leaf segments starting at 7 days, 14 days, 21 days and 28 days. The stem diameter (mm) was measured with use period shove starting 7 days, 14 days, 21 days, and 28 days.

3. Results and discussion

3.1 Nutrient Content

Based on the pH test results of liquid organic fertilizer in Table 1, It was observed that the longer the fermentation process, the more the pH value will increase. The pH value in this research is in accordance with the requirements for liquid organic fertilizer from the Decree of the Minister of Agriculture of the Republic of Indonesia number 261/KPTS/SR.310/M/4/2019 concerning Minimum Technical Requirements for Organic Fertilizers, Biological Fertilizers and Soil Improvements which states that the standard pH value in Liquid Organic Fertilizer between 4-9.

The pH value decreases at the beginning of the process due to the decomposition of organic materials due to microbial activity which produces organic acids. However, during processing time, the increasing in the pH value will occur due to the activity of microorganisms in decomposition which provide input of OH ions from the process of decomposing organic materia

Table 1. Nutrient Content of Liquid Organic Fertilizer from Milkfish Viscera

No.	Treatment	pH	Yield (%)	C-Organik (%)	Nitrogen (%)	C/N Ratio	Phosphor (%)	Potassium (%)
1.	A	$4,05 \pm 0,05^a$	$88,44 \pm 1,68^d$	$4,46 \pm 0,27^d$	$0,24 \pm 0,01^a$	$18,33 \pm 0,98^a$	$0,06 \pm 0,01^a$	$0,14 \pm 0,01^a$
2.	B	$4,65 \pm 0,17^b$	$85,78 \pm 0,77^c$	$3,57 \pm 0,22^c$	$0,28 \pm 0,01^b$	$12,61 \pm 1,15^b$	$0,06 \pm 0,01^a$	$0,16 \pm 0,01^b$
3.	C	$5,26 \pm 0,04^c$	$82,44 \pm 0,77^b$	$2,32 \pm 0,23^b$	$0,31 \pm 0,01^b$	$7,59 \pm 0,97^c$	$0,06 \pm 0,00^a$	$0,18 \pm 0,01^c$
4.	D	$5,80 \pm 0,16^d$	$77,33 \pm 1,15^a$	$1,34 \pm 0,18^a$	$0,34 \pm 0,01^c$	$3,90 \pm 0,57^d$	$0,06 \pm 0,00^a$	$0,20 \pm 0,01^d$

Note: Data are mean of three replicates ± standard deviation. Data followed by different superscript letters at the same column indicates significant differences. A = 7 days fermentation liquid organic fertilizer; B = 10 days fermentation liquid organic fertilizer; C = 13 days fermentation liquid organic fertilizer; D = 16 days fermentation liquid organic fertilizer.

The results of the process of decomposing organic material by microorganisms produce OH ions, which show an increase, in turn increasing the pH value of the liquid organic fertilizer [19, 20]. In the next process, microorganisms convert the organic acids that have been formed so that the material has a high pH and is close to neutral. The pH value of mature fertilizer will be close to neutral.

The yield test on liquid organic fertilizer from milkfish viscera waste in Table 1 shows that the longer the fermentation, the lower the yield value. The success of the fermentation process is influenced by the type of microorganism, the sugar used, and the length of fermentation [21]. The fertilizer in this study used molasses, which is produced in the sugar crystallization process. The nutritional content of molasses is mostly sugar, along with amino acids and minerals. The fermentation process produces alcohol and gas [22]. The longer the fermentation process, the higher the alcohol and gas produced, thereby reducing the yield of fertilizer. However, the decomposition process in this study went well because the results show high yield due to the role of Trichoderma sp. in decomposing organic materials during fermentation. The yield was higher than organic liquid fertilizer made from fish waste with EM4 biocatalyst addition at 33% [23], and higher than fertilizer made from Sargassum sp. with protease enzyme addition (44.19–65.83%) [24].

The C-organic content of liquid organic fertilizer decreases with longer fermentation. The C-organic content of liquid organic fertilizer from milkfish viscera waste does not meet SNI 19-7030-2004, which requires a minimum C-organic content of 9.8%. The lower yield is due to Trichoderma sp. using carbon as an energy source, reducing C-organic content. Longer fermentation increases microbial growth, consuming more carbon for metabolism, growth, and reproduction [25, 26]. During composting, carbon also decreases via CO_2 loss [25].

Nitrogen content in liquid organic fertilizer increases with fermentation time. However, the nitrogen content from milkfish viscera waste does not meet SNI 19-7030-2004 (minimum 0.40%). Low nitrogen at the start is due to Trichoderma sp. being in the adaptation phase, metabolizing carbon for growth. Nitrogen levels initially decrease as microorganisms use it for growth, and due to protein breakdown [25]. Later, nitrogen increases as microbial biomass stabilizes [26, 27].

The C/N ratio reflects nutrient balance. The low C/N ratio in 16-day fermented fertilizer indicates complete degradation by Trichoderma sp. Longer fermentation lowers carbon content and increases nitrogen, reducing the C/N ratio [27].

Phosphorus levels do not meet SNI 19-7030-2004 (minimum 0.10%), likely due to low total nitrogen in the material. Higher nitrogen promotes phosphorus breakdown, increasing phosphorus content over time [28]. Potassium levels, however, increase with fermentation and meet SNI 19-7030-2004 (minimum 0.20%). Potassium release is driven by microbial metabolism, cation exchange, and decomposition of organic matter [27].

3.2 Growth rate of purple eggplant plants

The results of the research showed for the age of 1 week, the height of the purple eggplant plants did not show a significant difference compared to the age of 2 weeks to 4 weeks since in the first week the plants are not yet optimal in absorbing the nutrients in liquid organic fertilizer.

Differences in plant height can be seen from the treatment of applying liquid organic fertilizer at different long time fermentation processes because liquid organic fertilizer is able to supply the nutrient needs of purple eggplant plants. The quality of life of plants is very dependent on the adequacy of nutrients from the environment, both nutrients from the soil or additional nutrients in the form of liquid organic fertilizer and the ability of the roots to absorb nutrients to support the vegetative phase of the plant such as plant height. Based on Syahputra and Elfis [29], applying fertilizer to purple eggplant plants optimally can influence the cell division process and cause a good increase in plant height, especially nitrogen which plays an important role in the photosynthesis.

Table 2. Growth Rate of Purple Eggplant Plants

Parameter	Treatment	Week (Mean ± SD)			
		1	2	3	4
Plant Height	K	9,00 ± 0,50A,a	10,17 ± 0,29B,a	14,03 ± 0,25C,a	17,27 ± 0,25D,a
	A	10,00 ± 0,00A,ab	11,83 ± 0,29B,b	17,17 ± 0,76C,b	21,17 ± 0,76D,b
	B	10,33 ± 0,58A,ab	12,83 ± 0,29B,bc	18,67 ± 0,58C,c	23,17 ± 0,29D,c
	C	10,67 ± 0,58A,b	14,17 ± 0,29B,c	19,83 ± 0,29C,cd	24,33 ± 0,58D,cd
	D	11,33 ± 0.58A,b	16,00 ± 1,00B,d	21,00 ± 0,50C,d	25,67 ± 0,76D,d
Number of Leaves	K	5,00 ± 0,00A,a	6,00 ± 0,00B,a	6,33 ± 0,58BC,a	7,00 ± 0,00C,a
	A	6,00 ± 0,00A,b	6,00 ± 0,00A,a	7,33 ± 0,58B,ab	8,00 ± 0,00B,b
	B	6,33 ± 0,58A,bc	6,67 ± 0,58A,ab	7,67 ± 0,58AB,ab	8,33 ± 0,58B,b
	C	7,00 ± 0,00A,c	7,00 ± 0,00A,b	8,00 ± 0,00B,b	9,33 ± 0,58C,c
	D	7,00 ± 0,00A,c	8,00 ± 0,00B,c	8,33 ± 0,58B,b	10,00 ± 0,00C,c
Leaf Width	K	6,70 ± 0,17A,a	7,10 ± 0,17B,a	7,53 ± 0,06C,a	7,93 ± 0,12D,a
	A	7,13 ± 0,12A,ab	8,30 ± 0,10B,b	9,37 ± 0,40C,b	11,23 ± 0,60D,b
	B	7,37 ± 0,12A,b	9,27 ± 0,23B,c	11,00 ± 0,50C,c	13,43 ± 0,81D,c
	C	7,57 ± 0,15A,b	9,57 ± 0,12B,c	11,63 ± 0,06C,cd	14,57 ± 0,06D,cd
	D	8,57 ± 0,40A,c	10,50 ± 0,44B,d	12,10 ± 0,36C,d	15,07 ± 0,40D,d
Stem Diameter	K	3,07 ± 0,12A,a	3,67 ± 0,15B,a	4,33 ± 0,15C,a	4,73 ± 0,06D,a
	A	3,37 ± 0,12A,b	4,33 ± 0,15B,b	5,33 ± 0,15C,b	6,00 ± 0,20D,b
	B	3,73 ± 0,06A,c	5,33 ± 0,15B,c	6,00 ± 0,20C,c	6,67 ± 0,15D,c
	C	4,07 ± 0,12A,d	5,73 ± 0,06B,d	6,67 ± 0,15C,d	7,33 ± 0,15D,d
	D	4,37 ± 0,12A,e	6,07 ± 0,12B,d	7,33 ± 0,15C,e	8,00 ± 0,20D,e

Note: Data are mean of three replicates ± standard deviation. K = Without aplication of liquid organic fertilizer; A (Application of 7 days fermentation liquid organic fertilizer); B (Application of 10 days fermentation liquid organic fertilizer); C (Application of liquid organic fertilizer fermentation 13 days); D (Application of liquid organic fertilizer fermentation 16 days). Superscripts with different capital letters on the same line indicate significant differences for observation times while superscripts with different lowercase letters in the same column indicate significant differences for the liquid organic fertilizer treatment.

process. The increase in plant height occurs due to the presence of apical meristem cells which continue to divide, which can influence the increase in plant size. Table 2. shows that the observation time for purple eggplant plants and the treatment of applying liquid organic fertilizer with different fermentation times gave less significant differences in results regarding the number of leaves of purple eggplant plants in each treatment. Since the addition of new leaves also occurs along with the fall of the old leaves. However, the number of leaves will continue to increase as the purple eggplant plant ages. The increase in the number of leaves of purple eggplant plants is caused by the presence of organic compounds contained in liquid organic fertilizer which can increase the effectiveness of optimal nutrient supply and absorption in purple eggplant plants. The availability of nutrients in plants responds to the formation of chlorophyll which is directly related to the number of leaves because chlorophyll is mostly found in leaves. The nutrient content, especially nitrogen, is the basic ingredient needed to form amino acids which will be used for plant metabolic processes so that it will influence the increase in the number of leaves of purple eggplant plants. Apart from nutrients, the number of leaves is influenced by sunlight, water, and plant spacing on plant growth and development, so that plants that have more leaves will have more energy available for photosynthesis than those with fewer leaves [30].

Table 2. shows that the observation time for purple eggplant plants resulted in differences in results regarding the leaf width

of purple eggplant plants in each treatment. Providing liquid organic fertilizer produces high leaf width because it contains the elements N, P and K. Nitrogen is important in terms of chlorophyll formation in leaves because nitrogen will increase the leaves ability to absorb sunlight. Photosynthate produced from the photosynthesis process will be broken down again through the respiration process and produce the energy needed by cells to carry out cell division and enlargement so that the leaves increase in width. Deep phosphorus fertilizer organic liquid works for development ribbon meristem tissue network. The fertilizer could extend the cells network which eventually affect the size of the leaf of eggplant. Potassium plays a role as activator enzyme essential in reaction photosynthesis and respiration as well as enzymes involved in protein and starch synthesis. The three factors above will interact to influence the growth of purple eggplant plants. The nutrient element that is very influential in the growth and formation of leaves is N. High levels of N generally produce more and bigger leaves, because liquid organic fertilizer contains cytokinins which can stimulate growth and formation more quickly [11].

The results of the research showed that there was a significant effect of providing liquid organic fertilizer from milkfish viscera waste with differences in fermentation time on the stem diameter of purple eggplant plants at the 1st to 4th week of age. Even though stem diameter is a slow growth phase compared to other vegetative growth, the stem diameter of purple eggplant plants will continue to increase as the purple eggplant plant ages. The element potassium (K) plays a role in strengthening plant growth so that leaves, flowers and fruit do not fall [31]. The nitrogen element plays a role in accelerating the process of cell division which causes growth in height and stem diameter. Apart from that, N also contains protein as an energy source for plant growth [32]. The presence of nitrogen elements in plants can increase the formation of chlorophyll in the leaves. Therefore, the presence of chlorophyll in leaves can speed up the rate of photosynthesis [31].

The increasing wet weight value of purple eggplant plants was caused by the size of the plant itself which includes plant length, number of leaves, leaf width, stem diameter and root length. Apart from that, the high wet weight in this treatment is also influenced by the speed of plant growth and the number of doses of liquid fertilizer given. Providing liquid organic fertilizer with a 10x dilution is the optimal concentration for the growth of purple eggplant plants. After there was water imbibition, the eggplant plants begin to grow. This is related to the influence of water on enzyme activity in the plant body. Syahputra and Elfis [29], mentioned the source of the nutrients provided comes from the liquid fertilizer that was applied. The liquid organic fertilizer provided will be absorbed by plants in solution form, so the fertilization process requires enough water because water functions as a solvent.

Table 3. Growth Rate of Purple Eggplant Plants

No.	Treatments	Wet Weight ± SD	Root Length ± SD
1	K	19.33 ± 1.53 a	23.67 ± 0.58 a
2	A	32.67 ± 2.08 b	26.67 ± 0.58 b
3	B	37.33 ± 0.58 c	30.00 ± 0.87 c
4	C	50.33 ± 1.53 d	33.33 ± 0.29 d
5	D	58.67 ± 2.08 e	36.50 ± 0.50 e

Note: Data are mean of three replicates ± standard deviation. Data followed by different superscript letters at the same column indicates significant differences. A = 7 days fermentation liquid organic fertilizer; B = 10 days fermentation liquid organic fertilizer; C = 13 days fermentation liquid organic fertilizer; D = 16 days fermentation liquid organic fertilizer.

The results of the study showed that liquid organic fertilizer produced from milkfish viscera waste with different fermentation times had a significant effect on the root length of purple eggplant plants at four weeks of age. In the treatment without liquid organic fertilizer, the lowest root length was observed due to the limited availability of nutrients, which restricted root growth in purple eggplant plants.

Immature liquid organic fertilizers are often contaminated with intermediate compounds such as ammonia and organic acids, which can cause plant toxicity and inhibit root elongation and seed germination. Fertilizer maturity can be evaluated using several indicators, including the C/N ratio and the NH_4^+/NO_3^- ratio. When toxic fertilizers are applied, the chemical components present in liquid organic fertilizer directly affect seed germination and plant root development. Enhanced root growth enables plants to absorb water and nutrients more efficiently.

Similar findings were reported by Phibunwatthanawong and Riddech [30], who observed improved root development with the application of mature organic fertilizers. Shama and Nimalan [33] also demonstrated enhanced growth of chili plants using liquid organic fertilizer derived from tuna viscera. Likewise, Ellyzatul et al. [34] reported improved growth of cucumber plants fertilized with fish waste–based fertilizers, while Jubin and Radzi [35] observed positive growth responses in maize treated with fertilizers produced from fish waste.

These results indicate that fish waste, particularly viscera, has strong potential to be processed into liquid organic fertilizer and can promote favorable plant growth. The utilization of fish waste as fertilizer contributes to reducing environmental pollution associated with fisheries by-products. Moreover, the application of fisheries waste within a circular economy framework offers additional environmental benefits in Indonesia, including improved soil fertility and reduced land degradation. Liquid organic fertilizers derived from fisheries waste are environmentally friendly, non-toxic, and support sustainable agricultural practices.

4. Conclusion

Differences in the long-time fermentation of liquid organic fertilizer produced different characteristics of liquid organic fertilizer regarding nutrients which include pH, yield, carbon-organic, nitrogen, phosphorus, and potassium as well as the growth rate of purple eggplant plants which include plant height, number of leaves, leaf width, diameter. stem, root length, and plant fresh weight. The best fermentation time for liquid organic fertilizer from milkfish viscera waste is 16 days. This can be seen from the results of various tests including pH 5.80, nitrogen 0.34%, phosphorus 0.06%, and potassium 0.20% as well as the growth rate at 4 weeks of age which includes a plant wet weight of 58.67 grams, length roots 36.67 cm, plant height 25.67 cm, number of leaves 9.33, leaf width 15.07 cm, and stem diameter 8.00 mm.

Conflicts of Interest

There are no conflicts of interest reported by the writers.

Author Contributions

Conceptualization, R.H. and E.N.D.; methodology, R.H. and L.P.; formal analysis, R.H.; investigation, E.N.D. and L.P.; resources, E.N.D.; data curation, R.H.; writing—original draft preparation, R.H.; writing—review and editing, E.N.D. and L.P.; visualization, L.P.; supervision, E.N.D.; project administration, E.N.D.; funding acquisition, E.N.D. All authors have read and agreed to the published version of the manuscript.

Data availability statement

The data presented in this study are available on request from the corresponding author.

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Ethical approval

Not applicable

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