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Optimizing simplified growing media to enhance cannabis cultivation

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Abstract This study evaluated the effects of different growing media on the vegetative growth, chlorophyll content, and inflorescence yield of *Cannabis sativa* L. 'Platinum Kush Breath Remix'. A substrate composed of peat moss, perlite, and vermiculite (3:1:1; PM) significantly enhanced plant height, stem diameter, number of nodes, and inflorescence yield. The highest chlorophyll a and total chlorophyll contents were observed in plants grown in a medium comprising coconut coir, perlite, vermiculite, and vermicompost (3:1:1:1; CC1), which was comparable to PM in terms of yield. Both PM and CC1 media significantly outperformed other treatments, indicating their suitability for optimizing *C. sativa* growth and productivity.

Keywords: Growing media, Cannabis, Peat moss, Coconut coir, Vermicompost, Rain tree

Introduction

Cannabis sativa L. is a medicinal plant indigenous to the Himalayan regions of Central Asia, encompassing parts of India, Nepal, Pakistan, and Southwestern China and is now spreading across Southeast Asia including Thailand (Elsohly *et al.*, 2017). Traditional medical uses include pain management, wound antisepsis, and muscle relaxation. The fibrous stems have also been extensively utilized in textile production, particularly for clothing materials, showcasing their diverse utility (Andre *et al.*, 2016).

Cannabis flowers are rich in pharmacologically active constituents, primarily cannabinoids. Δ^9-Tetrahydrocannabinol (THC), the major psychoactive compound, is associated with sedation, appetite stimulation, and

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sleep enhancement. Cannabidiol (CBD), a non-psychoactive component, possesses anticonvulsant, anti-inflammatory, and analgesic activities (Jin *et al*., 2020). Minor cannabinoids including cannabigerol (CBG) and cannabinol (CBN) as well as over 500 additional phytochemicals have also been reported (Radwan *et al*., 2021). Cannabis flowers contain flavonoids, phenolic compounds, saponins, and terpenes (Baldino *et al*., 2020). Together, these constituents create the "entourage effect" a synergistic interaction that enhances the overall therapeutic potential of the plant (Russo, 2011).

Following the recent legislative changes in 2022, cannabis cultivation was legalized in Thailand, leading to a rapid expansion in domestic production for medical and economic purposes. The legal framework established by the Ministry of Public Health, Notification B.E. 2565, (Chotpitayasunon *et al*., 2022) facilitated the widespread cultivation of cannabis in the country. Cultivation practices can be broadly categorized into three systems: soil cultivation (Kolo *et al*., 2022), soilless cultivation, and hydroponics (Bevan *et al*., 2021). Most Thai farmers grow cannabis in soil due to the low production cost. However, conventional soil cultivation poses significant concerns for the safety and quality of medicinal-grade cannabis (Hvězdová *et al*., 2018) due to the contamination of agricultural lands with heavy metals and chemical residues from pesticides and herbicides (Miao *et al*., 2011). Substrate culture presents a viable alternative method for cannabis cultivation in Thailand. Peat moss has emerged as a preferred soilless substrate in controlled-environment agriculture (CEA) due to its exceptional water retention capacity, superior aeration properties, and minimal contamination risk (Fields and Criscione, 2023). With particular advantages for high-value crops (Aydi *et al*., 2023). Erdal and Aktas (2025) demonstrated that peat moss enhanced plant height, stem diameter, and fresh and dry fruit weight in tomato cultivation, while incorporating peat moss into soil increased chlorophyll, flavonoid, and carotenoid levels in *Stevia rebaudiana* (Sardar *et al*., 2022). Varying the proportions of peat moss in the growing medium significantly impacts plant development and cannabinoid profiles. A growing medium containing 85% peat moss combined with 15% perlite yielded THC and CBD at 0.36 and 10.15%, respectively (Veazie *et al*., 2023). Coconut coir, a byproduct of the coconut milk industry, is a locally abundant and cost-effective alternative to traditional substrates (Weeranukul *et al*., 2018). Coconut coir shares many physical characteristics with peat moss including excellent moisture retention and drainage properties, while maintaining relatively low levels of chemical residues (Mariotti *et al*., 2020). Coutinho *et al*. (2023) found that substrates incorporating coconut coir enhanced the synthesis of bioactive compounds such as phenolics and flavonoids in *Passiflora alata*. In cannabis cultivation, coconut coir promotes the accumulation of CBD in the vegetative and flowering stages (Burgel *et al*., 2022). Several agricultural waste materials promote the growth of cannabis, with the incorporation of vermicompost into the growing media enhancing plant height, overall yield, and chlorophyll content (Stramkale *et al*., 2021). Using composted fallen leaves as fertilizer also supports and stimulates cannabis growth (Olson *et al*., 2024).

This study compared the effects of various growing media on cannabis growth during the vegetative and flowering stages. Plant growth parameters such as height, stem diameter, and biomass production were investigated to identify a cost-effective growing medium.

Materials and methods

Plant growth

Cuttings were obtained from healthy, mature *Cannabis sativa* L. 'Platinum Kush Breath Remix' mother plants. Actively growing shoots with multiple nodes were selected and trimmed to lengths of 10–20 cm (5–8 inches). The cuttings were inserted into a propagation medium composed of peat moss and perlite at a 4:1 ratio (v/v). Environmental conditions during rooting were maintained at 80% relative humidity and 20–25°C. After three weeks, rooted cuttings (20 cm height) were selected and transplanted into various growing media; peat moss, coconut coir, perlite, vermiculite, vermicompost, and claw leaf compost at different ratios, as detailed in Table 1.

Plants were cultivated in a controlled environment using a growing room under an 18/6-h light/dark photoperiod for six weeks. Broad-spectrum LED grow lights were used to deliver a photosynthetic photon flux density (PPFD) of 400–600 μmol/m²/s. The vegetative stage was limited to six weeks, a common practice among cannabis producers, with each plant grown in a 12 L air-flow pot. Environmental conditions within the growing room were maintained at 60–70% relative humidity (RH) and 25–27°C. The plants were fertigated weekly with Wicca Perfect Grow fertilizer during the vegetative stage.

The reproductive (flowering) stage lasted 63 days (nine weeks), during which the plants received 12 hours of light per day at an increased PPFD of 600–800 μmol/m²/s. Temperature and humidity during this stage were controlled at 20–22°C and 40–45% RH, respectively. Wicca Perfect Bloom fertilizer was applied weekly, with 500–600 mL of water delivered per plant.

Table 1. Composition ratios of the growing media

	Growing media	Ratio
PM	Peat moss, perlite, vermiculite	3:1:1
CC	Coconut coir, perlite, vermiculite	3:1:1
CC1	Coconut coir, perlite, vermiculite, vermicompost	3:1:1:1
CC2	Coconut coir, perlite, vermiculite, claw leaf compost	3:1:1:1

Treatments and experimental design

Similarly sized cannabis plants were transplanted into 12 L (16 × 16 inches) air-flow pots. The plants were grown in distinct substrates according to the different treatment groups. A completely randomized design (CRD) experiment was conducted with five replicates for each treatment. The experimental conditions were meticulously controlled to maintain the optimal growth environment for the cannabis plants throughout the study period.

Physiological parameters

During the vegetative stage, the plant growth parameters including plant height on the main stem, stem diameter, and number of nodes were measured at seven-day intervals for six consecutive weeks post-transplantation. In the reproductive stage, cannabis inflorescences were harvested, trimmed, and subjected to a controlled curing process. The harvested inflorescences were hung in a dark room and maintained at 24–25°C with a relative humidity of 45–50% for 14 days. After the curing period, the dry weight of the cannabis inflorescences was recorded.

Determination of chlorophyll a, chlorophyll b and total chlorophyll

The third fully expanded leaf from the top of the plant was harvested to analyze chlorophyll content at six weeks post-transplantation. The samples were dried in a hot air oven and ground into a fine powder. A 0.3 g sample was extracted with 10 mL of 95% ethanol using an Elmasonic ultrasonic machine at 40°C for 30 minutes. The extraction process was repeated three times to yield a total extract volume of 30 mL. The extract was then filtered through Whatman No. 1 filter paper and analyzed using a microplate reader, with absorbance measured at 666 nm and 653 nm.

The absorbance values obtained were used to calculate the concentrations of chlorophyll a, chlorophyll b, and total chlorophyll according to the method described by Thambavani and Sabitha (2011):

Chlorophyll a (Chl a) = 15.65 A666 – 7.340 A653
Chlorophyll b (Chl b) = 27.05 A653 – 11.21 A666
Total chlorophyll = Chlorophyll a + Chlorophyll b

Statistical design and analysis

Data were analyzed using Statistix v.10 software, employing a completely randomized design with five replicates per treatment. An analysis of variance (ANOVA) was conducted, and differences among treatments were tested using Tukey's Honestly Significant Difference (HSD) method at a 99% confidence level ($p < 0.01$).

Results

Plant height

A comparison of the cannabis plant heights during the first two weeks after planting (WAP) was not statistically significant differences among substrate types. However, from weeks 3 to 6, plant height differed significantly across treatments. PM (peat moss, perlite, vermiculite at a ratio of 3:1:1) substrate showed greater plant height (Table 2 and Figure 1) when compared among treatments. In week 3 after planting, plants grown in the PM substrate reached average heights of 32.4 cm which were statistically comparable to plants grown in CC (coconut coir, perlite, vermiculite at a ratio of 3:1:1) and CC2 (coconut coir, perlite, vermiculite, claw leaf compost at a ratio of 3:1:1:1) (28.0 cm and 30.4 cm). The PM substrate maintained a consistently high average plant height at 4-6 weeks after planting, with no significant differences from CC2 but the difference was significantly compared to CC and CC1 (coconut coir, perlite, vermiculite, vermicompost at a ratio of 3:1:1:1) (Table 2).

Stem diameter

One week after planting *C. sativa* L. ‘Platinum Kush Breath Remix’ into different growing media, plants grown in the PM medium showed a significantly greater stem diameter compared to those grown in CC, CC1, and CC2 media. This trend persisted throughout the six-week vegetative growth period. Plants in the PM medium consistently showed the highest stem diameter, ranging from 0.28 to 1.84 cm (weeks 1–6), whereas those in the CC medium recorded the lowest diameter of 1.16 cm at week 6 (Table 3 and Figure 2).

Table 2. Effect of various growing media on plant height of *Cannabis sativa* L. 'Platinum Kush Breath Remix'

Growing media	Plant height (cm)					
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
PM	17.5	23.1	32.4[a]	60.4[a]	71.6[a]	84.6[a]
CC	17.1	20.4	28.0[ab]	45.2[b]	59.2[b]	69.8[b]
CC 1	17.2	20.4	27.0[b]	47.4[b]	61.6[b]	72.4[b]
CC 2	17.3	22.8	30.4[ab]	54.8[ab]	67.2[ab]	74.6[ab]
F-test	ns	ns	**	**	**	**
C.V. (%)	33.8	14.38	7.89	8.05	6.33	6.26

Note: Numbers followed by the same letter in the same column are not significantly different at $p \leq 0.01$, ns= not significant

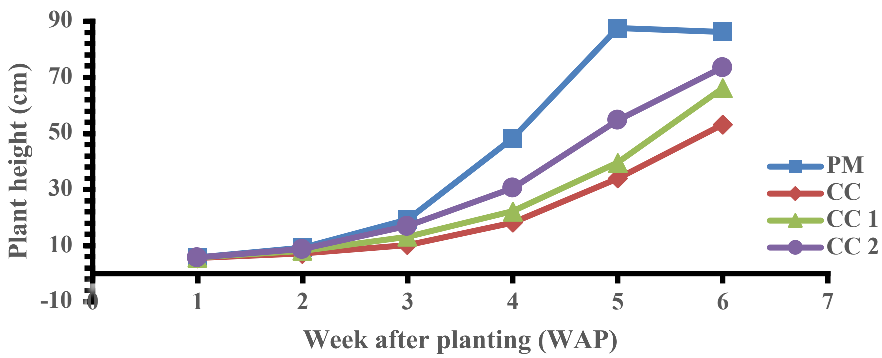

Figure 1. Effect of various growing media on plant height of *Cannabis sativa* L. 'Platinum Kush Breath Remix'

Table 3. Effect of various growing media on stem diameter of *Cannabis sativa* L. 'Platinum Kush Breath Remix'

Growing media	Stem diameter (cm)					
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
PM	0.28[a]	0.54[a]	1.12[a]	1.38[a]	1.64[a]	1.84[a]
CC	0.20[b]	0.30[b]	0.50[b]	0.66[c]	0.92[c]	1.16[c]
CC 1	0.20[b]	0.30[b]	0.48[b]	0.74[c]	0.98[bc]	1.24[bc]
CC 2	0.20[b]	0.34[b]	0.68[b]	1.06[b]	1.28[b]	1.42[b]
F-test	**	**	**	**	**	**
C.V. (%)	10.16	10.47	15.43	13.38	10.9	5.7

Note: Numbers followed by the same letter in the same column are not significantly different at $p \leq 0.01$

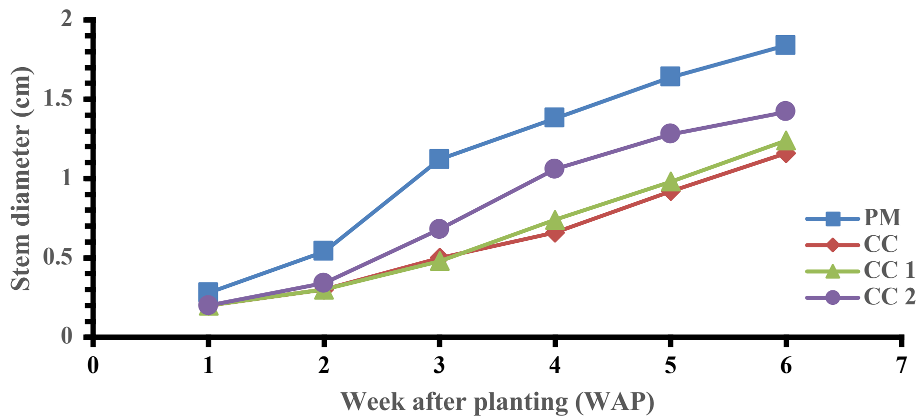

Figure 2. Effect of various growing media on stem diameter of *Cannabis sativa* L. 'Platinum Kush Breath Remix'

Number of nodes

During the first two weeks after planting was not statistically significant differences in the number of nodes were observed among the growing media. However, from weeks 3 to 6, significant differences emerged. Plants grown in the PM substrate consistently exhibited the highest number of nodes compared to the other treatments (Table 4; Figure 3). By week 3, plants in the PM substrate reached an average of 19.4 nodes, statistically comparable to those in CC2 (17.0 nodes). From weeks 4 to 6, the number of nodes in PM-grown plants increased steadily from 48.2 to 86.2, respectively showing a statistically significant difference as compared to the CC, CC1, and CC2 treatments.

Table 4. Effect of various growing media on the number of nodes in *Cannabis sativa* L. 'Platinum Kush Breath Remix'

Growing media	Number of nodes					
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
PM	5.8	9.2	19.4[a]	48.2[a]	87.6[a]	86.2[a]
CC	5.6	7.2	10.2[c]	18.2[c]	34.0[c]	53.2[c]
CC 1	5.8	8.2	13.2[bc]	22.2[bc]	39.6[c]	66.2[b]
CC 2	5.8	8.8	17.0[ab]	30.6[b]	54.8[b]	73.6[b]
F-test	ns	ns	**	**	**	**
C.V. (%)	20.16	12.42	16.28	13.77	9.79	4.80

Note: Numbers followed by the same letter in the same column are not significantly different at $p \leq 0.01$, ns= not significant

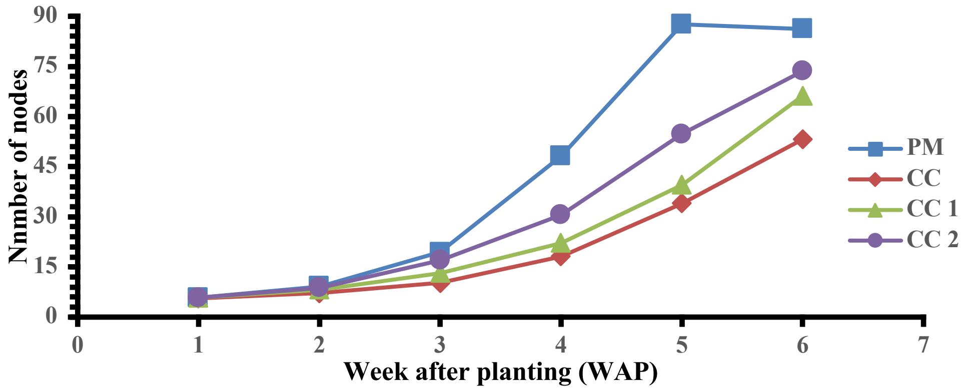

Figure 3. Effect of various growing media on the number of nodes in *Cannabis sativa* L. 'Platinum Kush Breath Remix'

Chlorophyll content in leaves

At six weeks after planting, the growing medium was significantly influenced in chlorophyll content in the cannabis leaves. Plants grown in the CC1 substrate exhibited the highest concentration of chlorophyll a at 2.120 mg/g dry weight (DW), significantly greater than all the other media (Table 5).

For chlorophyll b and total chlorophyll, plants grown in the CC1 and PM substrates displayed higher levels compared to the other treatments but with no significant differences. Chlorophyll b and total chlorophyll contents in CC1 were 4.041 and 6.161 mg/g DW, respectively while in PM, they were 4.397 and 5.262 mg/g DW.

Table 5. Effect of various growing media on chlorophyll a, chlorophyll b and total chlorophyll content in the leaves of *Cannabis sativa* L. 'Platinum Kush Breath Remix' at 6 weeks after planting

Growing media	Chlorophyll a (mg/g DW)	Chlorophyll b (mg/g DW)	Total chlorophyll (mg/g DW)
PM	0.865^{c}	4.397^{a}	5.262^{ab}
CC	0.734^{c}	3.574^{b}	4.308^{bc}
CC 1	2.120^{a}	4.041^{ab}	6.161^{a}
CC 2	1.203^{b}	2.293^{c}	3.495^{c}
F-test	**	**	**
C.V. (%)	7.73	9.69	9.01

Note: Numbers followed by the same letter in the same column are not significantly different at $p \leq 0.01$

Inflorescence yield

Inflorescence harvesting of *C. sativa* L. 'Platinum Kush Breath Remix' was conducted 15 weeks after planting. Results indicated that the growing media had a statistically significant effect on dry inflorescence yield. The highest inflorescence yield was observed in plants cultivated in the PM substrate (34.52 g/plant), which was not significantly different from CC1 (29.92 g/plant). By contrast, plants grown in the CC medium exhibited the lowest yield (18.08 g/plant), with no significant difference from those grown in CC2 (21.62 g/plant) (Table 6).

Table 6. Effect of various growing media on the inflorescence yield of *Cannabis sativa* L. 'Platinum Kush Breath Remix'

Growing media	Inflorescence yield (g/plant)
PM	34.52^{a}
CC	18.08^{b}
CC 1	29.92^{ab}
CC 2	21.62^{b}
F-test	**
C.V. (%)	26.17

Note: Numbers followed by the same letter in the same column are not significantly different at $p \leq 0.01$

Discussion

Plant height, stem diameter and number of nodes

Statistical analysis indicated highly significant differences ($p < 0.01$) among the growing media in cannabis plant height, stem diameter, and node number at 3–6 weeks after planting *Cannabis sativa* L. 'Platinum Kush Breath Remix'.

Plants grown in PM (peat moss, perlite, vermiculite at a ratio of 3:1:1) exhibited significantly greater growth performance than those grown in CC (coconut coir, perlite, vermiculite at a ratio of 3:1:1), CC1 (coconut coir, perlite, vermiculite, vermicompost at a ratio of 3:1:1:1), and CC2 (coconut coir, perlite, vermiculite, claw leaf compost at a ratio of 3:1:1:1). Plant heights ranged from 32.4 to 84.6 cm, stem diameters from 1.12 to 1.84 cm, and number of nodes counts from 19.4 to 86.2. This result was attributed to the superior nutrient composition of peat moss, containing 9.5 g total nitrogen, 0.2 g total phosphorus, and 0.3 g total potassium per kg (Ceglie *et al*., 2011), along with high organic matter contents of 800 g/kg (Lee *et al*., 2021), exceeding the other substrates tested. Walsh and McDonnell (2012) noted that organic matter-enriched media provide essential nutrients and enhance soil physical properties for plant growth. Improved soil structure facilitates root penetration, while water-holding capacity ensures consistent moisture availability. The moderately acidic pH of such media further favors cannabis cultivation (Nemati *et al*., 2021).

The enhanced growth performance in PM concurred with Burgel *et al*. (2022) who observed taller cannabis plants cultivated in peat-based media, while Fesendouz *et al*. (2025) reported that cucumber seedlings grown in peat moss attained a greater height than those grown in coconut coir. By contrast, CC1 (with worm castings) and CC2 (with composted claw leaf) had organic matter content of 58.98% (Narisara and Sawitri, 2012) and 54% (Voltr *et al*., 2021), respectively while coconut coir had the lowest.

Nagase and Dunnett (2011) emphasized that organic matter enhances water retention and drainage, enabling effective nutrient release under fluctuating moisture conditions. These findings supported the superior growth observed in CC1 and CC2 over CC, aligning with results reported by Raju *et al*. (2023).

Chlorophyll content in leaves

A comparative analysis of chlorophyll content in cannabis leaves grown in different substrate types showed that plants cultivated in the CC1 substrate exhibited significantly higher levels of chlorophyll a and total chlorophyll compared to those grown in CC and CC2. No significant difference in total chlorophyll content was observed between CC1 and PM. Chlorophyll b content in CC1 also showed an increasing trend and was statistically comparable to PM, suggesting that CC1 effectively enhanced overall chlorophyll accumulation.

The improved chlorophyll levels associated with CC1 were attributed to the inclusion of vermicompost, which is a rich source of magnesium (up to 275 mg/kg; Chaoui *et al*., 2003). Magnesium plays a pivotal role in chlorophyll biosynthesis and photosynthetic efficiency, consistent with findings by Meng *et al*. (2023), who reported positive correlations between soil magnesium content and chlorophyll a and b concentrations. Vermicompost typically possesses a low carbon to nitrogen ratio at 25:1 (Tchobanoglous *et al*., 1993) compared to other substrates used in this study such as 54:1 in PM (Thai Peat Product Co., Ltd., 2019) and 66:1 in CC (Tripetchkul *et al*., 2012), A lower C:N ratio accelerates organic matter decomposition and enhances nitrogen mineralization, thereby increasing nitrogen availability for plant uptake (Janssen, 1996). Nitrogen is a fundamental component of amino acids, chloroplasts, and chlorophyll-synthesizing enzymes which likely contributed to the observed increase in pigment accumulation in CC1-grown plants (Doncheva *et al*., 2001).

These results concurred with Muratbek Kyzy *et al*. (2023) who reported significant increases in chlorophyll content after vermicompost application. Similarly, Xu and Mou (2016) reported enhanced chlorophyll levels in spinach grown with vermicompost, and Kumari (2014) observed elevated chlorophyll a, b, and total chlorophyll in cannabis cultivated under similar conditions.

Dry cannabis inflorescence

Dry weight analysis of cannabis inflorescences revealed that plants cultivated in peat moss (PM) produced significantly higher inflorescence dry weight than those grown in coconut coir (CC) and CC2, with no significant difference between PM and CC1. Plants grown in CC exhibited the lowest inflorescence yield, attributed to the positive correlation between vegetative vigor and reproductive biomass accumulation in cannabis. Saloner and Bernstein (2020) stated that nitrogen plays a critical role during the vegetative phase, as it constitutes a major component of chlorophyll and the enzyme Rubisco; thus, nitrogen deficiency leads to reduced photosynthetic efficiency and limited biomass production. The PM medium contains 0.9% nitrogen (Ceglie *et al*., 2011), while the CC medium comprises only 0.5% nitrogen and has a comparatively lower organic matter contents (Raju *et al*., 2023), which may account for the reduced inflorescence dry weight observed in CC-grown plants. These findings aligned with Schober *et al*. (2023), who reported that cannabis cultivated in peat-based substrates accumulated significantly greater dry biomass in leaves and stems than those grown in coconut coir.

Our results showed that the PM substrate provided the most favorable conditions for cannabis growth and floral yield. However, no significant difference was observed between PM and CC2 in plant height and pigments in leaf. The CC1 substrate showed the highest accumulation of chlorophyll a and total chlorophyll in leaves, although chlorophyll b content did not differ significantly from plants grown in PM. Dry weight analysis of cannabis inflorescences revealed that plants cultivated in peat moss (PM) produced significantly higher inflorescence dry weight than those grown in coconut coir (CC) and CC2, with no significant difference between PM and CC1. Notably, PM is an imported substrate, whereas CC1 and CC2 offer economically viable alternatives to peat-based media. With further optimization, these locally sourced substrates could reduce reliance on imported peat moss and promote the sustainable use of domestic growing media.

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