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UTILIZATION OF SEPTIC TANK WASTE TO ENHANCEMENT THE GROWTH OF SPINACH IN VARIOUS MEDIA

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Abstract. *Septic tank waste could be used as a new alternative to be used as fertilizer because human excrement contains the availability of nutrients needed by plants. The study sought to determine the effect of liquid organic fertilizer from septic tank waste dose and plant media type on the growth and production of spinach. The experiment involved 9 treatments arranged a factorial experiment in a Randomized Complete Block Design (RCBD) with 3 replicates. The first factor is the dose of fermented septic tank waste, namely 0 mL/plant (F1), 0.4 mL/plant (F2), and 0.6 mL/plant (F3). The second factor is the plant media, namely soil without amendments or control (S0), soil + husk charcoal (S1), and soil + chicken manure (S2). The number of leaves, root length, plant height, fresh weight plant, root fresh weight, dry weight, and root dry weight were all observed variables. Soil + manure media differs significantly from all other variables observed, such as the number of plants, leaves, root length, fresh weight of the plant, root fresh weight, dry weight, and root dry weight of the plant. The presence of an interaction between fermented septic tank waste and the media is not found in all variables.*
Keywords: *media; organic agriculture; organic fertilizer; spinach; waste*

1. Introduction

Spinach (*Spinacia oleracea* L.) is a type of vegetable that is consumed by people on a daily basis because it contains nutrients, vitamins, and mineral salts such as iron which are beneficial to the human body. Spinach is high in vitamins A, C, and B, as well as important mineral salts such as phosphorus, calcium, and iron, all of which are beneficial for body growth and health (Fevria *et al*., 2021; Mdoda *et al*., 2022). The growth demand for spinach could not be met entirely by farmers (Lessy & Pratiwi, 2020; Stringer *et al*., 2020). The growing population of Indonesia and the world raises demand for vegetables. Based on BPS (2021), spinach production in 2021 was 171,706 tons, up from the previous year of 157,024 tons. This indicates that the community's demand for spinach is increasing. As a result, action must be taken to improve outcomes. Organic fertilization is one method to increase the production and quality of spinach plants (Tshikalange *et al*., 2022).

Liquid organic fertilizer (LOF) is a solution formed by the decomposition of organic matters derived from plant residues, animal and human wastes containing multiple elements (Wang *et al*.,

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2017). This organic fertilizer has the advantage of overcoming nutrient deficiencies quickly, having no problems with leaching nutrients, and also providing nutrients quickly (Abror & Alhaq, 2017; Yuniansyah *et al*., 2022). When compared to chemical fertilizers, LOF generally do not harm the soil or plants, even when used as frequently as possible. Furthermore, this fertilizer contains a binder, which allows the solution suspension applied to the soil surface to provide nutrients that plants could use (Nur *et al.*, 2016).

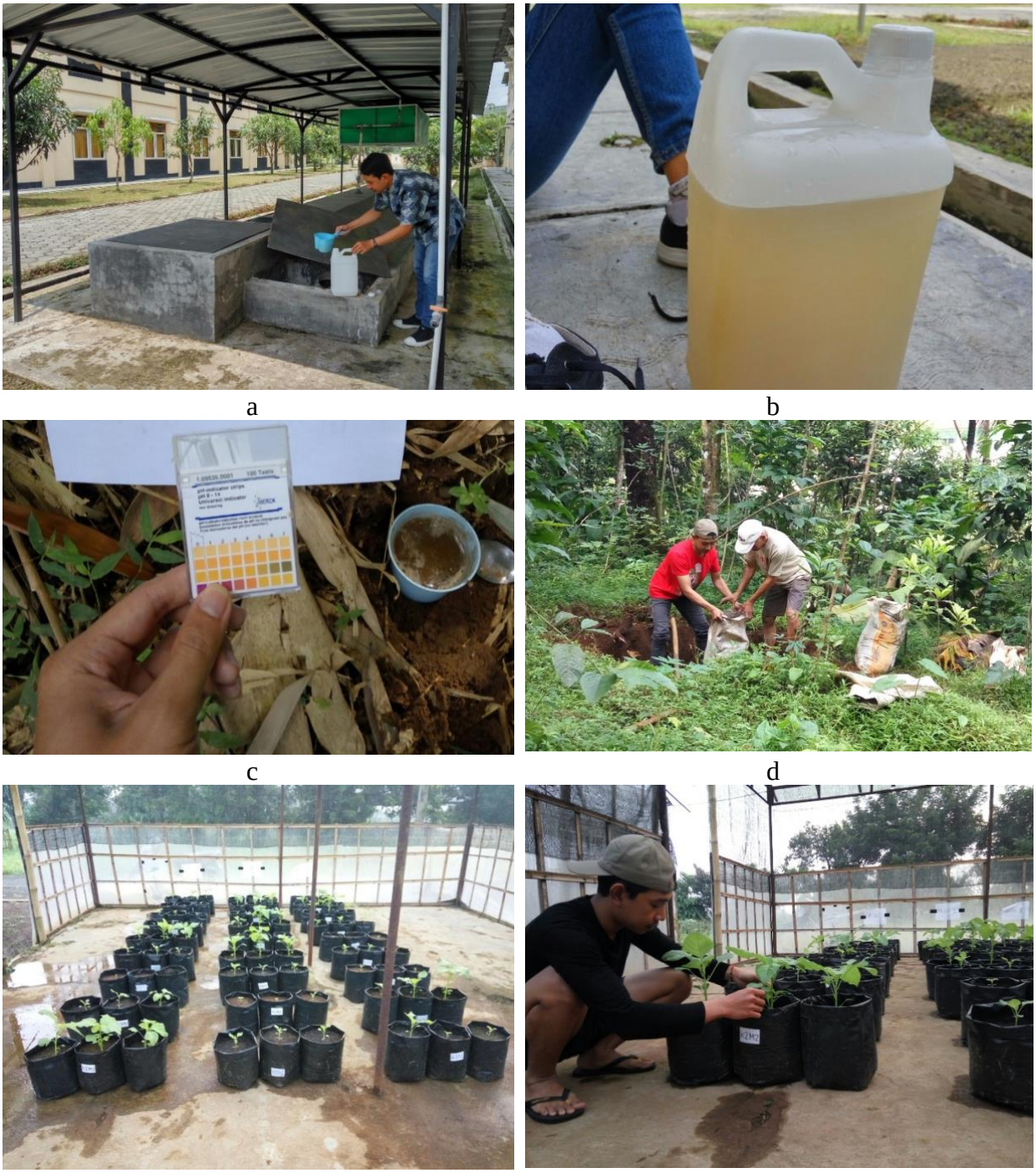
Today, there is a lot of news about septic tank waste being disposed carelessly by toilet suction service providers, which is the talk of many affected residents. Making a waste treatment site could serve as an alternative location for waste disposal (Saha *et al*., 2021). Fitriana *et al.* (2017) states that human fecal waste could be used as a new alternative to fertilizer because it contains nutrients that plants require (Tran *et al*., 2020). This waste can be obtained from household septic tanks which are usually designed like a bio-digester with 2 storage holes, the first is a fresh waste hole and the second is a waste container from the previous hole. In the first hole, an anaerobic fermentation process occurs, while in the second hole, solid waste (sludge) or liquid waste (slurry) is obtained. This fermented faecal waste has potential as a soil fertilizer because it is rich in elements N, P, and K (Andreev *et al*., 2018).

Solid organic fertilizers are more widely used in farming. Organic fertilizers applied to the soil could be used as soil amendments. One of the most frequently used soil amendments is rice husk charcoal. Charcoal husks are often used by farmers to improve agricultural land (Yoedhistira & Darmawan, 2022). In addition, there have been many studies using rice husk charcoal for mixed media and its effect on plant growth (Mishra *et al*., 2017). Agricultural waste could also be used as organic material, including waste from various types of livestock manure. Utilization of organic matter is one of the techniques for implementing organic farming (Caskiwan *et al*., 2019; Supriati & Herliana, 2014). One type of livestock manure that has the potential to become a useful organic material is chicken manure which in general has not been utilized optimally by the community, even though according to several research results, it has been found that chicken manure waste contains high enough organic matter so that it can be reapplied to plants as fertilizer (Dani *et al*., 2021). Chicken manure contains complete nutrients needed by plants for growth such as essential nutrient (Yoedhistira & Darmawan, 2022). This study aims to determine the effect of LOF dose and plant media on enhancing the growth and the production of spinach.

2. Methods

The study was conducted from January 2017 to February 2017 at the Screenhouse of the Faculty of Agriculture, Jenderal Soedirman University at an altitude of 110 meters above sea level

(7°24'28.7" S and 109°15'19.7" E). The materials used in the study consist of spinach seeds, LOF from septic tank waste (Figure 1a and 1b), chicken manure, husk charcoal, and marginal soil from Sunyalangu Village, Karanglewas District, Banyumas Regency (Figure 1c and 1d). The equipment used includes polybags, labels, rulers, analytical scales, ovens, plastic, plastic buckets, sprayers, measuring cups, drums or bowls, 2 mm diameter soil sieve, stationery and documentation tools.



a b c d e f

Figure 1. Research documentation a) collection of waste from septic tanks, b) LOF human septic tank waste, c) soil pH measurement, d) soil sampling, e) trial demonstration, f) data retrieval.

The experiment involved 9 treatments a factorial experiment in a Randomized Completely Block Design (RCBD) with 3 replicates. The first factor is the dose of LOF, namely 0 mL/plantation (F1), 0.4 mL/plantation (F2), 0.6 mL/plantation (F3). The LOF was applicated in 5 times, namely 5 DAT (days after planting), 10 DAT, 15 DAT, 20 DAT, and 25 DAT. The second factor is the plant media, namely soil without amendments or control (S0), soil + husk charcoal (S1), soil + chicken manure (S2). The media used was soil and chicken manure with details of 7 kg of soil 180 g of manure, soil with husk charcoal with details of 7 kg of soil, 180 g of husk charcoal, and soil without amendments (control) (Figure 1e and 1f).

Parameters observed included plant height, number of leaves, root length, plant fresh weight, root fresh weight, plant dry weight, and root dry weight. The data were analyzed using Analysis of Variance (ANOVA), and if they were significantly different, they were tested again with Duncan's Multiple Range Test (DMRT) at a 5% error level.

3. Results and Discussion

Based on the results of the initial soil analysis conducted at the Laboratory of the Assessment Institute for Agricultural Technology (Table 1), the soil used in this study has a pH of 5.31 which is classified as acid (Balittanah, 2009). Soil pH value affects the availability of nutrients needed by plants. The organic C content in the soil is in the low category (Balittanah, 2009), namely 1.08%. High organic C content in a soil indicates that the physical and chemical conditions of the soil are good as a medium for plant growth. Therefore, in this study the addition of organic matter was used as a treatment by adding chicken manure and husk charcoal at a dose of 5 tons/ha. The nutrient content of total N, available P, and available K is low, namely 0.17% N,18.67 ppm P_2O_5, 9.57 ppm K_2O, and CEC of 17.61 cmol(+)kg^{-1}, respectively.

Table 1. Results of soil analysis and LOF from septic tank waste

Parameter	Unit	Value
Soil propeties		
a. pH (H_2O)		5.31
b. C organic	(%)	1.08
c. N total	(%)	0.17
d. P (P_2O_5)	(ppm)	18.67
e. K (K_2O)	(ppm)	9.57
f. CEC	(cmol (+) kg^{-1})	17.61
Liquid organic fertilizer for septic tank waste		
a. pH (H_2O)		4.91
b. C organic	(%)	1.13
c. N total	(%)	4.29
d. P total (P_2O_5)	(%)	2.17
e. K total (K_2O)	(%)	1.69

Source: Laboratory analysis results

The results of the analysis of LOF from septic tank waste showed a pH value of 4.91 which was classified as very acidic (Balittanah, 2009). This happens because the fermentation uses an anaerobic system. The organic C content is classified as low at 1.13% (Balittanah, 2009). The nutrient content of N, P, and K is 4.29% N, 2.17% P_2O_5, and 1.69% K_2O, respectively.

Results showed that the dose of LOF had a significant effect only on the number of leaves parameter. While on the parameters of plant height, root length, fresh weight of plant, dry weight of plant, fresh weight of root and dry weight of root, the dose treatment factor had no significant effect. The application of various types of media had a very significant effect on all observation parameters. Interactions in the application of liquid organic fertilizer in various dose with various types of plant media did not have a significant effect on all observe parameters.

3.1. The effect of dose of LOF on the growth of spinach

The results of the analysis presented in Table 2 show that the LOF for septic tank waste on the number of leaves at (F3 was significantly different from the others. Results indicate that the best dose for the number of leaves is F3 with a value of 15.33 leaves. Yang *et al*. (2020) states, the higher dose of fertilizer given, the higher the nutrient content received by the plants.-The more frequent the frequency of fertilizer application carried out on plants, the higher the essential nutrient content. The increase in the number of leaves on plants can also be influenced by the availability of nitrogen (Table 1), this is in accordance with the statement of Mola *et al*. (2020), that N is a constituent component of many essential compounds for plants, the presence of N could stimulation the fundamental of chlorophyll is important for the process of photosynthesis. Lingga & Marsono (2013), stated that the proper dose of fertilizer is one of the considerations in plant growth.

The effect of LOF dose treatment on parameters that have no significant effect is thought to be caused by environmental influences. The soil used has a pH in the range of 5-5.5. This can mean that the soil is acidic (Gillespie *et al*., 2021). The pH is very important for the growth of pulled spinach. According to Savvas & Gruda (2018) a good pH range as a condition for growing pulled spinach plants is 6-7. Soil pH above 7 growth of young leaves (shoots) will turn yellowish white (chlorosis) due to the relatively small availability of nitrogen, iron, manganese, borium and copper. On the other hand, at a pH below 6, the growth of uprooted spinach plants will decrease due to the rapidly decreasing elements of phosphorus, potassium, sulfur, calcium and magnesium. The occurrence of abnormalities in soils that have a pH below 6 because the elements aluminum, iron, and manganese are toxic to these plants.

The optimum environmental temperature for pulling spinach plants is between 16-20^{o}C Chowdhury *et al*. (2021). During the research process, the minimum ambient temperature was

22°C (measured at 06.00-07.30) and the maximum temperature was 47°C (measured at 12.00-14.00). This temperature is less than optimal for the growth of spinach pull out. Low temperatures will inhibit the work of enzymes and genes, where as high temperatures will damage plants and could cause the rate of transpiration to increase Xi *et al*. (2021). Optimum relative humidity for the growth of spinach pull out is 60-80%. Show the maximum relative humidity was 95%. It could be concluded that 95% relative humidity is not good for the growth of spinach. The ideal relative humidity for spinach is 85%, if more than 90% has an adverse effect on plant growth, plants grow imperfectly, plants are not fertile and the quality of the leaves will be poor Chowdhury *et al*. (2021).

Table 2. The average effect of LOF dose and various plant media on the growth and yield of spinach

Treatment	PH (cm)	NL (leave)	RL (cm)	FWP (g)	FWR (g)	DWP (g)	DWR (g)
Dose of LOF							
F1	17.99a	11.26b	23.39a	18.49a	3.46a	1.46a	0.25a
F2	18.19a	13.56ab	22.49a	21.75a	4.28a	1.77a	0.31a
F3	19.71a	15.33a	23.20a	25.26a	5.19a	1.87a	0.35a
Plant Media							
S0	4.96c	4.04c	9.03c	0.14c	0.03c	0.03c	0.01c
S1	15.94b	9.01b	15.92b	3.45b	0.53b	0.37b	0.08b
S2	34.99a	27.11a	44.14a	61.92a	12.36a	4.71a	0.82a

Description: F1 = 0 mL/plantation, F2 = 0.4 mL/plantation, F3 = 0.6 mL/plantation. S0 = soil without amendments or control, S1 = soil + husk charcoal (M1), S2 = soil + chicken manure. PH = plant height, NL = number of leaves, RL = root length, FWP = fresh weight of plants, FWR = fresh weight of roots, DWP = dry weight of plants, DWR = dry weight of roots, numbers followed by the different letter in the same column are significantly in the 5% DMRT test.

3.2. Effect of plant media on the growth of spinach

a. *Plant height*

Table 2 showed that treatment S2 had the highest plant height compared to other treatments. The results indicated that the application of chicken manure could provide the best results compared to husk charcoal. This is due to the higher content of macro nutrient in chicken manure. The increase in plant height occurred because nitrogen stimulated the growth of apical meristems so that the plants increased in length when compared to other treatments (Qadir *et al*., 2017). Petropoulos *et al*. (2018) also said that plant height is affected by the application of nitrogen which could increase height up to 35 cm than plants that are not given nitrogen. High levels of nitrogen in the growing media also greatly affect the growth of the vegetative phase, which is characterized by the addition of plant cell volume (plant height and length) and other plant organs (Machado *et*

al., 2020). During this phase the role of the element nitrogen is very important, especially during cell division which is part of the metabolic processes of plant parts (Machado *et al*., 2018).

b. *Number of leaves*

The application of various types of plant media has a very significant effect on the parameter of the number of leaves. The results showed that treatment S2 had the highest effect compared to S1 and S0 on the number of leaves (Table 2). The increase in the number of leaves is strongly influenced by the elements essential nutrient in addition to soil and in the environmental factors such as temperature and light. This is also inseparability from the function of these three elements for plants, which can spur growth (Nemadodzi *et al*., 2017). The same opinion was conveyed by Thapa *et al*. (2021), that the nutrient that influences the growth and development of leaves is nitrogen. High nitrogen concentrations generally produce a greater number of leaves.

Gadallah *et al*. (2022), the vegetative organs of plant leaves require nitrogen in large quantities, because nitrogen is an element that played an important role forming amino acids and proteins as the basis for plants in compiling leaves. In addition, the presence of sufficient nitrogen in the soil can increase protein synthesis for cell division and enlargement which causes an increase in the number and increase in cell size so that plant growth and number of leaves increase (Agarwal *et al*., 2018). Rouphael *et al*. (2018), stated that the more sunlight the plant receives, the plant will respond by increased the number of leaf. With the increased in the number of leaf, the more carbohydrates produced by these plants in the process of photosynthesis so that it will accelerate plant growth and development.

c. *Root Length*

The use of various media has a very significant effect on the parameters of plant root length. The S2 showed the greatest effect compared to S1 and S0 on the parameter of plant root length (Table 2). Research conducted by Guo *et al*. (2019) also stated that root length was only significantly affected by the treatment of the media. Intara *et al*. (2011) suggested that manure plays a role in improving the soil's ability to bind water, affecting soil aggregates, improving soil structure providing the nutrients needed by plants, producing CO_2 and organic acids which help the mineralization process (Roidah, 2013).

Zulkarnain *et al*. (2013) shows media from manure contains complete nutrients such as macro nutrien. These elements are essential for plant growth and development. In addition, manure also contains microorganisms that can break down organic matter that is difficult for plants to digest into components that are easier for plants to absorb. The use of manure as a media can improve soil porosity. Manure undergoes a decomposition process and gradually produces humus. The interaction of humus with soil particles will create a more stable soil structure and

enlarge the pore space. This is in accordance with the results of research by Machado *et al*. (2020), that porosity is influenced by organic matter. The existence of good porosity is very supportive for the growth of plant roots.

d. *Plant Fresh Weight*

The use of various types media has a very significant effect on the parameters of plant fresh weight. The S2 showed the greatest effect compared to S1 and S0 on plant fresh weight parameters (Table 2). Water is the main component in plant life, about 70-90% of the fresh weight of plants in the form of water which is a supporting medium for biochemical reactions to take place. In the plant body, water can enter the plant tissue through the process of diffusion. In addition, the availability of water and compost in the soil will spur the formation and development of plant growth properties associated with the process of plant cells to enlarge.

Another factor influencing plant water availability is the transport of nutrients from the soil to the plants. Nutrients in soil are transported by water and absorbed by plants via diffusion and osmosis processes. The better the plants absorb nutrients, the more basic materials are available for the photosynthesis process. A successful photosynthesis process will promote the accumulation of carbohydrates and proteins in plants. Carbohydrate and protein accumulation as the result of photosynthesis will affect plant fresh weight (Barickman & Kopsell, 2016; Febriyono *et al*., 2017). Amir (2018) Biomass production is influenced by environmental factors such as light, temperature, and water content. If environmental factors are conducive to plant growth, the resulting photosynthate also increases so that the allocation of biomass to the part that is harvested is also relatively larger.

e. *Root Fresh Weight*

The use of various types of growing media has a very significant effect on the parameter of fresh weight of plant roots. The S2 showed the greatest effect compared to S1 and S0 on the fresh weight of plant roots (Table 2). It is suspected that in this treatment the need for N and P has been provided and fulfilled for the growth and yield of spinach plants. Lingga & Marsono (2013) which states that N for plants could stimulate overall plant growth, especially stems, leaves and roots. Furthermore Arista *et al*. (2015) added that in general the use of N in plants is able to produce faster vegetative growth, increase stem length, increase leaf size, give greener leaf color, and increase root length and volume which in turn affects wet weight. root.

f. *Plant Dry Weight*

The use of various media has a very significant effect on the parameters of plant dry weight. The S2 showed the greatest effect compared to S1 and S0 on plant dry weight parameters (Table 2). Growth in plant height, stems, and another factor influencing plant water availability is the

transport of nutrients from the soil to the plants. Nutrients in soil are transported by water and absorbed by plants via diffusion and osmosis processes. The better the plants absorb nutrients, the more basic materials are available for the photosynthesis process. A successful photosynthesis process will promote the accumulation of carbohydrates and proteins in plants (Wahono *et al*., 2018).

Dry weight produced by a plant is highly dependent on leaf development (Sarawa & Baco, 2014). The process of photosynthesis is an important factor in plant growth where the number of tall leaves could receive high sunlight as well, thus causing photosynthetic results to increase which then compounds from photosynthesis are distributed to all plant organs that need them and cause plant dry matter to become high. The dry weight is plant material after all the water contained in it is removed by heating it to 80ºC (Desoky *et al*., 2020). Plant dry weight is important to calculate, because dry weight is used to view plant metabolism and can represent the results of plant metabolites (Purnama *et al*., 2021).

g. *Root Dry Weight*

The use of various of media has a very significant effect on the root dry weight parameter. The S2 showed the greatest effect compared to S1 and S0 on the root dry weight parameter (Table 2). Dry root weight is one of the parameters that can describe root growth and development. Absorption of nutrient occurs at the tips of roots and root hairs, so the dry weight of roots can describe the roots ability to absorb mineral for overall root growth and development (Setiawati *et al*., 2018).

A high root dry weight value indicates that root formation is very good so that plants have the potential to absorb and utilize nutrients and water better for tissue formation and photosynthesis (Widyantika & Prijono, 2019). Root dry weight is an accumulation of organic compounds and is related to the growth of root length, the longer the root, the greater the root dry weight (Sofyan *et al*., 2014).

4. Conclusions

Utilization of septic tank waste from human feces can be used as an alternative as the main ingredient for making POC. This research was conducted to provide evidence that septic tank waste can be beneficial for cultivation. Results this study prove that administration of 0.6 mL septic tank waste LOF is the best dose because it affects the number of leaves. Soil + manure media is the best media because it increases plant height, number of leaves, root length, fresh weight of plant, fresh weight of root, dry weight of plant and dry weight of root. In this study there was no interaction in the application of liquid organic fertilizer in various doses and various types of media on all observation parameters.

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