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THE EFFECT OF LIQUID ORGANIC FERTILIZER FROM TOFU INDUSTRIAL WASTE AND EM4 ON THE GROWTH OF MUSTARD GREENS (*Brasicajuncea* L.)

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Abstract: This study aimed to determine the effect of liquid organic fertilizer (LOF) from tofu industry waste, EM4, and their combination on the growth of mustard greens (Brassica juncea L.) and to determine the most optimal dose to increase the growth of mustard greens. This study used a factorial Completely Randomized Design (CRD) consisting of 2 factors. The first factor is the dose of POC from the tofu industry waste, and the second is the dose of EM4. Each factor has five levels of fertilization with three replications. The treatment of liquid organic fertilizer from tofu industry waste consisted of 0 ml, 25 ml, 50 ml, 75 ml, and 100 ml. The EM4 treatment consisted of 0 ml, 1 ml, 2 ml, 3 ml, and 4 ml/100 ml water. The parameters observed in Green mustard growth were plant height, number of leaves, wet weight, leaf area, and dry weight. The results of the research showed that the POC of tofu waste, EM4, and its combination did not have a significant effect on all parameters.

Keywords: *Liquid Organic Fertilizer, Industrial Waste of Tofu, EM4, Growth Green Mustard*.

INTRODUCTION

Industrial wastewater is known to have a variety of organic matter content, which, if not managed properly, can negatively influence the environment. Organic compounds at high concentrations will cause pollution to the aquatic environment [1]. In the liquid waste of tofu, there are nutrients N, P, and K. Where N (nitrogen) serves for the formation or growth of vegetative parts of plants, such as leaves, stems, and roots, and can increase the breeding of microorganisms in the soil. [2]. Industrial liquid waste of tofu can be used as a liquid organic fertilizer that is safe for plants in a certain concentration. The use of organic fertilizers in the community is still low due to the lack of public knowledge about producing organic fertilizers from waste. One of them is industrial wastewater of tofu.

Tofu liquid waste can be used as liquid organic fertilizer through fermentation. In the fermentation process carried out by aerobic and anaerobic microorganisms, there is an overhaul of complex chemical compounds to be simpler, aimed at accelerating the absorption of nutrients in plants. Due to fermentation, nutrients N, P, K, and other nutrients contained in the liquid waste of tofu can be easily absorbed by plants [3]. Biologically, organic fertilizers are the main energy source or become foodstuffs for the activity of soil micro-bodies. The addition of organic fertilizers encourages the breeding of organic bodies and increases the availability of plant nutrients [4].

Society still depends on the use of inorganic fertilizers that can provide faster results, more practical, and easy to obtain, one of which is widely used is NPK fertilizer. However, excessive inorganic fertilizers can have negative environmental impacts, such as damaging soil structure and lowering soil fertility rates [5-7]. The use of effective microorganisms (EM 4) is one of the technologies that can be used in agricultural management efforts that can reduce negative influences on the environment. EM4 consists of a mixture of beneficial and naturally living microorganism cultures and can be applied as an inoculum to increase the diversity of soil and plant microorganisms [8]. EM4 contains 90% Lactobacillus sp bacteria and three other types of microorganisms, namely photosynthetic bacteria, Streptomyces sp, and yeast, that work synergistically to fertilize the soil and promote plant growth [9]. Processing of liquid tofu waste into liquid organic fertilizer needs to be added EM4 to improve the quality production of fertilizer.

Mustard plants are vegetable commodities that have commercial value and good prospects. In terms of technically and economically, society is very supportive, so it has the feasibility to be pursued in Indonesia. The part of mustard plants that are of economic value is the leaves, so efforts to increase production are attempted to increase vegetative. Fertilization is carried out [10]. Fertilization can be done using organic or inorganic fertilizers. Most farmers use inorganic fertilizers more often. It can lead to a deterioration of compounds or materials in the soil. By utilizing liquid tofu waste into liquid organic fertilizers, the community has other alternatives for fertilizing plants [11].

The purpose of this study is to find out (1) the effect of giving waste liquid organic fertilizer of tofu on the growth of mustard green plants, (2) the effect of EM4 administration on the growth of mustard green plants, and (3) the effect of giving a combination of liquid organic fertilizers of tofu and EM4 on the growth of mustard green plants, (4) the most optimal dose of liquid organic fertilizers of tofu and EM4 in increasing the growth of mustard green plants.

RESEARCH METHODS

This research was conducted from June to September at the Green House of the Faculty of Agriculture, Jl. Pendidikan 37, Unram Lama, Dasan Agung Baru, Selaparang District, Mataram City, West Nusa Tenggara. The Measurement of growth parameters is carried out at the Biology Laboratory, Faculty of Teacher Training and Education, Mataram University. The measured growth parameters are the height of the plant, number of leaves, wet weight, leaf area, and dry weight.

The materials used in the study were mustard seeds, liquid waste of tofu, soil, polybags, water, EM4, sugar, label paper, aluminum foil paper, and HVS paper. The tools used in the study were buckets/jerry cans, stirrers, hoes, earth sifters, meters, rulers, gloves, manual scales, measuring cups, hand sprayers, stationery, cameras, ovens, scissors, and analytical scales.

The stages of implementation of this study are: (1) making LOF from fermented tofu water waste for 14 days, (2) making EM4 solution that will be watered on plants once a week, (3) preparing planting media, (4) selecting good seeds, (5) planting seeds as many as eight seeds per polybag, (6) looting after the plant grows with several leaves as many as two strands, (7) conducting maintenance by watering and weeding, (8) giving LOF tofu waste and EM4 according to the treatment dose with a feeding interval once a week, (9) measuring plant growth parameters.

The technique of measuring the growth of mustard green plants is as follows: 1) The height of the plant is measured using a ruler, starting from the base of the stem closest to the root to the end of the unfolded longest leaf, 2) The number of leaves counted is the leaves that have opened perfectly, 3) the plant measures, Wet weight is harvested and cleaned from the attached soil using water carefully so as not to damage the plant parts, next dredged by the wind for 3-5 minutes. The part that is weighed to get the fresh weight of the plant is all parts of the plant except the root part, 4) Measurement of leaf area is carried out by gravimetric method using the formula:

$$\text{Leaf area} = \frac{\text{duplication weight}}{\text{paper weight(10x10cm)}} \times 100\ \text{cm}^2$$

5)Dry weight was measured by the plant wrapped using aluminum foil paper, then in the oven for 48 hours at a temperature of 700 C. Once in the oven, the sample is weighed using analytical scales.

The research design used is a factorial Complete Random Design (CRD). This research design consists of 2 factors that each have five levels of fertilization with three repetitions so that the experimental unit used as many as 75 plants. The first factor is the treatment with liquid organic fertilizer waste of tofu, namely P0: 0 ml (control), P1: 25 ml, P2: 50, P3: 75 ml, P4: 100 ml. The second factor is em4 treatment, namely E0: 0 ml / 100 ml of water, E1 : 1 ml / 100 ml of water, E2 : 2 ml / 100 ml of water, E3 : 3 ml / 100 ml of water, E4 : 4 ml / 100 ml of water.

Table 1. Combination of treatments

Treatment	P0	P1	P2	P3	P4
E0	P0E0	P1E0	P2E0	P3E0	P4E0
E1	P0E1	P1E1	P2E1	P3E1	P4E1
E2	P0E2	P1E2	P2E2	P3E2	P4E2
E3	P0E3	P1E3	P2E3	P3E3	P4E3
E4	P0E4	P1E4	P2E4	P3E4	P4E4

Data analysis was analyzed by using the application SPSS Statistic Version 25. The data obtained from this study were analyzed using a two-way ANOVA (Analysis of Variance) test to determine the effect of treatment on the growth of mustard green plants. Further tests can be done if F count > F table using the BNT test (Smallest Real Difference) at a significant level of 5% [12]. Suppose the statistical test calculation value (P-value) is greater than the value of α (5%). In that case, it can be concluded that H0 is accepted and can be formulated: P-value > α (0.05) = H0 failed to be rejected [13].

RESULTS AND DISCUSSIONS

The data of plant height measurement results obtained the highest average value on the P0E1 combination treatment (combination of 0 ml LOF of tofu waste and 1 ml of EM4/100 ml of water), which is 28.83 cm. Measurements of the number of leaves, leaf area, and dry weight obtained the highest average values on the P1E4 treatment (a combination of 25 ml of tofu waste LOF and 4 ml of EM4/100 ml of water), namely 10.33 strands continued, 67.45 cm2, and 8.99 gr respectively. Measurement of the wet weight of plants obtained the highest average value at P0E0 (control), which is 32.33 gr. Furthermore, the Measurement of data was analyzed using the ANOVA test to determine the effect of treatment on the growth parameters of mustard greens. The parameters measured include the height of the plant, number of leaves, wet weight, leaf area, and dry weight of the plant.

Table 2. ANOVA Test Recapitulation

No.	Growth parameters	Nilai P (sig)		
		LOF Tofu waste	EM4	LOF tofu waste*EM4
1	Plant's height	0.709	0.803	0.997
2	Number of leaves	0.852	0.375	0.658
3	Wet weight	0.131	0.310	0.916
4	Leaf area	0.302	0.028	0.771
5	Dry weight	0.356	0.056	0.943

The recapitulation of the ANOVA test of the main influence and interaction of liquid organic fertilizers (LOF) of tofu and EM4 waste on the growth of mustard greens is presented in the table 2.

The results of the ANOVA test of the main influence and interaction of liquid organic fertilizers (LOFs) of tofu and EM4 waste on the growth of mustard greens showed that all the main factors and interaction factors obtained from P (sig) value of > 0.05. Based on the analysis results, it can be known that the alternative hypothesis (H1) is rejected or the null hypothesis (H0) is accepted at the 5% test level. The results of the analysis can be concluded that the main factors of liquid organic fertilizer (LOF) of tofu waste. The main factors of EM4, the interaction factors of liquid organic fertilizers (LOF) of tofu waste, and EM4 did not exert a significant influence on all the observed green mustard growth parameters (Brassica juncea L.).

The administration of liquid organic fertilizers (LOF) of tofu and EM4 waste does not exert a significant influence on the growth of mustard green plants on all observed growth parameters, including plant height, the number of leaf strands, wet weight, leaf area, and dry weight of the plant. Organic fertilizers do not contain large amounts of nutrients. Still, adding organic matter to the soil can trigger the growth of microorganisms that help absorb nutrients and play an important role in improving soil structure [14;15].

In this study, the results of the ANOVA test showed that the main factors of liquid organic fertilizer (LOF) of tofu waste, the main factors of EM4, the interaction factors of liquid organic fertilizers (LOF) of tofu waste, and EM4 did not have a significant influence on all the observed green mustard growth parameters (Brassica juncea L.). The same results were also shown in the research conducted by [16; 17; 18; 19], which states that the administration of waste liquid organic fertilizers does not significantly influence plant growth parameters. However, the results of research conducted by [20; 21] state that the administration of waste liquid organic fertilizers tofu significantly influences plant growth parameters. In Savitri's study, researchers added several other ingredients that may increase the availability of nutrients in liquid organic fertilizers, such as the addition of chitosan. Researchers added Curcuma and lemongrass. In addition, the planting media used is a mixture of soil and sand, and the dose of liquid organic fertilizer given starts from a dose of more than 100 ml. This difference in results is likely due to differences in the added materials as well as the media used.

On the parameters of the number of leaves, the wet and dry weight of the plant without treatment (control) have quite good growth. The addition of the EM4 dose lowers those parameters. It is likely because the content in the planting media can support plant growth, so the addition of EM4 or LOF of tofu waste cannot be seen as the effect. The addition of EM4 can increase the availability of nutrients, but plants do not use it for their growth. The lowest compost and EM4 dose treatment already supports plant growth, then the increase in compost dose and EM4 dose cannot increase plant growth [22].

The results of the ANOVA test showed that the provision LOF of tofu waste and EM4 did not have a significant influence on the observed growth parameters. It was according to the low nitrogen, phosphorus, and potassium content in tofu liquid waste fertilizers and the planting media used. The liquid tofu waste used was made of 2 kg of soybeans mixed with 60 liters of water, and it was the last liquid waste from tofu treatment so that the protein content is not too much. The content of nitrogen and K2O in solid tofu waste (tofu pulp) is 1.24% and 1.34%. The result is greater than the content in tofu liquid waste which is only 0.27% nitrogen and 0.29% K2O [23]. The acidity level of the soil or the pH of the soil also affects the growth of the plant. The ability of plants to carry out the nutrient absorption process is influenced by the main factors, namely the acidity level of the soil or pH. Soils that have a neutral pH are good soils used for farming. Soils with a neutral pH are at 6.5-7.8. The chemical properties of the soil are closely related to fertilization activities. Knowing the chemical properties of the soil means getting an idea of the type and amount of fertilizer needed. Knowledge of the chemical properties of the soil can give an idea of fertilizer doses and fertilizer reactions after they have been given to the soil [24]

The low content of nitrogen, phosphorus, and potassium elements in organic fertilizers causes plant growth to be not optimal. Physiologically, nitrogen can spur the vegetative growth of plants and the development of plant organs so that it is faster to experience an increase in the number of leaves and the size of the leaf area. In addition, the element nitrogen is also part of chlorophyll. If the plant is exposed to nitrogen element deficiency, it can inhibit

the process of chlorophyll formation in the leaves. The element nitrogen plays an important role in the formation of green leaf substances used in the process of photosynthesis of plants. It can produce carbohydrates as food that will be used in the growth process [25]. Sufficient N, P, and K nutrients will stimulate overall growth such as stems and branches and be able to form broad leaf strands with high chlorophyll content so that the plant can produce enough assimilation to support its vegetative growth [26; 27]. Nitrogen is the main nutrient for plant growth, as it is a constituent of proteins and nucleic acids. Thus, it also arranges the protoplasm as a whole. If the N element is available, a lot will produce more protein so that the leaves can grow wider [28]. The provision of liquid organic fertilizers (LOF) of tofu waste and EM4 does not significantly influence all observed growth parameters due to the low nutrient content of N, P, and K in organic fertilizers.

P1E4 treatment (a combination of 25 ml LOF tofu and 4 ml EM4 / 100 ml of water) obtained the highest average growth of mustard green plants compared to other treatments. This is in line with the statement [29] that the volume of EM4 bio activators greatly affects the content of N, P, and K, because the more volume of EM4 bio activators, the higher the levels of N, P, and K. The average observation results of the lowest growth parameters are indicated by the combination treatment given 2 ml EM4 / 100 ml of water. The treatment of P1E2 (a combination of 25 ml LOF tofu and 2 ml EM4 / 100 ml of water), which has the height and least number of leaves, and the treatment of P3E2 (combination of 75 ml LOF tofu and 2 ml EM4 / 100 ml of water) which has a wet weight, leaf area, and lowest dry weight.

The increase in wet weight and dry weight of the plant is closely related to the number and area of leaves. If the plant has a large number of leaves, it will produce a high wet weight, and a wide leaf surface allows it to absorb more sunlight. The photosynthesis process takes place faster, resulting in the higher weight of the plant [30]. Although not significant, the results showed a link between the observed growth parameters where the treatment of P1E4 (a combination of 25 ml LOF tofu and 4 ml EM4 / 100 ml of water) has the average number of leaves the most: 10.33 strands and the largest leaf area is 67.45 cm^2 so that plants with P1E4 treatment have the largest wet weight and dry weight, namely wet weight 30.33 grams, and dry weight 8.99 gr.

The availability of nutrients strongly influences plant growth in an optimum and balanced state. A plant will thrive if all the nutrients needed are sufficient and available in the appropriate form for the plant to absorb. In liquid waste know, there are organic materials such as nitrogen (N) for the growth of buds, stems, and leaves, phosphorus (P) to stimulate the growth of roots, fruits, and seeds, and potassium (K) to increase plant resistance to disease pest attacks. However, it cannot be directly absorbed by plants because it is still in the form of compounds that need to be broken down into ions that are easily absorbed by plants [31]. Liquid waste of tofu is converted into fertilizer through the fermentation process with the help of EM4 bio activators. EM4 will decompose the nutrients in tofu liquid waste into simpler nutrients so that plants can directly absorb and use them to support their growth and development. Fermentation occurs in anaerobic environmental conditions where microorganisms decompose organic compounds such as proteins, carbohydrates, and fats into simpler forms of compounds. The advantage of anaerobic processes is that the process produces energy in the form of biogas, is easy to do, cheap, does not require large land, and does not require energy for aeration [32]. The fermentation process with EM4 that takes place anaerobically can eliminate unpleasant odors. The fermentation duration will affect the content of nutrient elements contained in the liquid waste of tofu because the longer it is fermented, the food source for these bacteria will also decrease over time the fermentation process occurs. Therefore, it is necessary to know the best period of the fermentation process so that it can produce enough nutrient content for plant growth [33].

The use of organic fertilizers in this study LOF waste of tofu and EM4 did not exert a significant influence and interaction on all observed growth parameters. In this study, EM4 should be used only during the fermentation process of liquid waste of tofu so that the content contained in the liquid waste can be decomposed by microorganisms contained in EM4. It is more recommended to combine liquid organic fertilizers (LOF) of tofu waste by adding inorganic fertilizers tailored to the symptoms of nutrient deficiency needed by plants. Fertilization activities, especially inorganic fertilizers, should be tailored to the needs of plants. Following the concept described in the Minimum Liebig law, the provision of fertilizers/nutrients that are effective in increasing crop yields is the nutrient whose availability is the most minimal/critical in the soil. Thus, the addition of inorganic fertilizers is adjusted to the symptoms of nutrient strength through visual observation or utilization of data from soil analysis [34]. Thus, its effect can be seen by the provision of treatment, including the combination treatment of LOF waste tofu and EM4.

CONCLUSION

Based on the results of research and discussion, it can be concluded that: (1) The provision LOF of tofu waste does not have a significant influence on all parameters of mustard growth, and (2) Em4 administration does not have a significant influence on the parameters of mustard growth. (3) The interaction of liquid organic fertilizers (LOF) tofu waste and EM4 has an unreal effect on all observed growth parameters, including

plant height, the number of leaves, wet weight, leaf area, and dry weight of mustard green plants.

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