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Seed source variation for leaf morphological traits of *Cinnamomum zeylanicum* in the central western ghats of Karnataka: Implications for Domestication

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Abstract
Cinnamomum zeylanicum (Lauraceae) known as 'true cinnamon' or 'sweet wood', is a native species of Sri Lanka and the Indian West Coast. Cinnamon leaves are widely used as spice, and for the extraction of an essential oil rich in eugenol, which is a highly sought after by the perfume and flavour industries. The study was undertaken during 2017-19 at various field sites of Central Western Ghats of Karnataka to characterize the leaf morphology of cinnamon. About 106 mother trees were selected from five different sources and both qualitative and quantitative leaf traits were evaluated. Wide variation was recorded between trees and sources for leaf parameters. Higher coefficient of variation among different leaf traits was observed for leaf colour followed by leaf flush colour. Among the selected trees, ovate shaped leaves with sub acute type of leaf tip was dominantly recorded. Only two trees G2 and K2 recorded the purple colour petiole with sweet taste. The leaves of trees from Jaddigadde source were larger in size, while those from Kankodlu and Siddapur source showed smaller size. Leaf markers that could be adopted to easily measure the magnitude of diversity, to select higher yielding types as well as for conservation.

Keywords: Western ghats, cinnamon, qualitative parameter, leaf flush colour, purple colour

Introduction
Cinnamomum zeylanicum (Lauraceae) popularly known as 'true cinnamon' is a native of Sri Lanka and the West coast region of India (Ravindran *et al.*, 2004) [16]. 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) [17]. Wide variability of the plant species occurs in the Western Ghats and in some parts of North Eastern states of India (Joy *et al.*, 1998) [9]. Cinnamon leaves are widely used for spice production, preparation of food items and extraction of essential oil. Leaf oil is a rich source of eugenol. The other constituents of the leaf oil are cinnamic aldehyde, benzaldehyde, pinene, phellandrene, methyl eugenol, geraniol, caryophyllene, *etc.* Leaf oil has tremendous use in flavouring industry and is often used as a substitute to the clove oil. Eugenol, the main constituent of the leaf oil, is used as starting material in the synthesis of several components of perfumery, flavouring and medicinal importance (Guenther, 1950) [8]. *C. zeylanicum* is also adopted in folk medicine as antispasmodic, carminative, stimulating, digestive, astringent, aphrodisiacal, antiseptic, antioxidant, aromatic, hypertensive, sedative and vasodilator agent (Lima *et al.*, 2005) [13]. India produced about 1659 tonnes of cinnamon spice in an area of 774 ha in 2006-07 and import from other countries ranges from 120-250 MT per annum (Singh and Singh, 2008) [18]. Presently, India has about 2800 ha area of cinnamon with 5050 tonnes production and Karnataka produces only about 0.2 per cent of the total production of the country (Anandaraj, 2015) [2].

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. Most of the economically valuable species of cinnamon possess triple-nerved leaves, except in camphor (*C. camphor*) where the leaves are penni-nerved. Leaf shape of cinnamon varies from oval to elliptic to lanceolate-oval or narrowly elliptic, leaf apex shortly or broadly acuminate and leaf base acutish or cuneate (Ravindran *et al.*, 2004) [17]. 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 (Wijesekera

et al., 1975). Krishnamoorthy *et al.* (1992) [12] have shown a large variation in leaf length, leaf breadth and leaf size index in *Cinnamomum zeylanicum.*

Morphological characters are markers that are adopted to measure the magnitude of diversity in plants based on the phenotype character (Lizawati *et al.*, 2018) [15]. Interactions of genotype and environmental factors play a role in generating such wide variations when planted in varied environments (Allard and Bradshaw, 1964; De Lenon *et al.* 2016) [1, 6]. In fact these variations could be adopted in selection of higher yielding types when the traits are genetically correlated. For instance, 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. A determination and comparison of morphological / biochemical variations among cultivated and commercial types helps in their genetic improvement, augments the domestication process of the species as well as aids in the development of cinnamon based industries (Ariyarathne *et al.*, 2018) [3]. However, there are no reports documenting leaf morphological variations in *Cinnamomum zeylanicum* of the central Western Ghats of India. Therefore, it is necessary to explore and characterize the leaf morphology of cinnamon planted in diverse areas of the Central Western Ghats.

Material and Methods

The present study was undertaken during 2017-19 at the College of Forestry, Sirsi, and at various field sites of hill zone of Karnataka. Uttara Kannada district is 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. The district shares its boundaries with Goa and Belagavi in north, Dharwad, Haveri and Shivamogga in the east and Udupi in the south. The Arabian sea borders on the west creating long continuous coast line, through narrow coastline stretching 120 km.

Study area consists of five plantation areas in three districts of the Karnataka namely Uttara Kannada, Shivamogga and Haveri (Table 1). Within these three districts mother trees were selected at Gejjehalli (Haveri district), Jaddigadde (Uttara Kannada, district), Kankodlu (Uttara Kannada, district), Manchale (Shivamogga, district) and Siddapura (Uttara Kannada, district).

Table 1: Geo-locations and characteristic forest types of the seed sources considered in the study

Seed Source	District, Nearest forest type, Population size of Cinnamon trees	Latitude	Longitude	Altitude (m)	Number of mother trees evaluated
Gajjehalli	Haveri Scrub forest (n=200)	N 14°44'14.9"	E 75°07'56.6"	584 m	25
Jaddigadde	Uttara Kannada Semi-evergreen forest (n=200)	N 14°48'09.2"	E 74°44'32.9"	486 m	25
Kankodlu	Uttara Kannada Evergreen forest (n= 450)	N 14°45'10.9"	E 74°50'53.9"	474 m	25
Manchale	Shivamogga Semi-evergreen forest (n=450)	N 14°10'21.9"	E 75°05'57.1"	624 m	21
Siddapura	Uttara Kannada Evergreen forest (n=100)	N 14°20'14.8"	E 74°52'35.6"	584 m	10
Total					106

Cinnamon plantations were identified by interacting with various state departments and progressive farmers. Among the 20 plantations assessed, five plantations of 8-10 years old were selected in different parts of Uttara Kannada, Shivamogga and Haveri districts of Karnataka. In each plantation 10-25 best trees were identified to undertake the characterization of leaf traits of mother trees. Superior trees in each plantation were selected based on eye ball screening and based on the experience of the plantation owners. The trees were marked and data was recorded to assess the different traits. Totally 106 mother trees were selected from five even aged plantations of Gejjehalli (Hangal), Jaddigadde (Sirsi), Kankodlu (Yellapur), Manchale and Siddapura (Siddapura). The mother trees selcted were given site specific codings / I.D. and used for data tabulation.

Gejjehalli (Hangal): G1 to G25
Jaddigadde (Sirsi): J1 to J25
Kankodlu (Yellapur): K1 to K25
Manchale (Sagara): M1 to M21
Siddapura (Siddapura): S1 to S10

Table 2: Observations on following leaf parameters were taken for recording the variation between trees and sources

Sl. No.	Leaf parameter	Procedure/descriptors used	Reference
1	Leaf length (cm)	Measured using measuring scale	--
2	Leaf breadth (cm)	Measured using measuring scale at three positions of the leaf and average value taken	--
3	Leaf area per plant (cm^2)	Recorded using leaf area meter (LI-COR-LI-3000C model)	--
4	Leaf flush colour	Green, Light pink / purple, Medium pink / purple, Deep pink / purple, Very deep pink/purple	Krishnamoorthy *et al.* (1988) and (1992) [10, 12]; Joy *et al.* (1998) [9]
5	Petiole colour	Green, Light purple, Purple	--
6	Leaf colour	Plae / light green, Green, Dark Green	Azad *et al.* (2016) [4]; Joy *et al.* (1998) [9]; Lizawati *et al.* (2018) [15]
7	Leaf shape	Elliptic, Ovate, Ovate-elliptic Ovate-lanceolate Oblong	
8	Leaf tip/apex shape	Obtuse, Sub-acute, Acuminate, Acute	
9	Leaf margin serration	Entire and Wavy	

Results and Discussion

Wide variation in leaf parameters was noticed among the selected trees of different sources. Leaf flush colour varied from green to deep purple colour; however, deep purple colour flush was recorded in only two trees (G2 and J11) and remaining trees exhibited purple to green colour. Higher coefficient of variation in leaf flush colour was recorded among trees of Siddapura source (41.77%) and least for Manchale (25.45%). Leaf colour also showed higher variation among the selected trees of different sources. Higher co-efficient of variation was observed for Jaddigadde (47.68%) and Kankodlu (45.81%) source, which it was least in Gejjehalli (26.67%). Leaf petiole colour and leaf margin traits showed uniformity without much variation. Only two trees (G2 and K2) exhibited light purple and purple colour petiole; all the tree leaves recorded only entire margin type. Leaf shape also varied among the trees and even between sources. Four types of leaf shapes *viz.* elliptic, ovate, ovate-elliptic, ovate-lanceolate and four types of leaf tips *viz*. acuminate, obtuse, acute and sub-acute were recorded among 106 selected trees. Interestingly, only one (J9) exhibited acute type of leaf tip shape. Among 106 trees screened, 44 trees exhibited ovate leaf shapes followed by elliptic leaf shapes (36 trees) and least proportion was by the ovate lanceolate type shape. Similar trend was noticed with respect to leaf tip shapes; maximum number of trees exhibited sub-acute type leaf tip (71 trees) followed by obtuse shaped leaf tip (18 trees) and acuminate shaped leaf tip (16 trees).

Considering the leaf flush colour, among the 106 trees, light purple colouration (39.62%) and medium purple colouration (38.68%) was predominantly expressed; 12.25 per cent of the trees recorded purple colour leaf flush and only 1.90 per cent trees exhibited dark purple coloured leaves and 7.55 per cent trees recorded green flush colour (Fig 1). With respect to mature leaf colour (Fig 2), majority trees expressed dark green coloured leaves (39.62%) followed by those with light green (31.13%) and remaining trees showed green colour leaves (29.25%).

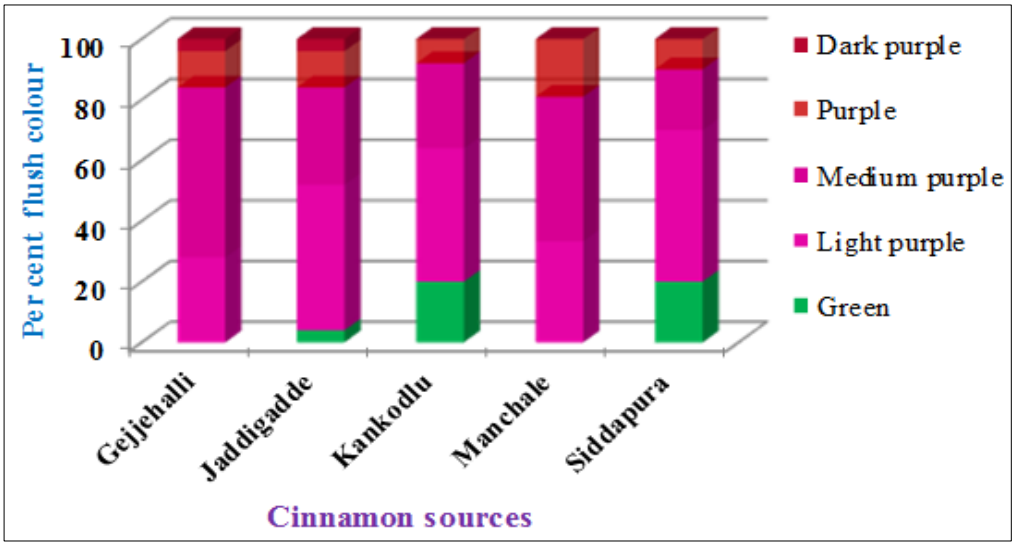


Fig 1: Variation in leaf flush colour among selected trees of different sources

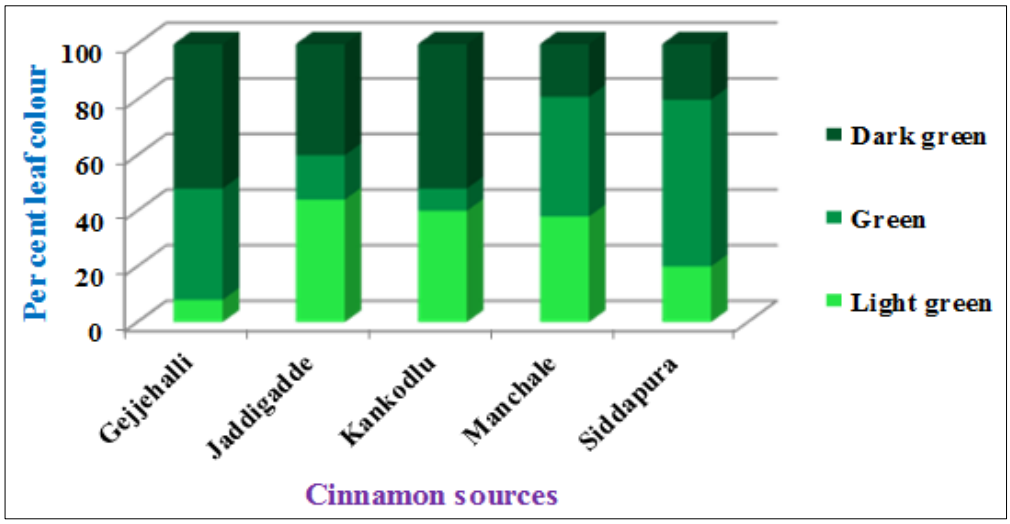


Fig 2: Variation in leaf colour among selected trees of different sources

With respect to the leaf petiole colour, only two trees (K2 from Kankodlu and G2 from Gejjehalli source) showed purplish colouration; all other trees showed green petiole colour. Four morpho-types with respect to leaf shapes *viz.* elliptic, ovate, ovate elliptic and ovate lanceolate were recorded (Fig 3), in which ovate type of leaf shape was predominant (41.51%). With respect to leaf tip shapes, four types *viz*., acuminate, obtuse, acute and sub acute types were recorded (Fig 4) among which, sub-acute tip shape (66.98%) was predominant. In all the trees screened, leaves had 'entire' leaf margin type.

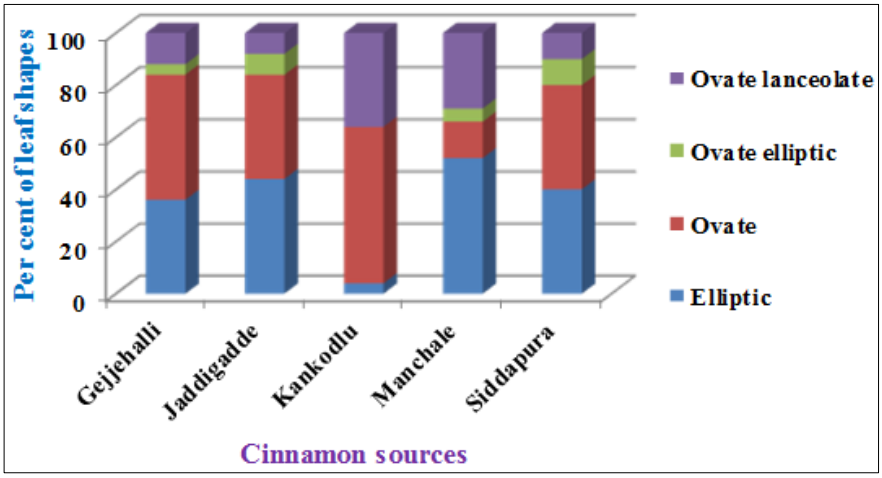


Fig 3: Variation in leaf shape among selected trees of different sources

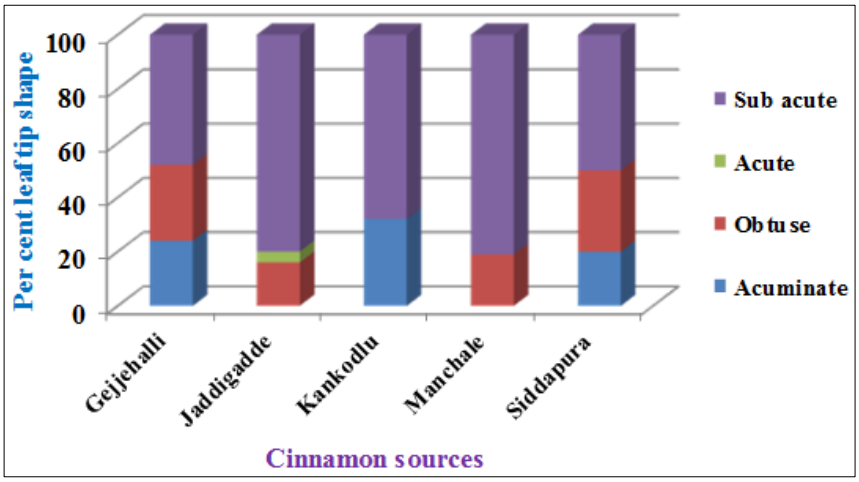
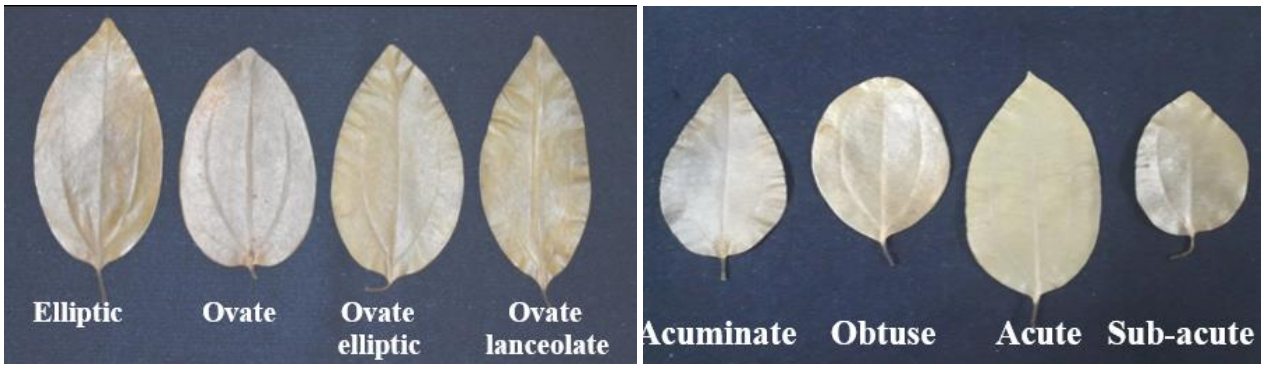


Fig 4: Variation in leaf tip shape among selected trees of different sources

a) Variation in leaf flush colour in *C. zeylanicum*

b) Variation in leaf colour in *C. zeylanicum*

c) Variation in petiole colour in *C. zeylanicum*



d) Variation in leaf shape in *C. zeylanicum* e) Variation leaf tip shape in *C. zeylanicum*

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

Considering the quantitative traits, significant within and between source variation was found with respect to leaf length (Table 3), leaf width (Table 6) and leaf area per plant (Table 9). Leaf length varied from 7.90 cm (S10) to 17.56 cm (J22), leaf width varied from 3.43 cm (K1) to 7.70 cm (J24) and leaf area per plant from 54.0 cm^2 (K1) to 135.40 cm^2 (J18). In general, the trees from Jaddigadde source possessed larger leaf size, while those from Kankodlu and Siddapur source recorded smaller sized leaves. Among the different quantitative leaf parameters considered, maximum coefficient of variation was recorded for leaf area per plant (15.47%) followed by leaf length (11.97%) and the least was observed for leaf width (10.57%). Higher coefficient of variation for all quantitative leaf traits was recorded for Siddapura and Kankodlu source. Thus there is a greater scope for the selection of trees for total leaf area per plant, which is an economically important trait in cinnamon.

Table 3: Variation for leaf length (cm) among selected trees of *C. zeylanicum* from different sources

Tree No	Leaf length (cm)	Tree No	Leaf length (cm)	Tree No	Leaf length (cm)	Tree No	Leaf length (cm)
G1	11.50	J3	11.28	K5	10.56	M7	10.40
G2	15.72	J4	11.46	K6	10.64	M8	15.08
G3	17.82	J5	11.58	K7	9.80	M9	15.44
G4	12.28	J6	12.22	K8	11.24	M10	15.38
G5	14.56	J7	11.50	K9	11.42	M11	15.58
G6	12.60	J8	15.62	K10	8.80	M12	11.84
G7	7.62	J9	14.18	K11	12.46	M13	13.10
G8	9.16	J10	12.24	K12	14.04	M14	14.82
G9	11.88	J11	10.44	K13	9.56	M15	13.90
G10	13.52	J12	15.44	K14	12.72	M16	11.92
G11	11.90	J13	14.62	K15	12.88	M17	14.96
G12	12.72	J14	12.78	K16	11.54	M18	10.30
G13	11.92	J15	14.46	K17	15.02	M19	13.78
G14	10.20	J16	14.48	K18	10.98	M20	12.12
G15	12.02	J17	16.66	K19	10.34	M21	12.20
G16	11.94	J18	16.58	K20	10.80	S1	10.96
G17	11.58	J19	16.98	K21	10.22	S2	9.12
G18	12.88	J20	12.06	K22	10.08	S3	11.78
G19	12.38	J21	12.00	K23	11.14	S4	11.74
G20	8.56	J22	17.56	K24	10.12	S5	9.94
G21	10.64	J23	14.28	K25	10.48	S6	14.12
G22	12.54	J24	14.88	M1	13.62	S7	12.34
G23	13.28	J25	12.90	M2	10.34	S8	14.26
G24	13.60	K1	10.16	M3	9.70	S9	15.72
G25	10.44	K2	13.72	M4	8.24	S10	7.90
J1	11.72	K3	9.54	M5	12.80		
J2	11.16	K4	9.12	M6	11.58		
Mean		12.31		SEm±		0.66	
C.D @ 5%		1.83		C.V (%)		11.97	

Table 4: Analysis of variance (ANOVA) for leaf length (cm)

Source of variation	DF	Mean squares	F-calculated	Significance
Treatment	105	23.919	11.01	0.000
Error	424	2.172		
Total	529			

Table 5: Mean variation for leaf length (cm) among different sources of *C. zeylanicum* pooled over all trees from a source

Source	Gejjehalli (G)	Jaddigadde (J)	Kankodlu (K)	Manchale (M)	Siddapura (S)
Mean	12.13	13.56	11.10	12.72	11.79
SEm±	0.69	0.65	0.50	0.77	0.73
C.D @ 5%	1.93	1.81	1.39	2.17	2.08
C.V (%)	12.64	10.63	9.96	13.57	13.78

Table 6: Variation for leaf width (cm) among selected trees of *C. zeylanicum* from different sources

Tree No	Leaf width (cm)	Tree No	Leaf width (cm)	Tree No	Leaf width (cm)	Tree No	Leaf width (cm)
G1	5.55	J3	6.09	K5	4.36	M7	4.82
G2	6.22	J4	5.08	K6	4.86	M8	6.05
G3	6.19	J5	6.47	K7	5.35	M9	5.67
G4	5.87	J6	6.48	K8	4.91	M10	7.38
G5	5.45	J7	6.38	K9	4.48	M11	7.41
G6	5.72	J8	6.99	K10	4.89	M12	5.79
G7	4.69	J9	6.13	K11	5.81	M13	5.82
G8	4.77	J10	5.73	K12	5.65	M14	6.07
G9	5.28	J11	5.86	K13	4.88	M15	5.27
G10	5.87	J12	6.83	K14	6.01	M16	5.66
G11	5.21	J13	6.68	K15	5.24	M17	6.23
G12	4.60	J14	6.67	K16	4.76	M18	5.41
G13	5.78	J15	7.10	K17	4.70	M19	5.69
G14	5.52	J16	6.51	K18	4.22	M20	4.86
G15	4.52	J17	7.71	K19	4.09	M21	4.93
G16	4.03	J18	8.48	K20	4.99	S1	3.61
G17	5.30	J19	7.30	K21	3.87	S2	3.90
G18	5.64	J20	6.19	K22	4.76	S3	5.55
G19	4.57	J21	6.10	K23	4.29	S4	4.81
G20	4.12	J22	6.49	K24	4.61	S5	3.63
G21	5.04	J23	7.48	K25	5.00	S6	5.41
G22	4.40	J24	7.70	M1	5.15	S7	5.46
G23	5.05	J25	5.77	M2	5.41	S8	4.85
G24	6.01	K1	3.43	M3	5.14	S9	4.87
G25	5.31	K2	4.98	M4	3.81	S10	4.76
J1	4.91	K3	4.47	M5	6.21		
J2	5.19	K4	5.03	M6	4.90		
Mean		5.45		SEm±		0.26	
C.D @ 5%		0.72		C.V (%)		10.57	

Table 7: Analysis of variance (ANOVA) for leaf width (cm)

Source of variation	DF	Mean squares	F-calculated	Significance
Treatment	105	4.742	14.303	0.000
Error	424	0.332		
Total	529			

Table 8: Mean variation for leaf width (cm) among different sources of *C. zeylanicum* pooled over all trees from a source

Source	Gejjehalli (G)	Jaddigadde (J)	Kankodlu (K)	Manchale (M)	Siddapura (S)
Mean	5.23	6.49	4.96	5.60	4.68
SEm±	0.28	0.28	0.31	0.27	0.27
C.D @ 5%	0.79	0.80	0.87	0.76	0.76
C.V (%)	12.02	9.76	10.65	10.78	12.69

Table 9: Variation for leaf area (cm^2) among selected trees of *C. zeylanicum* from different sources

Tree No	Leaf area (cm^2)	Tree No	Leaf area (cm^2)	Tree No	Leaf area (cm^2)	Tree No	Leaf area (cm^2)
G1	69.80	J3	77.80	K5	61.80	M7	66.80
G2	109.20	J4	67.00	K6	66.40	M8	102.40
G3	124.00	J5	85.00	K7	63.40	M9	106.40
G4	89.00	J6	88.00	K8	66.00	M10	129.20
G5	92.20	J7	82.20	K9	66.20	M11	131.80
G6	84.00	J8	109.80	K10	57.60	M12	88.40
G7	53.20	J9	95.00	K11	83.60	M13	91.00
G8	61.00	J10	76.00	K12	85.20	M14	107.00
G9	77.00	J11	69.80	K13	61.00	M15	88.20
G10	93.60	J12	107.20	K14	89.60	M16	86.00
G11	74.60	J13	99.80	K15	77.80	M17	109.40
G12	81.60	J14	90.40	K16	71.00	M18	70.00

G13	84.60	J15	102.20	K17	81.20	M19	92.20
G14	70.00	J16	96.00	K18	61.60	M20	76.20
G15	67.60	J17	125.40	K19	59.40	M21	78.20
G16	65.80	J18	135.40	K20	67.00	S1	61.00
G17	75.00	J19	118.00	K21	56.40	S2	54.80
G18	91.40	J20	80.40	K22	63.60	S3	75.60
G19	76.80	J21	77.20	K23	65.20	S4	78.60
G20	54.20	J22	111.40	K24	62.40	S5	52.80
G21	69.60	J23	106.00	K25	64.80	S6	90.40
G22	72.20	J24	111.40	M1	88.60	S7	90.20
G23	79.00	J25	77.80	M2	76.80	S8	86.40
G24	101.00	K1	54.00	M3	71.00	S9	98.80
G25	71.00	K2	83.40	M4	51.20	S10	53.20
J1	67.60	K3	58.00	M5	95.20		
J2	65.40	K4	58.00	M6	72.80		
Mean		81.27		SEm±		5.62	
C.D @ 5%		15.63		C.V (%)		15.47	

Table 10: Analysis of variance (ANOVA) for leaf area (cm^2)

Source of variation	DF	Mean squares	F-calculated	Significance
Treatment	105	1,847.04	11.687	0.000
Error	424	158.047		
Total	529			

Table 11: Variation for mean leaf area (cm^2) among different sources of *C. zeylanicum* pooled over all trees from a source

Source	Gejjehalli (G)	Jaddigadde (J)	Kankodlu (K)	Manchale (M)	Siddapura (S)
Mean	79.50	92.89	67.38	89.47	74.18
SEm±	5.53	6.26	3.29	6.67	6.33
C.D @ 5%	15.54	17.59	9.25	18.80	18.15
C.V (%)	15.56	15.07	10.92	16.68	19.07

Krishnamoorthy *et al.* (1992) [12] assessed seventy one 12 years old and uniformly grown Cinnamon accessions collected from different parts of Kerala and Sri Lanka. Leaf length was shown to vary from 8.75 to 20.69 cm with coefficient of variation of 17.83 per cent and leaf breadth ranged from 3.31 cm to 8.30 cm with coefficient of variation of 18.74 per cent. Purple colour ranged from 1.5 to 8.5 with 30.48 per cent variation in *Cinnamomum zeylanicum*. Regarding purple colour of flushes, 72 per cent reported medium colour (3-6 score) and 14 per cent light colour and 14 per cent intense purple colour (Joy *et al.*, 1998) [9].

Lizawati *et al.* (2017; 2018) [14, 15] reported morphological differences in cinnamon grown in West Sumatra. Lanceolate and elliptic leaf shape, acute and attenuate leaf tip shapes were recorded in 17 accessions of *Cinnamomum burmanii* in Jambi province of Indonesia. Syukur *et al.* (2012) [19] are of the opinion that qualitative characteristics are controlled by oligo genes, which are less influenced by environment, where as quantitative characters, controlled by poly genes, are influenced by environment. Azad *et al. (*2016) [4] have showed that about 50% of the open pollinated progeny were different than the mother plant with respect to leaf shape.

Studying morphology of leaves helps in identifying and describing the plant correctly. Certain characteristics like shape of a leaf, orientation towards the light help in identifying the conditions that are required by the plant to grow properly. The shape of the leaf can help to determine the physiological maturity of the plant. Krishnamoorthy *et al.* (1996) [11] have adopted leaf shape and leaf length to recognize two varieties of cinnamon. 'Navashree' variety showed lanceolate leaf shape with a mean leaf length of 13.40 cm and mean leaf width of 4.69 cm; whereas 'Nithyashree' variety showed ovate shape leaves with 15.40 cm mean leaf length and 5.70 cm mean leaf breadth. Similarly, Ariyarathne *et al.* (2018) [3] showed that 'Sri Gemunu' variety of cinnamon in Sri Lanka had oval shape leaves while 'Sri Wijaya' had lanceolate shaped leaves. Leaf apex shape in 'Sri Gemunu' was shown to be 'ovate elliptic' and 'acute' in 'Sri Wijaya'; average leaf length of 10.50 cm in 'Sri Gemunu' and 9.25 cm in 'Sri Wijaya'. They also stated that leaf characteristics such as shape, leaf apex shape, length and breadth can be adopted in morphological differentiation of cinnamon species. Krishnamoorthy *et al.* (1988) [10] and Gopalam (1997) [7] have noticed a correlation between flush colour and bark oil content, in which, the purple coloured plants showed about 29% higher oil content. Variability present between trees and sources for leaf characters can be utilized for identification of proper genotypes and indirect selection criteria for selection of superior cinnamon trees with high oil content, higher biomass and higher eugenol content. Leaf flush colour is considered as an indicator of higher essential oil and can be used as marker for indirect selection of higher oil yielding trees thus aiding the rapid domestication.

Conclusion

Wide variation was observed for leaf characteristics among selected trees and seed sources in *Cinnamomum zeylanicum*. Four morpho-types with respect to leaf shapes *viz*. elliptic, ovate, ovate elliptic and ovate lanceolate were recorded, in which ovate 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.

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References

1. Allard RW, Bradshaw AD. Implications of genotype-environmental interactions in applied plant breeding. Crop Science. 1964; 4:503-507.
2. Anandaraj M. Strategies for sustainable spice production - the way forward. Proc. Nat. Symp. on Spices Aroma. Crops, (SYMSAC –VIII) towards 2050 – Strateg. Sust. Spices Product, 16-18, December, 2015, TNAU, Coimbatore, India, 1964, 24-30p.
3. Ariyarathne HBMA, Weerasuriya SN, Senarath WTPSK. Comparison of morphological and chemical characteristics of two selected accessions and six wild species of genus *Cinnamomum* Schaeff. Sri Lankan J. Biol. 2018; 3(1):11-23.
4. Azad R, Ranawaka RAAK, Senanayake G, Wasanthakumara KL, Pushpakumara DKNG, Wijesinghe KGG *et al*. Morphological variation of cinnamon (*Cinnamomum verum* Persl) germplasm in Matara district of Sri Lanka. Int. J. Minor Fruits, Med. Aroma. Plants. 2016; 2(1):6-14.
5. Davis PH, Heywod VH, Robert EK. Principles of Angiosperm Taxonomy. New York Publisher Company and Krieger *Publishing Company*, Huntington, New York, 1973, 10-15.
6. De Leon N, Jannink JL, Edwards JW, Kaeppler SM. Introduction to a special issue on genotype by environment interaction. Crop Science. 2016; 56:2081-2089.
7. Gopalam A. Profile of essential chemical constituents in tree spices. In: Supplement to Cultivation and Utilization of Aromatic Plants (Ed. Handa, S. S. and Kaul, M. K.), RRL, CSIR publication, Jammu, 1997, 405-423.
8. Guenther E. The essential oils. Vol. IV. D. Van Nostrand Co. Inc., New York, 1950, 213-240.
9. Joy PP, Thomas J, Mathew S, Ibrahim KK. Growth, leaf oil yield and quality investigations in cinnamon (*Cinnamomum verum* Presl.). J. Med. Aroma. Plants Sci. 1998; 20(2):401-406.
10. Krishnamoorthy B, Gopalam A, Abraham J. Quality parameters of cinnamon (*Cinnamomum verum*) in relation to flush colour. Ind. Cocoa Arecanut Spices J. 1988; 12:38.
11. Krishnamoorthy B, Rema J, Zachariah TJ, Abraham J, Gopalam A. Navashree and Nithyashree - two new high yielding and high quality cinnamon (*Cinnamomum verum* Bercht and Presl.) selections. J. Spices Aroma. Crops. 1996; 5:28-33.
12. Krishnamoorthy B, Sasikumar B, Rema J, Gopalam A, Abraham J. Variability and association studies in cinnamon *(Cinnamomum verum).* J. Spices Aroma. Crops. 1992; 1(2):148-150.
13. Lima MP, Zoghbi MGB, Andrade EHA, Silva TMD, Fernandes CS. Constituintes volateis das folhas e dos galhos de *Cinnamomum zeylanicum* Blume. (Lauraceae). Acta Amazonica. 2005; 35(3):363-366.
14. Lizawati L, Riduan A, Neliyati N, Alia Y. Pros Sem Nas PERAGI. 2017; 1:187-194
15. Lizawati L, Riduan A, Neliyati N, Alia Y, Antony D. Genetic diversity of cinnamon plants (*Cinnamomum burmanii* BL.) at various altitude based on morphological character. Materials Sci. Engin. 2018; 434:1-7.
16. Ravindran PN, Nirmalbabu K, Shylaja M. Cinnamon and Cassia: The genus *Cinnamomum*. Medicinal and Aromatic Plants - Industrial Profiles. CRC Press, Florida, USA. 2004, 15-20.
17. Sasikumar B, Krishnamoorthy B, Saji KV, George JK, Peter KV, Ravindran PN. Spices diversity and conservation of plants that yield major spices in India. Plant Genet. Resour. Newslet. 1999; 118:19-26.
18. Singh VB, Singh K. Spices. New Age International (P) Publishers, New Delhi, India, 2008, 10-15.
19. Syukur M, Sujiprihati S, Yunianti R. Teknik Pemuliaan Tanaman. Jakarta, Penebar Swadaya Publishers, Jakarta, Indonesia, 2012, 25-35.