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# NUTRIENTS AND GROWING MEDIA EFFECT ON GROWTH AND PHYSIOLOGICAL TRAITS OF PAK CHOI PLANTS (*BRASSICA RAPA* L.)

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## SUMMARY

The demand for pak choi plants always increases over time. Hydroponics is one technique for the quick cultivation of pak choi. The advantages of hydroponics are its easy setup anywhere that is healthy and clean, requiring minimal areas and still having optimal production. Usually, hydroponics uses AB mix nutrients from various brands on the market. However, this research used NPK 16:16:16 and NASA liquid organic fertilizer to find alternative nutrients to increase the growth and production of pak choi by formulating an effective combination of nutrients and growing media using the nutrient film technique (NFT) system. The research commenced at a greenhouse of the Universitas Teuku Umar, Aceh, Indonesia. The split-plot design employed had nutrients for the main plot, N1 = AB mix Goodplant, N2 = NPK fertilizer 16:16:16, and N3 = NASA liquid organic fertilizer; and the growing media in the subplots, M1 = husk charcoal, M2 = rockwool, M3 = cocopeat, and M4 = sponge. The studied parameters were the plant's fresh and dry weights and chlorophyll a and b. The result showed that nutrition, growing media, and their interaction significantly affected the fresh and dry weights of the pak choi plants. The best combination of nutrients and growing media was AB mix nutrition and cocopeat (N1M3), which showed remarkable performance in increasing the growth and physiological traits of pak choi plants.

**Keywords**: Pak choi plants (*Brassica rapa* L.), hydroponic b nutrients, growing media, hydroponic NFT

**Key findings**: In the NFT hydroponic system, the plants grow in a shallow and circulated nutrient layer, and the plants can get enough water, nutrients, and oxygen. Application of nutrients and growing media significantly affected the fresh and dry weights of pak choi plants.

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## INTRODUCTION

The chief problem of modern agriculture today is the reduction of agricultural land. It can impact the insufficient supply of vegetable food needs in the market. Meanwhile, the demand for vegetable food essentials is rapidly increasing, one of which is pak choi. As time passes, cultivation methods become more varied and modern, such as the hydroponic method not needing soil. One of the hydroponic methods used in this research is the NFT (Nutrient Film Technique) hydroponics. The success of cultivating pak choi plants using hydroponics, especially NFT hydroponics, bears influences from the use of nutrients and planting media.

Pak choi's productivity is low due to the limited availability of cultivating land in Indonesia. Therefore, it is necessary to improve the pak choi cultivation and its products and increase the quantity with superb quality. Hydroponics is an alternative cultivation technique that can benefit vegetable planting. Pak choi is a short-lived plant with a high nutrient content. It is one of the most popular vegetable crops in the community, and its cultivation has broader market potential along with the increasing community needs for high-quality vegetables (Setiawati *et al*., 2019).

Hydroponics comes from two ancient Greek words, 'hydro,' meaning water, and 'ponos' or 'ponein,' meaning labor. The term hydroponics was first used in 1929 by Dr. Gericke, a California professor, who began to develop what previously had been a laboratory technique into a commercial means of growing plants. Hydroponics is a method of plant cultivation that uses water as a growing medium. In hydroponics, water becomes a planting medium with regulations from a machine to supply the required nutrients to cultivated plants. Plants will receive nutrients through water that passes through the roots.

In line with technological developments, hydroponics groupings comprised four types based on the irrigation system. The first is the Wick system, the second is a floating system, the third is the Nutrient Film Technique (NFT) system, and the fourth is the Aeroponic system (Salo, 2019). Hydroponic system cultivation focuses on how to provide water and nutrients in accordance with plant needs, plant age, and the environmental conditions where the plants are grown. Hydroponics using the NFT is a system that utilizes water to supply nutrients to the plants according to their needs, circulating in the plant's roots through thin water layers (Sari *et al*., 2019).

A hydroponic system depends on inorganic fertilizers as a nutrient solution (Setiawati *et al*., 2019). The NFT is a hydroponic system in plant cultivation that places the roots of a plant in nutritious, shallow water. Fertilizers dissolved in water undergo circulation to the plant roots periodically, depending on the type of hydroponic system used (Ningrum *et al*., 2014).

A nutrient solution of AB Mix consists of chemicals delivered through a planting medium and serves as plant nutrition for healthy, productive plant growth. An AB Mix contains macro- and micro-elements combined as nutrients vital for plant growth (Pohan and Oktoyournal, 2019). The Pearl NPK (16:16:16) is one that has prime nutrients for plants. Providing the NPK Mutiara fertilizer (16:16:16) has a good effect on plant growth due to the availability of nutrients N, P, and K in the fertilizer for a more efficient and balanced plant application. NPK fertilizer has advantages, including several nutrients in one fertilization; hence, it is more effective than a single fertilizer with just one element. One of the fertilizers commonly used by farmers is the NPK Mutiara 16:16:16 fertilizer (16% N, 16% $P_2O_5$, and 16% $K_2O$). The use of NPK fertilizer is more beneficial than single fertilization because it only requires one application to provide the three essential nutrients versus the separate applications of the nutrients contained in a single fertilizer; thus, compound fertilizers can replace single fertilizer, with its ease of use, storing, and transporting, minimizing space and costs (Sukmasari *et al*., 2019). NASA Liquid Organic Fertilizer (POC) is a type of fertilizer in liquid form and ionic structure that makes easy absorption by plants for an immediate effective increase in crop yields (Pardoso, 2014).

Hydroponic cultivation depends on the planting medium used, which functions as a support for plants and a place for roots to grow to absorb nutrients. There are several types of growing media in hydroponic systems. The agent used usually consists of inorganic or organic media. Inorganic media consists of stone, sand, and rockwool, while organic media has fern stems, compost, charcoal husk media, cocopeat, and sawdust (Lestari *et al*., 2020).

Husk charcoal is a black, burnt husk produced from an incomplete combustion process, making it a widely used planting medium in hydroponic systems. The composition of husk charcoal often consists of SiO 52% and C 31%. Other components include Fe2O3, K2O, MgO, CaO, MnO, and Cu in relatively small amounts, as well as, organic materials. Husk charcoal has the characteristics of being very light and coarse, so air circulation is high. Apart from that, husk charcoal has the advantage of having many pores for a high water-holding capacity; its black color can absorb sunlight effectively, preventing the emergence of diseases, such as bacteria and weeds (Lindawati, 2015).

The rockwool growing media consists of coal, limestone, and basalt, processed at high temperatures to form fibers. The process of making rockwool, involving high temperatures, makes it sterile from pathogenic microorganisms, pests, or weed seeds. Water also quickly passes through the rockwool fibers; thus, the rockwool structure provides an optimum water-to-air ratio for plant growth (Warjoto *et al*., 2020).

Cocopeat is an alternative planting medium that can serve for cultivating various types of plants, especially for hydroponic growing systems. Cocopeat has the property of quickly absorbing and storing water, and it has pores, which facilitate air exchange and the entry of sunlight. Cocopeat can keep the planting medium loose and fertile. The level of soil looseness is high, the formation of plant roots will be fast, and the plants will be healthier and more abundant. Cocopeat has a pH between 5.0 and 6.8; hence, any plant growth is excellent (Kuntardina *et al*., 2022).

Cocopeat has the advantage of having several beneficial ingredients, i.e., sodium (N), potassium (K), phosphorus (P), magnesium (Mg), and calcium (Ca) (Dalimoenthe, 2013; Andrea, 2015). Sukajat’s (2020) research showed that cocopeat growing media provided the best growth results for root growth, plant height, number of leaves, and fresh and dry weights of mustard pak choi (*Brassica rapa* subsp. chinensis) plants**.** Sponge-growing media has a water-holding capacity of 45% (Candra *et al*., 2020). Warjoto *et al*. (2020) stated that the sponge-growing media type has high porosity but low material density; thus, the water-holding capacity of the sponge media type is small. Based on the above discussion, the presented study conducted research on the effects of nutrients and growing media with the Nutrient Film Technique (NFT) on pak choi yields (*Brassica rapa* L.).

## MATERIALS AND METHODS

### Study site and experimental procedure

The practical research on pak choi (*Brassica rapa* L.) ensued from September to November 2022 at the greenhouse of the Faculty of Agriculture, Universitas Teuku Umar, Meulaboh, West Aceh, Indonesia (Figure 1).

### Materials and tools

The ingredients used in this study were seeds of Nauli (F1) variety of pak choi, water, AB mix Goodplant solution, NASA liquid organic fertilizer, NPK fertilizer (16:16:16), rockwool, cocopeat, sponge, rice husk charcoal, and other supporting materials. The tools handled in this study were hoes, wood, white gauze, meters, saws, scissors, knives, machetes, pamphlet boards, aerators, white gauze, scales, containers, calculators, water pumps, elbow connectors, Elbow T, PVC pipes, pipe punchers (drills), tape seals, pipe glue, stationery, oven, plank labels, banner, pen, pencil, book, ruler, stapler, whiteboard marker, wipe cloth, plastic bags, brown envelope, and spectrophotometer UV.


**Figure 1.** The pak choi plantation during 2022 in the greenhouse of the Faculty of Agriculture, Universitas Teuku Umar, Aceh, Indonesia.

**Research design and implementation**

The pak choi (*Brassica rapa* L.) experiment employed a split-plot design, with the nutrient solution treatments (N - with three levels) placed in the main plots, namely, N1 = AB mix Goodplant, N2 = NPK fertilizer 16:16:16, and N3 = NASA liquid organic fertilizer, and the growing media (M) in the subplots were M1 = husk charcoal, M2 = rockwool, M3 = cocopeat, and M4 = sponge. Each experimental unit had three replicates. The number of samples was five in each subunit, totaling 180. The AB mix concentration is 5 ml/L, NPK 16:16:16 is 2 g/L, and the NASA liquid organic fertilizer used is 6 ml/L. The research implementation includes making greenhouses, making NFT hydroponic construction, seeding seeds, preparing planting media, making nutrient solutions, planting pak choi seedlings, embroidery, plant maintenance (nutrition and water control), and harvesting.

**Parameters studied and analysis**

In the pak choi (*Brassica rapa* L.) experiment, the recorded data were for the parameters, such as the plant's fresh and dry weights and chlorophyll a and b. Observing the wet weight of plants transpired at 28 Days After Planting by weighing the earlier cleaned plants. Weighing commenced at harvest, acquiring the plant samples' weight using analytical scales. The dry weight (g) of mustard greens incur weighing after oven-drying for 72 h at a temperature of 65 °C. Analyzing chlorophyll a and b ran at the Plant Physiology Laboratory, University of North Sumatra, Medan. Data analysis used ANOVA (analysis of variance) and F test at 5%. Then, the means' further comparison and separation employed the least significant difference (LSD) test at the 5% probability level (Susilawati, 2015).

**RESULTS AND DISCUSSION**

**Fresh and dry weight of plants**

The results indicated that the nutrients and growing media applied individually and their interaction significantly affected the growth traits. A comparison of the average differences in the treatment means for fresh and dry weights through the LSD test appears in Tables 1 and 2. Results further revealed the N1 (AB mix solution) was the best nutritional treatment because it provided macro- and micro-nutrients needed by pak choi plants. The study results agree with past findings, which revealed that AB mix nutrition substantially influenced the growth of leaf number, width, and length, the number of roots, root length, and plant weight of pak choi (*Brassica rapa*) in the hydroponic system (Hermanto *et al*., 2021).

Growing media also has a noticeable effect on the fresh and dry weights of pak choi plants. Based on the results, it was visible that

**Table 1.** The influence of nutrients and growing media on the fresh weight (g) of pak choi plants.

| Parameters | Nutrients | | | Means (g) |
|---|---|---|---|---|
| Growing Media | N1 | N2 | N3 | |
| M1 | 193.00e | 96.20c | 4.60a | 97.93b |
| M2 | 210.20e | 49.40b | 9.40a | 89.67b |
| M3 | 216.80e | 59.60b | 3.40a | 93.27b |
| M4 | 126.60d | 29.40a | 4.60a | 53.53a |
| Means (g) | 186.65c | 58.65b | 5.50a | |

Numbers followed by the same notation indicate unreal differences according to the Least Significant Difference (LSD) test at a level of 5%. M1 = Rice husk charcoal, M2 = Rockwool, M3 = Cocopeat, M4 = Sponge, N1 = Goodplant AB mix solution, N2 = NPK fertilizer 16:16:16, and N3 = NASA liquid organic fertilizer.

**Table 2.** Effect of nutrients and growing media on the dry weight (g) of pak choi plants.

| Parameters | Nutrients | | | Means (g) |
|---|---|---|---|---|
| Growing Media | N1 | N2 | N3 | |
| M1 | 7.65d | 6.34c | 0.51a | 4.84b |
| M2 | 8.55d | 5.89c | 1.02a | 5.15c |
| M3 | 10.35e | 4.45b | 0.50a | 5.10b |
| M4 | 6.91c | 3.03b | 0.39a | 3.44a |
| Means (g) | 8.36c | 4.93b | 0.60a | |

Numbers followed by the same notation indicate unreal differences according to the Least Significant Difference (LSD) test at a level of 5%. M1 = Rice husk charcoal, M2 = Rockwool, M3 = Cocopeat, M4 = Sponge, N1 = Goodplant AB mix solution, N2 = NPK fertilizer 16:16:16, and N3 = NASA liquid organic fertilizer.

cocopeat media performed best in increasing pak choi's fresh and dry weights. According to Pranata (2018), the growing media must have good air exchange capabilities, macro and micropores, and existing balanced nutrient elements to support plant growth. This statement is in accordance with the characteristics of cocopeat, which influenced the development and production of pak choi plants. Additionally, cocopeat contains essential nutrients that plants need throughout their life cycle. The sponge planting medium's performance was inferior, providing the plant's lowest yield. However, these results contradicted previous findings by Barus *et al.* (2021), who found precisely the best pak choi growth with sponge media. These results authenticated that the response of plants in the growing medium may be different because it also has influences from other factors, such as the nutrients used, the amount of water absorbed, and environmental conditions.

The study identified the best combination as N1M3 (AB mix nutrition plus cocopeat growing media). The said combination boosted the fresh and dry weights of the pak choi plants with the NFT system used, which supports the nutrient circulation to run smoothly. Setiawati *et al.* (2019) reported that inorganic fertilizers combined with biofertilizers in hydroponic systems meaningfully influenced increasing the number of leaves and other growth traits. However, it did not significantly enhance the chlorophyll content. Maneeply *et al*. (2018) stated a significant difference in the plants' fresh weight using a hydroponic system. The deep flow technique (DFT) provides a flow of nutrient solution at a depth of 4 cm with a flow rate of 1.5 L/min. However, the NFT system has a solution depth of 1 to 3 mm and a flow rate of 1.0 L/min. Thus, the flow rate of the nutrient solution can affect the plant's fresh weight. The fresh weight of the crop also incurs strong influence from the water content contained in the plant tissues.

Based on the results, the NFT system had a noteworthy influence on the fresh and dry yields of pak choi plants because the mobilization of water and nutrients flowed smoothly. Nurza (2022) mentioned that, compared with the DFT, the NFT better promotes the growth traits and showed a significant difference in spinach (*Ipomoea reptans*) production. In the NFT system, the plants can get a continuous supply of water, oxygen, and nutrients with a fast flow without equipment constraints, such as pumps and water hoses.

**Chlorophyll a and b**

According to the results, the nutritional treatments considerably affected the parameters of chlorophyll a and b. However, the treatments for growing media have no significant effect on the chlorophyll content. (Tables 3 and 4) The outcomes showed that the best nutritional treatment was the provision of NPK fertilizer (16:16:16); however, for chlorophyll b parameters, the best performance emerged with the provision of AB mix nutrients. The NPK (16:16:16) nutrient solution can potentially substitute for the AB mix solution. It is due to the research results indicating that the chlorophyll a and b contents are not significantly dissimilar, whether given NPK 16:16:16 fertilizer, AB mix, or NASA organic fertilizer. However, the highest chlorophyll a and b contents, which are almost close in value, resulted when applying NPK 16:16:16 and AB mix fertilizer; thus, NPK 16:16:16 fertilizer can be an alternative to hydroponic nutrition for pak choi plants (Angming and Shen-Fushen, 2001; Rahman *et al*., 2022).

Chlorophyll analysis arose because chlorophyll a and b closely interlink to photosynthesis. Tondjo *et al.* (2015) mention that plant leaves are one of the main plant parts required in the biomass production of plants through photosynthesis. Besides, the leaf area correlates to plant production utilized in functional-structural plant models to mimic plant development. Nasution *et al*. (2020) reported that leaf area and leaf number were crucial factors in many agronomic and plant physiological hydroponic studies in pak choi plants (*Brassica rapa*).

The treatments of the growing media showed no significant effect on the production of chlorophyll a and b. An explanation is that it does not contain chlorophyll a or b depending on high conductivity and osmotic pressure, and the concentration of this solution does not affect the chlorophyll content in pak choi leaves. However, the interaction of N1M3 (AB mix and cocopeat solution) performed best for chlorophyll a and b contents. A suspicion is that the AB mix contains nitrogen and magnesium essential in forming chlorophyll, and cocopeat also contains nitrogen, which helps create chlorophyll. According to Yama and Kartiko (2020), the AB mix nutrition can provide sufficient nitrogen and magnesium elements for producing chlorophyll, providing adequate nutrition to plants for optimal chlorophyll enrichment.

Furthermore, the macroelement nitrogen is vital to the formation of chlorophyll, and aside from nitrogen, the microelement magnesium is also essential in leaf chlorophyll formation as the core of the chlorophyll molecule, which is a chelate of Mg in chloroplasts. Therefore, the availability of these two elements helps form more leaf chlorophyll. Ramadhan *et al*. (2018) reported that their nitrogen content analysis test in the cocopeat growing medium resulted in 0.37%. The recent results contrasted with the findings of Yunindanova *et al.* (2020), who mentioned that the plant growth parameters, including plant height, leaf number, width, and length of pak choi plants, were significantly different. The species adapted well to both concentrations. However, notable differences were evident in the combination of subspecies and nutrient concentration on plant growth and production parameters.

Suswati *et al*. (2015) revealed that the husk charcoal and cocopeat growing media were useful in vegetable and ornamental plant cultivation. Husk charcoal has a content of silicic acid (52%), nitrogen (0.18%), carbon (31%), fluorine (0.08%), potassium (0.3%), and calcium (0.14%). In husk charcoal, the silicates make the plants resistant to diseases caused by the hardening of the tissues. In addition, husk charcoal use hopes to enhance the potassium level in the soil as a plant nutrient.

**Table 3.** Effect of nutrients and growing media on chlorophyll a content (mg/g) in pak choi plants.

| Parameters | Nutrients | | | Means (mg/g) |
|---|---|---|---|---|
| Growing Media | N1 | N2 | N3 | |
| M1 | 1.31 | 1.45 | 0.93 | 1.23 |
| M2 | 1.33 | 1.50 | 0.86 | 1.23 |
| M3 | 1.56 | 1.45 | 0.73 | 1.25 |
| M4 | 1.46 | 1.40 | 1.14 | 1.34 |
| Means (mg/g) | 1.42 | 1.45 | 0.92 | |

Numbers followed by the same notation indicate unreal differences according to the Least Significant Difference (LSD) test at a level of 5%. M1 = Rice husk charcoal, M2 = Rockwool, M3 = Cocopeat, M4 = Sponge, N1 = Goodplant AB mix solution, N2 = NPK fertilizer 16:16:16, and N3 = NASA liquid organic fertilizer.

**Table 4.** Effect of nutrients and growing media on chlorophyll b content (mg/g) in pak choi plants.

| Parameters | Nutrients | | | Means (mg/g) |
|---|---|---|---|---|
| Growing Media | N1 | N2 | N3 | |
| M1 | 1.00 | 1.16 | 0.58 | 0.92 |
| M2 | 1.28 | 0.91 | 0.45 | 0.88 |
| M3 | 1.22 | 1.08 | 0.46 | 0.92 |
| M4 | 1.24 | 1.01 | 0.52 | 0.92 |
| Means (mg/g) | 1.19 | 1.04 | 0.50 | |

Numbers followed by the same notation indicate unreal differences according to the Least Significant Difference (LSD) test at a level of 5%. M1 = Rice husk charcoal, M2 = Rockwool, M3 = Cocopeat, M4 = Sponge, N1 = Goodplant AB mix solution, N2 = NPK fertilizer 16:16:16, and N3 = NASA liquid organic fertilizer.

## CONCLUSIONS

The nutrition and growing media applied individually and their combined use significantly affected the fresh and dry weights of pak choi plants. For chlorophyll a and b, the nutritional treatments have noticeable effects. The combined use of AB mix nutrition and cocopeat (N1M3) was the best combination, which showed remarkable performance in boosting the growth and physiological traits of pak choi plants.

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