Research Article

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# Coir pith compost is a suitable substrate for mass multiplication of true cinnamon (*Cinnamomum verum* J. Presl.)

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## Abstract

True cinnamon has been valued for multifaceted applications in pharma, aroma and food industries. Use of seedling progenies for establishment of commercial plantations result in production of non-uniform quality raw material. Hence, adoption of improved varieties and vegetative propagation is desirable. Further, to multiply superior germplasm in crop improvement programmes, vegetative propagation is the norm. However, being a difficult-to-root species, use of air layering is a viable option. The present study aimed at understanding the effect of substrates (coir pith compost and soil: farmyard manure) on air layering in four improved varieties of true cinnamon. Coir pith compost was reported to support better root induction (%), root growth, and post-separation establishment; with genotype-dependent variations. Highly significant interaction effects between genotypes and substrates were evident. Additionally, the study was extended to know the suitability of coir pith compost for 23 accessions of cinnamon, which revealed that the responding layers (with rooting/ callusing) ranged between 50 and 100%. A total of 78.3% accessions showed minimum of 70% responding layers thereby proving the practical utility of the method in field collection work. Hence, coir pith compost could be recommended for large-scale air layering of improved varieties of true cinnamon apart from multiplication of superior germplasm.

***Keywords***: Air layering, difficult-to-root species, marcottage, propagation, spice

## Introduction

True cinnamon (*Cinnamomum verum* J. Presl.) is one of the ancient species cultivated and utilized in flavouring, perfumery and pharma industries (Ribeiro-Santos *et al.*, 2017). The inner bark of this tree is sweet and aromatic (Farooqi *et al.*, 2005), which is the main product of commerce apart from leaves and roots. Traditionally it has been used in Ayurvedic formulations (Nanda *et al.*, 2015) for over 6,000 years (Rao and Gan, 2014) and during the COVID-19 pandemic, it was one of the key constituents of the immunity-boosting herbal teas and decoction prescribed by the Ministry of AYUSH, Government of India (https://www.ayush.gov.in).

True cinnamon is a multifunctional species that is known to have proven biological properties including antioxidant (Jayaprakasha *et al.*, 2007), insecticidal (Pandey *et al.*, 2012), anti-tumour (Kim *et al.*, 2015), antimicrobial (Nabavi *et al.*, 2015), hypoglycaemic (Cheng *et al.*, 2012) and anti-inflammatory (Gunawardena *et al.*, 2014) activities. Owing to the considerably low content of coumarins (Shimna *et al.*, 2017), the bark of true cinnamon has been considered a superior and desirable ingredient for food and flavoring industries than its coumarin-rich (Felter *et al.*, 2006) substitute- cassia/ Chinese cinnamon (*C. cassia* (L.) J. Presl).

Under the humid tropical condition, which is the natural habitat of this species, it regularly flowers and set fruits (Thangaselvabai *et al.*, 2009). As a result, it is generally propagated through seeds (Waman and Bohra, 2018) and numerous naturally grown seedlings in and around cinnamon plantations are seen in these regions. Due to the existence of protogynous dichogamy, cinnamon is cross-pollinated (Azad *et al.*, 2015) and considerable variability exists in the natural populations (Azad *et al.*, 2016). As cinnamon is an export-oriented commodity and is also being used in the pharmaceutical sector (Nanda *et al.*, 2015), obtaining produce of uniform quality is desirable. Hence, for commercial cultivation, use of improved varieties is envisaged. Further, during crop improvement work, while collecting the germplasm from different natural stands, reliable vegetative propagation technique is warranted. Air

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layering has been one of the easy yet effective methods of vegetative propagation in many difficult-to-root perennial species (Saroj and Singh, 2020). The suitability of air layering for large-scale propagation of cinnamon has already been demonstrated (Waman and Bohra, 2018).

The success of air layering is influenced by several internal factors such as endogenous nutrient status, endogenous auxin concentration, physiological state/ age of the branch, genotype/ genetic make-up of the plant, etc. (Mozumder *et al.*, 2017; Waseem *et al.*, 2017). Also, external factors such as auxin concentration, season of layering, weather parameters throughout the process (from layering up to the separation of layers from mother plants), type of substrate, hardening conditions etc. are known to influence the rooting process (Chaudhari *et al.*, 2018; Waman and Bohra, 2018; Mozumder *et al.*, 2017; Naik *et al.*, 2016; Maurya *et al.*, 2012).

The coconut palm (*Cocosnucifera* L.) yields coir pith as a byproduct, which is a lignocellulosic material that helps to bind the coconut-husk fibres intact in the fruit. It is a biological waste that is generated by the coir industries in the humid tropics with an estimated annual production of 7.5 mt in India alone (Nattudurai *et al.*, 2014).This material is characterized by the presence of high C:N ratio, phenols, lignocelluloses and the slow decomposition by natural means causes piling up of it in the production areas, thereby impacting the health of soil and water (Awasthi *et al.*, 2019). Considering this, conversion of coir pith into compost has been advocated as a sustainable means of disposal (Natchimuthu *et al.*, 2021). Plant propagation is a prominent field in which of coir pith compost could play an important role (Waman and Bohra, 2021); however, such studies in vegetative propagation such as air layering/ cutting in perennial horticultural species are limited. Soil and farmyard manure combination is amongst the most commonly used substrates due to ease of availability and affordability. Unlike annual horticultural crops, very limited improved varieties of perennial crop like cinnamon have been developed and variety-specific recommendations are not available in most cases. A review of the literature suggested that no studies are available on the effect of improved genotypes and substrates on air layering in true cinnamon. In the present study, the effect of two substrates was studied in four improved varieties of cinnamon to know their response to air layering. Further, the study was extended to know the suitability of coir pith compost for 23 identified collections of true cinnamon for use in crop improvement programmes.

## Materials and methods

### Experimental site and material

The experiment was conducted in the Division of Horticulture and Crop Improvement, ICAR-Central Island Agricultural Research Institute, Sri

**Table 1. Weather parameters of the experimental site during the study period**

| Month | Study on improved varieties (2020) | | | | Study on germplasm (2023) | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean temperature (°C) | | Rainfall (mm) | Mean relative humidity(%) | Mean temperature (°C) | | Rainfall (mm) | Mean relative humidity(%) |
| | Min. | Max. | | | Min. | Max. | | |
| July | 24.8 | 30.2 | 382.5 | 83.0 | 25.0 | 30.3 | 622.1 | 84.0 |
| August | 25.3 | 30.5 | 351.7 | 84.0 | 25.4 | 30.4 | 443.7 | 84.0 |
| September | 24.7 | 30.1 | 403.9 | 85.0 | 24.0 | 28.8 | 940.1 | 86.0 |
| October | 24.3 | 29.8 | 461.8 | 88.0 | 24.8 | 30.7 | 307.5 | 82.0 |

Vijaya Puram (Port Blair), Andaman and Nicobar Islands, India. Weather parameters during the study period have been presented in Table 1. Five years old plants of improved varieties of *Cinnamomum verum viz*. Konkan Tej (KT), Konkan Tejpatta (KTP), IISR Navasree (NAV) and IISR Nithyasree (NIT) were used for the experiment. These mother plants were grown under open conditions and the farm was maintained under rainfed conditions. The salient characteristics of these varieties under Andaman Islands conditions are given in Table 2. The selected varieties exhibited superior quality characteristics over the local check and hence, were used. Further, 23 accessions shortlisted for crop improvement programme were used for confirmation study.

area was cleared off of leaves and side branches. The upper cut end of the girdled portion was smeared with talc powder formulation of 4,000 mg/kg indole-3-butyric acid. The girdled portion was, then wrapped with the moistened substrate as per the treatment. Using polythene of 20 cm × 20 cm size, the substrate was covered and secured using thread.

**Record of data and analysis**

Layers were separated from the mother plants and the rooting percentage was calculated as [(number of rooted layers/ number of non-rooted layers) × 100]. For the record of growth variables *viz*. number of primary roots per layer, root length, and root thickness, ten representative layers from each germplasm were used for each substrate. Data on rooting parameters were analysed following two-way Analysis of Variance (ANOVA) using Web Agri Stat Package (WASP 2.0, ICAR-CCARI, Ela, Goa, India). For the 23 collections, the data was used for calculation of mean and standard error using Microsoft Excel.

**Table 2**. **Salient features of improved varieties of cinnamon grown under Andaman Island conditions**

| Variety | Bark dry recovery (%) | Bark oleoresin (%) | Bark essential oil (%) |
|---|---|---|---|
| Konkan Tej | 37.3 | 11.5 | 2.0 |
| Konkan Tejpatta | 31.3 | 9.1 | 2.0 |
| IISR Navasree | 42.4 | 9.9 | 1.6 |
| IISR Nithyasree | 34.1 | 9.1 | 0.8 |

(Waman *et al.* 2020)

**Substrates**

The performance of coir pith compost as a substrate for air layering was compared with 1:1 ratio (v/v) of soil: farmyard manure (FYM), a conventionally used substrate. Both the substrates were analyzed for their chemical properties. Standard procedures were adopted for determination of electrical conductivity, organic carbon (Walkley Black method), total nitrogen (Kjeldahl method), available phosphorus (Bray-1 method for soil: FYM and acid digestion vanadomolybdate yellow colour method for coir pith compost) and available K (1N ammonium acetate-flame photometric method in soil: FYM and acid digestion- flame photometric method for coir pith compost).

**Layering operation**

Air layering operation was performed following the procedure described earlier (Waman *et al*., 2018).Briefly, terminal shoots of about 25 cm length of pencil-sized thickness were selected for carrying out air layering. Before removing a ring of bark of about 2.5 cm width, the ringing

**Results and discussion**

Adoption of improved varieties and their propagation through vegetative means are important aspects in the area expansion of industrially important species. However, even though cinnamon is being cultivated on a commercial scale in tropical countries, most of the existing plantations are of seedling origin. Non-adoption of improved varieties and existence of wide variability in the product have been the major factors for non-uniform quality produce entering the markets. Though some aspects of air layering in cinnamon have been studied in the past (Waman and Bohra, 2018; Ranaware *et al.*, 1994, 1995; Hegde *et al.*, 1989), the response of improved varieties/ germplasm to air layering and substrates has not been studied so far. The present report addresses this issue to facilitate the large-scale multiplication of improved varieties apart from studying the usefulness of the substrate to the shortlisted germplasm.

The success of air layering operation largely depends on the prevailing weather conditions of the region (Saroj and Singh, 2020).Mean monthly weather parameters of the experimental site during the experimental period have been presented in Table 1. Adequate precipitation and high relative humidity are among the key external factors to support the root induction process in cinnamon. Taking leads from the earlier study (Waman and Bohra, 2018), layering operation was performed in July to enhance the layering success. Mean monthly rainfall during the study period varied between 351.7 mm to 461.8 mm, with 83.0 to 88.0% relative humidity. These conditions are considered congenial for carrying out air layering operations.

Substrates used for layering play a pivotal role in the induction of root primordia and their subsequent development. Both the substrates used were analyzed for their properties (Table 3), which suggested richness of coir pith compost in total nitrogen (1.63%), available P (1,700 ppm), available K (3,500 ppm), organic carbon (20.1%) with relatively lower electrical conductivity (1.64 mS/cm) than Soil: FYM substrate used in the study.

The process of root initiation in the present study was influenced by both varieties as well as substrates tested (Fig. 1). In general, irrespective of the varieties studied, rooting percentage was improved (Fig. 1 and 2) in layers prepared with CPC as substrate than that in SF substrate. Rooting percentage in CPC substrate varied between 80.0% (KT) and 100.0% (KTP and NIT); while in case of SF, the values ranged between 26.7% (KTP) and 93.8% (NIT). In case of varieties, rooting was least affected due to substrates in NIT (100.0% and 93.8%), while drastic variations were noticed in variety KTP

**Table 3. Properties of substrates used in the experiment**

| Parameter | Coir pith compost | Soil: FYM (1:1, v/v) |
|---|---|---|
| Total nitrogen (%) | 1.63 | 0.93 |
| Available P (mg/kg) | 1700.0 | 490.1 |
| Available K (mg/kg) | 3500.0 | 995.0 |
| Organic carbon (%) | 20.1 | 7.5 |
| Electrical conductivity (mS/cm) | 1.64 | 2.60 |

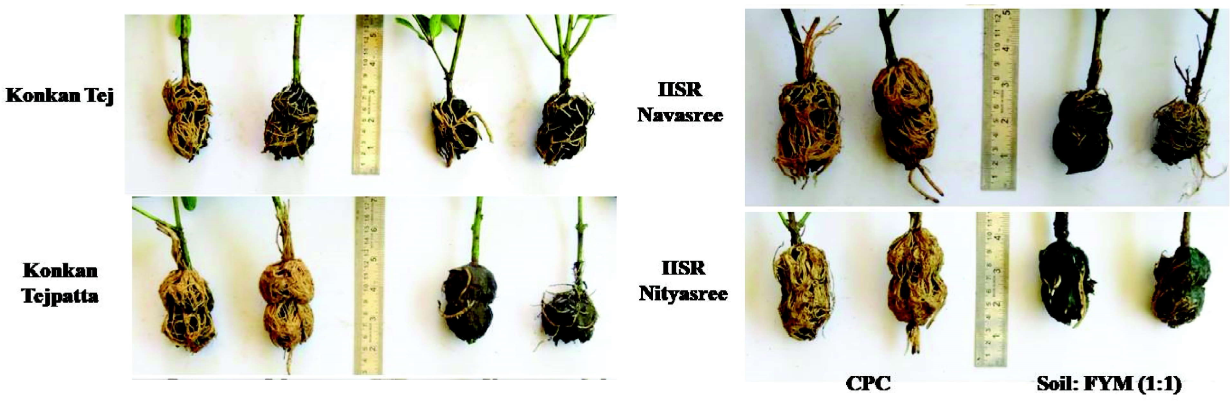


**Figure 1. Rooting in air layering of true cinnamon as influenced by varieties and substrates**

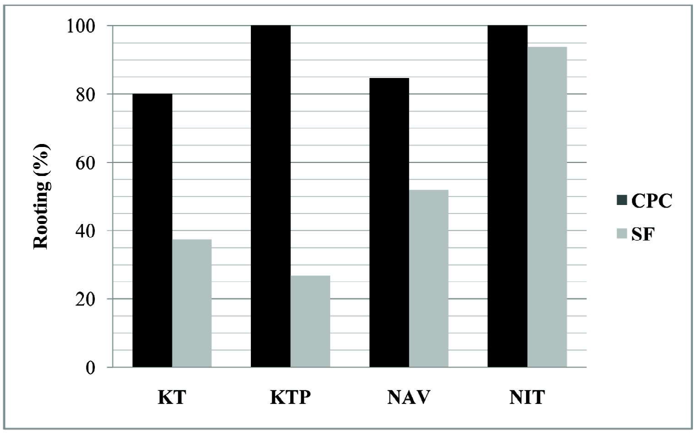


**Figure 2. Interaction effect of genotypes and substrates on induction of rooting (percentage) in air layering of cinnamon. CPC: coir pith compost; SF: soil: FYM (1:1, v/v), KT: Konkan Tej; KTP: Konkan Tejpatta; NAV: IISR-Navasree and NIT: IISR-Nithyasree**

(100.0% and 26.7%). These suggested that both factors had varying degrees of influence on the root induction process.

Successfully rooted layers were severed from the mother plants and transplanted into polybags to know their establishment success. Irrespective of the substrates used for layering, 100% plantlets of KTP got successfully established post-separation (Fig. 3). Interestingly, layers with SF substrate in this variety had the lowest rooting percentage; however, all the successfully rooted plants could get established during hardening. In other varieties, establishment percentage varied with substrates. In the variety NAV, all the layers from SF got established, while 90.9% of layers from CPC substrate could get established. In the remaining two varieties, layers obtained from CPC showed a superior establishment percentage than SF.

Rooting parameters are among the crucial observations which determine the post-separation establishment of the layers and their subsequent growth (Saroj and Singh, 2020). Factorial analysis was carried out to know the independent as well as interaction effects of the factors. The mean number of primary roots produced per air layer showed highly significant difference (1% level of significance) for both the factors and their interaction (Table 4). Among the genotypes, layers of variety NIT produced the highest number of primary roots (9.95), while it was the lowest in the variety KTP (4.75). Among the substrates, CPC significantly improved induction of primary roots with 8.90 roots per layer when compared

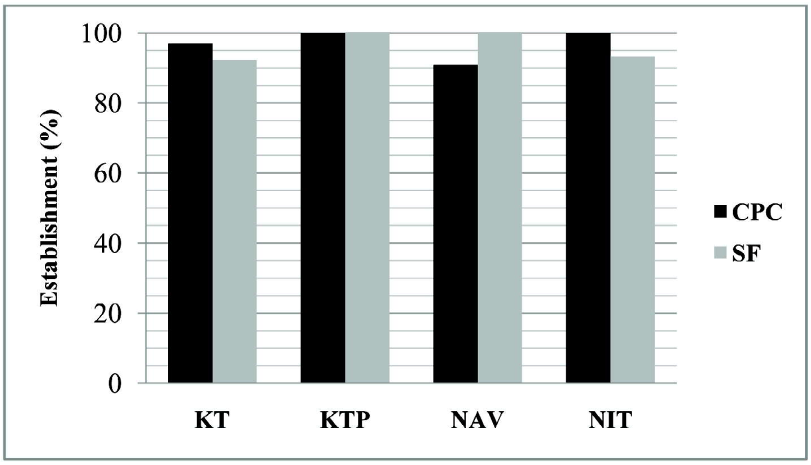


**Figure 3. Interaction effect of genotypes and substrates on establishment percentage in air layered cinnamon. CPC: coir pith compost; SF: soil: FYM (1:1, v/v), KT: Konkan Tej; KTP: Konkan Tejpatta; NAV: IISR-Navasree and NIT: IISR-Nithyasree**

**Table 4. Root induction parameters in air layering of true cinnamon as influenced by variety and substrates**

| Treatment | Mean No. of Primary Roots | Mean root length (cm) | Mean root thickness (mm) |
|---|---|---|---|
| **Factor A (Variety)** | | | |
| Konkan Tej (KT) | 6.25 | 6.07 | 2.67 |
| Konkan Tejpatta (KTP) | 4.75 | 6.94 | 2.38 |
| IISR-Navasree (NAV) | 6.35 | 8.30 | 2.43 |
| IISR- Nithyasree (NIT) | 9.95 | 9.64 | 2.21 |
| CD (5%) | 1.353 | 1.241 | 0.174 |
| CD (1%) | 1.798 | 1.650 | 0.231 |
| F test | ** | ** | ** |
| **Factor B (Substrate)** | | | |
| Coir pith compost (CPC) | 8.90 | 9.39 | 2.47 |
| Soil + FYM (SF) | 4.75 | 6.08 | 2.37 |
| CD (5%) | 0.956 | 0.878 | 0.123 |
| CD (1%) | 1.271 | 1.167 | 0.163 |
| F test | ** | ** | NS |
| **Interaction (Variety × substrate)** | | | |
| KT × CPC | 8.40 | 6.97 | 2.72 |
| KT × SF | 4.10 | 5.17 | 2.61 |
| KTP × CPC | 7.00 | 9.71 | 2.36 |
| KTP × SF | 2.50 | 4.16 | 2.40 |
| NAV × CPC | 9.90 | 10.05 | 2.66 |
| NAV × SF | 2.80 | 6.54 | 2.20 |
| NIT × CPC | 10.30 | 10.81 | 2.16 |
| NIT × SF | 9.60 | 8.46 | 2.26 |
| CD (5%) | 1.913 | 1.755 | 0.245 |
| CD (1%) | 2.543 | 2.333 | 0.326 |
| F test | ** | ** | ** |

***NS: non-significant, **: significant at 1% level of significance***

with 4.75 roots/ layer in SF. In case of interaction effect, as high as 10.30 roots/ layers were evident in NIT × CPC combination, which remained statistically on par with NAV × CPC (9.90), NIT × SF (9.60) and KT × CPC (8.40) combinations. The lowest numbers of primary roots were produced in layers derived from KTP × SF (2.50) and NAV × SF (2.80) combinations. Differences between roots produced in studied substrates in all the varieties suggest the crucial role of substrate in inducing the rooting in air layers.

Mean length of the primary root was highly significantly (1% level of significance) influenced by factors as well as their interaction (Table 4). Among the genotypes, longest roots were observed in variety NIT (9.64 cm), which was followed by NAV (8.30 cm). For this parameter also, the root length was significantly highest (9.39 cm) as against 6.08 cm in SF substrate. Among the interaction effect, combination involving CPC as substrate viz. NIT × CPC, NAV × CPC and KTP × CPC showed longest roots (10.81 cm, 10.05 cm and 9.71 cm, respectively). Produced roots were the thickest (2.67 mm) in the variety KT, which was significantly superior to all the other genotypes. The interaction effect suggested thick roots in combinations in the order KT × CPC (2.72 mm) > NAV × CPC (2.66 mm) > KT × SF (2.61 mm) > KTP × SF (2.40), although all these remained statistically similar. Non-significant differences were noticed among the substrates for this parameter.

Leaves present above the girdled region on the layered branch are known to produce carbohydrates and auxins, which are translocated to the girdled portion thereby facilitating the rooting process. The capacity of each genotype to synthesize these metabolites could vary due to several genetic, anatomical and physiological factors (Hartman *et al.*, 2010; Singh *et al.*, 2004).Variations in morphological parameters and photosynthetic pigments in the tested varieties have been reported by Waman *et al.* (2020). Similar differences in the endogenous auxins of these varieties could have contributed to varied success in the present study. Earlier researchers have also suggested the role of genotypes on rooting success in air layering of different crops (Mozumdar *et al.*, 2017).

Substrates have been reported to influence both rooting percentage and root growth parameters (Rathore, 2006). Both physical and chemical characteristics of the substrates are known to determine the success of the rooting process. Better rooting in a plant could be obtained if the substrate has optimum moisture retention capacity with adequate porosity to facilitate root aeration and drainage (de Lins *et al.*,2015).

In general, retention of optimum moisture and provision of aeration could have facilitated better induction and growth of the roots in CPC substrate during the present study. Further, higher concentrations of nutrients in the medium also help in nourishing the growing roots (Cahyo *et al.*,2019). These better rooting parameters might have helped the separated layers in the subsequent stage of establishment. Especially during the separation of the substrate from the layers during transplanting to poly bags, CPC substrate could be easily removed without causing any damage to the roots, whereas damage to roots during the separation of SF could be noticed at times due to compaction of this substrate. An increased level of compaction with an increase in the proportion

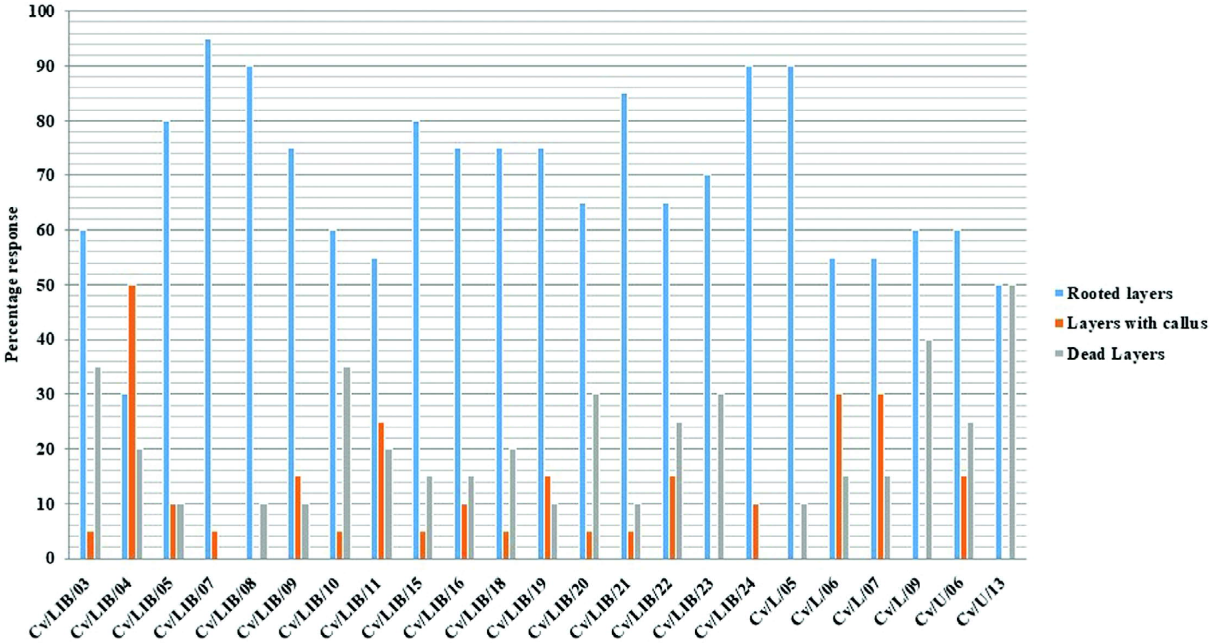


**Figure 4. Percent rooting success in 23 collections of true cinnamon multiplied using air layering with CPC as substrate**

of soil in the substrate has been reported earlier (Cahyo *et al.*,2019).

The CPC was further used for layering in the 23 collections (seedling progenies) which were identified for further crop improvement programme at the authors' institute. Results suggested that, among the tested collections, the rooting percentage ranged between 30 to 95% (Fig. 4). The callus induction is first phase of root induction and such layers which could produce callus could be rooted easily when they are treated with IBA during transplanting to the polybag in case of true cinnamon (data not presented). Hence, if the combined data of callusing + hardening data is considered, the success percentage is further improved to 50 to 100% among the collections. Root growth parameters were also influenced by the accession as revealed from the data presented in Table 5. Mean number of roots per layer ranged between 2.7 ± 0.49% (Cv/LIB/04) and 16.4 ± 2.23% (Cv/L/09). Root length was also influenced by the collection and the value ranged between 3.3 ± 0.49 cm (Cv/LIB/24) and 7.3 ± 0.21% (Cv/LIB/08). Overall, the rooting score varied between 1.3 ± 0.21 (Cv/LIB/04) and 3.0 ± 0.00 (Cv/L/05). This clearly indicates that the CPC could be used as a viable substrate for germplasm maintenance activities in true cinnamon.

Identification of a suitable substrate, which is available in desired quantity at a locality, is also equally important. Several substrates such as sand, soil, sawdust, moss grass, poultry manure, vermicompost and farmyard manure, sphagnum moss, peat, coconut fibres, humus etc. have been employed for rooting of air layers in different species (Waman and Bohra, 2021, 2018, 2021;

**Table 5. Root induction response in 23 accessions of true cinnamon multiplied using air layering with CPC as substrate**

| Accession | No. of roots/ layer | Mean root length (cm) | Rooting score |
|---|---|---|---|
| Cv/LIB/03 | 10.7 ± 1.47 | 7.0 ± 0.57 | 2.2 ± 0.20 |
| Cv/LIB/04 | 2.7 ± 0.49 | 4.9 ± 0.53 | 1.3 ± 0.21 |
| Cv/LIB/05 | 8.9 ± 1.80 | 5.4 ± 0.42 | 2.1 ± 0.35 |
| Cv/LIB/07 | 9.2 ± 1.32 | 5.5 ± 0.38 | 2.9 ± 0.10 |
| Cv/LIB/08 | 13.8 ± 3.37 | 7.3 ± 0.21 | 2.6 ± 0.16 |
| Cv/LIB/09 | 12.8 ± 2.05 | 5.5 ± 0.33 | 2.6 ± 0.16 |
| Cv/LIB/15 | 10.0 ± 2.96 | 4.8 ± 0.59 | 1.7 ± 0.33 |
| Cv/LIB/10 | 9.4 ± 1.69 | 5.7 ± 0.83 | 2.6 ± 0.27 |
| Cv/LIB/21 | 11.4 ± 2.01 | 5.7 ± 0.57 | 2.8 ± 0.13 |
| Cv/LIB/16 | 9.3 ± 1.93 | 5.1 ± 0.43 | 2.4 ± 0.22 |
| Cv/LIB/11 | 5.5 ± 1.04 | 4.1 ± 0.59 | 1.3 ± 0.16 |
| Cv/LIB/18 | 10.0 ± 1.48 | 6.9 ± 0.50 | 2.9 ± 0.10 |
| Cv/LIB/20 | 8.8 ± 1.47 | 5.7 ± 0.45 | 2.3 ± 0.16 |
| Cv/LIB/19 | 10.1 ± 1.57 | 6.2 ± 0.38 | 2.4 ± 0.16 |
| Cv/LIB/22 | 7.9 ± 0.85 | 6.4 ± 0.48 | 2.6 ± 0.16 |
| Cv/LIB/23 | 13.8 ± 1.37 | 6.5 ± 0.43 | 2.5 ± 0.17 |
| Cv/LIB/24 | 4.8 ± 1.05 | 3.3 ± 0.49 | 1.7 ± 0.29 |
| Cv/U/06 | 7.3 ± 1.32 | 5.4 ± 0.35 | 2.1 ± 0.23 |
| Cv/U/13 | 5.1 ± 0.82 | 6.0 ± 0.56 | 2.3 ± 0.21 |
| Cv/L/05 | 10.5 ± 1.34 | 7.1 ± 0.28 | 3.0 ± 0.00 |
| Cv/L/06 | 6.7 ± 1.30 | 4.6 ± 0.37 | 1.7 ± 0.15 |
| Cv/L/07 | 4.9 ± 1.17 | 5.7 ± 0.54 | 2.2 ± 0.32 |
| Cv/L/09 | 16.4 ± 2.23 | 6.3 ± 0.53 | 2.4 ± 0.16 |

de Lins *et al.*, 2015). Availability of some substrates in all the regions would not be always feasible, while the use of some substrates such as peat might not be environmentally sustainable considering their non-renewable nature (Udayana *et al.*, 2017).Also, use of non-soil substrates for air layering have been recommended for avoiding spread of plant nematodes in different crops (Poornima and Walia, 2021). Considering the superiority of CPC in the present study, it could be a viable and sustainable option from environment point of view as well as benefit of the propagation industry.

**Conclusion**

The influence of genotype (improved varieties and seedling collections) was observed in the air layering of cinnamon. Coir pith compost was found to support better root induction parameters, better root growth parameters and post-separation establishment in improved varieties of true cinnamon compared to conventionally used substrate. Further, use of coir pith compost as substrate favoured rooting process in 23 diverse collections thereby proving its utility in the collection and augmentation activities of cinnamon germplasm.

**Declaration of interest statement**

The authors declare that they do not have any relevant financial or non-financial interests to disclose.

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