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Original Research Paper

Effect of growing medium on growth and quality of melon seedlings (*Cucumis melo*)

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Abstract: This study aims to evaluate the influence of various media on the growth and quality of melon seedlings. The research was carried out at the Teaching Farm, Agriculture Faculty, Hasanuddin University, from August to September 2023. The experimental methodology compared seven types of growth medium: including soil; rice husk biochar; compost; a mix of soil and rice husk biochar; a mix of soil and compost; a mix of compost and rice husk biochar; and a mix of soil, compost, and rice husk biochar. A randomized complete block design was employed for the allocation of treatments, comprising three replicates. The parameters measured in this study were plant height (cm), the number of leaves, leaf area (cm^2), shoot weight (leaf and stem) (g), stem diameter (above 1 cm from surface of medium) (mm), root length (cm), number of root tips, root volume (cm^3), root weight (g), shoot to root ratio, seedling fresh weight, seedling dry weight, and seedling quality index. The type of growing medium had a significant influence on the growth and quality of melon plant seeds. Soil+rice husk biochar medium had the best effect on seedling height (16.5 cm), root length (31.5 cm), and fresh shoot weight (9.50 g). Compost+rice husk biochar had the best effect on total leaf area (235.2 cm^2), root volume (8.17 cm^3), and fresh biomass (14.01 g). Compost had the best effect on fresh root weight (4.95 g), dry biomass (1.24 g), and seedling quality index (0.277). Rice husk biochar medium led to the lowest shoot to root ratio (1.59). The reported findings showed that compost medium can produce the best quality melon seeds compared to other growing media.

Keywords: compost, quality, rice husk biochar, soil.

1. Introduction

Many valuable vegetable crops, including those from the Asteraceae, Brassicaceae, Cucurbitaceae, and Solanaceae families, are now commonly planted in the field as seedlings (Bantis dan Koukounaras, 2023). Melon is popular especially as fresh fruit or as an ingredient in the food industry. Melon production in Indonesia reached 118,696 t in 2022 (Central Bureau Statistics of Indonesia, 2023). Overall, the area of melon production in the world reached 1,068,238 ha in 2020, with China, Turkey, India, Afghanistan, and Iran being the countries having the highest productions (FAOSTAT, 2022).

Melon seedlings are produced in nurseries and their quality will be an essential for plant performance in the field. The production of quality seedlings in the nursery depends on temperature, humidity, nutrition, and general environmental conditions (Ozturk and Serdar, 2011; Haase et al., 2021)

Growing medium plays an essential role in plant propagation and cultivation (Marjenah et al., 2016). Various types of growing medium can be used for seedlings, such as soil, compost biochar, or a combination of the three. Research conducted by Madhavi et al. (2021) found a positive effect of using compost as a growing medium on the growth and production of strawberries, whereas other authors reported that using biochar as a growing medium affected positively the growth of tomato, leek, impatiens, and geranium seedlings (Chysargyris et al., 2020).

The main objective of this study was to assess the effect of different growing media on the early growth of melon seedlings. Seedling quality is a crucial factor in determining successful transplanting and subsequent field performance. Since the seedlings are still in their early growth phase, vegetative parameters provide the best indicators of their vigor and overall quality. The findings can help farmers, nursery operators, and agribusinesses make informed decisions on choosing the best substrate for large-scale melon seedling production, ultimately improving yield and profitability.

2. Materials and Methods

2.1. Study area

This research was conducted at the Teaching Farm, Agriculture Faculty, Hasanuddin University. The seedlings were transplanted in a greenhouse with a 14% ultra violet plastic roof. The research started in August 2023. The average air temperature during the study was 34.27±4.72 °C and air humidity was 60.33±14.22%.

2.2. Experimental design

The experimental protocol was based on the comparison between seven growing medium: soil (K); rice husk biochar (A); compost (B); a mix of soil and rice husk biochar (1:1 volume ratio) (C); a mix of soil and compost (1:1 volume ratio) (D); a mix of compost and rice husk biochar (1:1 volume ratio) (E); and a mix of soil, compost, and rice husk biochar (1:1:1 volume ratio) (F). A randomized complete block design (RCBD) was used for the treatment distribution with three replicates including three seedlinds each (a total of 63 seedlings).

Seedlings were grown in plastic pots (height = 10 cm, bottom diameter = 9 cm, and top diameter = 12 cm). Each pot was filled with same volumes of medium of the specific treatment. The medium properties are reported in Table 1. Melon seeds of the 'Golden Langkawi F1' variety were planted in each pot. Watering was carried out twice a day (morning and evening). Each pot was watered with the same volume of water (520 mL per pot). Watering was done by pouring directly onthe medium surface using a measuring cup. No fertilizer was applied. Seeds were cared for up to 21 days after sowing (DAS) until they grew into seedlings.

Table 1. Chemical properties of growing media.

Medium properties	Growing medium		
	Soil	Rice Husk Biochar	Compost
pH	6.58	7.22	6.95
C (%)	3.52	28.82	12.31
N (%)	0.28	1.15	0.55
C/N	13	25	22
P_2O_5 (ppm)	12.28	2.25	0.15
K (cmol kg^{-1})	0.28	1.95	1.14
CEC (cmol kg^{-1})	19.65	30.57	30.15

2.4. Data collection

The parameters measured in this study were plant height (cm), the number of leaves, leaf area (cm^2), shoot weight (leaf and stem) (g), stem diameter (above 1 cm from surface of medium) (mm), root length (cm), number of root tips, root volume (cm^3), root weight (g), shoot to root ratio, seedling fresh weight, seedling dry weight, and seedling quality index. Parameter measurements were carried out 21 DAS. Plant height and root length were measured with a ruler, stem diameter was measured with a caliper, leaf area was measured by analyzing leaf images with ImageJ software. Root volume was measured with the water displacement method. Root weight and seedling fresh and dry weights were measured with a digital scale. Dry weight was measured after the seedlings were dried in an oven at 120 °C until constant weight. Seedling quality index was determined using the Dickson Quality Index (Dickson et al., 1960) according to the following equation:

$$DQI = \frac{SDW}{\frac{PH}{SD} + \frac{SDW}{RDW}} \qquad \text{(eq. 1)}$$

Where SDW is the seedling dry weight, PH is the plant height, SD is the stem diameter, SDW is the shoot dry weight, and RDW is the root dry weight.

2.5. Data statistical processing

Data were analyzed with RStudio 4.2.1 version. A one-way analysis of variance (ANOVA) was used to assess the significance of the effect of the growing media on the measured parameters ($p \leq 0.05$). The Tukey's multiple range test was used as a post hoc test for mean separation. Pearson correlation analysis was used to further understand the relationships among the measured growth and quality parameters of melon seedlings.

3. Results

The analysis of variance showed that the growing medium significantly affected seedling height and total leaf area (Figures 1A and 1C). Conversily, the number of leaves and stem diameter parameters were not affected by the type of growing medium (Figures 1B and 1D). The highest average plant height of melon seedlings was recorded in S+RHB (16.5 cm), while the lowest was in RHB (11.2 cm) (Figure 1A). The highest total leaf area of melon seedlings was recorded in the C+RHB (235.2 cm^2), while the smallest was in the S medium (163.0 cm^2)

The growing medium significantly influenced both root length and volume (Figure 2A and 2B). S+RHB melon seedlings had the highest root length (31.5 cm), whereas the lowest was recorded in C (26.1 cm). Moreover, the largest root volume was recorded in C+RHB plants (8.17 cm^3), whereas the smallest was recorded in S and S+RHB plants (5.50 cm^3).

The growing medium significantly affected shoot and root fresh weight (Figures 3A and 3B), whereas no significant effect of the treaments was found in shoot and root dry weight.
S+RHB seedlings had the highest fresh shoot weight (9.80 g), wheras the lowest was recorded in RHB plants (7.32 g). In terms of fresh root weight seedlings on the C medium recorded the highest root fresh weight (4.84 g), whereas the lowest was found in S+C seedlings (2.88 g).

The growing medium significantly influenceed fresh and dry biomass, shoot to root ratio, and seedling quality index (Table 2).

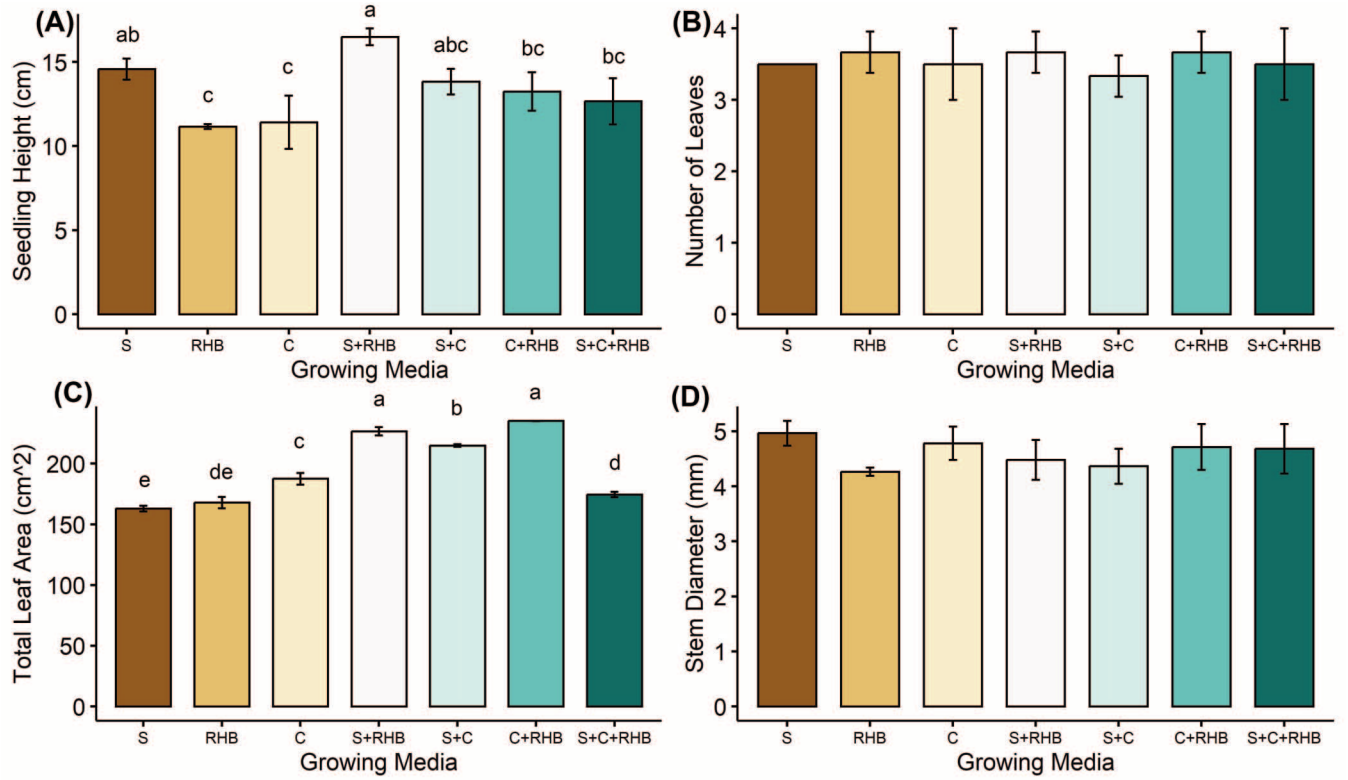

Figure 1. Seedling height, number of leaves, total leaf area, and stem diameter of melon seedling. Note: Means with the same letters are not significantly different ($p \leq 0.05$) according to Tukey's multiple range test.

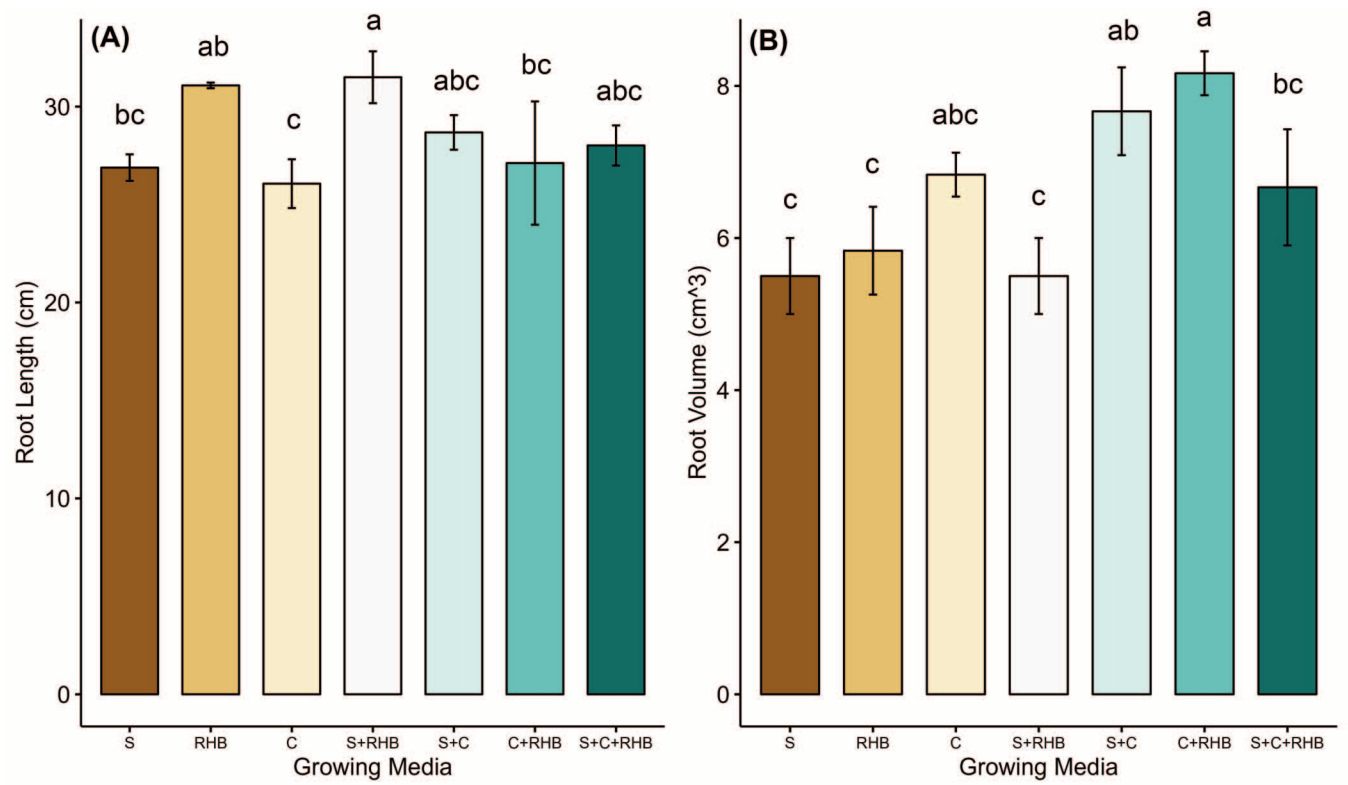

Figure 2. Root length and volume of melon seedling. Note: Values with the same letters are not significantly different at $p \leq 0.05$, according to Tukey's multiple range test.

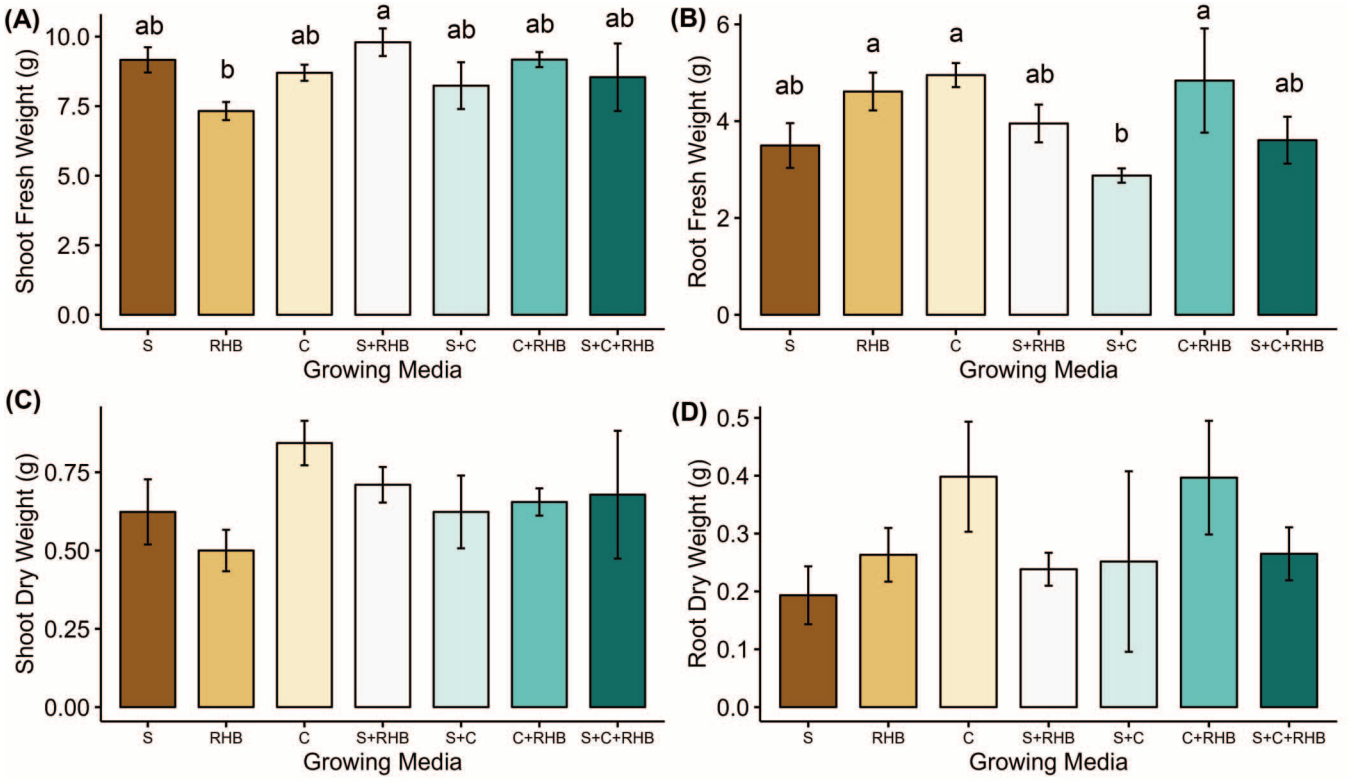

Figure 3. Shoot fresh weight, root fresh weight, shoot dry weight, and root dry weight of melon seedlings. Note: Values with the same letters are not significantly different at $p \leq 0.05$, according to Tukey's multiple range test.

Table 2. Contrast effect of several growing medium on fresh biomass, dry biomass, shoot to root ratio and seedling quality index of melon seedlings.

Growing medium	FB (g)	DB (g)	STRR	SQI
K *vs.* ABCDEF	Ns	*	*	*
ABC *vs.* DEF	Ns	Ns	**	Ns
AB *vs.* C	Ns	Ns	**	**
A *vs.* B	Ns	Ns	Ns	Ns
DE *vs.* F	Ns	**	Ns	**
D *vs.* E	**	Ns	**	*

Note: (*) significant at P<0.05, (**) significant at p<0.01, (Ns) non-significant. Soil (K), rice husk biochar (A), compost (B), soil + rice husk biochar (C), soil + compost (D), compost + rice husk biochar (E), and soil + compost + rice husk biochar (F). Fresh biomass (FB), dry biomass (DB), shoot to root ratio (STRR) and seedling quality index (SQI).

C+RHB seedlings had the highest fresh biomass (14.0 g), whereas the lowest was measured in S+C plants (11.1 g). Seedlings on the C medium recorded the highest dry biomass and seed quality index (1.24 g and 0.277, respectively). Moreover, the shoot-to-root ratio parameter was highest in S+C seedlings (2.86) and lowest in RHB plants (1.59) (Figure 4).

The correlation between the measured parameters is reported in Figure 5. The parameters that had a positive correlation and significant with the seedling quality index were: root dry weight (0.96), root fresh weight (0.77), and dry biomass (0.87).

The performance of melon seedlings on various types of growing medium can be seen in Figure 6.

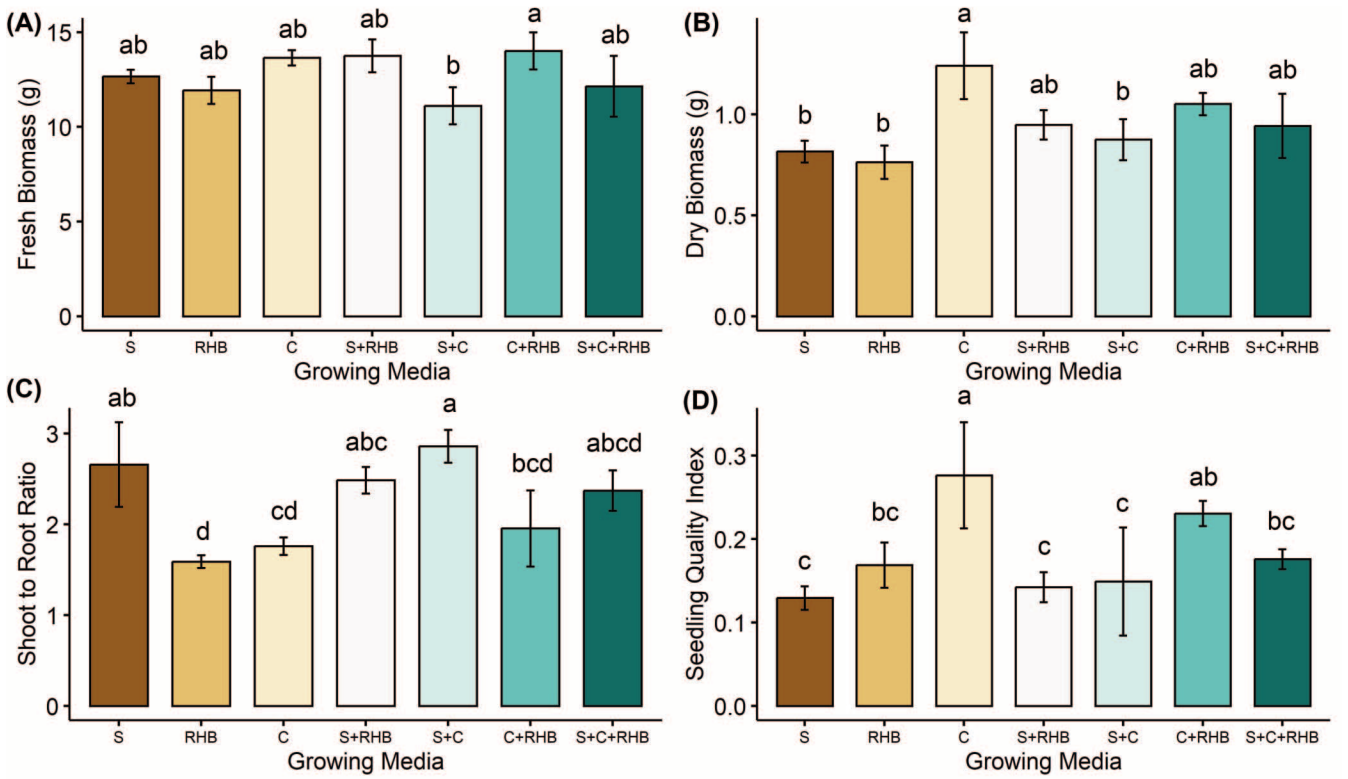

Figure 4. Fresh biomass, dry biomass, shoot to root ratio and seedling quality index of melon seedlings. Note: Values with the same letters are not significantly different at $p \leq 0.05$, according to Tukey's multiple range test.

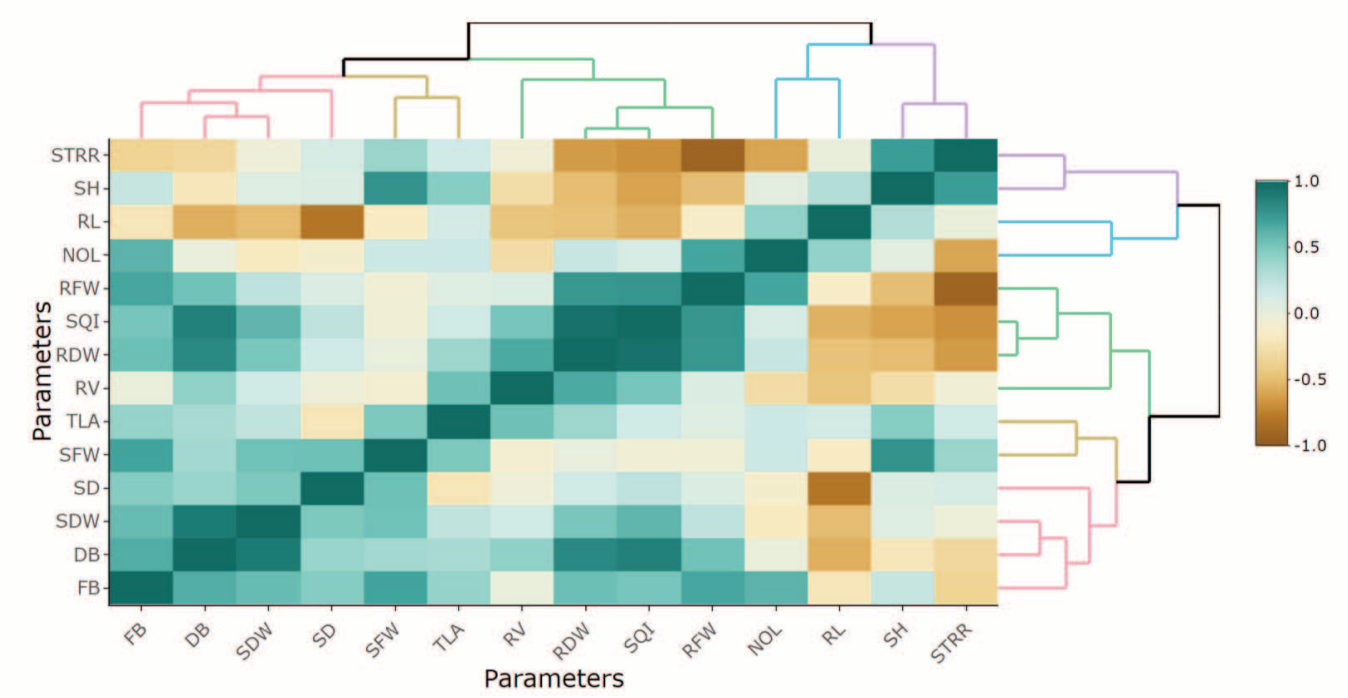

Figure 5. Heatmap correlation among parameters. Seedling height (SH), number of leaves (NOL), total leaf area (TLA), stem diameter (SD), root length (RL), root volume (RV), shoot fresh weight (SFW), root fresh weight (RFW), shoot dry weight (SDW), and root dry weight (RDW), fresh biomass (FB), dry biomass (DB), shoot to root ratio (STRR) and seedling quality index (SQI).

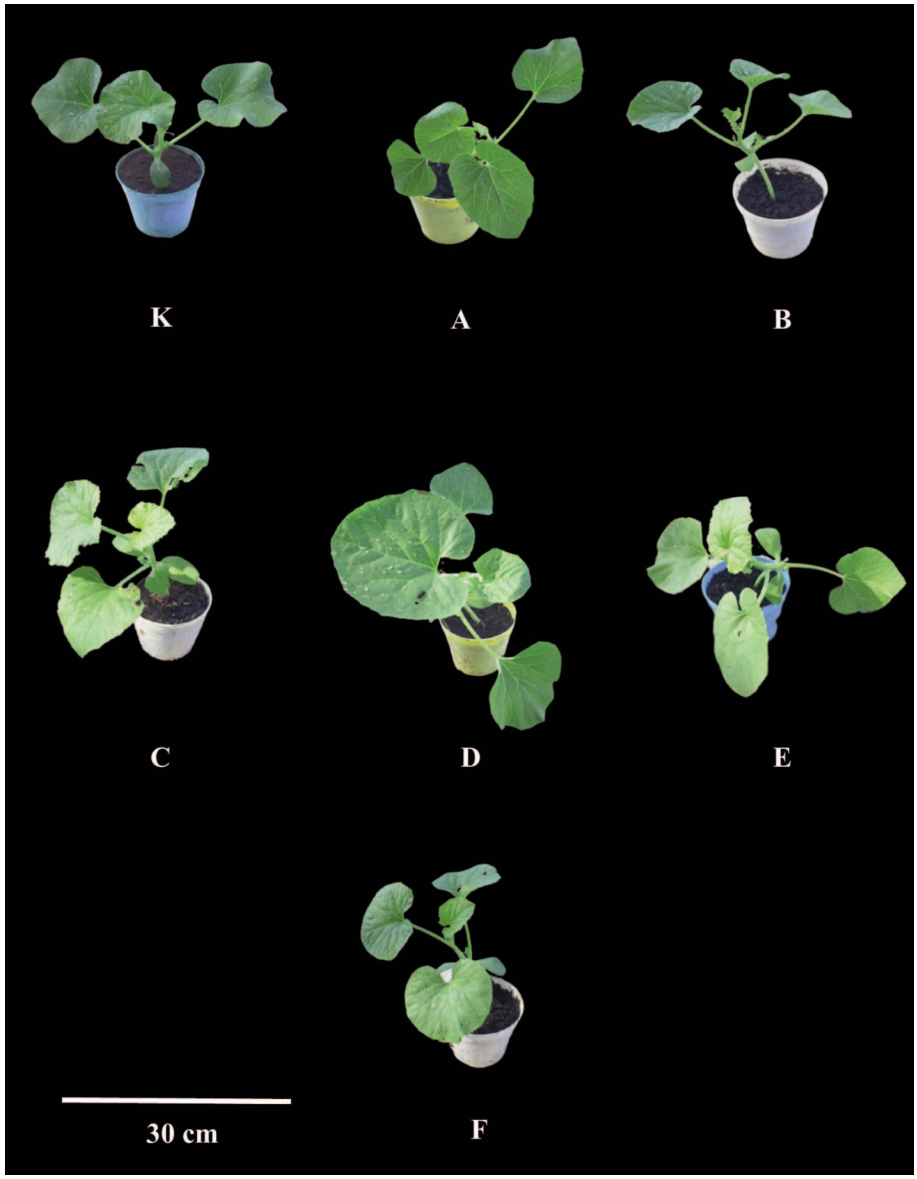

Figure 6. Melon seedlings grown on several growing media. Soil (**K**), rice husk biochar (**A**), compost (**B**), soil + rice husk biochar (**C**), soil + compost (**D**), compost + rice husk biochar (**E**), and soil + compost + rice husk biochar (**F**).

4. Discussion

The type of growing medium had a significant impact on seedling height and total leaf area. Melon seeds grown in S+RHB medium produce seedlings with the highest height and this suggests that the combination of these two growing media is beneficial to plant growth. Soil is the most used medium in plant nurseries, But the addition of rice husk biochar can improve its physical, chemical, and biological properties. Biochar is well known for its potential as a growing medium, since it contains various nutrients such as N, K, Fe, Mn, and Zn, has a high CEC, and has a high nutrient holding capacity (Nemati et al., 2014). The addition of biochar to the growing medium can boost the nutritional content of plant seeds while also increasing the amount of nutrients available (Chysargyris et al., 2020). The performance of the Borneo sour eggplant seedlings in terms of height, stem diameter, number of leaves and leaf length were improved by soil and compost medium (Sabri dan Bakar, 2021). However, Umar et al. (2021) found that soil medium was sufficient to support the growth of citrus plants, inducing the highest shoot length compared to other media. *Solanum marcocarpon* L. grown in topsoil showed the highest

leaf area, plant height, stem diameter, and leaf number compared to other types of medium (Ogunrotimi dan Kayode, 2018). Ossom and kunene (2010) found that topsoil had a high concentration of Ca, Mg and P.

When compared to S medium, C+RHB significantly increasd seedling total leaf area. The two medium mixtures contributed to an increase in leaf area. Compost is a type of medium that contains enough nutrients to support plant growth. Compost and rice husk biochar together contribute to providing enough nutrients to plants. Theeba et al. (2016) reported that compost made from poultry manure combined with rice husk biochar increased nutrients availability to plants by slowing down the degradation of the manure.

The melon seedlings with the longest roots were recorded on S+RHB medium, while the seedlings with the largest root volume were recorded on C+ RHB. The addition of rice husk biochar to soil directly improves the physical properties of the growing medium. Rice husk biochar can increase the porosity of the growing medium. Riniarti et al. (2019) found that the addition of biochar to the growing medium can increase root length, volume, and biomass of *Falcataria moluccana* seedlings. Because of the numerous numbers of micro- and meso-pores, rice husk biochar has a high-water holding capacity (Karam et al., 2022). These mesopores are also important for the movement of soil solution (Abukari, 2019). Rice husk biochar additionally supports crop growth, disease resistance, abiotic stress reduction, and photosynthesis. Soil fertility is also improved via lowering soil compaction and increasing aeration (Kumar et al., 2013, Yoo et al., 2014, Dong et al., 2014, Badar and Qureshi, 2014).

The seedlings grown on S+RHB had the highest fresh shoot weight. Biochar application is an appealing approach to improve plant growth during early developmental stages and to provide better crop stands and essential long-term high yields. Furthermore, biochar was reported to increase chlorophyll (a and b) and relative water content in maize seedlings (Ali et al., 2021). In our study, tthe heaviest root system was recorded in seedlings grown on the compost medium. Compost can increase crop yields by acting as a biofertilizer, but it can also increase product quality by increasing total phenolic content and antioxidant capacity. (Giménez et al., 2020). Moreover, seedlings grown on guar or jantar compost medium had higher tissue nutrient concentrations compared to other media (Mustafa et al., 2016).

Fresh and dry biomass of melon seedlings were influenced by different types of growing medium. The C+RHB medium induced the highest fresh biomass, while the highest dry biomass was recorded in the C seedlings. Several studies also found similar results using biochar and compost as a growing media. The chemical properties of polybag medium (pH, total C and N, C:N ratio, CEC, Mg, and Ca) were improved by biochar, compost, and biochar-compost amendments, and this resulted in an increased root and shoot growth, and the root to shoot ratio of palm oil seedlings (Radin et al., 2018). Compost-based growing medium can provide essential nutrients, especially nitrogen, imprving the nutritional status of *Pinus occidentalis* (Hubbel et al., 2018). When compost was used as a growing medium in peppers, it increased seedling biomass production (Bustamante et al., 2021).

The highest shoot to root ratio was recorded in seedlings grown on the soil medium, while the smallest was recorded in RHB plants. The mass-based ratio more accurately reflects the disparity in investment in shoot and root growth (Mašková et al., 2021). An increased root-to-shoot ratio was identified as a key variable in reducing transplant shock of muskmelon transplants in a wide range of environments (Franco and Leskovar, 2002). For optimal survival and growth, seedlings must have balanced root systems and shoots (Haase, 2008). For arid conditions, seedlings with larger root systems, and high R:S ratio may be preferable (Shalizi et al., 2019).

Seedlings grown on the compost medium had the highest quality index value compared to other growing media. The quality value of plant seeds can reflect the growth and development of plants in the field, especially for plants that require to be transplanted. The Dickson quality index assesses young plant quality objectively by incorporating morphological parameters that influence seedling and root perceived quality (Lin et al., 2019).

The differences in soil properties among the three-growing media soil, rice husk biochar, and compost can significantly influence melon seedling growth. Soil had a balanced pH and the highest phosphorus content (12.28 ppm), which is essential for root development. However, its low organic carbon (3.52%) and nitrogen (0.28%) may limit early seedling growth, as these nutrients are critical for shoot and root growth. Additionally, soil had the lowest potassium (0.28 cmol/kg) and cation exchange capacity (CEC) (19.65 cmol/kg), meaning that it may retain fewer nutrients compared to biochar and compost. While soil can serve as a base medium, its nutrient limitations suggest the need for organic amendments to enhance seedling vigor.

Rice husk biochar and compost provided significantly higher organic carbon, nitrogen, and potassium, making them more suitable for promoting early vegetative growth. Rice husk biochar had the highest organic carbon (28.82%), nitrogen (1.15%), and potassium (1.95 cmol/kg), improving soil aeration, microbial activity, and nutrient retention. However, its low phosphorus content (2.25 ppm) may require supplementation to support strong root development. Compost offered a more balanced nutrient profile, with moderate nitrogen (0.55%) and potassium (1.14 cmol/kg), along with a high CEC (30.15 cmol/kg), which enhanced nutrient retention and availability. However, its phosphorus content (0.15 ppm) was extremely low, which could limit root establishment. Another critical factor contributing to compost's superior seedling quality is its high capacity of cation exchange (CEC) (30.15 cmol/kg). A higher CEC enhances the retention of essential nutrients such as potassium, calcium, and magnesium (Yang et al., 2024), ensuring that seedlings receive a continuous supply of nutrients throughout their early growth stages. Moreover, compost enhances soil structure and aeration, reducing the risk of waterlogging while maintaining adequate moisture for root expansion (Mwonwuba et al., 2024). Although compost has low phosphorus content (0.15 ppm), its organic matter content may enhance phosphorus solubilization over time, leading to better nutrient uptake (Goldan et al., 2023).

Lin et al. (2019) reported a strong correlation between the seed quality index *of Pentas lanceolata* and overall plant biomass. Furthermore, the authors reported that total seedling dry weight was highly correlated with the Dickson Quality Index (DQI). These results underscore the value of seed quality as a predictor of subsequent biomass accumulation.

5. Conclusions

Compared to other media, the compost medium was the best when considering seedling quality parameters. However, both single and mixed media provided better effects for some parameters. Nonetheless, balanced growth between the shoots and roots remains an important factor in measuring seedling quality. Our study demonstrates that substrate composition significantly impacts seedling morphology during the vegetative phase, highlighting the need for careful substrate selection to optimize early growth performance in melons, but compost medium can produce the best quality melon seedlings, compared to another growing medium.

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Conflicts of Interest: The authors declare no conflict of interest.

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