Jurnal Pembelajaran Dan Biologi Nukleus p-ISSN: 2442-9481
Vol 11 (3): 1033 - 1055, September 2025 e-ISSN: 2685-7332

Synergistic Organic Wick and Nutrient Levels on The Morphological Performance of Pakcoy (*Brassica rapa* L.) in Hydroponic Axis System

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Submitted May 17 Th 2025, and Accepted August 30 Th 2025

Abstract

Background: *Pakcoy (Brassica rapa) production in Indonesia continues to rise, reaching 635,982 tons in 2018 and 652,723 tons in 2019. Improper irrigation often causes wilting and root rot. The wick hydroponic system offers a viable alternative but is suitable mainly for crops requiring limited water. Inorganic fertilizers enhance growth and yield, their long-term use poses environmental and human health risks. Organic fertilizers provide a sustainable solution without leaving harmful residues. Optimizing pakcoy cultivation in hydroponic systems requires selecting an appropriate wick material and the optimal concentration of organic fertilizer to achieve sustainable productivity.* **Methodology:** *This research was conducted with factorial experiment using a 2-factor completely randomized design, the first factor is the fertilizer concentration treatment consisting of 4 types (N0: AB Mix 3 ml/L-control, N1: LOF 6 ml/L, N2: LOF 9 ml/L, N3: LOF 12 ml/L) and the second factor is the type of wick treatment consisting of 4 types (S0: Flannel cloth wick-control, S1: Coconut fiber wick, S2: Bamboo fiber wick, S3: Banana stem wick). If the results obtained have significant, then continue the 5% DMRT test.* **Findings:** *The combined treatment of AB Mix at 3 ml/L and a coconut fiber wick exerted a significant influence on plant height between 15 and 25 DAP (13.37 cm), as well as on several yield parameters at 30 DAP, including crown fresh weight (17.97 g), root fresh weight (3.60 g), total fresh weight (21.57 g), and weight loss (0.24 g)***.** *The coconut fiber organic wick independently produced significant effects across all observed parameters, except for the number of leaves recorded at 5 DAP. Overall, the interaction between AB Mix at 3 ml/L and the coconut fiber wick demonstrated effective in enhancing the performance of pakcoy (B. rapa L.) compared with other treatment combinations.* **Contribution:** *This study provides valuable insights into optimizing the combination of fertilizer concentration and organic wick type in wick hydroponic systems to enhance the sustainable performance growth of pakcoy while promoting the utilization of environmentally friendly local materials.*

Keywords: *Brassica rapa; Liquid organic fertilizer; Organic wick; Pakcoy; Wick hydroponics*

https://doi.org/10.36987/jpbn.v11i3.7794

INTRODUCTION

Indonesian pakcoy production in 2018 and 2019 reached 635,982 tons and 652,723 tons, respectively, indicating an annual increase in pakcoy production (BPS, 2020). pakcoy boasts high nutritional value, making it ideal for consumption to support a healthy lifestyle. Because pakcoy is a short-lived crop, it is well-suited for hydroponic systems designed for rapid crop turnover, allowing for larger harvests in a shorter time to meet high market demand.

Problems often faced by pakcoy farmers are irregular watering can cause plants to wilt or root rot, temperatures that are too hot or cold can inhibit plant growth, lack of nutrients such as nitrogen, phosphorus, and potassium can cause plant growth to be inhibited and leaves to turn yellow. The solution to these problems for pakcoy plants is cultivation with a wick hydroponic system (Nugroho & Kurnia, 2025).

The wick hydroponic system uses a wick to circulate water and nutrients from the nutrient solution tub to the growing medium. The disadvantage of the wick system is that it is only suitable for plants that require little water, because of the limited absorption capacity of the wick in distributing nutrients to plants so that the quality of the wick plays an important role in draining water and nutrients from the nutrient solution tub to the root of the plant (Cahyani, 2023). Typically, flannel is used for the wick; but, in some locations, flannel is hard to locate, thus banana fronds, bamboo stalks, and coconut fiber will be used instead. Coir fiber has 35.6% cellulose and 32.7% lignin (Awali et al., 2020). Whereas banana frond fiber has 53.8% cellulose and 6.4% lignin, bamboo's organic composition conducts water due to its high cellulose concentration of 42.4-53.6% (Yunita & Mahyudin, 2017). Cellulose is an organic substance that is present in all plants and has the ability to absorb water (hygroscopic) (Pratama et al., 2019).

In addition to the wick, another factor that must be considered to support the growth and development process in pakcoy cultivation is the nutritional needs that must be met. AB Mix is the fertilizer most frequently used in hydroponics. Although AB Mixsolution, an inorganic fertilizer, can boost plant growth and productivity, it is not ecologically friendly and harmful to human health if eaten over an extended period of time. Additionally, using organic fertilizers won't leave plant products with residues (Elmi, 2022). Therefore, organic fertilizers are needed to reduce residues in inorganic fertilizers as nutrients in hydroponic plants. One of them is NASA LOF, which is a multipurpose liquid organic fertilizer with a special formula especially for plants made from purely organic ingredients. The advantages of using NASA liquid organic fertilizer are that it is more environmentally friendly and produces healthy vegetables free of chemicals (Nusantara, 2024).

Based on the description above, it is necessary to conduct research on the use of various types of wicks and fertilizers to determine their effect on the growth of pakcoy in the wick hydroponic system as a solution for farmers who have limited land. This research used various organic wicks made from coconut husk, bamboo fiber, and banana stems, which are typically used in hydroponic cultivation using flannel wicks, combined with various LOF concentrations.

METHOD

Research location

The experiment was carried out in the greenhouse of the Faculty of Agriculture, UPN "Veteran" Jawa Timur, during the period of October to November 2024. The research site is situated at an altitude ranging from 3 to 6 meters above sea level, characterized by an average minimum temperature of 23 °C and a maximum temperature of 34 °C. The area receives an annual average rainfall of approximately 165.3 mm and experiences relative humidity levels ranging from a minimum of 50 % to a maximum of 92 %.

Tools and Materials

The tools used in this research are nursery trays, measuring cups, hydroponic tubs, hacksaws, meters, rulers, toothpicks, impraboard, netpot, rockwool, pH meter, TDS meter, digital scales, label paper. The materials used in this study are pakcoy seeds, water, flannel cloth wick, coconut fiber, bamboo fiber, banana fronds, AB Mix, NASA LOF, pH Up and pH Down.

Data Collection

The experiment was designed using a factorial arrangement within a Completely Randomized Design (CRD) framework involving two experimental factors. The first factor corresponded to the application of NASA Liquid Organic Fertilizer (LOF) concentrations, which comprised four levels: N0 – AB Mix 3 ml/L (control), N1 – LOF 6 ml/L, N2 – LOF 9 ml/L, and N3 – LOF 12 ml/L. The second factor represented the types of organic wick materials, also consisting of four levels: S0 – Flannel wick (control), S1 – Coconut fiber wick, S2 – Bamboo fiber wick, and S3 – Banana stem wick. Each treatment combination was replicated three times, resulting in 16 total combinations and 48 experimental units within the hydroponic tub system.

Procedure

Media Preparation and Nursery

Seeding begins with selecting seeds by soaking the seeds in warm water for 15 minutes. Seeds that sink are the seeds that are planted. Rockwool was cut with a 12 x 6 cm hacksaw and then sliced into 3 sections vertically and 6 sections horizontally with a height of 3.5 cm. Rockwool that has been cut is given a hole 1-2 mm deep with a toothpick and spaced 2 x 2 cm. Filling each hole with 1 pakcoy seed using a toothpick with a little pressure so that it is not on the surface of the rockwool hole. Then the rockwool is transferred to the nursery tray and sprayed with water using a sprayer (rockwool is slightly moistened). Putting the seedling trays filled with seeds into a dark room for 2 days or 48 hours to accelerate shoot formation. Removing the seedling trays after 48 hours of nursery in a lighted place until day 15 so that the pakcoy seedlings can adjust to the environment.

Preparation of Nutrient Solution

The preparation of AB Mix nutrient solution is done by preparing 2 containers to hold 1 liter of water each, then stock powder A and stock B are mixed with water in each container containing 1 liter of water. The use of AB Mix is done by dissolving 1.5 mL of stock A and 1.5 mL of stock B into 1 liter of water, after the two nutrients are mixed then checking the concentration value of the nutrient solution and pH, the nutrients are stirred regularly so that they do not settle. The use of LOF nutrient solution is done by dissolving each concentration of liquid organic fertilizer treatment with 1 liter of water then checking the concentration of nutrient solution and pH. Water replacement in all AB Mix and LOF treatments is done at the time after observation.

Planting (Transplanting)

The pakcoy plant nursery is transferred from the nursery tray to the planting hole in the hydroponic wick system, before that each rockwool box measuring 2 x 2 cm is cut first. After the seedlings are planted, the wick system hydroponic tub is filled with water so that the pakcoy seedlings can absorb water through the wick. Make sure the roots of the plants hit the water that has been given nutrients beforehand, so that the roots can absorb nutrients and grow well. The transplanting process is done in the afternoon to reduce plant stress and carefully so as not to injure the plants.

Application of Nutrients

The application of this type of nutrient treatment is done by dissolving the nutrients with water according to the treatment concentration, then stirring the hydroponic tub and checking the concentration (ppm) and pH of the nutrient solution.

Plant Maintenance

Water checking is done every day. Water and nutrient replacement is done at 5-day intervals. Checking the pH and nutrient density (ppm) is done every day. The nutrient density value is attempted at 1050 - 1400 ppm, if the pH value is too low then pH up is given, otherwise if the pH value is too high then pH down is given, the pH value is maintained at around 7.0. Replanting is done maximum in the first week after transplanting due to environmental stress by looking at the appearance of the plants at that time by replacing dead plants. Pest and disease control uses a manual method by taking pests that attack and removing damaged plant parts and controlling them every day.

Harvesting

Harvesting is done in the morning so that the plants do not wither quickly due to direct sunlight (when the temperature is low). The harvest is placed in a shady place to protect the plants from wilting quickly.

Data analysis

The experimental data were statistically evaluated through Analysis of Variance (ANOVA), adopting a two-factor Completely Randomized Design (CRD) framework. The study was structured factorially, consisting of two independent variables: the first factor (N) represented the concentration treatments with four levels, while the second factor (S) referred to the types of organic wick materials, also comprising four levels. All experimental data obtained were subjected to analysis of variance to determine the presence of significant interactions or main effects among treatments. When the ANOVA results indicated statistical significance—where Fcount > Ftable at the 5% level but < Ftable at the 1% level—or a highly significant difference (Fcount > Ftable at the 1% level), the analysis was followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level to perform pairwise comparisons among all treatment means.

RESULT AND DISCUSSION

Plant Height

The results of the analysis of variance showed that there was a significant interaction between the concentration of liquid organic fertilizer (LOF) and the type of organic wick on the height of pakcoy plants at the age of 10 DAP to 25 DAP. The combination of the two factors gave a real effect at the age of 10 and 25 DAP and gave a very real effect at the age of 15 and 20 DAP. The average value of plant height at the age of 10 DAP to 25 DAP due to the combination of the two factors is presented in Table 1.

Table 1. shows that at the age of 10 DAP the treatment of a combination of AB Mix 3 ml/L and flannel wick (control) showed a greater number of pakcoy plant height of 6.20 cm but not significantly different from AB Mix 3 ml/L and coconut fiber wick with a value of 5.97 cm. The combination treatment of AB Mix 3 ml/L and coconut fiber wick showed higher pakcoy plant height results at the age of 15 to 25 DAP with consecutive values of 7.87 cm, 11.2 cm and 13.37 cm. The three numbers were not significantly different from the combination of AB Mix 3 ml/L treatment and flannel wick (control) which were 7.83 cm, 9.97 cm and 12.43 cm respectively. The combination of LOF Treatment 9 ml/L and banana leaf axis is a treatment combination that shows the lowest average number of pakcoy plant height at the age of 10 DAP with a value of 3.37 cm. At the age of 15 to 25 DAP, the treatment combination of LOF 6 ml/L and banana leaf axis showed the lowest average number of pakcoy plant height, namely 3.6 cm, 3.9 cm and 4.1 cm.

 p-ISSN: 2442-9481
e-ISSN: 2685-7332

Table 1. Average Plant Height of Pakcoy due to Combination of Liquid Organic Fertilizer Concentration and Organic Wick Type at the Age of 10 DAP to 25 DAP

Age	LOF Concentration	Type of Organic Wick			
		(control) Flannel Fabric	Coconut Coir	Bamboo Fiber	Banana Fronds
10 DAP	Control	6,20 e	5,97 e	4.33 abcd	3.57 abc
	6 ml/L	4.43 bcd	4.53 bcd	4.1 abcd	3.47 ab
	9 ml/L	4.07 abcd	4.63 cd	4.07 abcd	3,37 a
	12 ml/L	3.43 ab	5.1 de	4.17 abcd	3.8 abc
15 DAP	Control	7,83 e	7,87 e	5,47 d	4.07 abc
	6 ml/L	4.6 abcd	5.1 bcd	4.4 abcd	3,6 a
	9 ml/L	4.43 abcd	4.77 abcd	4.47 abcd	3,73 a
	12 ml/L	4 ab	5.33 cd	4.33 abcd	4.1 abc
20 DAP	Control	9,97 e	11,2 e	7,33 d	5.07 abc
	6 ml/L	5.07 abc	5.63 bcd	4.5 abc	3,9 a
	9 ml/L	5.2 abc	5 abc	4.77 abc	3.97 ab
	12 ml/L	4.53 abc	6.2 cd	4.57 abc	4.33 ab
25 DAP	Control	12,43 e	13,37 e	9,3 d	6.77 cd
	6 ml/L	6 abc	6.73 bcd	4.67 abc	4,1 a
	9 ml/L	5.8 abc	5.3 abc	5.1 abc	4.4 ab
	12 ml/L	5 abc	6.63 bc	4.7 abc	4.5 abc

Notes: Mean numbers followed by the same letter at the same age showed no significant difference at 5% DMRT test.

The LOF concentration factor gave a very significant effect on the height of pakcoy plants at the age of 30 DAP. At the age of 5 and 30 DAP pakcoy plants, the factor of the type of organic wick gives a very real influence on the parameters of plant height. The average value of pakcoy plant height due to the application of various concentrations of LOF and various types of axes at the age of 5 DAP and 30 DAP is presented in Table 2.

Table 2 shows that the coconut coir wick treatment shows a higher average with a value of 4.29 cm but not significantly different from the flannel cloth wick treatment which is 3.83 cm at the age of 5 DAP. At the age of 30 DAP, the coir wick treatment showed a higher average of 9.3 cm but was not significantly different from the flannel cloth wick treatment which was 8.75 cm. The concentration treatment at the age of 30 DAP in the control showed a value of 13.08 cm, this value was higher than all LOF treatments. The LOF treatment showed no significant difference. The banana leaf wick treatment at the age of 5 DAP and 30 DAP showed the lowest mean height of pakcoy plants, namely 3.31 cm and 5.6 cm, and was not significantly different from bamboo fiber.

Table 2. Average Pakcoy Plant Height due to the Treatment of Various Concentrations of Liquid Organic Fertilizer and Types of Organic Wicks at the Age of 5 DAP and 30 DAP

Treatment	Average Plant Height (cm)	
	5 DAP	30 DAP
LOF Concentration		
Control	4,08	13,08 b
6 ml/L	3,62	5,92 a
9 ml/L	3,62	5,57 a
12 ml/L	3,68	5,75 a
DMRT 5%	tn	
Organic Wick Type		
Flannel Fabric (control)	3.83 bc	8,75 b
Coconut Coir	4,29 c	9,3 b
Bamboo Fiber	3.58 ab	6,66 a
Banana Fronds	3,31 a	5,6 a
DMRT 5%		

Notes: Mean numbers followed by the same letter in the same column and treatment show no significant difference in the 5% DMRT test, tn = not significantly different.

Number of Plant Leaves

The results of the analysis of variance showed that there was a significant interaction between the concentration of liquid organic fertilizer (LOF) and the type of organic wick on the number of leaves of pakcoy plants at the age of 10 DAP, 20 DAP, 25 DAP and 30 DAP. The combination of the two factors gave a real effect at the age of 10 DAP and gave a very real effect at the age of 20 to 30 DAP. The average value of the number of plant leaves at the age of 10 DAP, 20 DAP, 25 DAP and 30 DAP due to the combination of the two factors is presented in Table 3.

Table 3. shows at the age of 10 DAP, 20 DAP, 25 DAP and 30 DAP the combination treatment of AB Mix 3 ml/L and flannel wick (control) showed a higher number of pakcoy plant leaves than other treatments. At 10 DAP the value of the combination treatment was 4.33 strands, at 20 DAP 7.57 strands, at 25 DAP 9.57 strands, and at 30 DAP 13 strands. The four values are greater but not significantly different from the combination of AB Mix 3 ml/L and coconut fiber wick, which is at 10 DAP 3.97 strands, at 20 DAP 7.37 strands, at 25 DAP 9.53 strands and at 30 DAP 12.77 strands.

The combination of 12 ml/L LOF treatment and flannel wick at the age of 10 DAP and 20 DAP showed the lowest average number of pakcoy plant leaves with a value of 2.67 strands and 3.77 strands. At the age of 25 DAP and 30 DAP the combination of LOF treatment of 6 ml/L and bamboo fiber axis showed the same average number of leaves of the lowest pakcoy plants, namely 4.1 strands.

Table 3. Average Number of Pakcoy Plant Leaves due to the Combination of Liquid Organic Fertilizer Concentration and Organic Wick Type at the Age of 10 DAP, 20 DAP, 25 DAP and 30 DAP

Average Number of Plant Leaves (strands)					
Age	**LOF Concentration**	**Type of Organic Wick**			
		(Control) Flannel Fabric	**Coconut Coir**	**Bamboo Fiber**	**Banana Fronds**
10 DAP	Control	4,33 e	3.97 de	3.7 cde	3.1 abc
	6 ml/L	3.1 abc	3.33 bcd	3.1 abc	2.9 ab
	9 ml/L	3.57 cd	3.47 bcd	3.13 abc	2.9 ab
	12 ml/L	2,67 a	3.57 cd	3.2 abc	3.1 abc
15 DAP	Control	7,57 e	7,37 e	5,8 d	4.9 cd
	6 ml/L	4.1 abc	4.57 abc	4.1 abc	4 ab
	9 ml/L	4.53 abc	4.33 abc	4.1 abc	4.13 abc
	12 ml/L	3,77 a	4.67 bc	4.33 abc	4.43 abc
20 DAP	Control	9,57 e	9,53 e	7,13 d	5.53 cd
	6 ml/L	5 abc	5.2 abc	4,1 a	4.1 ab
	9 ml/L	5.47 bc	4.67 abc	4.33 abc	4.47 abc
	12 ml/L	4.83 abc	5.2 abc	4.67 abc	4.43 abc
25 DAP	Control	13 d	12,77 d	9,1 c	6,2 b
	6 ml/L	5.87 ab	5.9 ab	4,1 a	4.1 ab
	9 ml/L	6 ab	4.77 ab	4.43 ab	4.47 ab
	12 ml/L	5.2 ab	6 ab	4.77 ab	4.43 ab

Notes: Mean numbers followed by the same letter at the same age showed no significant difference at 5% DMRT test.

The LOF concentration factor gives a very significant effect on the number of pakcoy plant leaves at the age of 5 and 15 DAP. At the age of 15 DAP pakcoy plants, the factor of the type of organic axis gives a very real influence on the parameter of the number of plant leaves. The average value of the number of leaves of pakcoy plants due to the application of various concentrations of LOF and various types of axes at the age of 5 DAP and 15 DAP is presented in Table 4.

Table 4. shows that at 5 DAP and 15 DAP, the control treatment (AB Mix 3 ml/L) showed a higher mean than the other treatments. At 5 DAP the control treatment showed a higher average with a value of 3.12 strands but was not significantly different from the 9 ml/L LOF treatment which was 2.92 strands. At 15 DAP the control treatment showed a higher average of 4.88 strands, this value was higher than all LOF treatments. The LOF treatment showed no significant difference. The treatment of the type of axis at 15 DAP showed 4.2 strands on the coconut fiber axis which was not significantly different from the control treatment (flannel cloth axis) with a value of 4.15 strands. The 6 ml/L LOF treatment showed the lowest average number of pakcoy plant

leaves with a value of 2.62 strands at 5 DAP. While the banana leaf wick treatment showed 3.39 strands which was the lowest average value of the number of leaves.

Table 4. Average Number of Leaves of Pakcoy Plants due to Treatment of Various Concentrations of Liquid Organic Fertilizer and Types of Organic Wicks at the Age of 5 DAP and 15 DAP

Treatment	Average Plant Height (cm)	
	5 DAP	**30 DAP**
LOF Concentration		
Control	3,12 b	4,88 b
6 ml/L	2,62 a	3,49 a
9 ml/L	2,92 b	3,48 a
12 ml/L	2.86 ab	3,63 a
DMRT 5%		
Organic Wick Type		
Flannel Fabric (control)	2,78	4.15 bc
Coconut Coir	3,05	4,2 c
Bamboo Fiber	2,81	3.73 ab
Banana Fronds	2,88	3,39 a
DMRT 5%	tn	

Notes: Mean numbers followed by the same letter in the same column indicate not significantly different at 5% DMRT test, tn = not significantly different.

Plant Leaf Area

The results of the analysis of variance showed that at the harvest age of 30 DAP there was a very significant interaction between the concentration of liquid organic fertilizer (LOF) and the type of organic axis on the leaf area of pakcoy plants. The factors of various concentrations of liquid organic fertilizer (LOF) and the type of organic wick each give a very real effect on the parameters of the leaf area of pakcoy plants at the harvest age of 30 DAP. The average value of plant leaf area at harvest age 30 DAP due to the combination of the two factors is presented in Table 5.

The treatment of a combination of AB Mix 3 ml/L and flannel cloth wick (control) at harvest age 30 DAP showed a greater number of pakcoy plant leaf area of 217.8 cm^2but not significantly different from AB Mix 3 ml/L and coconut fiber wick with a value of 175.38 cm^2. The table also shows that the treatment combination has the lowest average leaf area of pakcoy plants which is 7.15 cm^2in the treatment of LOF 6 ml/L and banana leaf axes.

Table 5. Average Leaf Area of Pakcoy Plants due to Combination of Liquid Organic Fertilizer Concentration and Organic Wick Type at Harvest Age 30 DAP

Average Leaf Area of Plants (cm^2)				
Treatment	**Organic Wick Type**			
	(control) Flannel Fabric	**Coconut Coir**	**Bamboo Fiber**	**Banana Frond**
LOF Concentration				
Control	217,8 c	175,38 c	77,76 b	30 ab
6 ml/L	22,32 a	18,6 a	7,74 a	7,15 a
9 ml/L	16,47 a	9,63 a	8,62 a	10,71 a
12 ml/L	16,39 a	20,53 a	13,62 a	9,8 a

Notes: Mean numbers followed by the same letter indicate not significantly different at 5% DMRT test.

Total Plant Wet Weight

The results of the analysis of variance showed that at the harvest age of 30 DAP there was a very significant interaction between the concentration of liquid organic fertilizer (LOF) and the type of organic axis on the total wet weight of pakcoy plants. In the factors of various concentrations of liquid organic fertilizer (LOF) and the type of organic wick each gave a very real effect on the total wet weight parameters of pakcoy plants at the harvest age of 30 DAP. The average value of total plant wet weight at harvest age 30 DAP due to the combination of the two factors is presented in Table 6.

Table 6. Average Total Wet Weight of Pakcoy Plants due to Combination of Liquid Organic Fertilizer Concentration and Organic Wick Type at Harvest Age 30 DAP

Average Total Wet Weight (gram)				
Treatment	**Type of Organic Wick**			
	(control) Flannel Fabric	**Coconut Coir**	**Bamboo Fiber**	**Banana Frond**
LOF Concentration				
Control	17,70 c	21,57 c	5,43 b	2.07 ab
6 ml/L	0.87 ab	1.67 ab	0.57 ab	0,50 a
9 ml/L	1.30 ab	0.70 ab	0.73 ab	0.57 ab
12 ml/L	1.00 ab	2.43 ab	0.97 ab	0.53 ab

Notes: Mean numbers followed by the same letter indicate not significantly different at 5% DMRT test.

The combined treatment of AB Mix 3 ml/L and coconut fiber wick at the harvest age of 30 DAP showed a greater total wet weight of pakcoy plants, namely 21.57 grams but not significantly different from AB Mix 3 ml/L and flannel cloth wick (control) with a value of 17.70 grams. The table also shows that the treatment combination has the lowest average number of total wet weight of pakcoy plants, which is 0.50 grams in the treatment of LOF 6 ml/L and banana leaf axis.

Plant Crown Wet Weight

The results of the analysis of variance showed that at the harvest age of 30 DAP there was a very significant interaction between the concentration of liquid organic fertilizer (LOF) and the type of organic axis on the wet weight of the pakcoy plant crown. In the factors of various concentrations of liquid organic fertilizer (LOF) and types of organic axes, each of them has a very significant effect on the parameters of the wet weight of the crown of pakcoy plants at the harvest age of 30 DAP. The average value of plant crown wet weight at harvest age 30 DAP due to the combination of the two factors is presented in Table 7.

Table 7. Average Wet Weight of Pakcoy Plant Canopy due to Combination of Liquid Organic Fertilizer Concentration and Organic Wick Type at Harvest Age 30 DAP

Average Crown Wet Weight (gram)				
Treatment	Type of Organic Wick			
	(control) Flannel Fabric	Coconut Coir	Bamboo Fiber	Banana Frond
LOF Concentration				
Control	14,77 c	17,97 c	4,53 b	1.73 ab
6 ml/L	0.77 ab	1.40 ab	0.47 ab	0,37 a
9 ml/L	1.10 ab	0.53 ab	0.60 ab	0.47 ab
12 ml/L	0.83 ab	2.00 ab	0.80 ab	0.43 ab

Notes: Mean numbers followed by the same letter indicate no significant difference in the 5% DMRT test.

The treatment of a combination of AB Mix 3 ml/L and coconut coir wick at harvest age 30 DAP showed a greater number of wet weight of pakcoy plant crowns, which was 17.97 grams but not significantly different from AB Mix 3 ml/L and flannel cloth wick (control) with a value of 14.77 grams. The table also shows that the treatment combination has the lowest average number of wet weight of pakcoy plants, which is 0.37 grams in the treatment of LOF 6 ml/L and banana frond axis.

Wet Weight of Plant Roots

The results of the analysis of variance showed that at harvest age 30 DAP there was a very significant interaction between the concentration of liquid organic fertilizer (LOF) and the type of organic axis on the wet weight of pakcoy plant roots. The factors of various concentrations of liquid organic fertilizer (LOF) and the type of organic wick each give a very significant effect on the parameter of the wet weight of the roots of pakcoy plants at the harvest age of 30 DAP. The average value of wet weight of plant roots at harvest age 30 DAP due to the combination of the two factors is presented in Table 8.

Table 8. Average Root Wet Weight of Pakcoy Plants due to Combination of Liquid Organic Fertilizer Concentration and Organic Wick Type at Harvest Age 30 DAP

Average Root Wet Weight (gram)				
Treatment	**Type of Organic Wick**			
	(control) Flannel Fabric	**Coconut Coir**	**Bamboo Fiber**	**Banana Frond**
LOF Concentration				
Control	2,93 c	3,60 c	0,90 b	0.33 ab
6 ml/L	0.17 ab	0.27 ab	0.10 ab	0,08 a
9 ml/L	0.23 ab	0.10 ab	0.13 ab	0.10 ab
12 ml/L	0.17 ab	0.40 ab	0.17 ab	0.10 ab

Notes: Mean numbers followed by the same letter indicate no significant difference in the 5% DMRT test.

The treatment of a combination of AB Mix 3 ml/L and coconut coir wick at harvest age 30 DAP showed a greater number of wet weight of pakcoy plant roots, namely 3.60 grams but not significantly different from AB Mix 3 ml/L and flannel wick (control) with a value of 2.93 grams. The table also shows that the treatment combination has the lowest average number of wet weight of pakcoy plant roots, which is 0.08 grams in the treatment of LOF 6 ml/L and banana frond axis.

Plant Root Length

The results of the analysis of variance showed that at the harvest age of 30 DAP there was a very significant interaction between the concentration of liquid organic fertilizer (LOF) and the type of organic axis on the root length of pakcoy plants. In various factors, the concentration of liquid organic fertilizer (LOF) and the type of organic axis each have a very significant effect on the root length parameters of pakcoy plants at harvest age 30 DAP. The average value of plant root length at harvest age 30 DAP due to the combination of the two factors is presented in Table 9.

The combined treatment of AB Mix 3 ml/L and flannel wick (control) at harvest age 30 DAP showed a greater number of pakcoy plant root lengths of 14.10 cm but not significantly different from AB Mix 3 ml/L and coconut fiber wick with a value of 12.33 cm. The table also shows that the treatment combination has the lowest average root length of pakcoy plants, which is 0.23 cm in the treatment of LOF 6 ml/L and banana leaf axis.

Table 9. Average Root Length of Pakcoy Plants due to Combination of Liquid Organic Fertilizer Concentration and Organic Wick Type at Harvest Age 30 DAP

Average Root Length (cm)				
Treatment	**Type of Organic Wick**			
	(control) Flannel Fabric	**Coconut Coir**	**Bamboo Fiber**	**Banana Frond**
LOF Concentration				
Control	14,10 c	12,33 c	3,23 b	1.17 ab
6 ml/L	0,47 a	0.93 ab	0,27 a	0,23a
9 ml/L	0.77 ab	0,33 a	0,37 a	0,30 a
12 ml/L	0,50 a	1.23 ab	0,47 a	0,30 a

Notes: Mean numbers followed by the same letter indicate no significant difference in the 5% DMRT test.

Plant Weight Shrinkage

The results of the analysis of variance showed that at harvest age 30 DAP there was a very significant interaction between the concentration of liquid organic fertilizer (LOF) and the type of organic axis on the shrinkage of pakcoy plant weight. The factors of various concentrations of liquid organic fertilizer (LOF) and the type of organic wick each give a very real effect on the parameter of shrinkage of pakcoy plant weight at harvest age 30 DAP. The average value of plant weight loss at harvest age 30 DAP due to the combination of the two factors is presented in Table 10.

Table 10. Average Weight Shrinkage of Pakcoy Plants due to Combination of Liquid Organic Fertilizer Concentration and Organic Wick Type at Harvest Age 30 DAP

Average Weight Shrinkage (gram)				
Treatment	**Type of Organic Wick**			
	(control) Flannel Fabric	**Coconut Coir**	**Bamboo Fiber**	**Banana Frond**
LOF Concentration				
Control	0,25 a	0,24 a	0,25 a	0,25 a
6 ml/L	0.38 ab	0.30 ab	0,83 c	0,79 c
9 ml/L	0.34 ab	0.29 ab	0.37 ab	0,52 b
12 ml/L	0.34 ab	0.34 ab	0,52 b	0.38 ab

Notes: Mean numbers followed by the same letter indicate not significantly different at 5% DMRT test.

The treatment of a combination of AB Mix 3 ml/L and coconut fiber wick at harvest age 30 DAP showed the best shrinkage rate of pakcoy plants which was 0.24 grams but not significantly different from the combination of AB Mix 3 ml/L and all types of wicks with the same value of 0.25 grams. The table also shows that the treatment combination has the highest average weight loss of pakcoy plants, which is 0.83 grams in the treatment of LOF 6 ml/L and bamboo fiber axes.

Combination of LOF Concentration Treatment and Type of Organic Wick on Growth and Yield of Pakcoy Plants

The Analysis of Variance (ANOVA) followed by the Duncan's Multiple Range Test (DMRT) at a 5% significance level revealed that a significant interaction occurred between the different concentrations of Liquid Organic Fertilizer (LOF) and the types of organic wick materials**.** This interaction significantly influenced the growth-related parameters, including plant height and leaf number, across multiple observation periods. Furthermore, a similar interaction effect was detected on the yield-related parameters, such as leaf area, total fresh weight, shoot fresh weight, root fresh weight, root length, and weight reduction.

AB Mix nutrition contains macro and micro nutrients, the higher the nutrient concentration value (ppm), the more nutrients in hydroponic nutrition (Sulistyowati & Nurhasanah, 2021). AB Mix 600 - 700 ppm contains enough N for pakcoy growth, so the number of leaves is more than LOF nutrition. N nutrients in plants are needed for starch synthesis in leaves, amino acid production for protein synthesis and to increase plant yields such as the number of leaves and plant height (Kumar et al., 2021). The application of LOF needs to be increased because the concentration of the solution in the LOF treatment is quite low, only around 300 ppm. Vegetable production with LOF has not been able to match AB Mix nutrition but can be used as hydroponic nutrition in organic farming (Phibunwatthanawong & Riddech, 2019). LOF alone has not been able to increase the growth of hydroponic pakcoy because of its low nutrient content. AB Mix nutrients used in this study contain macro nutrients (total N 25.9%; P 6.4%; K 31.2%; Ca 18.1%; 47Mg 6.6%; S 11.2%), and micro (Fe 0.35%; Cu 0.07%; Mn 0.06%; Zn 0.07%; B 0.04%; Mo 0.01%).

The pH measurement is done to determine the quality of the water solution and nutrients in hydroponics. If the pH quality is not appropriate, it can inhibit plant growth. The pH levels in pakcoy plants that are well used range from 6.0 - 7.5 (Sesanti & Sismanto, 2016). If the pH level is not in the ideal range, it can cause less than optimal nutrient absorption (Karoba et al., 2015). In the AB Mix treatment, the pH value tends to be stable at the age of the observation interval of 5 to 30 DAP. It is suspected that AB-mix has a buffer (buffer solution) that functions to maintain pH stability, so that the pH of the nutrient solution does not experience a significant decrease or increase in pH value (Lakshitowati & Murdono, 2021).

In this experiment, the application of NASA Liquid Organic Fertilizer (LOF) combined with various organic wick materials was observed to produce suboptimal growth performance in pakcoy plants. The macro- and micronutrient composition within the LOF nutrient solution was insufficient to meet the physiological nutrient demands of pakcoy cultivated under hydroponic conditions, resulting in stunted growth, smaller leaf size, and pale foliage coloration. When the nutrient concentration fails to fulfill the requirements necessary for essential physiological activities, the growth and developmental processes of plants are adversely affected, as noted by Hutasoit et al., (2018). Furthermore, Prasetyo (2014) emphasized that every plant species requires an adequate and balanced supply of both macro- and micronutrients to support normal growth and development; thus, nutrient deficiency inevitably leads to growth inhibition. At the initial growth stage, all pakcoy plants exhibited vibrant green leaves, indicating good early vigor. However, as the growth period progressed, visible physiological disorder symptoms emerged across all LOF treatments, consistent with nutrient deficiency effects described earlier. In contrast, plants receiving the AB Mix treatment showed no signs of physiological disturbance, suggesting that the inorganic nutrient formulation was able to sufficiently meet the nutritional requirements of pakcoy under hydroponic cultivation.

The treatment of AB Mix concentration of 3 ml/L and flannel wick showed higher numbers in the 10 DAP plant height parameter, 10 DAP, 20 to 30 DAP leaf number parameter, 30 DAP harvest age leaf area parameter and 30 DAP harvest age root length parameter. The wick system is a hydroponic system using the principle of capillarity of nutrient solutions, where direct absorption into plants using a wick. The best water absorbent material that can be used in the cardiovascular system is flannel. Coconut coir is easy to obtain, cheap, abundantly available, not easy to rot, resistant to pests and diseases. In addition, coconut fiber contains many nutrients that can trigger plant growth (Cahyani, 2023).

A notable response in plant height at 15 to 25 days after planting (DAP) was observed under the treatment combining an AB Mix concentration of 3 mL/L with a coconut fiber organic wick. This effect can be attributed to the adequacy of the AB Mix concentration, which supports optimal growth of *pakcoy* plants. The nutrient formulation, containing sufficient levels of nitrogen (N), phosphorus (P), and potassium (K), fulfills the plants' essential nutritional requirements, thus becoming a critical determinant of vegetative growth. Nutrient concentrations of approximately 1.5% N, 0.2% P, and 1.0% K within plant tissues are considered sufficient to sustain proper growth. For leafy vegetables, macronutrients such as N, P, and K are required in higher amounts than other elements. Nitrogen contributes to chlorophyll synthesis, which is essential for photosynthesis, as well as to the formation of proteins, lipids, and diverse organic compounds. Phosphorus plays a vital role in cell division and energy transfer, while potassium acts as an activator for numerous enzymes essential in photosynthetic and respiratory pathways. Increased nutrient supply, particularly of N, P, and K up to an optimal threshold, has been demonstrated to accelerate and enhance plant growth (Marginingsih et al., 2018).

No significant interaction was detected between the concentration and organic wick treatments on plant height and leaf number at 5 days after planting (DAP). Similarly, at 30 DAP, the combination of both factors did not produce a significant interaction on plant height, and at 15 DAP, no significant effect was found on the number of leaves. The absence of interaction effects is presumed to result from the lack of synergistic influence between fertilizer concentration and organic wick type, where each factor independently affected plant growth. Consequently, the parameters of plant height and leaf number showed no consistent response across observation intervals. This non-interactive relationship may be attributed to the differing characteristics of the two factors, each exerting distinct physiological roles in influencing plant growth. When two factors are simultaneously examined and one exhibits a stronger influence, the weaker factor tends to be masked, leading to minimal or no observable interaction. Each factor thus operates independently according to its inherent properties and mechanisms in supporting plant development (Purba & Maulana, 2021).

Wet weight is an indicator of the measurement of plant biomass which includes the results of photosynthesis, nutrient uptake, and water content processed through the biosynthesis process. The higher the photosynthesis yield and the water content contained in the plant, the wet weight of the plant will increase (Lestari et al., 2022). Based on the results of variance analysis and 5% DMRT test, it shows that there is a real interaction in the 3 parameters of wet weight of pakcoy plants consisting of crown wet weight, root wet weight and total wet weight in the AB Mix 3 ml/L treatment and coconut fiber organic wick at harvest age 30 DAP. Wet weight becomes a growth factor and functions in determining the value of plant yield (Marginingsih et al., 2018). According to Kogoya et al., (2018) plant wet weight is determined by several parameters, namely leaf area, number of leaves, root length, and plant height.

The right concentration of AB Mix nutrients causes plants to grow well because all the nutrients needed are met. If the plant has optimal growth, it will reduce weight loss, because the weight of the plant is more stable and the yield is good. Nutrient concentrations that are too high affect weight loss, because they will cause toxicity in plants, damaging the roots so that they interfere with the absorption of water and nutrients. This makes plants stressed and increases weight loss (Triani & Lestari, 2024). Analysis of variance followed by DMRT 5% gives the best response to the AB Mix 3 ml/L treatment and coconut coir axis on the parameter of weight loss of pakcoy plants at harvest age 30 DAP.

Effect of LOF Concentration Treatment on Growth and Yield of Pakcoy Plants

A significant influence of the 3 ml/L AB Mix treatment was observed across all measured parameters of pakcoy growth, including plant height from 10 to 30 days after planting (DAP), number of leaves at all observation intervals, and yield indicators such as leaf area, crown fresh weight, root fresh weight, total fresh weight, root length, and weight reduction. These results indicate that the 3 ml/L concentration of AB Mix provided a sufficient supply of available nutrients that could be effectively absorbed by pakcoy plants to support optimal physiological functions. As emphasized by Marginingsih et al., (2018), the growth of leaf vegetables have a higher demand for macronutrients such as nitrogen (N), phosphorus (P), and potassium (K) compared to other essential elements. Nitrogen plays a vital role in enhancing chlorophyll formation,

p-ISSN: 2442-9481
e-ISSN: 2685-7332

amino acid and protein synthesis, which in turn increases photosynthetic capacity and the accumulation of photosynthates. According to Fatma et al., (2019), these photosynthates are subsequently utilized for vegetative growth and biomass development. Phosphorus contributes significantly to root initiation and development, and when combined with nitrogen, it promotes the formation of root hairs that improve nutrient uptake efficiency. Such enhanced absorption capacity directly supports the acceleration of plant growth. Furthermore, potassium functions as both a catalytic and stimulatory agent in several phosphorylation and carbohydrate metabolism processes, in addition to activating key enzymes involved in photosynthesis and respiration.

As the plant height increases, a greater number of leaves tend to develop. An increased leaf count enhances the plant's capacity to intercept sunlight, thereby facilitating a more efficient photosynthetic process. The elevated rate of photosynthesis subsequently leads to a higher production of photosynthates, which promotes broader leaf expansion and greater fresh biomass accumulation. The fresh weight of a plant is primarily determined by the amount of water and nutrients retained within its tissue cells. Total fresh weight represents the cumulative biomass of the plant and serves as an indicator of metabolic activity, functioning as a key parameter for assessing growth performance and determining economic yield potential, particularly in vegetable crops. The presence of adequate macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), along with essential microelements in the nutrient solution, enhances photosynthetic efficiency and increases carbohydrate synthesis, thereby contributing to the formation of energy reserves essential for plant growth (Marginingsih et al., 2018).

The turgor pressure in the stems, leaves and roots is high due to the absorption of many N nutrients in the plant body which causes the water in the stems, leaves and roots to not evaporate and the parts remain wet. Total wet weight is influenced by the number of leaves and leaf area and is closely related to the amount of water in the plant body, especially in the leaves. If the water content in the plant body is low, the speed of the photosynthesis process will decrease so that little photosynthate is produced. However, if photosynthesis runs well, the photosynthate produced is also a lot, which will be used for the formation of organs and tissues in plants such as leaves, stems so that the total wet weight is getting bigger (Nurrohman et al., 2014). According to Yulianti (2022) oxygen is essential for metabolic processes, including active transport and absorption. Plants around the roots are met with sufficient oxygen levels, root growth and absorption of water and nutrients given will be good.

Weight loss is an important parameter that indicates the level of weight loss during the shelf life due to loss of water and organic matter through respiration and transpiration (Prana et al., 2024). Appropriate concentrations are important in hydroponics to ensure plants get enough nutrients to avoid deficiency or toxicity. Low concentrations of AB Mix Nutrition affect weight loss, because insufficient nutrients will inhibit plant growth, cause nutrient deficiencies and can then increase weight loss because plants do not grow optimally, roots do not grow well so that nutrient absorption is inhibited (Triani & Lestari, 2024).

The AB Mix 3 ml/L treatment did not show a significant effect on the average plant height at 5 DAP. This can occur because pakcoy plants are still in the adaptation period with the new growing environment and at the stage of entering the initial vegetative phase. In addition, it is also caused by the need for plant nutrients that can still be met by the place where it grows. And the nutrients contained in the fertilizer given are still in the process of being absorbed by plant organs. At the time of fertilizer application, plants only utilize nutrients according to their needs because the plants are still relatively small so that the needs of nutrients absorbed are only small (Xu et al., 2010).

The provision of liquid organic fertilizer shows poor growth. This is because the content of macro and micro nutrients is thought to be small so that pakcoy growth is less than optimal. In addition, there is a lack of nutrients N, P and K in these plants. Plants that do not get nutrients N, P and K in accordance with their nutrient needs will inhibit enzyme activity and will grow stunted and the leaves formed are small which results in decreased plant production. Growing plants need N, P and K to form new cells. Photosynthesis produces carbohydrates from CO2 and H2O, but the process takes place less optimally to produce proteins, nucleic acids and so on when nitrogen is deficient. In addition, micro-nutrient deficiencies are suspected. Although needed in small amounts, micro elements can affect plant growth. If plants lack micro-nutrients, namely Zn, Mo, Fe, Mn, Co and B, it can affect vegetative growth, one of which is the number of leaves. A plant will grow well if the elements needed are sufficiently available, and the elements have a form that is suitable for absorption by plants (Marginingsih et al., 2018).

LOF cannot be used as a primary fertilizer in hydroponic activities, because from the observation of plant height, number of leaves, fresh weight at harvest has very low results (Muhadiansyah et al., 2016), Meanwhile, according to research by Phibunwatthanawong & Riddech (2019) on the treatment of several types of LOF on hydroponic lettuce cultivation cannot provide higher fresh weight results than AB mix chemical nutrition, from some of these statements it can be concluded that the application of LOF alone in hydroponic cultivation cannot be used as a single nutrient because it cannot meet the macro and micro nutrient needs of plants.

Effect of Organic Wick Type Treatment on Growth and Yield of Pakcoy Plants

The treatment of coconut fiber wick showed a significant effect on all parameters of pakcoy plant growth and yield, namely on the parameters of plant height at all observation ages, number of leaves 10 DAP to 30 DAP, leaf area, root length, total wet weight, root wet weight, crown wet weight and wet weight. The wick commonly used in hydroponic systems is the flannel wick. The ability of flannel cloth wicks to deliver water very well is because flannel cloth is made of complex fabric fibers that are able to produce high capillarity so that it provides an optimal effect of providing water for the wearer (Laksono, 2020).

The organic fibers of coconut fiber are very good at absorbing nutrients and delivering them to plants. Coconut fiber is the outermost part of the coconut shell which has fine fibers, if the coconut fiber is broken down it will form fibers and fiber powder. Coconut fiber is one of the natural fibers that is cheap, environmentally friendly, durable, strong, not easy to rot, fungus resistant, pest resistant, widely available in nature, can absorb water three times the weight of the fiber, has a neutral pH, can maintain stable temperature circulation, and can be decomposed (Ayu et al., 2021).

The results of observations on mustard green plants with the treatment of variations in the type and length of the axis conducted by Ansar et al., (2019) showed that the use of coconut fiber with a length of 30 cm in planting mustard plants produced more leaves, the best plant height, and the highest leaf area index. It can be concluded that the productivity of plants using organic wicks made from coconut fiber is superior to flannel cloth.

The results of Cahyani (2023) research with the treatment of variations in wick material and LOF concentration on pakcoy plants showed that the flannel cloth wick was the best wick in all parameters of plant height, number of leaves, leaf area and wet weight of plants. However, the coconut fiber axis when compared to the bamboo fiber axis is better with higher values in the parameters of plant height, number of leaves, leaf area and plant wet weight.

The results of observations made by Vanesaputri et al., (2022) with the treatment of media types and axis types on red spinach plants showed that flannel axis was better than coconut coir axis and banana frond fiber, but coconut coir was better than banana frond fiber. The number of leaves and fresh weight parameters showed the highest number in the flannel wick, and the second highest in the coconut fiber treatment. The flannel axis treatment was significantly different from the banana frond axis but not significantly different from the coconut fiber axis. It can be concluded that the use of flannel and coconut fiber as a wick can deliver nutrient water well to meet the needs of plants.

The low weight loss is because the roots used as a tool to absorb nutrients grow evenly so that plants absorb nutrients well (Ghufroni et al., 2023). The decrease in plant weight is due to the process of transpiration and respiration causing a decrease in product quality due to reduced water which has an impact on product weight shrinkage (Hayati et al., 2017).

The treatment of coconut fiber organic wick type did not have a significant effect on the number of leaves at the age of 5 DAP. Pakcoy plants are still adapting to the surrounding environment because they have just moved. This condition is in accordance with the statement put forward by Purba & Maulana (2021), that plant growth and development can be influenced by external factors caused from outside the plant or environmental factors and internal factors originating from within the plant in the form of physiological factors and plant genetics.

Bamboo fiber wicks have poor performance because bamboo fiber wicks do not have maximum absorption so they cannot significantly affect plant growth and yield (Cahyani, 2023). As stated by Ahanger et al., (2017), when plants have difficulty absorbing these macronutrients, their growth rate is slow, affecting the production of several components. Maximum nutrient intake causes cells in the plant body to develop optimally because they are optimally differentiated.

Banana leaf fibers are easily rotten, so the ability to supply nutrient water will decrease. This ability to supply nutrient water will affect plant growth and yield (Ayilara et al., 2020). According to Wuriyudani et al., (2017), banana leaf fiber has a very high water absorption capacity, this is because banana fiber has pores that allow water to enter. This high absorption affects the durability of the fiber, the more the fiber absorbs water, the higher the possibility of the fiber becoming a microbial growth medium that causes rot in the fiber.

CONCLUSION

The combination of AB Mix 3 ml/L treatment and coconut fiber organic wick gave a significant effect on the observation parameter of plant height 15 to 25 DAP (13.37 cm), as well as the observation parameter of pakcoy yield at 30 DAP, namely crown wet weight (17.97 grams), root wet weight (3.60 grams), total wet weight (21.57 grams) and weight loss (0.24 grams). AB Mix 3 ml/L treatment gave a significant effect on all observation parameters except the observation parameter of plant height 5 DAP. The treatment of coconut fiber organic wick gives a significant effect on all observation parameters except the parameter of the number of leaves of plants 5 DAP. Based on the research conducted, AB Mix 3 ml/L and coconut fiber wick showed better results on the growth and yield of pakcoy plants than other treatment combinations. Furthermore, further research should be conducted using higher concentrations of liquid organic fertilizer to improve the growth and yield of pakcoy.

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How To Cite This Article, with *APA style* :

Edditya, S. H. N., Triani, N., & Santoso, J. (2025). Synergistic Organic Wick and Nutrient Levels on The Morphological Performance of Pakcoy (*Brassica rapa* L.) in Hydroponic Axis System. *Jurnal Pembelajaran dan Biologi Nukleus*, *11*(3), 1033-1055. https://doi.org/10.36987/jpbn.v11i3.7794

Conflict of interest : The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions : All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was submited by [**Shinta Hanif Nur Edditya**]. All authors contributed on previous version and revisions process of the manuscript. All authors read and approved the final manuscript.