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Effect of Growing Media on the Growth of Pak Choy (*Brassica rapa* L.) in NFT Hydroponic System

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ABSTRACT

Pak choy (*Brassica rapa* L.) is a widely popular vegetable in Indonesia that requires precise nutrient availability and stable environmental conditions for optimal development. This research aimed to evaluate the effectiveness of different growing media on the growth and productivity of pak choy within a Nutrient Film Technique (NFT) hydroponic system at RH Farm, Bogor. The study maintained critical environmental parameters, including a pH range of 5.5–6.5 and Electrical Conductivity (EC) levels between 1.5–2.5 mS/cm, to ensure consistent nutrient delivery. A quantitative approach compared two types of media: rockwool and cocopeat, using an independent samples t-test for data analysis. Growth parameters were recorded weekly from 7 to 30 Days After Transplanting (DAT), alongside final measurements of biomass accumulation. The results demonstrated that the choice of growing media significantly influenced all observed parameters ($p < 0.001$). Cocopeat consistently outperformed rockwool, achieving an average final height of 25 cm and a fresh weight of 167 grams, nearly double the 93 grams produced by rockwool. This superior performance is attributed to cocopeat's high Cation Exchange Capacity (CEC) and excellent water retention, which ensures stable nutrient supply and cell turgidity within the rhizosphere. In conclusion, cocopeat is a more effective and sustainable medium for optimizing pak choy productivity in NFT systems, offering significant advantages for commercial hydroponic enterprises.

INTRODUCTION

Pak choy (*Brassica rapa* L.) is a widely popular vegetable commodity with high consumer demand in Indonesia. Data from the Central Bureau of Statistics [BPS] indicate that pak choy production in Indonesia reached 727,467 tons in 2021, increased to 760,608 tons in 2022, and slightly decreased to 686,876 tons in 2023, reflecting production fluctuations in response to market dynamics (BPS, 2024). This vegetable contains essential vitamins such as A, C, and K, alongside vital minerals including calcium, iron, and magnesium, which are crucial for human health (Jayanti, 2020). As a crop characterized by a rapid growth cycle of approximately 25–30 days, pak choy requires precise nutrient availability and stable environmental conditions to achieve optimal vegetative development (Umarie et al., 2020).

The implementation of the Nutrient Film Technique (NFT) hydroponic system offers an efficient cultivation method by delivering a thin, continuous film of nutrient solution directly to the root zone, thereby enhancing nutrient uptake and ensuring rapid, uniform plant growth (Singgih et al., 2019). Hydroponics provides significant advantages, including higher yields, accelerated growth rates, fertilizer efficiency, and sustainable production (Setyoaji & Setiawan, 2021). In pak choy cultivation, the NFT system is particularly beneficial for maintaining consistent moisture and high dissolved oxygen levels, which are critical for the rapid vegetative development of leafy greens. However, the effectiveness of this system in maximizing plant potential is also highly dependent on the stability of the cultivation environment.

Hydroponic methods represent a strategic effort to increase agricultural productivity on limited land, such as residential yards or small-scale gardens (Bahzar & Santosa, 2017). RH Farm is a commercial organic hydroponic enterprise that utilizes the NFT system, evolving from a home-scale operation into a professional facility with numerous partnerships. The NFT system not only optimizes spatial and water efficiency as well as nutrient recirculation that reduces water waste by up to 90% compared to conventional farming (Manik et al., 2019) but also promotes eco-friendly production through sustainable media selection. Choosing the appropriate growing medium is critical, as it significantly dictates the trajectory of plant growth (Cholifah, 2025). Evaluating the effectiveness of different media is highly relevant at RH Farm, as the company continuously innovates to optimize production by maintaining critical environmental parameters, such as a pH range of 5.5–6.5 and Electrical Conductivity (EC) levels between 1.5–2.5 mS/cm (Sabneno et al., 2025).

Optimal media selection profoundly influences the final production output. Rockwool is a common choice due to its exceptional water-holding capacity—retaining up to 14 times its weight—and high porosity of 90%; however, this synthetic material poses environmental challenges as it is non-biodegradable and cannot be reused (Cholifah, 2025; Manik et al., 2019). Alternatively, cocopeat has emerged as a sustainable and practical option in NFT systems. Derived from coconut husk waste, cocopeat possesses physical properties that strongly support plant development, specifically its ability to store water and nutrients while maintaining a favorable neutral pH (De Side et al., 2022; Manik et al., 2019). This capacity is vital in NFT systems where roots receive a constant yet controlled nutrient supply (Triana et al., 2021). Proper media selection ensures adequate moisture retention, allowing pak choy roots to develop healthily and absorb nutrients efficiently. The distinct physical and chemical characteristics of rockwool and cocopeat provide a fundamental basis for evaluating their impact on pak choy performance (Cholifah, 2025). This study evaluated the effects of rockwool and cocopeat on the growth and productivity of pak choy within an NFT hydroponic system and identified the environmental factors influencing the interaction between these media at RH Farm.

RESEARCH METHODS

Time and Location

The research was conducted at Rumah Hidroponik (RH Farm), located on Jalan Raya Cifor, Situ Gede, West Bogor, Bogor City. The study was carried out over 1.5 months, from June 15 to July 30, 2025.

Tools and Materials

The equipment used in this study included an NFT system set, water reservoirs, water pumps, Total Dissolved Solids (TDS) meters, pH meters, rulers, measuring tapes, trays, net pots, scissors, digital scales, and thermo-hygrometers. The materials consisted of pak choy seeds (Nauli F1 variety), rockwool, cocopeat, spunbond fabric, water, AB mix nutrients, as well as pH up and pH down solutions.

Observation and Data Collection

Observations were conducted on *Brassica rapa* L. samples to evaluate the effectiveness of different growing media based on the experimental design. Growth parameters, including plant height (cm), leaf number, and leaf length (cm), were recorded weekly from 7 to 30 DAT, alongside root length (cm) measurements at the end of the period. Environmental and nutrient conditions were monitored thrice daily (09:00, 12:00, and 15:00 WIB) using digital meters and a thermohydrometer to maintain a pH range of 5.5–6.5 and optimal TDS, temperature, and humidity levels. Finally, plant fresh weight (g) was measured to assess total biomass accumulation and determine the most effective growing media for hydroponic pak choy cultivation.

Data Analysis

The data and information analysis employed both qualitative and quantitative methods. Qualitative analysis was conducted by comparing and interpreting field observations with relevant and significant scientific literature. Quantitative analysis involved the systematic processing of numerical data using Microsoft Excel and Minitab 18. Specifically, a two-sample t-test was utilized to compare the mean differences between the two treatment groups (independent variables) regarding plant growth parameters (dependent variables). The use of Excel and Minitab facilitated efficient data management, including inputting, grouping, and fundamental statistical calculations. This quantitative approach aimed to measure and test variables objectively to ensure scientifically accountable results. The analyzed data are presented in the form of tables and figures.

RESULTS AND DISCUSSION

Plant Height

The growth curve of pak choy plant height indicates a consistent greater mean values of cocopeat media over rockwool from the beginning to the end of the observation period (Figure 1). During the initial phase (7 DAT), plants grown in cocopeat reached a height of 9 cm, significantly outperforming those in rockwool, which only reached 6 cm. This growth advantage persisted until harvest (28 DAT), with a final height of 25 cm for cocopeat compared to 20 cm for rockwool. The two-sample t-test results, yielding a p-value of < 0.001, confirm that the differences in plant height between the two media were highly significant across all weekly observations.

The high water-holding capacity of cocopeat serves as a key factor in facilitating root adaptation and vegetative vigor from the early growth stages. The ability of cocopeat to maintain stable moisture levels within the NFT system supports more optimal cell elongation in the stems compared to rockwool, which tends to be more inert and possesses lower water retention (Siregar et al., 2023). Furthermore, the superior porosity and water-binding properties of cocopeat ensure a continuous supply of nutrient solution within the rhizosphere, thereby accelerating the photosynthetic rate which directly contributes to the increase in plant height.

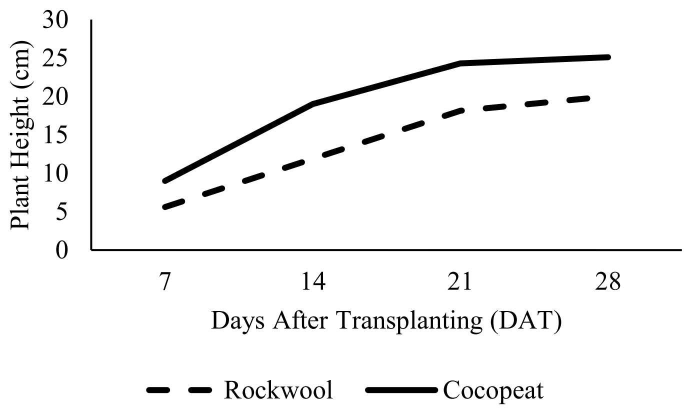

Figure 1. Plant height of pak choy on different growing media.

Number of Leaves

The leaf count chart illustrates more dynamic vegetative growth in cocopeat media compared to rockwool, reaching a final average of 16 leaves versus 15 leaves, respectively (Figure 2). Two-sample t-test results confirm highly significant differences ($p < 0.001$) throughout the observation weeks, proving the substantial impact of media type on vegetative organ initiation. The physicochemical properties of cocopeat accelerate metabolic activity and leaf tissue differentiation through stable water retention capacity (Nurhaliza, 2023). A higher leaf count expands the photosynthetic surface area for carbohydrate synthesis to support overall plant biomass (Siregar et al., 2023). Furthermore, high porosity in cocopeat enhances oxygen supply to the roots, triggering more progressive leaf initiation in pak choy (Lestari & Triani, 2024). In contrast, moisture fluctuations in rockwool within the NFT system hinder continuous nutrient distribution, thereby slowing the rate of leaf emergence (Cahyadi & Nurhayati, 2021).

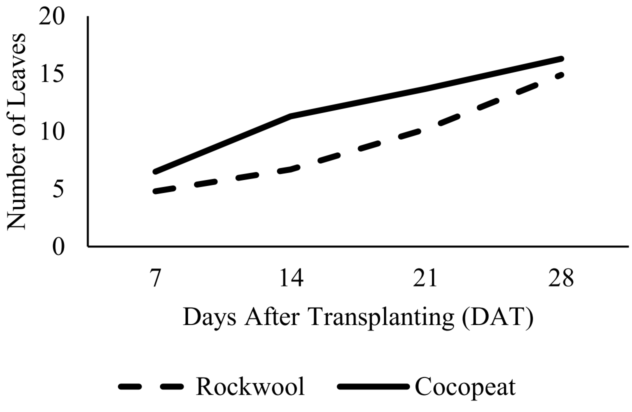

Figure 2. Number of leaves of pak choy on different growing media.

Leaf Length

The growth chart illustrates a faster and more stable increase in pak choy leaf length on cocopeat compared to rockwool, reaching a final average of 15 cm and 12 cm, respectively (Figure 3). Two-sample t-test results reveal highly significant differences ($p < 0.001$) across all observation weeks, confirming the substantial impact of the growth media on leaf dimensions. Although growth rates began to plateau during weeks 3 and 4, cocopeat consistently maintained the maximum leaf length. The physical properties of cocopeat in retaining moisture and nutrient supply accelerate leaf cell expansion and increase the overall canopy size (Siregar et al., 2023). High water-holding capacity ensures cell turgidity is maintained, optimizing the elongation of the leaf blades (Imbiri et al., 2021). Conversely, the lower water and nutrient storage capacity of rockwool results in limited fluid intake for young tissues, hindering leaf development (Nurhaliza, 2023). Efficient nutrient absorption in cocopeat reflects a healthier root system that supports a larger photosynthetic surface area (Ayni, 2025).

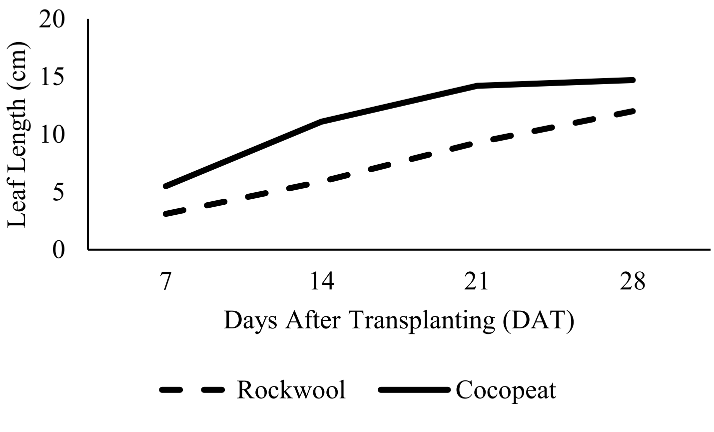

Figure 3. Leaf length of pak choy on different growing media.

Root Length

The root length chart reveals contrasting growth patterns between the two media, with final measurements reaching 11 cm for cocopeat and 10 cm for rockwool (Figure 4). Two-sample t-test results confirm highly significant differences ($p < 0.001$), proving that the physical characteristics of the substrate significantly dictate the morphology of the pak choy root system. Rockwool exhibited more stable weekly root elongation rates because its inorganic fibrous structure provides high total porosity (approximately 90%) and extensive macro-porosity, which ensures superior aeration extensive air-filled porosity for radical tissue development (Sabneno et al., 2025).

Consistent root elongation in rockwool is closely linked to superior drainage capabilities, which prevent excess water accumulation and ensure the oxygen availability required for cellular respiration. Optimal oxygen supply in the rhizosphere triggers the production of ATP energy necessary for cell elongation at the root tips (Charitsabita et al., 2019). Conversely, the high water-retention capacity of cocopeat risks lowering oxygen diffusion rates, which physiologically inhibits the elongation velocity of the primary roots (Cahyadi & Nurhayati, 2021). The denser structure of cocopeat compared to rockwool also imposes greater mechanical resistance, forcing the plant to divert energy to penetrate more compact media pores (Praseptiyani et al., 2023).

The moisture-saturated environment in cocopeat stimulates plants to prioritize the formation of compact, thick lateral root masses rather than vertical primary root extension (Ayni, 2025). This phenomenon represents a morphological adaptation of the pak choy plant to expand its nutrient absorption area in zones with limited oxygen (Putra & Widhiantari, 2025). Fast-draining media facilitate easier root penetration through a uniform macro-pore structure, thereby supporting more progressive longitudinal growth compared to massive organic media.

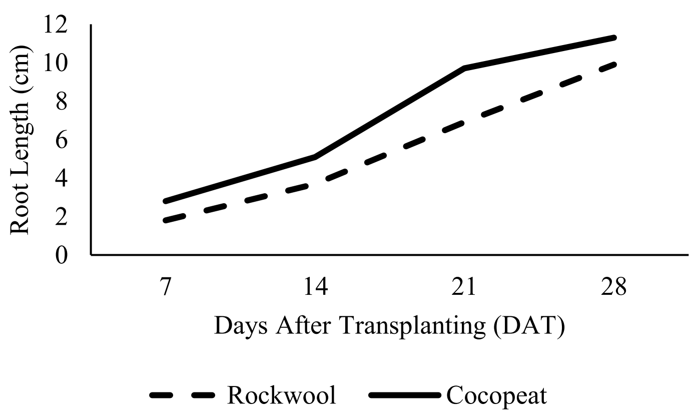

Figure 4. Root length of pak choy on different growing media.

Fresh Weight

The observation results indicate that the type of growing media significantly influences the fresh weight of pak choy at harvest (Figure 5). Based on the two-sample t-test, the fresh weight of plants in cocopeat media differs highly significantly from those in rockwool ($p < 0.001$), with average weights of 167 grams and 93 grams, respectively. The substantially higher weight achieved in cocopeat reflects stable water and nutrient absorption efficiency, driven by a higher Cation Exchange Capacity (CEC) compared to rockwool (Nazara et al., 2024). This mechanism was further supported by the controlled pH (5.5–6.5) and EC (1.5–2.5 mS/cm) throughout the study, which ensured that nutrients remained in a soluble form for optimal uptake. These chemical properties allow the organic media to bind essential nutrient cations in the rhizosphere and release them gradually according to plant needs, preventing excessive nutrient leaching within the NFT system.

Optimal water retention capacity in cocopeat contributes directly to increased tissue water content and cell turgidity. Given that the majority of leafy vegetable fresh weight consists of water, the stable fluid supply provided by organic media ensures maximum wet biomass accumulation (Madina & Koesriharti, 2023). The inert nature of rockwool results in a very low nutrient-binding capacity, making the plants entirely dependent on external nutrient flow without any media-based reserves. Limited root volume and inefficient nutrient distribution within inorganic fibers often restrict assimilate formation, causing the final plant weight to be less progressive than in organic media (Yaniastari et al., 2026).

Superior fresh weight productivity in cocopeat signifies effective translocation of photosynthetic products throughout the canopy tissues. The continuous availability of Nitrogen (N) within the media pores facilitates the synthesis of proteins and chlorophyll, which increases cell volume and density (Wahyuningsih et al., 2016). High dry matter accumulation demonstrates the plant's success in converting assimilates into dense cellular structures. In rockwool systems, high evapotranspiration rates are frequently not balanced by the limited water availability in the media pores, leading to micro-water stress that inhibits maximum weight gain in the shoot tissues (Miranda, 2017).

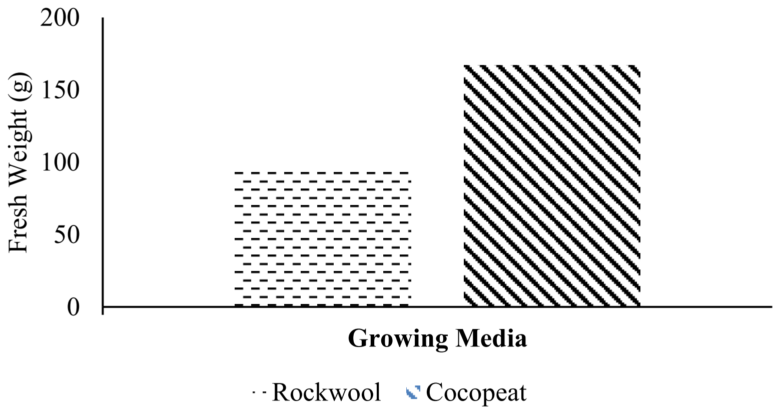

Figure 5. Fresh Weight of pak choy on different growing media

CONCLUSION

The selection of growing media in the NFT hydroponic system exerts a highly significant influence on all growth parameters and productivity of pak choy plants. Cocopeat media proves to be substantially superior to rockwool, particularly in increasing plant fresh weight with a difference of 74 grams, nearly doubling the yield of the inorganic media. This superiority is driven by the high Cation Exchange Capacity (CEC) and water retention of cocopeat, which ensures nutrient availability and cell turgidity stability to support maximum leaf expansion and biomass accumulation.

The uniform macro-pore structure of rockwool facilitates better aeration for primary root elongation, yet the limitations of its inert properties in binding nutrients lead to unstable nutrient distribution. The organic characteristics of cocopeat create a more consistent root environment for plant metabolism, although high moisture levels tend to shift root growth toward a more lateral and compact architecture. Overall, for pak choy production oriented toward harvest weight and vegetative quality, cocopeat media is a more effective and productive choice compared to rockwool. This effectiveness is further optimized by maintaining stable environmental factors, specifically a pH range of 5.5–6.5 and EC levels of 1.5–2.5 mS/cm, which ensure consistent nutrient solubility and uptake throughout the cultivation period.

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