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Biomass and Carbon Allocation in Different Components of *Simarouba glauca* and *Azadirachta indica*

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Abstract: *Global climate changing has been a focus for a long time in many fields, the increasing CO_2 concentration in atmosphere was considered as one main driving force for global warming. Carbon sequestration through biomass is considered as the most promising approach to mitigate the climate change. The present study was conducted to estimate the biomass and carbon allocation in different components of ten old trees viz., Simarouba glauca and Azadirachta indica at Hyderabad, Telangana. The study reveals that the above ground components were contributed 71.82% and below ground components contributed 28.17 % to the total biomass and carbon of the Simarouba glauca tree. In that, secondary branch component was recorded highest biomass and carbon allocation of 31.92 per cent followed by primary branch, primary root and stem. Of the total biomass and carbon stored in ten year old Azadirachta indica plantation, 63.91% was allocated in the above ground components where as 36.08% carbon was allocated in the below ground components of the trees. In that maximum biomass and carbon was allocated in primary roots (29.54%) followed by primary branch, secondary branch and stem.*

Keywords: *Allocation pattern, Biomass and Carbon, Simarouba glauca, Azadirachta indica,.*

INTRODUCTION

There is much concern that the increasing concentration of greenhouse gases (GHGs) in the atmosphere contributes to global warming and climate change by trapping long-wave radiation reflected from the earth's surface. Carbon dioxide (CO_2) is one of the main greenhouse gases because a huge volume of CO_2 is added to the atmosphere, when compare to all other greenhouse gases and made itself as a primary agent of global warming. It contributed 72 per cent of the total anthropogenic greenhouse gases, causing between 9-26 per cent of the greenhouse effect (Kiehl and Trenberth, 1997).

The IPCC estimates that the level of carbon dioxide in today's atmosphere is 31 per cent higher than it was at the start of the Industrial Revolution about 250 years ago. An atmospheric level of CO_2 has risen from 280 ppm at the pre-industrial to the present level of 375 ppm.

Concentration of atmospheric carbon dioxide can be lowered either by reducing emissions or by enabling the storage of carbon dioxide in the terrestrial ecosystem. Sequestration of biomass carbon is considered as the most promising approach to mitigate climate change (Kimble *et al.*, 2002). Carbon sequestration, *i.e.* capturing and storing carbon that would otherwise be emitted and remain in the atmosphere might be a suitable alternative to control atmospheric emission of carbon. Plants capture CO_2 during photosynthesis and transform it to sugar and subsequently to dead organic matter. As the trees grow, they sequester carbon in their tissues, and as the amount of tree biomass increases, the increase in atmospheric CO_2 is mitigated.

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Plantations or naturally regenerated trees can protect watersheds against droughts, flash floods or landslides thought to be more prevalent due to climate change. Trees play a vital role in mitigating the diverse effects of environmental carbon degradation and increasing concentration of carbon dioxide in the atmosphere. Trees promote sequestration of carbon into soil and plant biomass. Therefore tree based land use practices could be viable alternatives to store atmospheric carbon dioxide due to their cost effectiveness, high potential of carbon uptake and associated environmental as well as social benefits (Dhruw *et al*., 2009).

However, a methodology for evaluating the biological components of carbon flux remains a significant research issue. Differences in per cent and carbon among different tree species and among wood types within a single tree (Lamlom and Savidge, 2003) indicated the need to estimate biomass and carbon content for each species and each tree component. Most published studies on this subject, however, have focused on total aboveground biomass and carbon, whereas discrimination among the different parts of the tree, wood types, and stocking densities by age is rarely done. Since no scientific systematic study has been undertaken to estimate the carbon per cent in different tree components on the most demanding commercial and valuable oil yielding species *viz*., *Simarouba glauca* and *Azadirachta indica* of India.

Therefore an attempt was made with the objective to estimate the biomass and carbon allocation percent of tree components (leaves, branches, wood and roots) of *Simarouba glauca* and *Azadirachta indica* under dry area of Hyderabad, Telangana.

MATERIALS AND METHODS

Site Description

This study was conducted in Hayathanagar Research Farm (HRF) of the Central Research Institute for Dry land Agriculture, Hyderabad. The HRF is located at located at 17°27′N latitude, 78°35′ longitude with above mean sea level of 515 m. The mean annual temperature is 13.5°-38.6°C and the mean annual rainfall is 755 mm. The experimental soil represented Alfisol soil order (Typic Haplustalf), with pH slightly acidic to neutral (6.4) and EC 0.085 dS m^{-1}. The soils were low in available nitrogen (145 kg ha^{-1}), medium in available phosphorus (13.0 kg P ha^{-1}) and available potassium (175 kg ha^{-1}). The ten year old S*imarouba glauca* and *Azadiracta indica* plantations were selected for carbon sequestration study with 6 × 6m spacing. The experiment was carried out during 15th November, 2014 to 15th February, 2015 in winter season.

Demarcation and Enumeration for Measurements

The entire field was divided into plots of equal size and within each plot, 25% of the trees were marked representing the population and the growth parameters of these trees were monitored at regular intervals. Entire plantation was divided into three diameter classes *viz,* 0-10 cm, 10-20 cm and 20-30 cm for measuring the growth parameters. Three representative trees from each diameter class were selected for destructive sampling. Growth variables *viz*., tree height, basal diameter, DBH, crown height and crown width were measured before felling of trees. These measurements were recorded as per established procedure and the growth parameters of the selected trees are given in Table 1.

Biomass Estimation

The trees were felled at ground level using a mechanical chain saw (Poulan/Pro, USA). After recording the total height and DBH of the felled trees, the above ground portions were separated into wood, branches and leaves. For below ground biomass estimation, pits were excavated and complete recovery of roots was done from tree base. Fresh weights of the entire above and below ground tree components were recorded immediately after felling using appropriate spring scales. A small sample (500 gram (g)) of wood, branches and leaves was immediately transferred to the laboratory in double sealed polythene bags. The collected samples were dried at 80°C till constant weight was obtained. The oven dry weight of the whole sample was calculated using the formula given below (Gnana Mathuram, 2009).

Table 1
Descriptive statistics of *Simarouba glauca* and *Azardiracta indica*

Sl. No.	Variables	Units	*Simarouba glauca* Minimum	Maximum	Mean	SE (mean)	SD	*Azardiracta indica* Minimum	Maximum	Mean	SE (mean)	SD
1.	Tree height	m	3.400	4.600	3.955	0.141	0.424	4.400	6.750	5.485	0.317	0.951
2.	Basal Diameter	cm	8.000	25.20	16.12	2.201	6.603	8.600	24.00	16.93	2.112	6.338
3.	No. of branches	Numbers/tree	10.00	15.00	12.66	0.527	1.581	14.00	44.00	31.22	4.152	12.45
4.	DBH	cm	3.500	5.600	4.555	0.283	0.849	8.800	22.50	15.23	1.860	5.581
5.	Crown height	m	0.350	0.620	0.464	0.038	0.114	1.000	2.300	1.586	0.166	0.498
6.	Crown width	m	3.800	5.700	4.583	0.242	0.726	1.800	7.600	4.622	0.791	2.373
7.	Leaves biomass	kg/plant	2.000	8.800	4.455	0.985	2.955	1.200	4.000	2.511	0.383	1.149
8.	Stem biomass	kg/plant	4.500	21.00	10.99	2.229	6.688	4.000	36.00	17.03	4.711	14.13
9.	Primary branch biomass	kg/plant	7.280	36.00	18.65	4.010	12.03	6.200	71.00	31.61	9.853	29.56
10.	Secondary branch biomass	kg/plant	11.04	55.53	27.72	6.548	19.64	11.00	53.90	27.90	6.451	19.35
11.	Above ground biomass	kg/plant	27.95	118.8	61.82	13.65	40.95	24.00	164.0	79.05	21.37	64.13
12.	Below ground biomass	kg/plant	48.41	10.34	24.57	5.696	17.09	10.00	94.80	43.46	12.61	37.83
13.	Total biomass	kg/plant	38.29	167.2	86.40	19.34	58.02	34.00	258.8	122.5	33.98	101.9

Dry weight of the tree biomass

$$= \frac{\text{Oven dry weight of the sample}}{\text{Fresh weight of the sample}} \times \text{Fresh weight of the whole tree}$$

Biomass Carbon Estimation of Plantation

The plant samples of various components *viz.*, stem, branches, leaves and roots of the targeted trees species were collected separately, air dried and oven dried. Oven dried biomass samples were grounded in Willey Mill and carbon concentration in different tree components were determined based on ash per cent and determined by the procedure given by Allen *et al.* (1986).

$$\text{Ash }\% = \frac{(W_3 - W_1)}{(W_2 - W_1)} \times 100$$

Where,

W_1 = Weight of crucibles

W_2 = Weight of oven dried powdered samples + crucibles

W_3 = weight of ash + crucibles

Carbon Per cent Estimation in Biomass

Carbon per cent in above ground biomass, below ground biomass, litter and dead organic matter was estimated followed by Negi *et al.,* (2003) and Dhruw *et al.* (2009) using the follwing formula given below.

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

Biomass Carbon Stock

The carbon stock in the above ground biomass, below ground biomass, litter and dead organic matter was computed by using the following formula given below (Wani *et al.,* 2014).

Carbon = Biomass × Carbon per cent

The total biomass carbon was calculated by using the following formula,

Total biomass carbon stock (t C ha^{-1}) = AGB carbon + BGB carbon

RESULT AND DISCUSSION

Carbon content in fractionated biomass components *viz.*, leaf, branch, stem and root of *Simarouba glauca* and *Azadiracta indica* were estimated and results were presented below.

Biomass and Carbon Allocation in Different Components of *Simarouba Glauca*

The ten year old *Simarouba glauca* had a total biomass was 246.2 ton/ha and carbon stock was 103.5 t/ha and a single tree accounts about 88.91kg/tree and 36.89 kg/ha respectively. The above ground components were contributed 71.82% and below ground components contributed 28.17 % to the total biomass and carbon of the tree (Table 2 and Figure 1).

The secondary branch component of *Simarouba glauca* recorded highest biomass and carbon allocation of 31.92 per cent followed by primary branch (23.64%), primary root (22.34%) and stem (12.18%). The lowest percentage contribution of biomass and carbon was allocated in tertiary roots (1.566%) followed by leaf (4.145%) and secondary roots (4.270%). The findings are in conformity with that of Singh and Lodhiyal (2009) and Uma *et al.*, (2011). Also the branch biomass depends upon the size of the branches and structure of large and small branch sizes in the canopy (Heriansyah *et al.*, 2007). Similar variation in carbon content was reported by Dhruw *et al.* (2009). The variation in carbon content of different parts of the tree was also reported by Kaur *et al.* (2002), Ludang and Jaya (2007) and Negi *et al.* (2003). They estimated the carbon allocation in different components of some Indian trees and conclude that wood accumulated more carbon content when compare to leaf and bark in different genera of trees pertaining to conifers, deciduous, evergreen dicotyledons, monocotyledon and exotic tree species.

Table 2
Percent allocation in different parts of *Simarouba glauca*

Sl. No.	*Components ton/ha*	*Biomass ton/ha*	*Carbon*	*Percent contribution (%)*
I.	*Above Ground Biomass*			
	1. Leaf	12.02	4.291	4.145
	2. Stem	31.08	12.61	12.18
	3. Primary branches	57.43	24.47	23.64
	4. Secondary branches	77.45	33.04	31.92
II.	*Below Ground Biomass*			
	5. Primary roots	54.17	23.13	22.34
	6. Secondary roots	10.35	4.422	4.270
	7. Tertiary roots	3.797	1.621	1.566
III.	*Total Biomass*	246.2	103.5	100.0

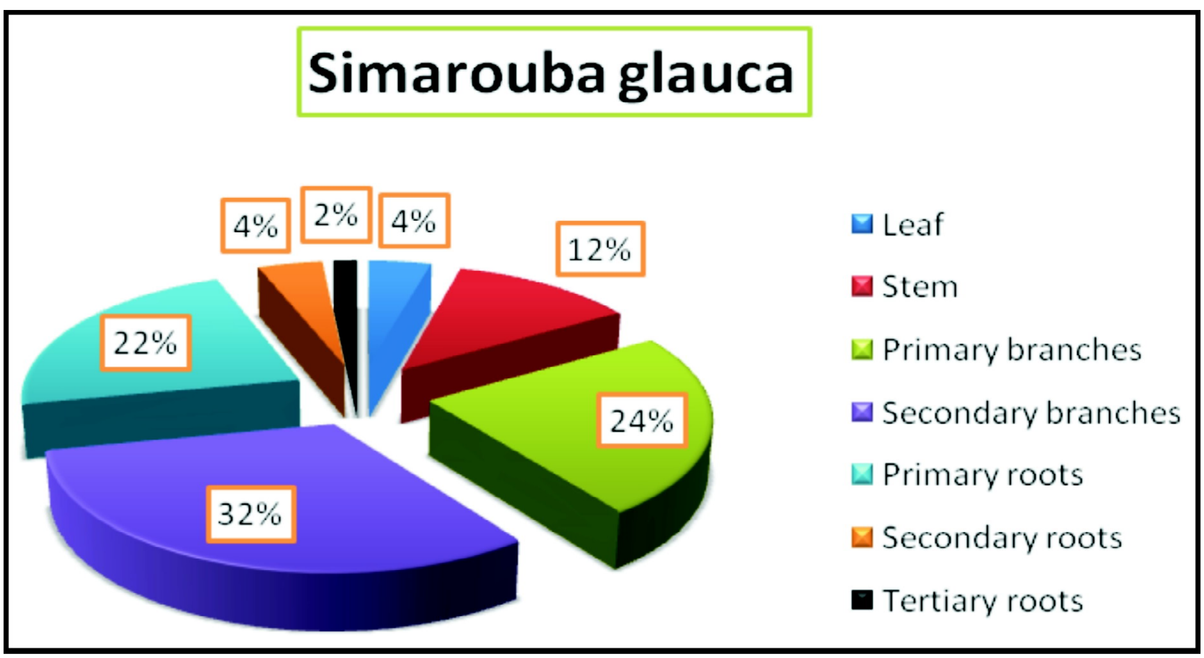

Figure 1 Biomass and Carbon allocation in different parts of *Simarouba glauca*

Biomass and Carbon Allocation in Different Components of *Azadirachta Indica*

The total biomass and carbon of ten year old *Azadirachta indica* plantation was calculated 338.8 t/ha and 137.9 t/ha and single tree accounts about 122.3 kg/tree and 49.79 kg/tree. Of the total biomass and carbon stored in ten year old *Azadirachta indica* plantation, 63.91% was allocated in the above ground components where as 36.08% carbon was allocated in the below ground components of the trees (Table 3 and Figure 2).

In that maximum biomass and carbon was allocated in primary roots (29.54%) followed by primary branch (27.19%), secondary branch (21.34%) and stem (13.74%). And the minimum percentage contribution was allocated in tertiary roots (1.607%) followed by leaf (1.646%) and secondary roots (4.942%). Wani *et al.* (2014) reported that trees produce large root system that needed for uptake of soil resources, thus resulting in higher values in higher diameter class. Several other worker also support this findings (Bhardwaj *et al.*, 2001; Raizda *et al.*, 2007; Yadava, 2010a; Uma *et al.*, 2011) who reported that root biomass is more in higher diameter class as compared to lower diameter class. The present findings were confirmed with Adams *et al.*, 1993; Richards *et al.*, 1993; Dixon *et al.*, 1995; Parks and Hardie, 1995; Callaway and McCard, 1996; Stavins, 1999 and Ludang and Jaya, 2007.

Table 3
Percent allocation in different parts of *Azardirachta indica*

Sl. No.	Components ton/ha	Biomass ton/ha	Carbon	Percent contribution (%)
I.	*Above Ground Biomass*			
	1. Leaf	6.946	2.271	1.646
	2. Stem	46.57	18.95	13.74
	3. Primary branches	87.84	37.50	27.19
	4. Secondary branches	78.08	29.43	21.34
II.	*Below Ground Biomass*			
	5. Primary roots	97.71	40.74	29.54
	6. Secondary roots	16.34	6.816	4.942
	7. Tertiary roots	5.317	2.217	1.607
III.	*Total Biomass*	338.8	137.9	100.0

CONCLUSION

The present study also revealed that carbon percentage allocation was more in secondary branches followed primary branches of ten year old *Simarouba glauca*. Total biomass and carbon allocated in *Azadiracta indica* plantation was 63.91% in the above ground components where as 36.08% carbon was allocated in the below ground components. In that maximum biomass and carbon was allocated in primary roots followed by primary branch and secondary branch. Our study reveals that a

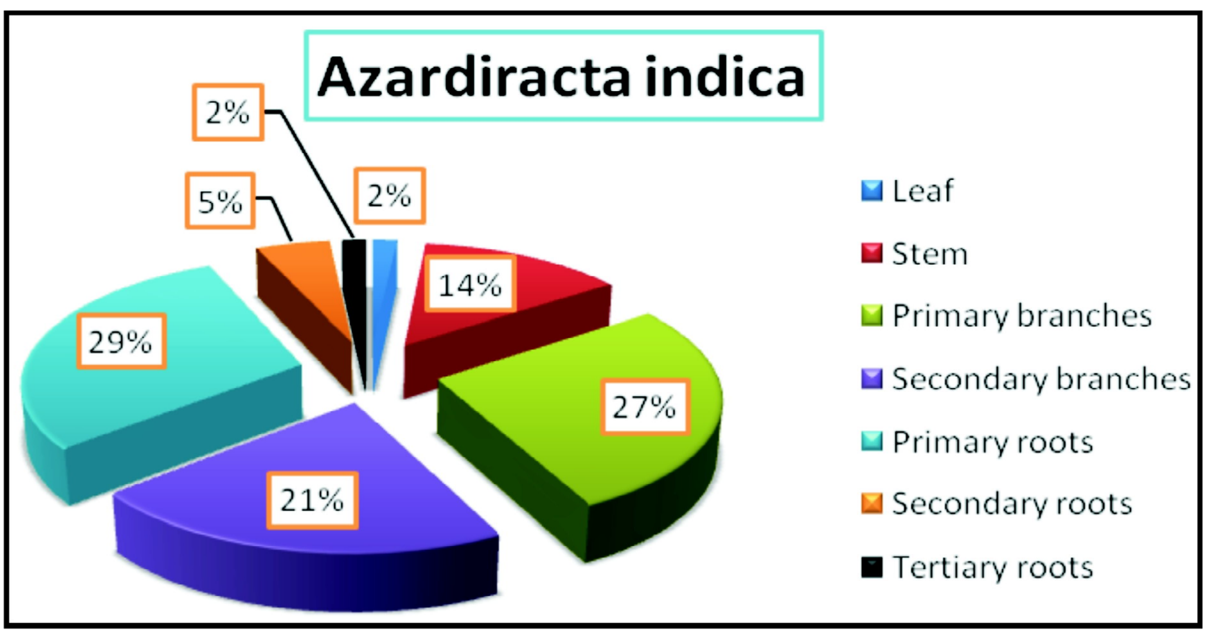

Figure 2 Biomass and Carbon allocation in different parts of *Azadiracta indica*

considerable amount of carbon allocated in ten year old *Simarouba glauca* and *Azadiracta indica* plantation, which acts as an additional carbon sink in the dry region of Hyderabad, Telangana.

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