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Variation for Qualitative Leaf Morphometric Traits among Half-Sib Progenies of *Cinnamomum zeylanicum* Blume. in the Western Ghats (Hill zone), Karnataka

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***Abstract*:** *Cinnamomum zeylanicum* (Lauraceae) known as 'true cinnamon' or 'sweet wood', native species of Sri Lanka and the Indian West Coast, is commercially valuable tree spice in India. Cinnamon leaves are widely used as spice, and possess an essential oil rich in eugenol, which is a highly sought after by the perfume and flavour industries. The study was undertaken during 2018-2020 at College of Forestry, Sirsi, Uttara Kannada. Seeds were collected from 106 superior mother trees of five different sources during June-July and progenies were established in nursery. After 24 months, qualitative leaf traits of progenies were evaluated. Wide variation was observed with respect to leaf parameters among progenies of different sources and even some progenies exhibited variation from its mother plants. Leaf colour, leaf petiole colour and leaf margin serration is almost similar in all the progenies; progenies of tree G2 and K2 recorded light purple and purple colour petiole, respectively as this character is entirely different from the entire progenies. The majority of progenies exhibited light purple colour leaves (50.94%) followed by medium purple colour leaves (28.30%). Only two progenies, G2 and K2 recorded the purple colour petiole with sweet taste. Five types of leaf shapes (elliptic, oblong, ovate, ovate elliptic and ovate lanceolate) and four leaf tip shapes (acuminate, obtuse, acute and sub acute) were recorded among selected progenies. G2 progeny produced oblong shaped leaves and majority of the progenies recorded elliptic leaf shape (51.89%) and sub acute leaf tip shape (69.81%). There was no variation among the progenies with respect to leaf margin (all are entire type). Leaf markers that could be adopted easily to measure the magnitude of diversity, to select higher yielding types as well as for conservation.

***Keywords*:** Western Ghats, Cinnamon, Qualitative parameter, Leaf flush colour

Cinnamomum zeylanicum (Lauraceae) popularly known as 'true cinnamon/cinnamon' is a native of Sri Lanka and the West coast region of India (Ravindran et al., 2004). It is believed that the genus *Cinnamomum* has a centre of diversity in the Western Ghats and the adjoining regions of South India (Sasikumar et al., 1999). Wide variability of the *Cinnamomum* species occurs in the Western Ghats and in some parts of North Eastern states of India. Of all the characters, qualitative and quantitative leaf traits are highly variable in the genus *Cinnamomum* and this variation is seen both at species and sub species levels. (Ravindran et al., 2004, Hanumantha 2020, Hanumantha et al., 2020). Leaf characteristics are highly variable in the genus *Cinnamomum* and these variation in leaf parameters can be used to recognize and describe species level similarities Niharika and Hanumantha (2024).

The flushing time coincides with the monsoon. Four different flush colours are noted among the cinnamon collections, *viz*., pure purple, purple dominated with green, green dominated with purple and pure green. Considering parameters such as bark pungency, leaf morphology, grittiness of the bark and leaves, eight types of cinnamon are recognized by cinnamon growers in Sri Lanka (Ravindran et al., 2004). Morphological characters are markers that are adopted to measure the magnitude of diversity in plants based on the phenotype character (Lizawati et al., 2018). Interactions of genotype and environmental factors play a role in generating such wide variations when planted in varied environments (De Leon et al., 2016). These variations could be adopted in selection of higher yielding types when the traits are genetically correlated. For instance, Wijesinghe and Gunarathna (2001) has shown that there is a positive correlation between leaf size and shape with yield in seven different types of cinnamon and reported that with large round leaves had high bark yield; high cinnamaldehyde content in inwardly curved leaves and high quality oil from the small round leaves.

Wide variability of cinnamon is also present in farmers' fields of Karnataka in terms of leaf traits because most of the farmer's plant trees originating from un-tested and un-domesticated sources (Hanumantha et al., 2020). Therefore, it is necessary to assess the variation present in leaf morphometric traits among half sib progenies of cinnamon, collected and raised from different superior trees of the Central Western Ghats.

MATERIAL AND METHODS

The present study was undertaken during 2018-2020 at the College of Forestry, Sirsi, and at various field sites of hill zone of Karnataka. Uttara Kannada district located in the Central Western Ghats between 13° 55' to 15° 32' N latitude and 74° 05' to 75° 05' E longitude with a geographic area of 10,291 km^2.In this study five plantation areas in three districts of the Karnataka namely Uttara Kannada (Jaddigadde, Kankodlu and Siddapura), Shivamogga (Manchale) and Haveri (Gejjehalli) (Table 1). Superior trees in each plantation were selected based on eye ball screening and based on the experience of the plantation owners. Totally 106 mother trees were selected from five even aged plantations (Table 1). Seeds were collected from the selected 106 mother trees and progenies were established. After 24 months qualitative leaf parameters were recorded for the progenies and data was used for further tabulation.

Table 1. Details of mother tree sources with their IDs

Place of collection	Taluk	Tree IDs	Number superior trees selected
Gejjehalli	Hangal	G1 to G25	25
Jaddigadde	Sirsi	J1 to J25	25
Kankodlu	Yellapur	K1 to K25	25
Manchale	Sagara	M1 to M21	21
Siddapura	Siddapura	S1 to S10	10
Total			106

RESULTS AND DISCUSSION

Variation in qualitative leaf parameters among half sib progenies: Wide variation was observed with respect to leaf parameters among progenies of different sources and even some progenies exhibited variation from its mother plants. Leaf colour, leaf petiole colour and leaf margin serration is almost similar in all the progenies; progenies of tree number G2 and K2 recorded light purple and purple colour petiole respectively as this character is entirely different from the entire progenies (Table 4, 6). The leaf colour and leaf margin serration is almost similar in the entire progenies and noticed dark green colour leaves and entire leaf margin serration (Table 4-8). In leaf colour, from Jaddigadde three progenies

Table 2. Brief review of the works carried out on leaf parameters of cinnamon trees/progenies

Leaf parameter	Procedure/descriptors used	Reference
Leaf flush colour	Green, Light pink / purple, Medium pink / purple, Deep pink / purple, Very deep pink/purple	Krishnamoorthy et al (1988) and (1992), Joy et al (1998)
Petiole colour	Green, Light purple, Purple	--
Leaf colour	Pale / light green, Green, Dark Green	Joy et al (1998), Azad et al (2016), Lizawatiet al (2018)
Leaf shape	Elliptic, Ovate, Ovate-elliptic Ovate-lanceolate Oblong	
Leaf tip/apex shape	Obtuse, Sub-acute, Acuminate, Acute	
Leaf margin serration	Entire and Wavy	
Leaf parameter variations for mother trees (Plantation trees)	Variation for leaf flush colour, leaf colour, leaf tip shape, leaf margin, leaf shape, petiole colour among different sources and mother trees	Hanumantha et al (2020)
Leaf parameter variations among mother trees (Natural trees)	Variation for leaf flush colour, leaf colour, leaf tip shape, leaf margin, leaf shape and petiole colour, among different sources and mother trees	Sourav Manoharan and Hanumantha (2023)

Table 3. Geo-locations and characteristic forest types of the seed sources of progenies considered in the study

Seed source	District, nearest forest type, population size of Cinnamon trees	Latitude & longitude	Altitude (m)	Number of mother trees selected	No. of progenies raised from each source	No. of progenies raised and evaluated per mother tree
Gajjehalli	Haveri Scrub forest (n=200)	N 14°44'14.9" E 75°07'56.6"	584 m	25	25	30
Jaddigadde	Uttara Kannada Semi-evergreen forest (n=200)	N 14°48'09.2" E 74°44'32.9"	486 m	25	15	30
Kankodlu	Uttara Kannada Evergreen forest (n= 450)	N 14°45'10.9" E 74°50'53.9"	474 m	25	25	30
Manchale	Shivamogga Semi-evergreen forest (n=450)	N 14°10'21.9" E 75°05'57.1"	624 m	21	15	30
Siddapura	Uttara Kannada Evergreen forest (n=100)	N 14°20'14.8" E 74°52'35.6"	584 m	10	10	30
Total					90	

(J1, J8 and J24), Kankodlu two progenies (K1 and K23) and from Manchale five progenies (M1, M12, M14, M17 and M18) recorded green coloured leaves. Leaf flush colour among progenies of different sources varied from green colour to pink colour; only three progenies G25, J4 and K2 recorded purple colour and remaining all progenies recorded from green to medium pink flush colour. With respect to leaf shape, the progenies recorded ovate, elliptic, ovate lanceolate, ovate elliptic shaped leaves; but interestingly G2 showed oblong shaped leaves (Table 4). Leaf tip also varied among progenies; majority of the progeny leaves recorded sub-acute tip shape followed by acuminate leaf tip shape; but tree number M1 showed obtuse leaf tip shape.

Among all 90 progenies (Fig. 1), majority of progenies exhibited light purple colour leaves (50.94%) followed by medium purple colour leaves (28.30%), only 3.78 per cent of the progenies recorded purple colour leaf flush and remaining progenies recorded green flush colour (16.98%). With respect to mature leaf colour (Fig. 2) majority of progenies produced dark green colour leaves (85.85%) followed by green colour leaves (14.15%). Only little variation was observed among the progenies for leaf petiole colour; only two progenies differed for petiole colour. Progeny of K2 (Kankodlu) exhibited purple colour petiole followed by progeny of G2 (Gejjehalli) light purple colour petiole and remaining 88 progenies recorded green colour petiole. Variation with respect to leaf shape and leaf tip shape also recorded among selected progenies (Fig. 3, 4). Five types of leaf shapes (elliptic, oblong, ovate, ovate elliptic and ovate lanceolate) and four leaf tip shapes (acuminate, obtuse, acute and sub acute) were recorded among selected progenies. Among all the progenies only G2 progeny produced oblong

Table 4. Variation for qualitative leaf characteristics among progenies of *C. zeylanicum* (Gejjehalli)

Progeny No.	Leaf flush colour	Leaf colour	Leaf shape	Leaf tip shape
G1	2	3	Ovate	Sub-Acute
G2	3	3	Oblong	Sub-Acute
G3	2	3	Ovate-Lanceolate	Sub-Acute
G4	2	3	Ovate-Lanceolate	Acuminate
G5	3	2	Ovate	Acuminate
G6	2	3	Elliptic	Sub-Acute
G7	2	3	Ovate-Lanceolate	Sub-Acute
G8	2	3	Elliptic	Sub-Acute
G9	1	3	Ovate-Lanceolate	Acuminate
G10	3	2	Elliptic	Acuminate
G11	3	3	Ovate	Sub-Acute
G12	1	3	Elliptic	Sub-Acute
G13	3	3	Elliptic	Sub-Acute
G14	2	3	Ovate	Sub-Acute
G15	2	3	Elliptic	Acuminate
G16	3	3	Elliptic	Sub-Acute
G17	1	3	Ovate	Sub-Acute
G18	2	3	Elliptic	Sub-Acute
G19	2	3	Ovate	Sub-Acute
G20	1	3	Elliptic	Sub-Acute
G21	2	3	Elliptic	Sub-Acute
G22	1	3	Elliptic	Sub-Acute
G23	2	3	Ovate	Sub-Acute
G24	3	3	Elliptic	Sub-Acute
G25	4	3	Elliptic	Sub-Acute

* All the progenies exhibited green petiole colour; but G2 exhibited light purple colour
**All the progenies exhibited entire leaf margin serration
Leaf flush colour: 1= Green 2= Light purple 3= Medium purple 4= Purple 5= Dark purple
Leaf colour: 1=Light green 2= Green 3= Dark green

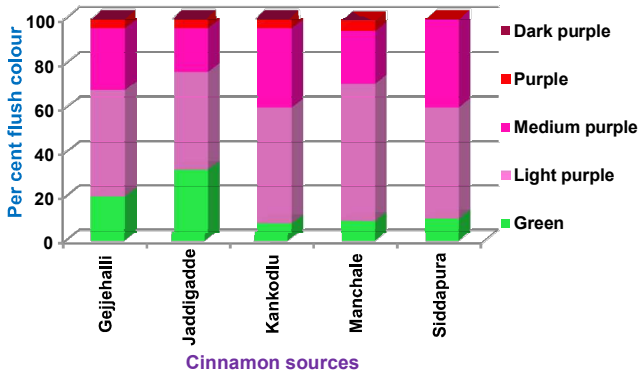


Fig. 1. Variation in leaf flush colour among progenies of different sources

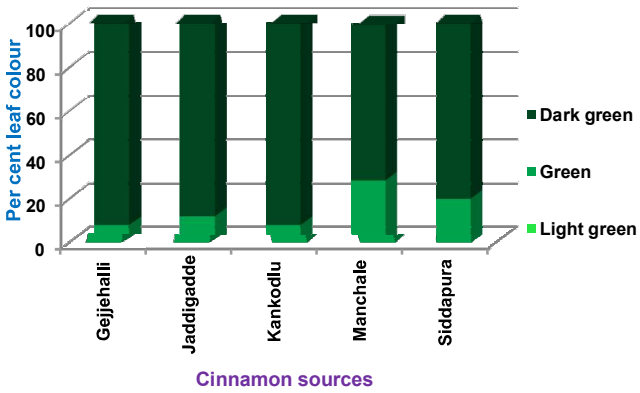


Fig. 2. Variation in leaf colour among progenies of different sources

Table 5. Variation for qualitative leaf characteristics among progenies of *C. zeylanicum* (Jaddigadde)

Progeny No.	Leaf flush colour	Leaf colour	Leaf shape	Leaf tip shape
J1	2.0	2.0	Ovate	Acuminate
J2	3.0	3.0	Ovate	Acuminate
J3	2.0	3.0	Ovate	Sub-Acute
J4	4.0	3.0	Elliptic	Sub-Acute
J5	1.0	3.0	Elliptic	Acuminate
J6	2.0	3.0	Elliptic	Sub-Acute
J7	3.0	3.0	Ovate	Acuminate
J8	1.0	2.0	Elliptic	Acuminate
J9	2.0	3.0	Elliptic	Sub-Acute
J10	1.0	3.0	Elliptic	Acuminate
J11	3.0	3.0	Ovate	Sub-Acute
J12	2.0	3.0	Elliptic	Sub-Acute
J13	2.0	3.0	Elliptic	Acuminate
J14	2.0	3.0	Elliptic	Sub-Acute
J15	1.0	3.0	Ovate-Elliptic	Sub-Acute
J16	1.0	3.0	Elliptic	Sub-Acute
J17	2.0	3.0	Ovate	Sub-Acute
J18	3.0	3.0	Elliptic	Sub-Acute
J19	1.0	3.0	Elliptic	Acuminate
J20	2.0	3.0	Elliptic	Sub-Acute
J21	2.0	3.0	Ovate	Sub-Acute
J22	2.0	3.0	Elliptic	Sub-Acute
J23	1.0	3.0	Ovate-Elliptic	Acuminate
J24	1.0	2.0	Elliptic	Sub-Acute
J25	3.0	3.0	Elliptic	Sub-Acute

*All the progenies exhibited green petiole colour
** All the progenies exhibited entire leaf margin serration
*** See the Table 2 for details of leaf flush colour and leaf colour

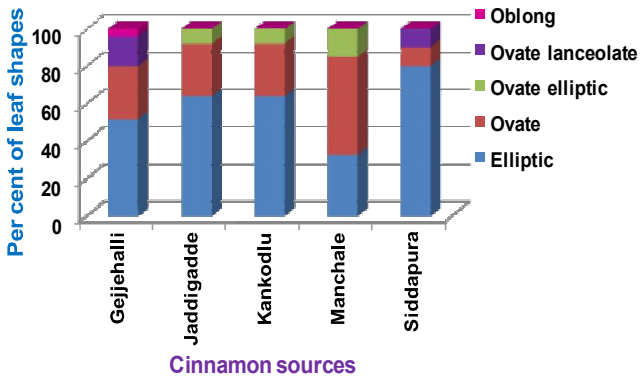


Fig. 3. Variation in leaf shape among progenies of different sources

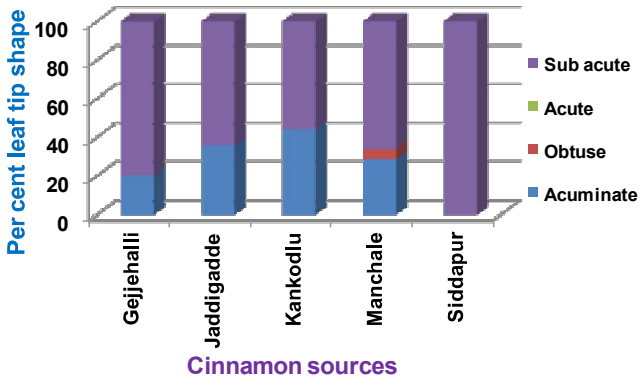


Fig. 4. Variation in leaf tip shape among progenies of different sources

Table 6. Variation for qualitative leaf characteristics among progenies of *C. zeylanicum* (Kankodlu)

Tree No.	Leaf flush colour	Leaf colour	Leaf shape	Leaf tip shape
K1	2	2	Ovate	Sub-Acute
K2	4	3	Ovate	Sub-Acute
K3	3	3	Ovate	Sub-Acute
K4	3	3	Elliptic	Acuminate
K5	2	3	Elliptic	Sub-Acute
K6	3	3	Elliptic	Acuminate
K7	3	3	Elliptic	Acuminate
K8	1	3	Elliptic	Acuminate
K9	3	3	Elliptic	Sub-Acute
K10	1	3	Elliptic	Sub-Acute
K11	2	3	Ovate	Sub-Acute
K12	2	3	Ovate	Sub-Acute
K13	3	3	Elliptic	Sub-Acute
K14	3	3	Elliptic	Acuminate
K15	2	3	Elliptic	Sub-Acute
K16	3	3	Ovate-Lanceolate	Sub-Acute
K17	2	3	Ovate	Acuminate
K18	2	3	Elliptic	Acuminate
K19	3	3	Ovate	Sub-Acute
K20	2	3	Ovate-Lanceolate	Acuminate
K21	2	3	Ovate-Lanceolate	Sub-Acute
K22	2	3	Ovate	Acuminate
K23	2	2	Ovate	Acuminate
K24	2	3	Ovate	Sub-Acute
K25	2	3	Ovate	Acuminate

* All the progenies exhibited green petiole colour; but K2 exhibited light purple colour
**All the progenies exhibited entire leaf margin serration
*** See the Table 2 for details of leaf flush colour and leaf colour

shaped leaves. Majority of the progenies recorded elliptic leaf shape (51.89%) and sub acute leaf tip shape (69.81%) leaves. There was no variation among the progenies with respect to leaf margin (all are entire margin type).

Characterization of qualitative traits of half sib progenies : Wide variation was observed with respect to leaf parameters among progenies of different sources and some progenies exhibited variation from its mother plants. Leaf flush colour among progenies of different sources varied from green colour to pink colour (Fig. 1). Only three progenies G25, J4 and K2 recorded purple colour and remaining all progenies exhibited green to medium pink flush colour (Plate 1a). The progenies recorded ovate, elliptic, ovate lanceolate, ovate elliptic shaped leaves; but

Table 7. Variation for qualitative leaf characteristics among progenies of *C. zeylanicum* (Manchale)

Progeny No.	Leaf flush colour	Leaf colour	Leaf shape	Leaf tip shape
M1	2.0	2.0	Elliptic	Obtuse
M2	2.0	3.0	Elliptic	Sub-Acute
M3	2.0	3.0	Ovate-Elliptic	Acuminate
M4	2.0	3.0	Ovate	Sub-Acute
M5	3.0	3.0	Ovate-Elliptic	Sub-Acute
M6	2.0	3.0	Ovate	Sub-Acute
M7	2.0	3.0	Elliptic	Sub-Acute
M8	2.0	3.0	Ovate	Sub-Acute
M9	2.0	2.0	Ovate	Sub-Acute
M10	3.0	3.0	Ovate	Acuminate
M11	2.0	3.0	Ovate	Sub-Acute
M12	3.0	2.0	Elliptic	Acuminate
M13	2.0	3.0	Ovate	Sub-Acute
M14	2.0	2.0	Ovate	Acuminate
M15	1.0	3.0	Elliptic	Sub-Acute
M16	3.0	3.0	Ovate-Elliptic	Sub-Acute
M17	1.0	2.0	Ovate	Acuminate
M18	2.0	2.0	Elliptic	Acuminate
M19	4.0	3.0	Ovate	Sub-Acute
M20	2.0	3.0	Ovate	Sub-Acute
M21	3.0	3.0	Elliptic	Sub-Acute
Mean	2.20	2.70		
S.D	0.70	0.46		
C.V (%)	31.29	17.05		

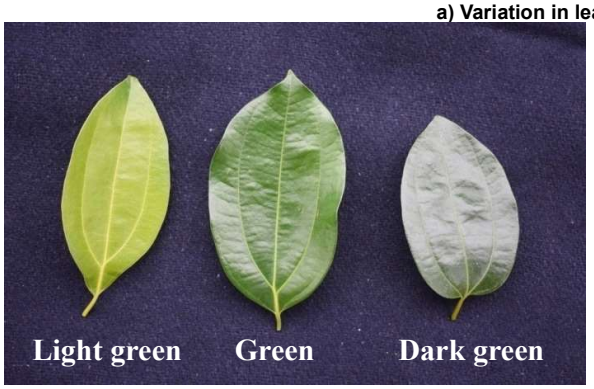
*All the progenies exhibited green petiole colour; ** All the progenies exhibited entire leaf margin serration
*** See the Table 4 for details of leaf flush colour and leaf colour

Table 8. Variation for qualitative leaf characteristics among progenies of *C. zeylanicum* (Siddapura)

Progeny No.	Leaf flush colour	Leaf colour	Leaf shape	Leaf tip shape
S1	3.0	3.0	Elliptic	Sub-Acute
S2	2.0	3.0	Elliptic	Sub-Acute
S3	2.0	2.0	Elliptic	Sub-Acute
S4	3.0	3.0	Elliptic	Sub-Acute
S5	2.0	3.0	Elliptic	Sub-Acute
S6	2.0	3.0	Elliptic	Sub-Acute
S7	2.0	2.0	Ovate-Lanceolate	Sub-Acute
S8	1.0	3.0	Ovate	Sub-Acute
S9	3.0	3.0	Elliptic	Sub-Acute
S10	3.0	3.0	Elliptic	Sub-Acute

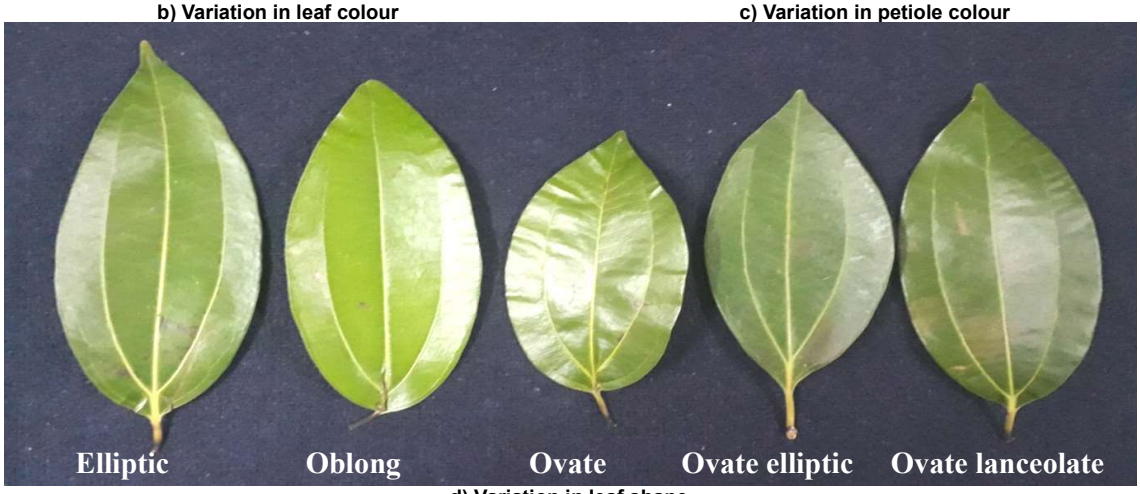
*All the progenies exhibited green petiole colour; ** All the progenies exhibited entire leaf margin serration
*** See the Table 4 for details of leaf flush colour and leaf colour

a) Variation in leaf flush colour

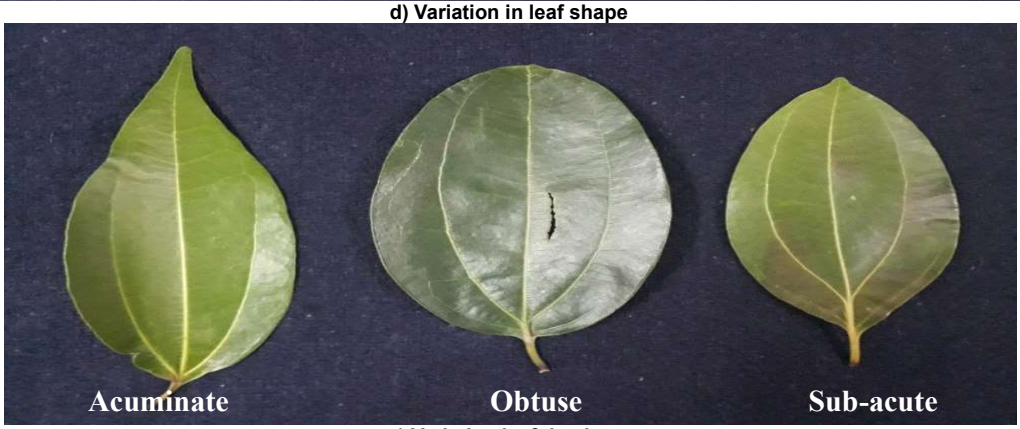


b) Variation in leaf colour

c) Variation in petiole colour



d) Variation in leaf shape



e) Variation leaf tip shape

Plate 1. Variation in leaf morphology among selected progenies of *C. zeylanicum*

interestingly G2 showed oblong shaped leaves (Plate 1d). Leaf tip also varied among progenies; majority of the progeny leaves recorded sub-acute leaf tip shape followed by acuminate leaf tip shape; but progeny of tree M1 showed obtuse leaf tip shape (Plate 1e). Over all, among 90 progenies, majority of trees exhibited light purple colour leaf flush (50.94%) followed by medium purple colour leaf flush (28.30%), 3.78 per cent of the progenies recorded purple colour leaf flush and 16.98 per cent green flush colour. In mature leaf colour (Fig 1, Plate b), majority of progenies produced dark green colour leaves (85.85%) followed by green colour leaves (14.15%). Little variation was observed among progenies for leaf petiole colour; only two progenies differed for petiole colour. Progeny of K2 (Kankodlu) exhibited purple colour petiole followed by progeny of G2 (Gejjehalli) light purple colour petiole and remaining progenies recorded green colour petiole (Plate 1c). Variation with respect to leaf shape and leaf tip shape also recorded among the progenies (Fig. 3, 4). Among all the progenies only G2 progeny produced oblong shape leaves. Majority of the progenies recorded elliptic shape leaves (51.89%) followed by ovate (34.91%) and for leaf tip shape sub-acute tip shape (69.81%) is dominated followed by acuminate type (29.25%). All the progenies leaves showed entire margin type. Several authors reported variations in leaf flush colour, leaf colour, leaf shape, leaf tip shape and leaf margin as reported in mother trees.

Variation between mother trees and progenies also observed for leaf parameters. Majority of the progenies expressed sub-acute type leaf tips as compared to mother trees. In progenies oblong leaf shape is recorded only for one progeny (G2). Azad et al (2015) reported variation in leaf characteristics (leaf shape, leaf base and leaf apex) of mother trees and progenies. Having different alleles in population, cross pollination can help different allelic combinations in the progeny. Such different allelic combinations can lead to new phenotypes in the progeny. Hanumantha et al (2020) reported elliptic, ovate, ovate-elliptic and ovate lanceolate leaf shape and sub-acute leaf tip shape followed by obtuse and acuminate among the majority of selected trees in *Cinnamomum zeylanicum.* Sourav Manoharan and Hanumantha (2023) reported five types of leaf shapes *viz.,* elliptic, oblong, ovate, ovate-elliptic and ovate lanceolate and four types of leaf apex *viz.,* acuminate, acute, sub-acute and obtuse among trees of six different sources in Uttara Kannada, Karnataka. Elliptic leaf shape and acuminate leaf tip was predominantly expressed and suggested that leaf morphometric traits could be easily used to measure the magnitude of diversity. Dattappa et al (2023) reported variation among 15 half sib progenies of cinnamon for leaf weight, leaf area and leaf weight per plant.

Variation in petiole colour was recorded for the first time in cinnamon and two progenies namely G2 and K2 exhibited purple coloured petioles. Even the taste and pungency of the petiole is entirely different from the other progenies; they have sweeter taste and lesser pungency. This character can be utilized for differentiating the individuals of cinnamon for future selection purposes. Cinnamon develops wide variety of flush colours and ranges from green to deep purple. Significant positive correlation between leaf flush colour and leaf oil content was observed suggesting genotypes with dark purple colour flush tend to possess higher in the leaf oil content. Hence, the leaf flush colour can be used as important qualitative parameter for selection of trees with high oil content. The quick visual observation of purple leaf flush colour will be useful for selection for higher leaf oil yield at least in preliminary screening. The study demonstrated that traits such as leaf colour, flush colour, leaf margin, leaf shape and leaf petiole traits could be considered while developing Distinctness, Uniformity and Stability (DUS) traits as descriptors.

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 good genotypes based on the results of progeny tests. Wide variation was observed for leaf characteristics among progenies of different sources in *Cinnamomum zeylanicum*. Five morpho-types with respect to leaf shapes *viz*. elliptic, oblong, ovate, ovate elliptic and ovate lanceolate were recorded, in which elliptic type of leaf shape was predominant. With respect to leaf tip shapes, four types *viz*., acuminate, obtuse, acute and sub-acute types were recorded among which, sub-acute tip shape was predominant. Only two trees (K2 from Kankodlu and G2 from Gejjehalli source) showed purplish colouration; all other trees showed green petiole colour. Leaf flush colour is considered as indicator of higher essential oil and can be used as marker for indirect selection of higher oil yielding trees. Leaf markers that could be adopted to easily measure the magnitude of diversity, to select higher yielding types as well as for conservation.

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