

The Effectiveness of Oil Palm Empty Fruit Bunch Growing Media and Liquid Organic Fertilizer on the Production of Pakcoy Mustard (*Brassica rapa*) in a Hydroponic System

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ABSTRACT

The study was conducted to determine the effectiveness of planting media and liquid organic fertilizer on the production of pakcoy mustard in a hydroponic system. Using a factorial Completely Randomized Design (RAL) method. The first factor of planting media consisted of four levels: M1: TKKS, M2: TKKS+cocopeat (75:25), M3: TKKS+cocopeat (50:50), M4: TKKS+cocopeat (25:75). The second factor of liquid organic fertilizer consisted of four levels: K1: AB Mix, K2: POC 10%, K3: POC 15%, K4: POC 20%. The total treatment was 16 combinations and 32 experimental units. The results of statistical tests showed that the combination of planting media and liquid organic fertilizer from fruit waste had no significant effect on plant height and number of leaves, but had a very significant effect on leaf width, leaf length, leaf area, sample weight, and weight per plot. In addition to the control treatment, the use of TKKS+cocopeat (75:25) planting media and 10% POC provided the best results, thus potentially increasing pak choy mustard production.

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Introduction

Pakcoy mustard (*Brassica rapa*) is one of the most popular vegetables in Indonesia due to its high nutritional content and ease of cultivation. In efforts to improve the productivity and quality of pakcoy plants, the use of appropriate growing media and fertilization is very important. Based on data from the Central Bureau of Statistics (2025), mustard production in Indonesia in 2024 increased compared to the previous year. In 2023, mustard production reached 6,868,756.65 tons, while in 2024, mustard production in Indonesia was 6,885,951.97 tons. This indicates that public consumption of mustard greens in 2024 increased compared to 2023.

The increase in agricultural production in Indonesia can be achieved through several methods, one of which is by implementing extensification and intensification efforts. Agricultural extensification is a method of increasing yield by expanding agricultural land,

while agricultural intensification is a method of improving agricultural output through optimal land utilization, such as the proper use of technology. One approach in implementing agricultural intensification is the utilization of organic materials. The use of organic materials can be applied through the application of liquid organic fertilizers. Hydroponic cultivation is a planting method that does not require soil and is highly suitable for urban areas with limited land availability. In recent years, hydroponics has been considered a promising approach for cultivating various types of plants (Nainggolan et al., 2022).

The growing medium commonly used in hydroponic cultivation is rockwool. However, there are several drawbacks to using rockwool, one of which is its relatively high cost, especially when it must be imported. The utilization of oil palm empty fruit bunches (TKKS) as a hydroponic growing medium offers advantages as a solid waste material that can be recycled, thereby reducing negative environmental impacts (Harahap et al., 2020). In addition, oil palm empty fruit bunches (TKKS) possess characteristics that are suitable for hydroponic plant requirements, such as the ability to absorb water and nutrients effectively, provide oxygen to plant roots, and offer a strong and stable structure. Furthermore, they are available in large quantities and can be obtained at an affordable cost (Lubis et al., 2023). In addition, the use of cocopeat is also an appropriate alternative growing medium to replace rockwool. According to (Simanjuntak et al., 2018) coconut coir dust (cocopeat) is chosen due to its high ability to retain and bind water.. Meanwhile, rice husk charcoal is widely used because of its ability to support plant stems, its high carbon (C) content, as well as its capacity to retain nutrients effectively and provide optimal aeration (Awali et al., 2020).

Organic waste generated from household activities has the potential to be utilized as raw material for the production of organic fertilizer. This fertilizer can then be used as a supporting medium for the growth of cultivated plants around residential yards (Sinaga et al., 2023). Organic fertilizer is a type of fertilizer produced from the waste materials of living organisms, including plants, animals, and humans. The main function of organic fertilizer is to improve the physical properties of plants, enhance soil structure, and increase the soil's ability to retain water. Organic fertilizers can be available in solid forms, such as manure, green manure, and compost, as well as in liquid forms, such as liquid fertilizer derived from fermented livestock urine or fermented fruit peels (Sinaga et al., 2023).

Based on its form, organic fertilizers can be classified into two types: liquid organic fertilizer (POC) and solid organic fertilizer (POP). POC is synthesized through the fermentation process of organic materials such as waste and agricultural products, and this fermentation is generally carried out under anaerobic conditions (Lubis et al., 2022). Liquid organic fertilizer is a type of fertilizer with a low chemical content, maximum 5%, and it can supply nutrients according to plant needs in the soil due to its liquid form. If there is an excess of fertilizer capacity in the soil, the plant can naturally regulate the absorption of the required fertilizer composition. In fertilization, liquid organic fertilizer is distributed more evenly and does not cause nutrient accumulation in one place, as it is 100% soluble. This type of fertilizer has the advantage of quickly overcoming nutrient deficiencies, does not

cause nutrient leaching problems, and is able to provide nutrients rapidly (Amin et al., 2023). The level of crop production is certainly influenced by soil fertility (Patty, 2024)

An analysis of macronutrient content (N, P, K, Ca, Mg) in liquid organic fertilizer made from tropical fruit peels shows that liquid organic fertilizer produced from pineapple peel and dragon fruit peel contains a higher level of nitrogen (N) than the quality standard, while phosphorus (P) and potassium (K) levels are below the standard. Meanwhile, liquid organic fertilizer made from pineapple peel and orange peel contains nitrogen (N), phosphorus (P), and potassium (K) levels that are all below the quality standard (Marjenah et al., 2018). According to the results of the study (Kurniawati, 2024) The nutrient content of liquid organic fertilizer made from dragon fruit peel and pineapple peel at the 6th week was N 5.11%, P 0.53%, K 0.471%, Ca 0.133%, Mg 0.022%, with a pH of 3.67.

Based on the statements above, the author conducted a study to determine the effectiveness of growing media and the application of liquid organic fertilizer from fruit waste on the production of pakcoy mustard (*Brassica rapa*) in a hydroponic system.

Method

This study was conducted in Bangun Rejo Village, Hamlet 5, Tanjung Morawa District, Deli Serdang, North Sumatra, from October to December 2025 using a wick hydroponic system. The materials used in this study included pakcoy mustard seeds, AB Mix fertilizer, rockwool, and liquid organic fertilizer made from mangosteen peel, kuini peel, orange peel, and papaya peel with code BZ 60624. In addition, sawdust, cocopeat, and oil palm empty fruit bunches (TKKS) were also used. The equipment used in this study included installation trays, net pots, barrels, flannel cloth, measuring cylinders, syringes, a TDS meter, a ruler, writing tools, a digital scale, a laptop, a scalpel, seedling trays, and toothpicks.

This study was conducted using a factorial completely randomized design (RAL) consisting of two factors, each with four levels and replicated twice for each treatment, resulting in a total of 32 experimental units. The first factor was the growing medium: M1: TKKS, M2: TKKS+cocopeat (25:75), M3: TKKS+cocopeat (50:50), and M4: TKKS+cocopeat (75:25). Faktor kedua adalah dosis pupuk organik cair limbah buah yang terdiri dari empat bagian: K: AB Mix, K2: POC 10%, K3: POC 15%, dan K4: POC 20%. The data were analyzed using ANOVA, and if the treatments showed a significant effect, further testing was conducted using Duncan's Multiple Range Test (DMRT).

The research procedures are as follows:

Sowing and Transplanting

The growing media were placed according to the experimental units and arranged in seedling trays. After that, the growing media were moistened with water until fully saturated, and a toothpick was used to make a hole in the center of the medium. One pakcoy seed was planted in each planting hole. The seedlings were watered daily with 1 liter of water until

10–14 days after sowing (HSS) or when the plants had 3–4 leaves, at which point they were ready for transplanting.

Application of Liquid Organic Fertilizer

The application of liquid organic fertilizer made from mangosteen peel, kuini peel, orange peel, and papaya peel with code BZ 60624 contains N 0.04%, P 0.03%, K 0.39%, organic carbon (C-organic) 0.90%, and has a pH of 4.72 (Laboratorium Badan Perakitan dan Modernisasi Pertanian, 2026). The nutrients from fruit peel waste were applied to plants aged 2–5 weeks after planting (MST) at weekly intervals, with dosages according to the treatments, namely K1: AB Mix (control), K2: POC 10%, K3: POC 15%, and K4: POC 20%. The preparation of concentration (%) was carried out as follows: for example, a 10% POC solution was made by mixing 10 ml of POC with 1000 ml of water, and the same method was applied for other concentrations. The amount of AB Mix solution applied to pakcoy plants was 700–1200 ppm, and the concentration was gradually increased starting from the second week of planting. All treatments had the same initial nutrient concentration level of 700–800 ppm. This concentration was then increased during weekly nutrient replacement, namely 900–1000 ppm in the second week of planting and 1100–1200 ppm in the third week of planting (Miranti et al., 2023).

Plant Maintenance

To ensure that the water absorbed meets the plant's requirements, measurements of pH, ppm levels, and water temperature were carried out daily. This was done using a pH meter, TDS meter, and thermometer.

Harvesting

Pakcoy plants were harvested at 42 to 45 days after transplanting (HST), characterized by broad leaves, dark green leaf color, and leaf edges beginning to droop. To ensure that the roots were not damaged, the plants were carefully removed from the net pots during harvesting.

Observation Parameters

Plant height (cm), number of leaves (leaves), leaf length (cm), leaf width (cm), and leaf area (cm), with a constant value using the formula: $LA_{0.5} = 0.393 + 0.705LW$ (Rusdiana et al., 2021), sample weight (g), weight per plot (g)

Results and Discussion

Plant Height

The statistical test results showed that the treatment of oil palm empty fruit bunch (TKKS) growing media and liquid organic fertilizer from fruit waste had no significant effect, and there was no interaction between the two treatments on the plant height of pakcoy mustard. The average plant height of pakcoy mustard at 5 weeks after planting (MST) can be seen in Table 1.

Table 1. Plant height (cm) of pakcoy mustard under growing media and liquid organic fertilizer from fruit waste treatments at 5 weeks after planting (MST)

Treatment	Mean	Notation
Growing Media		
M1 TKKS	14,60	a
M2 TKKS:Cocopeat (75:25)	13,88	a
M3 TKKS:Cocopeat (50:50)	13,46	a
M4 TKKS:Cocopeat (25:75)	13,42	a
Liquid Organic Fertilizer		
K1 AB Mix	14,79	a
K2 POC 10%	14,13	a
K3 POC 15%	13,29	a
K4 POC 20%	13,15	a

Note: Values followed by different letters indicate a significant difference at the 5% level (lowercase letters)

In Table 1, it can be seen that the highest average plant height of pakcoy mustard using oil palm empty fruit bunch (TKKS) growing media was found in treatment M1: TKKS, namely 14.60 cm, while the lowest was in treatment M4: TKKS+cocopeat (25:75), namely 13.42 cm. The best combination of TKKS+cocopeat growing media was found in treatment M2: TKKS+cocopeat (75:25), which was 13.88 cm. This is in line with previous research (Lubis et al., 2023) The growing media treatment using oil palm empty fruit bunches (TKKS) showed the highest results in all measured parameters, including plant height, number of leaves, root length, as well as yield per sample and per plot. This is likely due to the content of nitrogen (N), phosphorus (P), and potassium (K) in the TKKS growing media, which are essential for plant growth during both vegetative and generative phases. This finding is consistent with previous studies showing that pakcoy plants can grow well when cultivated using TKKS and rockwool growing media. After the cultivation period, the measured nutrient content in the TKKS growing media showed nitrogen (N) at 0.70%, phosphorus (P) at 1.117%, and potassium (K) at 0.465%. Meanwhile, in rockwool, the nutrient content recorded was 0.21% N, 1.290% P, and 0.392% K.

In Table 1, it can be seen that the highest average plant height of pakcoy mustard under the application of liquid organic fertilizer from fruit waste was found in treatment K1: AB Mix, namely 14.79 cm, while the lowest was in treatment K4: 20% POC, namely 13.15 cm. The best treatment for the concentration of liquid organic fertilizer from fruit waste was found in K2: POC 10%, which was 14.13 cm. The deficiency of nutrients in plants causes them not to grow optimally. This is further emphasized (Lubis et al., 2022) the photosynthesis process will proceed effectively when the availability of nutrients in the soil is balanced, neither excessive nor deficient, thereby supporting proper plant growth and production.

Number of Leaves

The statistical test results showed that the oil palm empty fruit bunch (TKKS) planting media treatment and liquid organic fertilizer from fruit waste had no significant effect, and there was no interaction between the two treatments on the number of leaves of pakcoy mustard plants. The average number of leaves of pakcoy mustard at 5 weeks after planting (MST) can be seen in Table 2.

Table 2. Number of leaves (leaves) of pakcoy mustard under growing media and liquid organic fertilizer from fruit waste treatments at 5 weeks after planting (MST)

Treatment	Mean	Notation
Growing Media		
M1 TKKS	8,50	a
M2 TKKS:Cocopeat (75:25)	7,83	a
M3 TKKS:Cocopeat (50:50)	7,79	a
M4 TKKS:Cocopeat (25:75)	7,71	a
Liquid Organic Fertilizer		
K1 AB Mix	8,17	a
K2 POC 10%	8,04	a
K3 POC 15%	7,96	a
K4 POC 20%	7,67	a

Note: Values followed by different letters indicate a significant difference at the 5% level (lowercase letters)

In Table 2, it can be seen that the highest average number of leaves of pakcoy mustard using oil palm empty fruit bunch (TKKS) growing media was found in treatment M1: TKKS, namely 8.50 leaves, while the lowest was in treatment M4: TKKS+cocopeat (25:75), namely 7.71 leaves. The best combination of TKKS+cocopeat growing media was found in treatment M2: TKKS+cocopeat (75:25), which was 7.83 leaves. In addition to nutrient requirements that must be met to support plant growth and production, environmental factors also play a role in inhibiting plant growth. This is consistent with previous research (Aisyah et al., 2025) weather has a significant influence on the study. High rainfall causes changes in the application of guano fertilizer and coconut water-based liquid organic fertilizer, which unpredictably affects the growth and yield of Chinese cabbage

In Table 2, it can be seen that the highest average number of leaves of pakcoy mustard under the application of liquid organic fertilizer from fruit waste was found in treatment K1: AB Mix, namely 8.17 leaves, while the lowest was in treatment K4: POC 20%, namely 7.67 leaves. The best treatment for the concentration of liquid organic fertilizer from fruit waste was found in K2: POC 10%, which was 8.04 leaves. According to previous research (Lubis et al., 2022) the application of liquid organic fertilizer (POC) and vegetables did not show a significant effect on the observations of plant height (cm) and number of leaves (leaves). Nutrient uptake in the soil can only occur when plant roots come into contact with the soil. Plant roots develop and penetrate soil particles, allowing interaction between the roots and nutrients dissolved in the soil.

Leaf Width

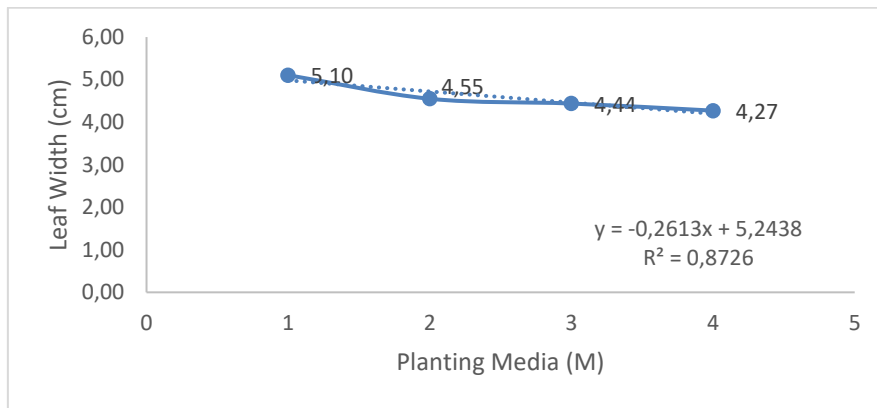
The statistical test results showed that the oil palm empty fruit bunch (TKKS) planting media treatment and the liquid organic fertilizer from fruit waste had a highly significant effect, and there was an interaction between the two treatments on the leaf width of pakcoy mustard plants. The average leaf width of pakcoy mustard plants at 5 weeks after planting (MST) can be seen in Table 3.

Table 3. Leaf width (cm) of pakcoy mustard under different planting media treatments and liquid organic fertilizer derived from fruit waste at 5 weeks after planting (MST)

Treatment	Mean	Notation
Growing Media		
M1 TKKS	5,10	d
M2 TKKS:Cocopeat (75:25)	4,55	bc
M3 TKKS:Cocopeat (50:50)	4,44	ab
M4 TKKS:Cocopeat (25:75)	4,27	a
Liquid Organic Fertilizer		
K1 AB Mix	4,85	c
K2 POC 10%	4,58	abc
K3 POC 15%	4,52	ab
K4 POC 20%	4,40	a

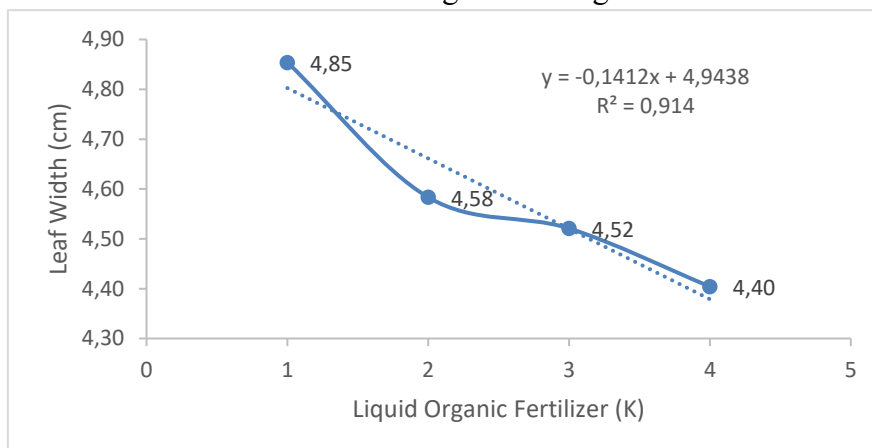
Note: Values followed by different letters indicate a significant difference at the 5% level (lowercase letters)

In Graph 1, it can be seen that the average leaf width of pakcoy mustard greens using oil palm empty fruit bunch (TKKS) planting media was highest in treatment M1: TKKS, at 5.10 cm, and lowest in treatment M4: TKKS+cocopeat (25:75), at 4.27 cm. The best combination treatment of TKKS+cocopeat planting media was found in treatment M2: TKKS+cocopeat (75:25), at 4.55 cm. This is in accordance with the study (Sirait et al., 2025) states that the total nitrogen content (N-total) in oil palm empty fruit bunches (TKKS) reaches 1.52%, far exceeding the minimum limit set by the Indonesian National Standard (SNI), which is 0.4%. This condition is highly advantageous, considering that nitrogen is an essential macronutrient required by plants in significant amounts, especially to support vegetative growth such as leaf and stem formation.



Graph 1. Leaf width of pakcoy mustard at 5 weeks after planting with the application of TKKS planting media

In Graph 2, it can be seen that the average leaf width of pakcoy mustard greens with the application of liquid organic fertilizer from fruit waste was highest in treatment K1: AB Mix, at 4.85 cm, and lowest in treatment K4: POC 20%, at 4.40 cm. The best treatment in terms of concentration of liquid organic fertilizer from fruit waste was found in treatment K2: POC 10%, at 4.58 cm. The nutrient most required by plants for leaf growth is nitrogen (N). A deficiency of nitrogen in plants can result in smaller leaves and earlier leaf drop. In addition, nitrogen deficiency can cause the leaves to turn yellow. This is in line with the study (Sinaga et al., 2023) The application of liquid organic fertilizer (POC) derived from fruit peels at a dose of 0.4 ml in treatment 3 (P3) showed the most optimal results compared to other treatments, including the positive control treatment using commercial POC. Plants that do not receive sufficient nitrogen tend to grow smaller and have smaller leaves as well.



Graph 2. Leaf width of pakcoy mustard greens at 5 weeks after planting with the application of liquid organic fertilizer from fruit waste

Leaf Length

The statistical test results showed that the oil palm empty fruit bunch (TKKS) planting media treatment and the liquid organic fertilizer from fruit waste had a highly significant effect, and there was an interaction between the two treatments on the leaf length of pakcoy

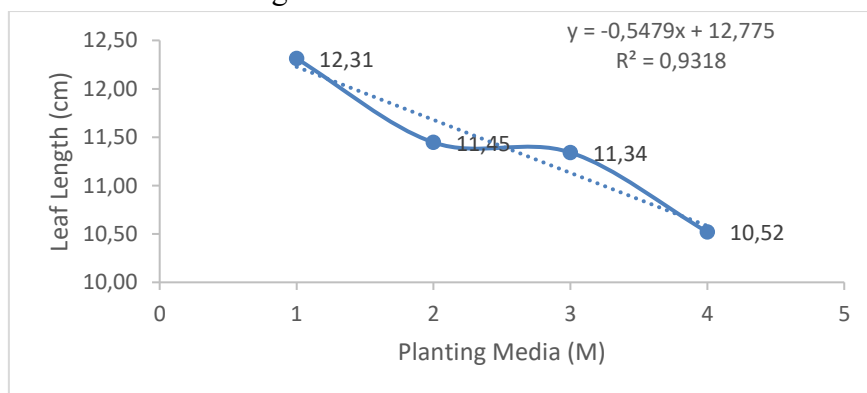
mustard plants. The average leaf length of pakcoy mustard plants at 5 weeks after planting (MST) can be seen in Table 4.

Table 4. Leaf length (cm) of pakcoy mustard under planting media and liquid organic fertilizer treatments at 5 weeks after planting (MST)

Treatment	Mean	Notation
Growing Media		
M1 TKKS	12,31	d
M2 TKKS:Cocopeat (75:25)	11,45	bc
M3 TKKS:Cocopeat (50:50)	11,34	b
M4 TKKS:Cocopeat (25:75)	10,52	a
Liquid Organic Fertilizer		
K1 AB Mix	12,19	d
K2 POC 10%	11,37	bc
K3 POC 15%	11,10	ab
K4 POC 20%	10,96	a

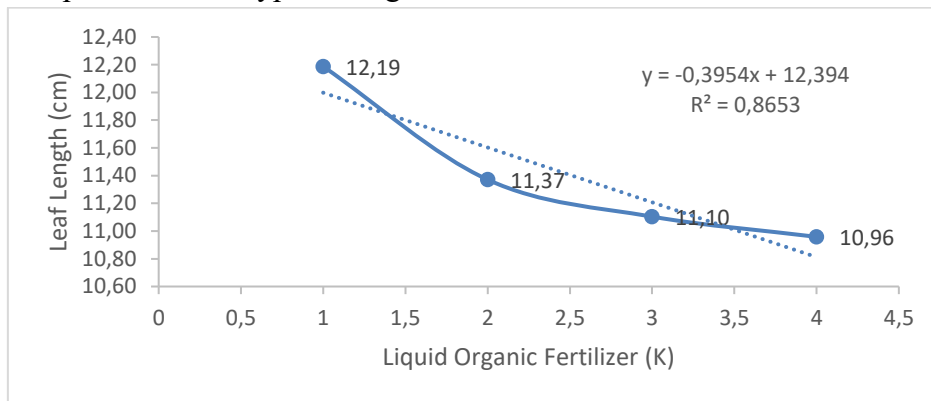
Note: Values followed by different letters indicate a significant difference at the 5% level (lowercase letters)

In Graph 3, it can be seen that the average leaf length of pakcoy mustard greens using oil palm empty fruit bunch (TKKS) planting media was highest in treatment M1: TKKS, at 12.31 cm, and lowest in treatment M4: TKKS+cocopeat (25:75), at 10.52 cm. The best combination treatment of TKKS+cocopeat planting media was found in treatment M2: TKKS+cocopeat (75:25), at 11.45 cm. Plant growth in terms of length is strongly influenced by phosphorus (P). This nutrient plays a role in cell division, which promotes leaf elongation and root formation, allowing leaves to grow longer. The phosphorus content in the TKKS planting media was sufficient to meet the nutrient needs of pakcoy mustard plants in this study. This is consistent with the study (Harahap et al., 2024) that phosphorus (P) is one of the most important and essential macronutrients for plants, as it functions in providing chemical energy required for almost all plant metabolic processes. In addition, phosphorus also contributes to root system growth, cell division processes, and increases yield in terms of seed and fruit weight.



Graph 3. Leaf length of pakcoy mustard at 5 weeks after planting with the application of TKKS planting media

In Graph 4, it can be seen that the average leaf length of pakcoy mustard greens with the application of liquid organic fertilizer from fruit waste was highest in treatment K1: AB Mix, at 12.19 cm, and lowest in treatment K4: POC 20%, at 10.96 cm. The best treatment in terms of concentration of liquid organic fertilizer from fruit waste was found in treatment K2: POC 10%, at 11.37 cm. The appropriate application of fertilizer dosage can improve plant growth and production optimally. Fertilizer dosage is applied to ensure that plants receive macro and micronutrients efficiently. This is in line with the study (Sembiring et al., 2024) Fertilizer is a crucial source of nutrients for plant growth, generally available naturally in soil, air, and animal manure. The function of fertilizer is highly significant in increasing plant productivity, especially in soils with low nutrient content. The environmentally friendly liquid organic fertilizer produced has a more balanced nutrient composition compared to other types of organic fertilizers.



Grafik 4. Leaf length of pakcoy mustard at 5 weeks after planting with the application of liquid organic fertilizer from fruit waste

Leaf Area

The statistical test results showed that the oil palm empty fruit bunch (TKKS) planting media treatment and the liquid organic fertilizer from fruit waste had a highly significant effect, and there was an interaction between the two treatments on the leaf area of pakcoy mustard plants. The average leaf area of pakcoy mustard plants at 5 weeks after planting (MST) can be seen in Table 5.

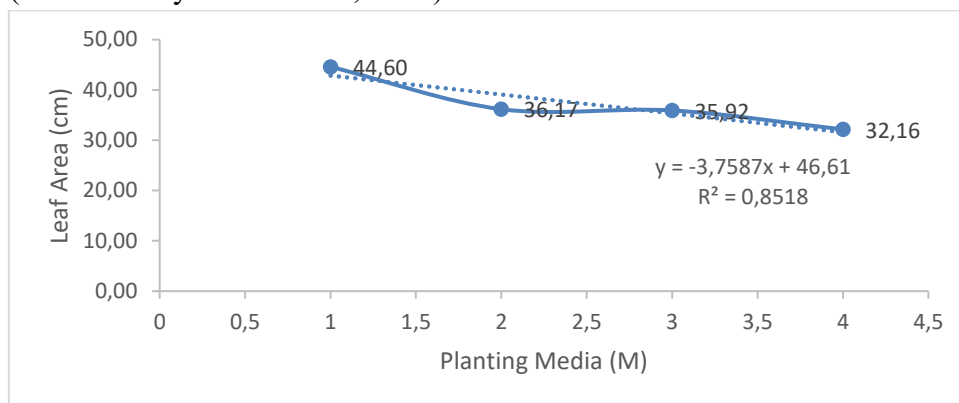
Table 5. Leaf area (cm) of pakcoy mustard under planting media and liquid organic fertilizer treatments at 5 weeks after planting (MST)

Treatment	Mean	Notation
Growing Media		
M1 TKKS	44,60	c
M2 TKKS:Cocopeat (75:25)	36,17	bc
M3 TKKS:Cocopeat (50:50)	35,92	ab
M4 TKKS:Cocopeat (25:75)	32,16	a
Liquid Organic Fertilizer		
K1 AB Mix	41,96	c

K2 POC 10%	37,53	bc
K3 POC 15%	35,59	ab
K4 POC 20%	33,77	a

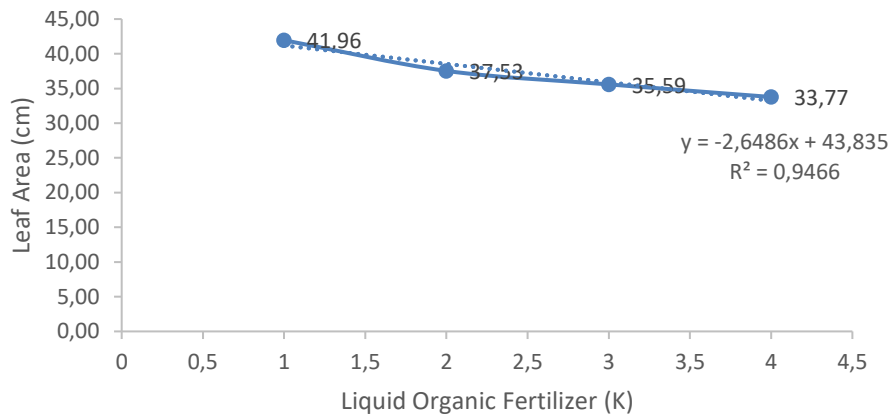
Note: Values followed by different letters indicate a significant difference at the 5% level (lowercase letters)

In Graph 5, it can be seen that the average leaf area of pakcoy mustard greens using oil palm empty fruit bunch (TKKS) planting media was highest in treatment M1: TKKS, at 44.60 cm, and lowest in treatment M4: TKKS+cocopeat (25:75), at 32.16 cm. The best combination treatment of TKKS+cocopeat planting media was found in treatment M2: TKKS+cocopeat (75:25), at 36.17 cm. This is due to the availability of nutrients in the oil palm empty fruit bunch planting media, which is able to meet the nutrient requirements of pakcoy mustard plants. Appropriate nutrient content promotes plant height growth, as the increase in plant height is directly related to the increase in available nutrients. These nutrients are very important in supporting root development, both in terms of the quantity of roots formed, which can have either positive or negative effects on overall plant growth (Ilmam Hidayat & Guritno, 2023)



Graph 5. Leaf area of pakcoy mustard at 5 weeks after planting with the application of TKKS planting media

In Graph 6, it can be seen that the average leaf area of pakcoy mustard greens with the application of liquid organic fertilizer from fruit waste was highest in treatment K1: AB Mix, at 41.96 cm, and lowest in treatment K4: POC 20%, at 33.77 cm. The best treatment in terms of concentration of liquid organic fertilizer from fruit waste was found in treatment K2: POC 10%, at 37.53 cm. The results of the study showed a significant difference between different POC treatments on the leaf area of pakcoy mustard greens. The use of AB Mix still gave the best results for leaf area; however, the application of fruit-waste liquid organic fertilizer at a 10% concentration was the closest to the results obtained with AB Mix compared to the 15% and 20% concentrations. This is in line with the study (Jemian, 2025) which found that a 10% concentration of liquid organic fertilizer (POC) can significantly enhance plant growth.



Graph 6. Leaf area of pakcoy mustard at 5 weeks after planting with the application of liquid organic fertilizer from fruit waste

Sample Weight

The statistical test results showed that the oil palm empty fruit bunch (TKKS) planting media treatment and the liquid organic fertilizer from fruit waste had a highly significant effect, and there was an interaction between the two treatments on the sample weight of pakcoy mustard plants. The average sample weight of pakcoy mustard plants at 5 weeks after planting (MST) can be seen in Table 6.

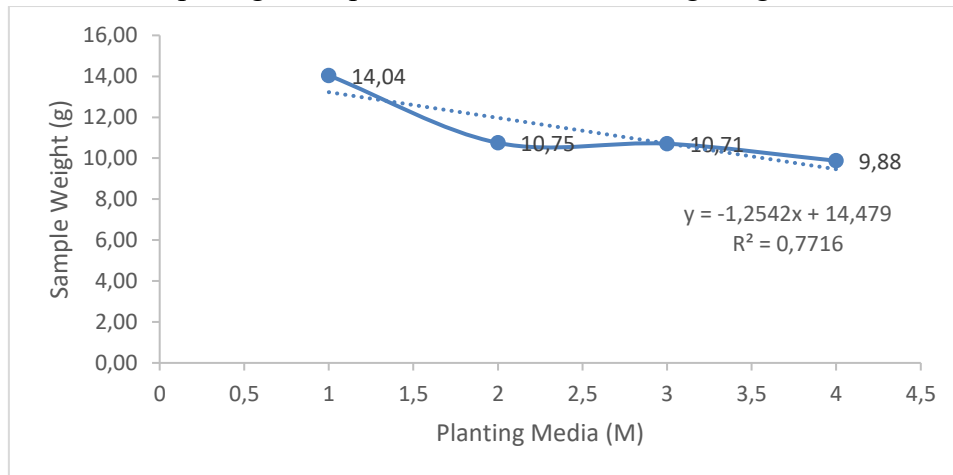
Table 6. Sample weight (g) of pakcoy mustard under planting media and liquid organic fertilizer treatments at 5 weeks after planting (MST)

Treatment	Mean	Notation
Growing Media		
M1 TKKS	14,04	c
M2 TKKS:Cocopeat (75:25)	10,75	ab
M3 TKKS:Cocopeat (50:50)	10,71	ab
M4 TKKS:Cocopeat (25:75)	9,88	a
Liquid Organic Fertilizer		
K1 AB Mix	14,33	c
K2 POC 10%	12,33	c
K3 POC 15%	9,42	ab
K4 POC 20%	9,29	a

Note: Values followed by different letters indicate a significant difference at the 5% level (lowercase letters)

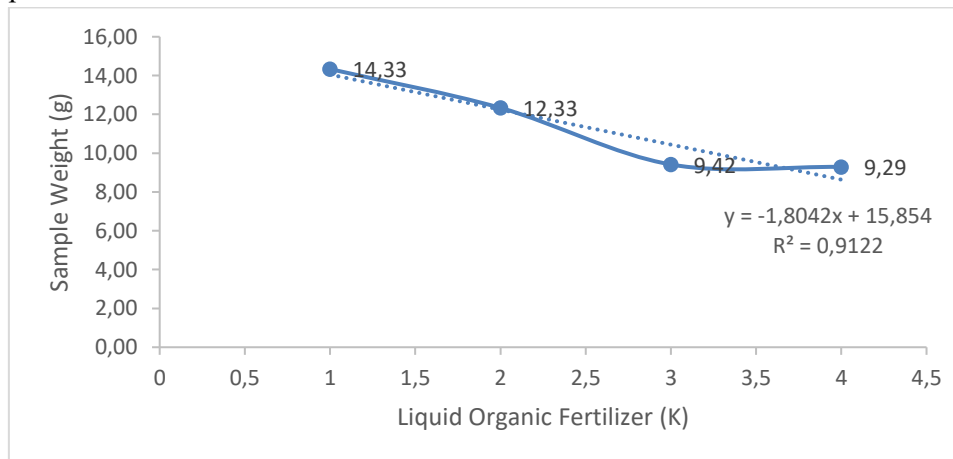
In Graph 7, it can be seen that the average sample weight of pakcoy mustard greens using oil palm empty fruit bunch (TKKS) planting media was highest in treatment M1: TKKS, at 14.04 g, and lowest in treatment M4: TKKS+cocopeat (25:75), at 9.88 g. The best combination treatment of TKKS+cocopeat planting media was found in treatment M2: TKKS+cocopeat (75:25), at 10.75 g. In addition to the availability of nutrients that are essential for plants, other supporting factors are also needed in the photosynthesis process,

such as water, which is able to transport nutrients absorbed by the roots and distribute them throughout the plant organs. According to (Putra et al., 2024) plant weight is obtained from the photosynthesis process and is stored during the plant's growth and development phases. Therefore, if plant growth proceeds well, the resulting weight will increase.



Graph 7. Sample weight of pakcoy mustard at 5 weeks after planting with the application of TKKS planting media

In Graph 8, it can be seen that the average sample weight of pakcoy mustard greens with the application of liquid organic fertilizer from fruit waste was highest in treatment K1: AB Mix, at 14.33 g, and lowest in treatment K4: POC 20%, at 9.29 g. The best treatment in terms of concentration of liquid organic fertilizer from fruit waste was found in treatment K2: POC 10%, at 12.33 g. (Luta, 2023) states that fertilizer is a very important factor in the success of increasing crop production. Fertilizer is also a highly important production input and contributes 20% to the success of increasing production.



Graph 8. Sample weight of pakcoy mustard at 5 weeks after planting with the application of liquid organic fertilizer from fruit waste

Weight Per Plot

The statistical test results showed that the oil palm empty fruit bunch (TKKS) planting media treatment and the liquid organic fertilizer from fruit waste had a highly significant effect, and there was an interaction between the two treatments on the plant weight per plot of pakcoy mustard greens.

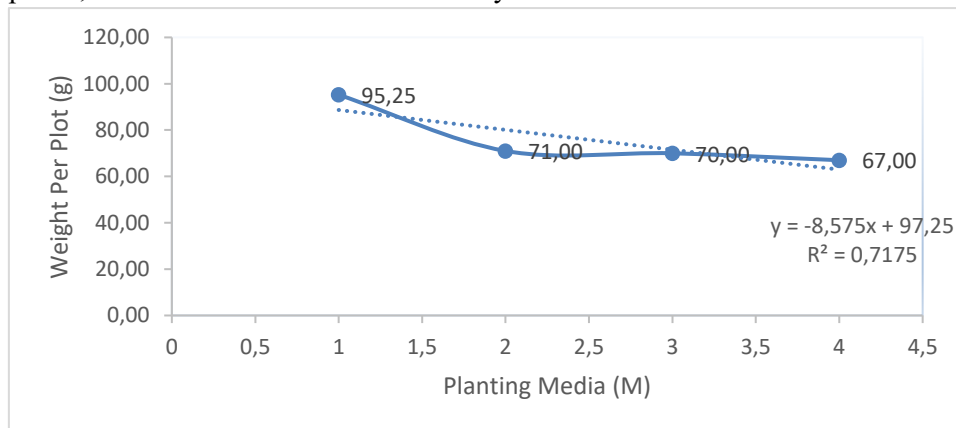
The average sample weight of pakcoy mustard greens at 5 weeks after planting (MST) can be seen in Table 7.

Table 7. Plant weight per plot (g) of pakcoy mustard under planting media and liquid organic fertilizer treatments at 5 weeks after planting (MST)

Treatment	Mean	Notation
Growing Media		
M1 TKKS	95,25	c
M2 TKKS:Cocopeat (75:25)	71,00	ab
M3 TKKS:Cocopeat (50:50)	70,00	ab
M4 TKKS:Cocopeat (25:75)	67,00	a
Liquid Organic Fertilizer		
K1 AB Mix	97,00	d
K2 POC 10%	81,50	bc
K3 POC 15%	73,25	b
K4 POC 20%	51,50	a

Note: Values followed by different letters indicate a significant difference at the 5% level (lowercase letters)

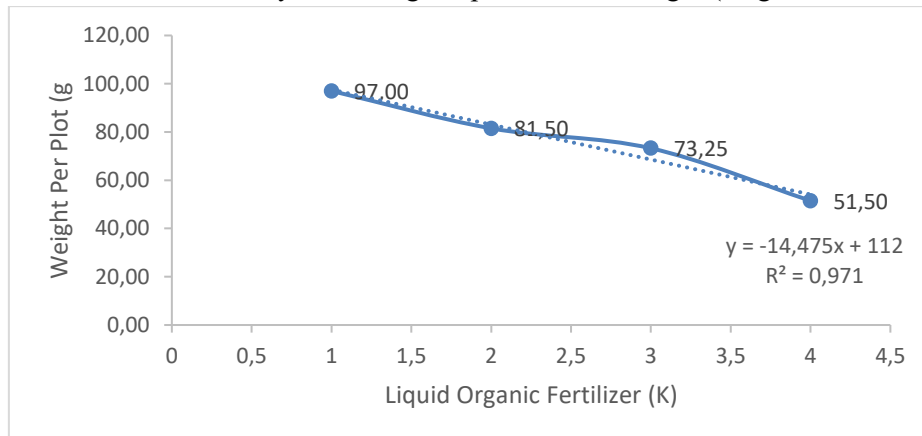
In Graph 9, it can be seen that the average plant weight per plot of pakcoy mustard greens using oil palm empty fruit bunch (TKKS) planting media was highest in treatment M1: TKKS, at 95.25 g, and lowest in treatment M4: TKKS+cocopeat (25:75), at 67.00 g. The best combination treatment of TKKS+cocopeat planting media was found in treatment M2: TKKS+cocopeat (75:25), at 71.00 g. (Zulkifli et al., 2022) states that fresh weight of plants is influenced by the nutrient absorption process through the roots, which is then stored in the leaves. (Alvita et al., 2024) also states that the availability of sufficient nutrients can accelerate the growth and productivity of pakcoy plants, which in turn enhances their ability to assimilate chemical substances.



Graph 9. Plant weight per plot of pakcoy mustard at 5 weeks after planting with the application of TKKS planting media

In Graph 10, it can be seen that the average plant weight per plot of pakcoy mustard greens with the application of liquid organic fertilizer from fruit waste was highest in treatment K1: AB Mix, at 97.00 g, and lowest in treatment K4: POC 20%, at 51.50 g. The best treatment in terms of concentration of liquid organic fertilizer from fruit waste was found in treatment K2: POC 10%, at 81.50 g. The plant's ability to carry out photosynthesis efficiently produces more photosynthates, which contributes to increased plant weight compared to other plants. The absorption of sufficient

amounts of water and CO₂, supported by sunlight, allows photosynthesis to proceed effectively so that more carbohydrates are produced for cell division. This ultimately increases the number and volume of cells, thereby increasing the plant's fresh weight (Nugroho et al., 2024).



Grafik 10. Plant weight per plot of pakcoy mustard at 5 weeks after planting with the application of liquid organic fertilizer from fruit waste

Conclusion

The results of the statistical analysis showed that the use of oil palm empty fruit bunch (TKKS) planting media and liquid organic fertilizer from fruit waste did not have a significant effect on the parameters of plant height (cm) and number of leaves (leaf count). However, there was a highly significant effect on leaf width (cm), leaf length (cm), leaf area (cm²), sample weight (g), and plant weight per plot (g), and there was also an interaction between TKKS planting media and liquid organic fertilizer from fruit waste. The TKKS planting media showed better results compared to other planting media combinations. The application of liquid organic fertilizer from fruit waste has not been able to replace AB Mix fertilizer in terms of growth and production of pakcoy mustard greens, although the use of 10% liquid organic fertilizer concentration has approached the results obtained with AB Mix. The best combination of TKKS and cocopeat planting media was found in treatment M2: TKKS+cocopeat (75:25), which produced a leaf width of 4.55 cm, leaf length of 11.45 cm, leaf area of 36.17 cm, sample weight of 10.75 g, and plant weight per plot of 71.00 g. Meanwhile, the most effective application of fruit-waste liquid organic fertilizer was found in treatment K2: POC 10%, with results of 4.58 cm leaf width, 11.37 cm leaf length, 37.53 cm leaf area, 12.33 g sample weight, and 81.50 g plant weight per plot.

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