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Utilization of Tofu Wastewater for The Growth of Red Spinach (*Alternanthera amoenavoss*) in Floating Raft Hydroponic Cultures

W Anggraini¹, M Zulfa¹, N N Prihantini², F Batubara³, Ririn Indriyani¹

¹Universitas Islam Negeri Raden Intan Lampung, Lampung, Indonesia

²Departemen Biokimia, Fakultas Kedokteran, Universitas Kristen Indonesia, Indonesia

³Departemen Biomedik, Fakultas Kedokteran, Universitas Kristen Indonesia, Indonesia

*wellyanggraini29@gmail.com

Abstract. This study aimed to determine the effect of giving liquid tofu fertilizer to the growth and yield of red spinach plants (*Alternanthera amoenavoss*) with floating raft hydroponic techniques. Research on red spinach growth parameters was carried out at Horti Park Lampung. The method used in this study was Complete Random Design (CRD) consisting of 4 concentration P0 (0% AB Mix), P1 (30%), P2 (45%) and P3 (60%) and 3 replications. The study was conducted for 4 weeks. Measurements and observations are carried out 4 times, i.e. every 1 week. The parameters measured were stem height, number of leaves, leaf width, root length. Then, the data analysis was performed using One Way ANOVA on SPSS 17, and register later with the LDS test at the level of 5% significance. The results showed that tofu wastewater available at P3 maintenance (60%) was significantly different from other treatments, and at the same time discussed liquid waste which was known at the time of preparation of P1 (30%) because, it did not depend on nutrients contained in inside, so it causes less growth, compared to the implementation of P0 (0%), P2 (45%) and P3 (60%).

1. Introduction

Tofu is one of the most popular side dishes in Indonesia. Indonesia tofu consumption per capita reached 7,039 kg/person with a growth rate of 0,09 % in 2013, with the average 84.000 tofu factories ranging from the household in Indonesia and became domestic industries [1]. With production, tofu is more than 2,56 million tons per day [2]. But, most industries haven't a waste treatment facility. Until now, nearly all tofu factories do not perform good waste management [3].

Industrial tofu waste consists of two wastes, liquid, and solid wastes. The tofu liquid waste is the biggest part of the tofu's waste and potentially contaminates the environment [4]. An average of 20 million m³/year of liquid waste each of the tofu industry produces. The liquid wastes from the tofu industries are generally discharged and surely disrupt the biotic and abiotic lives in water. So, the liquid waste from tofu without any treatment might cause the death of water organisms, causing damage to river ecosystems and harm to humans [1].

The wastewater of the tofu industry contains high organic ingredients, especially proteins and amino acids, contain high BOD, COD and TSS [5]. Tofu liquid waste contains high organic matter. These organic compounds can be in the form of protein that is 40-60%, carbohydrates 25-50%, oil,



and fat 10%, and have nutrients of N, P, K, Ca, Mg, and Fe [6]. Tofu wastewater contains organic substances that can cause the rapid growth of microbes in the water [3].

Because tofu wastewater (TW) is rich in biodegradable organic nutrients, many studies have been devoted to the use of biological methods to achieve the biotransformation of TW. For example, TW was utilized as a low-cost and available alternative medium for the production of vitamin B12 and lactic acid by microbial fermentation [7]. The waste from tofu production can be used as biogas [8], snacks, fodder and most potentially can be fertilizers [1].

Fertilizer most popular in plant growth. A survey in Wayharong Village, Waylima Subdistrict, Pesawaran District, Lampung, there was much regular tofu liquid wastes is reused to be something useful and is used to overcome environmental pollution that occurs as an organic fertilizer for the growth of various types of plants. So that later it will produce optimal plant growth. Like red spinach plants (*Alternanthera amoenavoss*).

Red spinach (*Alternanthera amoenavoss*) is a vegetable that has high nutrition and is especially favored by the people of Indonesia. Red spinach is the most popular vegetable species after green spinach, the nutritional superiority of red spinach vegetables, especially in the content of vitamin C, thiamine amino acid and riboflavin niacin. After that, red spinach is also rich in minerals. Furthermore, in red spinach has vitamin A which is (β -carotene) reaches 80-90%, β -carotene is provitamin A which is very important for the formation of vitamin A which functions as an antioxidant, the antioxidant is a class of terpenes biochemically composed by 8 isoprene groups. Therefore, red spinach plants are also rich in other minerals such as magnesium, zinc (zinc), potassium and phosphorus.[9] The spinach can be phytoremediation for waste water [10]. Red spinach can grow in soil media or hydroponic media. Hydroponics is a good growth media for the plant.

Hydroponics is farming cultivation by utilizing water without using soil which emphasizes the nutritional needs of plants. hydroponic farming methods that have been developed for 45 years. Plants planted in water are equipped with a solution of food or nutrients. Cultivations cultivate using the best water in a place where only one or two plants are planted with a high level of hydrogen content, which will make the content that is alkaline one level of low hydrogen content makes the content acidic.

This study uses red spinach because red spinach is easier in the process of planting. The period of planting, phytoremediation plant also have good nutrition and is beneficial for human health. These researchers want to add knowledge about a red spinach plant (*Alternanthera amoenavoss*) in addition to using tofu liquid waste fertilizer. Growth in red spinach (*Alternanthera amoenavoss*) management can use soil media or hydroponic media in floating raft hydroponic media.

2. Research Method

This study used a Completely Randomized Design (CRD) consisting of 4 concentration treatments, namely 30%, 45%, 60%, and 1 control using AB mix nutrition for each treatment 3 times repetition of nutrient solutions derived from liquid waste tofu which had been fermented into organic fertilizer for 10 days. The experimental units are as follows:

- K0: Control the maintenance of nutritional standards using a mixture of AB (nutrition).
- K1: 30% concentration using 300 tofu industrial nutrients / Liquid water waste (300 ml of liquid tofu waste fertilizer + 700 ordinary water).
- K2: 45% concentration uses nutrients from 450 / tofu liquid fertilizer industry (450 ml of liquid wastewater fertilizer know + 550 ordinary water).
- K3: 60% concentration uses nutrients from 600 / liquid fertilizer tofu industry (600 ml of liquid fertilizer know + 400 ordinary water).

Parameters in this study concluded stem height, number of leaves, leaf width, root length. Analysis data consist of Normality test, homogeneity test, one-way ANOVA test, LDS test, level 5%, with SPSS 17.

3. Results And Discussion

3.1 Result

3.1.1 Growth of Red Spinach Plants (*Alternanthera Amoena* Voss).

3.1.1.1 Stem Height

The results of measurements of stem height that have been given tofu industry waste fertilizer in various sizes, which can be seen in the ANOVA test on attachment data page 72, then tested using LSD 5% data for 4 weeks, the following table can be considered:

Table 1. Advanced LSD Test Results at Level 5%.

Treatments	Average (cm)
P0	14,7625 ^a
P1	11,4417 ^b
P2	12,5500 ^c
P3	14,0350 ^d

Explanation: the results above are followed by letters that do not indicate the same as different.

The results of the LSD test with a level of 5% showed the effect of the treatment of tofu using liquid fertilizer with those that were not the same using tofu liquid fertilizer, P0 (0%), P1 (30%), P2 (45%) and P3 (60%) showed significantly different. Red spinach plants in the calculation of stem height have a significant value, namely $P = 0.522$ ($P > 0.05$).

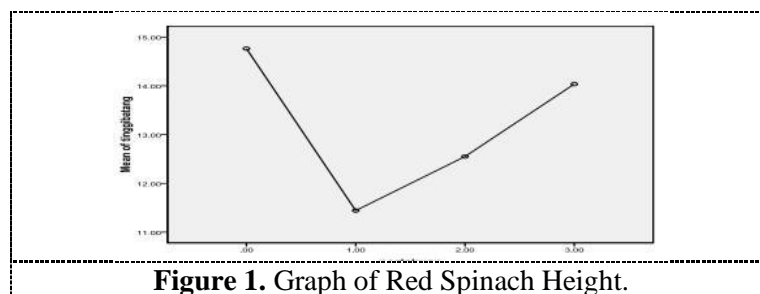


Figure 1. Graph of Red Spinach Height.

The graph above shows the difference in stem height in the treated red spinach plants between P0 (0%), P1 (30%), P2 (45%) and P3 (60%). Namely, the treatment at P0 (0%) shows the highest compared to the treatment between P2 (45%), P3 (60%) and the lowest treatment P1 (30%). The low treatment P1 (30%) is due to the lack of nutrients contained in it, so the growth is less than the treatment between P0 (0%), P2 (45%) and P3 (60%).

3.1.1.2 Number of Leaves

The results of the research that has been done with the calculation of ANOVA test in appendix p. 74, and continued by LDS at 5% are obtained from the average data on the number of leaves of red spinach plants, the following table can be considered

Table 2. Advanced LSD Test Results at Level 5%.

Treatments	Average (cm)
P0	10.0933 ^a
P1	7.5267 ^b
P2	8.2033 ^c
P3	9.3967 ^d

Explanation: *the results above are followed by letters that do not indicate the same as different.*

The results of the LSD test with a level of 5% showed the effect of the treatment of tofu liquid fertilizer with non-equal use of liquid tofu fertilizer, P0 (0%), P1 (30%), P2 (45%) and P3 (60%) showed significantly different. Red spinach plants in the calculation of the number of leaves have a significant value, namely $P = 0.179$ ($P > 0.05$).

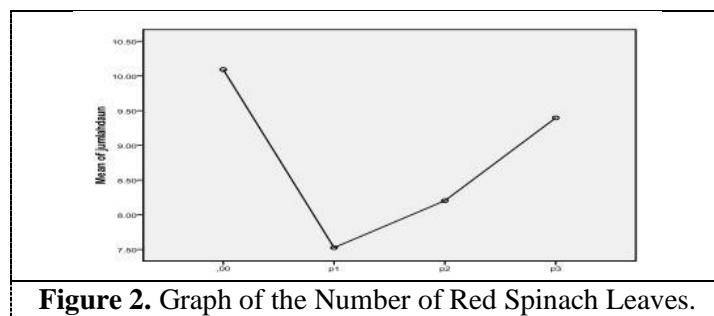


Figure 2. Graph of the Number of Red Spinach Leaves.

The graph above shows the difference in the number of leaves in the red spinach plants treated between P0 (0%), P1 (30%), P2 (45%) and P3 (60%). Namely, the treatment between P0 (0%) and P3 (60%) shows the highest, compared to the treatment between P1 (30%) and P2 (45%). This is because, the treatment at P0 (0%) and P3 (60%) gives the best results on the number of leaves, where the Nitrogen and Potassium elements in plants are very important. If the leaves grow well enough and affect the number of leaves and the quality of a plant.

3.1.1.3 Leaf Width

The results of the research that have been done with the calculation of the ANOVA test in appendix p. 76, and continued by LDS at the level of 5% were obtained from the data of the width of the red spinach plant leaves, the following table can be considered:

Table 3. Advanced LSD Test Results at Level 5%.

Treatments	Average (cm)
P0	5.1667 ^a
P1	3.4300 ^b
P2	4.4867 ^c

P3	5.4033 ^d
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Explanation: the results above are followed by letters that do not indicate the same as different.

The results of the LSD test with a level of 5% showed the effect of the treatment of tofu liquid fertilizer with non-equal use of liquid tofu fertilizer, P0 (0%), P1 (30%), P2 (45%) and P3 (60%) showed significantly different. Red spinach plants in the calculation of leaf width have a significant value, namely $P = 0.663$ ($P > 0.05$).

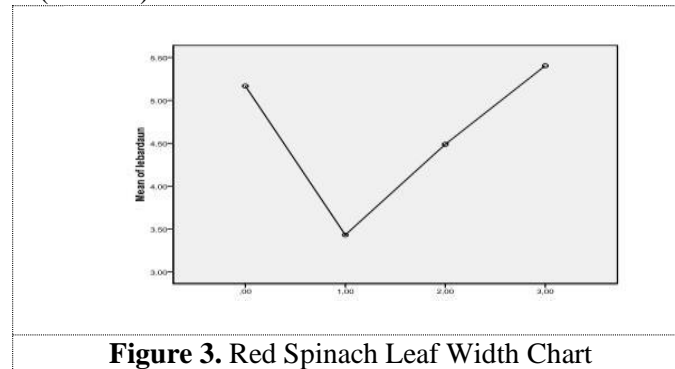


Figure 3. Red Spinach Leaf Width Chart

The graph above shows the difference in leaf width in the treated red spinach plants between P0 (0%), P1 (30%), P2 (45%) and P3 (60%). Where in P3 (60%) shows the highest compared to the treatment between P0 (0%), P1 (30%), and P2 (45%). Thus, the treatment of P3 (60%) nutrients contained in tofu industrial waste fertilizer influences the width of the leaves, especially Nitrogen, phosphorus, and potassium. Hormones as a regulation of growth and water are also needed for leaf tissue cells, so the treatment between P3 (60%) gives different results.

3.1.1.4 Root Length

From the results of the research that has been done by calculating the ANOVA test in appendix p. 78, and continued with LDS at the 5% level obtained from the data of the root length of the red spinach plant, the following table can be considered:

Table 4. Advanced LSD Test Results at Level 5%.

Treatments	Average (cm)
P0	12.0333 ^a
P1	10.1000 ^b
P2	11.1833 ^c
P3	13.6917 ^d

Explanation: the results above are followed by letters that do not indicate the same as different.

The results of the LSD test with a level of 5% showed the effect of the treatment of tofu liquid fertilizer with non-equal use of liquid tofu fertilizer, P0 (0%), P1 (30%), P2 (45%) and P3 (60%) showed significantly different. Red spinach plants in the calculation of root length have a significant value, namely $P = 0.457$ ($P > 0.05$).

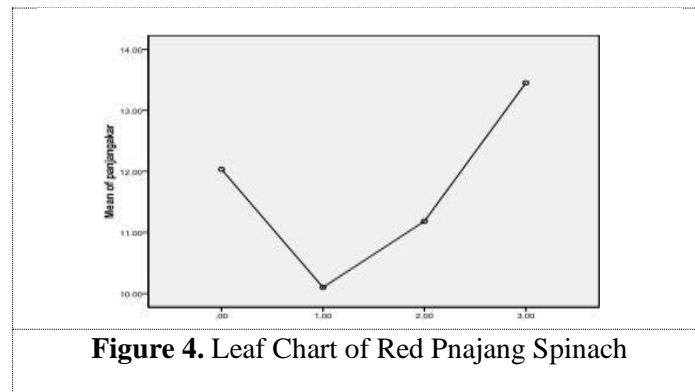


Figure 4. Leaf Chart of Red Pnjang Spinach

The graph above shows the difference in root length in red spinach plants between treatments between P0 (0%), P1 (30%), P2 (45%) and P3 (60%). Where in P3 (60%) shows the highest compared to the treatment between P0 (0%), P1 (30%), and P2 (45%). This is because the treatment in P3 (60%) of nutrients contained is very sufficient for the growth of red spinach.

3.2 Discussions

The results have been shown that the stem height in handling P0 (0%), P3 (60%), and P2 (45%) gave the best results, this resulted in not being fulfilled. However, it was significantly different from the treatment of P1 (30%). The growth was not optimal, this was due to the lack of nutrients [11]. The number of leaves in this study best results in the treatment of AB mix and the concentration in the treatment of tofu liquid waste which showed the highest amount of leaves in better plants, compared to treatment P1 (30%).

P0 (0%) and P3 (60%) concentrations contain sufficient nutrients compared to other concentrations of waste. The nutritional content of BOD, COD, K, N, and pH in tofu liquid waste fermentation can meet SNI 19-7030-2004 standards for the quality of organic fertilizer that was similar to the research by Dianursanti in which tofu wastewater after cultivation similar with Indonesian government standard [12]. Similar research was recorded by Syeda Azeem Unnisa, in which liquid water from food waste consists Nitrogen 1,15% [13] and by Henny Setiawati, in which liquid whey waste consists C, N, P_2O_5 , and K_2O or called Potassium [14]. The nitrogen content for growth functions as enlarging, increasing, greening vegetative growth, i.e. plants, especially in leaves. A similar observation was recorded by Christina Diana, in which effect liquid wastewater from tofu waste can be a significant increase in the growth for stem height *Theobroma cacao* L in concentration 80 ml/kg [15].

Growth in leaves is vegetative growth, where the nitrogen and potassium elements in plants play an important role in photosynthetic. That many nutrients in it have been specially formulated from mineral salts that dissolve water, contains important nutrients needed by plants to grow and develop so that the stem height and quantity and the optimal result are compared to treatment P1 (30%), P2 (45%) P3 (60% tofu liquid waste fertilizer). Similar research was recorded by Hadiyanto, in which the nutrient in tofu liquid water can be used to replace the external nutrients add to the medium [16]. So, the metabolism in a plant can be optimal.

Leaf within the treatment of P3 (60%) liquid waste fertilizer knew the best yield compared to the treatment. Increasing the width of the leaf begins at the base of the leaf laterally, so that the surrounding apex meristem is a submarginal starter with anticlinal division repeatedly called the meristem board. Nutrient content affects leaf width and number of leaves, especially Nitrogen, phosphorus, and potassium. The content of nitrogen (N) is the formation of chlorophyll and nutrients that play a role in it [17]. Potassium is vital to photosynthesis, protein synthesis and many other functions in plants. Potassium is known as the "quality nutrient" because of its important effect on factors such as size, shape, color, taste, shelf life and other quality-related measurements [18].

The treatment that experienced the best root length growth by knowing nutrient wastewater in the treatment of P3 (60%) compared to the treatment of P0 (0%) among other treatments showed that fermented liquid organic fertilizer knew a significant effect on root length in red spinach plants. Potassium in fertilizer can increase root growth and improves drought tolerance [18]. At the root that functions to absorb water and nutrients (minerals). The plant will die without nutrients, especially protein. To survive, plants need water and nutrients, plants absorb water and nutrients from the water using their roots.

The liquid waste fertilizer knows that the concentration of P3 (60%) has been able to meet the availability and uptake of nutrients by plants and is used for growth in plants. In addition to improving chemical properties, the provision of tofu liquid waste as organic fertilizer can also improve the physical and biological properties of plants [19]. Similar research was recorded by Dianursanti, in which tofu wastewater can be medium concentration cause consist of ammonium ion and phosphate ion that can be used directly in metabolism. The ammonium ion is needed in the photosynthetic process. Phosphate ion in the medium needed for energy metabolism, cell membrane stabilization, carbohydrate biosynthesis, amino acid biosynthesis, and cell replication. If photosynthesis product is decreasing, carbohydrate left in microalgae after respiration process will not be sufficient for cell replication [12].

4. Conclusion

The treatment using tofu liquid waste fertilizer affects the growth of red spinach plants (*Alternanthera Amoena Voss*) in the floating raft hydroponic technique which is a parameter of stem height, number of leaves, leaf width and root length.

The highest treatment of organic fertilizer fermentation knows fermentation in the growth of red spinach plants (*Alternanthera Amoena Voss*) is P3 (60% waste ie 600 ml liquid waste of tofu fertilizer + 400 liquid fertilizer nutrients) equal to treatment P0 (a mixture of 0% AB). Significantly different in treatment P1 (30%), in treatment P1 (30%) plants were stated to be less optimal in their growth, due to the lack of nutrients contained in water in the growth of red spinach. However, in treatment P2 (45%) there was no significant difference in the parameters of stem height, leaf number, leaf width, and root length.

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