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Increasing the Growth and Production of Pakcoy Plants (*Brassica rapa* L.) with Variations in Planting Media in Hydroponic Systems

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Abstract

Pakcoy (*Brassica rapa* L.) is a short-lived leafy vegetable with high nutrient requirements and is highly responsive to environmental conditions, making it well-suited for cultivation using hydroponic systems. Additionally, the limited availability of agricultural land in urban areas due to land conversion necessitates efficient cultivation methods that do not rely on soil. Hydroponic systems offer more precise control over nutrient management and the growing environment compared to conventional soil-based cultivation, potentially increasing production efficiency on limited land. The success of hydroponic pakcoy production is significantly influenced by the type of growing medium, which supports root development, maintains water availability, and facilitates aeration and nutrient absorption. Therefore, research on various growing media is essential to identify the most effective medium for enhancing pakcoy plant growth and yield. This study aims to: 1) determine the effect of various growing media on the growth and production of pakcoy plants in hydroponic systems (*Brassica rapa* L.); and 2) identify the best alternative growing medium for optimizing the growth and production of pakcoy in hydroponic cultivation. The research was conducted from May to July 2025 in the greenhouse of the Payakumbuh State Agricultural Polytechnic, Harau District, Lima Puluh Kota Regency, West Sumatra. This study employed a completely randomized design (CRD) with a non-factorial approach. The factor studied was the growing media, consisting of seven treatments: rockwool, bamboo humus, coconut fiber, chopped fern, rockwool + bamboo humus, rockwool + coconut fiber, and rockwool + chopped fern. The parameters observed included plant height, number of leaves, leaf width, leaf length, root length, and fresh plant weight. The results indicated that variations in growing media significantly affected the growth and production of Pakcoy plants in the hydroponic system. The combination of rockwool and coconut fiber as planting media yielded the best results for Pakcoy plant growth and production. Therefore, the optimal alternative planting media for Pakcoy growth and production in the hydroponic system was rockwool combined with coconut fiber.

Keywords: Cultivation Technology, Nutrition, Productivity, Soilless System, Nutrient Efficiency

1. Introduction

Hydroponics is a method of cultivating plants without soil, instead using nutrient solutions that contain essential plant nutrients. In a hydroponic system, the growing medium plays a crucial role by supporting the plants, providing a site for root attachment, storing water, and facilitating aeration, all of which Influence root development and nutrient absorption (Purba et al., 2021). The physical characteristics of the growing medium, such as porosity, water retention capacity, and aeration capacity, are vital for successful plant growth in hydroponic systems.

Pakcoy (*Brassica rapa* L.) is a leafy vegetable widely cultivated hydroponically due to its relatively short life cycle, simple nutritional requirements, and high economic and nutritional value. Additionally, the increasing conversion of agricultural land into residential and urban areas has reduced the availability of planting land, creating a need for efficient, soil-independent cultivation systems.

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Under these circumstances, hydroponics offers an ideal solution by maximizing planting space, optimizing water and nutrient use, and enabling production on limited land. Pakcoy's high adaptability to hydroponic systems makes it suitable for household, educational, and commercial cultivation. (Suarsana et al., 2019; Nurjannah et al., 2022) . Various factors, including the type of growing medium used, Influence the growth of Pakcoy in hydroponic systems.

Various studies have shown that different types of hydroponic growing media significantly affect plant growth, as evidenced by plant height, leaf number, leaf area, and fresh weight. Nurifah & Fajarfika (2020) reported that variations in hydroponic growing media resulted in differences in growth and yield in *Brassicaceae* plants. This finding suggests that growing media not only provides support for plants but also helps create an optimal rooting environment.

Growing media such as rockwool are the most commonly used in hydroponic cultivation due to their stable, sterile fiber structure, water retention, and good aeration for plant roots (Purba et al., 2021). However, rockwool has several drawbacks, including its relatively high price, difficulty in biodegrading, and dependence on imported materials. These conditions have prompted the need to explore alternative growing media that are more environmentally friendly and readily available.

Organic growing media such as coconut fiber, bamboo humus, and chopped fern have potential as alternative media in hydroponic cultivation due to their good water retention capacity and structure that supports root development. Research by Nurjannah et al. (2022) and Nabila et al. (2024) showed that the use of multiple organic media in a wick hydroponic system resulted in varied growth responses in Pakcoy plants. These differences are related to the physical characteristics of the growing media, which Influence the rooting environment.

Another study specifically examining the use of organic growing media for Pakcoy was conducted by Muzafri et al. (2023). The results showed that the use of various organic growing media significantly affected the growth and yield of Pakcoy (*Brassica rapa* L.). This finding confirms that different types of organic growing media can elicit distinct growth responses in Pakcoy plants across the tested cultivation systems. Furthermore, differences in the characteristics of hydroponic growing media also affect aeration and humidity conditions around the plant roots. Warjoto et al. (2020) reported that different hydroponic growing media elicited distinct growth responses in leafy vegetables.

Various studies have examined the effects of growing media on Pakcoy growth; however, most have focused on a single medium or on comparing media separately, without comprehensively evaluating combinations of growing media within a single cultivation system. Research on the use of organic media combinations as a sustainable alternative to hydroponic media is also relatively limited. Given this context, further investigation is needed to understand Pakcoy plants' growth responses to various growing media, particularly comparing rockwool, organic media, and their combinations in hydroponic systems. The objectives of this study are: 1) to determine the effect of growing media on the growth and production of Pakcoy (*Brassica rapa* L.); and 2) to identify the best alternative growing media for the growth and production of Pakcoy (*Brassica rapa* L.).

2. Material and Methods

2.1. Time and Place

This research was conducted in May – July 2025, in *the greenhouse* of Payakumbuh State Agricultural Polytechnic, Harau District, Lima Puluh Kota Regency, West Sumatra, with coordinates 0 ^{O} 10' 12.2" South Latitude and 100 ^{O} 39' 56.8" East Longitude, at an altitude of 540 M above sea level.

2.2. Tools and materials

The tools used are an NFT hydroponic installation with a 3% slope, a Sakai Pro brand aquarium pump (Eco-106, 40 W, 3.0 m total head, 3200 L/H output), a ruler, label paper, scales, a seedling tray, stationery, and a camera. The materials used were rockwool, bamboo humus, coconut fiber, chopped fern, AB Mix (EC 1.8–2.2 mS/cm, pH 5.5–6.5), EM-4, and Nauli F1 variety Pakcoy seeds.

2.3. Experimental Design

This study used a non-factorial completely randomized design (CRD). The factors studied were the growing media, with 7 treatments: rockwool, bamboo humus, coconut fiber, chopped fern, rockwool + bamboo humus, rockwool + coconut fiber, and rockwool + chopped fern. Each treatment consisted of 3 replications, with 1 replication comprising 7 plants and 4 plants used as sample plants; thus, the total population across all treatments was 147 plants.

2.4. Research Implementation

The research used an experimental method. The study began with the preparation of the planting medium: bamboo humus from the inner layer of dead bamboo, fermented with EM4 for 1 week. Next, coconut fiber was soaked in water for 1 week to neutralize growth inhibitors; the soaking water was changed daily. The fern roots were finely chopped (2–3 cm) and then sterilized. Next was preparing for the NFT hydroponic system installation. The NFT channel was prepared with a 3% slope, then the AB Mix nutrient preparation (EC 1.8–2.2 mS/cm, pH 5.5–6.5) was applied. Next was the sowing of Pakcoy seeds. The Pakcoy seeds were sown in the planting medium according to the treatment. After the seedlings were 2 weeks old, they were transferred to the installation according to the

treatment.

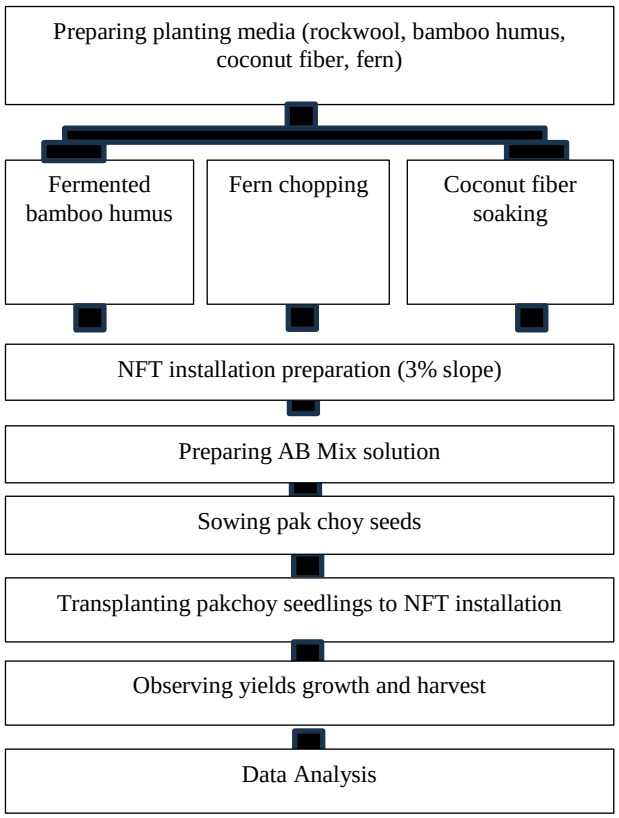


Figure 1. Research flow diagram

2.5. Data Observation and Analysis

The parameters observed include:

a. Plant height (cm) is measured by measuring the plant from the base of the stem to the longest leaf.
b. Number of leaves (strands): done by directly counting the number of leaves on the plant one by one.
c. Leaf width (cm): measured by measuring the widest leaf on the plant using a ruler.
d. Leaf length (cm) was measured by measuring the longest leaf on the plant using a ruler.
e. Root length (cm); observed by pulling out the plant and measuring the length of the plant's roots.
f. Fresh weight (g/plant); carried out by weighing the harvest of each plant according to the treatment.

Data were analyzed using analysis of variance or the F test. Treatments that showed a significant effect were further tested using *the Duncan Multiple Range Test* (DMRT) at a 5% significance level. Data analysis was performed using IBM SPSS Statistics version 26 software.

3. Results and Discussion

3.1. Plant height (cm) and number of leaves (blades)

Based on observations of pakcoy plant growth, including plant height (cm) and number of leaves (blades), the results showed that variations in planting media had a significant effect on plant height and number of leaves, as presented in Table 1.

Table 1. Average growth of plant height and number of leaves of pak choy plants at the age of 35 days after planting.

Planting Media Treatment	Plant Height (cm)	Number of leaves (blades)
Rockwool	23.7 ± 0.15 b	15.2 ± 0.22 b
Bamboo Humus	23.7 ± 0.20 b	14.6 ± 0.28 a
Coconut Fiber	23.8 ± 0.18 b	15.4 ± 0.24 b
Chopped Fern	22.2 ± 0.43 a	14.3 ± 0.25 a
Rockwool + Bamboo Humus	24.2 ± 0.18 b	15.6 ± 0.20 b
Rockwool + Coconut Fiber	28.8 ± 0.38 c	17.0 ± 0.30 c
Rockwool + Chopped Fern	23.9 ± 0.22 b	15.3 ± 0.21 b

Description: Numbers followed by the same letter in the same column show no significant difference based on the DMRT test at the 5% level.

The rockwool and coconut fiber **mixed** media treatment produced the tallest plants compared to either single media or other combinations. This increase in plant height indicates that the physical condition of the growing medium plays a crucial role in supporting vegetative growth, particularly during the stem-formation phase.

Rockwool is known for its stable structure and ability to retain moisture around the roots, while coconut fiber boasts high porosity and good water-holding capacity. The combination of these two media balances water and oxygen availability in the root zone, thereby optimizing root respiration and nutrient absorption. These conditions support cell division and elongation, ultimately increasing plant height (Abad et al., 2002; Awang et al., 2009; Valupi et al., 2021).

The height of Pakcoy plants in the rockwool + coconut fiber treatment in this study reached 28.8 cm, significantly higher than the study by Lestari (2024), which reported plant heights of 7.42–10.03 cm in various single growing media. The plant height in this treatment was approximately 2.9–3.9 times that of the maximum height in previous studies, indicating that the combination of rockwool and coconut fiber media provided greater plant height growth than the media used in previous studies.

The number of Pakcoy leaves varied across different growing media. The rockwool + coconut fiber treatment produced the highest number of leaves and significantly differed from the other treatments. A greater number of

leaves reflects better vegetative growth conditions and greater photosynthetic capacity. Leaf formation is closely related to nitrogen availability and the efficiency of nutrient uptake by the roots. A well-aerated growing medium allows roots to obtain sufficient oxygen, thus optimizing root respiration and supporting effective nitrogen uptake. Nitrogen plays a crucial role in the formation of leaf tissue, chlorophyll, and plant structural proteins.

These results are in line with the findings of Sarkar et al (2021); Chhetri et al (2022) who reported that the type of growing medium in a hydroponic system significantly affects the growth of lettuce and Pakcoy plants, where media such as cocopeat and sponges that have better porosity and water-oxygenation capacity can support a higher number of leaves and vegetative growth compared to other media such as perlite in the Nutrient Film Technique (NFT) system. Therefore, the use of a combination of media with a good porous structure tends to increase the availability of water, nutrients, and root aeration, which in turn improves the vegetative parameters of the plant.

3.2. Leaf width (cm), Leaf length (cm), and Root length (cm)

Based on observations of pak choy plant growth, including leaf width, leaf length, and root length, it was found that variations in planting media had a significant effect on these traits, as shown in Table 2.

Table 2. Average leaf width, leaf length, and root length of Pakcoy plants at 35 days after planting.

Planting Media Treatment	Leaf Width (cm)	Leaf Length (cm)	Root Length (cm)
Rockwool	9.27 ± 0.03 ab	15.43 ± 0.23 a	38.87 ± 3.47 ab
Bamboo Humus	8.83 ± 0.18 a	15.32 ± 0.29 a	36.77 ± 3.47 a
Coconut Fiber	9.13 ± 0.20 ab	15.23 ± 0.29 a	38.33 ± 3.47 ab
Chopped Fern	8.97 ± 0.12 a	14.93 ± 0.55 a	34.23 ± 3.47 a
Rockwool + Bamboo Humus	9.37 ± 0.12 b	15.30 ± 0.12 a	36.23 ± 3.47 a
Rockwool + Coconut Fiber	9.87 ± 0.07c	16.80 ± 0.31b	41.67 ± 3.47 b
Rockwool + Chopped Fern	9.20 ± 0.15 ab	15.43 ± 0.20 a	41.43 ± 3.47 b

Description: Numbers followed by the same letter in the same column show no significant difference based on the DMRT test at the 5% level.

The leaf width of Pakcoy (*Brassica rapa* L.) is significantly affected by the type of growing media used. The media plays a crucial role in determining the root system's physical and physiological conditions, particularly water availability, aeration, and nutrient absorption. The rockwool and coconut fiber combination produced the largest leaf width, indicating that it provides optimal growing conditions for vegetative growth, particularly during the leaf enlargement phase.

Coconut fiber (cocopeat) has a high water retention capacity and can maintain stable media humidity. Adequate water availability significantly influences cell turgor pressure, a major factor in leaf cell expansion and enlargement. Munns et al. (2000) explained that plant water status is directly related to the rate of leaf expansion, such that water limitations reduce turgor pressure and directly inhibit leaf cell growth. Therefore, a growing medium with good water retention, such as coconut fiber, plays a crucial role in supporting increased Pakcoy leaf width.

In addition to water, aeration of the growing medium also affects root health and nutrient uptake efficiency. The combination of rockwool and coconut fiber has good porosity, providing adequate oxygen to plant roots. Optimal aeration conditions support root physiological activity and enhance potassium (K) uptake. Potassium is known to play a crucial role in regulating cell osmotic balance, maintaining turgor pressure, and controlling stomatal opening, which, in turn, indirectly affects leaf growth and enlargement (Xu et al., 2017).

Wider leaves have a larger photosynthetic surface area, thus increasing the plant's ability to capture light and carry out photosynthesis. Increased leaf area enhances carbon assimilation and plant biomass accumulation. Research on horticultural crops shows that organic fiber-based media, such as coconut fiber, are effective in increasing vegetative growth, including leaf parameters, due to the balance between water retention and aeration that optimally supports plant physiological processes (Abad et al., 2002; Awang et al., 2009; Umarie et al., 2020).

Pakcoy leaf length shows a pattern consistent with leaf width, where the F medium treatment (rockwool + coconut fiber) produces the longest leaves and is significantly different from the other treatments. Leaf length reflects the success of the cell division and elongation processes that occur actively during the vegetative phase, which are greatly influenced by the rooting environment. The availability of water and balanced nutrients in the growing medium plays an important role in supporting plant metabolic processes, including the synthesis of chlorophyll and proteins that directly contribute to leaf growth. Tuxun et al. (2025) stated that soilless cultivation provides more controlled root conditions for water and nutrient supply, supporting efficient plant growth. This condition is very important in hydroponic systems because extreme humidity fluctuations can inhibit leaf cell elongation.

Selecting the right growing medium in a hydroponic system also significantly affects the quality of leafy vegetable growth. Savvas and Gruda (2018) reported that mixed media generally provide a better growing environment than single media because they combine the physical and chemical advantages of each material. A combination of rockwool and coconut fiber, for example,

can improve aeration and water retention, thereby supporting longer, more uniform Pakcoy leaf growth.

The highest root length was obtained in the rockwool + coconut fiber treatment, although not significantly different from the rockwool + chopped fern treatment. This finding indicates that the mixed media provides a better rooting environment. The root length of Pakcoy plants in this study ranged from 34.23 to 41.67 cm, with the highest value observed in the rockwool + coconut fiber treatment (41.67 cm). This value is higher than that reported by Al Muzafri et al. (2023), who reported Pakcoy root length in rockwool growing media of 32.4 cm in a wick hydroponic system, as well as in coconut fiber and other organic media ranging from 22.5–29.7 cm. This comparison indicates that the combination of rockwool + coconut fiber media supports Pakcoy root development more optimally than several single organic growing media tested in previous studies, while also highlighting the contribution of media composition to more conducive rooting conditions.

3.3. Fresh weight (g/plant)

Based on observations of pak choy plant production, it was found that variations in planting media had a significant effect on plant production, as shown in Table 3.

Table 3. Average fresh weight of pak choy plants at 35 days after planting

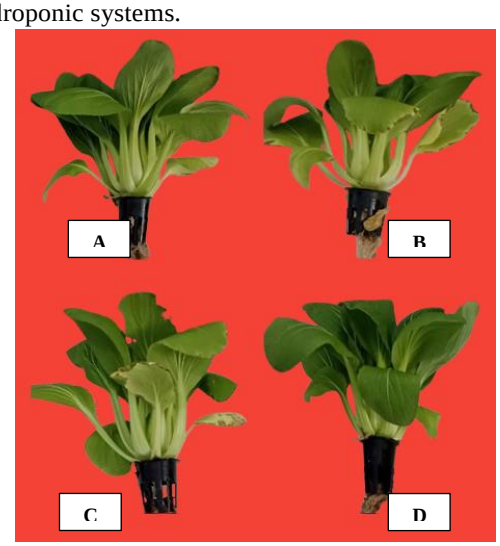
Planting Media Treatment	Fresh weight (g/plant)
Rockwool	132.0 ± 4.60 ab
Bamboo Humus	116.0 ± 4.10 a
Coconut Fiber	125.0 ± 4.30 a
Chopped Fern	121.8 ± 5.20 a
Rockwool + Bamboo Humus	123.0 ± 2.00 a
Rockwool + Coconut Fiber	143.7 ± 3.10 c
Rockwool + Chopped Fern	133.0 ± 3.80 ab

Description: Numbers followed by the same letter in the same column show no significant difference based on the DMRT test at the 5% level.

Plant fresh weight is a key parameter commonly used to assess the productivity of leafy vegetables, including Pakcoy (*Brassica rapa* L.), as it reflects the accumulation of vegetative biomass formed during the growth period. The results showed that the rockwool + coconut fiber media treatment produced the highest fresh weight and was significantly higher than that of other treatments. This increase in fresh weight was due to improved vegetative growth, as indicated by increased plant height, leaf number, and leaf size.

Physiologically, the increase in fresh plant weight is related to the plant's ability to produce and accumulate biomass through photosynthesis and the distribution of assimilation products to plant tissues. Rouphael et al. (2018) reported that increased vegetative growth in leafy vegetables, particularly leaf area and photosynthetic activity, directly contributed to increased fresh plant weight. The fresh weight of Pakcoy plants in this study ranged from 116.0 to 143.7 g per plant, with the highest value observed in the rockwool + coconut fiber treatment (143.7 g). Quantitatively, this value is higher than that reported by Muzafri et al. (2023), who found that the fresh weight of Pakcoy in various growing media (rockwool, coconut fiber, rice husks, burnt rice husks, chopped fern leaves) in a wick hydroponic system ranged from 32.5–49.4 g. The results of this study indicate that the combination of rockwool and coconut fiber is more effective at increasing biomass accumulation than the single media used in previous studies.

The growing medium in a hydroponic system plays a crucial role in providing a rooting environment that supports water and nutrient uptake. A medium with a balance between water-holding capacity and good aeration will support optimal root development, allowing for more efficient nutrient uptake. Sambo et al. (2019) explain that optimal rooting conditions in a soilless system are key factors in supporting vegetative growth and plant biomass accumulation, as roots function as the center of water and nutrient absorption, which determines plant physiological performance. The combination of rockwool and coconut fiber has the potential to provide a better physical environment than either medium alone, as rockwool offers high porosity and good aeration, while coconut fiber provides high water-holding capacity. This combination of physical properties allows plant roots to develop well and obtain a relatively stable supply of water and nutrients, thereby increasing vegetative growth, as reflected in higher fresh weight. Therefore, a combination of rockwool and coconut fiber can be recommended as an effective alternative growing medium to increase Pakcoy production in hydroponic systems.



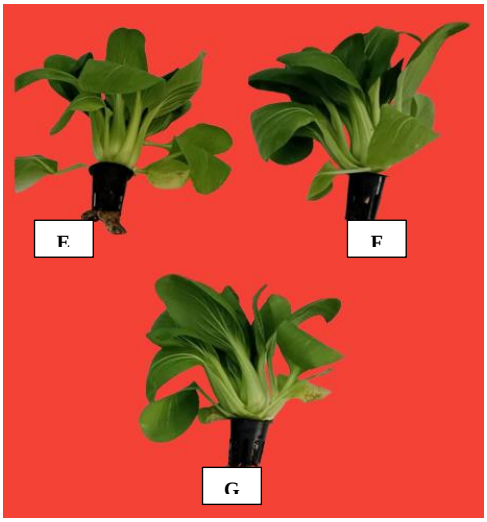


Figure 2. Fresh weight of pak choy plants. Description: A = Rockwool, B = Bamboo Humus, C = Coconut Fiber, D = Chopped Fern, E = Rockwool + Bamboo Humus, F = Rockwool + Coconut Fiber, G = Rockwool + Chopped Fern.

4. Conclusion

The growing medium significantly influenced Pakcoy growth and yield in hydroponic systems. A key strength of this study is that the rockwool-coconut fiber mixture consistently produced the highest growth and yield, as demonstrated by plant height, leaf number, root length, and fresh weight per plant. Based on these results, rockwool and coconut fiber are recommended as alternative growing media for hydroponic users to enhance pok choy growth and yield.

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