Potential of Plantation Trees for Biomass and Carbon Sequestration in Foothills of Jakanari Forest, Coimbatore, Western Tamil Nadu, India

Hari Prasath Natarajan (prasathforestry@gmail.com)
TNAU: Tamil Nadu Agricultural University
Balasubramanian Arunachalam
TNAU: Tamil Nadu Agricultural University
Sivaprakash Muthuswamy
TNAU: Tamil Nadu Agricultural University
Radhakrishnan Suthandhirajan
TNAU: Tamil Nadu Agricultural University
Swathiga Ganesan
TNAU: Tamil Nadu Agricultural University
Anjali Satheedan
TNAU: Tamil Nadu Agricultural University
Manimaran Vellan
TNAU: Tamil Nadu Agricultural University

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Abstract

Afforestation and reforestation have a greater potential for appropriate absorbtion of carbon from environment that helps in mitigating and reducing the global warming nature of both the developing and developed countries. Hence, the present study for assessing the carbon sequestration potential of 7 trees (*Dalbergia latifolia*, *Albizia lebbeck*, *Dalbergia sissoo*, *Gmelina arborea*, *Swietenia macrophylla*, *Tectona grandis*, and *Terminalia bellirica*) have been evaluated in Forest College and Research Institute (FC&RI), Mettupalayam in the surroundings of the Jakanari Reserve Forest, Northern part of Coimbatore for its biomass of trees, biomass carbon, ecophysiological (Photosynthesis and Transpiration rate) attributes and carbon isotope discrimination potential of trees. The study revealed that *Dalbergia sissoo* and *Tectona grandis* have the highest potential for biomass and biomass carbon production and as well as these two species also performed well under the eco-physiological condition by having the highest potential of growing in water scarcity conditions through carbon isotope discrimination identification. *Dalbergia latifolia* and *Swietenia macrophylla* are not able to cope with the prevailing dry condition; hence these species can be used for moist land conditions. Confirmation of the present study reveals that the *Dalbergia sissoo* and *Tectona grandis* are the best suitable tree species recommended for maximum carbon sequestration potential.

Introduction

Industrial improvement behavior in the world for the past 70–80 years in both rural and urban areas particularly taken up due to deforestation, degradation of forest lands, agricultural practices, and the burning of fossil fuels. Population explosion in the developing and developed countries leads to a huge development in industrial sectors, which is a mandatory exercise to fulfill the need of people. And particularly these resulted in the emission of greenhouse gases (GHG), especially CO_2, which significantly and produce a direct impact on the climate by causing extreme weather conditions around the world (Choudhary et al. 2014). Additionally, this rise in global temperature causes unpredictable rainfall in terms of time and amount, followed by frequently results in extreme weather, most severe pest and disease outbreaks in the agricultural crops, horticultural plantations, and even under the tree plantations also (Lobell et al. 2008; Choudhary et al. 2014). The rapid population growth is also in confirmation of the associated rise in demand for fuel wood, tree products, and construction materials (Avtar et al. 2014).

Forests and tree-based plantations are the most efficient and long-lasting feasible strategies to mitigate climate change issues by an process of highest prospective rates of carbon acceptance and storage, as its associated with environmental and social benefits (Brown et al. 1996). This is necessary to overcome these challenging situations sustainably (Costa 1996). In line with the present needs, the countries need forests and forest-based goods on a larger scale to meet the basic economic needs through the development of tree plantations in farmlands. Additionally, the growth of plantations is lowering the heaviness on natural forests for timber and other properties, but then some of the circumstances have driven land use for non-forestry activities (Evans and Turnbull 2004; Dabi et al. 2021). Tree plantations can be used for regeneration of land, ecological restoration, conservation of resource, and other water conservation methods in addition for providing an socioeconomic advantages by lowering local people's poverty, particularly in developing countries (Avtar et al. 2014; Dabi et al. 2021). When comparing to other terrestrial ecosystems, forests play a significant role in the carbon cycle as a source and sink of carbon emissions (IPCC 2006; Eriksson and Berg 2007). Forests stores an highest storage of weight and biomass carbon than any other terrestrial carbon sequestering system (Li et al. 2011). According to Liao et al. (2010), 3.96 lakh hectares of land were covered in tree plantations worldwide during 2005, whereas now the scenario has changed that most of the land owners are shifting to tree cultivation, mainly because of its less labour necessity and low input cost than other farm activities. The current involvement among the people leads to a maximum increase of roughly 2 percent in the plantation improvement annually. To reduce future climate change effects and sequester carbon from the atmosphere, forest plantations have been promoted on large scale by both the government as well as non-governmental organizations (Liao et al. 2010; Dabi et al. 2021). The level of carbon accumulation by plantation species has also developed into a significant factor of enhancing the world environment with the high trees, both in terms of its effects and the calculation of carbon trading during climate change negotiations (Avtar et al. 2014). The landscape-level carbon storage is significantly impacted by forest crops, especially plantations (Laosuwan et al. 2012).

The potential for increasing plantations in India through afforestation to store carbon is enormous because the country is nearly having 30–40 percent of land under un-utilized conditions. The performance of a tree species in producing biomass, which ultimately reflects the tree species' capacity to sequester carbon, and this is also shown by the ecophysiological behavior of species over a day (Hari Prasath et al. 2014). Two stable isotopes of carbon, 12C, and 13C are often present in tree carbon, which is normally having a role of 12C (Lighter and more prevalent of the two isotopes of carbon) and 13C (Greater abundance than its heavier counterpart). Additionally, this carbon isotope discrimination is crucial to correlate with the tree biometric attributes, biomass, and biomass carbon of trees, which has severe important influence on the site's water availability (Hari Prasath et al. 2017). It is always remarkable to note that, the discrimination of carbon isotopes will always find notable differences between tree species and populations within species.

Research on biomass, biomass carbon, ecophysiology, and carbon isotope discrimination was conducted individually on a large scale under different locality conditions, which showed promising results based on that location (Bordoloi et al. 2017; Hari Prasath et al. 2014; Hari Prasath et al. 2017; Dabi et al. 2021; Choudhary et al. 2014; McBrayer and Cromack 1980; MacDicken 1997). But additionally, no research has been done on the combination of all those factors, which is necessary to understand the scientific capacity of trees to store carbon under dryland locations. Based on the above conditions and phenomenon, the current study set out to characterize the biomass, the carbon content in various tree sections (Stem, branches, leaves, and root), eco-physiological characteristics (Photosynthetic and transpirational processes), and carbon isotope discrimination potential of trees. This may offer fresh knowledge to help these species contribute more effectively to the growing ecosystem service as carbon fixation and storage.

Materials And Methods

The Forest College and Research Institute (FC&RI), TNAU is situated in Mettupalayam, which is close to the Jakanari Reserve Forest and is 40 kilometers from the northern part of Coimbatore with an elevation of 320 meters above MSL and average annual rainfall of 925.50 millimeters. The tree plantation at FC&RI is situated at 11°21'N longitude and 77°58'E latitude. At the experimental site, the highest and lowest temperatures recorded throughout the 2019–2023 study period were 38.8°C and 17.7°C, respectively. The location studied for carrying out this study is Illupanatham soil series with pH-7.87, mildly alkaline soil. The ground was a well-drained, salinity-free loamy sand (EC-0.20 dSm^{-1}). The native vegetation that was present in the study area was cleared by using the mechanical method of land preparation and the following tree species were then planted in a Randomized Block Design (RBD) with six replications with 20 trees/replication: Lebbeck (*Albizia lebbeck*), Sissoo (*Dalbergia sissoo* Roxb.), Gmelina (*Gmelina arborea* Roxb.), Rosewood (*Dalbergia latifolia*), Large Leaf Mahogany (*Swietenia macrophylla* King.), Teak (*Tectona grandis* L.) and Bellerica (*Terminalia bellirica*). The tree species were used for estimating the biomass, and biomass carbon of tree species by measuring the parameters, viz., Bole height, Diameter at Breast Height (DBH) were noted once every three months, and destruction of the tree was made to find out its biomass.

a) Biomass estimation in trees

The above and below-ground biomass estimation of trees were assessed by follwoing the destructive sampling method given by Lasco et al. (2005).

b) Carbon and biomass carbon estimation in trees

Estimation of the carbon content through litter, dead organic matter, above-ground biomass (AGB), and below-ground biomass (BGB) were measured by using the formula given by Dey (2005) and Dhruw et al. (2009).

Carbon % = 100 % - {Ash % + Molecular weight of O_2 (53.3 %) in $C_6H_{12}O_6$}

Using the formula shown below, the carbon stock in the dead organic matter, litter, above-ground biomass, and below-ground biomass was calculated.

Carbon (MT) = Biomass (MT) x Carbon per cent

The samples of fractionated biomass includes leaf, stem, branch, and root samples, further the percentage of organic biomass carbon was calculated using the described method. The carbon percent value was used to calculate the above-ground organic biomass carbon (t ha-1), below-ground organic biomass carbon (t ha-1), and total organic biomass carbon (t ha-1) for each species of tree. This information is then displayed on a hectare basis by the number of trees in a hectare.

c) Ecophysiological attributes in trees

A portable photosynthesis system was used to measure the eco-physiological characteristics of seven different tree species between the hours of 8 and 11 on a sunny day. These measurements will serve as a parameter for analysing the potential of the targeted tree species to capture carbon.

d) Carbon isotope discrimination potential in trees

In a four-year-old afforested plantation, the Δ13C was measured in tree fractionation samples of seven different tree species. The Isotope Ratio Mass Spectrometer (IRMS) at the National Facility for Stable Isotope Studies in Biological Sciences located at the Department of Crop Physiology, University of Agricultural Science, Bengaluru, Karnataka, was used to calculate the Δ13C of the tree samples.

Statistical Analysis

To determine the statistical implication of the carbon sequestration in trees results, analyses of differences in the biomass carbon and eco-physiological parameters, namely, ABG, BGB, Total biomass, Carbon content, Biomass carbon, Photosynthetic rate, Transpiration rate, and Carbon isotope discrimination, were carried out using the Randomized Block Design (RBD). The correlation coefficient, a non-linear regression analysis toolkit utilizing the Microsoft Excel Analysis Toolpak, and one-way ANOVA by the Software Package for Social Sciences (SPSS) in Version 16.0 were used for the statistical tests and interpretation of the data.

Results And Discussion

a) Accumulation of weight and Biomass carbon in trees

The growth physiognomies of the trees, the density of the wood, and locality factors where the tree is planted and develops play an important role in how quickly carbon can be sequestered in trees (Nair et al. 2010). A critical step in determining forest biomass and carbon stocks is by quantifying the biomass of woody plants, which will be acting as a source for biomass carbon sequestration (Pilli et al. 2006). In the current study, the fractionation of total biomass (Table 1) in trees revealed that the maximum biomass of 21.938 ± 0.63 tonne ha^{-1} at the age of 4 years plantation was registered in *Tectona grandis* followed by *Dalbergia sissoo* (20.426 ± 0.64 tonne ha^{-1}), *Terminalia bellirica* (13.36 ± 0.23 tonne ha^{-1}) and *Albizia lebbeck* (12.652 ± 0.03 tonne ha^{-1}). In a related manner, Poffenberger et al. (2001) found that under the same age class conditions, the carbon sequestration level in Madhya Pradesh's Teak forest ranged between 0.52 and 3.44 t C ha^{-1} yr^{-1}. The minimum total biomass of 5.205 ± 0.27 tonne ha^{-1} was observed in *Dalbergia latifolia*. Regarding the above-ground biomass, *Tectona grandis* accumulated the highest aboveground biomass (17.332 ± 0.41 tonne ha^{-1}) followed by *Dalbergia sissoo* (16.158 ± 0.54 tonne ha^{-1}). As a result, Goel and Singh (2008) similarly came to the same conclusion that *Dalbergia sissoo* produced biomass per hectare at the age cycle of 5 years, with utmost above-ground biomass of 13.52 in segmented bole, followed by branch and leaf, respectively, in Uttar Pradesh, India. In respect of below-ground biomass (Table 1 & Fig. No. 1), the highest (4.606 ± 0.22 tonne ha^{-1}) & lowest (1.055 ± 0.01 tonne ha^{-1}) below-ground biomass were recorded in *Tectona grandis* and *Dalbergia latifolia* respectively. For correlating the environmental quality in trees, the biotic and abiotic and meteorological parameters are relevant factors, whereas the evaluation of the root biomass and the association with biomass concentration and root: shoot ratios are significant variables (Cairns et al. 1997).

Table 1. Biomass and Biomass carbon (tonne ha^{-1}) **of 4 year old tree plantation in foothills of Jakanari Forest, Coimbatore, Western Tamil Nadu, India**

Sl. No.	Tree Species	Above ground biomass (tonne ha^{-1})	Below ground biomass (tonne ha^{-1})	Total Biomass (tonne ha^{-1})	Carbon content (%)	Biomass carbon (tonne ha^{-1})
1	*Albizia lebbeck*	10.121 ± 0.16	2.531 ± 0.06	12.652 ± 0.03	41.56 ± 1.39	5.258 ± 0.28
2	*Dalbergia sissoo*	16.158 ± 0.54	4.268 ± 0.18	20.426 ± 0.64	43.37 ± 3.09	8.859 ± 0.24
3	*Dalbergia latifolia*	4.150 ± 0.20	1.055 ± 0.01	5.205 ± 0.27	42.58 ± 2.86	2.216 ± 0.05
4	*Gmelina arborea*	9.516 ± 0.36	2.365 ± 0.08	11.881 ± 0.02	42.56 ± 2.78	5.057 ± 0.21
5	*Swietenia macrophylla*	7.668 ± 0.08	2.001 ± 0.10	9.669 ± 0.06	41.70 ± 2.29	4.032 ± 0.24
6	*Tectona grandis*	17.332 ± 0.41	4.606 ± 0.22	21.938 ± 0.63	42.77 ± 1.04	9.383 ± 0.57
7	*Terminalia bellirica*	10.651 ± 0.08	2.709 ± 0.04	13.36 ± 0.23	42.09 ± 2.39	5.623 ± 0.30
	SE(d)	0.332	0.112	0.395	2.338	0.325
	CD (0.05%)	0.724**	0.244**	0.861**	NS	0.708**

Carbon content of the fractionated tree parts (Table 1 & Fig. No. 1) was recorded highest in *Dalbergia sissoo* (43.37 ± 3.09 tonne ha^{-1}) followed by *Tectona grandis* (42.77 ± 1.04 tonne ha^{-1}), *Dalbergia latifolia* (42.58 ± 2.86 tonnes ha^{-1}), *Gmelina arborea* (42.56 ± 2.78 tonnes ha^{-1}) and *Terminallia bellirica* (42.09 ± 2.39 tonne ha^{-1}) which were on par with each other and lowest carbon content in *Swietenia macrophylla* (41.70 ± 2.29 tonne ha^{-1}) and *Albizia lebbeck* (41.56 ± 1.39 tonne ha^{-1}). According to Higuera and Martinez's (2006) research, oak tree branches, followed by wood, active leaves, and dead leaves, capture the most carbon content are consistent with this present result and another important phenomenon is that stem and branch is having the highest biomass rather then leaves as because of its density. When a tree's precise carbon content is unknown for so many years, many researchers have estimated it to be between 45 and 50 percent of its dry mass (Birdsey 1992; Isaev et al. 1993; Kobak 1988; Kurz et al. 1992). The values discovered in this study are roughly in line with these estimations.

A complicated interaction between a tree's carbon source (leaves) and carbon sink (trunk) organs may be the cause of the variance in carbon allocation among its constituent parts (Genard et al. 2008). *Tectona grandis* produced the most biomass carbon, 9.383 0.57 tonne ha^{-1}. Since the stem helped the tree develop through photosynthesis and ultimately stored the most food produced during photosynthesis by loading glucose molecule in wood components and hardening tissue as plants mature, the stem made up most of the biomass carbon in the tree (Hari Prasath et al. 2016). The next best was observed in *Dalbergia sissoo* (8.859 ± 0.24 tonne ha^{-1}) followed by *Terminalia bellirica* (5.623 ± 0.30 tonne ha^{-1}), *Albizia lebbeck* (5.258 ± 0.28 tonne ha^{-1}) and *Gmelina arborea* (5.057 ± 0.21 tonne ha^{-1}). A similar line of results is also reported by Dhruw et al. (2009) that *Dalbergia sissoo* is a highly potential tree species, which is having the highest capacity of storing carbon especially in the stem region rather than in the root, branch, and leaf. The primary determining factor of biomass productivity is how much photosynthesis is happening in the trees for its growth, which is eventually representing the carbon content nature of the trees (Ram Newaj et al. 2007).

b) Carbon isotope discrimination in trees

Due to the fact that the carbon isotopes has shown difference of variation during its photosynthesis and that has greatly impacted by stress on water, plant leaves carbon isotope discrimination (or "leaf") is a recognized indication of historical hydro climate, that eventually indicating the species' acceptance of the harsh/dry climate (Tibby et al. 2016). The factors of major locality, viz., climatic, edaphic, biotic, and topographic combined with genetics has an important role in influencing the nature of the isotopic signature in plant tissues, because carbon isotope ratio (Δ13C) offers a temporally integrated signature on the photosynthesis through foliar and stomatal conductance, that eventually replicate the nature of the gaseous exchange and biometric growth of tree species against the difficult condition with the less water (Seibt et al. 2008; Ryan et al. 2006). Even under challenging environmental conditions, the tree species' productivity and water use efficiency are always intermingled phenomena that are reflected in the 13C estimation. Carbon isotope variance of the tree species will be always found to be significantly varied between the seasonal fluctuations in status of soil water availability, air temperature, and changes in a water status for integrative variable in identifying the carbon isotope discrimination potential (Garcia et al. 2004).

Table 2. Photosynthesis rate, Transpiration rate and Carbon isotope (C_{13}/C_{12}) discrimination potential of 4 year old tree plantation in foothills of Jakanari Forest, Coimbatore, Western Tamil Nadu, India

Sl. No.	Tree Species	Photosynthesis rate (μ mol. m^{-2} s^{-1})	Transpiration rate (m mol. m^{-2} s^{-1})	Carbon isotope (C_{13}/C_{12})
1	*Albizia lebbeck*	9.18 ± 0.04	5.01 ± 0.03	19.19 ± 0.43
2	*Dalbergia sissoo*	17.17 ± 0.44	5.33 ± 0.06	20.98 ± 1.13
3	*Dalbergia latifolia*	10.09 ± 0.56	3.85 ± 0.15	18.05 ± 0.88
4	*Gmelina arborea*	13.23 ± 0.12	5.78 ± 0.38	19.56 ± 0.71
5	*Swietenia macrophylla*	8.34 ± 0.02	3.73 ± 0.20	19.28 ± 0.35
6	*Tectona grandis*	14.55 ± 0.87	6.56 ± 0.27	20.01 ± 1.19
7	*Terminalia bellirica*	12.90 ± 0.55	4.47 ± 0.32	19.86 ± 0.77
	SE(d)	0.484	0.231	0.852
	CD (0.05%)	1.055**	0.503**	1.857*

In the present study, the highest carbon isotope (Table 2) was registered in *Dalbergia sissoo* (20.98 ± 1.13 C_{13}/C_{12}) and *Tectona grandis* (20.01 ± 1.19 C_{13}/C_{12}) which were followed by *Terminalia bellirica* (19.86 ± 0.77 C_{13}/C_{12}), *Gmelina arborea* (19.56 ± 0.71 C_{13}/C_{12}), *Swietenia macrophylla* (19.28 ± 0.35 C_{13}/C_{12}) and *Albizia lebbeck* (19.19 ± 0.43 C_{13}/C_{12}) in which all were on par with each other where the lowest carbon isotope was observed in *Dalbergia latifolia* (18.05 ± 0.88 C_{13}/C_{12}). Maximum carbon isotope discrimination potential in tree species aided in water use efficiency in tree plantation under wasteland conditions according to Hari Prasath et al. (2017)

c) Eco-physiological attributes in trees

Effectively evaluating the capacity for carbon sequestration involves looking at the rates of photosynthesis and transpiration of the selected tree species in a 4-year-old tree plantation. The ecophysiological behavior of a tree species reveals, how well it performs in producing biomass over a day-by-day process, which ultimately represents, how effective the different tree species can store carbon (Gikloo et al. 2012). The highest photosynthetic rate (17.17 ± 0.44 μ mol. m^{-2} s^{-1}) was recorded in *Dalbergia sissoo* followed by *Tectona grandis* (14.55 ± 0.87 μ mol. m^{-2} s^{-1}), *Gmelina arborea* (13.23 ± 0.12 μ mol. m^{-2} s^{-1}) and *Terminalia bellirica* (12.90 ± 0.55 μ mol. m^{-2} s^{-1}) and the minimum photosynthetic rate was obtained in *Swietenia macrophylla* (8.34 ± 0.02 μ mol. m^{-2} s^{-1}). It's noteworthy to observe that trees that are very resistant achieve the highest rates of photosynthesis at a fairly high level or are even unaffected by the stress, but the net assimilation of CO2 by species that are less tolerant or sensitive is significantly reduced and this was reported by Hari Prasath et al. (2011) and Ferner et al. (2012). Concerning transpiration rate, *Tectona grandis* accounted maximum transpiration rate of 6.56 ± 0.27 μ mol. m^{-2} s^{-1} followed by *Gmelina arborea* (5.78 ± 0.38 μ mol. m^{-2} s^{-1}), *Dalbergia sissoo* (5.33 ± 0.06 μ mol. m^{-2} s^{-1}) and *Albizia lebbeck* (5.01 ± 0.03 μ mol. m^{-2} s^{-1}) and minimum transpiration rate (Table 2) was obtained in *Swietenia macrophylla* (3.73 ± 0.20 μ mol. m^{-2} s^{-1}). Curiously, the study supports by Hari Prasath et al. (2014) outcomes that *Dalbergia sissoo* is having a high ecophysiological rate, which was caused by the species' C4 behavior and its acting factors. The current study tested the ecophysiological response of four-year-old plantation trees in Tamil Nadu's western zone conditions in the foothills of the Jakanari forest and noted the variations in the ecophysiological behavior of seven tree species. This result is also in line with the factors that the water interactions, transpiration, and other ecophysiological behaviors namely leaf turgor were impacted by environmental conditions (Yvens et al. 2009).

d) Diurnal variation of Photosynthetic rate in plantation trees

The ecophysiological characteristics in connection to various climatic conditions aid in the prediction of a species' effectiveness in terms of growth, carbon sequestration, and adjusting the stomatal temperature to control water processes (Rao et al. 2008). Generally, the growth potential of tree species was identified with the modulation of photosynthetic efficiency in seven species (*Albizzia lebbeck*, *Dalbergia sissoo*, *Dalbergia latifolia*, *Gmelina arborea*, *Swietenia macrophylla*, *Tectona grandis*, and *Terminalia bellerica*) with the growth of 4-year-old plantation in foothills of Jakanari Forest. The *Dalbergia sissoo* tree performed the highest photosynthesis rate at 8 AM with 18.82 μ mol. m^{-2} s^{-1}, and the same tree had performed the highest rate at 9.00 AM, 10 AM, 11 AM, 12 PM, 1 PM, 2 PM, 3 PM, 4 PM, and 5.00 PM with 18.56 μ mol. m^{-2} s^{-1}, 18.36 μ mol. m^{-2} s^{-1}, 17.40 μ mol. m^{-2} s^{-1}, 17.01 μ mol. m^{-2} s^{-1} followed by *Tectona grandis, Gmelina arborea, Terminalia bellerica, and Albizzia lebbeck*.

The lowest photosynthetic rate (Table 3) was observed in *Dalbergia latifolia* with 5.42 μ mol. m^{-2} s^{-1} at 3.00 PM. According to Bakshi (1996) findings, the diurnal monitoring of photosynthesis revealed a significant rate of photosynthetic activity in eucalyptus. In order to ensure high productivity under water-logged conditions, it is assumed that the high photosynthetic rate is linked to high transpiration and stomatal conductance. These eventually played a part in the carbon sequestration capability of tree species.

Table 3. Diurnal variation of Photosynthetic rate (μ mol. m^{-2} s^{-1}) **of 4 year old tree plantation in foothills of Jakanari Forest, Coimbatore, Western Tamil Nadu, India**

Sl. No.	Tree Species	8.00 AM	9.00 AM	10.00 AM	11.00 AM	12.00 Noon	1.00 PM	2.00 PM	3.00 PM	4.00 PM	5.00 PM
1	*Albizia lebbeck*	8.83	11.50	16.78	13.41	14.57	10.33	15.42	17.52	12.98	11.20
2	*Dalbergia sissoo*	18.82	18.56	18.36	18.16	17.40	17.01	13.09	15.69	8.05	16.54
3	*Dalbergia latifolia*	7.93	7.84	8.28	8.67	6.15	9.49	8.15	5.42	8.11	6.09
4	*Gmelina arborea*	10.55	16.56	12.86	18.55	16.68	15.61	14.71	13.82	7.79	11.84
5	*Swietenia macrophylla*	7.28	9.09	7.61	9.02	6.75	8.32	8.29	8.68	8.13	10.04
6	*Tectona grandis*	14.46	16.97	13.23	14.96	11.78	13.08	10.74	12.14	8.45	6.09
7	*Terminalia bellirica*	10.53	13.46	10.28	10.40	8.09	7.30	6.50	6.75	6.89	5.48
	SE(d)	0.51	0.55	0.39	0.69	0.71	0.52	0.48	0.59	0.46	0.38
	CD (0.05%)	1.11**	1.21**	0.86**	1.50**	1.55**	1.14**	1.05**	1.29**	1.02**	0.83**

The correlation studies between biomass carbon, physiological parameters, and carbon isotopes revealed that biomass carbon showed a strong correlation with Carbon isotopes, photosynthetic rate, and Transpiration rate with correlation coefficient (r) values of 0.877, 0.799, and 0.791, respectively (Table 4).

Table 4. Correlation co-efficient between biomass carbon, physiological parameters and carbon isotopes

	Biomass Carbon	Photosynthesis rate	Transpiration rate	Carbon isotopes
Biomass Carbon	1			
Photosynthesis rate	0.799*	1		
Transpiration rate	0.791*	0.666	1	
Carbon isotopes	0.877**	0.805**	0.561	1

Conclusion

In order to reduce the damaging effects of climate change on the terrestrial environment, trees in farmland conditions play a crucial role in using the subjective advantages provided by ecosystem services that may eventually assist in the sequestration of atmospheric carbon through biomass. In this particular case, the carbon content of the tree contributed to an estimated standard of 40 to 50% of tree mass as reported by many scientific researchers. It's also interesting to note that tree species, even individual components have different capacities for storing atmospheric CO_2. Therefore, according to the current result, *Tectona grandis* and *Dalbergia sissoo* would be effective and efficient carbon sequestration solutions that suit the environmental fitness through ecophysiological and carbon isotope discrimination capacity. These two species are also the most likely to be able to survive a water shortage even in difficult circumstances and these results will overlay the way for potential research on other significant plantations as well as for other departments and agencies engaged in climate change mitigation, biomass, and carbon mapping projects.

Declarations

All authors are ready to afford all financial or non-financial interests that are directly or indirectly related to the work submitted for publication.

Ethical Approval

Not applicable

Consent to Participate

Not applicable

Consent to Publish

The authors give consent for the publication of identifiable details, text, tables, and figures to be published in the above journal.

Authors Contributions

Dr. Hari Prasath Natarajan, Dr. Balasubramanian Arunachalam, Dr. Sivaprakash Muthuswamy, Dr. Radhakrishnan Suthandhirajan, and Dr. Swathiga Ganesan contributed to the conceptualization, investigation and writing original draft and Ms. Anjali Satheedan, and Mr. Manimaran Vellan contribute to review, editing and preparation of the final draft.

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Competing Interests

The authors declare that they have no competing interests" in this article.

Availability of data and materials

All data generated or analyzed during this study are included in this manuscript article and some of the datasets generated during and/or analyzed during the current study are not publicly available.

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Figures

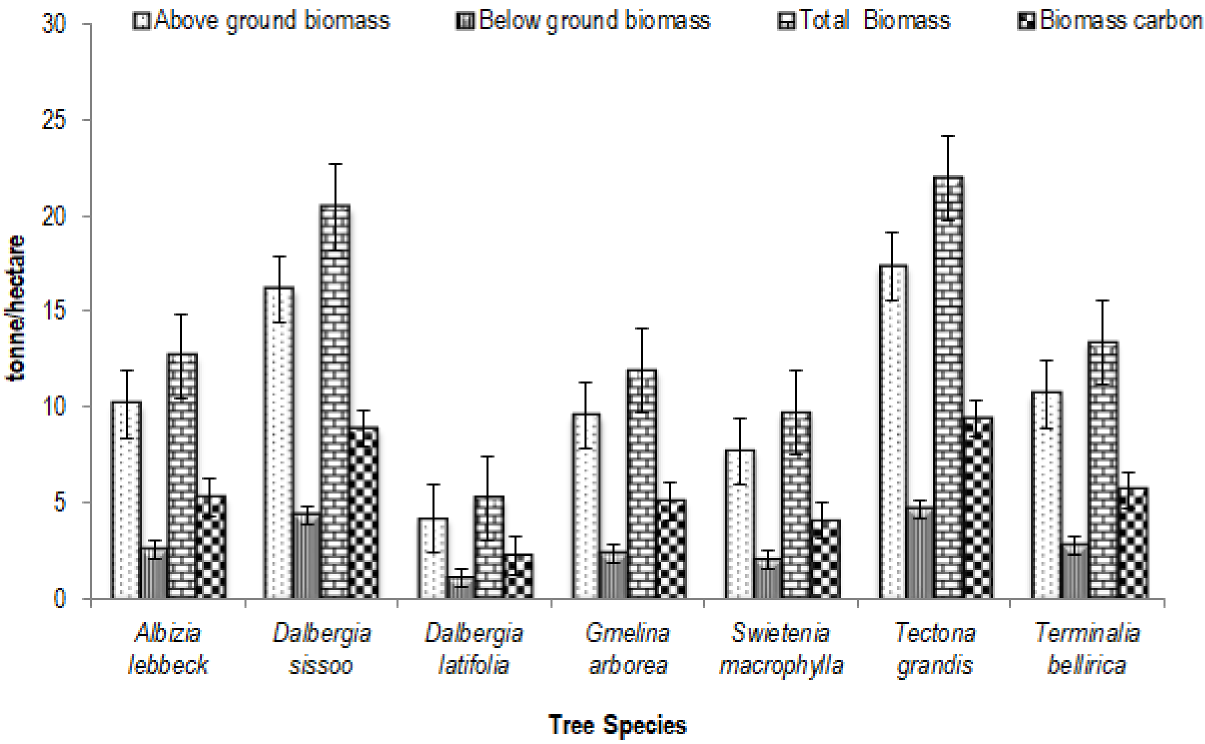

Figure 1

Biomass and Biomass carbon (tonne ha^{-1}) **of 4 year old tree plantation in foothills of Jakanari Forest, Coimbatore, Western Tamil Nadu, India**

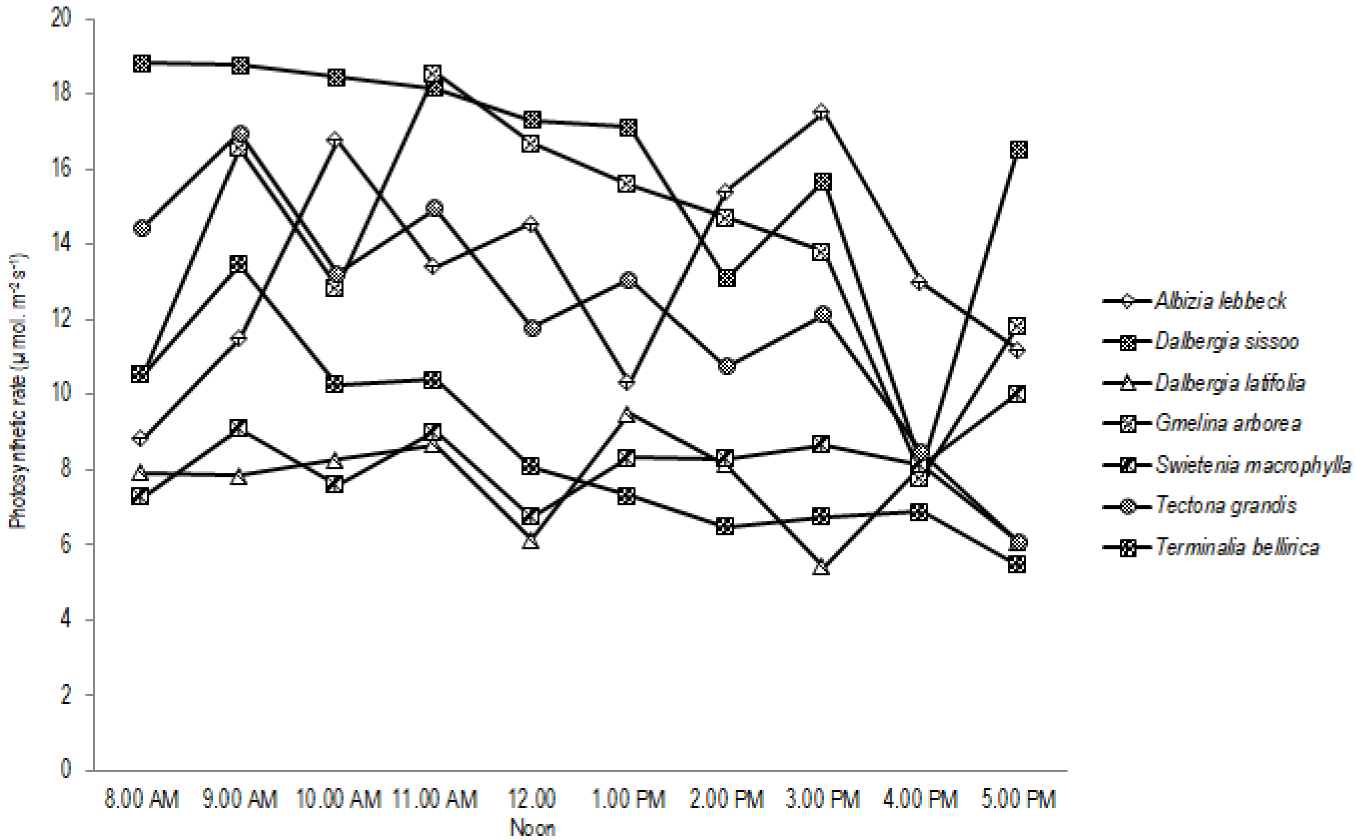

Figure 2

Diurnal variation of photosynthetic rate (μ mol. m^{-2} s^{-1}) **of 4 year old tree plantation in foothills of Jakanari Forest, Coimbatore, Western Tamil Nadu, India**

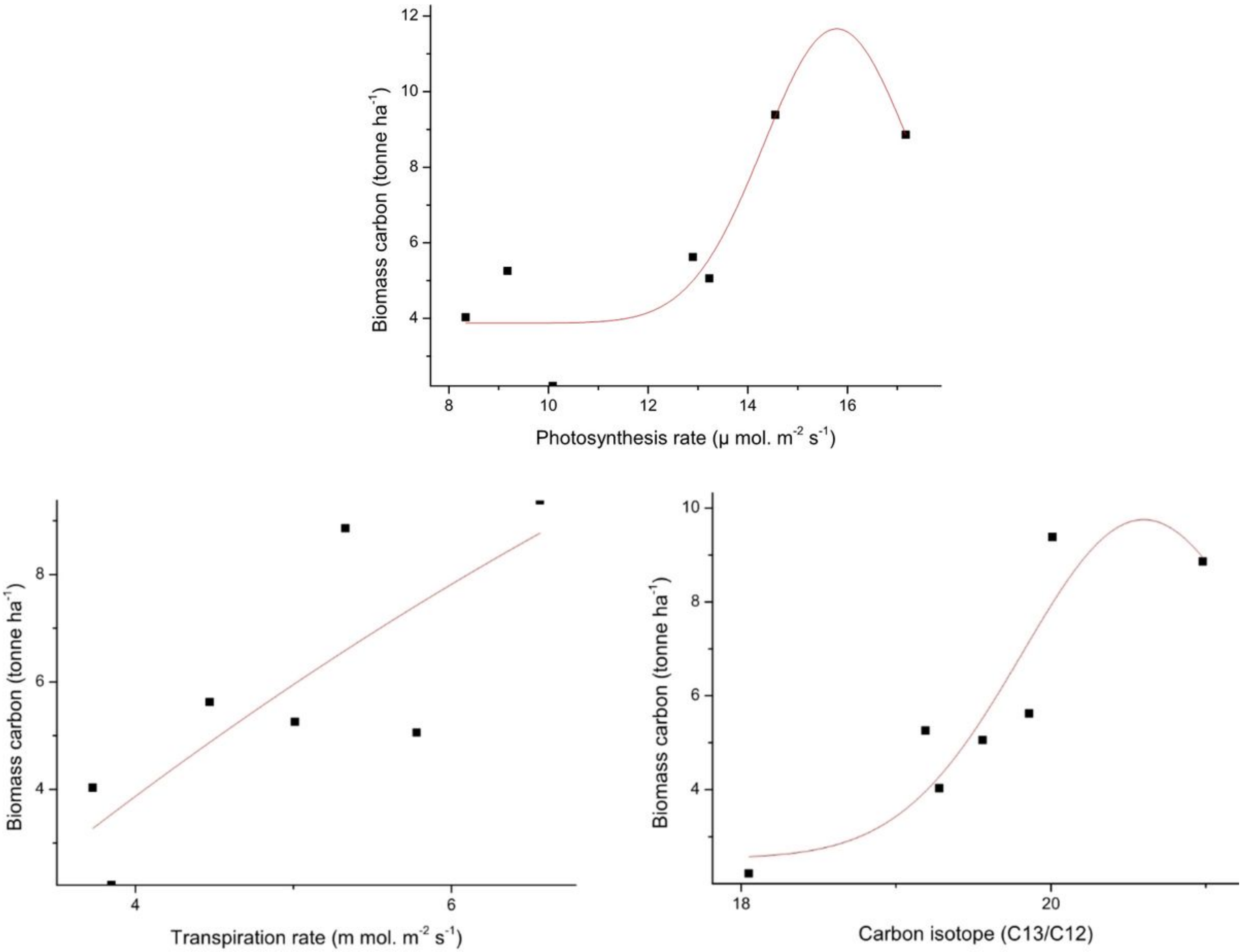

Figure 3

Non-linear regression analysis between Total biomass and a) Photosynthesis rate b) Transpiration rate c) Carbon biomass