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Utilization of WWTP Output into Liquid Organic Fertilizer on the Growth of Pak Choi (*Brassica rapa* L.)

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ABSTRACT

Industrial wastewater generally contains many nutrients and organic materials that can be useful as a source of nutrition for plants. Processing wastewater into liquid organic fertilizer (LOF) can be a solution to manage industrial wastewater produced and can reduce the negative environmental impact of direct discharge into the environment. This study aims to determine the effect and optimal concentration of LOF from WWTP output of PT X on pak choi (*Brassica rapa* L.) plant growth and analyze the quality of LOF content according to SNI in the Minister of Agriculture Regulation Number 70 of 2011. This study used the complete randomized design (CRD) method, with the following treatment combinations: A (control, 100% WWTP output of PT X), B (20% LOF), C (40% LOF), D (60% LOF), E (80% LOF), F (100% LOF). Each treatment was repeated three times so that 18 test plants were obtained. Observation variables include height, number of leaves, leaf width, and fresh weight of *Brassica rapa* L. plants. Data analysis using SPSS one-way analysis of variance (ANOVA) test and continued to DMRT test. The results showed that the provision of LOF from WWTP output of PT X had a significant effect on the growth of *Brassica rapa* plants in the parameters of plant height in the fourth and fifth weeks, the number of leaves from the second to the fifth week, the leaf width parameter in the fifth week, and the fresh weight parameter. The optimal treatment for the LOF comparison of all parameters is in treatment D (60% LOF). The test results of LOF content contain C-organic 3.61%, nitrogen 1.1%, phosphate 0.385%, potassium 0.485%, and pH 5.27. These values have not met the SNI LOF in the Minister of Agriculture Number 70 Regulation of 2011. There is a need for the addition of organic ingredients that can increase the N, P, and K content in order to increase the POC yields and have a higher impact on plants.

Keywords: wastewater, WWTP output, liquid organic fertilizer, *Brassica rapa* L.

INTRODUCTION

The rapid development of the industrial sector can provide significant benefits to support the lives of Indonesian people [1]. Industry is the central pillar of the economy that continues to grow and develop every year, including various fields such as food, textiles, agriculture, technology, etc. However, the industry's production process cannot be separated from the waste or residue produced [2]. The food industry is one of the most significant contributors to liquid waste during production [3]. This is because the food industry uses large amounts of water in the production process. One of the industries engaged in food is PT X, located in Wonogiri, Central Java, Indonesia.

In general, waste treatment is formed or realized to reduce the amount of waste substances resulting from production activities that will damage the environment [4]. One of the environmental management efforts that can be done is to make a wastewater management plant (WWTP). The WWTP's purpose is to reduce contaminants in the wastewater and avoid a decrease in the quality of the surrounding environment [5]. In a WWTP, the desired result is that the treated water discharged into the environment must meet the specified quality standards. However, the treated water from WWTP generally still contains various organic and inorganic substances, which, if it exceeds the predetermined quality standards, can cause pollution [6]. If this happens it can cause the quality of an environment to decrease, if the quality of an environment decreases it can have an impact on human life and vice versa [7].

Based on the Regulation of the Minister of Environment and Forestry Number 5 of 2021 concerning Procedures for Issuing Technical Approval and Operational Feasibility Letters for Environmental Pollution Control, wastewater can be used as the primary process such as production and flushing processes for operational support such as boilers and raw water reserves; for by-products such as fertilizer, energy, and compost; to add nutrients to cultivated soil, as well as for watering and washing plants, roads, hydrants, recreational ponds, and washing vehicles. PT X wastewater can be used for by-products such as fertilizer because food industry wastewater generally contains organic nutrients. The use of WWTP outlet water as LOF compared to other effluent management strategies has several advantages and challenges in terms of environmental sustainability as it can utilize treated wastewater as a source of nutrients for plants, reducing the volume of effluent discharged into the environment. In addition, it can reduce the need for chemical fertilizers, save natural resources, and reduce greenhouse gas emissions from chemical fertilizer production.

The LOF product is a liquid organic fertilizer and comes from the decay of organic materials with more than one nutrient content type. LOF has the potential to improve soil quality, increase plant productivity, and reduce farmers' dependence on chemical fertilizers that have the potential to damage the environment. This is because this fertilizer is processed by composting so that it does not cause environmental side effects [8]. However, the availability of quality LOF is currently limited, while the need for organic fertilizers is increasing. In facing this challenge, efforts are needed to find innovative solutions to produce LOF to meet the increasing agricultural needs. Making LOF from WWTP output of PT X is done by adding EW4 (effective microorganism). EW4 contains a mixture of live microorganisms that are beneficial for the absorption and supply of nutrients in the soil. These microorganisms or bacteria that have "good" properties involve lactic acid bacteria (*Lactobacillus* sp.), photosynthetic bacteria (*Rhodopseudomonas* sp.), *Actinomycetes* sp., *Streptomyces* sp., yeast, and cellulose-degrading fungi [9]. This study aims to determine the effect and optimal concentration of LOF from the WWTP output of PT X on the growth of *Brassica rapa* L. plants and analyze its content according to SNI in the Minister of Agriculture Regulation Number 70 of 2011. The article also aims to assess the potential for transformation of industrial sewage into a useful organic fertilizer, which can contribute to reducing the negative impact of sewage on the environment and increase the availability of ecological fertilizers in agriculture.

METHOD

Research location

This study's sampling location was the outlet basin of the PT X WWTP in Wonogiri, Central Java. The LOF sample testing was conducted at the Soil Chemistry Laboratory, Faculty of Agriculture, Sebelas Maret University. *Brassica rapa* L. planting uses polybags with soil media placed in a place with a protective roof from rainwater. The research was conducted from February to July 2024.

Tools and materials

The tools for making LOF are 10-liter jerry cans, bottles, small clear hoses, polybags, hand sprayers, rulers, digital scales, stationery, and cameras. The primary materials in this study are PT X WWTP outlet water samples, EW4, brown sugar, pak choi plant seeds, clean water, and planting media.

Procedure

Making of LOF

The materials used are 9.000 ml from WWTP output of PT X, 60 ml of EW4 activator, and 300 ml of brown sugar solution mixed and stirred until smooth. After mixing, it is put into a jerry can, which is then tightly closed and given a pipe for gas release connected to a bottle filled with clean water Then, it is placed in a dark place with room temperature that is not exposed to direct sunlight and fermented for 15 days. After 15 days of fermentation, the content of N, P, K, C-organic, and pH was tested. POC is ready to be applied to *Brassica rapa* L. plants.

Brassica rapa planting

Pak choi (*Brassica rapa* L.) seeds are seeded by sowing pak choi seeds on the planting media. Pak choi seed nursery media is watered using clean water every morning or evening within two weeks after planting or produces 3–4 leaves. The seedlings were then transferred into polybags containing the prepared planting media. Each polybag includes one pak choi plant and is labeled with information according to the treatment carried out. Planting carried out from the seedling process to the harvest period is carried out under the same or homogeneous environmental conditions between treatments, starting from planting time, homogenized planting media, planting location, watering time, and the same weather factors.

Application of LOF to Brassica rapa L.

LOF watering is done once a week with different LOF concentration treatments, namely:
- A: 100% concentration from WWTP output of PT X (control)
- B: Concentration of 20% LOF + 80% water
- C: Concentration of 40% LOF + 60% water
- D: Concentration of 60% LOF + 40% water
- E: Concentration of 80% LOF + 20% water
- F: 100% LOF concentratio

In this study sing 100% WWTP outlet water is the control treatment because the focus of the research is on the utilization of wastewater from industry X. By using WWTP outlet water as a control, researchers can directly evaluate the effect of treated wastewater compared to wastewater without additional treatment. Clean water or other growth media may not provide a direct and precise comparison of the effects of LOF produced from WWTP output of PT X. The experiment was conducted with 5 treatments and 1 control with each repeated 3 times so that in total there were 18 plants, as shown in Table 1.

Observation variable

Plant height (cm)

Measured from the base of the stem to the tip of the longest leaf using a ruler. Measurements for each treatment and replication were carried out once a week until harvest time at 1, 2, 3, 4, 5 weeks after planting (MST).

Total number of leaves (blade)

The number of leaves was counted starting from the young leaves that had opened completely to the oldest leaves. Observations were made at 1, 2, 3, 4, 5 weeks after planting (MST).

Leaf width (cm)

Measurement of leaf width was carried out on the widest leaf at the time of observation by measuring from the left edge to the right edge of the leaf using a ruler. Measurements for each treatment and replication were carried out once a week until harvest time, namely at 1, 2, 3, 4, 5 weeks after planting (MST).

Fresh weight (gram)

Performed by weighing each sample at the end of the study using a digital scale. Weighing was done at the end of the study after harvest time.

Data analysis

This research uses an experimental method using a completely randomized design (CRD) pattern consisting of 5 treatments and 1 control with 3 replicates so that there are 18 test plants. The data obtained were then analyzed using the SPSS one way analysis of variance (ANOVA) test at the 5% level to determine the effect of LOF on *Brassica rapa* growth. With the hypothesis acceptance criteria as follows: Accept H0, if the Sig value. < 0.05 and Reject H0, if the Sig value. > 0.05. Then continued with the DMRT (Duncan's multiple range test) further test to determine the optimal concentration of LOF application. Laboratory tests were also carried out on the LOF content after the fermentation process which included C-organic, nitrogen, phosphate, potassium, and

Table 1. Experiment scheme

Repeat	Treatment					
	A	B	C	D	E	F
1	A1	B1	C1	D1	E1	F1
2	A2	B2	C2	D2	E2	F2
3	A3	B3	C3	D3	E3	F3

Note: Plants of polybag: 1 plant, total treatments: 6 treatments, experiment repeat: 3 replications, total plants: 18 plants.

pH. The tested parameters were then compared with the SNI LOF according to the Minister of Agriculture Regulation Number 70 of 2011 concerning organic fertilizers, biofertilizers, and soil improvers. Data obtained from experimental tests and laboratory tests were then analyzed descriptively quantitatively.

RESULTS AND DISCUSSION

Effect and optimal concentration of LOF from WWTP output of PT X on plant growth

Brassica rapa L

After the LOF fermentation process for 15 days, trials were conducted using LOF products on *Brassica rapa* L plant growth. Tests were carried out by applying five different concentration treatments, namely B, C, D, E, and F, with their respective doses (20%, 40%, 60%, 80%, and 100% LOF) and added treatment A as a control (100% WWTP output of PT X). Each treatment had three repetitions, and observations on each plant were made once a week for five weeks after planting. The parameters observed were plant height, total leaf number, width, and fresh weight. The following are the results of observations of *Brassica rapa* L growth after watering using LOF made from the WWTP output of PT X

Plant height

The difference in *Brassica rapa* L plant height in each treatment from week zero to week five is shown in Figure 1. Based on Figure 1, it can be seen that the results of the average *Brassica rapa* L plant height replication every week found that plants given treatment D (60% LOF) had a higher average plant height compared to other

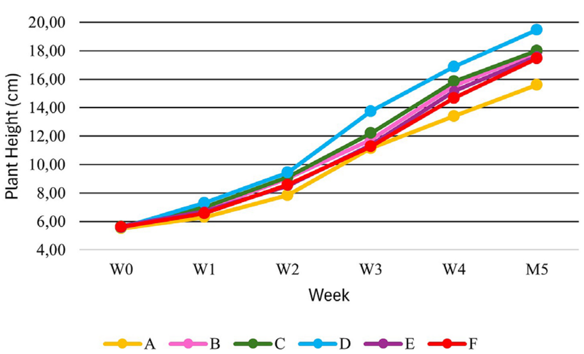

Figure 1. Average height of *Brassica rapa* L for file weeks

treatments. The plant height of treatment D in the first to fifth week is 7.30 cm, 9.43 cm, 13.73 cm, 16.87 cm, and 19.47 cm. At the same time, *Brassica rapa* L plants with the lowest height occurred in treatment A (control) with 100% watering of WWTP output of PT X with plant height from the first to the fifth week of 6.30 cm, 7.83 cm, 11.13 cm, 13.40 cm, and 15.60 cm. While treatment A (control) showed the lowest growth. This is because plants lack nutrients and nutrients so that growth is less than optimal [10]. In the process of optimal plant growth, plants need sufficient nutrients, water, and oxygen [11].

Based on the results of the one way ANOVA analysis in Table 2 during the first week and the second week, the value of Sig. (0.576 and 0.845) greater than 0.05 indicates that there is no significant difference in plant height in various treatments. In the first and second weeks the plants are still in the adaptation period with the new planting media so that the POC in the early stages of plant height growth has not been seen significantly.

In the third week the Sig. value of 0.267 was also still greater than 0.05 indicating that the difference in plant height between treatments was not significant. However, the high growth response began to appear even though it did not look significantly different. According to [12], plant responses to fertilizers are often not immediately visible in the early stages because plants need time to absorb and utilize available nutrients. For the fourth and fifth weeks, the Sig. (0.003 and 0.005) are less than 0.05, indicating a significant difference in plant height between the various treatments. This indicates that the treatment of various POC concentrations began to have a significant effect on the growth of *Brassica rapa* L plant height after several weeks of observation. According to research conducted by [13], plants show a significant increase in growth after several weeks of POC application. The results of this study are in line with the results of this study that the application of NPK POC in the fifth and sixth weeks gave significant results on plant height growth.

DMRT (Duncan multiple range test) was used for further tests to identify significant differences between treatment pairs in detail if ANOVA showed differences (Table 3) [14]. In the first week (W1), the SPAD values were all followed by the same letter (a), which means no significant difference among all treatments. All values followed by ”a” indicate no significant difference between treatments. In the second and third

Table 2. One-way ANOVA test results of *Brassica rapa* L. plant height increase for five weeks

ANOVA						
Specification		Sum of squares	df	Mean square	F	Sig.
Week ke-1	Between groups	1.812	5	0.362	0.792	0.576
	Within groups	5.493	12	0.458		
	Total	7.305	17			
Week ke-2	Between groups	4.818	5	0.964	0.393	0.845
	Within groups	29.447	12	2.454		
	Total	34.264	17			
Week ke-3	Between groups	14.256	5	2.851	1.480	0.267
	Within groups	23.113	12	1.926		
	Total	37.369	17			
Week ke-4	Between groups	20.411	5	4.082	6.735	0.003**
	Within groups	7.273	12	0.606		
	Total	27.684	17			
Week ke-5	Between groups	23.163	5	4.633	6.154	0.005**
	Within groups	9.033	12	0.753		
	Total	32.196	17			

Note: ** Significantly different.

Table 3. DMRT test results of *Brassica rapa* L plant height at 5% level

Experiment	Value SPAD				
	W1	W2	W3	W4	W5
A	6.30a	7.83a	11.13a	13.40a	15.60a
B	6.83a	9.03a	11.73a	15.53bc	17.90bc
C	7.00a	9.10a	12.20a	15.83bc	18.00bc
D	7.30a	9.43a	13.73a	16.87c	19.47d
E	6.70a	8.50a	11.36a	15.17b	17.60b
F	6.57a	8.57a	11.26a	14.67ab	17.47b

Note: Different letters behind the numbers in the same column indicate significantly different values based on the Duncan test at the 5% level.

weeks, there were also no significant differences between treatments. This suggests that the effect of LOF treatment is not yet significant in the early stages of growth. In the third week, treatment D showed the highest average value of plant height (13.73 cm), but the difference with other treatments was still insignificant. Starting from the fourth week, the difference between treatments appeared significant. Treatment D (16.87c) had a higher average value and was significantly different from treatment A (13.40a) and also treatment E (15.17b). If the N element in the soil is sufficiently available, the photosynthesis process will run smoothly and photosynthate will increase so that plant elongation can be accelerated [15]. Meanwhile, the lowest plant yield occurs in treatment A (control), this is because *Brassica rapa* L. plants lack nutrients which cause plants to become stunted [16]. In addition, treatment F (100% LOF) also showed low results. According to [17], the application of LOF with a concentration that is too high or too concentrated can affect plant growth to be inhibited and poisonous.

Total leaf

Based on Figure 2, it can be seen that the results of the average number of leaf blades of *Brassica rapa* L. plants each week found that plants given 60% LOF treatment (treatment D) had an average number of leaf blades more than the other treatments, with an average number of leaves in the first to fifth week of 5, 7, 10, 13.33, and 14.33 blades. While *Brassica rapa* L. plants with the least number of leaves occurred in treatment A (control) with 100% watering from

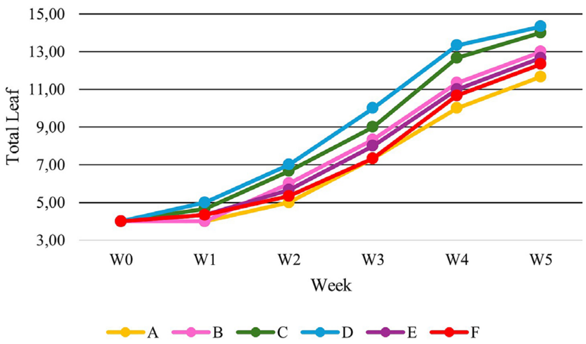

Figure 2. Average total leaves of *Brassica rapa* L. for five weeks

WWTP output of PT X with an average number of leaves from the first to the fifth week of 4, 5l 7.33, 10l and 11.67 strands. The increase in plant height shows the activity of xylem formation and cell enlargement, this causes the cambium to be pushed outward and new cells are formed so that the plant increases in height and forms new internodes so that leaflets are formed [16].

Based on Table 4, the one-way ANOVA analysis results on the variable number of leaf blades in the first week with a Sig value. (0.506) greater than 0.05 indicates no significant difference between the different treatments. This week, all LOF treatments did not have a significant effect on the growth of the number of leaf blades.

The absorption of nutrients from LOF is not optimal, and plants are still adapting to new planting media and treatments [18]. In the second week, there was a significant difference between treatments with a Sig value. (0.033). This value is smaller than 0.05, which indicates a significant difference in the number of leaves between the treatments given. This difference suggests that the effect of the treatment began to be seen in the second week, so some treatments started to have a tangible impact on increasing the number of leaves. In the third week, the difference was more significant with a Sig. Value of 0.004. This indicates that the LOF treatment has a more significant impact on the number of leaves than the previous week. Specific treatments began to show higher effectiveness in increasing the number of leaves on plants. In the fourth week, the ANOVA results showed a significant difference with a Sig. value of 0.008. In the fifth week, significant differences were still seen with a Sig. value of 0.007. This difference indicates that the effect of the treatment on the number of leaves is increasingly evident and significant.

The results of the DMRT analysis of the development of the number of leaves of *Brassica rapa* L plants at five weeks of observation are presented in Table 5.

In the first week of observation, there were no significant differences between treatments with SPAD values ranging from 4 to 5, followed by the same letter (a) indicating no significant differences between treatments. In the second week,

Table 4. One-way ANOVA test results of Brassica rapa total leaf for five weeks

ANOVA						
Specification		Sum of squares	df	Mean square	F	Sig.
Week ke-1	Between groups	2.278	5	0.456	0.911	0.506
	Within groups	6.000	12	0.500		
	Total	8.278	17			
Week ke-2	Between groups	8.944	5	1.789	3.578	0.033**
	Within groups	6.000	12	0.500		
	Total	14.944	17			
Week ke-3	Between groups	16.000	5	3.200	6.400	0.004**
	Within groups	6.000	12	0.500		
	Total	22.000	17			
Week ke-4	Between groups	23.833	5	4.767	5.363	0.008**
	Within groups	10.667	12	0.889		
	Total	34.500	17			
Week ke-5	Between groups	15.333	5	3.067	5.520	0.007**
	Within groups	6.667	12	0.556		
	Total	22.000	17			

Note: ** Significantly different.

Table 5. DMRT test results of Brassica rapa total leaf at 5% level

Experiment	Value SPAD				
	W1	W2	W3	W4	W5
A	4.00a	5.00a	7.33a	10.00a	11.67a
B	4.00a	6.00abc	8.33ab	11.33ab	13.00abc
C	4.67a	6.67bc	9.00bc	12.67bc	14.00bc
D	5.00a	7.00c	10.00c	13.33c	14.33c
E	4.33a	5.67abc	8.00ab	11.00ab	12.67ab
F	4.33a	5.33ab	7.33a	10.67a	12.33a

Note: Different letters behind the numbers in the same column indicate significantly different values based on the Duncan test at the 5% level.

treatment D (7.00c) showed significant differences from treatment A (5.00a) and treatment F (5.33ab). In addition, in the second week, treatment C (6.67bc) showed a significant difference from treatment A (5.00a). In the third week of observation, treatment D again showed more leaves (10.00c) than the other treatments, followed by treatment C (9.00bc). Both treatments differed significantly from treatments A and F, which still showed lower leaf development (5.00a and 5.33ab). In the fourth and fifth weeks, the difference became more apparent. Treatments D (13.33c and 14.33c) and C (12.67bc and 14.00bc) continued to show significantly higher number of leaves and substantially different from treatments A (10.00a and 11.67a) and F (10.67a and12.33a). Treatments D and C showed significant differences every week compared to other treatments. However, treatment C was not below treatment D. The development of the highest number of leaves every week occurred in treatment D with 60% LOF concentration. While the lowest number of leaves was shown in treatment A (control) and treatment F (100% LOF). This can occur because plants need the right fertilizer concentration, too low or high concentrations will reduce plant productivity [19]. Giving LOF at too high a dose can cause plants to become stressed and poisoned so that the physiological processes of plants are disturbed and their growth is unstable [20].

Leaf width

The graph of the average leaf growth of *Brassica rapa* L plants from week zero to week five in six different treatments is presented in Figure 3. Based on the Figure, it can be seen that in the first and second weeks, from week to week, there was an increase in leaf width, but not significantly. All treatments experienced relatively the same increase in leaf width. In the third week, the increase began to appear; treatment D looked superior and showed the most significant increase in leaf width compared to the other treatments. Similar to the fourth and fifth weeks, treatment D with a concentration of 60% LOF consistently positively affected the growth of leaf width in *Brassica rapa* L plants. This could be due to the optimal balance of nutrients provided by LOF, including nitrogen and phosphate which are sufficient to support optimal leaf development. The increase in the number of leaves is related to the increase in plant height, if the plant is taller, the number of leaf growth points will increase [21].

Based on Table 6, it can be seen that the Sig. value in the first week is 0.780 or greater than 0.05, indicating no significant difference between treatments on the number of leaves.

In the second week, the Sig. (0.934) is also greater than 0.05, meaning there is no significant difference between the treatments on the number of leaves of *Brassica rapa* L plants. This indicates that until the second week, the LOF treatment did not have a significantly different impact on the number of leaves of *Brassica rapa* L plants. In the third week, the Sig. (0.158) was still greater than

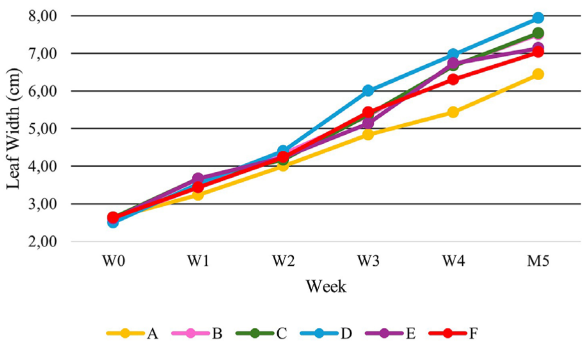

Figure 3. Average leaf width of *Brassica rapa* L. for five weeks

Table 6. Results of one-way ANOVA test of *Brassica rapa* L leaf width growth for five weeks

ANOVA						
Specification		Sum of squares	df	Mean square	F	Sig.
Week ke-1	Between groups	0.409	5	0.082	0.486	0.780
	Within groups	2.020	12	0.168		
	Total	2.429	17			
Week ke-2	Between groups	0.289	5	0.058	0.246	0.934
	Within groups	2.827	12	0.236		
	Total	3.116	17			
Week ke-3	Between groups	2.232	5	0.446	1.960	0.158
	Within groups	2.733	12	0.228		
	Total	4.965	17			
Week ke-4	Between groups	4.489	5	0.898	2.315	0.108
	Within groups	4.653	12	0.388		
	Total	9.143	17			
Week ke-5	Between groups	4.009	5	0.802	3.372	0.039**
	Within groups	2.853	12	0.238		
	Total	6.863	17			

Note: ** Significantly different.

0.05 but began to approach a significant value. This indicates a clearer trend of differences between treatments, even though it is not statistically significant. Plants began to respond to the application of LOF, which was watered every week. In the fourth week, the Sig. (0.108) was closer to the significant value than the previous week but still above 0.05. This shows a tendency for differences between treatments, although not significant enough. For the fifth week, the Sig. (0.039) is smaller than 0.05, indicating a significant difference between treatments on the number of leaves of *Brassica rapa* L. plants. This suggests that in the fifth week, the effect of LOF began to be seen significantly (Table 6).

The results of the DMRT analysis on the growth of leaf width of *Brassica rapa* L. plants at five weeks of observation are presented in Table 7.

The data shows the difference in leaf width under the influence of various LOF treatments from WWTP output of PT X. In the first week, all treatments followed by the same letter (a), there was no significant difference in leaf width among all treatments. The second week also showed similar results to the first week; all treatments were followed by the same letter (a), indicating no significant difference in leaf width growth between treatments. In the third week, treatment D (60% LOF) showed a value of 6.00b, which had a significant difference compared to treatment A (control) with a value of (4.83a). This indicates that treatment D began to have a positive effect on increasing the leaf width of *Brassica rapa* L. plants. In the fourth week, there was a clearer difference between treatment D (6.97b) and treatment A (5.43a). The letter ”b” indicates

Table 7. DMRT test results of Brassica rapaleaf width at 5% level

Experiment	Value SPAD				
	W1	W2	W3	W4	W5
A	3.23a	4.00a	4.83a	5.43a	6.43a
B	3.43a	4.33a	5.33ab	6.67b	7.50b
C	3.67a	4.17a	5.37ab	6.67b	7.53b
D	3.53a	4.40a	6.00b	6.97b	7.93b
E	3.67a	4.23a	5.13ab	6.73b	7.13ab
F	3.43a	4.23a	5.43ab	6.30ab	7.03ab

Note: Different letters behind the numbers in the same column indicate significantly different values based on the Duncan test at the 5% level.

that the treatment is significantly superior. In the fifth week, treatments D (7.93b), B (7.50b), and C (7.53b) showed higher and more significant results compared to treatment A (6.43a). Treatment D (60% LOF) consistently showed higher and significantly different results than the other treatments, especially in weeks 3, 4, and 5. This indicates that treatment D has a more significant positive impact on increasing leaf width in *Brassica rapa* L. As for the results of the lowest leaf width treatment A (control) compared to other treatments. According to [22], differences in leaf width are caused by the content of nutrients applied, if the nutrients given are in accordance with their needs, they can help plant growth and development properly. According to [19], the widest leaf area of plants can increase the rate of photosynthesis and accelerate the accumulation of photosynthesis so as to encourage the growth and development of plant organs such as the number of leaves, leaf area, stems, and roots.

Fresh weight

The fresh weight of *Brassica rapa* L. plants in six different treatments using LOF from WWTP output of PT X is shown in Figure 4.

Plant fresh weight is an important parameter that reflects the overall plant health and productivity level. Plant wet weight consists of leaves, stalks, and stems. Plant wet weight is measured by weighing the plants after harvesting before the plants wilt so that the plants do not lose too much water content. Based on Figure 3, treatment D showed the highest fresh weight results, averaging 44.433 grams. Treatments C and B also showed promising results with fresh weights of 39.00 grams and 36.33 grams, respectively. These two treatments are close to optimal results, although not as big as treatment D. Treatments E and F showed lower fresh weight with an average value of 31.33 grams and 29.33 grams. Meanwhile, the lowest yield occurred in treatment A (control), with an average of 23.33 grams. As a control watered with WWTP output of PT X every day. Plant A has the lowest fresh weight results. Plant fresh weight or plant wet weight can be influenced by the optimal availability of nutrients in the soil that can be absorbed by plant roots [23].

Based on Table 8, the one-way ANOVA analysis results on the fresh weight variable of *Brassica rapa* L. plants with Sig. (0.040) is smaller than 0.05, which means there is a significant difference in the fresh weight of *Brassica rapa* L. plants among the various treatments. This shows that the application of LOF from the WWTP output of PT X significantly increases the fresh weight

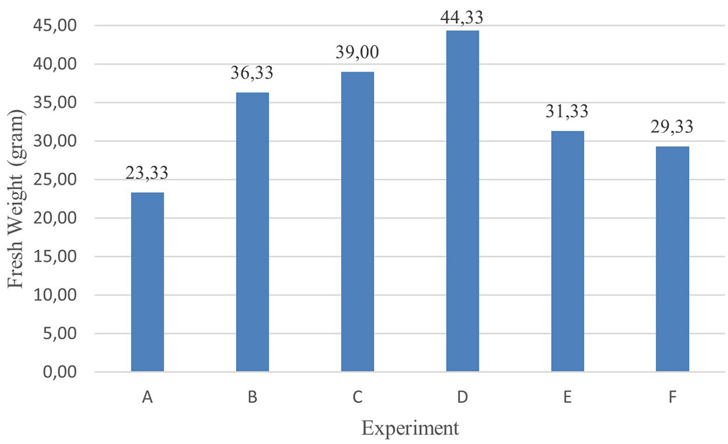

Figure 4. Average fresh weight of *Brassica rapa* L. for five weeks

Table 8. One-way ANOVA test results of fresh weight of *Brassica rapa*

ANOVA					
Specification	Sum of squares	df	Mean square	F	Sig.
Between groups	839.611	5	167.922	3.351	0.040**
Within groups	601.333	12	50.111		
Total	1440.944	17			

Note: ** Significantly different.

of plants. Thus, the application of LOF has a significant impact on the wet weight of plants because the application of LOF can routinely spur metabolism in *Brassica rapa* L. plants [24]. According to [21], plant fresh weight is related to the amount of water absorbed and the amount of nutrients provided. In addition, metabolic processes in plants can also affect the wet weight of plants, because an increase in the rate of photosynthesis will increase the rate of formation of carbohydrates and food substances [25]. According to [26], the accumulation of plant height, number of leaves, leaf width, and roots can affect the fresh weight of plants, the better the plant growth, the fresh weight will increase.

Differences in the fresh weight of *Brassica rapa* plants are due to differences in nutrient content in each treatment. Lack of nutrients and nutrients in the soil can result in low plant productivity [27]. If nutrients in the soil are not available, the development and growth of plants can be inhibited so that their production can decrease, which will reduce the fresh weight of plants [28]. The effect of LOF on the fresh weight of *Brassica rapa* plants was continued with the DMRT test at the 5% level. Based on the DMRT test results in Table 9, there is a significant difference in the wet weight of *Brassica rapa* L. plants among the various treatments. Treatment D showed a significant and highest value (44.33c). The low fresh weight of *Brassica rapa* L. plants in treatments A and F is caused by the composition of elements that are too low and too high. To obtain optimal plant fresh weight, balanced and appropriate nutrients are needed with the needs of plants [11]. The application of nutrient-rich fertilizers can significantly increase biomass production and plant fresh weight [29] Quality LOF can increase nutrient availability and improve soil structure through microorganism activity [30].

Table 9. DMRT test results of *Brassica rapa* L. fresh weight at 5% level

Experiment	Value
A	23.33a
B	36.33abc
C	39.00bc
D	44.33c
E	31.33abc
F	29.33ab

Note: Different letters behind the numbers in the same column indicate significantly different values based on the Duncan test at the 5% level.

Quality analysis of LOF content according to SNI in Regulation of the Minister of Agriculture No. 70 of 2011 Various internal and external factors influence the development and growth of pak choi (*Brassica rapa* L.) plants [31]. Internal factors are in the form of the genetic ability of plants, while external factors come from outside or the environment and available nutrients [32]. Nutrition is one of the main factors determining plant yield growth rate and quality [33]. Fertilization is one way to meet the needs of plants and can increase crop yields because it can provide nutrients for plant development and growth so that plants can grow optimally [34]. The sufficiency of nutrients during the growth of *Brassica rapa* L plants with the addition of LOF allows plants to absorb more nutrients [35]. The following is the content of LOF made from the WWTP output of PT X based on SNI in the Regulation of the Minister of Agriculture Number 70 of 2011 concerning organic fertilizers, biofertilizers, and soil improvers:

C-organic

The C-organic or organic carbon content in LOF is a vital parameter to show fertilizer's quality and effectiveness in supporting plant growth [36]. Organic carbon is one of the main components of organic matter that plays an important role in providing nutrients for plants, improving soil structure, increasing water retention, and supporting the activity of soil microorganisms [37]. Wastewater in industry X contains remnants of organic matter such as sugar and protein from X's production process. The organic carbon content in the wastewater-based LOF from the WWTP output of PT X is 3.61%, which means that it does not meet the technical requirements of SNI as stated in the Regulation of the Minister of Agriculture Number 70 of 2011. However, the value of LOF made from the WWTP output of PT X is still classified as suitable for use as fertilizer for plants because the content is still above 2%. According to [38], soil with optimal productivity requires more than 2% organic carbon so that the organic matter content does not decrease over time. Based on research conducted by [39], the content of 2 test samples before and after fermentation is still lower than the standard of the Minister of Agriculture Regulation Number 70 of 2011, only ranging from 0.42–1.40%, this is due to the application of EW4 which can break down carbohydrate compounds into simpler compounds. Low C-organic content is caused by the fermentation process which lacks carbon sources so that the growth of microorganisms is inhibited because they do not have sufficient energy sources [40].

Nitrogen

Nitrogen is a macronutrient that is very important for plant vegetative growth because it is needed for starch synthesis in leaves, amino acid production, and more optimal photosynthesis results [41]. In LOF made from WWTP output of PT X, the nitrogen content is one of the critical elements determining LOF's effectiveness in supporting plant vegetative growth. Wastewater from industry X contains various residual organic materials such as sugar, protein, and X residue. The results of laboratory tests show that the total nitrogen content in LOF from wastewater from WWTP output of PT X is 1.1%. Based on the SNI in the Regulation of the Minister of Agriculture Number 70 of 2011, the expected nitrogen content is 3% to 6%. Thus, the nitrogen content in the LOF from the WWTP output of PT X does not meet the minimum standards set by SNI. Low nitrogen content in LOF can reduce the effectiveness of fertilizer for plants [42]. The higher nitrogen levels in plants give plants broader leaves with greener leaf color, so photosynthesis is more optimal [43]. Based on research conducted by [44], in the five LOF samples made from laundry liquid waste with varying EW4 concentrations, the nitrogen content is still below the standard of the Minister of Agriculture Regulation Number 70 of 2011, which is still below 0.04%. The study said that the low nitrogen content that occurred was likely due to the length of time of fermentation so that the content of organic matter decreased.

Phosphate

Phosphate is one of the essential macronutrients required for various plant physiological functions, including energy generation, root development, and DNA synthesis [45]. In addition, phosphate is also required in root development, seed, and flower formation, strengthening roots and stems, cell division and division, and transporting genetic traits [46]. Laboratory test results show that the P_2O_5 content in LOF made from WWTP output of PT X is 0.385%, which means that the content is still far below the set standard. Phosphate helps plants provide food for cells so that the energy cells need is sufficient to carry out cell division, and stem elongation will be faster [47]. If the plant lacks the element P, the development of the plant is not perfect, or it cannot carry out metabolic processes optimally [48]. Phosphate-deficient plants usually show slow growth and appear stunted [49]. Based on research conducted by [44]. the five LOF samples made from laundry liquid waste with varying EW4 concentrations have a phosphate content that is still far below the standard of the Minister of Agriculture Regulation Number 70 of 2011, which is still below 0.005%.

Potassium

Potassium is one of the three essential macronutrients besides nitrogen and phosphate that plants require in large quantities [50]. Potassium is important in plant metabolism and physiological processes [51]. These physiological processes include controlling osmotic pressure, pH stability, increasing plant resistance to certain diseases, and regulating water through stomata [52]. In addition, potassium also has a role in plant resistance to certain diseases and can improve plant quality [53]. The laboratory test results in Table 10 show that the total nitrogen content in LOF from the WWTP output of PT X is 0.485%. Based on SNI in the Regulation of the Minister of Agriculture Number 70 of 2011, the expected nitrogen content is 3% to 6%. Thus, the nitrogen content in the LOF from the WWTP output of PT X does not meet the minimum standards set by SNI. Potassium-rich LOF can improve plant health by improving osmotic regulation and photosynthetic efficiency [54]. Based on research conducted by [55], the potassium content in four variations of LOF from the utilization of food waste has the highest value of 0.29%, which means it is not in accordance with the standards of the Minister of Agriculture Regulation Number 70 of 2011. To improve the quality of LOF, it is necessary to make adjustments in the production process such as using materials that contain N, P, K in greater quantities. This can be done by adding raw materials from forage waste or manure [56].

pH

The degree of acidity or pH is an important parameter that can affect the availability of nutrients for plants and the interaction between plants and soil microorganisms [57]. pH measurement is carried out to measure the acidity or basicity of LOF [58]. An appropriate pH value can increase the effectiveness of LOF as an organic fertilizer for plant growth [59]. Table 10 shows that the content of tofu industry wastewater after fermentation for 15 days has an acidic pH with a value of 5.27. This indicates that the pH of the LOF is in accordance with the SNI LOF standard. During the LOF fermentation process, pH plays a vital role in determining the activity and survival of microorganisms that play a role in the decomposition of organic matter. Inappropriate pH values can inhibit fermentation activity and cause microorganisms' death [60]. A pH value that is too acidic (low) causes the enzyme activity of microorganisms to be inhibited because the enzyme structure is damaged so that the fermentation process does not take place properly and produces products that are not suitable [61]. Like acidic conditions, pH that is too alkaline can also inhibit the growth of microorganisms [19]. Fermentative microorganisms that cannot survive in alkaline conditions will experience structural changes in proteins and cell membranes so that they cannot work optimally and experience a decrease in activity due to too high a pH [62].

The content of LOF made from industrial outlet water X has lower results than SNI but the results of making this LOF have a positive impact because it can reduce environmental pollution and has the potential for soil fertilization. In addition, the application of LOF can also reduce spending on buying inorganic fertilizers and has the potential to be marketed [63]. To increase the nutrient content in LOF from WWTP Output of PT X, it is necessary to add auxiliary organic ingredients. According to [64], the auxiliary materials that can be used are chopped plants in the form of pruning from the legume family, weeds, or forages that are known to have high nutrient content. In addition, the addition of organic matter can also be done by using animal feces or urine such as goats, sheep, and cows which have high nutrient content [65]. According to [25], animal manure is rich in nutrients such as nitrogen, phosphorus, and potassium. The content of urine in addition to increasing plant growth also improves physical, chemical properties and soil microbial populations, and controls plant pests [66].

Table 10. Test results of LOF from WWTP output of PT X

No	Analysis	Result	SNI
1.	C-organic	3.61%	Min 6%
2.	N-total	1.1%	3–6%
3.	P_2O_5	0.385%	3–6%
4.	K_2O	0.485%	3–6%
5.	pH	5.27	4–9

CONCLUSIONS

The application of wastewater-based LOF from WWTP output of PT X has a significant effect on the growth of pak choi (*Brassica rapa* L.) plants in the fourth and fifth week of plant height parameters, the number of leaf parameters from the second to the fifth week, the leaf width parameter in the fifth week, and the fresh weight parameter. The optimal treatment of the LOF comparison of all parameters is in treatment D (60% LOF) with an average height of 19.47 cm, number of leaves of 14 strands, leaf width of 7.93 cm, and fresh weight of 44.33 grams.

Liquid organic fertilizer (LOF) from wastewater from WWTP output of PT X contains C-organic 3.61%, nitrogen 1.1%, phosphate 0.385%, potassium 0.485%, and pH 5.27. These values have not met the SNI LOF in the Minister of Agriculture Number 70 Regulation of 2011.

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