Agrogenesis Journal of Sustainable Agriculture and Innovation. 2025. 1(1); 53-63

AGROGENESIS
Journal of Sustainable Agriculture and Innovation
www.agrogenesis.umi.ac.id

Effectiveness of Cocopeatnut Water and Various Growing Media on the Growth and Yield of Mustard Microgreens (*Brassica juncea* L.)

Syahriana TN[1], St. Subaedah[1*], Hidrawati Ambo Ala[1]

[1] Agrotechnology Study Program, Faculty of Agriculture, Universitas Muslim Indonesia, Urip Sumoharjo km.5, Panaikang, Panakkukang District, Makassar City, South Sulawesi 90231, Indonesia.

ARTICLE INFO

Keywords:
Cocopeatnut Water
Compost
Mustard Microgreens
Organic Substrates
Plant Growth

Article History:
Received: February 04, 2025
Accepted: June 26, 2024

*) Corresponding author:
E-mail: st.subaedah@umi.ac.id

ABSTRACT

Microgreens represent a modern agricultural innovation characterized by rapid harvest cycles and high nutritional value. This study aimed to evaluate the effects of Cocopeatnut water and various growing media on the growth and yield of mustard microgreens (*Brassica juncea* L.). A Completely Randomized Design (CRD) with a factorial pattern was applied, involving three irrigation treatments (100% Cocopeatnut water, 50% Cocopeatnut water + 50% distilled water, and 100% distilled water) and four types of growing media (soil, compost, Cocopeat, and rice husk charcoal). Observed parameters included plant height, fresh weight and consumable biomass per unit area and per tray, and crude protein content. The results showed that growing media significantly influenced most growth parameters, while Cocopeatnut water had a notable effect on plant height and consumable biomass per tray. The protein content of microgreens was higher than that of mature plants. Compost consistently produced the best growth performance across treatments. Cocopeatnut water, rich in natural plant hormones and nutrients, positively supported early plant development. The interaction between specific irrigation types and growing media led to enhanced plant performance compared to individual treatments. These findings suggest an environmentally friendly and nutrient-dense cultivation method suitable for urban agriculture. The study recommends the use of locally available organic materials to improve the sustainability, productivity, and quality of microgreens.

INTRODUCTION

Microgreens have emerged as a promising sector of urban farming due to their rapid growth cycles and high nutritional density, making them attractive from both agricultural and health perspectives. Mustard greens (*Brassica juncea* L.), known for their adaptability and nutritional value, exemplify the benefits of microgreens, as they can be harvested within two weeks after sowing and offer significant health benefits due to higher levels of vitamins and antioxidants compared to mature vegetables (Uher et al., 2023). Numerous studies have reported that microgreens are enriched with essential vitamins, minerals, and antioxidants that positively contribute to human health (Martínez-Ispizua et al., 2022; Renna et al., 2020) .

The cultivation of microgreens, particularly through the use of effective growing media and nutrient sources, is critical to optimizing their growth and nutritional profile. Although microgreens are commonly grown in soilless systems, the choice of growing medium directly affects root development, moisture retention, and aeration-factors that are crucial for optimal plant growth (Bulgari et al., 2021). A specific focus on alternative growing media such as Cocopeat, rice husk charcoal, and organic compost presents opportunities to enhance the sustainability of urban agriculture (Gioia et al., 2021). Previous studies have shown that organic substrates can support microgreen growth while also potentially improving their nutritional content.

Cocopeatnut water is an appealing organic nutrient source due to its richness in growth-promoting hormones such as cytokinins and gibberellins, as well as macro- and micronutrients essential for plant vitality (Tilahun et al., 2024). Prior research on other horticultural crops has praised the effectiveness of Cocopeatnut water as a growth stimulant and organic fertilizer (Christofi et al., 2023). However, empirical research on its effect during the microgreen stage of mustard greens remains limited.

ISSN: 3090-2657
DOI: https://doi.org/10.33096/agrogenesis.v1i1.680

Therefore, examining the synergistic effects of Cocopeatnut water combined with various types of growing media on mustard green microgreens not only addresses a significant gap in the literature but also offers the potential for an environmentally friendly approach to urban food production.

This innovative combination holds promise for advancing sustainable practices in urban agriculture. The growing interest in microgreens due to their high market value and minimal resource requirements makes them a viable solution for communities with limited agricultural space (Seth et al., 2025). Overall, this study aims to enrich the body of knowledge on microgreen cultivation by evaluating the growth and nutritional outcomes resulting from the application of Cocopeatnut water across diverse organic media a novel approach that may enhance crop quality and inform future agricultural practices.

METERIALS AND METHODS

This research was conducted at Fresko Organic Farm, located in Pattalassang District, Gowa Regency, South Sulawesi Province. The study was carried out from June to July 2024. The materials used in this research included mustard green (*Brassica juncea* L.) seeds, soil, compost, Cocopeat, rice husk charcoal, distilled water, and Cocopeatnut water. The tools employed in the experiment consisted of plastic trays (22 cm × 17 cm × 4 cm), a sprayer, LED lamps, microgreen racks, a ruler, a digital scale, a camera, and stationery.

The experimental method used was a Completely Randomized Design (CRD) with a factorial pattern consisting of two factors. The first factor was Cocopeatnut water application (A), which included three treatment levels: (A1) 100% distilled water, (A2) 100% Cocopeatnut water, and (A3) 50% distilled water + 50% Cocopeatnut water. The second factor was the growing media, coded as (M), which consisted of four types: (M1) Soil, (M2) Compost, (M3) Cocopeat, and (M4) Rice husk charcoal.

RESULTS AND DISCUSSION

1. Plant Height

The observed data on plant height and the results of the analysis of variance are presented in Table 1. The analysis of variance showed that the treatment of Cocopeatnut water application, growing media, and the interaction between the two had a highly significant effect on the height of mustard green microgreens.

Table 1. Average Plant Height of Mustard Green Microgreens (cm) Under the Combination of Distilled Water, Cocopeatnut Water, and Various Growing Media Treatments.

Treatment	Types of Growing Media				LSD 0.05
	Soil	Compost	Cocopeat	Rice Husk Charcoal	
A1 (Distilled Water 100%)	4.65^{c}_{x}	7.35^{a}_{y}	6.45^{b}_{x}	7.40^{a}_{y}	
A2 (Distilled Water 100%)	4.72^{c}_{x}	8.18^{a}_{x}	6.72^{b}_{x}	7.70^{a}_{xy}	0.42
A3 (Distilled Water 50% + Cocopeatnut Water 50%)	4.73^{c}_{x}	7.63^{a}_{y}	4.65^{b}_{x}	7.83^{a}_{x}	

Note: Numbers followed by different letters (a. b. x. and y) in the same row or column indicate a significant difference based on the LSD test at the 0.05 level.

Based on Table 1. the best treatment for promoting plant height in mustard green microgreens was generally observed in the combination of A2 (100% Cocopeatnut water) with M2 (compost) as the growing medium. which resulted in an average plant height of 8.18 cm. This combination consistently produced higher plant heights compared to other treatment combinations. In contrast. the lowest plant heights were observed in the A1 (100% distilled water) with M1 (soil) and A3 (50% distilled water + 50% Cocopeatnut water) with M3 (Cocopeat) combinations. both yielding an average plant height of 4.65 cm.

The use of 100% Cocopeatnut water with compost as the growing medium produced plant heights nearly twice as tall as those grown with 100% distilled water on soil or with the distilled and Cocopeatnut water mixture on Cocopeat. This indicates that both the type of growing medium and the concentration of Cocopeatnut water used in irrigation have a significant influence on the plant height development of mustard green microgreens.

The findings of this study indicate that the combination of 100% Cocopeatnut water with compost as a growing medium resulted in a significant increase in the height of mustard green microgreens. with an average height reaching 8.18 cm. This performance was higher compared to other treatments. such as the combination of 100% distilled water with soil and a 50% distilled water and 50% Cocopeatnut water mixture with Cocopeat. both of which yielded an average plant height of 4.65 cm. This observation emphasizes the influence of both the choice of growing medium and the nutrient source-specifically Cocopeatnut water-on microgreen growth (Ramadhani et al., 2023).

Cocopeatnut water. which is rich in cytokinins and other growth-promoting nutrients. enhances plant metabolism and growth. which is crucial for young plants like microgreens with rapid growth cycles (Fahima & Arthur, 2024). This study supports existing literature emphasizing the effectiveness of Cocopeatnut water in promoting plant height and biomass in various crops. suggesting that it can also benefit microgreens by facilitating better root development and nutrient uptake (Arzeta-Ríos et al., 2020).

Furthermore. the use of compost as a growing medium likely enhances this effect by providing essential nutrients and improving soil structure. aeration. and moisture retention capabilities. Organic substrates such as compost can improve moisture retention. which is necessary for optimal seedling development. aligning with the findings of this study that attribute higher plant heights to compost's water-retention properties (Jat et al., 2021). Along with Cocopeatnut water. the availability of both water and nutrients was maximized. resulting in plant height nearly double that of the 100% distilled water treatments. indicating a compounding effect of both factors on microgreen growth (Manna & Siddique, 2024).

Moreover. these findings highlight that the variation in plant height among treatments emphasizes the relationship between water supply and nutrient delivery in microgreen cultivation. Proper water management is critical for maximizing plant productivity; in the context of this research. using a natural plant growth stimulant like Cocopeatnut water could represent a sustainable practice for urban agriculture. where resources may be limited (Surendran et al., 2019). Therefore. integrating these findings leads to a better understanding that optimizing both the medium and nutrient application can significantly enhance the productivity of mustard green microgreens. making it a promising practice for urban farming.

2. Fresh Wight per 25 cm^2

The observations of the fresh weight of the plants, which were conducted by taking samples per 25 cm² and analyzing the variance, are presented in Table 2. The results of the analysis of variance show that the growing media treatment had a very significant effect on the fresh weight of the plants. However, the Cocopeatnut water treatment and the interaction between Cocopeatnut water application and growing media did not have a significant effect.

Table 2. Average Fresh Weight of Microgreen Mustard Plants per 25 cm² (g) on the Combination of Treatments with Distilled Water, Cocopeatnut Water, and Various Types of Growing Media.

Treatment	Types of Growing Media			
	Soil	Compost	Cocopeat	Rice Husk Charcoal
A1 (Distilled Water 100%)	2.33	5.67	4.67	5.33
A2 (Distilled Water 100%)	2.67	6.67	5.67	5.33
A3 (Distilled Water 50% + Cocopeatnut Water 50%)	2.67	6.67	5.33	5.33
Mean	2.56 c	6.33 a	5.22 b	5.33 b
LSD 0.05	0.76			

Note: Numbers followed by different letters (a, b) in the same row or column indicate a significant difference based on the LSD test at the 0.05 level.

Based on Table 2. which presents the average fresh weight of mustard green microgreens per 25 cm² (grams). it can be observed that the best treatment in producing the highest fresh weight was found in the growing medium M2 (compost). with an average fresh weight of 6.33 g. This medium significantly produced higher fresh weight compared to the other growing media. Conversely. the lowest fresh weight of mustard green microgreens was observed in growing medium M1 (soil). with an average fresh weight of only 2.56 g. The fresh weight produced in this medium was considerably lower than that of the other media.

This comparison highlights a substantial difference in the fresh weight of mustard green microgreens. which is influenced by the type of growing medium used. The compost medium provided more favorable conditions for growth and fresh weight accumulation compared to the soil medium. Although the Cocopeatnut water and distilled water treatments varied. the primary factor affecting fresh weight appears to be the type of growing medium employed.

The significant difference in fresh weight strongly emphasizes the crucial role of growing media in microgreen production. Compost medium likely provides a more favorable environment for plant growth due to its rich nutrient content and better water retention capacity. which are essential for seedling development and biomass accumulation (Lu et al., 2022).

Compost can enhance soil biodiversity and microbial activity. which not only improves nutrient availability but also promotes root development and overall plant health (Thepsilvisut et al., 2023). In contrast. soil media demonstrated lower biomass production. which may be due to inadequate nutrient supply and suboptimal physical properties. Soil may not retain moisture as effectively as compost. leading to potential water stress that negatively affects growth (Misra & Gibson, 2021). Several studies support this. indicating that microgreens grown in compost or enriched organic media consistently show better growth parameters compared to those grown in conventional soil (Kamal et al., 2020; Wojdyło et al., 2020).

Furthermore. the variations in fresh weight across treatments suggest that while the type of growing medium is the primary factor. the addition of different nutrient sources such as Cocopeatnut water also influences growth responses. However. in this case. the inherent properties of compost. such as its balanced nutrient profile. appear to have a greater impact on fresh weight outcomes than variations in irrigation methods (Thepsilvisut et al., 2023). Some studies also highlight that optimal microgreen growth is significantly enhanced by the use of organic substrates that manage plant nutrients more effectively than traditional soil (Misra & Gibson, 2021)

Other research has noted that growing media with high water-holding capacity. such as vermiculite. can also increase the fresh weight of microgreens. indicating that moisture retention and nutrient supply in the media are critical for maximizing biomass (Septirosya et al., 2024). The success of compost in improving fresh weight suggests a potential approach for urban farming practices aimed at increasing yield and sustainability. This supports the idea that urban agriculture can benefit from the use of compost as a primary nutrient management resource. aligning with sustainable farming practices that prioritize organic amendments (Lunt et al., 2022).

.

3. Fresh Weight Per Tray

The results of the observed fresh weight of plants per tray and their variance analysis are presented in Table 3. The results of the variance analysis indicate that the planting medium treatment had a highly significant effect on the fresh weight of the plants. However. the Cocopeatnut water application treatment and the interaction between Cocopeatnut water application and planting medium did not have a significant effect.

Table 3. Average Fresh Weight of Mustard Microgreen Plants Per Tray (g) Under Combinations of Cocopeatnut Water Application and Various Planting Media.

Treatment	Types of Growing Media			
	Soil	Compost	Cocopeat	Rice Husk Charcoal
A1 (Distilled Water 100%)	7.33	12.33	11.67	11.67
A2 (Distilled Water 100%)	7.33	14.67	13.00	12.67
A3 (Distilled Water 50% + Cocopeatnut Water 50%)	6.33	14.00	12.33	12.00
Mean	7.00 c	13.67 a	12.33 ab	12.11 b
LSD 0.05		1.54		

Note: Numbers followed by different letters (a, b, c) in the same row or column indicate a significant difference based on the LSD test at the 0.05 level.

Based on Table 3. which presents the average fresh weight of mustard microgreens per tray (in grams). it is observed that the best treatment for producing the highest fresh weight is on the M2 (Compost) planting medium. with an average fresh weight reaching 13.67 g. This planting medium significantly produced a higher fresh weight per tray compared to other planting media.

Conversely. the lowest treatment for producing the fresh weight of mustard microgreens per tray is seen on the M1 (Soil) planting medium. with an average fresh weight of only 7.00 g. The fresh weight produced on this planting medium is considerably lower compared to the other planting media.

The crucial role of growing media in optimizing plant growth and biomass production is evident. The significant increase in fresh weight associated with the compost medium can be attributed to its richer nutrient content and better water retention capacity compared to conventional soil media.

Compost functions as an organic substrate that not only provides essential nutrients but also improves soil structure. resulting in better aeration and optimal root development. Research shows that compost enhances microbial activity and nutrient availability in the soil. which can positively support the growth of various plant species. including mustard greens (Sugiharti et al., 2022). When grown in compost. the microbial ecosystem works synergistically with plant roots. facilitating effective nutrient uptake and boosting the overall vitality of the plant (Santoso, 2022).

The lower fresh weight in the M1 (soil) treatment appears to stem from suboptimal nutrient supply and potentially inadequate moisture retention. which are common challenges in conventional soil cultivation. Previous studies indicate that soil may have limitations in providing sufficient nutrients. especially in intensively cultivated urban environments. thereby hindering plant growth. Additionally. nutrient leaching in soil can impede the availability of essential nutrients. particularly nitrogen. phosphorus. and potassium. which are critical for biomass accumulation in plants like mustard greens (Tunsagool et al., 2023).

Practically. the significant difference in biomass outcomes underscores the potential of using compost as an effective nutrient source. Integrating compost into cultivation systems aligns with sustainable agricultural practices. reducing reliance on chemical fertilizers while improving soil health. Therefore. urban agriculture initiatives could benefit greatly from adopting compost-based cultivation techniques.

Furthermore. enhancing nutrient management in compost can yield even greater increases in fresh weight. Research shows that the timing and method of nutrient application can significantly affect crop yields (Muthu et al., 2023). Implementing strategies that optimize nutrient delivery methods. such as using biologically active compounds found in various organic fertilizers or employing liquid organic fertilizers alongside compost. can further maximize the benefits observed in this study (Sugiharti et al., 2022)

4. Consumption Weight Per 25 cm^2

The observations of the consumption weight of the plants, which were conducted by taking samples per 25 cm² and analyzing the variance, are presented in Table 4. The results of the analysis of variance show that the growing media treatment had a very significant effect on the consumption weight of the plants. However, the Cocopeatnut water treatment and the interaction between Cocopeatnut water application and growing media did not have a significant effect.

Table 4. Average Consumption Weight of Microgreen Mustard Plants per 25 cm² (g) on the Combination of Cocopeatnut Water Application and Various Types of Growing Media.

Treatment	Types of Growing Media			
	Soil	Compost	Cocopeat	Rice Husk Charcoal
A1 (Distilled Water 100%)	2.00	4.00	4.00	3.33
A2 (Distilled Water 100%)	1.67	5.33	4.67	5.00
A3 (Distilled Water 50% + Cocopeatnut Water 50%)	1.67	5.00	3.67	4.00
Mean	1.78 b	4.78 a	4.11 a	4.11 a
LSD 0.05	0.96			

Note: Numbers followed by different letters (a, b) in the same row or column indicate a significant difference based on the LSD test at the 0.05 level.

Based on Table 4. which presents the average consumption weight of mustard microgreens per 25 cm² (grams). it is observed that the best treatment for producing the highest consumption weight is on the M2 (Compost) planting medium. with an average consumption weight reaching 4.78 g. This planting medium significantly produced a higher consumption weight compared to the M1 (Soil) planting medium.

Conversely. the lowest treatment for producing the consumption weight of mustard microgreens per 25 cm² is seen on the M1 (Soil) planting medium. with an average consumption weight of only 1.78 g. The consumption weight produced on this planting medium is considerably lower compared to the other planting media.

This comparison indicates that the type of planting medium has a significant influence on the consumption weight of mustard microgreens. The Compost planting medium yields a much higher consumption weight compared to the Soil planting medium. Meanwhile. the M3 (Cocopeat) and M4 (Rice Husk Charcoal) planting media show results that are not significantly different from the M2 (Compost) planting medium. The Cocopeatnut water and aquades treatments in combination with certain planting media also affect consumption weight. but the greatest influence is seen in the differences between the types of planting media.

The superior performance of the M2 (Compost) medium can be attributed to several factors. including higher nutrient availability and better water retention capacity. Compost-based media. such as Compost. are well known for their ability to efficiently supply essential nutrients to plants while maintaining adequate moisture levels-both of which are crucial during the rapid growth phase of microgreens (Septirosya et al., 2024). This aligns with studies showing that compost-enriched growing media make a substantial contribution to the yield and nutritional quality of microgreens by enhancing nutrient bioavailability and promoting better root development (Celestino et al., 2024)

In contrast. the lower performance observed with the M1 (Soil) medium may reflect the potential limitations of traditional soil-based media. which often lack the necessary nutrients and water retention capacity when compared to organic alternatives. Soil media can become compacted. reducing porosity and affecting oxygen availability to the roots. which ultimately inhibits root development and plant growth (Komeroski et al., 2024). This is particularly relevant for microgreens. which have a short growth cycle and require optimal conditions for successful development (Frąszczak & Kleiber, 2022).

Furthermore. although the consumption weights from the M3 (Cocopeat) and M4 (Rice Husk Charcoal) growing media were not statistically different from M2. the marked difference between these media and M1 underscores the importance of selecting suitable substrates to meet the specific requirements of microgreen cultivation (Johnson et al., 2020). The use of nutrient-rich solutions such as Cocopeatnut water in conjunction with these viable growing substrates could further enhance the growth characteristics of mustard microgreens. considering the natural growth hormones and nutrients provided by such solutions (Marchioni et al., 2021).

Importantly. the findings of this study support the growing body of evidence indicating that the use of organic-based substrates facilitates higher yields and may also enhance the functional properties of the produce. For example. microgreens grown in compost-rich media often contain higher levels of bioactive compounds. potentially offering greater health benefits compared to those cultivated in conventional soil (Shibaeva et al., 2023). This reinforces the argument for adopting more sustainable and health-oriented agricultural practices. especially as urban agriculture continues to evolve and seek methods for maximizing yield and nutritional value in space-limited environments.

5. Consumotion Weight per tray

The observations of the consumption weight of the plants per tray and their analysis of variance are presented in Table 5. The results of the analysis of variance show that the growing media treatment had a very significant effect on the consumption weight of the plants. There was a significant effect on the Cocopeatnut water treatment, but no significant effect on the interaction between Cocopeatnut water application and growing media.

Table 5. Average Consumption Weight of Microgreen Mustard Plants per Tray (g) on the Combination of Cocopeatnut Water Application and Various Types of Growing Media.

Treatment	Types of Growing Media				Mean	LSD 0.05
	Soil	Compost	Cocopeat	Rice Husk Charcoal		
A1 (Distilled Water 100%)	5.33	10.00	9.67	9.67	8.67 b	1.15
A2 (Distilled Water 100%)	5.33	13.00	11.00	11.33	10.17 a	
A3 (Distilled Water 50% + Cocopeatnut Water 50%)	5.00	12.33	10.67	10.00	9.50 ab	
Mean	5.22 b	11.78 a	10.44 a	10.33 a		
LSD 0.05			1.61			

Note: Numbers followed by different letters (a, b) in the same row or column indicate a significant difference based on the LSD test at the 0.05 level.

Based on Table 5. which presents the average consumption weight of mustard microgreens per tray (grams). it can be observed that the best treatment for producing the highest consumption weight is on the M2 (Compost) planting medium. with an average consumption weight reaching 11.78 g. This planting medium significantly produced a higher consumption weight per tray compared to the M1 (Soil) planting medium. Conversely. the lowest treatment for producing the consumption weight of mustard microgreens per tray is seen on the M1 (Soil) planting medium. with an average consumption weight of only 5.22 g. The consumption weight produced on this planting medium is considerably lower compared to the other planting media.

This comparison shows a significant difference in the consumption weight of mustard microgreens per tray influenced by the type of planting medium. The use of the Compost planting medium yields a superior consumption weight compared to the Soil planting medium. Although there is variation in the Cocopeatnut water and aquades treatments. the influence of the planting medium type appears to be the main factor in determining the total consumption weight per tray.

The higher consumption weight observed in the M2 (Compost) medium can be attributed to its superior characteristics. particularly its composition that supports optimal plant growth and development. Compost-based media. such as Compost. offer rich nutrient content and enhanced moisture retention—key factors that promote vigorous growth. especially in fast-growing crops like microgreens. Research has shown that a growing medium capable of maintaining adequate moisture levels and providing sufficient aeration can significantly enhance the yield and quality of microgreens. ultimately increasing their consumption weight. The higher phosphorus content and organic matter in compost also support improved root development and nutrient absorption. which may explain the higher consumption weight found in this study (Rus et al., 2023)

In contrast. the M1 (Soil) growing medium produced the lowest consumption weight. suggesting that this medium may be insufficient in terms of nutrient supply and moisture retention. Traditional soil-based media often struggle to provide the same level of nutrient availability and aeration as organic compost. potentially limiting the growth potential of microgreens. These shortcomings of soil-based media have been supported by findings indicating higher yields and improved microgreen quality in compost-based systems (Matra et al., 2021)

Furthermore. although additional treatments such as Cocopeatnut water and aquades showed some variation. the primary factor influencing consumption weight remained the type of growing medium used. Studies show that nutrient dynamics and overall plant health are largely determined by the characteristics of the growing medium (Kong et al., 2023). reinforcing the findings of this study. The optimal balance of water. nutrients. and beneficial microbial activity in the Compost medium likely contributed to its success in increasing the consumption weight of mustard microgreens compared to the Soil medium. The Compost medium not only supports greater biomass accumulation but also enhances the marketability and health benefits of these nutrient-dense crops. making it a recommended choice for both commercial and urban farming practices.

6. Protein Content

The results of the protein content test for microgreen mustard plants and adult mustard plants are presented in Table 6.

Table 6. Laboratory Test Results of Protein Content in Microgreen Mustard and Adult Mustard Plants

No.	Sample	Crude Protein (%)
1.	Mustard	1.95
2.	Micrigreen Mustard	3.97

Table 6 presents the laboratory test results of crude protein content in adult mustard plants and microgreen mustard. Based on the data in the table. it is evident that the crude protein content in microgreen mustard (3.97%) is much higher compared to the crude protein content in adult mustard (1.95%). This difference indicates that microgreen mustard contains approximately twice as much crude protein as older mustard plants. These results suggest that microgreen mustard can be a more potential source of protein compared to adult mustard in terms of protein content per unit weight.

This data confirms that mustard microgreens contain almost twice the amount of protein per unit weight compared to their mature plant counterparts. This difference in protein content highlights the potential of mustard microgreens as a more concentrated source of protein. making them an attractive option for those seeking nutrient-dense food sources.

The high protein content found in microgreens can be attributed to several factors inherent to their growth stage. Microgreens. often harvested shortly after germination. are still in a phase of rapid cell division and biomass accumulation. which supports higher concentrations of nutrients. including protein. Research has shown that microgreens tend to have higher levels of bioactive compounds and minerals compared to their mature forms. indicating a greater overall nutritional density. as confirmed by studies that show this trend across various microgreen species. which often display higher concentrations of protein. vitamins. and phytochemicals due to their youthful stage of development (Johnson et al., 2020).

Additionally. the methodology of growing microgreens in controlled environments. such as with optimized light conditions and nutrient-rich media. can further enhance their nutritional composition. For instance. studies have shown that manipulating light spectra. such as using LED technology. can positively influence the accumulation of phytochemicals and nutrients in microgreens. including protein content (Teng et al., 2024). Furthermore. the choice of growing substrates is crucial. as it can significantly affect the biochemical composition of microgreens. including their protein levels (Sanyukta et al., 2023).

The superior protein content of mustard microgreens compared to mature plants suggests opportunities for incorporating them as functional foods or 'superfoods' in diets. especially for individuals seeking plant-based nutrition sources. The significant increase in essential nutrients makes microgreens a viable alternative to conventional vegetables. potentially addressing nutritional gaps in various consumer diets. Emerging agricultural practices focusing on microgreen cultivation could thus play a key role in enhancing food security while promoting health benefits through their high protein and nutrient profiles (Gao et al., 2021).

Leveraging the potential of microgreens as a high-protein food source aligns with current dietary trends favoring plant-based nutrition and presents an environmentally sustainable approach to food production.

CONCLUSIONS

This study demonstrated that the combination of 100% Cocopeatnut water and compost growing media resulted in the best growth and yield of mustard microgreens. with a plant height reaching 8.18 cm and a crude protein content of 3.97%. Compost proved superior in enhancing fresh weight and edible biomass. These findings confirm that the use of Cocopeatnut water and compost is an effective and sustainable strategy for microgreen cultivation. particularly in supporting efficient and nutritionally valuable urban agriculture.

REFERENCES

Arzeta-Ríos, A. J., Guerra-Ramírez, D., Reyes-Trejo, B., Ybarra-Moncada, Ma. C., & Zuleta-Prada, H. (2020). Microwave heating effect on total phenolics and antioxidant activity of green and mature coconut water. *International Journal of Food Engineering*, *16*(12). https://doi.org/10.1515/ijfe-2019-0378

Bulgari, R., Negri, M., Santoro, P., & Ferrante, A. (2021). Quality Evaluation of Indoor-Grown Microgreens Cultivated on Three Different Substrates. *Horticulturae*, *7*(5), 96. https://doi.org/10.3390/horticulturae7050096

Celestino, S., Nyoman, I. R. A. I., & Darmawati, I. D. A. A. Y. U. P. (2024). Growth response and yield quality of broccoli microgreen (Brassica oleracea var. Italica Planck) to LEDs irradiance duration and types of nutrients. *Magna Scientia Advanced Biology and Pharmacy*, *11*(1), 033–038. https://doi.org/10.30574/msabp.2024.11.1.0082

Christofi, A., Margariti, G., Salapatas, A., Papageorgiou, G., Zervas, P., Karampiperis, P., Koukourikos, A., Tarantilis, P. A., Kaparakou, E. H., Misiakos, K., & Makarona, E. (2023). Determining the Nutrient Content of Hydroponically-Cultivated Microgreens with Immersible Silicon Photonic Sensors: A Preliminary Feasibility Study. *Sensors (Basel, Switzerland)*, *23*(13), 5937. https://doi.org/10.3390/s23135937

Uher, S. F., Radman, S., Opačić, N., Dujmović, M., Benko, B., Lagundžija, D., Mijić, V., Prša, L., Babac, S., & Šic Žlabur, J. (2023). Alfalfa, Cabbage, Beet and Fennel Microgreens in Floating Hydroponics—Perspective Nutritious Food? *Plants*, *12*(11), 2098. https://doi.org/10.3390/plants12112098

Fahima, S., & Arthur, F. C. R. (2024). Growth Response and Yield of Stevia (Stevia rebaudiana) to Giving Old Coconut Water and Different Types of Irrigation. *Journal of Soilscape and Agriculture*, *2*(2). https://doi.org/10.19184/jsa.v2i2.832

Frąszczak, B., & Kleiber, T. (2022). Microgreens Biometric and Fluorescence Response to Iron (Fe) Biofortification. *International Journal of Molecular Sciences*, *23*(23), 14553. https://doi.org/10.3390/ijms232314553

Gao, M., He, R., Shi, R., Li, Y., Song, S., Zhang, Y., Su, W., & Liu, H. (2021). Combination of Selenium and UVA Radiation Affects Growth and Phytochemicals of Broccoli Microgreens. *Molecules (Basel, Switzerland)*, *26*(15), 4646. https://doi.org/10.3390/molecules26154646

Gioia, F. Di, Petropoulos, S. A., Ferreira, I. C. F. R., & Rosskopf, E. N. (2021). Microgreens: from trendy vegetables to functional food and potential nutrition security resource. *Acta Horticulturae*, *1321*, 235–242. https://doi.org/10.17660/actahortic.2021.1321.31

Jat, R. S., Choudhary, R. L., Singh, H. V., Meena, M. K., Singh, V. V., & Rai, P. K. (2021). Sustainability, productivity, profitability and soil health with conservation agriculture based sustainable intensification of oilseed brassica production system. *Scientific Reports*, *11*(1), 13366. https://doi.org/10.1038/s41598-021-92801-z

Johnson, S. A., Prenni, J. E., Heuberger, A. L., Isweiri, H., Chaparro, J. M., Newman, S. E., Uchanski, M. E., Omerigic, H. M., Michell, K. A., Bunning, M., Foster, M. T., Thompson, H. J., & Weir, T. L. (2020). Comprehensive Evaluation of Metabolites and Minerals in 6 Microgreen Species and the Influence of Maturity. *Current Developments in Nutrition*, *5*(2), nzaa180–nzaa180. https://doi.org/10.1093/cdn/nzaa180

Kamal, K. Y., Khodaeiaminjan, M., El-Tantawy, A. A., Moneim, D. A., Salam, A. A., Ash-shormillesy, S. M. A. I., Attia, A., Ali, M. A. S., Herranz, R., El-Esawi, M. A., Nassrallah, A. A., & Ramadan, M. F. (2020). Evaluation of growth and nutritional value of Brassica microgreens grown under red, blue and green LEDs combinations. *Physiologia Plantarum*, *169*(4), 625–638. https://doi.org/10.1111/ppl.13083

Komeroski, M. R., Beninca, T., Portal, K. A., Malheiros, P. S., Klug, T. V, Flores, S. H., & Rios, A. O. (2024). Postharvest Quality of Arugula (Eruca sativa) Microgreens Determined by Microbiological, Physico-Chemical, and Sensory Parameters. *Foods (Basel, Switzerland)*, *13*(19), 3020. https://doi.org/10.3390/foods13193020

Kong, Y., Masabni, J., & Niu, G. (2023). Effect of Temperature Variation and Blue and Red LEDs on the Elongation of Arugula and Mustard Microgreens. *Horticulturae*, *9*(5), 608. https://doi.org/10.3390/horticulturae9050608

Lu, S., Pentico, D., Castro, R., Dinh, S., Love, J. J., Larom, D. L., Pérez, R. L., & Liu, C. (2022). Effect of Ultraviolet Light Exposure and Compost Tea Supplementation on Growth, Antioxidant Activities, and Microbiome of Hydroponically Grown Mustard Greens. *ACS Agricultural Science & Technology*, *2*(3), 521–533. https://doi.org/10.1021/acsagscitech.1c00292

Lunt, P. H., Fuller, K., Fox, M., Goodhew, S., & Murphy, T. R. (2022). Comparing the thermal conductivity of three artificial soils under differing moisture and density conditions for use in green infrastructure. *Soil Use and Management*, *39*(1), 260–269. https://doi.org/10.1111/sum.12841

Manna, T., & Siddique, A. (2024). Impact of Humic Acid and Sulphur application on growth and yield of Indian Mustard under variable Water moisture regimes. *IOP Conference Series: Earth and Environmental Science*, *1327*(1), 012033. https://doi.org/10.1088/1755-1315/1327/1/012033

Marchioni, I., Martinelli, M., Ascrizzi, R., Gabbrielli, C., Flamini, G., Pistelli, L., & Pistelli, L. (2021). Small Functional Foods: Comparative Phytochemical and Nutritional Analyses of Five Microgreens of the Brassicaceae Family. *Foods (Basel, Switzerland)*, *10*(2), 427. https://doi.org/10.3390/foods10020427

Martínez-Ispizua, E., Calatayud, Á., Marsal, J. I., Cannata, C., Basile, F., Abdelkhalik, A., Soler, S., Valcárcel, J. V., & Martínez-Cuenca, M.-R. (2022). The Nutritional Quality Potential of Microgreens, Baby Leaves, and Adult Lettuce: An Underexploited Nutraceutical Source. *Foods*, *11*(3), 423. https://doi.org/10.3390/foods11030423

Matra, K., Saengha, W., Tanakaran, Y., Karirat, T., Buranrat, B., Deeseenthum, S., & Luang-In, V. (2021). Effect of Pre-soaking Mustard Green Seeds Prior to Cold Plasma Treatment on Bioactive Aspects of Microgreens. *Tropical Journal of Natural Product Research*, *5*(8), 1422–1426. https://doi.org/10.26538/tjnpr/v5i8.16

Misra, G., & Gibson, K. E. (2021). Characterization of Microgreen Growing Operations and Associated Food Safety Practices. *Food Protection Trends*, *41*(1), 56. https://doi.org/10.4315/1541-9576-41.1.56

Muthu, H. D., Izhar, T. N. T., Zakarya, I. A., Saad, F. N. M., & Ngaa, M. H. (2023). Comparative Study between Organic Liquid Fertilizer and Commercial Liquid Fertilizer and Their Growth Performances on Mustard Greens. *IOP Conference Series: Earth and Environmental Science*, *1135*(1), 012002. https://doi.org/10.1088/1755-1315/1135/1/012002

Ramadhani, M. F., Prihatiningrum, A. E., & Abror, M. (2023). Optimization of Mustard Pakcoy Growth: The Influence of Media Composition and Coconut Water Concentration. *IOP Conference Series: Earth and Environmental Science*, *1242*(1), 012004. https://doi.org/10.1088/1755-1315/1242/1/012004

Renna, M., Stellacci, A. M., Corbo, F., & Santamaria, P. (2020). The Use of a Nutrient Quality Score is Effective to Assess the Overall Nutritional Value of Three Brassica Microgreens. *Foods*, *9*(9), 1226. https://doi.org/10.3390/foods9091226

Rus, R. C., Salisu, M. A., Usaizan, N., Nashir, I. M., Yusuff, O., Sulaiman, Z., & Hammed, A. (2023). Influence of Composition of Soilless Substrates Monitored with Iot Sensor Nodes on the Growth, Nutrient and Fruit Quality of Rockmelons (Cucumis melo Var. Cantalupensis). *Indian Journal Of Agricultural Research*, *Of*. https://doi.org/10.18805/ijare.af-758

Santoso, A. B. (2022). Effect of Dosage and Time Interval of Application of Liquid Organic Fertilizer Gamal Leaves on Growth and Yield of Mustard Plants (Brassica Juncea L.). *AGARICUS: Advances Agriculture Science & Farming*, *1*(3), 127–130. https://doi.org/10.32764/agaricus.v1i3.2435

Sanyukta, Brar, D. S., Pant, K., Kaur, S., Nanda, V., Nayik, G. A., Ramniwas, S., Rasane, P., & Ercisli, S. (2023). Comprehensive Analysis of Physicochemical, Functional, Thermal, and Morphological Properties of Microgreens from Different Botanical Sources. *ACS Omega*, *8*(32), 29558–29567. https://doi.org/10.1021/acsomega.3c03429

Septirosya, T., Septiana, D., Oktari, R. D., Solfan, B., & Aryanti, E. (2024). Sulforaphane content enhancement of red cabbage microgreens by using different planting media and nutrition solution. *IOP Conference Series: Earth and Environmental Science*, *1302*(1), 012016. https://doi.org/10.1088/1755-1315/1302/1/012016

Seth, T., Mishra, G. P., Chattopadhyay, A., Deb Roy, P., Devi, M., Sahu, A., Sarangi, S. K., Mhatre, C. S., Lyngdoh, Y. A., Chandra, V., Dikshit, H. K., & Nair, R. M. (2025). Microgreens: Functional Food for Nutrition and Dietary Diversification. *Plants (Basel, Switzerland)*, *14*(4), 526. https://doi.org/10.3390/plants14040526

Shibaeva, T., Rubaeva, A., Sherudilo, E., & Titov, A. (2023). The effect of mineral nutrition on yield, nutritional value and consumer safety of radish microgreens under different photoperiods. *BIO Web of Conferences*, *67*, 02025. https://doi.org/10.1051/bioconf/20236702025

Sugiharti, I. E. P., Raksun, A., & Mertha, I. G. (2022). The effect of liquid organic fertilizer from tofu industrial waste and EM4 on the growth of mustard greens (Brasicajuncea L.). *Jurnal Pijar Mipa*, *17*(4), 554–559. https://doi.org/10.29303/jpm.v17i4.3412

Surendran, U., Sushanth, C. M., Joseph, E. J., Al-Ansari, N., & Yaseen, Z. M. (2019). FAO CROPWAT Model-Based Irrigation Requirements for Coconut to Improve Crop and Water Productivity in Kerala, India. *Sustainability*, *11*(18), 5132. https://doi.org/10.3390/su11185132

Teng, Z., Luo, Y., Sun, J., Li, Y., Pearlstein, D. J., Oehler, M. A., Fitzwater, J. D., Zhou, B., Chang, C. Y., Hassan, M. A., Chen, P., Wang, Q., & Fonseca, J. M. (2024). Effect of Far-Red Light on Biomass Accumulation, Plant Morphology, and Phytonutrient Composition of Ruby Streaks Mustard at Microgreen, Baby Leaf, and Flowering Stages. *Journal of Agricultural and Food Chemistry*, *72*(17), 9587–9598. https://doi.org/10.1021/acs.jafc.3c06834

Thepsilvisut, O., Sukree, N., Chutimanukul, P., Athinuwat, D., Chuaboon, W., Poomipan, P., Vachirayagorn, V., Pimpha, N., Chutimanukul, P., & Ehara, H. (2023). Efficacy of Agricultural and Food Wastes as the Growing Media for Sunflower and Water Spinach Microgreens Production. *Horticulturae*, *9*(8), 876. https://doi.org/10.3390/horticulturae9080876

Tilahun, S., Baek, M. W., An, K.-S., Choi, H. R., Lee, J. H., Tae, S. H., Park, D. S., Hong, J. S., & Jeong, C. S. (2024). Preharvest Methyl Jasmonate Treatment Affects the Mineral Profile, Metabolites, and Antioxidant Capacity of Radish Microgreens Produced without Substrate. *Foods (Basel, Switzerland)*, *13*(5), 789. https://doi.org/10.3390/foods13050789

Tunsagool, P., Pimpak, V., Promwat, P., Kwandee, P., Kruaweangmol, P., Roytrakul, S., & Withayagiat, U. (2023). Metabolomic profiling of health-benefit compounds in fresh and preserved mustard greens. *International Journal of Food Science & Technology*, *59*(6), 4290–4299. https://doi.org/10.1111/ijfs.16865

Wojdyło, A., Nowicka, P., Tkacz, K., & Turkiewicz, I. P. (2020). Sprouts vs. Microgreens as Novel Functional Foods: Variation of Nutritional and Phytochemical Profiles and Their In Vitro Bioactive Properties. *Molecules (Basel, Switzerland)*, *25*(20), 4648. https://doi.org/10.3390/molecules25204648