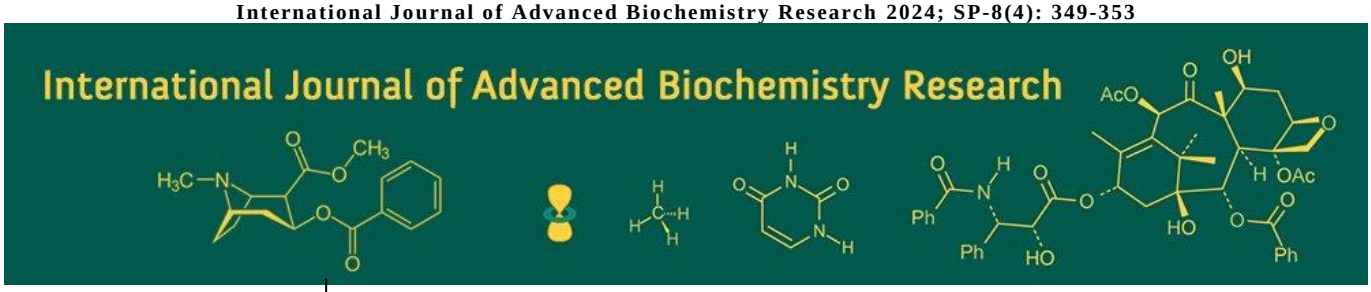

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Variations in growth and leaf qualitative parameters observed among half-sibling progenies of *Cinnamomum zeylanicum* Blume

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Abstract
A field trial was conducted at the Bakkal Botanical Garden near Sirsi, to assess the growth and leaf qualitative parameters among two years old half-sib progenies of *Cinnamomum zeylanicum.* The trial included 15 half-sibling families with three replication derived from 15 plus trees identified from Uttara Kannada and Shimoga districts. The growth and leaf qualitative parameters of the progenies were evaluated at 24 months after planting. The germplasm was established in January 2020. A wide variation was observed among the progenies. The highest mean plant height was observed in K13 (171.66 cm) family, maximum average girth at the collar region was recorded in the family K13 (32.52 mm), higher mean number of leaves per plant were observed in G11 (591.66), the highest number of branches were found in the half-sib family G11 (43.33). The leaf flush colour was noted among the families with the G4, G16 and K13 families showing a medium purple colour and S4 showing a purple colour. The S4 had purple leaf flushing while the K18 had green leaf flushing. While considering the different growth parameters at 24 MAP the best families are K13, K16, S1, S4 and G11, these families can be used for further breeding and tree improvement programme.

Keywords: Half-sib progeny, plus tree, progeny evaluation and months after planting

Introduction
Cinnamomum zeylanicum Blume, commonly referred to as cinnamon, originates from Sri Lanka, where it thrives in its natural habitat. It holds the distinction of being India's inaugural spice crop and is fondly called "sweet wood." The regions conducive to cinnamon growth are primarily situated along the Malabar Coast of India and within Sri Lanka. Its cultivation extends to diverse areas, including the Western Ghats, the Coastal Hills of Karnataka, and the Naga Hills of Assam. Moreover, a scattering of cinnamon trees can be spotted in the Konkan region of Maharashtra (Sasikumar *et al.,* 1999) [13]. Recently, cinnamon's prominence has surged due to a substantial body of scientific research that underscores its potential therapeutic and medicinal properties (Zare *et al.,* 2019; Sadeghi *et al.,* 2019) [17, 13]. The genus Cinnamomum exhibits considerable variation in qualitative and quantitative leaf traits, which is evident at both species and sub-species levels. Notably, most economically valuable cinnamon species have triple-nerved leaves, with the exception of camphor (*C. camphor*) that features penni-nerved leaves. Cinnamon leaves come in various shapes, ranging from oval to elliptic, lanceolate-oval or narrowly elliptic. The leaf apex may be shortly or broadly acuminate, while the leaf base is either acutish or cuneate (Ravindran *et al.,* 2004) [11]. The timing of leaf emergence in cinnamon aligns with the monsoon season. Notably, collections of cinnamon exhibit four distinct variations in leaf emergence colours: pure purple, purple with a dominant green undertone, green with a dominant purple undertone and pure green. Within Sri Lanka, cinnamon cultivators classify eight distinct cinnamon types based on several factors, such as the pungency of the bark, the shape of the leaves and the texture of both the bark and leaves (Wijesekera *et al.,* 1975) [15].
Cinnamon occupies a significant position as one of the most widely utilized spices globally. Its versatility shines through a diverse array of recipes, ranging from delightful breakfast rolls and spiced cookies to indulgent puddings, pies, quick breads and chutneys.

Interestingly, Cinnamon holds the second-place position among the most popular spices in both the United States and Europe, with black pepper being the sole contender ahead (Ravindran *et al.*, 2004) [11]. The principal commercial product derived from cinnamon trees is the dried bark of the stems, available in various forms such as quills, quilling and chips. Conversely, essential oils are extracted from three distinct sources: leaves, stem bark and root bark (Wijesekara *et al.*, 1975) [15]. In Karnataka's spice industry, there is currently a high demand for immature cinnamon fruits leading to increased profits for farmers who engage in their harvesting and marketing.

The evaluation of germplasm plays a crucial role in selecting high-yielding and promising varieties in any crop. In this context, the present study was conducted to assess the variation in growth and leaf qualitative parameters among half-sibling progenies of identified superior trees *in Cinnamomum zeylanicum* at 24 months after planting (MAP).

Materials and Methods

The study area consists of germplasm conservation site in Bakkal Botanical Garden near Hulekal, Sirsi, Uttara Kannada district has an area of 10,291 km^2 and located in the Central Western Ghats between 13° 55' and 15° 32' N latitude and 74° 05' to 75° 05' E longitude. The district is bordered by Goa and Belgaum in the north, Dharwad, Haveri and Shivamogga in the east and Udupi in the south of Karnataka. The experiment was laid out in Complete Randomised Block Design (RCBD) design with three replications. The following 15 progenies were tested.

Family I.D.	Name of the Hamlet (Forest Range)
J2 and J6	Jaddigadde (Sirsi), Uttara Kannada dist.
G4, G11, G16 and G24	Gejjehalli (Hangal), Haveri dist.
K5, K10, K13, K16 and K18	Kankodlu (Yellapura) Uttara Kannada dist.
S1, S4, S5 and S9	Siddapura (Siddapura)Shimoga dist.

Seedling growth and yield parameters were measured using the following methods: Plant height (m) was determined by employing a wooden scale, measuring from the ground level up to the highest point of the plant. The girth at the collar region (mm) was assessed using a digital calliper, specifically at the collar region of the plant. In cases where there were two stems, measurements were taken for both stems, and the average value was calculated. The number of leaves per plant and the number of branches per plant were manually counted and recorded. The qualitative leaf characters include leaf flush colour, leaf colour and pungency level are recorded manually by giving scoring to them and also leaf petiole colour, leaf margin serration were recorded manually. The one factor analysis was made by using standard ANOVA prepared by Department of Mathematics Statistics, CCS HAU, Hissar (139-143).

Results and Discussion

An analysis of fifteen half sib progenies for growth parameters indicated that mean plant height, girth at collar region, number of leaves and number of branches per plant varied significantly between families and among progenies. A wide variation was observed among the progenies for growth parameters (Table 1). Among the four parameters, maximum coefficient of variation (CV) was exhibited by number of leaves per plant (57.67%), followed by number of branches per plant (39.35%) and lowest was found for plant height (21.24%). The highest mean plant height was observed in K13 (171.66 cm) family, followed by G11 (138.33 cm) and the lowest is in K18 (77 cm) family. The maximum average girth at the collar region was recorded in the family K13 (32.52 mm) and the lowest was recorded in the K18 family (16.14 mm). The higher mean number of leaves per plant were observed in G11 (591.66) and the lowest number of leaves were observed G24 (92) family. The highest number of branches were found in the half-sib family G11 (43.33) and the lowest were observed in the S9 (9.66) and K10 (9.66) families respectively. Among the different traits, plant height, number of leaves per plant and number of branches per plant were significantly different, whereas girth at the collar region did not show significant differences.

The variation in the growth parameters among the half-sib progenies are largely due to the genotypic variation and hence are very useful to the breeder. Such progeny variations have been reported by many authors. Hanumantha (2020) [3] studied on *Cinnamomum zeylanicum* and analysed the 90 progenies collectively and reported the average plant height at 24 MAT which varied significantly, with a coefficient of variation of 8.33 percent and a mean of 73.12 cm. Significant variations in mean plant height were found, ranging from 42.00 cm (M15) to 95.93 cm (S3). The highest maximum plant height was recorded by Siddapura source progeny (90.13 cm), while Manchale source progeny had the lowest height (54.86 cm). The plant height showed significant variations both within and between sources. For *Cinnamomum zeylanicum* seedlings that were 10 months old, Swarnapali and Subasinghe (2004) [14] noted that the average plant height ranged from 30 to 40 cm.

In *Cinnamomum glanduliferum*, an assessment of 34 open pollinated families, Huanqiong *et al*. (2014) [5] have shown significant differences in tree height, crown diameter and dbh between families after nine years. *Cinnamomum burmannii* seedlings that were 12 months old from eight different seedling sources showed variation, according to Lan *et al*. (2012) [10]. Lechang source seedlings grew the best, whereas Chongyi source seedlings grew the worst among the various sources. Using the independent trial-and-error method, 10 pedigrees that grew more quickly during the seedling stage were initially selected. In the Lechang source, the average plant height and diameter were 15.6 cm and 4.25 mm.

Variations in leaf qualitative parameters were observed among the half-sib progenies. The leaf flush colour was noted among the families with the G4, G16 and K13 families showing a medium purple colour and S4 showing a purple color (Table 2). The S4 had purple leaf flushing while the K18 had green leaf flushing. The leaf color ranges from light green to dark green: J6, G4 G24 and S1 were light green, while K13 was dark green. The leaf pungency was assessed with organoleptic tests and classified as low pungency level to the high pungency level. Among the families J2, G24 and K5 showed the medium pungency, whereas G16 showed a high pungency level and remaining families showed the low pungency level. There was no variation among the progenies with respect to leaf margin (entire leaf margin) and also there is no variation in leaf petiole color (green) (Plate 1).

The variations in leaf flush color, leaf color and leaf petiole color have been shown to be genetically controlling it. The deep pink leaf flush color has been associated with higher leaf oil content in *C. zeylanicum* (Kaul *et al.,* 1996; Bakkali *et al.,* 2008) [7, 2]. Leaf flush color is an indicator of higher oil content in cinnamon. Hanumantha (2020) [3] reported on leaf parameters and varied greatly among progenies from different sources. The flush color of leaf progenies from various sources ranged from green to pink/purple only three progenies, G25, J4 and K2, recorded purple flush color, while the remaining all progenies recorded green to medium pink flush color. He conjectured that deep purple flush colour could indicate a high oil content. However, Krishnamoorthy *et al.,* (1992) [8] and Joy *et al.,* (1998) [6] suggested that such variations in leaf oil content may be influenced by genotypic variations as well as environmental influences.

The leaf pungency was assessed by organoleptic tests, in which pungency levels were observed to vary from 'mild' to 'strong'; J2, G24 and K5 showed the 'medium' pungency level, whereas G16 showed the 'strong' pungency level and the remaining families showed the 'mild' pungency level. There was no variation among the progenies with respect to leaf margin (entire leaf margin) and also there was no variation in leaf petiole color (green).

Table 1: Variation in growth parameters among half-sib progenies of *Cinnamomum zeylanicum* at 24 months after planting (MAP)

Family I. D	Plant height (cm)	Girth at collar region (mm)	No. of leaves/plant	No. of branches/plant
	Mean±SE	Mean±SE	Mean±SE	Mean±SE
J2	109.00±13.05	29.65±2.87	283.66±121.53	26.00±7.50
J6	117.00 ±2.30	27.29±3.97	342.66±79.64	26.00±4.04
G4	103.66±20.33	19.42±2.45	293.33±118.27	26.33±8.45
G11	138.33±11.05	29.03±3.65	591.66±51.20	43.33±3.48
G16	95.00±21.54	21.47±5.01	159.00±66.38	19.00±4.35
G24	102.33±19.80	19.18±2.11	92.00±34.12	30.33±7.53
K5	98.33±12.86	28.31±1.04	262.00±64.96	10.66±0.88
K10	113.66±11.31	24.56±4.37	268.33±66.99	9.66±1.45
K13	171.66±21.98	32.52±6.16	280.00±67.00	11.66±0.88
K16	134.33±3.66	27.39±2.66	335.33±38.62	31.66±3.18
K18	77.00±9.71	16.14±1.80	103.33±31.57	12.66±2.90
S1	105.00±11.15	21.70±6.71	575.33±263.13	12.00±4.35
S4	114.33±7.35	30.81±4.33	533.66±143.95	39.33±10.80
S5	124.00±15.39	25.95±2.86	162.66±17.37	38.00±3.78
S9	130.33±3.38	27.61±2.84	224.33±18.22	9.66±0.88
CD@5%	41.27	NS	291.34	15.27
S.Em±	14.17	3.96	100.05	5.24
CV (%)	21.24	26.99	57.67	39.35

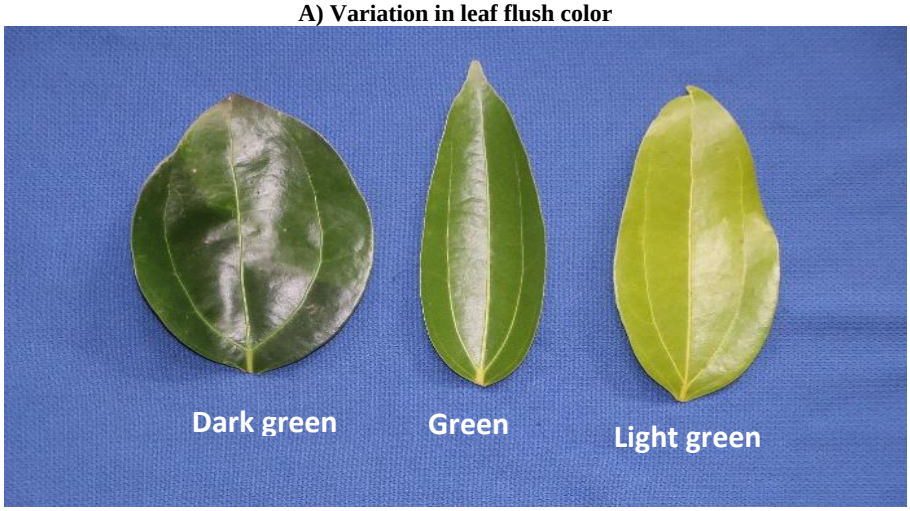
CD = Critical Difference; S.Em = Standard error of Means; CV = Coefficient of Variation; NS = Non-Significant

Table 2: Variation for leaf qualitative characters among half-sib progenies of *Cinnamomum zeylanicum* at 24 months after planting (MAP)

Family ID	Leaf characteristics				
	Leaf flush colour	Leaf colour	Pungency	Leaf petiole colour	Leaf margin serration
J2	2	2.	2	Green	Entire
J6	2	1	1	Green	Entire
G4	3	1	1	Green	Entire
G11	2	2	1	Green	Entire
G16	3	2	3	Green	Entire
G24	2	1	2	Green	Entire
K5	2	2	2	Green	Entire
K10	2	2	1	Green	Entire
K13	3	3	1	Green	Entire
K16	2	2	1	Green	Entire
K18	1	2	1	Green	Entire
S1	2	1	1	Green	Entire
S4	4	2	1	Green	Entire
S5	2	2	1	Green	Entire
S9	2	2	1	Green	Entire
CD@5%	0.82	0.96	1.13		
S.Em±	0.28	0.33	0.39		
CV (%)	18.26	26.05	41.60		

Leaf flush colour: 1= Green 2= Light purple 3= Medium purple 4= purple
Leaf colour: 1= Light green 2=Green 3= Dark Green
Pungency level: 1= mild 2= Medium 3= strong
CD = Critical Difference; S.Em = Standard error of Means; CV = Coefficient of Variation;
NS = Non-Significant

A) Variation in leaf flush color



b) Variation in leaf color

Plate 1: Variation in leaf morphology among half -sib progenies of *C. zeylanicum*

Conclusion

Conducting progeny testing of plus trees is a crucial step in determining the breeding value of the selected trees. Karnataka is blessed with abundant diversity of cinnamon, both in natural forests and farmers' fields. Unfortunately, very little or no research has been carried out so far to enhance the genetic traits of cinnamon. Surprisingly, there are currently no cinnamon varieties released specifically for Karnataka. Given the diverse agro-ecological conditions found in the Western Ghats, coastal regions, and plains of Karnataka, it is imperative to identify and select superior genotypes that are well-suited for the state. While considering the different growth parameters at 24 MAP the best families are K13, K16, S4, S1 and G11 these families can be used for further breeding and tree improvement programme.

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