Effect of different altitudinal zones on growth parameters of *Garcinia indica* (Choisy) in Uttara Kannada, Karnataka, India

Abstract

This study examines the impact of altitudinal variation on the growth of *Garcinia indica* in Agro-climatic Zone-9 of Karnataka, specifically in the Uttara Kannada district of the Western Ghats. Eight experimental sites, categorized into four altitudinal zones (Plains, Up-ghat, Mid-ghat, and Coastal), were analyzed for tree height, girth, and crown diameter. Results show significant growth variations, with the Up-ghat zone having the highest mean tree height (10.73 m), the Coastal zone showing the largest girth (69.67 cm), and the Mid-ghat zone exhibiting the widest crown diameter (7.08 m). Four type of canopy found viz., Pyramidal, Full-crowned, Weeping and Spreading. These growth differences are influenced by environmental factors such as rainfall, humidity, and light availability, which are more favourable in higher altitude regions. The findings have practical implications for commercial *Garcinia indica* cultivation, indicating plains and up-ghat as optimal for higher productivity. Understanding these growth patterns supports sustainable harvesting and improved yields for industries using kokum butter and extracts.

Keywords: *Garcinia indica, tropical evergreen, high-quality drinks, dysentery*

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 (Roberts, 1984). *Garcinia indica* is a tropical evergreen, slender tree with sloping branches, it reaches heights of 15 m. 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). The tree is mostly found along the Konkan region of Maharashtra's Ratnagiri district, Goa, in Karnataka's district of Uttara Kannada, Udupi, Dakshina Kannada. It is known by various names across India including Murugalu in Kannada, Tallow tree in English and in Malayalam it is called Punarpuli (Swami *et al*., 2014).

The rind and seeds of the *Garcinia indica* fruit have a wide range of uses, including culinary, cuisine, fruit drinks, medicines and industrial. It's also known as an Indian spice with a nice flavour and a sweet acidic (sour) taste, making it a favourite culinary addition. In several Indian recipes, it is historically used as an acidulant. This tree is gaining popularity as

its fruits have a wide range of applications, from pharmaceuticals to high-quality drinks. Dysentery, tumours, cardiac problems, stomach acidity and liver ailments have all been claimed to be treated with kokum. Garcinol, hydroxy citric acid and anthocyanin pigment are three significant chemical elements found in fruit rind. Garcinol is a fat-soluble yellow pigment that contains hydroxy citric acid, an acidulant and physiologically active chemical that has been demonstrated to help people lose weight (Krishnamurthy *et al.*, 1982).

Garcinia is an evergreen, tall growing tree found in the West coast of India, it flourishes well in coastal part at a hight of 10 to 16 m, having girth of 50 to 100 cm with conical shaped greenish crown. The tree is grows will in high rain fall with medium altitude zones (Rema and Krishnamurthy, 2000). A full-grown *G. indica* tree attains a height of about 16 to 20 meters. The tree itself is ornamental with a dense canopy having lush green leaves with red tinged tender emerging leaves. Being a pyramid shaped handsome evergreen tree, it is a good choice for growing along the roads and railway tracts (Bridgwater*et al.*, 2012). *Garcinia* species are generally small or medium sized evergreen trees are distributed in pantropical regions, with high species richness in South-East Asia. *Garcinia indica* is evergreen to semi-evergreen tree up to 15 m height, exudation milky, branches with conical crown or pendulous drooping, the tree grows very good in ghat areas as compare to plain areas (Shameer *et al.*, 2016).

Garcinia indica is a slow-growing slender, tropical evergreen tree which grows to a height of 10–18 m naturally spread in Western Ghats and also in North-Eastern states (Singh, 1993).

Subash Chandran (1996) reported on *Garcinia indica* having different canopy shapes viz., drooping and pyramidal shape with 10-15m height.

Garcinia indica canopies were basically either pyramidal or conical or of spreading (Priyadevi *et al.*, 2013).

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.

*Garcinia indica v*ariability studies on different *G. indica* species indicated significant differences among kola species with the most discriminative traits related to the plant size and fruit parameters such as fruit length, fruit thickness and fruit weight. *Garcinia kola* was the tallest species displaying the largest fruit thickness (Durand *et al*., 2016).

Garcinia species are generally small or medium sized evergreen trees, (occasionally shrubs: *G. buchneri* Engl.), and are distributed in pantropical regions, with high species richness in South-East Asia. *Garcinia indica* is evergreen to semi-evergreen tree up to 15 m high, exudation milky, branches with conical crown or pendulous drooping. Branches with conical crown or pendulous drooping and berries smooth, not grooved, deep purple when ripe (Shameer *et al*., 2016).

MATERIAL AND METHODS

The present study was conducted in the Agro-climatic Zone-9 of Karnataka, specifically in the Uttara Kannada district, part of the central Western Ghats, which is characterized by tropical climate conditions. The research focused on *Garcinia indica*, a species predominantly occurring in evergreen to semi-evergreen forests, naturally distributed across these locations and found on farmlands. Eight experimental sites were selected based on varying altitudes and rainfall patterns, categorized into four zones: Plains (Zone-A, 600 m MSL and above), up-ghat (Zone-B, 500-600 m MSL), mid-ghat (Zone-C,400-500 m MSL) and coastal (Zone-D, 400 m MSL and below). In each zone, two sites were randomly chosen, and five trees per site were selected for study. The sampling locations were distributed across Kumta taluk (Kathgal, Divage, Devimane, Ragihosalli) and Sirsi taluk (Janmane, Yeddalli, Islur, Banavasi). The region experiences a monsoonal climate, with rainfall ranging between 2000-4000 mm annually, predominantly during the southwest monsoon (June-September). The annual temperature ranges from 18°C to 31°C, with relative humidity peaking above 90% in July-August and dropping to as low as 40% in March-April.

Stand enumeration and various instruments used for different parameter

The Chaturvedi and Khanna (1982) technique of stand enumeration was used. Using a tape measure, the Girth at breast height (GBH) was measured at 1.37 meters above sea level and recorded in centimetres (cm). Using a Ravi altimeter, the tree's total height (measured in

meters) from base to tip was determined. Two perpendicular directions were used to estimate the tree's crown spread. The crown diameter was determined by averaging the two results.

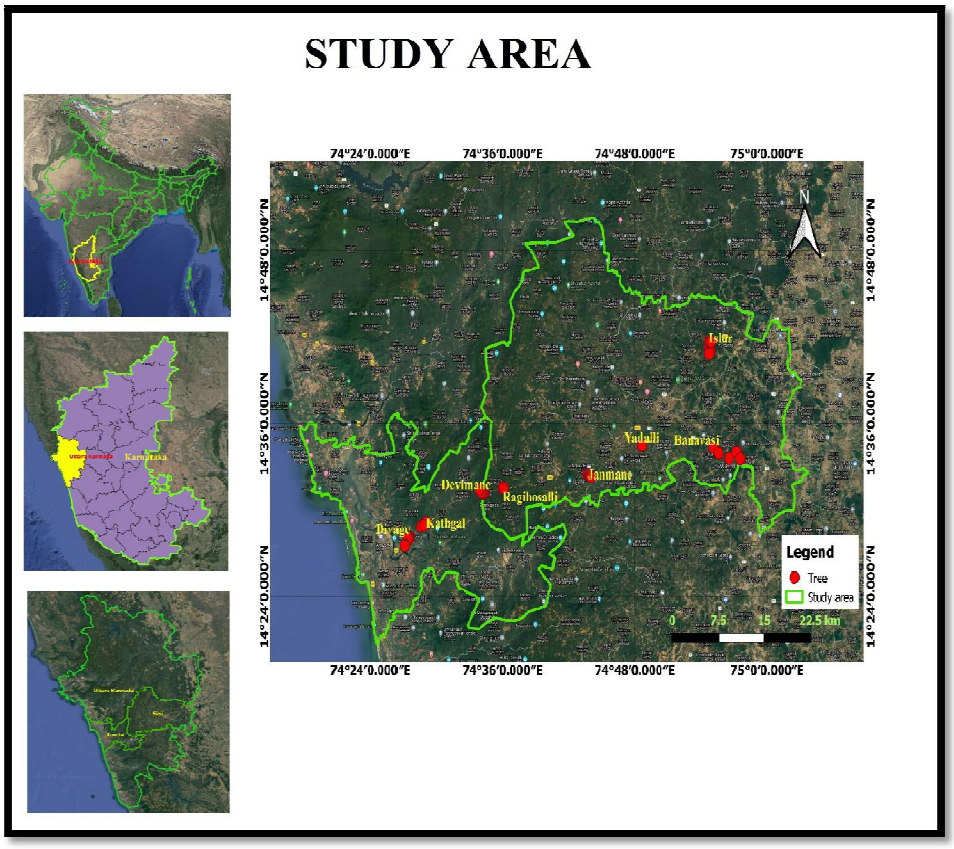

Fig 1: Study Area

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 (Plains)	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 (Divage)	77.8	3800 - 4722	120	24.9

* Rainfall data by KSNDMC report 2019

Table 2. Effect of altitudinal Zone and site variation on growth parameters

Altitudinal Zone	Site	Total tree height (m)	Girth at breast height (cm)	Crown diameter (m)
Zone-A (Plains)	**S_1 (Banavasi)**	10.79	66.40	6.24
	S_2 (Islur)	10.34	64.47	6.74
	Mean	**10.57[b]**	**65.43[c]**	**6.49[c]**
Zone-B (Up-ghat)	**S_1 (Yeddalli)**	9.41	61.60	6.18
	S_2 (Janmane)	12.05	66.33	7.17
	Mean	**10.73[a]**	**63.97[d]**	**6.67[b]**
Zone-C (Mid-ghat)	**S_1 (Devimane)**	10.70	68.07	6.94
	S_2 (Ragihosalli)	10.41	68.53	7.23
	Mean	**10.56[b]**	**68.30[b]**	**7.08[a]**
Zone-D (Coastal)	**S_1 (Kathgal)**	9.17	68.53	6.02
	S_2 (Divage)	11.47	70.80	7.07
	Mean	**10.32[c]**	**69.67[a]**	**6.54[b]**
SEm ±	**Zone**	**0.031**	**0.260**	**0.071**
	Site	**0.035**	**0.290**	**0.080**
	Interaction	**0.070**	**0.518**	**0.160**
CD @ 5%	**Zone**	**0.088**	**0.731**	**0.204**
	Site	**0.099**	**0.818**	**0.228**
	Interaction	**0.198**	**1.635**	**0.456**

* a indicated that significantly maximum value
b indicated that second highest value
c indicated that third highest value
d indicate that lowest value

Table 3: Tree shapes of *G. indica* in the study area

Crown shape	Trees	Share (%)
Pyramidal	29	72.5
Full-crowned	6	15
Weeping	3	7.5
Spreading	2	5

Total	**40**	**100**

RESULTS AND DISCUSSION

Table 2 represents influence of site conditions on tree height of *Garcinia indica* which reports that among the different zones, the highest mean tree height was observed in up-ghat (10.73 m), while lowest was observed in mid-ghat and coastal (10.32 m). Whereas, maximum mean crown diameter was noticed in mid-ghat (7.08 m) and minimum was observed in plain (6.49 m) and highest girth at breast height was recorded in coastal (69.67 cm) and lowest was recorded in up-ghat (63.97 cm).

Among the different experimental study sites of different zones, the highest tree height was observed in site Janmane (S2-12.05 m) of up-ghat and lowest was observed in site Kathagal (S1-9.17 m) of coastal as indicated in. The maximum tree girth was observed in site Divage (S2-70.80 cm) of Coastal and minimum was recorded in site Kathgal (S1-61.60 cm). The widest tree crown diameter recorded in site Ragihosalli (S2-7.23 m) of mid-ghat and shortest was observed in site Kathgal (S1-6.0 m) of Coastal.

Table 3 shows there are four different crown shape were recorded in experimental study area of Agro climatic zone 9. This shows that there is variation exist among the zones and sites. Where pyramidal crown shape shows dominant, (72.5 %) 29 trees followed by full-crowned trees (15 %) 6 trees, then weeping crown shape (7.5 %) 3 trees and distribution of trees under spreading shape of crown (5 %) 2 tree was found to be least.

Several climatic factors like moisture, rainfall, number of rainy days, temperature and wind etc. affect the vegetation. Among the climatic factors viz., altitude, rainfall and number of rainy days were most important. The present study, showed significant effect of altitudinal zones and sites on various growth parameters such as total or mean tree height, girth and crown diameter.

Higher growth is found in Plains and Up-ghat for growth parameters like total height, higher tree girth was found in mid-ghat and coastal. Highest mean crown diameter was found in mid-ghat and coastal. This may be due to moderate relative humidity, maximum rainfall and moderate light incident in the higher altitudinal region compared to lower altitudinal region. The location of the site had an effect on typical weather because of the latitude, elevation or proximity to weather modifying capabilities together with mountains or huge bodies of water and lush evergreen forests with rich organic nutrients in the soil, which helps in the better growth.

Conclusion

There was significant influence of site conditions on the growth parameters of *Garcinia indica* such as tree height, crown diameter and girth. Highest mean tree height was observed in up-ghat (10.73 m). Whereas, maximum girth (69.67 cm) in coastal and widest mean crown diameter was recorded in mid-ghat (7.08 m). Height, Girth and crown diameter showed significant variation between the Zones higher growth is found in plain and up-ghat region for growth parameters like total height and bole height. From this observation we can conclude that there is some noticeable effect of different altitude (in taken altitudinal range) zones on the growth of *G. indica* trees in Uttara Kannada region.

- The information on tree height, crown diameter, and girth in each zone aids in determining the best areas (plains and up-ghat) to cultivate *Garcinia indica*. This would make it possible for businesses to obtain their raw materials from regions with the largest potential output, guaranteeing a steady and superior supply of fruits and seedsthe main ingredients in industrial goods like kokum butter, drinks, and pharmaceutical extractsinto the market.
- By identifying growth zones for trees (e.g., up-ghat for height and coastal for girth), enterprises may concentrate on growing the plant in these areas to enhance fruit production and harvest efficiency, hence increasing total productivity.
- Changes in growth brought on by altitude may have an impact on the fruits' or seeds' chemical makeup. Kokum butter, which is utilised in the food, medicine, and cosmetics sectors, is one example of an end product whose quality is consistently maintained by choosing plant material from the zones with the best development circumstances. Maintaining standardised active substances for use in medicine or cooking is crucial.
- The data enables companies to implement management strategies tailored to individual sites. By coordinating harvesting dates with zones that exhibit quicker growth or bigger fruit production, they can ensure sustainable and effective use of resources while minimising overexploitation in less productive regions.
- The notable growth variance between zones points to potential for breeding initiatives. Plants from areas where the plants exhibit higher growth qualities can be employed as seeds or cuttings by industries who are committed to producing high-quality plant material. This aids in the development of genetically improved strains for marketable uses.

- Understanding growth variances may also assist companies in developing regionally specific branding. For instance, they may promote items containing *Garcinia indica* from particular zones as being of higher calibre, therefore enabling premium pricing.

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