Distribution, Growth and Aboveground Biomass of Teak (*Tectona grandis L.*) Plantation in Mullaitivu District of Sri Lanka

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Abstract- Teak plantation was established in Northern Province of Sri Lanka since 1960's and it is widely used for the purpose as timber in Sri Lanka. Among the districts of the Northern region, Mullaitivu is a potential district for teak plantation. However, no scientific studies were done regarding teak plantation and its distribution pattern in Northern region. Therefore, a study was carried out to assess the distribution patterns, growth conditions and aboveground biomass in Mullaitivu district during the period of February to May, 2015. Plant height, diameter (dbh), crown height and canopy diameter were measured from selected teak plants in four locations such as Mulliyawalai, Mankulam, Karripatammuripu and Theravil. The measurements were taken with square plot of the size 15m × 15m and findings from the Mulliyawalai and Theravil sites had same aged plantation of 22 years, highest average height and dbh value had observed in Theravil site as 19.80±0.28 m and 20.10±0.24 cm, respectively. The highest aboveground biomass of 410.37t/ha and tree volume of 579.58m^3/ha was found in Mulliyawalai. Among the four locations, the highest average aboveground biomass (1,301.49t/ha) and tree volume (2,043.77m^3/ha) were observed in Karripatammuripu plantation. From this study Theravil site was selected as the best site for the plantation of teak.

Index Terms- Aboveground biomass, Diameter-height-volume, Distribution, Mullaitivu, Teak plantation

I. INTRODUCTION

Tectona grandis is one of the most valuable timber species grown in tropics [1]. It produces high quality wood. Teak can be grown successfully in low elevations of wet, dry and intermediate zones of Sri Lanka [2]. Planting of tree species is one of the agro-forestry methods which has been practiced in Sri Lanka and known as plantation forestry [3]. Plantation forests in tropics can significantly aid economic development of rural people [4]. Forest plantation establishment was commenced in Sri Lanka far back from 1870s. The earliest plantation of teak has been traced back to 1680 when a Dutchman, Van Rhede, successfully introduced it to Sri Lanka [2]. In the district, teak is widespread with other plantation such as Eucalyptus, Casuarina, Khaya, and Halmilla [5]. Due to the civil war, majority of the trees were destroyed and availability of the quality timber for infrastructure development, is one of the problem encountered by Northern region. Available information is quiet less on carbon stock, biomass estimation, yield table and growth measurements in dry zone areas. The specific objectives of this study are to assess the distribution patterns and estimate carbon stock of teak plantation in Mullaitivu district of Sri Lanka.

II. MATERIALS AND METHODOLOGY

The experiment was conducted in Teak plantation forest in Mullaitivu district falls under dry zone low country agro-ecological region of Sri Lanka with coordinates of 09°14′N 80°32′E, has bimodal rainfall pattern. Average annual rainfall varies from 1300 mm to 2416mm and temperature ranges from 23^0C to 39.3^0C. The district has Kilinochchi district on its Northern border, Trincomalee district and Vavuniya district and part of the Mannar district in the south, Mannar district in the West and the sea in the East. It covers land area approximately 251,690 ha (including forest area excluding large inland water). This district accounts for 3.8% of the country's total area. Approximately 167,850 hectares which is 64.1% of the total land area consist of forest within that 2,740 hectares (1.6 % of total forest) of plantation forest occurred [5].

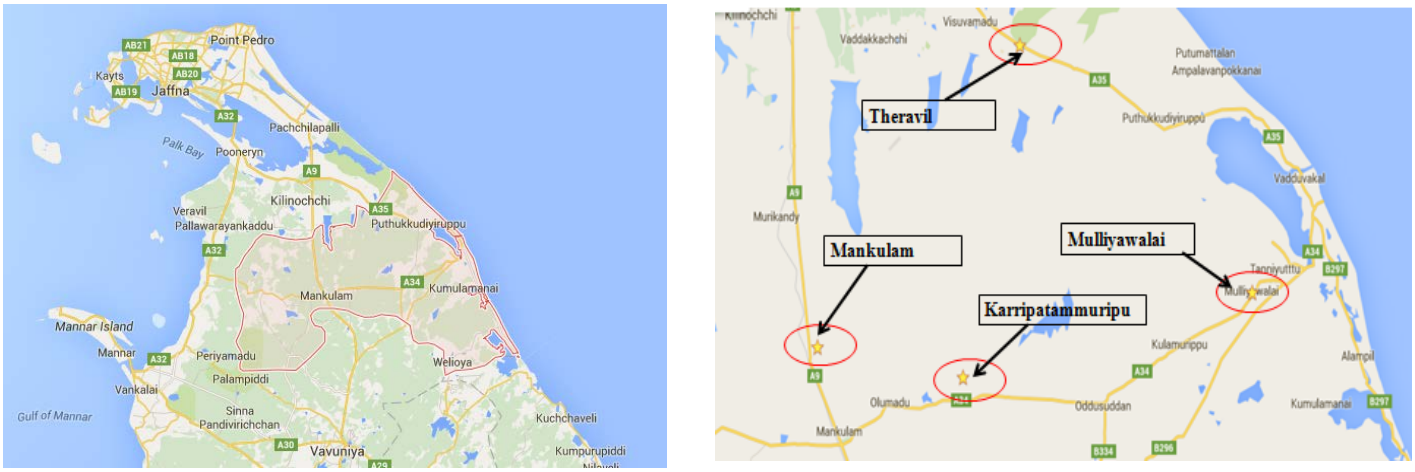

Figure 1: Mullaitivu District, Sri Lanka and Sampling location in the District
(Source: Google map, 2016)

Table 1: Dimension of field selected in area

	Plantation site	Range	Beat	Field size (m^2)	Spacing (m^2)	Number of plants in a plots
1	Mullijavalai	Mullaitivu	Maritampattu	15×15	1.75×1.75	73
2	Theravil	Mullaitivu	Maritampettu	15×15	3×3	25
3	Karripatammuripu	Olumadu,	Mankulam	15×15	1.75×1.75	25
4	Mankulam	Olumadu	Mankulam	15×15	3×3	73

Note: *number of plants per plots varied with plant spacing of teak plantation in the district*

In this study, the Mullaitivu district was further divided into two ranges as Mullaitivu and Olumadu. Mullaitivu range is divided into six beats. Olumadu range is divided into four beats. Among those, Theravil and Mulliyawalai beats were selected from Mullaitivu range. Similarly, Oddusuddan and Karripatammuripu beats were selected from Olumadu range. Square plot samples were selected through random and individual plot size was 15m×15m. Height of the tree, diameter of the tree, crown height of the tree, and canopy diameter of the tree were recorded. Secondary data was collected from the Forest Department of Sri Lanka regarding the teak plantations in the Mullaitivu district. Field measurement was entered and tabulated into an Excel spreadsheet. Data analysis was done using Minitab (Minitab 2014) and Micro Soft Excel 2007. Allometric equation was used to estimate the above ground biomass and tree volume reported by [6] [7] [8] and [9], respectively. Amount of carbon stored in the vegetation role play in carbon sequestration and climate change [10].

$$Y=0.153.D^{2.382}$$

Where, Y-Above Ground Biomass (kg/tree); D-Diameter at Brest Height (cm).

$$V= \exp (-9.7327+2.055*LN (d) +0.773*LN (h))$$

Over bark to 5 cm cut off; where, exp = exponential; ln = natural logarithm; V = Merchantable wood volume per tree (m^3); d=Diameter at breast height (cm); h = Total tree height (m)

III. RESULTS AND DISCUSSION

Now it is the time to articulate the research work with ideas gathered in above steps by adopting any of the below suitable approaches:

A. Teak height and dbh variation in the study areas

Highest average height (29.5±0.375 m) and average dbh (42.1±0.865 cm) were observed in Karripatammuripu. Mulliyawalai and Theravil sites had the same aged plantation (22 years). But Theravil site had the highest average height and dbh value 19.8±0.282 m and 20.1±0.238 cm respectively. Among the same age plantation observed in Mulliyawalai and Theravil, 75% of the plants were

identified with more than 16.7 m and 17.3 m height respectively. The 25% of the plants observed from Mulliyawalai and Theravil were with more than 18.5 m and 22.2 m height respectively. Among the same age plantation observed in Mulliyawalai and Theravil, 75% of the plants were identified with more than 13.36 cm and 18.14 cm diameter respectively. The 25% of the plants observed from Mulliyawalai and Theravil were with more than 18.14 cm and 21.95 cm diameter, respectively.

Table 2: Variations in average height and average dbh for different sites in the study area

Range	**Plantation site**	**Beat**	**Planting year**	**Mean height(m)** ±SE	**Mean dbh (cm)±SE**
Mullaitivu	Mulliyawalai	Mulliyawalai	1993	17.4±0.087	16.2±0.214
	Theravil	Theravil	1993	19.8±0.282	20.1±0.238
Olumadu	Karripatammuripu	Oddusuddan	1980	29.5±0.375	42.1±0.865
	Mankulam	Oddusuddan	2002	14.7±0.097	12.3±0.084

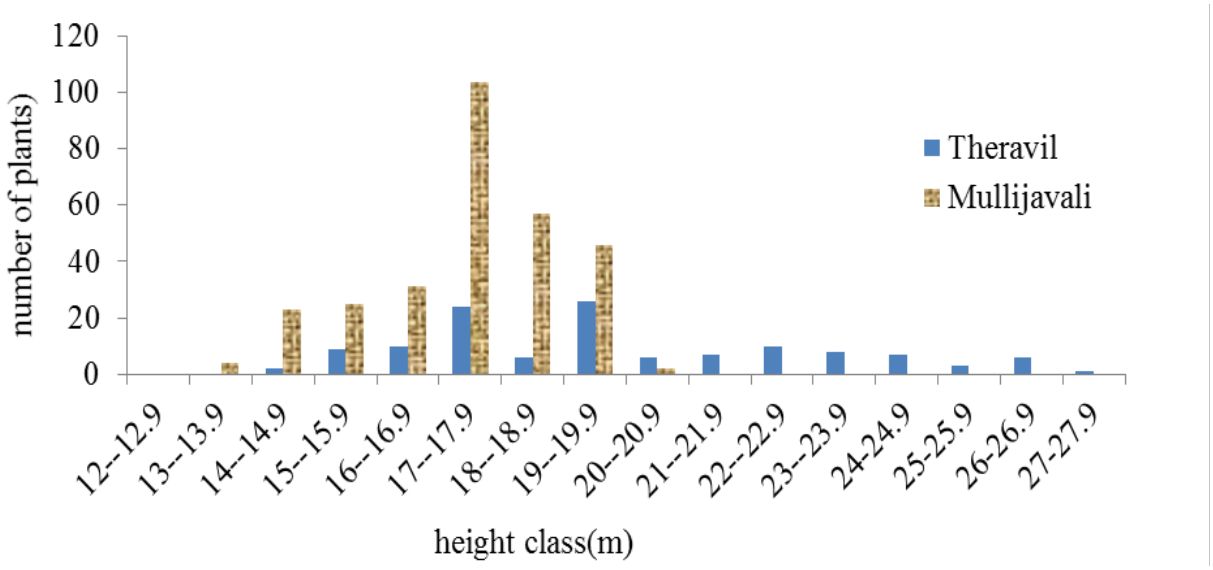

Figure 2: Variation in the height class between Theravil and Mulliyawalai.

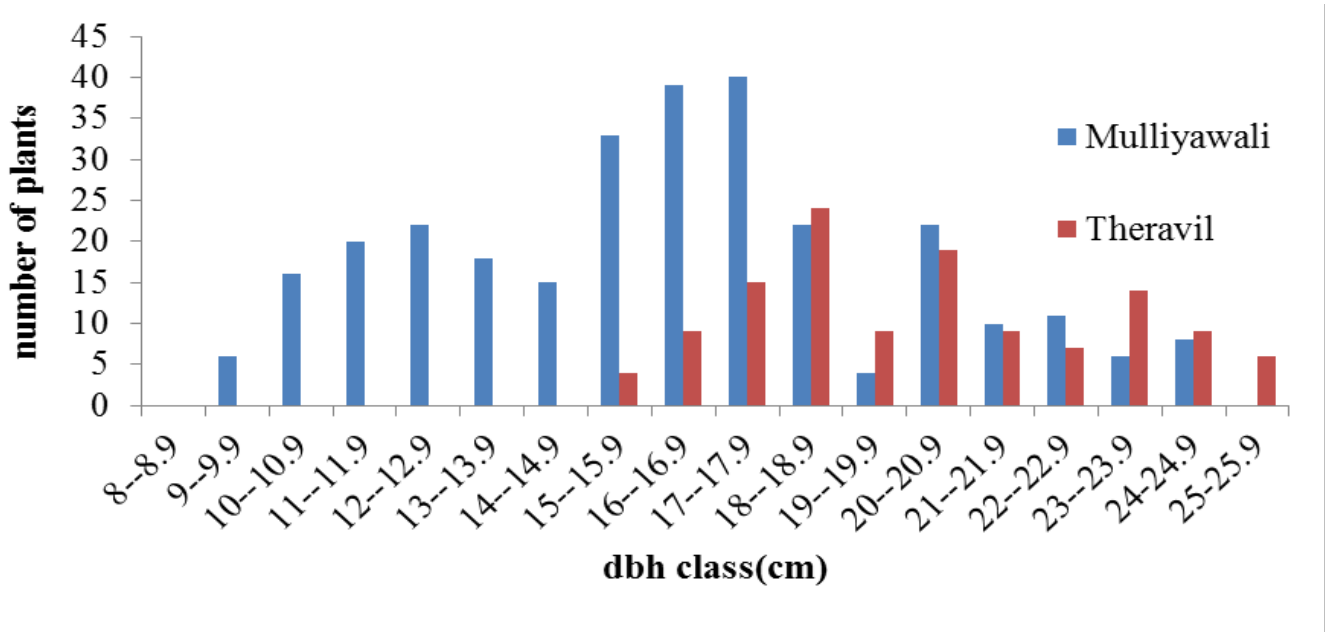

Figure 3: Variation in the dbh among Theravil and Mulliyawalai.

B. Teak volume and above ground carbon stock in the study areas

Highest average volume was observed in Karripatammuripu (1.8±0.09 m3) compared with other sites. Among the same age (22years) plants in Mulliyawalai and Theravil estimated average volume was high in Mulliyawalai (0.178±.005 m^3). Highest aboveground biomass was observed in Karripatammuripu (1301.494 t/ha) compared with other sites. Among the same age plants (22 years) observed in Mulliyawalai and Theravil, the highest average aboveground biomass was observed in Theravil (201.905±5.716 kg/tree).

Table 3: Comparison of tree volume in the different sites.

Plantation site	Planting year	Number of plants/ha	Total volume (m^3/ha)	Mean volume(m^3/ha) ±SE
Mulliyawavalai	1993	3245	579.579	0.178±.005
Theravil	1993	1112	331.8	0.298±0.010
Mankulam	2002	3245	275.173	0.084±0.001
Karripatammuripu	1980	1112	2,043.769	1.839±0.088

Number of plants per ha vareid due to the plantation site had different spacing (table 1).

Table 4: Comparison of above ground biomass in the different sites.

Plantation site	Planting year	Total above ground biomass(t/ha)	Mean Above ground biomass(kg/tree) ±SE
Mulliyawalai	1993	410.365	126.482±3.883
Theravil	1993	224.339	201.905±5.716
Mankulam	2002	200.793	61.888±1.001
Karripatammuripu	1980	1301.494	1171.344±53.854

IV. CONCLUSION

About four potential teak sites are Theravil, Mulliyawalai, Mankulam and Karripatammuripu. Mulliyawalai and Theravil were planted in same year 1993. Average height and diameter were high in Theravil. Different height and diameter were recorded with

different age of the trees. Positive correlation was observed between height and diameter in all sites. Positive strong correlation relationship was observed between canopy diameter and tree diameter in all sites.

Among the same age trees, estimated volume was higher in Mulliyawalai than Theravil. For the same age teak plantation in Mulliyawalai and Theravil estimate value for the biomass higher in Mulliyawalai. Estimated biomass for whole plantation was high in Karripatammuripu.

SUGGESSION

Because of Theravil site having suitable condition for growth and development of teak plantation, it is better site for regenerate the teak. Most of Teak plantations were damaged by wild elephants. Therefore electrical fences should be established to prevent the damage to the younger plantations. They have the potential for the availability of land and participation of government and non government organization. Timber production is better option for increase marginal production. Branching is increased, after the thinning and there by pruning should be practiced every year to prevent that. Further researches are needed to confirm this variation for the development of plantation forestry sector in terms of site class index, Allometric equation for dry zone and model development.

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