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Growth Biometry of Farm grown Teak (*Tectona grandis* Linn. F) in High Rainfall Zone of Tamil Nadu

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Abstract
Teak is an extremely popular timber species regarded as a paragon among timber due to its natural durability, stability and other wood properties. The growth biometry of farm grown teak is a critical aspect of understanding and is crucial for optimizing the cultivation of this valuable hardwood tree under farm settings. The present investigation was carried out in 6 revenue blocks in four age classes under High Rainfall Agro climatic zone in Kanyakumari district of Tamil Nadu to determine the growth and correlate the age with growth biometry of farm grown teak. The boundary plantations of 15-20 years age class, has the maximum DBH (0.285 m), height (11.35 m) and volume (0.760 m^3). Positive correlation was observed between diameter at breast height (dbh) (k=0.985, p<0.05), total height (k=0.999, p<0.01), total volume (k=0.922, p<0.05) with the age of the plantations. High Rainfall zone is more suitable for cultivation of teak in farm land conditions owing to the favourable climatic conditions coupled with management practices followed in tree cultivation.

Keywords: Teak, growth biometry, high rainfall zone, age classes, correlation

Introduction
Teak (*Tectona grandis*) is an economically important tree species comes under the family Lamiaceae and is indigenous to India and Southeast Asian region. Natural teak forests in India is distributed in an area of 6.8 M ha and teak plantations in an area of 1.68 M ha (FAO, 2015). Teak plantations are found in the state of Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka, Kerala, Gujarat, Orissa, Andhra Pradesh, Rajasthan and Manipur (Awasthi, 2020) [1]. Teak grows well in regions having rainfall range of 900-2500 mm and temperature regime of 17 °C to 43 °C (Die *et al.,* 2012) [6]. Farm-grown teak has gained significant attention as a valuable timber species due to its exceptional growth characteristics and high-quality wood. Large scale plantations began in India in the first half of 19th century, and were introduced in Africa and America just before the beginning of the 20th century (Evans, 2009) [8]. The establishment and successful growth of teak is significant for its optimal utilization. Growth biometry refers to the scientific measurement and analysis of various growth parameters of trees throughout their life cycle. It involves the assessment of key factors such as height growth, diameter growth and volume increment. Understanding the growth biometry or the quantitative measurements of growth parameters of farm-grown teak is essential for effective plantation management, yield prediction, and sustainable forestry practices.

Based on the influence of rainfall, irrigation and cropping pattern, Tamil Nadu has been classified into seven agro-climatic zones (Kumar *et al.*, 2021) [10]. In the seven agro climatic zones, teak cultivation is amenable in farmlands of five agroclimatic zones which provides optimum climatic and edaphic conditions (Balasubramanian, 2019) [2]. The High Rainfall Zone, ensure abundant rainfall and moderate temperature which is an ideal environment for growth of teak trees. The soil composition and topography of this region also play a crucial role in nurturing healthy teak plantations. Teak is a long rotation crop which requires extended period to harvest, with its rotation ranging up to 60 years under natural conditions (Budiadi and Ishii 2017) [3]. The rotation period of teak may be reduced by suitable silvicultural practices (Buvaneswaran *et al.*, 2006) [4]. Teak grown in farmlands under precision silviculture techniques is amenable for early harvest, which considerably reduce the rotation period. The productivity of short rotation teak is high with a mean annual increment of 10-20 m^3/ha/year

(Sasidharan, 2021) [13]. In recent years, there has been consistent interest among farmers to grow teak in farm lands under short rotations for its high price and great demand in the market (Shukla *et al.*, 2021) [14] However, the study on growth biometry of teak in farmlands has not been much explored in the High Rainfall Zone. In order to determine the growth performance of farm grown teak, growth biometry need to be evaluated in an extensive manner. The present study focus on the growth performances of farm grown teak based on age classes in High Rainfall Zone of Tamil Nadu.

Materials and Methods

The study was conducted in High Rainfall Zone of Tamil Nadu covering six blocks of Kanyakumari District (8°02'60.00" N, 77°14'60.00" E), which includes Melpuram, Munchirai, Killiyur, Thiruvattar, Thuckaly and Kurunthancode blocks. Among these blocks, a total of 14 block plantations and 8 boundary plantations were taken up for the study to estimate the growth biometry of farm grown teak under 4 different age-classes (0-5, 5-10, 10-15 and 15-20).

The biometric parameters namely tree height and DBH (Diameter at breast height) were estimated for the above indicated age-classes in both boundary and block plantation of Teak. DBH of teak trees were measured at a standard height 1.37 m height of trees were measured from the ground level to the leading terminal tip using Laser Distance Meter (Ravi *et al.*, 2019, Raviperumal *et al.*, 2018) [11, 12], The volume of farm grown teak was estimated using the formula of Chaturvedi and Khanna (1982) and the results are expressed in cubic meter (m^3).

$$V = \pi r^2 h$$

Where, V = Volume r = Radius and h = Top height

Karl Pearson's correlation co-efficient was worked out by using IBM SPSS (Statistical Package of the Social Science) and Agricolae under R environment in High rainfall zone of Tamil Nadu for correlating age with growth parameters.

Result and Discussion

The growth biometry of farm grown teak in High Rainfall Zone of Tamil Nadu was assessed in four age classes, *viz*., 0-5 years, 5-10 years, 10-15 years and 15-20 years for block plantations and boundary plantations. Significant variations in biometric attributes i.e. (DBH, Height and Volume) were observed in four age classes under High Rainfall Zone of Tamil Nadu.

From (Table 1), The Diameter at Breast Height (DBH) was found to be highest in the age class of 15-20 years (0.285 m), whereas the lowest DBH was recorded in the age class 0-5 years (0.047 m). The tree height was maximum in the age class 15-20 years with the value of 11.35 m, whereas the minimum height (4.63 m) was recorded in age class of 0-5 years. The tree volume was highest in the age class of 15-20 years (0.760 m^3) and the lowest in the age class of 0-5 years (0.009 m^3)

The comparison of biometric attributes of farm grown teak in high rainfall zone to boundary plantations and block plantations of farm grown teak trees it revealed that the boundary plantation of the age class of 15-20 years expressed the maximum diameter at breast height (0.285 m), tree height (11.35 m) and volume (0.760 m^3) when compared to block plantations, which showed the diameter at breast height (0.269 m), tree height (11.14 m) and volume (0.673 m^3). The superiority of growth parameters in boundary plantation is attributed to better management practices, wider spacing, less competition for light, water, space and nutrients than block plantation. The research results are in accordance with the findings of Zahabu *et al*. (2015) [15] who revealed that wider spacing favours teak growth in forest plantation of Tanzania and the diameter at breast height and total height of the increased with respect to increase in spacing. Further the improved growth performance of boundary plantations was related to wider spacing adopted in boundary planting in comparison with closer spacing followed for block plantations in teak.

The increase in volume of teak trees boundary plantations in comparison to block plantations is due to variation for competing resources like light, water and nutrients from neighbouring trees and good management of the teak planted in farm boundaries starting from seedling stage (Dotaniya *et al*., 2013) [7]. The finding are in line with the performance of growth and volume in eucalyptus under boundary plantation which was better when compared to that of block plantations in farmlands (Kidanu *et al*., 2005) [9].

The relationship between tree age and growth biometry of farm grown teak plantations were highly significant in High Rainfall Agroclimatic Zone of Tamil Nadu. The tree age exhibited positive significant correlation with growth parameters *viz*., Diameter at Breast Height, Tree Height and Tree Volume.

The correlation coefficient revealed (Table 2), positive correlation between diameter at breast height (dbh) (k=0.985, $p<0.05$) of trees, total tree height (k=0.999, $p<0.01$) and total tree volume (k=0.922, $p<0.05$) with the age of teak plantations grown in farmlands. The result agree with the findings of Cordero *et al.*, (2001) [5] who revealed that tree foliage, branch, stem and total biomass of trees was highly correlated with diameter at breast height ($r > 0.91$), and inferred a clear increment with increasing diameter at breast height.

Table 1: Growth biometry of farm grown teak in block and boundary plantations

Plantation	Age Class	Diameter At Breast Height (m)	Height (m)	Volume (m^3)
Block	0-5	0.047	4.63	0.009
	5-10	0.092	7.28	0.054
	10-15	0.176	9.49	0.246
	15-20	0.269	11.14	0.673
	MEAN	0.146	8.13	0.246
	S.Ed	0.049	1.410	0.151
	CD	0.205	5.925	0.636
Boundary	0-5	0.069	5.99	0.033
	5-10	0.101	7.62	0.064
	10-15	0.190	10.05	0.277
	15-20	0.285	11.35	0.760
	Mean	0.161	8.75	0.276

	S.Ed	0.048	1.202	0.168
	CD	0.204	5.050	0.704

Table 2: Correlation between Age and Growth biometry of farm grown teak

Correlation				
Pearson's Correlation	**Age**	**DBH(m)**	**Total Height(m)**	**Total Volume(m^3)**
Age	1			
DBH(m)	0.985*	1		
Total Height(m)	0.999**	0.975*	1	
Total Volume(m^3)	0.922	0.972*	0.902	1
*. Correlation is significant at the 0.05 level (2-tailed).				
**. Correlation is significant at the 0.01 level (2-tailed).				

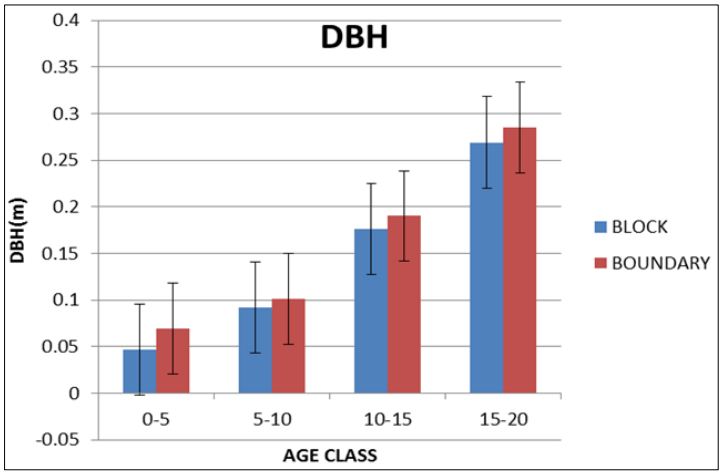

Fig 1: Comparison of DBH of block and boundary plantations of farm grown teak under High Rainfall zone

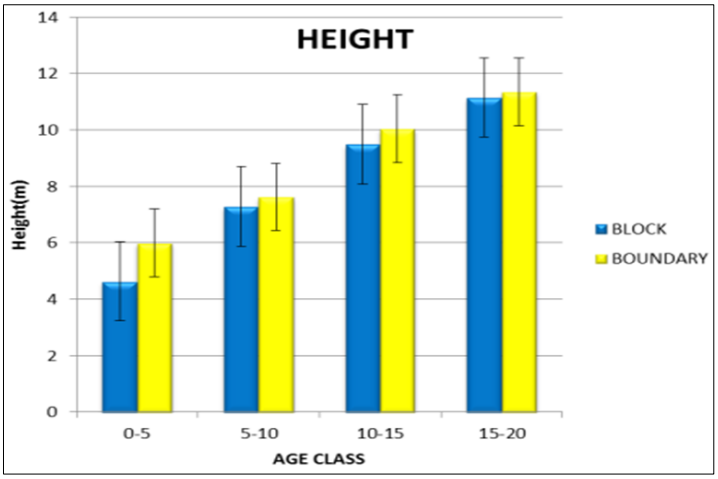

Fig 2: Comparison of Height of block and boundary plantations of farm grown teak under High Rainfall Zone

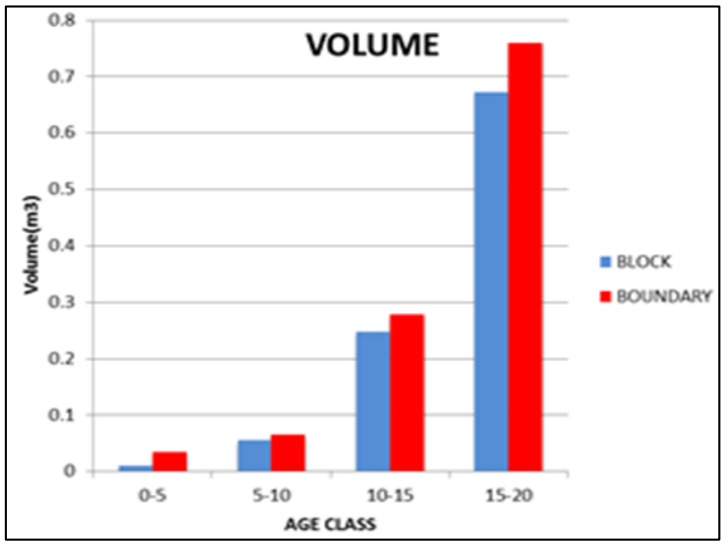

Fig 3: Comparison of Volume of block and boundary plantations of farm grown teak under High Rainfall zone

Conclusion

Farm grown teak in the age class 15-20 years experienced better biometric growth in both boundary (Height 11.35 m and DBH 0.285 m) and block (Height 11.14 m and DBH 0.269 m) plantations. The farm-grown teak plantation in high rainfall agroclimatic zone represents promising and sustainable agroforestry model that significantly improve the economic aspects of tree growers, address environmental challenges and assure social benefits to the farming communities. The unique combination of favourable climatic conditions prevailing in high rainfall agroclimatic zone and good forestry practices adopted in this region favours teak growth. The age of teak plantation and variation in average weather parameters present in the high rainfall zone reflects in a fitting manner for the growth biometrics of teak which helps the tree growers to decide harvest period for teak that is economically viable, environmentally sustainable and socially acceptable limit during the growth phase of this paramount significant fast growing tree in farmland which is a recognized timber tree at local, regional and global level.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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