Journal Home page : www.jeb.co.in ★ E-mail : editor@jeb.co.in

JEB
Journal of Environmental Biology

ISSN: 0254-8704
CODEN: JEBIDP

# Comparative study on growth performance of two shade trees in tea agroforestry system

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**Publication Info**

*Paper received:*
24 May 2013

*Revised received:*
05 October 2013

*Accepted:*
26 November 2013

**Abstract**

An attempt was made to study the stem growth of two native dominant shade tree species in terms of annual girth increment in three dominant girth size categories for two years in tea agroforestry system of Barak Valley, Assam. Fifty two sampling plots of 0.1 ha size were established and all trees exceeding 10 cm girth over bark at breast height (1.37 m) were uniquely identified, tagged, and annually measured for girth increment, using metal tape during December 2010-12. *Albizia lebbeck* and *A. odoratissima* were dominant shade tree species registering 82% of appearance of the individuals studied. The girth class was categorized into six different categories where 30-50 cm, 50-70 cm and 70-90 cm were dominating girth classes and selected for increment study. Mean annual girth increment ranged from 1.41 cm in *Albizia odoratissima* (50-70 cm girth class) to 2.97 cm in *Albizia lebbeck* (70-90 cm girth class) for the first year and 1.70 cm in *Albizia odoratissima* (50-70 cm girth class) to 3.09 cm in *Albizia lebbeck* (70-90 cm girth class) for the second year. *Albizia lebbeck* exhibited better growth in all prominent girth classes as compared to *Albizia odoratissima* during the observation period. The two shade tree species showed similar trend of growth in both the years of observation and significant difference in girth increment.

**Key words**

Girth increment, Native shade tree, Tea agroforestry



## Introduction

Assessment of growth rate of the stand is useful to evaluate its potential to offset the emission of green house gases and to plan appropriate management strategies to enhance Carbon–sinks. Long-term studies have reported increase in biomass in tropical forests in south-east Asia (Phillips, 1996; Lewis *et al*., 2009), individual growth pattern of tropical forest trees (Pelissier and Pascal, 2000; da Silva *et al*.; 2002), diameter growth pattern of trees in traditional agroforestry system of Kerala (Chandrashekara, 2007) and growth patterns of shade trees in coffee agroforestry system of South India (Nath *et al*., 2011). Plants fix atmospheric carbon in the tissues; thereby transform carbon from atmosphere to the biological systems. The agroforestry system is considered a better climate change mitigation option than ocean and other terrestrial options due to secondary environmental benefits. The tree components in agroforestry systems can be significant sinks of atmospheric carbon due to their fast growth and high productivity (Pandey, 2002; Yadava, 2010; Kumar and Nair 2011). Tree species and system management can influence carbon storage in agroforestry systems (Albrecht and Kandji, 2003).

Tea is grown under a canopy of trees which provide partial shade. These tree species conserve soil from erosion and the impact of rainfall drops, enrich soil fertility and organic matter content through leaf litter and support diverse flora and fauna, especially many bird species. In the beginning of tea plantations of Assam, the planting communities considered the criteria of using the forest tree canopy as shade tree for tea. Gradually studies regarding the importance of shade pattern and selection of shade trees were carried out by several workers like Visser (1961), Hadfield (1974) and Mohotti (2004). Since the later part of 20$^{th}$ century planting of shade trees among tea bushes became a practice in plains of North East India. *Albizia chinensis* was the first tree used as shade tree. Other leguminous species such as *Albizia odoratissima, Dalbergia assamica, Erythrina indica* etc. were also introduced simultaneously (Barua, 2007). Other

prominent tea growing countries in the world like Sri Lanka, Indonesia followed the example of North East India and initiated incorporation of shade trees in tea plantation. The species of shade trees used and the method of their planting were quite different in different regions of the globe. The non-leguminous *Grevillea robusta* along with some other species of genus *Erythrina* and *Gliricidia* is planted in Sri Lanka (Beddage and Mohotti, 2005). In Indonesia, *Albizia chinensis, Albizia moluccana, Albizia falcata, Leucaena glauca, Erythrina* spp. are frequently used as shade trees in tea plantation. In Africa, the growers prefer *Grevillea robusta, Albizia gummifera, Albizia adianthifolia, Gliricidia maculata* etc. as shade trees in tea plantations (Barua, 2007). The aim of this study was to compare the growth performance in terms of annual girth increment of *Albizia lebbeck* and *Albizia odoratissima,* the two dominant native shade trees in tea agroforestry system of Cachar district, Assam.

## Materials and Methods

**Study area :** The Barak valley covers an area of 6922 sq. km. and experiences subtropical warm and humid climate with average rainfall of 2570 mm. The maximum temperature ranges from 25.3 to 33.5°C while minimum from 11.6 to 25.3°C. The Barak Valley region has an undulating topography characterized by hills, hillocks, wide plains and low-lying waterlogged areas. The study was conducted in Rosekandy Tea Estate in Cachar district of Barak Valley in North East India and is situated between 24º39´27.7''-24º40´49.3''N latitudes and 92º39´49.9''-92º41´46.8"E longitudes (Fig. 1). The growth study was conducted during December 2010 to 2012.

**Sampling and measurement :** For sampling shade trees in agroforestry system sample plot (quadrat) of 0.1 ha (31.62 m × 31.62 m) were randomly placed at the site. Total 52 quadrats were demarcated and treated as permanent plot for further study (Dadhwal *et al*., 2009). At plantation site, *Albizia lebbeck* and *Albizia odoratissima* emerged as dominant shade tree species registering 82% appearance among the individuals sampled. Again out of all considered girth class categories 30-50 cm, 50-70 cm and 70-90 cm class dominated the plantation with 89% frequency of considered girth class categories which led us to concentrate in the growth study of these two species. In all considered girth classes of both the shade tree species equal number of individuals (60) were selected using random number table for further analysis of data (in 70-90 cm girth class of *Albizia lebbeck* 35 individuals were observed due to lack of sufficient trees).

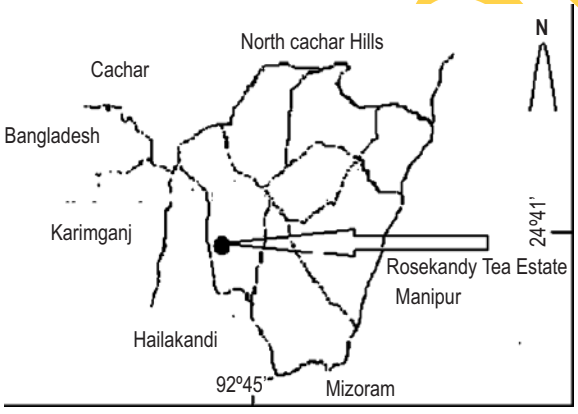


**Fig. 1 :** Location of the study site in Cachar district, Assam

All trees exceeding 10 cm GBH (girth over bark at breast height (1.37 m) or above buttressing) were uniquely identified and tagged, and were measured for girth using a metal tape during December 2010. Any tree exhibiting defects or bulges at or near the measurement height was noted. Such trees were not used in calculating girth increments, and were only used in calculating stand basal areas. The data comprised of repeated re-measurements (December 2011 and December 2012) of all the shade trees available within the sample plots. Annual girth increments were calculated by subtracting the girth measurement of the previous year from each year's girth measurement.

**Statistical Analysis :** The statistical software SPSS; version 15, Origin; version 7 and MS-Exel 2010 were used for analyzing the data. For preparing random number table online random number generator was used. One-way analysis of difference (ANOVA) was performed to compare the population means of annual girth increment between different girth classes of the datasets followed by LSD analysis. The student's t-test was performed to compare the growth of the shade trees between two years.

## Results and Discussion

Seven shade tree species were recorded namely *Albizia odoratissima, A. lebbeck, A. chinensis, A. procera, Dalbergia sissoo, Derris robusta* and *Senna siamea. Albizia lebbeck* and *Albizia odoratissima were* the dominant shade trees in the sampling plots registering 82% of appearance of the individuals. Mean tree density of 209 stem $ha^{-1}$ and mean basal area 7.25 $m^2$ $ha^{-1}$ were recorded at plantation site.

*Albizia lebbeck* and *Albizia odoratissima* showed the occurrence of 89 and 87% of individuals respectively in the dominant girth classes. Density and basal area ranged from 8-23 stem $ha^{-1}$ and 0.33-0.59 $m^2$ $ha^{-1}$ in *Albizia lebbeck* and 17-45 stem $ha^{-1}$ and 0.25-1.81 $m^2$ $ha^{-1}$ in *Albizia odoratissima* (Table 1).

At 30-50 cm girth class, annual increment was 1.81 cm in 2011 and 2.27 cm in 2012. The increment value dropped to 1.41 cm and 1.70 cm at 50-70 cm and gradually increased in the next successive girth class (70-90 cm) by 1.44 cm and 1.86 cm in the respective years. Mean increment of trees differed in both years significantly at 99% confidence interval (paired sample t-test).

**Table 1 :** Stand characteristics of the study site in tea agroforestry system of Cachar district, Assam

| Botanical Name | Family | Density (stem ha$^{-1}$) | Basal area (m$^2$ ha$^{-1}$) |
|---|---|---|---|
| *Albizia chinensis* (Osbeck)Merrill | Mimosaceae | 1.15 ± 0.52 | 0.09 ± 0.01 |
| *Albizia lebbeck* (L.)Benth. | Mimosaceae | 58.07 ± 5.17 | 1.66 ± 0.02 |
| *Albizia odoratissima* (L.F.) Benth. | Mimosaceae | 113.07 ± 6.54 | 4.38 ± 0.05 |
| *Albizia procera* (Roxb.)Benth. | Mimosaceae | 0.19 ± 0.00 | 0.03 ± 0.001 |
| *Dalbergia sissoo* (Roxb. ex. DC.) | Papilionaceae | 1.92 ± 0.00 | 0.03 ± 0.001 |
| *Derris robusta* (Roxb.ex DC.)Benth. | Papilionaceae | 33.08 ± 4.72 | 1.01 ± 0.02 |
| *Senna siamea* (Lam.) H.S.Irwin & Barneby | Caesalpiniaceae | 1.35 ± 0.67 | 0.05 ± 0.001 |

(Average values ± standard deviation)

**Table 2 :** Density, basal area and occurrence of two shade tree species in dominant girth classes in tea agroforestry system of Cachar district, Assam

| Shade tree species | Girth class (cm) | Density (stem ha$^{-1}$) | Basal area (m$^2$ ha$^{-1}$) | Occurrence (%) |
|---|---|---|---|---|
| *Albizia lebbeck* | 30-50 | 23 ± 2.09 | 0.33 ± 0.01 | 40 |
| | 50-70 | 21 ± 1.68 | 0.59 ± 0.01 | 36 |
| | 70-90 | 8 ± 0.95 | 0.37 ± 0.01 | 13 |
| *Albizia odoratissima* | 30-50 | 17 ± 1.52 | 0.25 ± 0.004 | 15 |
| | 50-70 | 45 ± 2.64 | 1.31 ± 0.02 | 40 |
| | 70-90 | 37 ± 2.33 | 1.81 ± 0.02 | 32 |

(Average values ± standard deviation)

ANOVA showed that the 2012 mean girth increment of 30-50 cm class was significantly different with mean of 50-70 cm class increment at 0.05 levels. The species exhibited increasing trend of girth increment with respect to change in girth size. The minimum increment (2.17 cm and 2.64 cm) was observed at 30-50 cm girth class followed by 2.40 cm and 2.67 cm at 50-70 cm girth class and maximum increment (2.97 cm and 3.09 cm) occurred at 70-90 cm girth class in the two respective years of study. Mean annual increment of trees differ in both years significantly at 99% confidence interval (paired sample t-test). The mean increment of 30-50 cm class is significantly different with mean increment of 70-90 cm class at 0.05 levels in 2011. It is relevant to mention here that high coefficient of variation in annual girth increment (74-88%) was observed in different girth classes of *A.odoratissima* and *A.lebbeck* during the study period which could be assigned to the microclimatic, topographic or other abiotic factors including characteristics of tree barks and competition with tea bushes. Such large scale variation in annual increment was also reported in studies on growth of tropical trees in Central Amazon (da Silva *et al*., 2002).

The paired t-test showed that variation in girth increment between years for both the species was significant ($p < 0.01$) and that growth in 2011-2012 (rainfall 2551.5 mm) was significantly greater than the growth in 2010-2011 (rainfall 2077.9 mm).

Similar trend of girth increment was observed in *Albizia odoratissima* and *A.lebbeck* in both the year of observation. The figures presenting girth increment for the concerned species revealed different growth patterns of the two shade tree species (Fig. 2). *Albizia odoratissima* show more growth in smaller girth class and gradually declined with increased girth size. The mean annual girth increment in *Albizia lebbeck* was 2.97 cm and 3.09 cm and of *Albizia odoratissima* was 1.81 cm and 2.27 cm for 2011

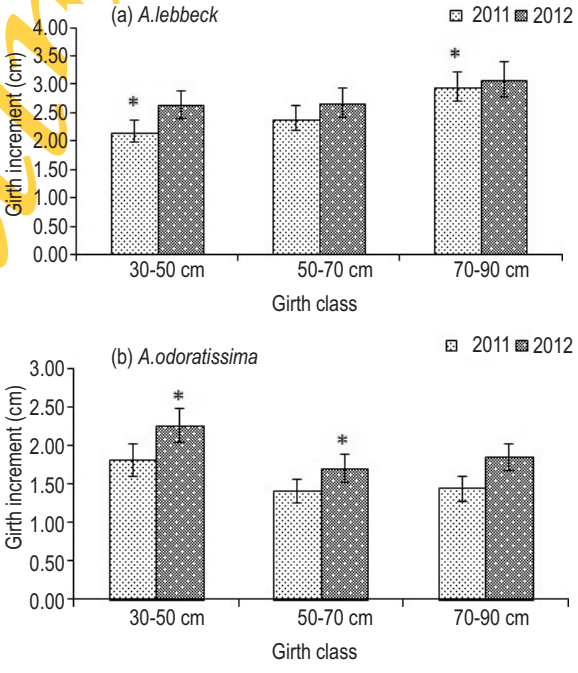


**Fig. 2 :** Girth increment of (a) *Albizia lebbeck* and (b) *Albizia odoratissima* in tea agroforestry system of Cachar district, Assam; Bars indicate ± S.E.; * indicates significant differences of girth increment between specific girth classes at 0.05 level

and 2012.There is as such no published information on the girth increment of shade trees in tea agroforestry system although similar studies are available for shade trees in coffee agroforestry systems (Nath *et al*., 2011) in India. The girth increment values in the present study showed similarity with the observations of Sundaram and Parthasarathy (2002) in tropical wet evergreen forest of Eastern Ghats, India. If the mean annual increment values of the present study are converted into mean diameter at breast height increment to compare with the other increment studies, the values were 0.58 cm and 0.72 cm for *Albizia odoratissima* and 0.94 and 0.98 for *Albizia lebbeck* in the years. These values are comparable to increment values of native shade trees like *Lagerstroemia microcarpa* (0.88 cm), *Dalbergia latifolia* (0.57 cm) and *Syzygium cumini* (0.82 cm) of coffee agroforestry system in Southern India which are recommended for planting as shade trees despite lower annual dbh increment than the exotic *Grevillea robusta* (Nath *et al*., 2011). The growth pattern of *Albizia lebbeck* shows similarity with the growth of Mahogany (*Swietenia macrophylla*) which also revealed the mean annual dbh increment of 1.01 cm. Again girth increments increased from smaller girth class to larger girth class of the trees along with inter- annual variation in growth (Shono and Snook 2006).

The results of the present study have indicated the growth performance in terms of girth increment between two dominant shade trees in tea agroforestry system.

## Acknowledgments

The authors sincerely thank Mr. I. B. Ubhadia, Manager of Rosekandy Tea Estate for kind permission to carry out the study. We are thankful to Tea Research Association Cachar Advisory Centre for providing meteorology data of the study period. One of the authors (RMK) is thankful to the University Grants Commission (UGC) for providing fellowship. The authors thank two anonymous reviewers for constructive comments which helped improve the manuscript.

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