



Cocopeat Perlite Mixture as an Alternative for Rooted Cuttings Growth Medium of *Impatiens hawkeri x platypetala* in Indonesia

Herni Shintiavira^{1*}, Minangsari Dewanti¹, Fitri Rachmawati¹, Yati Nurlaeni², Dani Nurdina¹, Sadli¹, Safani Ariyantika¹ and Suskandari Kartikaningrum¹

¹Research Center for Horticulture and Estate Crops, Research Organization for Agriculture and Food, National Research and Innovation Agency (BRIN), Bogor, Indonesia; ²Research Center for Plant Conservation, Botanical Garden and Forestry, National Research and Innovation Agency (BRIN), Bogor, Indonesia

*Corresponding author: virgro@yahoo.co.id

Abstract

Impatiens hawkeri x platypetala rooted cuttings are typically cultivated using rice husks as a substrate. However, due to the poor water-holding capacity of this medium, *Impatiens* grows slowly in this environment. A viable alternative is the cocopeat perlite mixture which has a better water-holding capacity compared to the rice husk. Currently, there is no sufficient information available regarding the best growth medium to improve the quality of *I. hawkeri x platypetala* rooted cuttings in Indonesia. Therefore, this study aimed to obtain the best medium for quality rooted cuttings *I. hawkeri x platypetala*. The method employed was a randomized complete block design with two factors. The first factor was the *Impatiens* varieties consisting of Impala Agrihorti, Imadata Agrihorti, and Lavender, while the second was the growth medium, comprised of four levels namely rice husk (control), as well as a mixture of cocopeat with 3%, 5% and 8% perlite. The result showed that there was no interaction between varieties and growth medium. The mixture of 3% perlite in cocopeat exhibited better outcomes compared to other treatments. This medium increased the number and length of roots, stem diameter, plant height, leaves thickness, leaves number and survival rate. Therefore, the addition of 3% perlite in cocopeat could replace the rice husk as a rooted cutting growth medium for *I. hawkeri x platypetala*.

Keywords: assimilate partitioning; morphology; soilless culture; survival rate; water-holding capacity

Cite this as: Shintiavira, H., Dewanti, M., Rachmawati, F., Nurlaeni, Y., Nurdina, D., Sadli, Ariyantika, S., & Kartikaningrum, S. (2023). Cocopeat Perlite Mixture as an Alternative for Rooted Cuttings Growth Medium of *Impatiens hawkeri x platypetala* in Indonesia. *Caraka Tani: Journal of Sustainable Agriculture*, 38(2), 359-370. doi: <http://dx.doi.org/10.20961/carakatani.v38i2.73876>

INTRODUCTION

Impatiens, an ornamental plant with a high economic potential, is well known for absorbing air and soil pollution (W. Liu et al., 2021; Y. Liu et al., 2021), as well as its medicinal and ornamental values (Luo et al., 2021). The preferred cultivar is *Impatiens hawkeri* which has bright, fluorescent and single-colored blossoms, as well as deep dark and single-colored foliage. Indonesia has produced several varieties

of *Impatiens*, including the crossing between *I. hawkeri x I. platypetala*, known for their heat-tolerant genotype (Soehendi et al., 2022). Different drought-tolerant varieties have been released including *Impatiens* 'Impala Agrihorti' and 'Imadata Agrihorti'. Both varieties have the potential to be used as landscape plant in lowlands and highlands. Currently, the development and use of *Impatiens* as an ornamental plant, specifically for landscape has a relatively high opportunity with the development of (1) agro-

* Received for publication May 18, 2023

Accepted after corrections August 9, 2023

tourism, (2) entertainment venues or tourist sites and (3) city parks. To satisfy consumer expectations, high-quality rooted cuttings must be made accessible for optimal plant growth and yield quality. The growth medium, nutrients, tray size, plant age and the timing of transplantation influence the quality of rooted cuttings (Di Benedetto and Pagani, 2012).

Soilless cultures can improve crop output sustainability as well as the efficient use of water and nutrients (Suarez-Caceres et al., 2021). These systems are sustainable agriculture methods for boosting plant productivity and conserving resources (Mourouzidou et al., 2023). Both organic and inorganic substrates including perlite, vermiculite, gravel and rockwool, have great potential to be used as growth medium. Some examples of organic substrates include cocopeat, peat moss and sawdust, among others. Both substrates are intriguing due to their availability and recyclable nature (Masquelier et al., 2022). These substrates serve as a means of transferring microorganisms into the growth medium (Bamdad et al., 2022) and are environmentally friendly (A'saf et al., 2020).

Impatiens 'Impala Agrihorti' and 'Imadata Agrihorti' rooted cuttings have been successfully propagated using rice husk as the growth medium. Rice husks exhibit high total pore spaces, which can contribute to increased root system growth (Permanasari and Susila, 2018). However, *Impatiens* plant requires high humidity during the rooting process, and the use of rice husks results in hampered growth. To enhance the quality of rooted cuttings, particularly in *I. hawkeri x platypetala* variety, alternative growth mediums are needed. Sphagnum peat moss, perlite and vermiculite are growth mediums frequently used in the development of *Impatiens* rooted cuttings (Lojo et al., 2019), as well as cocopeat, perlite and peat mixed medium (2:2:1) for *Impatiens walleriana* (Ghanbari et al., 2019). However, there is limited available information regarding these mediums in Indonesia.

The different growth medium offers quality plant production due to their good water-holding capacity, aeration and nutrient status (Singh et al., 2023), although their effectiveness can be influenced by genotype, environment and production management (Francini and Sebastiani, 2019). In Indonesia and other tropical regions, the cocopeat medium stands out as a widely accessible option (Ayu et al., 2021). It has several advantages including structural and water

retention properties, biodegradable in nature, as well as rich in carbon and other nutrients (Bharti et al., 2021). However, its high water-holding capacity can impede water and air exchange, resulting in low aeration and oxygen diffusion for the roots (Awang et al., 2009). This is because cocopeat reduces soil pore size, leading to a drop in total porosity, which lowers oxygen levels and prevents respiration thereby altering the anatomy and morphology of plant (Lojo et al., 2019). To address this, perlite can be added to improve plant growth and viability of the medium (Kazemi et al., 2020). Perlite enhances the physical characteristics of the medium by increasing the total porosity (Ilahi and Ahmad, 2017). Cocopeat and perlite have been identified as appropriate growth medium for certain greenhouse cultures (Ghehsareh et al., 2012). The incorporation of perlite into cocopeat can increase aeration and water retention (Banitalebi et al., 2021). Lojo et al. (2021) employed a perlite mixture of about 20% in a medium for *I. walleriana*. A commercial nursery in Indonesia also used a mixture of cocopeat and 5% perlite as a growth medium for rooted cuttings of several ornamental plant. Therefore, this study aimed to investigate the effects of various rooting medium, including rice husk as a control and a mixture of cocopeat with perlite in varying concentration ranges, on three *I. hawkeri x platypetala* cultivars, namely 'Impala Agrihorti', 'Imadata Agrihorti' and 'Lavender'. The results will provide information on the best growth medium to improve the quality of *Impatiens* rooted cutting varieties.

MATERIALS AND METHOD

Plant material preparation

This study was conducted from September to October 2022 at Bina Usaha Flora Company's greenhouse in West Java, Indonesia, located at 6°43'45"S, 107°4'31"E and 836 m above sea level. Cuttings from the mother plant of *Impatiens*, namely 'Impala Agrihorti', 'Imadata Agrihorti' and 'Lavender' were used as the planting material. The shoot cuttings were measured at the same height of 3 to 4 cm, and root-stimulating agents were applied 5 minutes before planting. Furthermore, rice husk, as well as cocopeat + 3%, 5% and 8% perlite were used as the medium on which the cuttings of the shoots were planted. The cuttings were planted on trays with 200 planting holes in a greenhouse exposed to 60% shade, and irrigate was carried out daily.

Measurement of environment and growth medium properties

Light intensity was measured above the plant canopy using a lux meter, while air temperature and humidity were recorded with a thermohygrometer. The measurements were carried out in the morning (09.00 a.m.), afternoon (12.00 p.m.) and evening (03.00 p.m.) (Shintiavira et al., 2023). Before planting, the pH values for the growth medium were determined by combining 10 g medium with 50 ml water, agitating for 30 minutes and leaving it standing for 24 hours. The electrical conductivity (EC) values were obtained by mixing 40 g medium with 80 ml water, agitating for 15 minutes and leaving for 60 minutes. The mixture was filtered using an EC meter (Hanna H1981–51) before conducting the measurements. The soil moisturizer and temperatures were assessed by a moisturizer meter and a thermometer. The pH and EC values were calculated based on a previous study by Awang et al. (2009).

Study design

A randomized complete block design (RCBD) with two factors was employed in the investigation. The first factor was the *Impatiens* varieties, consisting of 1) Impala Agrihorti, 2) Imadata Agrihorti and 3) Lavender. Meanwhile, the second factor was the growth medium for rooted cuttings, which consisted of 4 levels, namely rice husk (control), cocopeat + 3% perlite, cocopeat + 5% perlite, and cocopeat + 8% perlite. Each of the treatments was replicated three times.

Morphology

The following morphological observations were made: 1) the number of primary root branches, 2) the root length, which referred to the distance between the base of the stem and the tip of the longest root, 3) the stem diameter, measured beneath the node from which the last petiole grew, 4) the plant height, considered as the distance between the apical shoot tip to the base of the stem, 5) the leaves thickness, measured using micrometers three leaves from the top (Huang et al., 2022), 6) survival rate,

calculated as the number of growth plant divided by the total number of plant x 100% (Wang et al., 2018). The morphological characteristics were assessed at 14, 21 and 28 days after planting (DAP).

Assimilate partitioning

The organs of the plant, such as leaves, stems and roots, were harvested separately and oven-dried for 96 hours at 80 °C (Lojo et al., 2017). The dried organs were then weighed to determine their total dry weight, root mass ratio (root dry weight divided by the total dry weight), stem mass ratio (stem dry weight divided by the total dry weight) and leaves mass ratio (leaves dry weight divided by the total dry weight). These parameters were measured 28 DAP.

Data analysis

The data were analyzed using analysis of variance (ANOVA) to determine the effect of all treatments. This was followed by the Duncan Multiple Range Test (DMRT) with a of 5%. All data analysis was conducted using the SAS 9.4 program.

RESULTS AND DISCUSSION

Environment

Environmental observations during the rooted cutting plant growth showed that the average temperature, relative humidity, and light intensity were 26.38 °C, 81.17% and 7388 Lux respectively as shown in Table 1. According to a previous study, the *Impatiens* juvenile requires temperatures in the range of 21.50 to 26.50 °C (Shintiavira et al., 2023). This indicates that the *Impatiens* were provided with optimal conditions in this study for their growth and development.

The cocopeat + 3%, 5% and 8% perlite as well as rice husk had pH values of 5.3, 5.3, 5.8 and 6.5 (Table 2), while the EC values were 2.25, 2.06, 1.08 and 0.81 $\mu\text{S cm}^{-1}$, respectively. This showed that the higher the perlite concentration, the lower the EC value, as also discovered by Alavi et al. (2020). According to Awang et al. (2009), the initial pH and EC of the growth medium had a direct impact on nutrient

Table 1. Temperature, relative humidity and light intensity during the growth of *Impatiens* cuttings

Variables	Time			Average
	09.00 a.m.	12.00 p.m.	03.00 p.m.	
Temperature (°C)	26.16	28.17	24.83	26.38
Relative humidity (%)	88.50	69.17	85.83	81.17
Light intensity (Lux)	4500	13000	4666	7388

availability. The cocopeat + 3%, 5% and 8% perlite as well as rice husk had soil moisturizer values of 19.9% to 90%; 17.8% to 80.0%; 15.50% to 80.0% and 10.2% to 50.00%, while the temperature was 22.3, 22.3, 22.5 and 23.5 °C, respectively. As proven by Dede et al. (2006), the acceptable range for EC and pH of *Impatiens* growth medium was 0.75 to 3.49 $\mu\text{S cm}^{-1}$ and 5.2 to 6.5, respectively. Alam et al. (2020) also stated that the water-retaining capacity of the growth medium was affected by the moisture content. Additionally, Sarkar et al. (2021) reported that cocopeat had a higher moisture content, with better pH and EC compared to the rice husk as a growth medium for lettuce.

Morphology

The good quality of *Impatiens* rooted cutting is determined by the strong stem, branch and root (Lopez and Runkle, 2008). These properties are influenced by genotype, environment and production management (Francini and Sebastiani, 2019). Genetically, different characters were found in each variety. Some genotypes produced different root systems in varying growth mediums, influencing plant growth and development (Kazemi et al., 2020).

Number of roots

There was no interaction observed between varieties and rooted cutting medium in relation to the number of roots (Table 3). *Impatiens*

'Lavender' had the highest number of roots compared to other varieties, from 14 to 28 DAP. The cocopeat mixture with 3% to 8% perlite exhibited a significant increase in the number of roots compared to the rice husk. As the bulk densities of the medium increased, the pore spaces for air were reduced, leading to higher retention of moisture content, greater EC and low oxygen for root growth (Kumarasinghe et al., 2015; Patil et al., 2020). According to Adekiya et al. (2022), cocopeat has a higher porosity than the rice husk, thereby facilitating enhanced root penetration for nutrient absorption and stimulating the growth of more roots.

Root length

There was no interaction between varieties and rooted cutting medium in terms of root length as shown in Table 4. *Impatiens* 'Lavender' had the highest root length compared to the other varieties, from 14 to 28 DAP. The cocopeat mixture containing 3% to 8% perlite increased the number of roots compared to the rice husk, and the most significant growth was observed in the 3% perlite treatment. This medium showed the capacity to effectively anchor the root system, thereby facilitating the absorption of water and nutrients, resulting in the formation of longer roots due to the activity of the lateral meristem (Li et al., 2018). The increase in root width caused by the lateral spread influenced the dry weight (Djaingsastro et al., 2021). The application of

Table 2. EC, pH, soil moisturizer and soil temperature of rooted cutting mediums

Treatments	EC ($\mu\text{S cm}^{-1}$)	pH	Soil moisturizer (%)	Soil temperature (°C)
Cocopeat + 3% perlite	2.25	5.3	19.9-90.0	22.3
Cocopeat + 5% perlite	2.06	5.3	17.8-80.0	22.3
Cocopeat + 8% perlite	1.08	5.8	15.5-80.0	22.5
Rice husk (control)	0.81	6.5	10.2-50.0	23.5

Table 3. Number of roots for *Impatiens* cuttings in various growth mediums

Treatments	Days after planting		
	14	21	28
Varieties			
Impala Agrihorti	9.43 ^a	13.75 ^b	15.61 ^b
Imadata Agrihorti	9.53 ^a	11.91 ^b	19.01 ^a
Lavender	12.81 ^a	18.11 ^a	21.83 ^a
Rooted cuttings medium			
Cocopeat + 3% perlite	11.55 ^a	15.70 ^a	18.33 ^{ab}
Cocopeat + 5% perlite	11.77 ^a	16.07 ^a	20.33 ^a
Cocopeat + 8% perlite	11.81 ^a	15.26 ^a	20.81 ^a
Rice husk (control)	9.60 ^b	11.33 ^b	15.78 ^b
CV (%)	18.38	18.61	18.06

Notes: Numbers followed by the same letter in the same column show no significant difference based on the DMRT with an $\alpha = 0.05$. CV = coefficient variation

cocopeat as a growth medium increased vegetative growth in a young persimmon orchard by improving the water and nutrient status of plants (Parra et al., 2022).

Stem diameter

There was no interaction between varieties and rooted cutting medium in terms of stem diameter as shown in Table 5. *Impatiens* 'Imadata Agrihorti' had the largest diameter compared to other varieties at 28 DAP. The cocopeat mixture containing 3% to 8% perlite significantly increased the stem diameter more than the rice husk. The enhanced stem diameter can be attributed to the support provided by root elongation, which contributed to overall shoot growth and stability (Tracy et al., 2013). Under optimal soil water supply, high stem hydraulic conductivity allows quick water transport from stems into leaves to compensate for transpiration water loss and consequently maintain high daily water potential (Zhang and Cao, 2009).

Number of leaves

There was no interaction between varieties and rooted cutting medium in relation to leaves number as shown in Table 6. All *Impatiens* varieties had nearly the same values and there was no significant difference in the number of leaves at 14 and 28 DAP. The 3% to 8% perlite in cocopeat significantly increased the number of leaves from 14 to 28 DAP, and the most significant result was produced by the 3% perlite treatment. According to Adekiya et al. (2022), cocopeat mediums have higher water retention, contributing to a rise in the number of leaves in tomatoes. The higher number and length of the root improved nutrient uptake and increased stem hydraulic conductivity, facilitating both leaves growth and mesophyll cell expansion (Zhang and Cao, 2009). Djaingsastro et al. (2021) reported that the cocopeat might assist the planting medium in holding the water content for the optimal photosynthetic process

Table 4. Root length of *Impatiens* cuttings in various growth mediums (cm)

Treatments	Days after planting		
	14	21	28
Varieties			
Impala Agrihorti	4.06 ^b	5.96 ^a	5.86 ^b
Imadata Agrihorti	3.76 ^b	4.95 ^b	5.31 ^b
Lavender	4.62 ^a	6.70 ^a	6.83 ^a
Rooted cuttings medium			
Cocopeat + 3% perlite	4.41 ^a	6.18 ^a	6.42 ^a
Cocopeat + 5% perlite	4.49 ^a	6.10 ^a	6.17 ^{ab}
Cocopeat + 8% perlite	4.29 ^a	6.09 ^a	6.17 ^{ab}
Rice husk (control)	3.16 ^b	5.11 ^a	5.25 ^b
CV (%)	12.68	17.29	15.88

Notes: Numbers followed by the same letter in the same column show no significant difference based on the DMRT with an $\alpha = 0.05$. CV = coefficient variation

Table 5. Stem diameter of *Impatiens* cuttings in various rooted cutting mediums (mm)

Treatments	Days after planting		
	14	21	28
Varieties			
Impala Agrihorti	2.30 ^a	2.77 ^a	2.80 ^b
Imadata Agrihorti	2.19 ^a	2.66 ^a	3.04 ^a
Lavender	2.37 ^a	2.33 ^b	2.80 ^b
Rooted cuttings medium			
Cocopeat + 3% perlite	2.31 ^a	2.62 ^a	3.16 ^a
Cocopeat + 5% perlite	2.40 ^a	2.64 ^a	3.09 ^a
Cocopeat + 8% perlite	2.36 ^a	2.61 ^a	2.82 ^{ab}
Rice husk (Control)	2.12 ^b	2.48 ^a	2.50 ^b
CV (%)	7.19	9.67	11.50

Notes: Numbers followed by the same letter in the same column show no significant difference based on the DMRT with an $\alpha = 0.05$. CV = coefficient variation

and transportation. This, in turn, significantly impacted vegetative growth and productivity, evidenced by the number of leaves.

Plant height

There was no interaction between varieties and rooted cutting medium in relation to plant height as shown in Table 7. *Impatiens* 'Impala Agrihorti' had a faster growth rate than 'Lavender' and 'Imadata Agrihorti' from 14 to 28 DAP. The 3% to 8% perlite in cocopeat significantly increased the plant height compared to the rice husk, and the most significant result was produced by the 3%. Auxin accumulation in the root tip increased growth and allocated more carbohydrates for the elevation of the plant height (Li et al., 2018). According to Sarkar et al. (2021), cocopeat provided ample microclimate conditions in the root region and increased plant height, number of leaves, as well as fresh biomass components compared to rice husk in lettuce.

Leaves thickness

There was no interaction between varieties and rooted cutting medium in terms of leaves thickness as shown in Table 8. *Impatiens* 'Imadata Agrihorti' had the highest leaves thickness compared to other varieties. The cocopeat mixture with 3% to 8% perlite increased the leaves thickness and the most significant result was yielded by the 3% perlite. According to Zhang and Cao (2009), leaves with greater thickness often have dense veins and wide vascular bundles to accelerate the diffusion of water and nutrients. This phenomenon underscores the correlation between stem hydraulic conductivity and nutrient use efficiency.

Survival rates

There was no interaction between varieties and rooted cutting medium in relation to the survival rate as illustrated in Table 9. *Impatiens* 'Lavender' had the highest survival rate at 14 to 28 DAP compared to other varieties. The 3%, 5% and 8%

Table 6. Number of leaves of *Impatiens* cuttings in various growth mediums

Treatments	Days after planting		
	14	21	28
Varieties			
Impala Agrihorti	5.50 ^a	6.00 ^a	6.02 ^a
Imadata Agrihorti	5.56 ^a	5.17 ^b	6.19 ^a
Lavender	5.68 ^a	5.49 ^{ab}	6.61 ^a
Rooted cuttings medium			
Cocopeat + 3% perlite	5.66 ^a	5.67 ^a	6.94 ^a
Cocopeat + 5% perlite	5.77 ^a	5.62 ^{ab}	6.47 ^a
Cocopeat + 8% perlite	5.62 ^a	5.41 ^{ab}	6.36 ^a
Rice husk (Control)	4.88 ^b	5.15 ^b	5.33 ^b
CV (%)	6.90	8.10	13.45

Notes: Numbers followed by the same letter in the same column show no significant difference based on the DMRT with an $\alpha = 0.05$. CV = coefficient variation

Table 7. Plant height of *Impatiens* cuttings in various rooted cutting mediums (cm)

Treatments	Days after planting		
	14	21	28
Varieties			
Impala Agrihorti	4.78 ^a	5.28 ^a	7.40 ^a
Imadata Agrihorti	2.92 ^c	3.42 ^c	4.98 ^c
Lavender	4.20 ^a	4.70 ^b	6.60 ^b
Rooted cuttings medium			
Cocopeat + 3% perlite	4.23 ^a	4.73 ^a	4.23 ^a
Cocopeat + 5% perlite	4.16 ^a	4.66 ^a	4.16 ^a
Cocopeat + 8% perlite	3.98 ^{ab}	4.48 ^{ab}	3.98 ^{ab}
Rice husk (Control)	3.50 ^b	4.00 ^b	3.50 ^b
CV (%)	14.23	12.69	9.58

Notes: Numbers followed by the same letter in the same column show no significant difference based on the DMRT with an $\alpha = 0.05$. CV = coefficient variation

perlite in cocopeat increased the survival rate by 83.33%, 82.75% and 79.78%, respectively. The production of adventitious roots can increase the survival rate of rooted cuttings (Singh et al., 2015).

Assimilate partitioning

There was no interaction between varieties and rooted cutting medium in terms of the total dry weight as shown in Table 10. The total weight was similar among the varieties, but there were differences in the assimilation distribution to the root, leaves and stem. Pagani et al. (2015) reported that the use of different plant sinks influenced the assimilate partitioning for each plant organ. *Impatiens* 'Impala Agrihorti' showed a better ability for leaves assimilation, presumably due to its larger plant size and broader leaves. *Impatiens* 'Imadata Agrihorti' exhibited more efficient assimilation towards the stem, while 'Lavender' showed a greater root and leaves assimilation due to the strength of the root system. Based on the results, the cocopeat + perlite (3%,

5% and 8%) and rice husk had pH values of 5.3, 5.3, 5.8 and 6.5, respectively. This shows that the higher the pH of the medium, the lower the total dry weight of the plant. According to Massa et al. (2018), high pH (from 5.99 to 7.47) decreased the dry weight of *Impatiens*. Djaingsastro et al. (2021) also stated that higher EC created the best-quality plant, evident from the increased height and root volume, resulting in enhanced fresh and dry weight.

Based on the results, the different growth mediums examined had similar effects in all varieties. This study showed that *Impatiens* cuttings demonstrated a preference for growth medium with higher EC values (2.25 $\mu\text{S cm}^{-1}$). This was in contrast to the results of Xu et al. (2021) stating that higher EC ($> 2.0 \text{ dS m}^{-1}$) inhibited the growth of roots in nasturtium cuttings. The elevated EC values of cocopeat in perlite showcased nutrient availability in the growth medium, potentially impacting the quality of *Impatiens*. According to Kobori et al. (2022),

Table 8. Leaves thickness of *Impatiens* in various rooted cutting mediums (mm)

Treatments	Days after planting		
	14	21	28
Varieties			
Impala Agrihorti	0.20 ^b	0.21 ^c	0.21 ^c
Imadata Agrihorti	0.24 ^a	0.29 ^a	0.29 ^a
Lavender	0.23 ^b	0.24 ^b	0.24 ^b
Rooted cuttings medium			
Cocopeat + 3% perlite	0.24 ^a	0.26 ^a	0.26 ^a
Cocopeat + 5% perlite	0.23 ^{ab}	0.25 ^{ab}	0.25 ^{ab}
Cocopeat + 8% perlite	0.23 ^{ab}	0.24 ^{bc}	0.24 ^{bc}
Rice husk (Control)	0.22 ^b	0.23 ^c	0.23 ^c
CV (%)	8.05	5.33	8.78

Notes: Numbers followed by the same letter in the same column show no significant difference based on the DMRT with an $\alpha = 0.05$. CV = coefficient variation

Table 9. The survival rate of *Impatiens* in various rooted cuttings mediums

Treatments	Survival rate (%)
Varieties	
Impala Agrihorti	80.48 ^b
Imadata Agrihorti	77.94 ^b
Lavender	84.18 ^a
Rooted cuttings medium	
Cocopeat + 3% perlite	83.33 ^a
Cocopeat + 5% perlite	82.75 ^a
Cocopeat + 8% perlite	79.78 ^{ab}
Rice husk (Control)	77.56 ^b
CV (%)	4.74

Notes: Numbers followed by the same letter in the same column show no significant difference based on the DMRT with an $\alpha = 0.05$. CV = coefficient variation

Table 10. Assimilate partitioning of *Impatiens* in various rooted cutting mediums at 28 DAP

Treatments	Root dry weight (g)	Stem dry weight (g)	Leaves dry weight (g)	Total dry weight (g)	Root mass ratio	Stem mass ratio	Leaves mass ratio
Varieties							
Impala Agrihorti	0.009 ^b	0.021 ^{ab}	0.049 ^a	0.080 ^a	0.12 ^c	0.26 ^b	0.53 ^a
Imadata Agrihorti	0.012 ^{ab}	0.028 ^a	0.049 ^a	0.083 ^a	0.15 ^b	0.32 ^a	0.40 ^b
Lavender	0.01 ^a	0.019 ^b	0.047 ^a	0.080 ^a	0.17 ^a	0.23 ^b	0.51 ^a
Rooted cuttings medium							
C + 3% perlite	0.015 ^a	0.022 ^{ab}	0.054 ^a	0.094 ^a	0.16 ^a	0.24 ^a	0.53 ^a
C + 5% perlite	0.011 ^a	0.026 ^a	0.045 ^{ab}	0.081 ^a	0.13 ^{ab}	0.30 ^a	0.56 ^a
C + 8% perlite	0.014 ^a	0.025 ^{ab}	0.050 ^a	0.087 ^a	0.15 ^{ab}	0.28 ^a	0.56 ^a
Rice husk (Control)	0.008 ^a	0.017 ^b	0.037 ^b	0.063 ^b	0.12 ^b	0.27 ^a	0.26 ^b
CV (%)	33.49	35.54	21.13	22.71	20.61	24.07	25.04

Notes: Numbers followed by the same letter in the same column show no significant difference based on the DMRT with an $\alpha = 0.05$. C = cocopeat medium, CV = coefficient variation

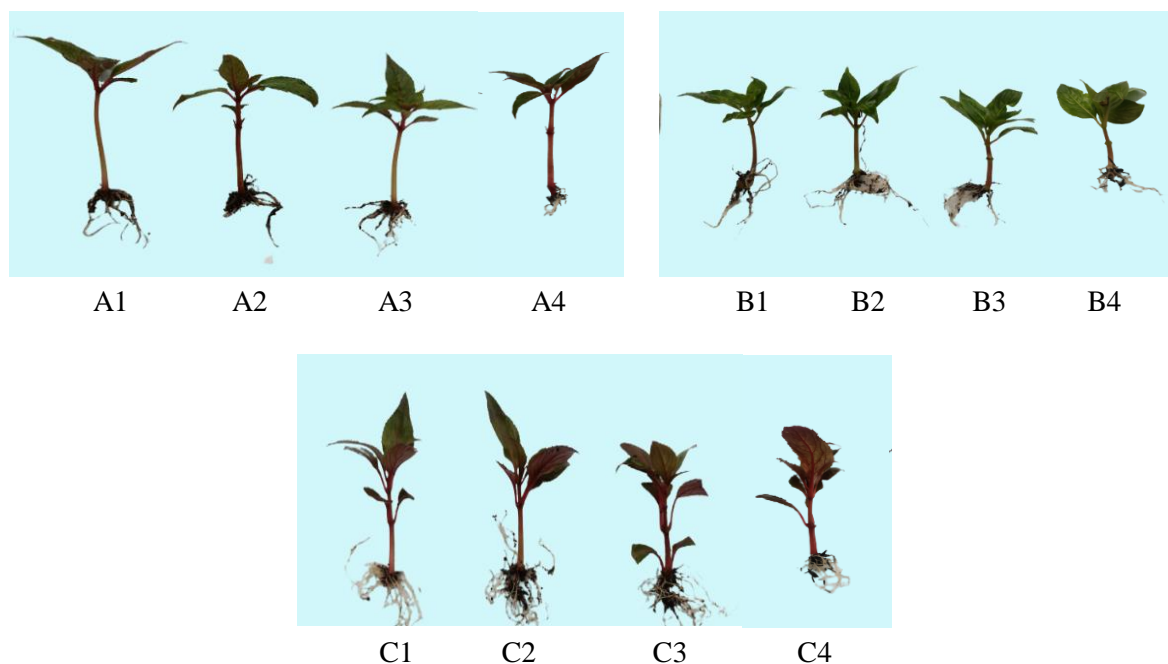


Figure 1. Rooted cuttings of *Impatiens* 'Impala Agrihorti' (A), 'Imadata Agrihorti' (B), 'Lavender' (C), and levels of perlite concentration such as 3% (1), 5% (2), 8% (3) and rice husk (4) at 28 DAP

the quality index of *Impatiens* rooted cuttings is indicated by the dry mass, plant height and stem diameter.

The *Impatiens* plant could produce more root dry weights when cultivated in a medium featuring elevated nutrient status combined with higher moisture content (Kazemi et al., 2020). This outcome can be attributed to the significant influence of root growth on nutrient uptake (Singh et al., 2023). Additionally, the allocation of assimilates within the plant further supports the growth in stem diameter and leaves number (Lojo et al., 2019). The increment in stem

diameter facilitated nutrient transportation to the leaves (Zhang and Cao, 2009), while the higher number of leaves enhanced photosynthetic activities leading to increased assimilation for further growth (Adekiya et al., 2022). The performance of *Impatiens* rooted cuttings is shown in Figure 1.

CONCLUSIONS

The growth medium of *Impatiens* rooted cuttings composed of 3% perlite in cocopeat exhibited better performance compared to rice husk in all varieties. This medium had lower pH,

as well as higher EC and moisture than the others. These features increased the number and length of roots, contributing to the growth of stem diameter, plant height, leaves thickness, leaves number and survival rate. Future studies are recommended to explore plant growth, promoting microorganisms in soilless systems as an alternative for sustainable agriculture growth medium.

ACKNOWLEDGEMENT

The authors are grateful to both Ir. Ida Widaningsih and Asep Setiono, the General Manager and Production Manager respectively at Bina Usaha Flora Company, West Java, Indonesia, for supporting this study.

REFERENCES

- A'saf, T. S., Al-Ajlouni, M. G., Ayad, J. Y., Othman, Y. A., & Hilaire, R. St. (2020). Science of the total environment performance of six different soilless green roof substrates for the Mediterranean region. *Science of the Total Environment*, 730, 139182. <https://doi.org/10.1016/j.scitotenv.2020.139182>
- Adekiya, A. O., Ayeni, J. F., Olayanju, A., Aremu, C., Akpor, O. B., Olaniran, A. F., Wutem Sunny Ejue, Ndupuechi, D. I., & Suleiman, O. K. (2022). Potentials of soilless substrates from biochar and rice husk as a replacement for cocopeat in Nigeria on tomato (*Solanum lycopersicum*). *Research on Crops*, 23(1), 139–148. <https://doi.org/10.31830/2348-7542.2022.020>
- Alam, M. N. H. Z., Othman, N. S. I. A., Samsudin, S. A., Johari, A., Hassim, M. H., & Kamaruddin, M. J. (2020). Carbonized rice husk and cocopeat as alternative media bed for aquaponic system. *Sains Malaysiana*, 49(3), 483–492. <http://dx.doi.org/10.17576/jsm-2020-4903-03>
- Alavi, S. A., Ghehsareh, A. M., Soleymani, A., Panahpour, E., & Mozafari, M. (2020). Ecotoxicology and environmental safety peppermint (*Mentha piperita* L.) growth and biochemical properties affected by magnetized saline water. *Ecotoxicology and Environmental Safety*, 201, 110775. <https://doi.org/10.1016/j.ecoenv.2020.110775>
- Awang, Y., Shaharom, A. S., Mohamad, R. B., & Selamat, A. (2009). Chemical and physical characteristics of cocopeat-based media mixtures and their effects on the growth and development of *Celosia cristata*. *American Journal of Agricultural and Biological Sciences*, 4(1), 63–71. <https://doi.org/10.3844/ajabssp.2009.63.71>
- Ayu, D. P., Putri, E. R., Izza, P. R., & Nurkhamamah, Z. (2021). Pengolahan limbah serabut kelapa menjadi media tanam cocopeat dan cocofiber di Dusun Pepen. *Jurnal Praksis Dan Dedikasi (JPDS)*, 4(2), 93–100. <http://dx.doi.org/10.17977/um032v4i2p92-100>
- Bamdad, H., Papari, S., Lazarovits, G., & Berruti, F. (2022). Soil amendments for sustainable agriculture: Microbial organic fertilizers. *Soil Use and Management*, 38(1), 94–120. <https://doi.org/10.1111/sum.12762>
- Banitalebi, G., Mosaddeghi, M. R., & Shariatmadari, H. (2021). Evaluation of physico-chemical properties of biochar-based mixtures for soilless growth media. *Journal of Material Cycles and Waste Management*, 23(3), 950–964. <https://doi.org/10.1007/s10163-021-01181-z>
- Bharti, A., Prasanna, R., Dantuluri, V. S. R., Chawla, G., Shivay, Y. S., & Nain, L. (2021). Cyanobacterium - amended mixes as priming options for stimulating growth and improving nutrient availability in nursery-grown Chrysanthemum rooted stem cuttings. *Acta Physiologiae Plantarum*, 43(7), 102. <https://doi.org/10.1007/s11738-021-03273-7>
- Dede, Ö. H., Köseoğlu, G., Özdemir, S., & Celebi, A. (2006). Effects of organic waste substrates on the growth of impatiens. *Turkish Journal of Agriculture and Forestry*, 30(5), 375–381. Retrieved from <https://journals.tubitak.gov.tr/agriculture/vol30/iss5/8>
- Di Benedetto, A., & Pagani, A. (2012). Difficulties and possibilities of alternative substrates for ornamental bedding plants: An ecophysiological approach. *Peat: Formation, Uses and Biological Effects*. New York, USA: Nova Science Publishers. Retrieved from https://scholar.google.com/scholar?hl=id&as_sdt=0%2C5&q=Difficultie+s+and+possibilities+of+alternative+substrates+for+ornamental+bedding+plants%E2%80%AF%3AAAn+ecophysiological+approach&btnG=
- Djaingsastro, A. J., Sinaga, H., & Sitorus, R. M. (2021). The effect of cocopeat and rice husk

- planting media hydroponically on the growth of palm oil in pre nursery. *BIOLINK (Jurnal Biologi Lingkungan Industri Kesehatan)*, 7(2), 195–203. <https://doi.org/10.31289/biolink.v7i2.4115>
- Francini, A., & Sebastiani, L. (2019). Abiotic stress effects on performance of horticultural crops. *Horticulturae*, 5(4), 67. <https://doi.org/10.3390/horticulturae5040067>
- Ghanbari, M. A., Jowkar, A., Salehi, H., & Zarei, M. (2019). Effects of polyploidization on petal characteristics and optical properties of *Impatiens walleriana* (Hook.). *Plant Cell, Tissue and Organ Culture (PCTOC)*, 138(2), 299–310. <https://doi.org/10.1007/s11240-019-01625-3>
- Ghehsareh, A. M., Hematian, M., & Kalbasi, M. (2012). Comparison of date-palm wastes and perlite as culture substrates on growing indices in greenhouse cucumber. *International Journal of Recycling of Organic Waste in Agriculture*, 1, 5. <https://doi.org/10.1186/2251-7715-1-5>
- Huang, W., Zhong, Y., Zhang, C., Ren, M., Du, Y., & Song, X. (2022). Leaf traits and water use characteristic of *Impatiens hainanensis*, a limestone endemic plant under different altitudes in dry and foggy seasons. *Water*, 14(2), 139. <https://doi.org/10.3390/w14020139>
- Ilahi, W. F. F., & Ahmad, D. (2017). A Study on the physical and hydraulic characteristics of cocopeat perlite mixture as a growing media in containerized plant production. *Sains Malaysiana*, 46(6), 975–980. <http://dx.doi.org/10.17576/jsm-2017-4606-17>
- Kazemi, F., Rabbani, M., & Jozay, M. (2020). Investigating the plant and air-quality performances of an internal green wall system under hydroponic conditions. *Journal of Environmental Management*, 275, 111230. <https://doi.org/10.1016/j.jenvman.2020.111230>
- Kobori, M. M. R. G., Mello, S. de C., Freitas, I. S. de, Silveira, F. F., Alves, M. C., & Azevedo, R. A. (2022). Supplemental light with different blue and red ratios in the physiology, yield and quality of *Impatiens*. *Scientia Horticulturae*, 306, 111424. <https://doi.org/10.1016/j.scienta.2022.111424>
- Kumarasinghe, H., Subasinghe, S., & Ransimala, D. (2015). Effect of coco peat particle size for optimum growth nursery plant of greenhouse vegetables. *Tropical Agricultural Research & Extension*, 18(1), 51–57. Retrieved from <http://ir.lib.ruh.ac.lk/xmlui/handle/iruror/7877>
- Li, Z., Zhang, X., Zhao, Y., Li, Y., Zhang, G., Peng, Z., & Zhang, J. (2018). Enhancing auxin accumulation in maize root tips improves root growth and dwarfs plant height. *Plant Biotechnology Journal*, 16(1), 86–99. <https://doi.org/10.1111/pbi.12751>
- Liu, W., Wu, J., Lian, J., Zhang, X., Zeb, A., Zhou, Q., & Sun, Y. (2021). Potential use of *Impatiens balsamina* L. For bioremediation of lead and polychlorinated biphenyl contaminated soils. *Land Degradation & Development*, 32(13), 3773–3784. <https://doi.org/10.1002/ldr.3857>
- Liu, Y., Xu, W., Wang, Y., Hao, W., Zhou, Q., & Liu, J. (2021). Growth responses and accumulation characteristics of three ornamental plants to Sn contamination in soil. *Agriculture*, 11(3), 205. <https://doi.org/10.3390/agriculture11030205>
- Lojo, J. De, Gandolfo, E., Giardina, E., Boschi, C., & Benedetto, A. Di. (2019). Growing media quality and plug cell volume would be interactive abiotic stresses for *Impatiens walleriana* pot yield. *Asian Journal of Agricultural and Horticultural Research*, 4(1), 1–14. <https://doi.org/10.9734/AJAHR/2019/v4i130008>
- Lojo, J. De, Gandolfo, E., Gómez, D., Feuring, V., Monti, S., & Giardina, E. (2017). Root restriction effects on the bedding pot plant *Impatiens walleriana*. *Journal of Experiment Agriculture International*, 15(4), 1–16. <https://doi.org/10.9734/JEAI/2017/31997>
- Lojo, J. M. De, Gandolfo, E., Feuring, V., Giardina, E. B., Boschi, C. L., & Benedetto, A. Di. (2021). Garden post-transplant effects of pre-transplant plug cell volume and growing medium quality (as abiotic stresses) in *Impatiens walleriana*. *Ornamental Horticulture*, 27(3), 320–333. <https://doi.org/10.1590/2447-536X.v27i3.2295>
- Lopez, R. G., & Runkle, E. S. (2008). Photosynthetic daily light integral during propagation influences rooting and growth

- of cuttings and subsequent development of New Guinea Impatiens and Petunia. *HortScience*, 43(7), 2052–2059. <https://doi.org/10.21273/HORTSCI.43.7.2052>
- Luo, C., Li, Y., Budhathoki, R., Shi, J., Yer, H., Li, X., Yan, B., Wang, Q., Wen, Y., Huang, M., & Huang, H. (2021). Complete chloroplast genomes of *Impatiens cyanantha* and *Impatiens monticola*: Insights into genome structures, mutational hotspots, comparative and phylogenetic analysis with its congeneric species. *PLoS ONE*, 16(4), e0248182. <https://doi.org/10.1371/journal.pone.0248182>
- Masquelier, S., Sozzi, T., Bouvet, J. C., Bésiers, J., & Deogratias, J. M. (2022). Conception and development of recycled raw materials (coconut fiber and bagasse)-based substrates enriched with soil microorganisms (Arbuscular Mycorrhizal fungi, *Trichoderma* spp. and *Pseudomonas* spp.) for the soilless cultivation of tomato (*S. lycopersicum*). *Agronomy*, 12(4), 767. <https://doi.org/10.3390/agronomy12040767>
- Massa, D., Prisa, D., Lazzereschi, S., Cacini, S., & Burchi, G. (2018). Heterogeneous response of two bedding plants to peat substitution by two green composts. *Horticultural Science*, 45(3), 164–172. <https://doi.org/10.17221/1/2017-HORTSCI>
- Mourouzidou, S., Ntinis, G. K., Tsaballa, A., & Monokrousos, N. (2023). Introducing the power of plant growth promoting microorganisms in soilless systems: A promising alternative for sustainable agriculture. *Sustainability*, 15(7), 5959. <https://doi.org/10.3390/su15075959>
- Pagani, A., Molinari, J., Lavado, R., & Benedetto, A. Di. (2015). Behavior of *Impatiens wallerana* Hook. f in alternative pot substrates: Mechanisms involved and research perspectives. *Journal of Plant Nutrition*, 38(14), 2185–2203. <https://doi.org/10.1080/01904167.2014.988357>
- Parra, M., Abrisqueta, I., Hortelano, D., Alarcon, J. J., Intrigliolo, D. S., & Rubio-Asensio, J. S. (2022). Open field soilless system using cocopeat substrate bags improves tree performance in a young Mediterranean persimmon orchard. *Scientia Horticulturae*, 291, 110614. <https://doi.org/10.1016/j.scienta.2021.110614>
- Patil, S. T., Kadam, U. S., Mane, M. S., Mahale, D. M., & Dhekale, J. S. (2020). Hydroponic growth media (substrate): A review. *International Research Journal of Pure & Applied Chemistry*, 21(23), 106–113. <https://doi.org/10.9734/IRJPAC/2020/v21i2330307>
- Permanasari, P. N., & Susila, A. D. (2018). Studi jenis media pembibitan terhadap pertumbuhan bibit mentimun (*Cucumis sativus* L.). *Agrovigor: Jurnal Agroekoteknologi*, 11(1), 58–64. <https://doi.org/10.21107/agrovigor.v11i1.4376>
- Sarkar, M. D., Rahman, M. J., Uddain, J., Quamrizzaman, M., Azad, M. O. K., Rahman, M. H., Islam, M. J., Rahman, M. S., Chou, K.-Y., & Naznin, M. T. (2021). Nutritional content of red leaf lettuce (*Lactuca sativa* L.) grown in organic substrates. *Plants*, 10(6), 1220. <https://doi.org/10.3390/plants10061220>
- Shintiavira, H., Purba, A. E., Kartikaningrum, S., & Koseki, A. (2023). Identifying drought-tolerant *Impatiens* genotypes by using water stress treatment. *Caraka Tani: Journal of Sustainable Agriculture*, 38(1), 40–52. <https://doi.org/10.20961/carakatani.v38i1.62652>
- Singh, A. K., Singh, R., Kumar, R., Gupta, A. K., Kumar, H., Rai, A., Kanawjia, A., Tomar, K. S., Pandey, G., Singh, B., Kumar, S., Dwivedi, S. V., Kumar, S., Pathania, K., Ojha, G., & Singh, A. (2023). Evaluating sustainable and environment friendly growing media composition for pot mum (*Chrysanthemum morifolium* Ramat.). *Sustainability*, 15(1), 536. <https://doi.org/10.3390/su15010536>
- Singh, V. P., Nimbolkar, P. K., Singh, S. K., Mishra, N. K., & Tripathi, A. (2015). Effect of growing media, Pgrs and seasonal variability on rooting ability and survival of lemon (*Citrus limon* L.) cuttings. *International Journal of Agriculture, Environment and Biotechnology*, 8(3), 593–599. <https://doi.org/10.5958/2230-732X.2015.00065.0>
- Soehendi, R., Kartikaningrum, S., Wegadara, M., Ratule, M. T., Thamrin, M., & Marwoto, B. (2022). Interspecific hybridization of *Impatiens* sp. II *International Symposium on Tropical and Subtropical Ornamentals 1334*(pp. 37–46). <https://doi.org/10.17660/ActaHortic.2022.1334.5>

- Suarez-Caceres, G. P., Perez-Urrestarazu, L., Aviles, M., Borrero, C., Eguibar, J. R. L., & Fernandez-Cabanas, V. M. (2021). Susceptibility to water-borne plant diseases of hydroponic vs. aquaponics systems. *Aquaculture*, *544*, 737093. <https://doi.org/10.1016/j.aquaculture.2021.737093>
- Tracy, S. R., Black, C. R., Roberts, J. A., & Mooney, S. J. (2013). Exploring the interacting effect of soil texture and bulk density on root system development in tomato (*Solanum lycopersicum* L.). *Environmental and Experimental Botany*, *91*, 38–47. <https://doi.org/10.1016/j.envexpbot.2013.03.003>
- Wang, W., He, Y., Cao, Z., & Deng, Z. (2018). Induction of tetraploids in *Impatiens walleriana* and characterization of their changes in morphology and resistance to Downy Mildew. *HortScience horts*, *53*(7), 925–931. <https://doi.org/10.21273/HORTSCI13093-18>
- Xu, W., Lu, N., Kikuchi, M., & Takagaki, M. (2021). Effects of node position and electric conductivity of nutrient solution on adventitious rooting of nasturtium (*Tropaeolum majus* L.) cuttings. *Agronomy*, *11*(2), 363. <https://doi.org/10.3390/agronomy11020363>
- Zhang, J., & Cao, K. (2009). Stem hydraulics mediates leaf water status, carbon gain, nutrient use efficiencies and plant growth rates across dipterocarp species. *Functional Ecology*, *23*(4), 658–667. <https://doi.org/10.1111/j.1365-2435.2009.01552.x>