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POTTING MEDIA OPTIMIZATION FOR QUALITY SEEDLING PRODUCTION OF BLACK PEPPER (*PIPER NIGRAM*) USING RUNNER SHOOT CUTTINGS

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Abstract

The present study was conducted in the lath house of Citrus Research Station, Bangladesh Agricultural Research Institute, Jaintapur, Sylhet, during the years 2020 and 2021 (from April to July) to find out the best potting media for quality seedling production of black pepper from runner shoot cuttings. Two growing media, namely soil and coco dust, and two nutrient sources, viz. vermicompost and farmyard manure (FYM) were combined in different ratios to make nine potting media combinations. These were: T_1 = soil alone, T_2 = coco dust alone, T_3 = soil + coco dust (1:1 v/v), T_4 = soil + vermicompost (1:1 v/v), T_5 = soil + FYM (1:1 v/v), T_6 = coco dust + vermicompost (1:1 v/v), T_7 = coco dust + FYM (1:1 v/v), T_8 = soil + coco dust + vermicompost (1:1:1 v/v), T_9 = soil + coco dust + FYM (1:1:1 v/v). The experiment was laid out in a randomized complete block design with three replications using ten cuttings per replication for each treatment. Among the different potting media compositions, coco dust + vermicompost at 1:1 v/v ratio resulted in the earliest sprouting (17 days and 19 days), the highest success in sprouting percentage (100% and 86.67%), maximum survival percentage (94.33% and 89%), and maximum number of newly emerged leaves cutting^{-1} (4.67) compared to the control and other treatments in both years (2020 and 2021). This treatment also performed best in terms of root parameters viz. maximum number of primary roots cutting^{-1} (15.67 and 16), longest root (24 cm and 19 cm), maximum root fresh weight (1.05 g and 1.14 g) and root dry weight (0.07 g and 0.42 g). Additionally, the longest shoot (37 cm and 39 cm) and the maximum shoot fresh weight (12.90 g and 17.99 g) and dry weight (3.14 g and 4.29 g) were also recorded in coco dust + vermicompost (1:1 v/v). The study suggests that the media consisting of coco dust + vermicompost (1:1 v/v) could be a better option for maximizing high- quality seedling production of black pepper using runner shoots cutting.

Keywords: Black pepper, Seedling, Potting media, Coco dust, Vermicompost, Cutting, Runner shoot

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Introduction

Black pepper (*Piper nigrum* L.), a member of the Piperaceae family, is a perennial climbing plant which dried fruits are used as spice. In Bangladesh, it is popularly known as 'Golmorich' cultivated mainly in Sylhet, Habiganj, Chattogram and Bogura districts including three hill districts, Khagrachari, Rangamati and Bandarban. Black pepper is a familiar spice in our country because it is a constant companion in the cooking of women to make their cooking taste incomparable. It is called the 'King of Spices' and 'black gold' worldwide. The crop originated in India and is now cultivated in tropical regions of the world (Hao *et al*., 2012). Currently, it is largely grown in India, Brazil, Indonesia, Malaysia, Vietnam and China (Talucder, 2019). Bangladesh has a strong domestic demand for black pepper and imports regularly to meet the national demand (Anon., 2018). However, among several challenges, which hinder black pepper production in Bangladesh, the unavailability of quality planting materials for large scale multiplication is an important one (Talucder, 2019). Black pepper can be propagated through both sexually by seeds and asexually by cuttings, grafting, budding and layering. Due to its heterozygous nature, seedlings do not breed true to type and known to have long juvenile (pre-bearing) period. So, vegetative propagation is commercially adopted in this crop. Among vegetative methods, propagation through cuttings is preferred for large scale multiplication of this spice crop because this method is comparatively easy compared to other vegetative means. Good quality planting material of black pepper can be produced vegetatively, especially by cutting in a short period, which is ideal and also cost-effective (Abassi *et al*., 2010; Ee and Shang, 2017). Cuttings taken from runner shoots (Creeping shoots on the ground) and orthotropic shoots (erect growing shoots) are used commercially for black pepper's vegetative propagation. However, it is quite difficult to establish vine cuttings in the nursery because of their high mortality rate (Ee and Shang, 2017). As a result, to select a proper potting media for raising quality seedlings of black pepper using runner shoot cuttings in the nursery is very important.

Potting or rooting medium is important for rooting and overall success of the cuttings under nursery conditions (Agbo and Omaliko, 2006). Moreover, potting media plays a crucial role by providing the necessary support, aeration, moisture retention, and nutrients for healthy root development, directly impact the overall growth and success of young plants; essentially acting as a foundation for strong, robust root systems that can effectively absorb water and nutrients (Nadoda *et al*., 2023). A high-quality growing medium significantly influences the growth, establishment, and survival, as well as aiding in further establishment of the saplings under field conditions (Landis *et al*., 2014). However, there are a limited number of researches regarding the outcomes of different potting media on black pepper cuttings in Bangladesh. Therefore, the present investigation was carried out to optimize the potting media for raising quality seedlings of black pepper using runner shoot cutting under nursery condition.

Materials and Methods

The present investigation was conducted in a naturally well-ventilated lath house at the nursery of Citrus Research Station, Bangladesh Agricultural Research Institute (BARI), Jaintapur, Sylhet, for two consecutive years, 2020 and 2021. The study area was geographically located between 25.13562º N latitude and 92.13217º E longitude with an average elevation of 34 meters. The climatic condition was characterized by hot and humid summer and a relatively cold winter with the maximum temperature of 35.45°C in May, and the lowest 9.48°C in January, while maximum rainfall occurs in June (762 mm) and minimum in January (0.42 mm) (Rahman *et al*., 2022). The experimental location lies on the Northern and Eastern Piedmont Plains (AEZ 22 of Bangladesh) having very strongly acidic (pH < 4.2) sandy loam soil. We have used garden top soil for the experiment. The soil analysis stated that the present status of nitrogen 0.14%, potassium 0.26 meq 100 g^{-1} soil, calcium 1.09 meq 100 g^{-1} soil, magnesium 0.57 meq 100 g^{-1} soil, sulfur 20.62 µg g^{-1} soil, zinc 3,07 µg g^{-1} soil and boron 1.56 µg g^{-1} soil. Nutrient and chemical properties of farmyard manure and vermicompost with coco dust from the secondary sources are presented in Table 1.

Table 1. Nutrients and chemical properties of Farm Yard Manure (FYM) (Ravimycin, 2016; Hoque *et al*., 2022), Vermicompost (VC) (Ravimycin, 2016; Chahal *et al*., 2019) and Coco dust (Raquepo *et al*., 2024)

Nutrients/Chemical properties	Farm Yard Manure	Vermicompost	Coco dust
Organic C (%)	13.6	11.8	8.61
N (%)	2.63	1.03	0.431
P (%)	9.17	6.59	0.061
K (%)	1.55	2.95	1.792
Ca (%)	7.8	4.55	0.228
Mg (%)	2.44	1.19	0.134
Na (%)	-	-	0.279
Cl (%)	-	-	1.172
S (%)	0.42	0.5	0.039
B (ppm)	33.7	35	23.5
Zn (ppm)	22.8	16.2	29.4
Mn (ppm)	84.9	65.3	27.3
Cu (ppm)	4.8	3.12	6.5
Fe (ppm)	182	132.8	510.5
pH	6.7	6.9	6.2
EC (dS m^{-1})	3.6	3.1	1.28

The treatments comprised nine treatments, viz. T_1 = soil alone, T_2 = coco dust alone, T_3 = soil + coco dust (1:1 v/v), T_4 = soil + vermicompost soil (1:1 v/v), T_5 = soil + FYM (1:1 v/v), T_6 = coco dust + vermicompost (1:1 v/v), T_7 = coco dust + FYM (1:1 v/v), T_8 = soil + coco dust + vermicompost (1:1:1 v/v), T_9 = soil + coco dust + FYM (1:1:1 v/v) where soil and coco dust was used as the basal potting media, and farmyard manure (FYM) and vermicompost as nutrient suppliers. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Each replication contained 10 black poly bags (7"×6") filled with the respective potting media. A total number of 270 (9×3×10) poly bags and 270 cuttings were used in the study.

Runner shoot cuttings of black pepper (*Piper nigrum* 'BARI Golmorich-1') were used as the planting material. The cuttings were collected from the black pepper garden of Citrus Research Station. The runner shoots (3 months old) were collected from the healthy mother plants (5-10 years old) for preparing the cuttings. The cuttings were prepared by giving a slant cut at the bottom and a round cut at the top keeping 4 nodes (approximate length 19 cm, diameter 2.3 mm and internode distance 6.3 cm) and one leaf at the top. To avoid fungal contamination, the cuttings were soaked in Mancozeb (Indofil @ 2g L^{-1} of water) for 30 minutes followed by drying under shade for 30 minutes.

The cuttings were planted in nursery poly bags inserting two basal nodes deep in the potting media. One cutting was planted in each poly bag. The poly bags were watered immediately after planting the cuttings. Nursery poly bags having 8 (eight) holes at the bottom were used in the study so that the excess water can drain out easily. Other nursery managements were done at a regular interval.

Data were recorded on number of newly emerged leaves cutting^{-1}, number of primary roots cutting^{-1}, root length (cm), shoot length (cm), root fresh weight (g), root dry weight (g), shoot fresh weight (g) and dry weight (g) from 5 cuttings in both 2020 and 2021 after 60 days of cutting plantation. Data were also recorded on days to first sprouting, percentage of success, percentage of survival in both years. Percentage of success and percentage of survival data collected from the experiment were subjected to arc-sign transformation for normal distribution. Then, the transformed data were analyzed. Data on shoot and root parameters were also collected. Before recording the root parameters data, all the roots were gently washed under running water and dried under shade for 30 minutes. In case of dry weight determination, all the roots and shoots were oven dried in a conviction oven (ESCO, Singapore) for 72 hours at 80°C. The recorded data were compiled and analyzed statistically using R 4.2.0 program and means were separated by Least Significant Difference (LSD) test at 5% level of significance.

Results and Discussion

Days to first sprout

The influence of potting media on days to first sprouting of black pepper cutting varied significantly among the treatments in both years of 2020 and 2021 (Fig. 1A). The results showed that T_6 treatment took the shortest time (17 and 19 days in 2020 and 2021, respectively) followed by T_3 and T_4 (20 days) in the first year and by T_7 (24 days) in the second year. The maximum days required for sprouting was recorded in T_1 (24 days in 2020 and 28 days in 2021) followed by T_9 (22.33 days) in the first year and by T_4 and T_5 (27 days) in the second year. From the results it is evident that time required for sprouting of black pepper cutting in 2021 was higher than that of 2020.

Sprouting of black pepper cutting could be achieved easily when the potting media has enough porosity, sufficient water holding and draining capacity, providing aeration to ensure root formation and growth (Landis *et al*., 2014). Early sprouting using T_6 in our study indicated that T_6 offered superior conditions to the black pepper cuttings for the sprouting, compared to the other treatments. This could be due to using coco dust in this potting media, which have higher water holding and draining capacity, maximizing moisture supply as well as sufficient porosity, which could be resulted in faster roots emergence in cuttings. This potting media also contains vermicompost derived from cattle waste. Edwards and Burrows (1988) reported that vermicompost is highly porous, offering sufficient aeration, drainage and water-holding capacity. Moreover, it contains readily available plant nutrients, like nitrates, phosphorus, potassium, calcium, magnesium, and others etc. Furthermore, it contains biologically active substances like plant growth regulators (Tomati *et al*., 1990). This finding agrees with Prajwal *et al*., (2024) who recorded the least number of days to first and complete sprouting.

Number of newly emerged leaves cutting^{-1}

Number of newly emerged leaves cutting^{-1} was significantly affected by different potting media (Fig. 1B). The maximum number of newly emerged leaves cutting^{-1} was found in T_6 (4.67) in both years. In the first year, the second highest leaves cutting^{-1} was recorded in T_5 (3.33), while, in the second year, treatment T_7 (4.0) gave the second highest leaves cutting^{-1}. In 2020, the least number of newly emerged leaves cutting^{-1} was observed in T_8 and T_9 (1.33) followed by T_1 (1.67), whereas in 2021, its least number was noted in T_1 (2.0).

The number of leaves per plant is an important indicator of the ability of the plant to accumulate assimilates for the development of the plant (Weraduwage *et al*., 2015). It was observed that the vines sprouted earlier had higher number of leaves than those delayed to sprout. However, the subsequent increase in the number of leaves is regulated by the ability of the young plant to uptake nutrients required for growth and development, which is governed by the media composition (Akinrinola *et al*., 2023). In the present study, we found maximum number of leaves cutting^{-1} from treatment T_6 (coco dust + vermicompost at 1:1 v/v ratio), which could be attributed to the well-balanced growing environment created by coco dust and vermicompost together. Coco dust provides water retention and drainage facilities as well as improves aeration; while, vermicompost provides adequate supply of nutrients required for photosynthate accumulation (Prajwal *et al*., 2024). Moreover, vermicompost is a rich source of nitrogen, which is required for photosynthesis and cell multiplication leading to maximize leaf number (Akinrinola *et al*., 2023). Balanced media conditions are conducive to optimal root health also. As vermicompost contains some natural plant growth substances, these substances can stimulate cell division and leaf initiation, lead to an increase in the number of leaves (Grobkinsky *et al*., 2016). Prasath *et al*. (2014) found higher number of leaves in black pepper cuttings grown in media consisting of cocopeat + vermicompost + *Trichoderma viridae* compared to other media. Usendi *et al.* (2022) also achieved maximum number of leaves in *Piper betel* treated with regular potting mixture and vermicompost (1:1). Contrary, lower number of leaves cutting^{-1} was observed in T_1 (soil alone) agrees with the findings of Ismail-Embong *et al.* (2021), who reported under nutrient deficient conditions that fewer leaves are produced.

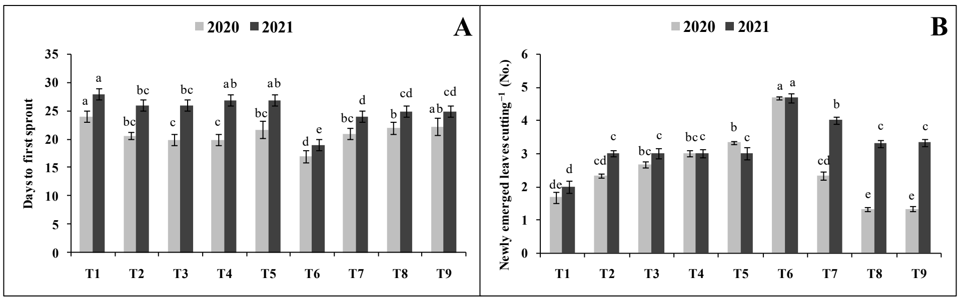

Fig.1. Effect of different potting media on time required to first sprouting (A), and number of newly emerged leaves cutting^{-1} (B) in black pepper cuttings under nursery conditions.

[T_1 = soil alone, T_2 = coco dust alone, T_3 = soil + coco dust (1:1 v/v), T_4 = soil + vermicompost soil (1:1 v/v), T_5 = soil + FYM (1:1 v/v), T_6 = coco dust + vermicompost (1:1 v/v), T_7 = coco dust + FYM (1:1 v/v), T_8 = soil + coco dust + vermicompost (1:1:1 v/v), T_9 = soil + coco dust + FYM (1:1:1 v/v)]. * Means followed by similar letter (s) are not significantly different at 5 % level of probability by Least Significant Difference (LSD) test.

Success percentage of sprouting

After 60 days of cutting plantation, success percentage of sprouting of black pepper cutting was significantly influenced by potting media treatments in both years

(Table 2). The highest sprouting percentage was found in T_6 treatment (100.00% in 2020 and 89.00% in 2021) followed by T_4 (91.33%), T_2 (91.67%) and T_5 (93.67%) in the first year and by T_7 (82.33%) in the second year. In 2020, the least sprouting percentage was recorded in T_9 (73.00%), followed by T_8 (73.33%), whereas it's minimum percentage was found in T_1 (44.67%) in 2021.

Coco dust holds moisture effectively, that prevents dehydration of the cuttings. Vermicompost provides essential elements for plant growth. Moreover, vermicompost contains growth promoting substances and beneficial microorganisms that improve media health and nutrient cycling, creating a thriving ecosystem that improve nutrient availability and enhanced sprouting. Therefore, the superior performance of T_6 (coco dust + vermicompost at 1:1 v/v ratio) could be attributed to the nutrient rich environment of this potting media which support stout sprouting. Besides, the presence of growth promoting substances in the media might assist in better utilization of stored carbohydrates, and other factors for sprouting. Similar result was also reported by Akshay *et al*. (2014) who obtained highest sprouting in black pepper cuttings growing on the potting media comprised regular potting mixture and vermicompost at an equal ratio. Vadiraj *et al.* (1992) also reported similar results, stated that vermicompost could be an excellent source of plant growth regulators, which enhanced plant growth. Additionally, the higher sprouting percentage might be linked to the higher porosity and water holding capacity of coco peat (Landis *et al*., 2014).

Percentage of survival

In both years of the study, the potting media treatments significantly influenced percentage of survival of black pepper cuttings (Table 2). The maximum survival was found in T_6 (94.33% and 86.67% in 2020 and 2021, respectively) followed by T_5 (89.67%) in 2020. The second highest survival was recorded in T_7 (73.33%) in 2021. In the first year, the minimum survival was recorded in T_8 (42.00%), followed by T_7 (59.33%); while in the second year, the least survival was observed in T_1 (33.33%) followed by T_5 (40.33%), and both T_3 and T_4 (46.67).

Lower survival percentage is generally occurred due to unfavorable environmental conditions or inherent properties of the growing media that hampers development (Akinrinola *et al*., 2023). As our experiment was conducted in lath house the effect of environment was little. Therefore, percent survival of the black pepper cuttings might be attributed to the compositions of the potting media. Coco dust is an excellent potting media and improves root development, enhance nutrient uptake and increase diseases resistance. It also ensures the production of healthy, vigorous and uniform quality seedlings (Mohanta *et al*., 2020). On the other hand, vermicompost contains growth promoting substances and beneficial microorganisms that improve media health and nutrient cycling. The combined effect of coco dust and vermicompost in the potting media create a convenient environment for the black pepper cuttings and allocate more resources to root development and overall growth and contributes in higher survival percentage. Moreover, Atiyeh *et al.* (2002) stated that the presence of humic acid in vermicompost improves the physical properties of soil and facilitates to utilize plant nutrients, which also contributed to higher survival rates. Similar result for black pepper cuttings was also reported by Prajwal *et al.* (2024) in their study.

Table 2. Effect of different potting media on sprouting and survival (%) of black pepper cuttings under nursery conditions (60 days after cutting plantation)

Treatments	Success in sprouting (%)		Survival (%)	
	2020	2021	2020	2021
T_1	80.33 # (63.70)	44.67 (41.93)	67.33 (55.15)	33.33 (35.20)
T_2	91.67 (73.31)	75.33 (60.27)	82.33 (65.20)	53.33 (46.92)
T_3	85.00 (67.40)	69.00 (56.19)	77.67 (61.82)	46.67 (43.08)
T_4	91.33 (73.25)	69.00 (56.19)	78.67 (62.53)	46.67 (43.08)
T_5	93.67 (75.49)	69.00 (56.19)	89.67 (71.53)	40.33 (39.39)
T_6	100.00 (90.00)	89.00 (70.80)	94.33 (76.31)	86.67 (68.99)
T_7	80.00 (63.45)	82.33 (65.24)	59.33 (50.39)	73.33 (59.02)
T_8	73.33 (58.91)	75.33 (60.27)	42.00 (40.39)	60.00 (50.81)
T_9	73.00 (58.70)	75.33 (60.27)	64.67 (53.54)	60.00 (50.81)
LSD (0.05)	4.93 (4.47)	2.31 (1.62)	3.90 (2.56)	0.60 (1.06)

Figures in the parenthesis are arc sine transformed values. [T_1 = soil alone, T_2 = coco dust alone, T_3 = soil + coco dust (1:1 v/v), T_4 = soil + vermicompost (1:1 v/v), T_5 = soil + FYM (1:1 v/v), T_6 = coco dust + vermicompost (1:1 v/v), T_7 = coco dust + FYM (1:1 v/v), T_8 = soil + coco dust + vermicompost (1:1:1 v/v), T_9 = soil + coco dust + FYM (1:1:1 v/v)].

Root parameters

Number of primary roots cutting^{-1}

Table 3 illustrated that the treatment T_6 gave the maximum number of primary roots cutting^{-1} (15.67 and 16 in 2020 and 2021, respectively), followed by T_3 and T_5 (11) in the first year and by T_2 (11.67) and T_7 (11.67) in the second year (Table 3). In 2020, the lowest number of primary roots cutting^{-1} was recorded in T_1 and T_9 (4.33) followed by T_8 (6), whereas in 2021, its minimum value was found in T_1 (4.33), which was statistically similar to T_4 (5).

An adequate nutrient level is essential for root growth and development, and promotes formation of multiple roots. In our study potting media comprising coco dust and vermicompost performed better in terms of number of primary roots cutting^{-1}, which might be due to the excellent structure, porosity and nutrients in available form such as nitrate nitrogen and soluble phosphorus for excellent in rooting. Moreover, growth promoting substances in vermicompost might offer better rooting ability (Singh *et al*., 2002). The results corroborate with the results of previous researchers (Munasinghe, 2023; Hazarika *et al*, 2022).

Root length

Root length was significantly influenced by different potting media (Table 3). Maximum root length was found in T_6 (24 cm in 2020 and 19 cm in 2021) followed by T_3 (15.33 cm) in the first year and by T_8 (15 cm) in the second year. In 2020, the minimum root length was recorded in T_9 (6 cm) followed by T_1 (9 cm) while, in 2021, its least value was observed in T_1 (4.33 cm).

Among the various treatments, the potting media containing coco dust with soil and vermicompost increased root growth. In our study, maximum increase in root length was obtained in media comprising coco dust + vermicompost at an equal ratio (1:1 v/v). Coco dust with great porosity and good aeration leads to proper gas exchange by maintaining sufficient oxygen supply to the root side by side simultaneous removal of respiratory CO_2 helped in root elongation. Nutrient (N, P and K) rich vermicompost maintains easy availability of nutrients that ultimately helps root growth and development (Prajwal *et al*., 2024). Thus, coco dusts amend with vermicompost in the ratio of 1:1 v/v enhance nutrient availability as well as gaseous: exchange that led to root proliferation, resulting in longer and thicker roots with increased volume. Since this treatment is a balance of air, moisture and nutrition, helps in increasing in physiological activity might have resulted in accumulation of carbohydrates which cause more root growth. Similar findings were reported by Renuka *et al*., (2015) in media cocopeat + vermicompost (2:1) in Gerbera, Renuka and Chandra (2017) in the media comprising cocopeat + vermicompost in carnation, Munasinghe (2023) and Prajwal *et al*. (2024) in media coco peat and vermicompost in black pepper.

Root fresh weight

The maximum root fresh weight was observed in T_6 (1.05 and 1.14 g in 2020 and 2021, respectively) followed by T_4 (0.50 g) in 2020 and T_2 (0.84 g) in 2021 (Table 3). The lowest root fresh weight was found in T_1 (0.07 g and 0.19 g in 2020 and 2021, respectively) which was statistically similar with T_9 (0.13 g) in 2020.

Essentially, the environmental conditions within the root zone significantly influence root development and root mass. The increase in root mass in potted cuttings depends on various factors including moisture content of the media, media texture and structure (compaction), root zone temperature, capability of the media to release nutrient in sufficient amount, media porosity for better aeration (oxygen levels), pH level, light conditions, and the presence of beneficial microbes (Lynch *et al.,* 2012). In our study the potting media formulating with coco dust and vermicompost increased root fresh weight, which might be due to the better rooting zone microclimate created by the mutual interaction of coco dust and vermicompost. Similar result was also stipulated by Prajwal *et al*. (2024) who found maximum root fresh weight in black pepper cuttings using potting media composed of coco dust and vermicompost.

Root dry weight

The maximum root dry weight was found in T_6 (0.39 and 0.42 g in 2020 and 2021, respectively) followed by T_5 (0.20 g) and T_4 (0.19 g) in 2020 and T_2 (0.33 g) in 2021 (Table 3). In 2020, the least root dry weight was recorded in T_1 (0.03 g), followed by T_9 (0.05 g) and T_8 (0.08 g), whereas in 2021, the treatment T_4 (0.03 g) recorded the lowest root dry weight, followed by and T_1 (0.07 g) and T_3 (0.09 g).

Root dry mass of potted cuttings could be affected by various factors like growing media compaction (structure and texture), water stress (drought or water logging), nutrient availability, aeration, temperature, light intensity, all of which influence the plant's ability to produce and allocate carbohydrates to increase root dry matter (Brouwer, 1963). The present study showed maximum dry root weight in the media coco dust and vermicompost in an equal ratio, which might be due to vigorous growth of roots for the porosity, water holding capacity, and nutrient exchange properties of the media. The ability of coco dust for retaining nutrients in the root zone ensures a steady supply of essential nutrients for the cutting's growth and development, leading to increase dry matter production in roots. The vermicompost benefits include nutrient enrichment, microbial activity, hormonal stimulation, moisture retention, pH stability, disease resistance, stress tolerance, and support for photosynthesis. Thus, the combined effect of coco dust and vermicompost might have stimulated the cuttings to increase root dry mass. These results get support from the findings of Thankamani *et al*. (1996) in black pepper with soil + vermicompost. Usendi *et al.* (2022) also noticed highest root dry weight in betel vine with potting mixture and vermicompost at an equal proportion.

Table 3. Effect of potting media on root parameters of black pepper cuttings under nursery conditions (60 days after cutting plantation)

Treatments	Primary roots Cutting $^{-1}$ (No.)		Maximum root length (cm)		Root fresh weight (g)		Root dry weight (g)	
	2020	2021	2020	2021	2020	2021	2020	2021
T_1	4.33	4.33	9.00	4.33	0.07	0.19	0.03	0.07
T_2	8.00	11.67	12.00	7.33	0.32	0.84	0.12	0.33
T_3	11.00	6.67	15.33	7.67	0.43	0.24	0.16	0.09
T_4	9.00	5.00	11.67	4.67	0.50	0.08	0.19	0.03
T_5	11.00	5.67	13.00	7.67	0.51	0.29	0.20	0.11
T_6	15.67	16.00	24.00	19.00	1.05	1.14	0.39	0.43
T_7	8.33	11.67	11.00	11.33	0.32	0.71	0.13	0.29
T_8	6.00	8.00	10.00	15.00	0.21	0.66	0.08	0.25
T_9	4.33	10.67	6.00	12.67	0.13	0.47	0.05	0.18
LSD (0.05)	2.50	1.07	2.55	1.20	0.06	0.06	0.008	0.007

T_1 = soil alone, T_2 = coco dust alone, T_3 = soil + coco dust (1:1 v/v), T_4 = soil + vermicompost (1:1 v/v), T_5 = soil + FYM (1:1 v/v), T_6 = coco dust + vermicompost (1:1 v/v), T_7 = coco dust + FYM (1:1 v/v), T_8 = soil + coco dust + vermicompost (1:1:1 v/v), T_9 = soil + coco dust + FYM (1:1:1 v/v).

Shoot parameters

Shoot length

The different potting media significantly influenced shoot length of black pepper cuttings in both years (Table 4). The treatment T_6 produced the maximum shoot length (37 cm and 39 cm in 2020 and 2021, respectively) followed by T_3 (31.67 cm) and T_5 (31.33 cm) in 2020 and by T_4 (35 cm) and T_2 (34 cm) in 2021. The lowest shoot length was recorded in T_1 (20.67 cm in 2020 and 26 cm in 2021).

Rate of increase in shoot growth is an important factor for nursery grown potted seedlings. Potting media significantly affect the shoot length by ensuring nutrients availability especially nitrogen and phosphorus, and other necessary factors such as moisture content of the media, media pH, texture, microclimate, as well as aeration levels. As a result, nutrient deficiencies, poor water drainage, extreme pH, lower porous media as well as extreme high or low temperatures leading to reduced shoot length (Passioura, 2002). In our study, black pepper cuttings grown in the media T_6 (coco dust + vermicompost at 1:1 v/v ratio) recorded the longest shoot which might be attributed to favorable microclimatic condition as well as the presence of adequate nutrients in the media. Similar results were also reported by Akshay *et al.* (2014) in the media comprising regular potting mixture and vermicompost at equal ratio in black pepper, Prasath *et al*. (2014) in the media containing coir pith with *Trichoderma viridae* and vermicompost; and Usendi *et* *al*. (2022) in *Piper betle* L. with media composed of regular potting mixture and vermicompost at equal ratio.

Shoot fresh weight

Shoot fresh weight was also significantly influenced by various potting media (Table 4). The highest shoot fresh weight was recorded in T_6 (12.90 and 17.99 g in 2020 and 2021, respectively) followed by T_3 (8.63 g), T4 (8.40 g) and T_5 (8.24 g) in 2020 and by T_9 (16.90 g) in 2021. In 2020, the lowest shoot fresh weight was found in T_1 (3.95 g) followed by T_8 (3.99 g) while the least shoot fresh weight was noted in T_1 (10.25 g) followed by T_7 (10.76 g) and T_5 (10.91 g).

Shoot fresh weight is one of the most important attributes for evaluating seedling growth and development, which are significantly influenced by the types of potting media. Difference in potting media compositions could lead to variations in the overall shoot fresh weight due to various factors like nutrient availability, drainage capacity, and aeration within the medium. Generally, a well-draining, nutrient-rich rooting medium will promote higher shoot fresh weight compared to a poorly draining or nutrient-deficient one (Passioura, 2002). In our study the highest shoot fresh weight was obtained from the cuttings grown on the potting media T_6 (coco dust + vermicompost at 1:1 v/v ratio) might be due to its excellent water holding capacity, nutrient availability, porosity as well as the presence of growth promoting substances. These results are in line with the findings of Kodithuwakku *et al*. (2016) in black pepper cuttings.

Shoot dry weight

Potting media treatments significantly affected shoot dry weight of cuttings (Table 4). In 2020, the treatment T_6 gave the maximum shoot dry weight (3.14 g) followed by T_3 (2.76 g) being identical with T_2 (2.36 g) and T_5 (2.25 g) and the minimum shoot dry weight was recorded in T_1 (0.76 g), which was followed by T_8 (1.02 g) and T_9 (1.04 g) (Table 4). But in 2021, the highest shoot dry weight was obtained from T_2 (4.74 g) followed by T_6 (4.29 g) and the lowest shoot dry weight was recorded in T_1 (1.92 g).

Shoot dry weight of the potted seedlings are also affected by the composition of media. The potting media characters that affect shoot dry weight includes water retention capacity, nutrient releasing ability, and microclimate in the pot created by the media itself (Passioura, 2002). In our study cuttings grown in T_6 (coco dust + vermicompost 1:1 v/v) exhibited maximum shoot dry weight in both 2020 and 2021, might be due to the presence of coco dust that assisted in increased shoot dry weight. These results are in conformity with Vadiraj *et al*. (1992) and Srinivasan and Hamza (2000).

Table 4. Effect of different potting media on shoot growth attributes of black pepper cuttings under nursery conditions (60 days after cutting plantation)

Treatments	Shoot length (cm)		Shoot fresh weight (g)		Shoot dry weight (g)	
	2020	2021	2020	2021	2020	2021
T_1	20.67	26.00	3.95	10.25	0.76	1.92
T_2	26.67	34.00	7.33	15.13	2.36	4.74
T_3	31.67	32.00	8.63	13.14	2.76	4.09
T_4	30.33	35.00	8.40	15.44	1.83	3.29
T_5	31.33	29.00	8.24	10.91	2.25	2.89
T_6	37.00	39.00	12.90	17.99	3.14	4.29
T_7	25.67	27.00	5.67	10.76	1.27	2.37
T_8	23.67	30.00	3.99	12.33	1.02	3.15
T_9	22.67	38.00	4.53	16.90	1.04	3.77
LSD (0.05)	1.98	1.73	0.57	0.67	0.031	0.077

[T_1 = soil alone, T_2 = coco dust alone, T_3 = soil + coco dust (1:1 v/v), T_4 = soil + vermicompost (1:1 v/v), T_5 = soil + FYM (1:1 v/v), T_6 = coco dust + vermicompost (1:1 v/v), T_7 = coco dust + FYM (1:1 v/v), T_8 = soil + coco dust + vermicompost (1:1:1 v/v), T_9 = soil + coco dust + FYM (1:1:1 v/v)].

Conclusion

Based on the experimental results, it can be concluded that coco dust in combination with vermicompost at a 1:1 ratio in volume basis was a superior growing media for producing the maximum number of healthy seedlings of black pepper within a short period. Therefore, this media could be suggested for the production of high-quality seedlings of black pepper using cuttings raised from runner shoots.

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