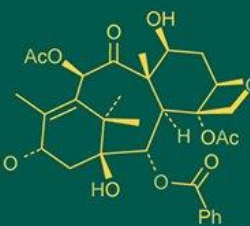
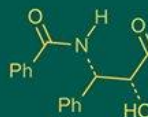
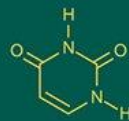
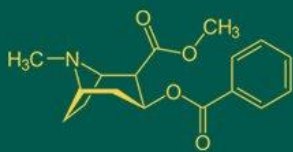


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Growth dynamics and productivity of Dandeli teak (*Tectona grandis* L.f.) Plantations across different site quality classes in Karnataka

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Abstract

Growth and productivity are important indicators for evaluating the performance and yield potential of forest plantations. The present study was conducted to assess the growth dynamics and productivity of Dandeli teak (*Tectona grandis* L.f.) plantations across different site quality classes in the Haliyal Forest Division of Karnataka. Growth parameters, namely girth at breast height (GBH), total height and clear bole height, along with productivity parameters including basal area, clear bole volume and total stand volume, were evaluated across different age gradations. The results revealed that site quality had a significant influence on tree height, clear bole height and clear bole volume, whereas girth, basal area and total stand volume did not differ significantly between the two site quality classes. Site Quality III recorded higher mean total height (15.75 m), clear bole height (7.31 m), clear bole volume (100.80 m³ ha⁻¹) and total stand volume (223.79 m³ ha⁻¹) compared with Site Quality IV. Although Site Quality IV recorded a marginally higher mean girth (1.07 m) than Site Quality III (1.04 m), the difference was not statistically significant. All growth and productivity parameters increased significantly with stand age, with the highest values recorded in plantations older than 100 years, indicating continuous biomass accumulation and stand development. The study demonstrates that stand age is the primary factor influencing teak growth and productivity, while site quality mainly affects height growth and merchantable bole development. The favourable growth performance observed in both site quality classes indicates the high productive potential of Dandeli teak plantations. The findings provide valuable baseline information for sustainable plantation management, yield prediction and future teak improvement programmes in the Haliyal Forest Division of Karnataka.

Keywords: Age gradation, site quality, Dandeli teak, merchantable timber, productivity

Introduction

Teak (*Tectona grandis* L.f.) is one of the most valuable tropical hardwood tree species in the world and is widely cultivated because of its superior timber quality, durability and high economic returns. Teak is native to India, Myanmar, Thailand and Laos. Teak has been extensively planted across tropical regions of Asia, Africa and Latin America to meet the increasing demand for quality timber. In India, teak occupies a prominent position in natural forests and plantation forestry, contributing substantially to the timber economy and supporting sustainable forest management. The species is highly preferred for furniture, construction, shipbuilding and decorative wood products owing to its excellent mechanical properties, dimensional stability and natural resistance to decay and insect attack (Anish *et al.* 2015) ^[1].

Growth and productivity are fundamental indicators for evaluating the performance and sustainability of forest plantations. In teak, these parameters are influenced by a combination of factors, including site quality, stand age, climate, soil characteristics, silvicultural practices and stocking density. Variations in these factors determine tree height, girth, basal area, stand volume and biomass accumulation, ultimately affecting timber yield and economic returns (Sankar 2022) ^[2]. Assessing growth dynamics across different site quality classes provides valuable information for understanding stand development, optimizing rotation age and improving plantation productivity. Such evaluations also assist forest managers in identifying antibacterial ^[17, 18] activities.

productive sites and formulating appropriate silvicultural interventions for maximizing timber production.

Dandeli teak plantations of Karnataka are well known for producing high-quality timber and have earned a strong reputation in national and international markets. However, quantitative information on their growth performance and productivity under different site quality classes remains limited. A comprehensive assessment of stand growth, basal area and volume production is therefore essential to understand the productive potential of these plantations and to support evidence-based forest management. The present study was undertaken to evaluate the growth dynamics and productivity of Dandeli teak plantations across different site quality classes in the Haliyal Forest Division of Karnataka, thereby providing scientific information for sustainable plantation management and enhancing the documented uniqueness of Dandeli teak plantations.

Materials and Methods

Study area

The present research work was carried on "Growth and productivity of Dandeli teak Plantations across different site quality classes" in the year 2025-26. The location of the experimental site was at Haliyal Forest Divisions, Canara Circle, Uttara Kannada district, Karnataka. The experimental site is situated at 15° 16' N latitude and 76° 37' E longitude, with an average elevation of 473 m above mean sea level. Geographically, the division lies between the coastal belt and the Deccan plateau, resulting in diverse topography that includes undulating hills, valleys and plains. The study area experiences south west monsoon which is experienced from June to October. Small quantity of rainfall is received from the retreating monsoon in November. The dry season is long and last for more than six months, summer showers are also received sometimes in the month of the April and pre-monsoon showers in the month of May. The mean annual rainfall is about 2500 mm. The mean monthly temperature ranges from 25°C to 33°C. The forests of Haliyal forest division are predominantly tropical moist deciduous and semi-evergreen in nature.

Methodology

Based on information acquired through preliminary reconnaissance survey in the Haliyal Forest Division, representative teak stands belonging to seven representative age classes (41-50, 51-60, 61-70, 71-80, 81-90, 91-100 and above 100 year) with two site qualities classes (SQ III and SQ IV) together constituting a total of fourteen teak plantations were selected for the study (Table 1). With the help of forest staff five representative standard sample plot size of 20×20 m was laid by using random sampling method in each sampling site. The plots were selected and demarcated in a manner that they represent the whole area of each plantation and the growth parameters were recorded. After laying out the plots, all teak trees in each plot were measured for height, girth at breast height and bole height.

Statistical analysis

The data obtained from each of the experiments for all the parameters were subjected to analysis of variance (ANOVA) using OPSTAT statistical packages as described by Jayaraman (2001) [3] to assess the effectiveness of the various treatments. Two factor anova was considered for statistical analysis. The site quality was considered as main treatment

(factor A) and age gradation was treated as sub treatment (factor B). The plots in the age gradation were considered as replicates. The design followed for data analyses was RCBD. The level of significance was calculated as F test at $p=0.05$. The critical difference value was calculated wherever F test found significant. Comparisons of means were carried out using critical difference wherever needed.

Results and Discussion

The growth and productivity parameters of Dandeli teak plantations across different site quality classes and age gradations are presented in Table 2. Growth parameters included girth at breast height (GBH), total height and clear bole height, while productivity parameters comprised basal area, clear bole volume and total stand volume. No significant difference in GBH was observed between the two site quality classes, although SQ IV recorded a marginally higher mean girth (1.07 m) than SQ III (1.04 m). In contrast, age gradation had a significant influence on girth, which increased progressively from 0.76–1.34 m in SQ III and from 0.77–1.31 m in SQ IV between the 41–50 year and >100 year age classes. The interaction between site quality and age gradation was non-significant. Total height and clear bole height differed significantly between site quality classes, with SQ III recording higher mean total height (15.75 m) and clear bole height (7.31 m) than SQ IV. Both parameters increased significantly with stand age. Total height ranged from 12.05 to 21.12 m in SQ III and from 11.20 to 19.96 m in SQ IV, while clear bole height increased from 4.35 to 12.05 m and from 4.42 to 10.14 m, respectively. The interaction between site quality and age gradation was significant for both height parameters. Basal area increased significantly with age but did not differ significantly between site quality classes. Although SQ III recorded a slightly higher mean basal area ($30.59 \text{ m}^2 \text{ ha}^{-1}$) than SQ IV ($29.08 \text{ m}^2 \text{ ha}^{-1}$), the interaction effect was non-significant, indicating a similar pattern of basal area development across age classes.

Clear bole volume was significantly influenced by both site quality and age. SQ III recorded a significantly higher mean clear bole volume ($100.80 \text{ m}^3 \text{ ha}^{-1}$) than SQ IV ($88.68 \text{ m}^3 \text{ ha}^{-1}$). Clear bole volume increased from 42.31 to $167.91 \text{ m}^3 \text{ ha}^{-1}$ in SQ III and from 42.79 to $143.72 \text{ m}^3 \text{ ha}^{-1}$ in SQ IV with increasing stand age. The interaction between site quality and age gradation was non-significant, suggesting a similar trend of volume accumulation across age classes. Similarly, total stand volume increased significantly with age but did not differ significantly between site quality classes. Mean total volume was comparatively higher in SQ III ($223.79 \text{ m}^3 \text{ ha}^{-1}$) than in SQ IV ($214.38 \text{ m}^3 \text{ ha}^{-1}$). Across age gradations, total volume increased from 119.27 to $369.72 \text{ m}^3 \text{ ha}^{-1}$ in SQ III and from 109.63 to $342.82 \text{ m}^3 \text{ ha}^{-1}$ in SQ IV. The non-significant interaction effect indicated a comparable pattern of stand volume development in both site quality classes.

Tree growth and productivity increased consistently with stand age, indicating the normal growth pattern of teak plantations. Although site quality IV recorded a marginally higher mean girth (1.07 m) than SQ III (1.04 m), the difference was not significant, suggesting that site quality had limited influence on stem diameter in mature plantations. Similar observations were reported by Sankar (2022) [2] and Hu *et al.* (2021) [4] who found no significant relationship between site quality and DBH in teak and *Quercus mongolica*, respectively. Variations in girth may also be influenced by stand density, spacing and silvicultural

management practices, as reported by Kunhamu *et al.* (2009) [5].

In contrast, total height and clear bole height were significantly higher in SQ III than in SQ IV, indicating that height growth is more responsive to site conditions than stem diameter. Tree height is widely regarded as a reliable indicator of site productivity because it is strongly influenced by climatic and edaphic factors. Similar findings were reported by Minoche *et al.* (2017) [6] who observed a stronger influence of site characteristics on tree height than on diameter. Gunaga *et al.* (2014) [7] also reported superior height growth and clear bole development in Dandeli teak plantations under favourable site conditions. The comparatively higher clear bole height in SQ III may be attributed to favourable growing conditions, natural self-pruning and stand competition, while appropriate silvicultural practices such as pruning and thinning further enhance merchantable bole development (Sankar, 2022) [2]. The relatively lower height observed in the 91–100 year age

class of SQ III may reflect local management-related factors rather than inherent site productivity.

Basal area, clear bole volume and total stand volume increased significantly with stand age, reflecting continuous radial growth and biomass accumulation. Although SQ III recorded comparatively higher basal area (fig 1), clear bole volume (fig 2) and total volume (fig 3) than SQ IV, the differences between site quality classes were generally small, indicating that both site classes provide favourable conditions for teak growth. Similar age-related increases in stand productivity have been reported in teak plantations by Sankar (2022) [2], Shaikh (2015) [8] and Shahapurmath *et al.* (2016) [9]. Higher stand volumes in older plantations are primarily the result of cumulative stem growth, increased photosynthetic capacity and sustained biomass production over time. Stand density and silvicultural management also influence stand productivity, with wider spacing generally promoting greater basal area and volume development (Kunhamu *et al.*, 2009) [5].

Table 1: Details of the Plantations selected based on site quality and age gradation from different ranges of Haliyal Forest Division

Site Quality	Age Class	Range	Year of planting	Age
III	41-50	Virnoli	1975	49
	51-60	Dandeli	1965	59
	61-70	Virnoli	1960	64
	71-80	Dandeli	1949	75
	81-90	Virnoli	1946	80
	91-100	Dandeli	1926	98
	Above 100	Joida	1923	101
IV	41-50	Bhagavati	1977	47
	51-60	Barchi	1973	51
	61-70	Barchi	1954	70
	71-80	Bhagavati	1952	72
	81-90	Bhagavati	1939	85
	91-100	Sambrani	1930	94
	Above 100	Sambrani	1923	101

Table 2: Growth and productivity of teak plantations as influenced by site quality and age gradation in Haliyal Forest Division

Site Quality (SQ)	Age Gradation (AG)	Girth (m)		Total height (m)		Clear bole height (m)		Basal area (m ² ha ⁻¹)		Clear bole volume (m ³ ha ⁻¹)		Total Volume (m ³ ha ⁻¹)	
SQ III	41-50	0.76		12.05		4.35		19.85		42.31		119.27	
	51-60	0.80		13.74		4.82		21.09		51.29		127.01	
	61-70	0.84		15.32		5.68		21.78		73.06		137.48	
	71-80	1.13		15.52		7.04		32.45		120.39		233.79	
	81-90	1.15		16.08		7.28		38.45		122.59		268.79	
	91-100	1.29		16.44		9.96		38.64		128.03		310.32	
	100+	1.34		21.12		12.05		41.88		167.91		369.72	
	Mean	1.04		15.75		7.31		30.59		100.80		223.79	
SQ IV	41-50	0.77		11.20		4.42		19.81		42.79		109.63	
	51-60	0.81		12.10		4.50		21.34		46.52		111.21	
	61-70	0.90		12.15		5.44		21.91		51.28		122.43	
	71-80	1.21		13.30		6.75		32.08		92.55		241.52	
	81-90	1.24		15.14		7.03		33.85		111.84		255.48	
	91-100	1.26		17.94		9.85		37.02		132.09		317.57	
	100+	1.31		19.96		10.14		37.56		143.72		342.82	
	Mean	1.07		14.54		6.88		29.08		88.68		214.38	
		SEm ±	CD (p=0.05)	SEm ±	CD (p=0.05)	SEm ±	CD (p=0.05)	SEm ±	CD (p=0.05)	SEm ±	CD (p=0.05)	SEm ±	CD (p=0.05)
Site quality (SQ)		0.02	NS	0.15	0.43	0.15	0.42	0.93	NS	4.25	12.08	7.59	NS
Age gradation (AG)		0.03	0.10	0.28	0.80	0.27	0.78	1.74	4.95	7.94	22.60	14.21	40.43
SO x AG		0.05	NS	0.40	1.13	0.39	1.10	2.46	NS	11.23	NS	20.09	NS

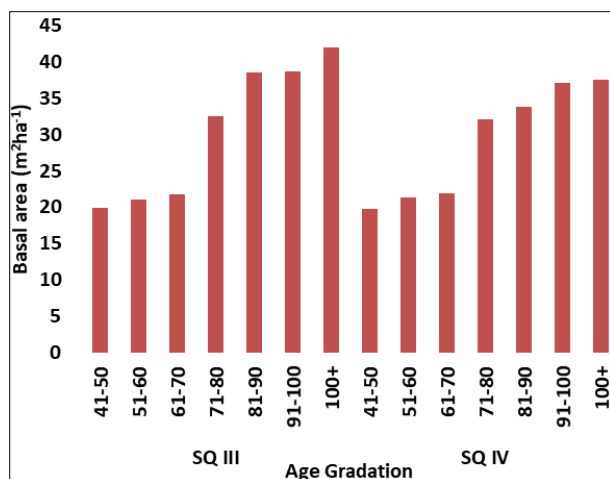


Fig 1: Effect of Site Quality and Age Gradation on Basal area of Teak plantation

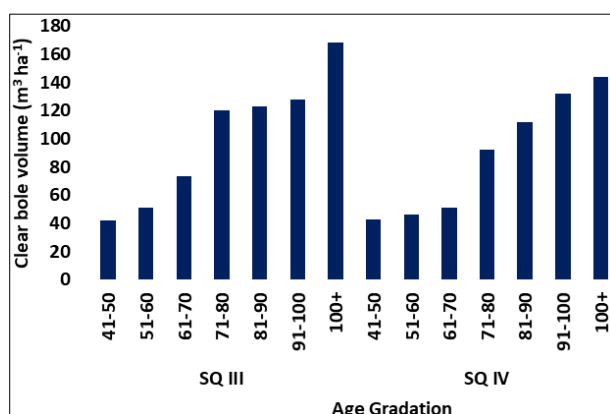


Fig 2: Effect of Site Quality and Age Gradation on Clear Bole Volume of Teak plantation

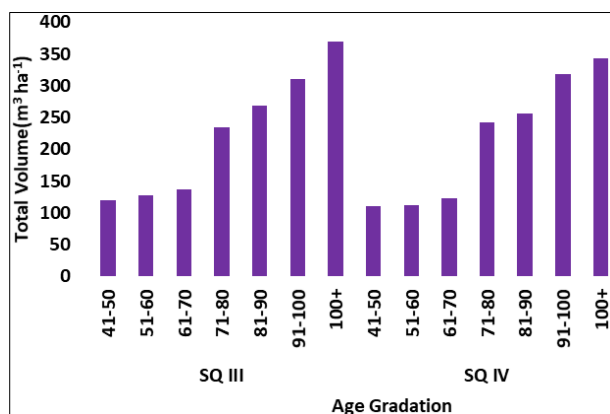


Fig 3: Effect of Site Quality and Age Gradation on Total Volume of Teak plantation

Conclusion

The present study demonstrated that growth and productivity of Dandeli teak plantations were primarily influenced by stand age, while the effect of site quality was evident mainly in height growth and clear bole development. Total height, clear bole height and clear bole volume were significantly higher in Site Quality III, whereas girth, basal area and total stand volume did not differ significantly between the two site quality classes. All growth and productivity parameters increased progressively with advancing age, with the highest values recorded in plantations older than 100 years, indicating continuous biomass accumulation and timber

production. Overall, both site quality classes supported good teak growth and productivity, highlighting the favourable growing conditions of the Haliyal Forest Division. These findings provide useful information for plantation management, yield prediction and sustainable utilization of Dandeli teak plantations.

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