Original Research Article

Effect of different altitudinal on leafparameters of *Garcinia indica* (Choisy) in Uttara Kannada

Abstract

Garcinia indica is native tree species found in the Western Ghats of India and is important for commerce, ecology and medicine. This study looks into the morphometric characteristics of *G. indica* leaves and how they vary in the Uttara Kannada area of Karnataka, India, across various altitudinal zones. Eight test locations were chosen and divided into four altitudinal zones (Zones A (plains), Zone B (up-ghat), Zone C (mid-ghat) and Zone D (Coastal)) each of which corresponded to a distinct elevation and rainfall level. Forty trees were used to gather leaf samples and measurements of the leaves' length, breadth, weight and moisture content were noted. The findings showed that there was a considerable altitude-dependent variation in leaf characteristics, with Zone-A showing the largest mean leaf length (9.48 cm), breadth (3.68 cm) and Zone-C showing the highest leaf weight (0.85 g). Four leaf types were noted: lanceolate, elliptical, ovate, and obovate. The elliptical leaf shape was found to be the most prevalent. The study emphasises how bioclimatic factors affect the morphology of *G. indica* leaves and it suggests that altitude is a major factor in determining the size and weight of leaves. This study supports the conservation and widespread use of *G. indica* by shedding light on its variety and ability to adapt to different environments.

1. Introduction

The genus Garcinia, which belongs to the Cluciaceae family, has about 200 species that are found throughout the world's tropics, mostly in Asia, Africa and Polynesia. They are polygamous evergreen trees, many of them are endemic and commercially significant, as well as having powerful therapeutic effects (Roberts, 1984). *Garcinia indica* is a indigenous tree spice crop that originated and is produced in India's Western Ghats, Maharashtra's South Konkan area, Coorg, Wynad and Goa. It found in evergreen and semi-evergreen woods as well as a home garden tree (Subash Chandran, 2005). The tree may be found in abundance in Maharashtra's Konkan region, Goa, Karnataka's and Kerala's coastal parts, Assam's evergreen forests, Khasi, and Jantia hills, West Bengal, and Gujarat's evergreen forests. It is found in forests, riversides, and wasteland, as well as being grown on a modest basis. The tree is

mostly found along the Konkan region of Maharashtra's Ratnagiri district, Goa, Karnataka's Uttara Kannada, Udupi, and Dakshina Kannada districts and Kerala's Kasaragod area. It is known by various names across India including Tallow tree in English, Murugalu in Kannada and in Malayalam it is called Punarpuli. Bindin, Biran, Bhirand, Bhinda, Kokum, Katambi, Panarpuli, Ratamba or Amsolare the other names for *G. indica* (Swami *et al*., 2014).

Garcinia indica is a tropical evergreen, slender tree with sloping branches, it reaches heights of 15m. The thin bark is lined and the leaves are elliptic, oblong or oblong-lanceolate, deep-green glossy leaves, 5.5-8 cm long and 2.5-3 cm broad. The flowers are fleshy, dark pink, solitary or in spreading cluster during the month of November-February. The fruit is brownish-grey or dark purple marbled with yellow, and is crowned by the 4-parted fruit is round, about 4 cm (1.5 inc) in diameter with 5-8 seeds. *Garcinia indica* flourishes very well up to an elevation of about 800 m from MSL. It requires warm and humid tropical climate. It thrives well in coastal areas receiving over 250 cm of rainfall. It grows well in lateritic, alluvial soils having depth of 1.0 m and pH of 6.7. The mature kokum fruit is either dark purple or crimson with a yellow tint. It has 3-8 big seeds embedded in a red acid pulp in a regular pattern, similar to orange segments, in a white pulpy substance (Krishnamurthy, 1984; Krishnamurthy et al., 1982).

The fruit is round to oval in shape and weighs between 21 and 85 g. The fruit is mainly used for culinary purposes. Kokum is collected from the wild, grown in home gardens and cultivated at a limited scale as a rain fed crop, the dried rind of the fruit is used primarily as an acidulent in cosmetic products and moisturising, and the rind has medicinal properties and is used in the treatment of piles, dysentery, tumours, and heart complaints in the Western Ghats region, where it is estimated to be grown on an area of 1200 ha with an annual production of 10,400 tonnes. (Patil *et al.*, 2009).

Sobir *et al.*,(2013) identified variability in *Garcinia mangostana*with respect to morphological characters like tree shape, fruit shape and petal colour in several populations of Indonesia.

Parthsarathy and Nandakishore (2014) studied on Garcinia genetic resources collection, which includes 15 species from the Western Ghats and the Eastern Himalaya. The morphological characterizations of the species in these two eco systems show that there is diversity within the same ecosystem and similarities between the species in these two ecosystems.

2. MATERIAL AND METHODS

The study was carried out in Karnataka's Agro-climatic Zone 9, particularly in the Uttara Kannada district of the Western Ghats, where Garcinia indica is available in evergreen to semi-evergreen forests and farmlands. The region experiences tropical monsoonal rainfall from June to September, ranging from 2500 to 4000 mm annually. Relative humidity reaches over 90% in July and August, dropping to 40% in March and April, with temperatures between 18°C and 31°C. To assess the effects of altitude and precipitation, eight sites were selected across four altitudinal zones: Plains (Zone-A, ≥600 m MSL), Up-Ghat (Zone-B, 500-600 m MSL), Mid-Ghat (Zone-C, 400-500 m MSL) and Coastal (Zone-D ≤400 m MSL). Two sites per zone were chosen and five trees per site taken as replicates. The study sites included four locations in Kumta taluk (Kathgal, Divage, Devimane, Ragihosalli) and four site in Sirsi taluk (Janmane, Yeddalli, Islur and Banavasi). A Randomized Complete Block Design (RCBD) with three factors was used for statistical analysis. Leaf samples were collected from trees of girth class between the 60-75 cm in the month of January to March 2021. Two sites were selected per location and five trees per site were assessed for leaf morphology. 15 leaves were drawn from each tree within a tree 5 leaves were taken in each 3 side of tree crown randomly to analyzed for color, shape, length (L) and width (W), with precise measurements using a calibrated scale.

Table 1. Geographical and climatic information of study area in Uttara Kannada district, Karnataka

Altitudinal Zone	Site (Location)	Altitude (m)	Mean annual rainfall (mm)	Annual rainy days	Mean annual temperature (°C)
Zone-A (Plain)	S_1 (Banavasi)	603.6	2545 - 3456	97	30.5
	S_2 (Islur)	670.4	2578 - 3269	97	30.9
Zone-B (Up-ghat)	S_1 (Yeddalli)	550.3	2784 – 3568	110	28.9
	S_2 (Janmane)	536.4	2756 – 3645	110	26.0
Zone-C (Mid-ghat)	S_1 (Devimane)	431.6	2986 – 3865	100	27.0
	S_2 (Ragihosalli)	436.3	3157 – 3945	100	25.0
Zone-D (Coastal)	S_1 (Kathgal)	52.4	3800 – 4722	120	25.6
	S_2	77.8	3800 - 4722	120	24.9

(Divage)

* Rainfall data by KSNDMC report 2019

Table 2. Leaf shape and colour observed during the study

Leaf shape	Trees	Share (%)	Leaf colour	Trees	Share (%)
Elliptical	19	47.5	Dark green	36	90
Ovate	13	32.5			
Obovate	5	12.5	Light green	4	10
Lanceolate	3	7.5			
Total	**40**	**100**	**Total**	**40**	**100**

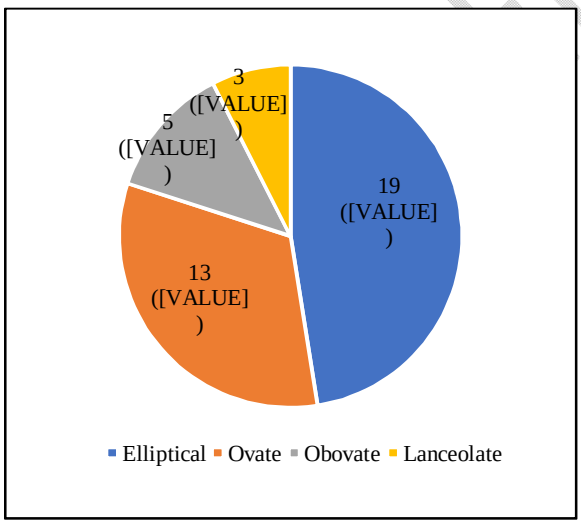

Fig 1. Percentage of leaf shapes variation in*Garcinia indica*

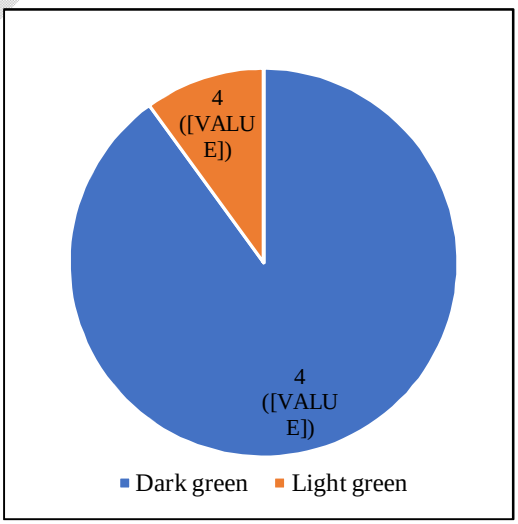

Fig 2. Percentage of Leaf colour variation in *Garcinia indica*

Table 3. Effect of altitudinal Zones and sites variation on leaf parameters

Altitudinal zone	Tree	Leaf length (cm)		Leaf width (cm)		Fresh leaf weight (g)		Dry leaf weight (g)		Leaf moisture Content (%)	
		Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
Zone A	G1-G6	9.20	9.79	3.67	3.81	0.66	0.88	0.16	0.19	61.054	61.552
	G2-G7	9.49	9.93	3.69	3.56	0.69	0.86	0.16	0.19	60.607	62.326
	G3-G8	10.55	9.45	3.49	3.72	0.65	0.90	0.18	0.19	58.016	62.455
	G4-G9	10.82	10.46	3.58	3.97	0.86	1.03	0.19	0.21	61.270	63.057
	G5-G10	9.65	9.05	3.85	3.49	0.76	0.84	0.17	0.18	60.939	62.068
	Mean of site	**9.94**	**9.74**	**3.65**	**3.71**	**0.72**	**0.50**	**0.17**	**0.19**	**(60.377) 75.55**	**(62.292) 78.41**
	Mean of zone	***9.84^{a}***		***3.68^{a}***		***0.81^{ab}***		***0.18^{b}***		***(61.334) 76.98^{a}***	
Zone B	G11-G16	7.96	9.45	3.03	4.23	0.53	0.87	0.13	0.19	59.552	61.822
	G12-G17	8.13	8.40	3.05	3.63	0.60	0.65	0.14	0.17	60.900	59.283
	G13-G18	8.40	8.87	3.80	3.81	0.78	0.70	0.19	0.17	59.695	59.961
	G14-G19	8.29	8.67	3.63	3.49	0.73	0.67	0.16	0.17	61.436	59.107
	G15-G20	9.16	9.20	3.30	3.93	0.70	0.77	0.17	0.18	59.923	60.484
	Mean of site	**8.39**	**8.92**	**3.36**	**3.82**	**0.67**	**0.73**	**0.16**	**0.18**	**(60.301) 75.47**	**(60.131) 75.22**
	Mean of zone	***8.65^{b}***		***3.59^{ab}***		***0.71^{b}***		***0.17^{b}***		***(60.216) 75.34^{b}***	
Zone C	G21-G26	8.27	8.55	3.55	3.45	0.66	0.74	0.18	0.18	57.668	59.92
	G22-G27	7.83	8.46	3.78	3.53	0.75	0.88	0.17	0.21	61.129	60.558
	G23-G28	8.29	9.13	3.78	3.49	0.83	0.88	0.20	0.21	60.146	60.938
	G24-G29	9.06	9.55	3.82	3.12	0.94	1.03	0.23	0.23	59.949	61.873
	G25-G30	8.31	9.15	3.77	3.37	0.91	0.84	0.22	0.19	60.445	61.548
	Mean of site	**8.35**	**8.97**	**3.74**	**3.39**	**0.82**	**0.88**	**0.20**	**0.20**	**(59.867) 74.78**	**(60.969) 76.47**
	Mean of zone	***8.66^{b}***		***3.57^{ab}***		***0.85^{a}***		***0.20^{a}***		***(60.418) 75.62^{b}***	
Zone D	G31-G36	7.78	7.55	2.99	3.40	0.40	0.57	0.10	0.17	60.770	56.711
	G32-G37	8.26	8.42	3.33	3.34	0.50	0.58	0.15	0.17	55.472	56.880
	G33-G38	8.71	8.08	3.88	3.43	0.68	0.55	0.18	0.17	58.278	55.491
	G34-G39	8.59	7.28	3.55	3.59	0.59	0.55	0.17	0.16	57.231	57.018
	G35-G40	8.65	7.52	3.82	3.65	0.67	0.60	0.17	0.18	58.729	57.049
	Mean of site	**8.40**	**7.77**	**3.51**	**3.48**	**0.57**	**0.57**	**0.15**	**0.17**	**(58.096) 72.03**	**(56.630) 69.76**
	Mean of zone	***8.09^{b}***		***3.50^{b}***		***0.57^{b}***		***0.16^{b}***		***(57.363) 70.89^{b}***	
		CD @ 5%	**SEm±**	**CD @ 5%**	**SEm±**	**CD @ 5%**	**SEm±**	**CD @ 5%**	**SEm±**	**CD @ 5%**	**SEm±**
For Zone		0.278	0.099	0.129	0.046	0.048	0.017	0.010	0.004	0.746	0.265
For Site		NS	0.070	NS	0.032	0.034	0.012	0.007	0.003	NS	0.187
For Tree		0.310	0.110	NS	0.051	0.054	0.019	0.011	0.004	NS	0.296
Zone x Site		0.392	0.139	0.182	0.065	0.068	0.024	NS	0.005	1.055	0.375
Zone x Tree		0.621	0.220	0.289	0.102	0.107	0.038	NS	0.008	NS	0.592
Site x Tree		0.439	0.156	0.204	0.072	0.076	0.027	0.016	0.006	NS	0.419
Zone x Site x Tree		NS	0.312	0.408	0.145	NS	0.054	NS	0.011	2.359	0.838

❖ Bracket value indicates that the value is angular transformed

3. RESULT AND DISCUSSION

Table 2 indicates that leaf parameters *viz.*, leaf shape and leaf colour of *Garcinia indica* from different sites and Zones of Uttara Kannada district. The highest percentage of leaf shape was

elliptical (47.5 %) followed by ovate (32.5 %) and lowest was recorded in lanceolate (7.5 %) shown in Fig 1 and Fig 2. The leaf colour variation in study area. The highest percentage of leaf colour was reported to be dark green (90 %) was also observed and the lowest was reported as light green (10 %).

Variation in leaf morphometric traits of *G. indica viz.*, leaf length (cm), leaf width (cm), fresh leaf weight (g), dry leaf weight (g) and leaf moisture content were presented in the Table 3. The results revealed that, there was significant difference between the Zones in case of leaf parameters. Leaf length of *Garcinia indica* among different zones the highest mean leaf length was recorded in Zone-A (9.84 cm) and lowest mean was recorded in Zone-D (8.09 cm). Among the different sites of zones, the site S1 of Zone-A recorded highest leaf length (9.94 cm), lowest leaf length was recorded in site S2 of Zone-D (7.77 cm). Among the individual tree basis, the highest leaf length was recorded G4 (10.82 cm) of S1 of Zone-A and lowest was recorded G39 (7.28 cm) of S2 of Zone-D.

The leaf width variation among individual trees, sites and zones. Among different zones, the widest mean leaf width was reported in Zone-A (3.68 cm) and shortest was recorded in Zone-D (3.50 cm). Among the different sites the widest leaf width was recorded in site S2 (3.82 cm) of Zone-B and shortest was recorded at site S2 (3.39 cm) of Zone-C. The leaf width ranges from 2.99 to 4.33 cm. The widest leaf width was recorded in G16 (4.23 cm) of site S2 of Zone-B and shortest leaf width was recorded in G31 (2.99 cm) of site S1 of Zone-D.

The fresh leaf weight among different zones, site and individual trees. Among different zones the highest mean fresh leaf weight was reported in Zone-C (0.85 g) and lowest was reported in Zone-D (0.57 g). Whereas among the different sites, the highest fresh leaf weight was recorded in site S2 (0.90 g) of Zone-A and lowest was recorded in site S1 and S2 (0.57 g) of Zone-D. On individual tree basis, the highest leaf fresh weight was recorded in both G9 and G29 (1.03 g) of Site S2 in Zone-A and Zone-C respectively and lowest fresh leaf weight was recorded in G31 (0.40 g) of Site S1 of Zone-D.

The dry leaf weight in Zones, sites and individual trees. The highest mean dry leaf weight was recorded in Zone-C (0.20 g) and lowest was recorded in Zone-D (0.16). Whereas among of different sites, the highest dry leaf weight was recorded in Site S1 and S2 (0.20 g) of Zone-C and lowest was recorded in Site S1 (0.15 g) of Zone-D. Dry leaf weight on individual tree basis. The maximum dry leaf weight was recorded in G21 and G29 (0.23 g) of site S1 and S2 of Zone-C and minimum dry leaf weight was recorded in G31 (0.10 g) of Site S1 of Zone-D.

The percentage of variation in leaf moisture content among different zones, sites and individual trees. The maximum mean percentage of leaf moisture content was observed in Zone-A (76.98 %) and minimum was observed in Zone-D (70.89 %). Whereas among the different sites, the maximum percentage of leaf moisture content was observed in site S2 (78.41 %) of Zone-A and minimum was observed in site S2 (69.76 %) of Zone-D. Leaf moisture content on individual trees basis leaf moisture content ranges from 67.87 % to 79.49 %. The highest percentage of leaf moisture content was observed in G9 (79.49 %) of Site S2 of Zone-A and lowest was observed in G32 (67.87 %) site S1 of Zone-D.

Similar results were reported by Madappa and Bopaiah (2012), where he studied on *Garcinia gummi-gutta* growing in Western Ghat regions of Kodagu, Dakshina Kannada, Uttara Kannada and parts of Kerala. The plant species leaf size was reported variations. The average size of leaf length ranges from 9.7 to 14.1 cm, leaf width of 2.8 to 5.1 cm and average weight of the fresh leaf before drying is 1.212 to 2.440 mg on *Garcinia gummi-gutta*.

Priyadevi*et al*., (2013),leaf length showed a good variation ranging from a minimum of 6.24 to 11.95 cm. Leaf width of all accessions studied varied from 2.42 to 5.25 cm.

Present study indicates that, there was variation among both Zones and sites. Maximum leaf length and width of *Garcinia indica* was observed in higher altitudinal region. Similar observations were done by Priyadevi*et al.,* (2013), where he observed the variation in case of leaf traits were predominant in altitudinal Zones, he also observed leaf were heavier in higher altitudinal regions compare to lower altitude.

Four different shaped leaf were observed among the study area. within the 40 trees 19 trees showed Elliptical shaped (47.5 %) leaf followed by 13 trees with Ovate (32.5 %), 5 trees with obovate (12.5 %) and 3 trees with Lanceolate shaped (7.5 %) leaf. Similar observations were made by Priyadevi*et al.,*(2013), says that presence of several different shaped leaf of *Garcinia indica* from different accessions of Western Ghats in Goa, including above mentioned shapes.

4. CONCLUSION

The present work influence how bioclimatic conditions especially high ghat and rainfall have influence the leaf morphometric features of Garcinia indica. Variations in leaf width, length and weight were noted throughout many altitudinal zones; Zone-A (Plains) showed the best leaf length and breadth; Zone-C (Mid-ghat) showed best leaf weight. These results give insightful information for choosing planting material as trees from Zone-A, which are higher elevations, would be more suited for places where greater leaf size is required, while trees

from Zone-C could be perfect for areas where higher leaf biomass is vital. Since leaf size and weight directly affect yield and quality of bioactive chemicals, this is especially pertinent for sectors using Garcinia indica in food processing, medications, and cosmetics. Moreover, the identification of particular sites with better leaf traits (such S2 of G16 for leaf width, G4 for leaf length, and G9 and G29 for leaf weight) can direct the choice of superior genotypes for propagation and commercial farming, so improving resource management and economic viability in the Garcinia indica value chain.

5. REFERENCES

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