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Carbon Sequestration Potential of a Few Selected Tree Species in Coimbatore District, Tamil Nadu

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Authors' contributions

This work was carried out in collaboration between all authors. Authors ARMH and AB designed the study, performed the statistical analysis wrote the protocol and author MS prepared wrote the first draft of the manuscript. Authors BP and DA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted to know the carbon sequestration potential of few selected tree species at Forest College and Research Institute, Mettupalayam. 26 tree species were selected and categorized into different height class as 0-3 m, 3-6 m and 6-9 m from various institutions of Coimbatore. The growth parameters such as height, Diameter at Breast Height were recorded and estimated the biomass carbon. The calculated biomass was then converted into mass of carbon sequestered. These data allowed us to estimate the total mass of carbon sequestered. Maximum biomass accumulation was recorded in height class 6 m to 9 m found in *Delonix regia* (157.64 kg tree^{-1}) and the minimum was recorded in *Gmelina arborea* (0.19 kg tree^{-1}) in the height class 0-3 m.

Keywords: Carbon sequestration; climate change; trees; biomass carbon.

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1. INTRODUCTION

Climate change or global warming is largely dictated by increased emission of carbon dioxide (CO_2) in atmosphere [1]. Awareness of the effects of carbon dioxide emissions from fossil fuel use on the global climate system has sparked research into strategies to mitigate the effects of these emissions. The mitigation of climate change demands, determined commitment of scientists to develop strategies to effectively manage the issues of the changing climate through carbon sequestration. Carbon sequestration is thought to be a promising solution for reducing atmospheric carbon dioxide, an important greenhouse gas.

Among different modes of carbon sequestration developed by different scientists, tree carbon sequestration found to be more promising and less cost consuming effort [2]. About two third of terrestrial carbon is sequestered in the standing forest, forest under storey plants, leaf and forest debris [3]. A considerable interest has been generated about carbon sequestration through afforestation and reforestation activities [4].

Natural forest can sequester carbon permanently but it loses carbon on account of harvest or natural death. Hence, plantation recognized importance in mitigating climate change and it led countries to study their carbon budgets and initiate the assessment of enhancing and maintaining carbon sequestration of their resource. Concern about rising atmospheric concentrations of greenhouse gases has prompted the search for methods of sequestering carbon in plant biomass [5]. Recently biomass is being increasingly used to help quantify pools and fluxes of Green House Gases (GHG) from terrestrial biosphere associated with land use and land cover changes [6]. In India, planted forests of short- rotation tree species have huge carbon sequestration potential and elaborate some possible opportunities for sustainable carbon forestry [7]. In urban settings, to 14 per cent of all carbon stored is perhaps stored in trees, making urban trees an important source of carbon sequestration [8]. It is very important to know the carbon sequestration potential of particular species for urban plantation to neutralize the carbon. With the backdrop of all these studies the research was designed with the objective to evaluate growth and biomass carbon accumulation in selected trees for carbon sequestration potential.

2. MATERIALS AND METHODS

2.1 Location of the Study Area

The study was carried out in 5 educational institutions covered under project Vision carbon Neutral- A joint initiative for promotion of Carbon Neutral Schools/ Institutions, Coimbatore. The study area includes The K'sirs International School, Chinnavedampatti, Coimbatore, The Western Ghats International School, Ettimadai, Coimbatore, Delhi Public School, Onapalayam, Coimbatore, The Jeyandra Saraswathi School, Singanallur, Coimbatore and The Park College of Engineering, Kanniyur, Coimbatore.The study was carried from August 2014 to May 2015.

The trees were selected from above said educational institutions are here as follows *Acacia auriculiformis, Bauhinia racemosa, Cassia fistula, Cassia siamea, Delonix regia, Gmelina arborea, Grevelia robusta, Leuceana leucocephala, Melia dubia, Pongamia pinnata, Peltophorum pterocarpum, Spathodia campanulata, Aleurites fordii, Polyalthia longifolia, Albizzia lebbeck, Tecoma stans, Terminalia arjuna* and *Kaya senagalensis.* These tree species were grouped based on height class as 0-3 m, 3 m-6 m and 6-9 m.

The following procedures were adopted to assess the carbon sequestration potential of selected tree species. The parameters namely height (m), DBH (cm) were recorded to analyse the biomass carbon and DBH will be converted into meter for volume calculation.

2.2 Volume Estimation

The volume of trees was estimated using the following formula and expressed in cubic metre (cm^3) [9].

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

Where, (V= Volume ,r = Radius & h = Total height)

2.3 Estimation of Biomass in Trees

The biomass of the trees were estimated using non-destructive sampling method. Above Ground Biomass, Below Ground Biomass & Total Biomass estimated.

Table 1. Tree biomass (kg/ tree) of species in different height class interval

S. No	Species	Height class (0-3M)			Height class (3-6M)			Height class (6- 9M)		
		AGB	BGB	Total	AGB	BGB	Total	AGB	BGB	Total
1	*Acacia auriculiformis*	4.68	1.22	5.90	50.58	13.15	63.74	102.46	26.64	129.09
2	*Bauhinia racemosa*	0.34	0.09	0.43	10.73	2.79	13.52	35.96	9.35	45.31
3	*Cassia fistula*	4.10	1.07	5.17	70.83	18.42	89.24	170.44	44.31	214.75
4	*Cassia siamea*	4.84	1.26	6.10	13.61	3.54	17.15	54.19	14.09	68.28
5	*Delonix regia*	3.50	0.91	4.40	109.00	28.34	137.34	250.22	65.06	315.28
6	*Gmelina arborea*	0.30	0.08	0.37	7.20	1.87	9.07	25.11	6.53	31.64
7	*Grevelia robusta*	3.41	0.89	4.29	9.20	2.39	11.59	43.89	11.41	55.31
8	*Leuceana leucocephala*	2.18	0.57	2.75	8.26	2.15	10.40	47.89	12.45	60.34
9	*Melia dubia*	0.84	0.22	1.05	10.22	2.66	12.88	35.53	9.24	44.77
10	*Pongamia pinnata*	3.92	1.02	4.94	11.74	3.05	14.79	51.52	13.39	64.91
11	*Spathodia campanulata*	0.58	0.15	0.73	18.22	4.74	22.96	202.33	52.61	254.94
12	*Peltophorum pterocarpum*	0.87	0.23	1.10	16.63	4.32	20.96	163.54	42.52	206.06
13	*Aleurites fordii*	2.81	0.73	3.54	16.04	4.17	20.21	-	-	-
14	*Polyalthia longifolia*	2.91	0.76	3.67	31.35	8.15	39.51	-	-	-
15	*Albizzia lebbeck*	-	-	-	30.97	8.05	39.02	190.05	49.41	239.46
16	*Tecoma stans*	-	-	-	13.93	3.62	17.56	36.36	9.45	45.81
17	*Terminalia arjuna*	1.95	0.51	2.45	46.09	11.98	58.07	-	-	-
18	*Kaya senagalensis*	2.58	0.67	3.25	-	-	-	144.80	37.65	182.45

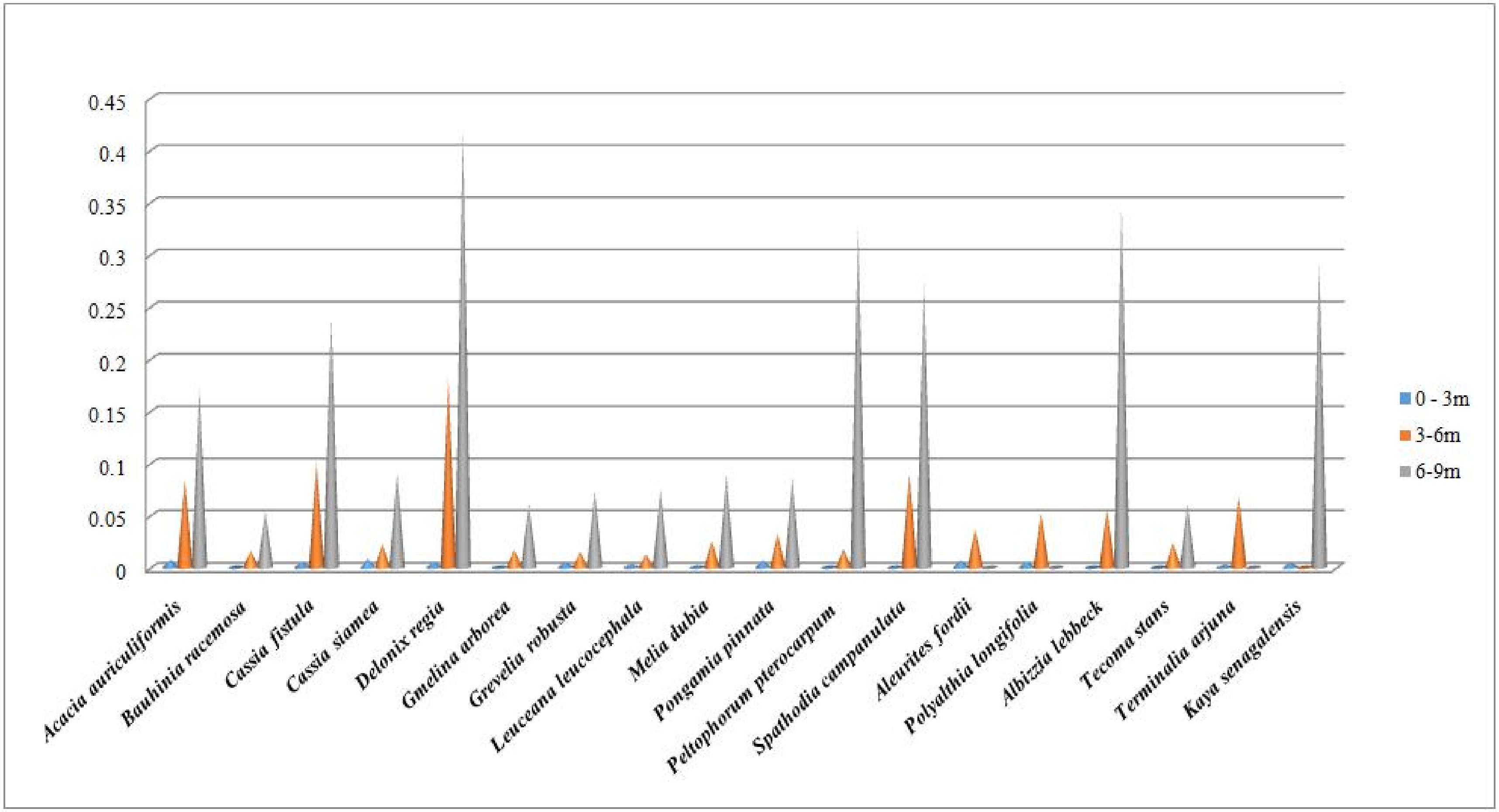

Fig. 1. Tree volume (m^3) at different height class

2.4 Above Ground Biomass (AGB)

AGB (kg/tree) = Volume of tree (m^3) x Wood density (kg/m^3)

Note: The wood density of tree species was unavailable, the standard average value 0.6 gm/cm^3 were taken.

2.5 The Below Ground Biomass (BGB)

Below Ground Biomass includes all biomass of live roots excluding fine roots having < 2 mm diameter. The Below Ground Biomass was calculated by multiplying AGB by 0.26 factors as the root: shoot ratio given by Ravindranath and Ostwald, 2008 method [10].

Below Ground Biomass (Kg $tree^{-1}$) or (ton $tree^{-1}$) = AGB (Kg $tree^{-1}$) or (ton $tree^{-1}$) x 0.26

2.6 Total Biomass

Total biomass is the sum of the above and below ground biomass. [11]. Total Biomass (TB) = Above Ground Biomass + Below Ground Biomass. Total Biomass estimated using [12] method

Total Biomass (Kg $tree^{-1}$) or (ton $tree^{-1}$) = AGB + BGB

2.7 Carbon Estimation

Generally, for any plant species 50% of its biomass is considered as carbon [12] i.e., Carbon Storage = Biomass x 50% or Biomass/2

3. RESULTS AND DISCUSSION

The carbon stocking potential of selected trees in study area was assessed. The selected tree species were categorized into different height class as 0-3 m, 3-6 m and 6-9 m. The biomass carbon was estimated through non-destructive method. For this study total volume, above ground biomass, below ground biomass and total biomass obtained and the results are given here under.

3.1 Carbon Content (kg $tree^{-1}$/ individual)

The total biomass carbon of selected tree species for different height class was estimated and presented in Table 1. In height class 0.1 m to 3 m, the maximum carbon content was registered in *Cassia siamea* (3.05 kg $tree^{-1}$) followed by *Acacia auriculiformis* (2.95 kg $tree^{-1}$) and *Cassia fistula* (2.59 kg $tree^{-1}$). The minimum biomass carbon was observed in *Gmelina arborea* (0.19 kg $tree^{-1}$) for the same height class. Which shows that the maximum total

Table 2. Carbon content (kg/tree) of trees in different height class interval

S. No	Species	Height (0-3M)	Height class (3-6M)	Height class (6- 9M)
1	*Acacia auriculiformis*	2.95	31.87	64.55
2	*Bauhinia racemose*	0.22	6.76	22.66
3	*Cassia fistula*	2.59	44.62	107.38
4	*Cassia siamea*	3.05	8.58	34.14
5	*Delonix regia*	2.20	68.67	157.64
6	*Gmelina arborea*	0.19	4.54	15.82
7	*Grevelia robusta*	2.15	5.80	27.66
8	*Leuceana leucocephala*	1.38	5.20	30.17
9	*Melia dubia*	0.53	6.44	22.39
10	*Pongamia pinnata*	2.47	7.40	32.46
11	*Peltophorum pterocarpum*	0.37	11.48	127.47
12	*Spathodia campanulata*	0.55	10.48	103.03
13	*Aleurites fordii*	1.77	10.11	-
14	*Polyalthia longifolia*	1.84	19.76	-
15	*Albizzia lebbeck*	-	19.51	119.73
16	*Tecoma stans*	-	8.78	22.91
17	*Terminalia arjuna*	1.23	29.04	-
18	*Kaya senagalensis*	1.63	-	91.23

biomass ultimately resulted in highest biomass carbon. *Delonix regia* recorded the maximum biomass carbon with the value of 68.67 kg tree^{-1} followed by *Cassia fistula* (44.62 kg tree^{-1}) and *Acacia auriculiformis* (31.87 kg tree^{-1}) for the height class 3 m to 6 m. The minimum biomass carbon was observed in *Gmelina arborea* (4.54 kg tree^{-1}) for the same height class. With respect to 6 m to 9 m height class, the maximum biomass carbon accumulation was found in *Delonix regia* (157.64 kg tree^{-1}) and the minimum was recorded in *Gmelina arborea* (15.82 kg tree^{-1}). Among different height class studied the maximum biomass carbon accumulation was registered in 6 m to 9 m height class. The carbon sequestration capacity of a tree species depends upon its age, height, girth size, biomass accumulation capacity, canopy diameter and most important wood specific density [13]. The present study indicated that variation in height and DBH influenced on carbon sequestration capacity of trees. Similarly, [14] measured the carbon sequestration rate and above ground biomass carbon potential of four young species of Shorea robusta, Albizzia lebbek, Tectona grandis and Artocarpus integrifolia by the non destructive method in West Bengal and observed that carbon sequestration rate of *Albizzia lebbek* was higher than *Shorea robusta* followed by *A. integrifolia* and *T. grandis*. The increased biomass carbon observed in trees having wide girth/height due to maximize light interception and increased photosynthetic rate.

4. CONCLUSION

In this particular study the level of carbon sequestration by different trees are calculated at a set of intervals. The study revealed that irrespective of age the species has differ in their carbon sequestration potential due to their biomass production. This study can be used to neutralize the carbon production in various industries by planting fast growing tree species with high carbon sequestration potential in short span of time. Planting trees such as *Gmelina arborea, Delonix regia* and *Cassia siamea* in closer spacing can be motivated to mitigate the carbon emission problems and it will reduce the atmospheric carbon in short span of time.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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