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Variation in Rooting Response of Hardwood Cuttings in *Cinnamomum zeylanicum* Blume

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Abstract: Efficient delivery of improved and tested germplasm in a clonally propagated tree is often influenced by tree-to-tree variation for vegetative propagation. Though cinnamon is a very important and one of the oldest known tree spices of India, individual level and seed source level variations for rooting response of stem cuttings are not very well understood. An experiment was carried out at the College of Forestry, Sirsi, UAS, Dharwad during 2019-20 in which stem cuttings from 90 morphologically superior mother trees from five different geographical sources were tested for their rooting ability in a structured experiment. Not all mother trees produced rooted cuttings. Overall, significant tree-to tree variation was observed with respect to rooting per cent (range: 20.00 to 50.00 per cent), number of shoots, number of roots and number of leaves per cutting. However, the rooting ability was not influenced by the seed-source. Per cent rooting and number of roots per cutting were positively associated suggesting that mother trees that showed good rooting abilities tended to produce larger root biomass. Differences among mother trees for rooting ability of stem cuttings is neither contributed by the age of the mother tree, nor its girth / girth of the stem cuttings used for the experimentation, pointing to the genetic influence. It is suggested to include rooting ability as an important trait while selecting the superior types in cinnamon.

Keywords: Cinnamon, Vegetative propagation, Hardwood cuttings, Ortet, Rooting percent

Cinnamon, *Cinnamomum verum* Presl. (syn: *C. zeylanicum* Blume., Family: Lauraceae) is one of the earliest known and most important tree spice of India. It is cultivated as well as wild collected for its aromatic bark, leaf and immature fruits used extensively as a spice and as a medicine (Hanumantha et al., 2020; Hanumantha and Vasudeva 2022). India produces about 1659 tonnes of this spice and about 120-250 MT are imported annually. The genus *Cinnamomum* consists of about 250 species (Willis 1973) comprising of evergreen trees and shrubs. *Cinnamomum verum*, though indigenous to Sri Lanka, occurs naturally in the Western Ghats of India, which is considered as the secondary centre of origin. Cinnamon is propagated by either through seeds or clonally through cuttings or layers. Seeds of cinnamon are recalcitrant in nature and when sown immediately after harvest, they show 90-94 per cent germination; however, seeds loose viability quickly and complete loss of viability occurs after 40 days . Several workers have shown that cinnamon can be propagated through stem cuttings with three leaved young shoots (Nageswari et al., 2000, Joy et al., 2005). However, fine tune experiments to bring out the influence of seed sources and tree-to-tree variations have not been attempted (Hanumantha 2020). Such variations are important since efficient vegetative propagation and the delivery of improved and tested germplasm are at the heart of clonal horticulture or clonal forestry. These variations could be adopted in selection of higher yielding types when the traits are genetically correlated (Hanumantha and Vasudeva 2025). As propagation rates directly influence the economic viability, a challenge arises in those species which inherently have poor amenability to vegetative propagation and unpredictable rooting ability within a species.

The tree-to-tree variations for rooting ability are ignored while selecting the superior types of cinnamon perhaps because of lack good data on such variations. However in several forest tree species such variations have been thoroughly investigated and results have been mainstreamed for clonal propagation. For instance, considering over 2,39,000 stem cuttings from nearly 2200 clones of loblolly pine (*Pinus taeda* L.), Baltunis et al. (2005) have shown that rooting ability was controlled genetically with a broad sense heritability of 0.8. Studies on such variations in rooting response of cinnamon cuttings are very scanty. The present investigation was carried out to study the variation in rooting response of selected superior trees among different seed sources of *Cinnamomum zeylanicum*.

MATERIAL AND METHODS

The experiment was carried out at the College of Forestry, Sirsi, UAS, Dharwad during 2019-20 (N 14°36'21.8" and E 74°50'53.4" with temperature form 20°C to 32°C with mean annual temperature of 25 °C). Average annual rainfall of this site is 3395 mm with a mean relative humidity of 85 per cent.

During March-April 2018, about 106 morphologically superior and high yielding mother trees or candidate plus trees (CPTs) of cinnamon were selected in 8-10 years aged plantations from five different geographical sources *viz.,* Gejjehalli (Hangal), Jaddigadde (Sirsi), Kankodlu(Yellapur), Manchale (Sagar) and Siddapur (Hanumantha 2020).These sites are located right within the Western Ghats biodiversity hotspot. Cuttings were collected from 90 selected trees of cinnamon during June-July, 2019. Semi-hard wood cuttings of 20 cm length and 8.5 mm to 11.5 mm diameter with one or two leaves were prepared. The cuttings were planted in root trainers containing coir pith on the same day. Before planting, root trainers were drenched with 0.1 per cent fungicide Bavistin and finally the basal end of the stem cuttings were dipped in IBA (Indole Butyric Acid of 2000 ppm strength prepared in powder form) to enhance rooting. A total of 24 cuttings in three replications of 8 each were planted in root trainers for each selected tree and placed in a mist chamber and watering was done as when required. Planted cuttings started sprouting after 10-15 days and rooting started after one month after planting. Complete root development was noticed after 3 months. After three months the cuttings were evaluated for per cent rooting, number of shoots, number of leaves per shoot and number roots.

Statistical analysis: Data were analyzed using one way Anova in OPSTAT software.

RESULTS AND DISCUSSION

Good sprouting of stem cuttings was observed in all the 90 mother trees after two weeks of setting them in root trainers. However stem cuttings from only 26 mother trees survived beyond four weeks, suggesting an overall tree-level survival success of stem cuttings at 28.89 % (Table 1). In Siddapur source, stem cuttings from 50.00 % of mother trees showed survival followed by that of Kankodlu source (32.00%), the lowest survival success was shown in Gejjehalli source (20.00%). Overall the results indicated that out of 2160 stem cuttings set for rooting, 461 cuttings (21.34 %) showed rooting. Nageswari et al., (2000) obtained 50 per cent rooting when hard and semi-hard wood cuttings were treated with IAA at 100 ppm strength. Ananthan and Chezhiyan (2002) reported 82.6 per cent rooting of hard wood cuttings with 2500 ppm NAA. Considering the seed source as treatments, there was no significant variation in per cent rooting, mean number of shoots / roots / leaves per cutting (Table 2). This suggests that tree-to-tree variation is more important than the seed source variations. All the 26 mother trees (ortets) showed statistically significant tree-to tree variation with respect to rooting per cent, number of shoots, number of roots and number of leaves per cutting (Table 3). Ortet number S1 recorded highest rooting percent (50.00%), with highest mean number of roots (2.00), shoots (3.00) and moderately high number of leaves per cutting (4.00). The ortet number G23 showed the lowest per cent rooting (8.33 %) with relatively low number of roots/shoots (1.50) and leaves (3.83) per cutting. Co-efficient of variation was on moderately higher side in all the traits; for per cent rooting (28.97 %), roots per cutting (29.66%), number shoots

Table 1. Geo-locations, altitude, age of the plantations and sample size of mother trees considered

Seed source	District	Latitude	Longitude	Altitude (m above msl)	Age of the plantation (years)	No. of mother trees from which stem cuttings were collected	No. of mother trees showing rooting success
Gejjehalli	Haveri	N 14°44'14.9"	E 75°07'56.6"	584 m	08	25	05 (20.00 %)
Jaddigadde	Uttara Kannada	N 14°48'09.2"	E 74°44'32.9"	486 m	10	15	04 (26.6 %)
Kankodlu	Uttara Kannada	N 14°45'10.9"	E 74°50'53.9"	474 m	08	25	08 (32.00 %)
Manchale	Shimoga	N 14°10'21.9"	E 75°05'57.1"	624 m	08	15	04 (26.66%)
Siddapura	Uttara Kannada	N 14°20'14.8"	E 74°52'35.6"	584 m	9	10	05 (50.00%)
					Total	90	26 (28.89%)

Table 2. Seed source variation for percent rooting, number of shoots/roots/leaves per cutting (Mean±SEm)

Seed source	Percent rooting	Mean number of shoots per cutting	Mean number of roots per cutting	Mean number of leaves per cutting
Gejjehalli	12.50± 2.63	1.33± 0.10	2.30± 0.25	3.02± 0.29
Jaddigadde	26.04± 1.79	1.46± 0.16	1.50± 0.18	2.42± 0.20
Kankodlu	22.92± 3.16	1.42± 0.14	1.44± 0.16	3.23± 0.25
Manchale	16.67± 1.26	1.58± 0.12	1.71± 0.14	2.50± 0.24
Siddapura	25. 00± 3.22	1.61± 0.15	1.77± 0.26	2.93± 0.32
CD (p=0.05)	NS	NS	NS	NS

Table 3. Tree-to-tree variation in per cent rooting, mean number of shoots/roots/leaves per cutting in *Cinnamomum zeylanicum*

Seed source and Tree ID	Tree trunk girth (cm)	Mean diameter of stem cutting (mm)	Percent rooting of stem cuttings	Mean number of shoots per cutting after 90 days	Mean number of roots per cutting after 90 days	Mean number of leaves per cutting after 90 days
Gejjehalli						
G11	28.5	9.56	12.50a (16.90)	1.83	2.33	3.00
G16	38.0	9.20	16.67a (23.80)	1.17	1.50	2.33
G23	26.5	9.81	08.33a (13.80)	1.33	1.50	3.83
G24	39.0	10.74	12.50a (20.70)	1.00	4.33	3.83
G 25	33.0	9.17	25.00b (29.49)	1.33	1.83	2.17
CD (p=0.05)	--	0.86	(7.81)	0.30	0.74	0.85
Jaddigadde						
J1	28.0	9.01	20.83a (26.90)	1.67	1.50	2.33
J6	45.5	8.79	25.00a (30.00)	1.83	2.00	3.00
J7	43.5	9.62	25.00 a (29.49)	1.33	1.17	2.00
J25	28.2	9.12	33.33b (35.17)	1.00	1.33	2.33
CD (p=0.05)	--	NA	(5.40)	0.50	0.53	0.62
Kankodlu						
K3	33.0	9.70	25.00b (30.00)	1.17	1.33	3.33
K8	28.0	8.31	25.00b (29.49)	1.33	1.33	2.83
K9	27.5	7.70	37.50c (37.59)	2.00	1.17	4.83
K13	18.0	8.97	33.33c (35.17)	1.67	1.67	3.50
K16	23.5	9.38	25.00b (29.49)	1.83	1.17	2.83
K18	14.0	9.29	12.50a (20.70)	1.17	1.33	2.83
K20	14.0	8.94	12.50a (16.90)	1.17	1.67	3.83
K22	29.0	8.79	12.50a (20.70)	1.00	1.83	1.83
CD (p=0.05)	--	0.69	(9.15)	0.40	0.45	0.72
Manchale						
M1	18.0	9.02	16.67b (23.80)	1.50	1.67	2.67
M3	14.5	9.38	12.50a (20.70)	1.33	1.33	2.00
M7	19.0	9.12	16.67b (23.80)	1.67	1.83	2.33
M21	19.0	9.92	20.83b (26.90)	1.83	2.00	3.00
CD (p=0.05)	--	0.68	(3.820	0.36	0.42	0.73
Siddapura						
S1	39.0	8.54	50.00c (45.00)	2.00	3.00	4.00
S2	31.0	9.09	12.50a (20.70)	1.17	1.50	2.33
S5	18.0	9.27	12.50a (16.90)	1.00	1.17	2.00
S8	43.0	9.09	25.00b (30.00)	1.83	1.67	2.67
S9	50.0	11.47	25.00b (29.49)	2.00	1.50	3.67
CD (p=0.05)	--	0.95	(9.5)	0.44	0.77	0.94
Pooled over all sources						
Mean	28.80	9.27	21.31	1.47	1.72	2.90

* Values in the parenthesis indicate the arc sine transformed values
Mean values with same superscript within a seed source, do not statistically differ

(25.87%) and least for number of leaves (21.93%). Per cent rooting and number of roots per cutting were positively associated (Y = 0.064x + 0.350; R^2 = 0.855; r = 0.928) suggesting that mother trees that showed good rooting abilities tended to produce larger root biomass.

Tree to tree variation in rooting of stem cuttings reported in this study has been corroborated the results of several studies. Significant variation between cultivars and between Chemlali de Sfax clones was observed for rooting ability by Khabou and Drira (2000). Rooting of stem cuttings involve complex interactions of age of the mother tree, season of collection of stem cuttings, physiological condition of the cuttings, genetic interactions *etc*. In the current study the performance of a mother tree with respect to the per cent rooting was not significantly correlated with its trunk girth and average girth of the stem cuttings used for rooting . The age of the plantations considered in the study was similar, ranging from eight to ten years. These facts suggest that the differences among mother trees for rooting ability of stem cuttings is neither contributed by the age of the mother tree, nor its girth / girth of the stem cuttings used for the experimentation. Hence it may concluded that statistically significant tree-to-tree differences for rooting ability identified in this study perhaps represents the genetic potential of the mother trees.

Plate 1. Rooting response of hardwood cuttings in *Cinnamomum zeylanicum*

Genetic control of rooting percentages among stem cuttings has been variously attributed to provenance, family, and within-family effects. Foster et al. (2010) shown that rooting ability of stem cuttings originating from different clones(Loblolly pine) was virtually due to additive gene effects, with little evidence for dominance gene effects and with no epistasis. Baltunis et al. (2005) observed that rooting ability was controlled genetically with a broad sense heritability of 0.8 based on over 2,39,000 stem cuttings from nearly 2200 clones of loblolly pine (*Pinus taeda* L.). Shepherd et al. (2005) have shown that *P. elliottii* × *P. caribaea* hybrid families are highly variable for rooting percentage and root biomass and have moderate to strong clonal heritability. Rooting processes for the production of vegetative propagules of *Eucalyptus* such as micro-cutting and mini-cutting techniques have been used for the propagation of selected clones (superior trees), which allows considerable gains for commercial production due to higher rooting rates and a reduced time for mini-cutting formation (Stape et al., 2001, Titon et al., 2020). Chaitra Kotrabasappa Muddi and Hanumantha (2024) reported the source variation for rooting behavior in selected superior trees of cinnamon. Among the selected sources overall performance of Gejjehalli source was better (rooting: 46.67%) followed by Siddapura source with 2000 ppm IBA treatment; which may be due to family and within-family effects, genetic interactions with different concentrations of IBA treatment. The tree to tree variation for both rooting percentage and root biomass was extensive in cinnamon. The stronger genetic control and the greater economic imperative to increase rooting percentage suggest that it will have a higher priority for genetic improvement than root biomass.

CONCLUSION

Cinnamomum zeylanicum is one of the most valuable tree spices in Karnataka. Wide variability is present among the different species of cinnamon. The variations present among the different source can be used for identification of superior mother trees which respond better to vegetative reproduction. Wide variation was observed for rooting behavior among selected superior trees of different sources in *Cinnamomum zeylanicum*. Statistically significant tree-to-tree differences for rooting ability identified perhaps represents the genetic potential of the mother trees. Hence it is essential to consider the rooting ability while selecting individuals for large scale clonal propagation. The study helps to determine the variation among the selected superior trees/Candidate Plus Trees (CPT) for their rooting behavior and selecting the superior trees in cinnamon based on their rooting ability. Superior trees with early rooting/higher per cent of rooting can be further used for mass production of elite quality seedlings and distribution to farmers.

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