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Growth and Yield of Lettuce (*Lactuca sativa* L.) Using the Deep Flow Technique (DFT) System with Different Growing Media

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ARTICLE INFO

Keywords: DFT, Hydroponics, Growing Media, Lettuce.

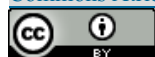
Received : 6 August 2026

Revised : 26 September 2026

Accepted : 27 October 2026

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ABSTRACT

Hydroponic systems generally use rockwool as a growing medium. Growing media such as husk charcoal, cocopeat, and sawdust are agricultural waste that can be utilized as planting media for hydroponic cultivation, in terms of growing media that are easily available and widely available. This study aimed to evaluate the effects of different growing media on the growth and yield of lettuce cultivated using the Deep Flow Technique (DFT) hydroponic system and to identify suitable alternatives to rockwool. The experiment was conducted in Sempaja Selatan from June to July 2023 using a single-factor Randomized Complete Block Design (RCBD) with four treatments: rockwool, rice husk charcoal, cocopeat, and sawdust. Each treatment was replicated four times, with a total of 40 plants per treatment (10 plants per replication). Data were analyzed using analysis of variance (ANOVA) followed by Duncan's Multiple Range Test at the 5% significance level. The ANOVA results showed significantly different among the growing media on plant height, number of leaves, fresh weight, and dry weight, but no significant differences in stem diameter and leaf area. Sawdust produced the highest plant height (10.55 cm) and number of leaves (25.60 leaves per plant), while cocopeat resulted in the highest leaf area (1,226.36 cm²), fresh weight (148.15 g), and dry weight (10.53 g). Rice husk charcoal produced the largest stem diameter (11.70 mm). These findings indicate that alternative growing media can support lettuce cultivation in DFT hydroponic systems, although their suitability depends on the growth variable considered. Their affordability and availability make them potential alternatives to rockwool, particularly for household-scale cultivation.

INTRODUCTION

Limited land for growing crops, especially vegetables in urban areas, has become a significant issue for people trying to engage in farming activities. Hydroponics, a plant cultivation system that does not use soil, offers a viable alternative to address this problem. It provides numerous advantages, including applicability in small spaces, better environmental control, efficient water use, faster growth, higher yields, minimal contamination, and flexibility in choosing growing media.

Lettuce (*Lactuca sativa* L.) is highly nutritious and possesses good commercial value, making it a promising crop for development. It is beneficial for

human health: per 100 g, lettuce contains protein (1.2 g), fat (0.2 g), carbohydrates (2.9 g), calcium (22 mg), and vitamin A. It is relatively easy to cultivate both traditionally and hydroponically, exhibits resistance to environmental stress, and holds strong economic potential.

One commonly used hydroponic system is the Deep Flow Technique (DFT). This system maintains a nutrient solution depth of 5 cm or more, ensuring water circulation and availability even during electrical failures that cause pump malfunctions. It also allows for efficient temperature and pH control,

reduces the risk of disease, and facilitates easier observation.

The growing medium most commonly used in hydroponic cultivation is rockwool. However, agricultural wastes such as rice husk charcoal, sawdust, and cocopeat can be utilized as sustainable alternatives. These materials are easy to obtain and widely available. Based on this background, this study was conducted to evaluate the "Growth and Yield of Hydroponic Lettuce (*Lactuca sativa* L.) Using the DFT System with Different Growing Media."

METHODS

The experiment was carried out from June to July 2023, in Sempaja Selatan Subdistrict, Samarinda City, East Kalimantan. The materials used included lettuce seeds (var. Grand Rapids), rockwool growing media, rice husk charcoal, cocopeat, sawdust, AB Mix nutrients, and rainwater. The equipment used included a hydroponic deep flow technique (DFT) module, pH meter, TDS meter, tape measure, leaf area meter, oven, mobile phone camera, stationery, netpot, bucket, and measuring cup.

The experiment was arranged in a Randomized Complete Block Design (RCBD), with a single

factor: growing media (M), consisting of m_0 = rockwool, m_1 = rice husk charcoal, m_2 = cocopeat, and m_3 = sawdust. Each treatment was replicated 4 times. Each replication contained 10 plants, resulting in a total of 40 plants per treatment. From each replication, 5 plants were selected as samples.

The observed variables consist of plant height, stem diameter, number of leaves, leaf area, fresh weight, and dry weight of the plant, observed at harvest. Total Dissolved Solids (TDS), temperature, and pH of the nutrient solution were observed daily and their averages were taken. The data were analyzed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test at a 5% significance level to compare the means of two treatments.

RESULTS AND DISCUSSION

The ANOVA results show that the type of growing media has a significantly different effect on the plant height, number of leaves, fresh weight and dry weight of the plants, TDS of the solution, and pH. Meanwhile, no significant differences were observed for stem diameter, leaf area, and solution temperature. A summary of the research results is presented in Table 1.

Table 1. Recap of Data Analysis Results on the Growth and Yield of Lettuce (*Lactuca sativa* L.) Using the Deep Flow Technique (DFT) System with Different Growing Media

Growing Media (M)	Plant Height (sheets)	Stem Diameter (mm)	Number of Leaves (sheets)	Leaf Area (cm ²)	Fresh Plant Weight (g)	Dry Plant Weight (g)	TDS (ppm)	Solution Temperature (°C)	pH
ANOVA	*	ns	*	ns	*	*	*	ns	*
m_0 (Rockwool)	4.96a	11.22	15.15a	1,224.09	97.25a	3.20a	869.90a	28.23	4.99ab
m_1 (Rice Husk Charcoal)	5.35a	11.70	16.15a	1,074.51	125.30b	9.64bc	874.88a	28.51	5.70c
m_2 (Cocopeat)	8.81b	10.34	23.80b	1,226.36	148.15b	10.53c	887.04b	28.26	5.19b
m_3 (Sawdust)	10.55b	8.85	25.60b	1,136.53	124.50ab	6.61b	865.77a	27.95	4.79a

Note: Means followed by the same letter within a column are not significantly different according to DMRT at the 5% significance level. * = significantly different; ns = not significant.

Plant Height

The results showed that sawdust yielded the highest plant height (10.55 cm), which was not significantly different from cocopeat (8.81 cm), but was significantly different from rockwool and rice husk charcoal. The highest vegetative growth in the sawdust treatment is likely due to the inherent

nutrient content in the sawdust, which supplemented the AB Mix solution. Sawdust contains essential macronutrients and micronutrients, such as N (1.33%), P (0.07%), K (0.60%), and Ca (1.44%) (Tan, 1994). The addition of these nutrients, particularly calcium, has been shown to significantly

improve the yield and growth of hydroponic lettuce (Suryatini et al., 2020).

Stem Diameter

The DMRT results at the 5% significance level showed that rice husk charcoal produced the largest stem diameter (11.70 mm), though it was not significantly different from the other treatments. Overall, the growing media did not cause a significant difference in stem diameter, likely because the nitrogen (N) supply from the AB Mix nutrient solution was already sufficient for all plants. However, rice husk charcoal contains essential nutrients, including N, which is crucial during the vegetative phase and may contribute to slightly better stem thickness (Munthe, 2018).

Number of Leaves

The results showed that sawdust produced the highest number of leaves (25.60 leaves), which was not significantly different from cocopeat (23.80 leaves), but was significantly higher than rockwool (15.15 leaves) and rice husk charcoal (16.15 leaves). Cocopeat and sawdust provide the best results for leaf production because these media have excellent porosity, allowing roots to grow and absorb nutrients optimally. Furthermore, cocopeat can retain nutrients that support plant growth (Nurifah & Fajartika, 2020). A higher number of leaves increases the surface area for sunlight absorption, thereby optimizing the photosynthesis process and photosynthate production (Mutakin et al., 2019).

Leaf Area

The DMRT results indicated that cocopeat produced the largest leaf area (1,226.36 cm²), though it was not significantly different from the other treatments. An increase in leaf area enhances light absorption for photosynthesis, producing more photosynthates that are distributed to all plant organs via the phloem (Miranda, 2017). Cocopeat contains the micronutrient copper (Cu), which plays a vital role in electron transport during photosynthesis and root formation. Additionally, it contains zinc (Zn),

which aids in root growth and leaf expansion (Ramawati, 2018).

Fresh Weight of Plants

The DMRT results showed that cocopeat produced the heaviest fresh weight (148.15 g), which was significantly different from rockwool, but not significantly different from rice husk charcoal and sawdust. This is because cocopeat contains essential nutrients such as calcium (Ca), magnesium (Mg), potassium (K), nitrogen (N), and phosphorus (P) (Muliawan, 2009). Rice husk charcoal also yielded a relatively high fresh weight (125.30 g) due to its nutrient content, including N (0.3%), P₂O₅ (15%), and K₂O (31%) (Fahmi, 2013).

Nitrogen stimulates vegetative growth and supports effective photosynthesis and chlorophyll formation (Patti et al., 2013). Phosphorus aids in cell division, particularly in roots, positively affecting canopy growth (Munthe et al., 2018), while potassium is crucial for leaf development, photosynthesis, and stomatal regulation (Munir, 2016). The lightest fresh weight was observed in the rockwool treatment, likely because rockwool functions primarily as a physical support and water reservoir, without providing additional inherent nutrients like the organic media.

Plant Dry Weight

Cocopeat produced the heaviest dry weight (10.53 g), which was not significantly different from rice husk charcoal (9.64 g), but was significantly different from sawdust and rockwool. Plant dry weight represents the accumulation of carbohydrates, proteins, and other organic materials after water is removed. A higher dry weight indicates increased photosynthetic activity and a higher yield of photosynthates (Nugroho et al., 2019).

TDS of Nutrient Solution

The TDS levels in the nutrient solution for the cocopeat treatment (887.04 ppm) were significantly different from the other treatments. TDS indicates the concentration of dissolved ions in the nutrient solution. The higher TDS in the cocopeat treatment

is suspected to be due to the leaching of inherent nutrients from the cocopeat into the solution, including Ca, Mg, K, Na, and P (Muliawan, 2009). This elevated nutrient availability directly influenced the growth and yield of the lettuce, particularly in terms of fresh weight, dry weight, and leaf area.

Nutrient Solution Temperature

ANOVA showed no significant difference in the effect of the growing media on the nutrient solution temperature. The average temperatures across the four media ranged from 27.95°C to 28.51°C. These temperatures fall within the optimal range for lettuce cultivation (20-30°C). Temperatures above 30°C can inhibit growth and cause bitterness in the leaves (Telaumbanua et al., 2014).

Nutrient Solution pH

The pH of the nutrient solution was significantly affected by the growing media. The rice husk charcoal treatment (pH 5.70) was significantly different from the others. A good nutrient solution for lettuce should maintain a pH range of 5.5–6.5 (Brechner & Both, 2013). Solutions outside this range can impair nutrient solubility and root absorption (Lingga, 2012; Karoba et al., 2015). The variations in pH observed in this study were influenced by the initial pH of the growing media; for instance, cocopeat typically has a pH ranging from 5.0 to 6.8 (Kuntardina, 2022). The ideal pH range for hydroponic nutrient solutions is between 5.5 and 6.5. At this pH, nutrients can dissolve and be available to plants. At a lower pH than this range, nutrient solubility is incomplete and nutrients may start to precipitate, making them unavailable for plant roots to absorb (Karoba, 2015).

CONCLUSION

The type of growing media significantly affected the plant height, number of leaves, fresh weight, and dry weight of hydroponic lettuce, but did not significantly affect stem diameter and leaf area. Cocopeat is the most suitable growing medium to replace rockwool under these research conditions, as

it yielded the highest fresh weight, dry weight, and leaf area. Other media, such as rice husk charcoal and sawdust, can also be used as effective alternatives. Cocopeat is highly recommended due to its inherent nutrient content, excellent moisture retention, and local availability.

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