The Utilization of Tofu Waste Water as An Addition of Nutrition in Hydroponic Media to Lettuce Growth (*Lactuca sativa* L.)

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Abstract. Lettuce is a vegetable that is easily cultivated and can be a source of essential vitamins and minerals for the body. This study aims to determine the effect of using tofu wastewater as a nutrient addition to hydroponic media on the growth of lettuce (*Lactuca sativa* L.). The method used in this study was an experimental method with a randomized block design (RBD) of 5 treatments and 6 repetitions. The treatments were *P*0 (0 ml POC+60 ml AB mix/kontrol), *P*1 (20 ml POC+40 ml AB mix), *P*2 (30 ml POC+30 ml AB mix), *P*3 (40 ml POC+20 ml AB mix), dan *P*4 (60 ml POC+0 ml AB mix). The research data were analyzed using the normality and homogeneity tests as a prerequisite test. These were then followed by the ANAVA and LSD tests at the 5% level. The application of tofu wastewater as a nutrient addition in *P*2 treatment had the best results with an average plant height of 22.55 cm, wet weight of 5.73 g, and dry weight of 0.34 g. Therefore, it can be concluded that the utilization of tofu wastewater as a nutrient addition to hydroponic media affected the growth of lettuce (*Lactuca sativa* L.).

1. Introduction

Indonesia is an agricultural country that has a tropical climate which makes its lands very fertile and suitable for agriculture and plantations. Almost all of Indonesia's residents seek income from natural products in the form of agriculture and plantations. Under these conditions, the government has been trying to develop and increase agricultural and plantation products.

The growing population in Indonesia causes the availability and quality of land for agriculture to decrease. This is because the land which is suitable for agriculture and cultivation has been transformed into areas for housing, offices, industries, roads, and so on. One way to increase the productivity of vegetable crops in a narrow area is by hydroponic cultivation of vegetable crops. Hydroponics is a way of farming without using soil as a planting medium. In general, this term is known as "farming without land." Based on several hydroponic studies that have been conducted, it shows that various kinds of media can affect plant growth and yield. According to Mas'ud (2009), different nutrients and growing media can provide different results on the growth and yield of lettuce plants.

Lettuce (*Lactuca sativa* L.) is a seasonal plant that can grow in sub-tropical climates, but is able to adapt well to tropical climates. Pracaya (2003) states that lettuce cultivation is easy as long as there is organic matter available in the soil, sufficient sunlight and not stagnant water. Public awareness concerning health is increasing over time. Vitamins and minerals that are widely found in vegetables...
are needed to support public health, making this commodity now increasing and becoming a concern. In addition, vegetables contain fiber which is very good for digestion.

Lettuce is favored by most Indonesians, especially used as a salad or fresh vegetables. These vegetables contain water which is rich in carbohydrates, fiber and protein. Lettuce provides about 15 calories for every 100 grams (Novriani, 2014). Thus, lettuce has a very important role in supporting public health. Healthy vegetables can be produced by organic cultivation, namely by using organic ingredients to support the growth of cultivated vegetables.

At the same time, many industrial activities in Indonesia always produce waste, one of which is the tofu industry. Tofu production produces solid and liquid waste. If these waste are not handled properly, they would cause environmental pollution. Solid waste is generated from filtering and clumping processes. Most of the solid waste are used by tofu makers to be processed into oncom, tempe gembus or animal feed. Meanwhile, liquid waste are produced from the process of soaking, washing, boiling, and printing. Almost all of these processes produce liquid waste which results in high liquid waste of tofu (Suprapti, 2005).

The abundance of tofu wastewater generated from the production process is one of the reasons for the treatment of tofu wastewater because the waste contains very high organic materials such as carbohydrates, protein, fat, potassium and so on. One of the treatments that can be done is by using tofu waste water as organic liquid fertilizer. Tofu wastewater contains nutrients and provides nutrients for plants. According to Indonesia’s Research and Development Team, wastewater contains important elements for plants such as N, P, and K.

Tofu wastewater also contains high organic materials, especially protein and amino acids. The results of the analysis state that tofu wastewater contains carbohydrates, proteins, fats and contains nutrients, namely N, P, K, Ca, Mg, and Fe (Aliyenah et al., 2015). Protein in tofu wastewater when decomposed by microbes would release N compounds which can eventually be absorbed by plant roots. The utilization of tofu wastewater as additional nutrients in hydroponic media is expected to supply sufficient amounts of both macro and micro nutrients to maximize the growth of lettuce plants. The purpose of this study was to measure the effectiveness of tofu wastewater as a nutrient addition to hydroponic media on the growth of lettuce (Lactuca sativa L.).

2. Methodology

This study used an experimental method with a research design, namely a randomized block design (RBD) of 5 treatments and 6 repetitions. The treatments were \( P_0 \) (0 ml POC+60 ml AB mix/kontrol), \( P_1 \) (20 ml POC+40 ml AB mix), \( P_2 \) (30 ml POC+30 ml AB mix), \( P_3 \) (40 ml POC+20 ml AB mix), dan \( P_4 \) (60 ml POC+0 ml AB mix).

Research Procedures

The early stages of the research started by sowing lettuce seeds for 14 days using rockwool as a planting medium. The next stage was the manufacture of liquid organic fertilizer (POC) from tofu wastewater by entering 6 liters of tofu wastewater, 40 ml of EM_4, and 200 ml of sugar solution into a bucket. After that, they were stirred until blended and then covered tightly. The POC was fermented for 15 days.

The making of hydroponic media "wick system" began by preparing a used impraboard, which was cut to a size slightly exceeding the nutrition tub (basin). Next, a hole was made on the impraboard with the size of the net pot as many as 6 holes. Then the flannel cloth was installed in the gap in the net pot as a wick. The net pot was then placed in each hole on the impraboard and then the nutrition tub (basin) was covered with the impraboard sheet. Data collection for parameters including height, wet weight and dry weight of plants was carried out at 30 days after transplanting.

Data Analysis

Data analysis in this study used the Analysis of Variance (ANOVA) one factor at the 5% level and then continued with the LSD test to determine the difference in effect between treatments.
3. Result and Discussion

As the results of the research on the use of tofu wastewater as a nutrient addition to hydroponic media on the growth of lettuce (*Lactuca sativa L.*) at the age of 30 HSPT (days after planting) included plant height, wet weight, and dry weight. The data for the three parameters are presented in Table 1.

| Treatment | Plant Height (cm) | Wet Weight (gram) | Dry Weight (gram) |
|-----------|-------------------|-------------------|-------------------|
| P₀        | 17.60<sup>ab</sup> | 3.46<sup>a</sup>  | 0.24<sup>ab</sup> |
| P₁        | 19.55<sup>bc</sup> | 3.59<sup>ab</sup> | 0.26<sup>bc</sup> |
| P₂        | 22.55<sup>c</sup> | 5.73<sup>b</sup>  | 0.34<sup>c</sup>  |
| P₃        | 16.48<sup>ab</sup> | 2.87<sup>a</sup>  | 0.22<sup>c</sup>  |
| P₄        | 13.85<sup>c</sup> | 1.62<sup>a</sup>  | 0.15<sup>c</sup>  |

Note: The numbers followed by different letters on each line show significantly different based on the LSD test at 5% level.

**Plant Height**

Data on plant height showed that in the treatment of giving 30 ml of tofu waste water organic fertilizer which were mixed with AB mix solution of 30 ml (P₂) produced the highest yield with an average of 22.55 cm. In the control treatment (P₀) obtained an average result of 17.60 cm. While the lowest yield was in the treatment of 60 ml of tofu wastewater liquid organic fertilizer without mixing it with AB mix (P₄) with an average of 13.85 cm.

The results of the normality test showed that lettuce plant height data were normally distributed. The results of the Barlett homogeneity test showed that the height data of lettuce had homogeneous variants. Meanwhile, in the ANOVA test results, one factor at the 5% level indicated that there was a significant effect on the provision of tofu wastewater as an addition of nutrients to the height of lettuce plants.

The LSD test at the 5% level showed that the treatment of 30 ml of tofu waste water organic fertilizer mixed with 30 ml of AB mix (P₂) was significantly different from the control treatment (P₀).

**Plant Wet Weight**

Based on the data on the results of the wet weight of the plant, it can be seen that in the treatment of giving 30 ml of tofu waste water organic fertilizer which were mixed with AB mix solution of 30 ml (P₂) produced the highest yield with an average of 5.73 grams. The control treatment (P₀) obtained an average yield of 3.46 grams. Meanwhile, the lowest yield was in the treatment of tofu wastewater liquid organic fertilizer as much as 60 ml without being mixed with AB mix (P₄) with an average of 1.62 grams.

The results of the normality test showed that the wet weight data for lettuce were normally distributed. The results of the Barlett homogeneity test showed that the wet weight data of lettuce was homogeneous. As for the ANOVA test results, one factor at the 5% level indicated that there was a significant effect on the provision of tofu wastewater as an addition of nutrients to the wet weight of lettuce plants. The LSD test at the 5% level showed that the treatment of 30 ml of tofu waste water organic fertilizer mixed with 30 ml of AB mix (P₂) was significantly different from the control treatment (P₀).

**Plant Dry Weight**

Based on the results of plant dry weight, it can be seen that the treatment of 30 ml of tofu wastewater organic fertilizer mixed with 30 ml of AB mix solution (P₂) produced the highest yield with an average of 0.34 grams. The control treatment (P₀) obtained an average result of 0.24 grams. Meanwhile, the
The lowest yield was in the treatment of 60 ml of tofu wastewater liquid organic fertilizer without mixing it with AB mix (P4) with an average of 0.15 grams.

The results of the normality test showed that the dry weight of lettuce was normally distributed. The results of the Bartlett homogeneity test showed that the dry weight data of lettuce had homogeneous variants. With regards to the ANOVA test results, one factor at the 5% level indicated that there was a significant effect on the provision of tofu wastewater as an addition of nutrients to the dry weight of lettuce plants. The LSD test at the 5% level showed that the treatment of 30 ml of tofu wastewater organic fertilizer mixed with 30 ml of AB mix (P2) was significantly different from the control treatment (P0).

The results showed that each treatment of tofu wastewater as an addition of nutrients had an effect on plant height, wet weight, and plant dry weight. The treatment of 30 ml tofu wastewater and 30 ml AB mix (P2) showed better results for the parameters of height, wet weight, and plant dry weight. This was probably due to the availability of nutrients in the treatment containing the right nutrients for lettuce growth. According to Wijayanti and Susila (2013), AB mix contains nutrients including NH4 (14 ppm), NO3 (150,5 ppm), H2PO4 (38,75 ppm), and K (253,5 ppm) which are able to complement nutrient elements contained in the tofu wastewater organic fertilizer, making the growth of lettuce is better than other treatments.

The treatment of 60 ml of tofu wastewater without AB mix (P4) obtained lower results compared to other treatments. This was probably caused by a lack of nutrients needed by plants which caused plants not to grow optimally. This in line with Muhadiansyah et al. (2016) who stated that the nutrients contained in organic fertilizers cannot replace the nutrients contained in AB mix fertilizers so that plants lack nutrients and do not grow optimally. Based on the results of the Laboratory of the Indonesian Spice and Medicinal Plants Research Institute (BALITRO), it was discovered that liquid organic fertilizer from tofu wastewater contains several nutrients, including N (0.006%), F (157.12 ppm), and K (87 ppm). This showed that the content of N, P, and K in liquid organic fertilizer from tofu wastewater was low, making plant growth less effective.

Tofu wastewater treatment as much as 40 ml (P3) and 60 ml (P4) showed low results compared to control treatment (P0), because the higher the concentration of tofu wastewater the lower the results. This was presumably due to the concentration of organic fertilizers from tofu wastewater, making it difficult for plants to absorb nutrients and causing stunted plant growth. This is in line with Lakitan (2010) who found that nutrient content with a concentration higher than the concentration required for growth, can cause poisoning to plants, causing inhibition of plant growth.

At the height of the treatment plants, 30 ml of tofu wastewater and 30 ml of AB mix (P2) showed that the plant yield was the highest compared to other treatments. This was probably because the treatment of 30 ml of tofu wastewater and 30 ml of AB mix had sufficient nitrogen (N) availability and nutrients for the height growth of lettuce compared to other treatments. According to Susetya (2018), the elemental content of N in liquid organic fertilizers serves to accelerate plant growth, increase plant height, and stimulate germination. According to Toruan et al. (2015), the application of liquid organic fertilizers containing elements of N, P, K, Mg, and Ca would cause accelerated cell division and cell elongation, thereby affecting plant height growth. The increase in the number of cells in the shoots would result in an increase in the height of the lettuce plant.

The roles of the elements N, P, and K are very important in plant growth. P elements that are absorbed by plants can increase vegetative growth. Element P is able to form energy in the form of ATP which plays a role in the absorption of other nutrients, including N which is needed in increasing plant height (Subandi, 2015). The wet weight of treatment plants 30 ml tofu wastewater and 30 ml AB mix (P2) showed higher yields than the control treatment (P0). This was probably due to the composition of the tofu waste liquid organic fertilizer and AB mix which contained the right nutrients so that the nutrient availability was met in the nutrient solution. This is in accordance with Abdillah et al. (2017) who discovered that the availability of nutrients and proper nutrition could increase the number of leaves, leaf area, and plant height, thereby increasing plant fresh weight.
Plant wet weight in the treatment of 60 ml tofu wastewater without AB mix (P₄) showed low results. This was probably due to the lack of micronutrients such as Zn, Mo, Fe, Mn, Co, and B. These micro elements can affect plant vegetative growth, especially the number of leaves, causing reduced wet weight in plants (Muhadiansyah et al., 2016).

The results of plant dry weight in the treatment of 30 ml of tofu wastewater and 30 ml of AB mix (P₂) showed higher yields than the control (P₀). According to Kusumawati et al. (2015), the greater the dry weight of the plant, the better the plant growth and development. According to Parman (2007), plant dry weight is a balance between taking CO₂ (photosynthesis) and releasing CO₂ (respiration). If the respiration is greater than the plant photosynthesis, the dry weight will be reduced. Liquid organic fertilizer from tofu wastewater contains phosphorus (P) nutrients which will increase root growth and development (Mulyono, 2016) and calcium (Ca) for the formation of hair/root hairs, affecting the ability of plants to absorb water. This caused plants with different treatments to absorb different amounts of water and then the water will evaporate during the drying process (Parman, 2007).

Based on the results of the LSD test at the 5% level in Table 1 for all parameters, it can be seen that the treatment of 40 ml of tofu wastewater (P₃) was not significantly different from the provision of 60 ml of tofu wastewater (P₄). Moreover, the two treatments showed low results compared to treatment control (P₀). This was probably due to the low nutrient content in liquid organic fertilizers so that plants experienced nutrient and nutrient deficiency. This is in line with Lakitan (2010) who found that when the availability of nutrients is less than what is needed by plants their metabolism will be disturbed. The provision of nutrients that are not proportional to the needs of the plant will result in stunted growth of roots, stems and leaves (stunted).

Liquid organic fertilizers from tofu wastewater cannot stand alone without other components to support plant growth. Liquid organic fertilizer from tofu wastewater needs to be combined with other ingredients that have a higher nutrient content and are precise in composition so that they can help the growth of lettuce plants (Aliyenah et al., 2015).

4. Conclusion
The conclusion from this research is that there is an effect of giving tofu wastewater as the addition of nutrients to hydroponic media on plant height, wet weight and dry weight of lettuce plants. The provision of 30 ml tofu wastewater and 30 ml AB mix is the right composition to reduce the use of AB mix because it produces better results than other treatments. The treatment of 60 ml tofu wastewater without AB mix showed the lowest results compared to other treatments.

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