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Interactive Effects of AB Mix Nutrient and Gandasil D Fertilizer on Productivity of Pakcoy (*Brassica rapa* L.) in Wick Hydroponics

Chintia Dinda Mellyaningtyas, Ramdan Hidayat(*), Yonny Koentjoro

Agrotechnology Study Program, Faculty of Agriculture,
Pembangunan Nasional "Veteran" Java Timur University
Jl. Rungkut Madya, Gn. Anyar, Kec. Gn. Anyar, Surabaya, East Java, 60294 Indonesia

***Corresponding author** : ramdan_h@upnjatim.ac.id

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Background: *National Pakcoy (Brassica rapa L.) production declined by approximately 9.69 % from 2022 to 2023 due to climate variability, suboptimal cultivation practices, and agricultural land-use conversion, highlighting the need for alternative production strategies. Wick-based hydroponic cultivation with optimized nutrient management using AB Mix and Gandasil D foliar fertilizer is therefore investigated for its potential to enhance nutrient uptake efficiency, vegetative growth, and yield of pakcoy in a sustainable manner.* **Methodology:** *the study conducted in Gubeng District, Surabaya, utilized a factorial Completely Randomized Design (CRD). The first factor was AB Mix concentration (500 ppm, 1000 ppm, 1500 ppm), and the second was Gandasil D foliar fertilizer concentration (Control, 1 g/L, 2 g/L, 3 g/L). Observation parameters include, plant length (cm), leaf area (cm^2), total fresh weight, shoot fresh weight, and shoot dry weight. Further analysis was performed using the Honestly Significant Difference (HSD) test at a 5% significance level.* **Findings:** *showed a significant interaction between the AB Mix concentration and Gandasil D foliar fertilizer on the plant shoot dry weight, with the highest yield (6.27 g) achieved by the combination of 1500 ppm AB Mix and 2 g/L Gandasil D. The single treatment of 1500 ppm AB Mix concentration yielded the best average for all observed parameters, including: plant length (16.73 cm), leaf area (688.04 cm^2), total fresh weight (64.15 g), shoot fresh weight (51.56 g), and shoot dry weight (6.27 g). The 2 g/L Gandasil D concentration treatment provided the highest results for total fresh weight (56.09 g) and shoot fresh weight (45.28 g). The combination of 1,500 ppm AB Mix and 2 g/L Gandasil D demonstrated the most optimal results for the growth and yield of pakcoy plants compared to other treatment combinations.* **Contribution:** *These findings provide information regarding the selection of the optimal AB Mix and Gandasil D concentrations to maximize the growth and yield of pakcoy in the wick hydroponic system, which can be utilized in educational or training programs for communities practicing urban farming.*

Keywords: *AB Mix; Gandasil D; Hydroponic; Pakcoy; Wick*

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INTRODUCTION

Pakcoy (*Brassica rapa* L.) is one of the most popular vegetable commodities from the Brassicaceae family in Indonesia, known for its ease of cultivation. However, data from the Central Statistics Agency (BPS) shows that national pakcoy production and productivity experienced a significant decrease from 2022 to 2023. In 2022, pakcoy production was 760,608 tons and dropped to 686,876 tons in 2023. Pakcoy productivity in Indonesia reached 10.65 tons/ha in 2022 and decreased to 9.93 tons/ha in 2023 (Badan Pusat Statistik, 2024). This decline, which contrasts with the constantly increasing market demand, necessitates Indonesia to resort to imports to meet domestic needs.

The decrease in pakcoy productivity is caused by several factors, such as: global climate change, the lack of implementation of proper and correct cultivation techniques, reduced soil fertility, and the diminishing availability of agricultural land due to land-use conversion (Hadisuwito, 2015). Therefore, an efficient, alternative cultivation solution is needed, especially in urban areas. The wick system hydroponics emerges as a relevant method due to its advantages of being simple, low-cost, not requiring electricity, and easy to implement, making it an ideal choice for optimizing limited urban land. However, the wick system hydroponics has a drawback: the nutrients tend to settle easily due to the lack of water circulation, which prevents the plants from absorbing nutrients optimally (Hendra & Andoko, 2014).

In hydroponic cultivation, nutrients are a key factor. The main nutrient commonly used is AB Mix, which provides complete macro and micro nutrients for plants (Endy, 2015). The use of AB mix fertilizer results in the best vegetative growth and harvest yield in spinach, pakcoy, and lettuce plants. The composition of AB mix fertilizer is considered to have the balanced content required by plants. The correct nutrient concentration in hydroponics is extremely crucial because plants absorb it directly from the solution, and an inappropriate dosage (too high/low) can cause stress, inhibit growth (toxicity/nutrient deficiency), and even reduce harvest quality. Therefore, a balance of nutrients (macro & micro) and pH monitoring are essential to support optimal plant metabolism (Nugraha & Susila, 2015). Research by Ramaidani (2021) shows that an AB Mix concentration of 1000 ppm yielded the best pakcoy growth. At the 1000 ppm concentration, positive responses were shown for plant height, stem length, leaf length, leaf diameter, and leaf count in pakcoy plants. Furoidah (2018) research indicates that an AB Mix concentration of 1100 ppm gave the best results for hydroponic mustard green growth. Research by Ainina & Aini (2018) showed that at 1000 ppm AB mix nutrients, the fresh consumption weight was heavier compared to other treatments. Furthermore, 1500 ppm of AB mix nutrients was able to provide the highest total fresh weight compared to other treatments.

Besides absorption through the roots, nutrient supplementation via the leaves is also significant. Foliar fertilization can meet up to 10% of the plant's nutrient needs, accelerating nutrient uptake. One foliar fertilizer dominant in Nitrogen (N) and good for vegetative growth is Gandasil D. The N content in Gandasil D plays a vital role in accelerating growth, but the application concentration must be precise to avoid phytotoxicity. Gandasil D is a type of granular fertilizer that is dissolved in water,

allowing it to be easily absorbed and translocated to all parts of the plant, thus supporting the plant's growth and development process (Uluputty, 2017). The concentration of fertilizer applied directly to the leaves must be carefully considered. Excessive use of foliar fertilizer will cause symptoms such as leaf burn, wilting, drying, and eventual dropping. Conversely, if the given concentration is too low, the nutrient requirements will not be met (Qorina, 2021).

Research by Nazar et al., (2024) indicates that the application of Gandasil D Foliar Fertilizer at a concentration of 3 g/l of water provides the best effect on the yield of conventionally grown pakcoy (plant height, leaf count, leaf area, fresh weight, and shoot fresh weight). The analysis of variance in Tuwongkesong et al., (2023) study showed that Gandasil D treatments of 0 g/l, 0.5 g/l, 1 g/l, 1.5 g/l, and 2 g/l significantly affected plant height, leaf count, leaf width, fresh weight, and root volume in green mustard plants. The Gandasil fertilizer with the 2 g/l treatment provided the highest average results for plant height, leaf count, leaf width, fresh weight, and root volume. Aprilinsia (2022) research indicated that the concentration of foliar fertilizer significantly affects the growth and yield of caisim (mustard greens). A Gandasil D concentration of 2 g/l had the highest average values for the parameters of plant height, leaf length, and plant weight per sample. Fauzi's (2024) research also showed that a Gandasil D foliar fertilizer concentration of 2 g/l can provide the best growth and yield for pagoda mustard greens grown indoors hydroponically.

The combination of AB Mix and foliar fertilizer is considered capable of increasing the efficiency of fertilization in hydroponic systems. AB Mix fulfills basic nutrient requirements through the roots, while foliar fertilizer can be an additional supplement that accelerates absorption and corrects nutrient deficiencies not adequately met by the roots, especially under stress or rapid growth conditions (Rahmawati et al., 2020). The combination of AB Mix and Gandasil D provides a synergistic effect that benefits the plants. AB Mix supplies nutrient needs through the roots, while Gandasil D supports this through direct absorption by the leaves, particularly when the roots have limitations in absorbing certain nutrients. The addition of Gandasil D can enhance photosynthesis efficiency, accelerate chlorophyll formation, and improve the quality of the crop yield (Sari & Pranoto, 2020).

The application of foliar fertilizer in conjunction with AB Mix nutrients can significantly increase the fresh weight and height of pakcoy plants compared to giving AB Mix alone (Wahyuni & Maulana, 2021). This is due to the synergistic role between the two nutrient sources in supporting the processes of photosynthesis, chlorophyll formation, and cell division. Premindau's (2020) research showed an interaction between the AB Mix dosage and the Gandasil D dosage regarding the leaf area in hydroponically grown red lettuce. The application of a 1g Gandasil D dosage showed good results for the growth of leaf count, leaf length, leaf chlorophyll production, and plant fresh weight. Saputra et al., (2019) indicated that the combination of AB-Mix nutrients and Gandasil D fertilizer increased the growth and yield of hydroponic peppermint plants across the variables of root volume, leaf count, shoot fresh weight, and shoot dry weight. The combined treatment of AB-Mix 75% + Gandasil D 2 g/l was the efficient dosage to produce the highest shoot fresh weight in hydroponic peppermint plants.

Considering the synergistic potential between the basal AB Mix nutrient solution and the Gandasil D supplemental fertilizer, coupled with the urgent need to enhance pakcoy production amidst land limitations, it is essential to investigate the optimal combination of these treatments. Therefore, this research aims to determine the individual and combined effects of AB Mix concentration and Gandasil D foliar fertilizer on the growth and yield of pakcoy cultivated using the wick hydroponic system. The findings of this study are expected to provide concrete scientific information and benchmarks for farmers, academics, and the community practicing urban farming, guiding the selection of the best AB Mix and Gandasil D concentrations to optimize pakcoy growth and yield in wick system hydroponics.

METHOD

Study Site and Environmental Conditions

The research was conducted at the researcher's garden (semi-outdoor) located in Gubeng Sub-district, Surabaya City, Indonesia (coordinates point -7.2843333˚S, 112.7501354˚E). The site is situated at an elevation of 3 - 6 meters above sea level (masl), with an average minimum temperature of 23˚C and a maximum temperature of 34˚C. The average annual rainfall is 165.3 mm, and the average air humidity ranges from a minimum of 50% to a maximum of 92%.

Plant Material and Treatment

The equipment utilized in this study included a wick hydroponic system installation, seeding trays (with a capacity of 90 seedlings), netpots, a sprayer pump, a pH meter, a TDS/EC meter, a ruler, a digital scale (with 0.1 g accuracy/precision), measuring cups, plant labels, stationery, and documentation tools. The materials used were pakcoy seeds, water, AB Mix nutrient solution (Goodplant brand), rockwool growing media, and Gandasil D fertilizer. Gandasil D is a crystal-form compound foliar fertilizer from PT Kalatham, rich in macronutrients (N 20%, P2O5 15%, K2O 15%, MgSO4 1%) and micronutrients (Mn, B, Cu, Co, Zn), as well as vitamins essential for plant vegetative growth (leaves/stems).

The pakcoy seeds used were the Nauli F1 variety. Seeds were sown in rockwool cubes, which were cut into 2.5 x 2.5 x 2.5 cm sizes. The availability of nutrients was monitored daily by measuring the ppm value using a TDS meter. If the ppm value dropped, AB Mix was added gradually until the required ppm concentration was achieved. The stability of the pH was maintained by daily measurement using a pH meter. The recommended pH range for hydroponic cultivation is 6.5 - 7. If the pH was too low, a pH up solution was administered; conversely, if the pH was too high, a pH down solution was applied.

Hydroponic Wick System Setup

The wick hydroponic system was set up using styrofoam boxes as the hydroponic reservoirs. A total of 36 styrofoam units were constructed, each measuring 20 cm in height, 50 cm in length, and 38 cm in width. The lids of the styrofoam boxes were perforated with 7 cm diameter holes to accommodate the netpots. Each reservoir

was designed to have 6 planting holes. Flannel cloth strips were attached to the netpots to function as wicks, drawing the nutrient solution up from the reservoir. Finally, each styrofoam box was filled with water (or nutrient solution) to a depth of 10 cm.

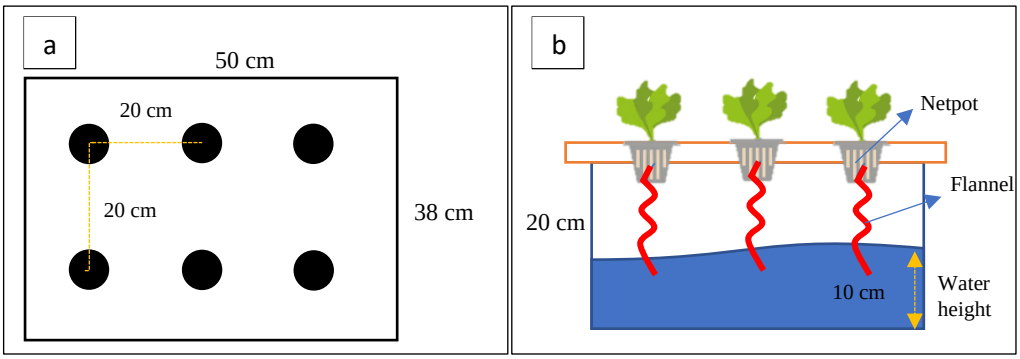

Figure 1. Wick Hydroponic System Construction; a) Plant Spacing. b) Wick Hydroponic System (by Author).

Experimental Design

This study utilized a Factorial Experiment with two factors, arranged in a Completely Randomized Design (CRD). The first factor was the concentration of AB Mix nutrient solution, consisting of three treatment levels, and the second factor was the concentration of Gandasil D foliar fertilizer, consisting of four treatment levels, i.e:
Factor I : AB Mix Concentration (A), consisting of three levels:

A1: 500 ppm

A2: 1000 ppm

A3: 1500 ppm

Factor II : Gandasil D Foliar Fertilizer Concentration (K), consisting of four levels:

K0: Control (0 g/L)

K1: 1 g/L

K2: 2 g/L

K3: 3 g/L

This design resulted in 12 treatment combinations. Each treatment combination was replicated three times, yielding a total of 36 experimental units. In each experimental unit (reservoir) where 6 plants were maintained, 3 plants were randomly selected for observation. Thus, a total of 108 plants were observed out of the 216 total pakcoy plants grown.

Table 1. Treatment Combination of AB Mix Concentration and Gandasil D Foliar Fertilizer

AB Mix Concentration	Gandasil D Fertilizer Concentration			
	K_0	K_1	K_2	K_3

A_1	$A_1 K_0$	$A_1 K_1$	$A_1 K_2$	$A_1 K_3$
A_2	$A_2 K_0$	$A_2 K_1$	$A_2 K_2$	$A_2 K_3$
A_3	$A_3 K_0$	$A_3 K_1$	$A_3 K_2$	$A_3 K_3$

Description:
$A_1 K_0$ = AB Mix Concentration 500 ppm + Gandasil D Concentration 0 g/L
$A_1 K_1$ = AB Mix Concentration 500 ppm + Gandasil D Concentration 1 g/L
$A_1 K_2$ = AB Mix Concentration 500 ppm + Gandasil D Concentration 2 g/L
$A_1 K_3$ = AB Mix Concentration 500 ppm + Gandasil D Concentration 3 g/L
$A_2 K_0$ = AB Mix Concentration 1000 ppm + Gandasil D Concentration 0 g/L
$A_2 K_1$ = AB Mix Concentration 1000 ppm + Gandasil D Concentration 1 g/L
$A_2 K_2$ = AB Mix Concentration 1000 ppm + Gandasil D Concentration 2 g/L
$A_2 K_3$ = AB Mix Concentration 1000 ppm + Gandasil D Concentration 3 g/L
$A_3 K_0$ = AB Mix Concentration 1500 ppm + Gandasil D Concentration 0 g/L
$A_3 K_1$ = AB Mix Concentration 1500 ppm + Gandasil D Concentration 1 g/L
$A_3 K_2$ = AB Mix Concentration 1500 ppm + Gandasil D Concentration 2 g/L
$A_3 K_3$ = AB Mix Concentration 1500 ppm + Gandasil D Concentration 3 g/L

Fertilizer Application

The application of Gandasil D was performed by dissolving the fertilizer in water, followed by spraying it onto the pakcoy plants. The fertilizer was dissolved according to the designated treatment levels (K1: 1 g/L, K2: 2 g/L, and K3: 3 g/L) into separate 1-liter volumes of water. The fertilizer solution was sprayed evenly over the entire surface of the pakcoy leaves in the morning. Application of Gandasil D was conducted at 7-day intervals on 7 DAS (Days After Sowing), 14 DAS, and 21 DAS. To prevent cross-contamination, plants were separated using plastic barriers during spraying to ensure that fertilizer from one treatment did not splash onto plants with different treatments. Before the main fertilizer application, the required solution volume per plant was determined. This was done by spraying a sample of the largest plant with water using the sprayer until the entire lower surface of the leaves was uniformly wet. The recorded volume of water used served as the standard reference for determining the amount of foliar fertilizer solution to be sprayed on every plant.

Observation parameter

Plant Length (cm)

Plant length will be measured using a ruler from the base of the stem to the tip of the highest pakcoy leaf. Measurements will commence 5 days after transplanting and continue every 5 days until the pakcoy plants are harvested.

Leaf Area (cm^2)

Leaf area will be determined by measuring the largest leaf on each observed plant after harvest. The calculation for leaf area will use the following formula (Sitompul & Guritno, 1995):

$$\text{Leaf Area} = \text{Length} \times \text{Width} \times \text{Leaf Constant} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Note: The leaf constant for pakcoy has been previously calculated and determined to be 0.68.

Total Fresh Weight

The total fresh weight of the plant will be obtained by weighing the entire plant, from the leaf tips to the root tips, using a digital scale.

Shoot Fresh Weight

The shoot fresh weight will be determined by weighing the marketable (consumable) part of the plant, from the leaf tips to the base of the stem, using a digital scale.

Shoot Dry Weight

Shoot dry weight will be measured after the pakcoy plants are harvested. The shoot portion will be air-dried and then oven-dried at 60∘C for 48 hours, after which it will be weighed using a digital scale.

Statistical Analysis

The data obtained from the experiment were analyzed using Analysis of Variance (ANOVA) based on a Factorial Completely Randomized Design (CRD). The mathematical model equation used for calculating the ANOVA for a factorial CRD is as follows:

$$Yijk = \mu + \alpha i + \beta j + (\alpha\beta)ij + \varepsilon_{ijk} \quad \text{.....................................} \quad (2)$$

Description:

Yijk	: The observed value of the variable in the i-th level of factor A, the j-th level of factor K, and the k-th replication.
μ	: The overall mean effect.
αi	: The effect of the i-th level of Factor A (AB Mix concentration).
βj	: The effect of the j-th level of Factor B (Gandasil D concentration).
(αβ)ij	: The effect of the interaction between the i-th level of Factor A and the j-th level of Factor B.
ε_{ijk}	: The random error effect of the treatment combination of the i-th level of Factor A (AB Mix Concentration) and the j-th level of Factor B (Gandasil D Concentration) in the k-th replication.

If the F-test indicates a significant effect, further analysis will be conducted using the Honestly Significant Difference (HSD) test at the 5% significance level, with the following equation:

$$HSD\ 0{,}05 = q0{,}05\ (p;db) \times \sqrt{\frac{MSE}{r}} \quad \text{.....................................} \quad (3)$$

Description:

HSD	: Honestly Significant Difference (The critical value for mean comparison).
q(p,db)	: Studentized Range Statistic (obtained from the Studentized Range Table) at the significance level 0,05, with p treatments/means being compared, and db degrees of freedom for error.
MSE	: Mean Square Error (or KTG / Kuadrat Tengah Galat) obtained from the ANOVA table.
r	: Number of replications per treatment.

If a significant effect is observed only for the AB Mix concentration (A), the HSD equation is as follows:

$$\text{BNJ } 0{,}05 = q0{,}05\ (p;db) \times \sqrt{\frac{MSE}{r \times nK}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

If a significant effect is observed only for the Gandasil D concentration (K), the HSD equation is as follows:

$$\text{BNJ } 0{,}05 = q0{,}05\ (p;db) \times \sqrt{\frac{MSE}{r \times nA}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Description:

BNJ0,05 : The critical value for the Honestly Significant Difference at the 5% level.
q0,05 (p; db) : The Studentized Range Statistic value (q-value) for p treatment means, and db degrees of freedom for the error (at the 5% level).
MSE : Mean Square Error (KT Galat) obtained from the ANOVA table.
r : Number of replications.
nK : Number of levels for the other factor (Factor K / Gandasil D concentration).
nA : Number of levels for the other factor (Factor A / AB Mix concentration).

RESULT

Plant Length

The analysis of variance for the combined effects of AB Mix concentration and Gandasil D foliar fertilizer on pakcoy plant length indicated no significant interaction at any observation age. However, the single treatment of AB Mix concentration significantly affected plant length at 5 days after transplanting (DAT) and had a highly significant effect on plant length at 10, 15, 20, and 25 DAT. Conversely, the single treatment of Gandasil D foliar fertilizer had no significant effect on plant length at any observation age. The average pakcoy plant lengths influenced by the single effects of AB Mix concentration and Gandasil D foliar fertilizer are presented in Table 2.

Table 2. Average Pakcoy Plant Length under AB Mix and Gandasil D Foliar Fertilizer Treatments at 5, 10, 15, 20, and 25 DAT

	Plant Length (cm) … DAT……				
Treatments	**5**	**10**	**15**	**20**	**25**
AB Mix Concentration					
500 ppm (A_1)	6,66 a	7,89 a	8,82 a	10,60 a	13,26 a
1000 ppm (A_2)	7,16 b	8,78 b	10,53 b	13,16 b	15,99 b
1500 ppm (A_3)	7,17 b	9,82 c	12,35 c	14,25 c	16,73 b
HSD 5%	0,43	0,56	0,81	0,78	0,77
σ					
Concentration of Gandasil D Foliar Fertilizer					
0 g/l (K_0)	6,96	8,93	10,34	12,37	14,74
1 g/l (K_1)	7,08	8,95	10,84	12,96	15,60
2 g/l (K_2)	6,99	8,78	10,52	12,78	15,87
3 g/l (K_3)	6,94	8,66	10,55	12,57	15,09

HSD 5% σ	ns	ns	ns	ns	ns

Note: Numbers followed by the same letter within the same treatment and observation age indicate no significant difference at the 5% Honestly Significant Difference (HSD) test; ns = not significant. σ

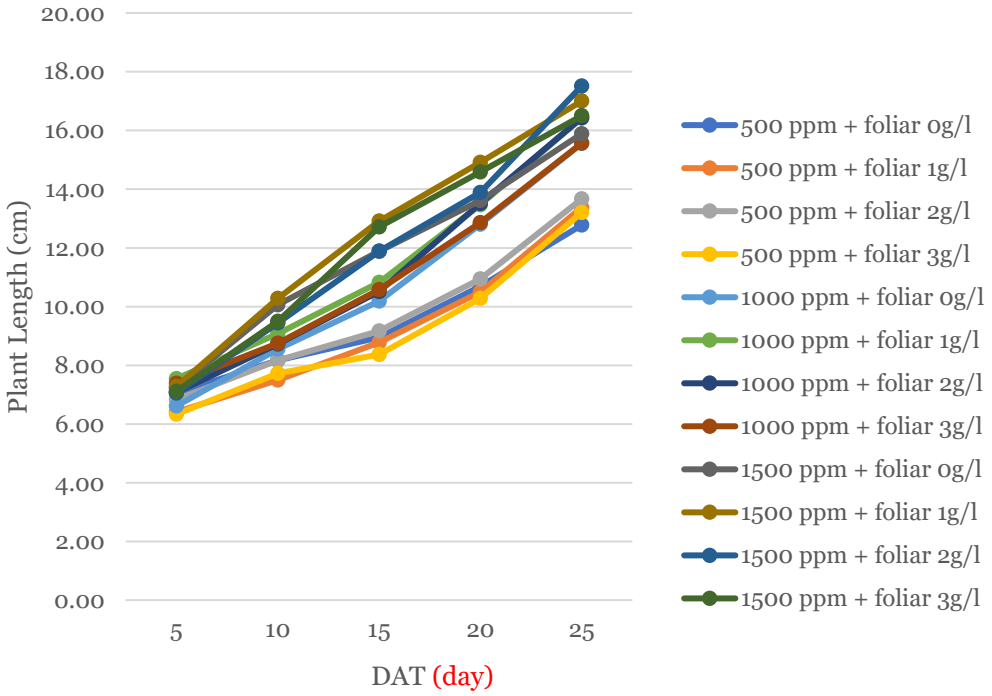

Figure 2. Rate of Increase in Pakcoy Plant Height Under Different Concentrations of AB Mix and Gandasil D Foliar Fertilizer Treatments.

Table 2 indicates that the 1500 ppm AB Mix concentration consistently resulted in the longest pakcoy plants, showing a significant difference compared to other concentrations. However, at 5 and 25 days after transplanting (DAT), there was no significant difference between the 1500 ppm and 1000 ppm AB Mix treatments. Notably, the 1500 ppm AB Mix treatment led to a 26.16% increase in pakcoy plant length at 25 DAT when compared to the 500 ppm AB Mix treatment. Furthermore, Table 2 also suggests that while the Gandasil D foliar fertilizer treatments tended to increase pakcoy plant length, this increase was not statistically significant compared to the control.

Figure 2 shows the graph of the average plant length based on the treatment combinations. The graph indicates that the combination treatment of AB Mix and Gandasil D concentrations yielded non-significant results. The highest final plant length was obtained from the combination treatment of AB Mix 1500 ppm and Gandasil D 2 g/L, measuring 17.51 cm.

Leaf Area

The analysis of variance for the combined effects of AB Mix concentration and Gandasil D foliar fertilizer on pakcoy leaf area revealed no significant interaction.

However, the single treatment of AB Mix concentration had a highly significant effect on pakcoy leaf area. Conversely, the single treatment of Gandasil D foliar fertilizer did not significantly affect pakcoy leaf area. The average pakcoy leaf area as influenced by the single effects of AB Mix concentration and Gandasil D foliar fertilizer is presented in Table 3.

Table 3. Average Pakcoy Leaf Area under AB Mix and Gandasil D Foliar Fertilizer Treatments

Treatments	Leaf Area (cm^2)
AB Mix Concentration	
500 ppm	321,18 a
1000 ppm	599,48 b
1500 ppm	688,04 b
HSD 5%	90,84
σ	31.11
Concentration of Gandasil D Foliar Fertilizer	
0 g/l	488,17
1 g/l	544,49
2 g/l	608,37
3 g/l	503,91
HSD 5%	ns
σ	35.92

Note: Numbers followed by the same letter within the same treatment and observation age indicate no significant difference at the 5% Honestly Significant Difference (HSD) test; ns = not significant

Table 3 illustrates that the 1500 ppm AB Mix concentration resulted in the largest pakcoy leaf area, showing a significant difference from the 500 ppm AB Mix treatment. However, it was not significantly different from the 1000 ppm AB Mix treatment. Notably, the 1500 ppm AB Mix treatment led to a substantial 114.22% increase in pakcoy leaf area compared to the 500 ppm AB Mix treatment. Additionally, Table 3 indicates that while the Gandasil D foliar fertilizer treatments tended to increase pakcoy leaf area, this increase was not statistically significant when compared to the control.

Total Plant Fresh Weight

The analysis of variance for the combined effects of AB Mix concentration and Gandasil D foliar fertilizer on the total fresh weight of pakcoy plants indicated no significant interaction. However, both the single treatment of AB Mix concentration and the single treatment of Gandasil D foliar fertilizer had a highly significant effect on the total fresh weight of pakcoy plants. The average total fresh weight of pakcoy plants influenced by the single effects of AB Mix concentration and Gandasil D foliar fertilizer is presented in Table 4.

Table 4. Average Total Fresh Weight of Pakcoy Plants under AB Mix and Gandasil D Foliar Fertilizer Treatments

Treatments	Total Fresh Weight (g)
Concentration AB Mix	
500 ppm	31,21 a
1000 ppm	59,09 b
1500 ppm	64,15 c
HSD 5%	3,29
σ	1.127
Concentration of Gandasil D Foliar Fertilizer	
0 g/l	47,32 a
1 g/l	53,77 b
2 g/l	56,09 b
3 g/l	48,75 a
HSD 5%	4.59
σ	1.3

Note: Numbers followed by the same letter within the same treatment and observation age indicate no significant difference at the 5% Honestly Significant Difference (HSD) test.

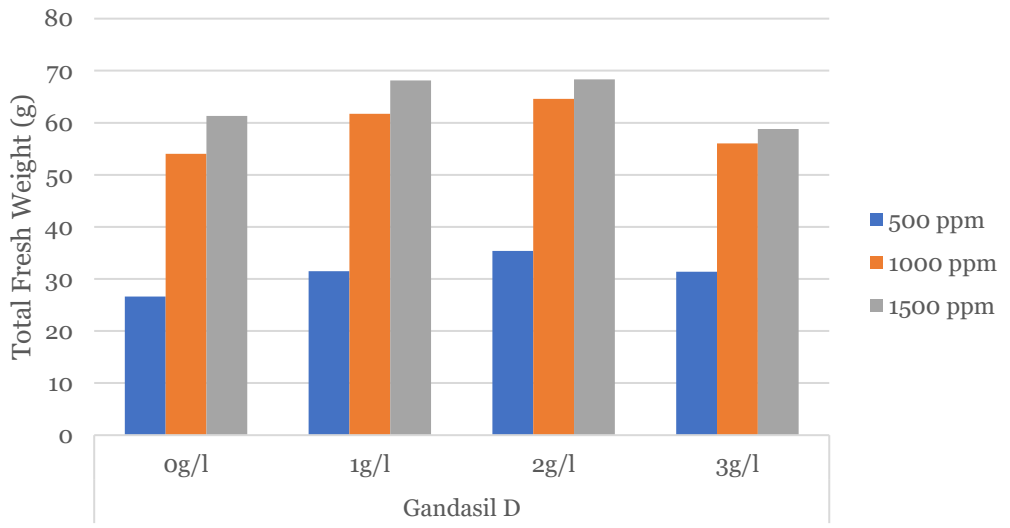

Figure 3. Graph of Mean Total Fresh Weight of Pakcoy Plants Under Different Concentrations of AB Mix and Gandasil D Foliar Fertilizer Treatments

Table 4 and figure 3 reveals that the 1500 ppm AB Mix concentration yielded the highest total fresh weight for pakcoy plants, significantly differing from other concentrations. This treatment resulted in a substantial 105.54 % increase in total fresh weight compared to the 500 ppm AB Mix treatment. Furthermore, Table 4 indicates that Gandasil D foliar fertilizer treatments generally increased the total fresh weight of pakcoy plants. Specifically, the 2 g/L concentration of Gandasil D produced the heaviest total fresh weight, showing a significant difference from other concentrations, although it was not significantly different from the 1 g/L concentration. This 2 g/L

Gandasil D treatment led to an 18.53% increase in total fresh weight compared to the control.

Shoot Fresh Weight

The analysis of variance for the combined effects of AB Mix concentration and Gandasil D foliar fertilizer on the shoot fresh weight of pakcoy plants indicated no significant interaction. However, both the single treatment of AB Mix concentration and the single treatment of Gandasil D foliar fertilizer had a highly significant effect on the shoot fresh weight of pakcoy plants. The average shoot fresh weight of pakcoy plants influenced by the single effects of AB Mix concentration and Gandasil D foliar fertilizer is presented in Table 5.

Table 5. Average Shoot Fresh Weight of Pakcoy Plants under AB Mix and Gandasil D Foliar Fertilizer Treatments

Treatments	Shoot Fresh Weight (g)
AB Mix Concentration	
500 ppm	22,54 a
1000 ppm	48,51 b
1500 ppm	51,56 b
HSD 5%	3,49
σ	1.194
Concentration of Gandasil D Foliar Fertilizer	
0 g/l	36,27 a
1 g/l	43,27 b
2 g/l	45,28 b
3 g/l	38,43 ab
HSD 5%	4,87
σ	1.379

Note: Numbers followed by the same letter within the same treatment and observation age indicate no significant difference at the 5% Honestly Significant Difference (HSD) test.

Table 5 shows that the 1500 ppm AB Mix concentration yielded the highest shoot fresh weight for pakcoy plants, significantly differing from the 500 ppm concentration, but not significantly different from the 1000 ppm concentration. This 1500 ppm AB Mix treatment resulted in a substantial 128.74% increase in shoot fresh weight compared to the 500 ppm AB Mix treatment. Furthermore, Table 5 indicates that Gandasil D foliar fertilizer treatments generally tended to increase the shoot fresh weight of pakcoy plants. Specifically, the 2 g/L concentration of Gandasil D produced the heaviest shoot fresh weight, showing a significant difference from the control treatment, but not significantly different from the 1 g/L and 3 g/L concentrations. This 2 g/L Gandasil D treatment led to a 24.84% increase in total pakcoy fresh weight compared to the control group.

Shoot Dry Weight

The analysis of variance for the combined effects of AB Mix concentration and Gandasil D foliar fertilizer on the shoot dry weight of pakcoy plants showed a significant interaction. Furthermore, both the single treatment of AB Mix concentration and the single treatment of Gandasil D foliar fertilizer had a highly significant effect on the shoot dry weight of pakcoy plants. The average shoot dry weight of pakcoy plants as influenced by the combination of AB Mix and Gandasil D foliar fertilizer treatments is presented in Table 6.

Table 6. Average Shoot Dry Weight of Pakcoy Plants under Combined AB Mix and Gandasil D Foliar Fertilizer Treatments

	Shoot Dry Weight (g)			
Treatments	**Concentration of Gandasil D Foliar Fertilizer**			
AB Mix Concentration	**0 g/l**	**1 g/l**	**2 g/l**	**3 g/l**
500 ppm	2,03 a	2,40 a	2,63 a	2,40 a
1000 ppm	4,47 bc	5,13 c	5,83 cd	4,63 bc
1500 ppm	4,20 b	6,00 d	**6,27 d**	4,57 bc
HSD 5%	0,76			
σ	0.176			

Note: Numbers followed by the same letter within the same treatment and observation age indicate no significant difference at the 5% Honestly Significant Difference (HSD) test.

Table 6 reveals that the combination of 1500 ppm AB Mix and 2 g/L Gandasil D resulted in the highest average shoot dry weight, significantly differing from all other treatment combinations. The only exceptions were the combinations of 1500 ppm AB Mix with 1 g/L Gandasil D, and 1000 ppm AB Mix with 2 g/L Gandasil D, where no significant difference was observed. This optimal combination of 1500 ppm AB Mix and 2 g/L Gandasil D led to a remarkable 208.87% increase in total pakcoy dry weight when compared to the combination of 500 ppm AB Mix and the control Gandasil D treatment.

DISCUSSION

The research findings for plant length indicate a direct correlation: higher nutrient concentrations result in greater plant length. The average plant length observed at 1500 ppm was significantly different from that at 500 ppm across all observation ages. This aligns with Afthansia & Maghfoer (2018), who state that proper vegetative growth, which influences plant length, is heavily dependent on the nutrient components provided. Variations in nutrient concentrations during the vegetative phase lead to differences in plant growth processes. This is consistent with Rizal (2017) research, which found that AB Mix is the optimal nutrient solution for pakcoy growth, significantly affecting plant height. Our observations suggest that the appropriate nutrient concentration for pakcoy plant height is 1500 ppm. This conclusion is further supported by Mushafi (2016), who also determined that 1500 ppm AB Mix is the suitable concentration for mustard greens.

Leaf area in plants is significantly influenced by various factors, including

nutrient availability. According to Mafaza (2021), a nutrient concentration of 1500 ppm was the most optimal level for the growth of Chinese mustard (*Brassica rapa* subsp. *parachinensis*) plants, particularly influencing the leaf area parameter. Our analysis of variance for pakcoy leaf area similarly showed a highly significant effect at 1500 ppm, yielding the highest average leaf area. This finding aligns with the results for the fresh weight of pakcoy, where plants at the 1500 ppm concentration also exhibited the highest average fresh weight. This supports Yama & Kartiko (2020), who found that AB Mix at 1500 ppm can influence the fresh weight of pakcoy in wick hydroponic systems.

The increase in plant weight is directly related to increases in plant length, leaf number, and leaf area. This is consistent with Alfian & Muhardi (2022), who suggested that an increase in the leaf area of pakcoy plants automatically leads to a corresponding increase in the plant's fresh weight. This phenomenon is attributed to the fact that leaves are the primary organs for water storage. Consequently, a greater leaf area correlates with higher plant water content, ultimately leading to a higher fresh weight in pakcoy plants.

A single application of Gandasil D foliar fertilizer at a concentration of 2 g/L resulted in the highest total fresh weight of 56.09 g. This suggests that this concentration effectively provided optimal nutrients to support vegetative growth. The complete macro and micronutrient content of Gandasil D, particularly nitrogen, phosphorus, and potassium, plays a crucial role in tissue formation and plant metabolic activity (Nurcahyo & Ariani, 2017). Research by Fauzi (2024) indicates that a 2 g/L concentration of Gandasil D foliar fertilizer can provide optimal growth and yield for pagoda mustard cultivated in an indoor hydroponic system. However, this finding was not significantly different from the 1 g/L treatment, suggesting that both concentrations are sufficiently effective in enhancing biomass accumulation.

The highest shoot fresh weight was also observed at the 2 g/L concentration, measuring 45.28 g, though this was not significantly different from the 1 g/L and 3 g/L treatments. This suggests a positive response of shoot growth to increased fertilizer concentration, but with a tendency to reach a saturation point at certain doses. Therefore, using Gandasil D at a concentration of 1–2 g/L is considered efficient for increasing both total and shoot fresh weight of the plants. Syifa et al., (2020) reported that the fresh weight of pagoda mustard plants is influenced by the sufficient availability of plant nutrients. The photosynthates produced during photosynthesis also affect plant fresh weight; an increased rate of photosynthesis boosts the formation of carbohydrates and other nutrients that support plant development, especially in shoots, roots, and leaves, thereby increasing plant fresh weight.

This observations reveal a significant interaction between AB Mix nutrient concentration and Gandasil D foliar fertilizer on the shoot dry weight of pakcoy. The combination of 1500 ppm AB Mix and 2 g/L Gandasil D yielded the highest average shoot dry weight of 6.27g. This finding aligns with Frank (2011), who stated that increasing nutrient concentration can boost a plant's dry weight. This is because dry weight directly correlates with the ratio of absorbed nitrogen to plant biomass. A higher dry weight indicates a more efficient photosynthetic process and greater nutrient uptake by the plant. This is also consistent with Sarif et al., (2015), who emphasized that dry weight is a key indicator of successful plant growth in mustard (*Brassica rapa*),

reflecting the net result of plant metabolism, including photosynthesis. However, the 6.27g shoot dry weight was not significantly different from the combinations of 1500 ppm AB Mix with 1 g/L Gandasil D, or 1000 ppm AB Mix with 2 g/L Gandasil D. This lack of significant difference suggests that nutrient availability was already sufficient at the 1000 ppm AB Mix and 2 g/L Gandasil D concentrations. The availability of nutrients directly influences a plant's dry weight production, as growth in one part of the plant is often accompanied by growth in other parts. Putra et al., (2019) further support this by noting that a plant's dry matter content depends on the extent of nutrient uptake by the roots throughout the growth process.

The efficacy of the wick hydroponic system for pakcoy cultivation is relatively good for beginners or home-scale operations due to its low cost and ease of management. However, its main drawback is that nutrient uptake is not as effective as in other systems. This ineffective nutrient absorption is primarily attributed to the static (non-circulating) nature of the water/nutrient solution. The optimized combination of AB Mix at a concentration of 1,500 ppm and Gandasil D 2 g/l was found to be the most effective treatment for pakcoy yield and growth in the wick system. This specific nutrient combination represents a successful strategy to enhance nutrient assimilation efficiency in pakcoy plants grown using the passive wick hydroponic method.

CONCLUSION

Based on the field observations and statistical analysis, it can be concluded that there was a significant interaction between the combination of AB Mix concentration and Gandasil D foliar fertilizer treatment on the shoot dry weight of the plants.The highest shoot dry weight was obtained from the combination of AB Mix 1,500 ppm and Gandasil D 2g/l, yielding 6.27 g. For the single factor treatment, AB Mix at a concentration of 1,500 ppm yielded the best results for all observed parameters: plant Length (16.73 cm), leaf area (688.04 cm), total fresh weight (64,15 g), shoot fresh weight (51.56 g), and shoot dry weight (6.27 g). The single treatment of Gandasil D foliar fertilizer at a concentration of 2g/l showed the highest results for total fresh weight (56.09 g) and shoot fresh weight (45.28 g). The combination of AB Mix 1,500 ppm and Gandasil D 2g/l demonstrated the most optimal results for pakcoy plant growth and yield compared to the other treatment combinations. Furthermore, subsequent research is recommended to analyze the plant chlorophyll content and to investigate other types of foliar fertilizers for comparative purposes in an effort to further enhance pakcoy growth and yield.

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