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Original Research Article

Estimation of Carbon Sequestration Potential of Different Multipurpose Tree Species Grown under Energy Plantation of Jharkhand Region of India

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A b s t r a c t

The present study was conducted on potential of carbon sequestration by different multipurpose tree species of energy plantation in different agro-climatic sub zones of Jharkhand state of India. The tree species studied were *Acacia auriculiformis* A.cum (ex Benth.), *Cassia siamea* lam and *Eucalyptus hybrid* of four years old plantation from the different location. The dry ashing method was used for estimating the total carbon content in the tree. The data for carbon estimation of above ground parts (bole, branches, leaves and bark) and below ground parts (roots) were collected. The observation of the study resulted that maximum carbon sequestration obtained by *Eucalyptus hybrid* (31.56 kg C/tree/year) compared to other two species whereas below ground maximum carbon sequestration obtained by *Acacia auriculiformis* (2.62 kg C/tree/year) followed by *Cassia siamea* (2.14 kg C /tree/year) whereas the minimum carbon sequestration of root obtained by *Eucalyptus hybrid.*

K e y w o r d s

Above ground biomass
Below ground biomass
Carbon sequestration
Energy plantation
Multipurpose tree

Introduction

Carbon sequestration is a popular term in use, but the phenomenon is not new. It is a natural method for the removal of carbon from the atmosphere by storing it in biosphere (Dhruva, 2008; Chavan and Rasal, 2010). The cost aspects of forest based carbon sequestration, as an offset mechanism is particularly important. It determines how carbon sequestration compares with other potential carbon offset mechanisms in the broader scheme of greenhouse gas reduction policies. According to the protocol, each country will be given carbon credits based on the carbon emission and sequestration scenario. If developing countries like India have to improve on the issue of carbon credits, then role of vegetation patches in carbon sequestration should be considered. Several studies have established the fact that carbon sequestration by trees could provide relatively low cost net emission reduction (Adams et

al., 1992). It is predicted that carbon dioxide emission to the atmosphere would increase from 7.4 Gigatons (Gt) C per yr in 1997 to approximately 26 Gt C per yr by 2100 (Houghton et al., 1997). This global scenario has generated interest n strategies to reduce emission of carbon dioxide to the atmosphere or to offset emission by storing additional carbon in forest trees (Houghton et al., 1990). There are a number of factors that influence the carbon sequestration rates of a tree *i.e.* temperature, rainfall, soil type and quality, biotic components like microbial growth, predation, pollination etc. besides, topographical features and human disturbances are also important factors (Newaj et al., 2001) for carbon sequestration rates. To determine the roles of trees in mitigating atmospheric CO_2 content, it is essential to have accurate inventory of carbon content in trees. Carbon sequestration occurs within various pools in agro-forestry systems depending on their structure and management, including live trees, standing and down dead trees, understory shrubs, annual crops, leaf litter, and soil. However, most of the change in carbon sequestration occurs as result of growth, and thus biomass accumulation, of live trees. Other pools such as down deadwood, understory and litter change relatively slow (Smith et al., 2006).

The actual carbon sequestration potentiality has not so far been assessed. As these species can be found at different elevations, aspects and site quality which require assessment of total carbon sequestration potential of such forest. Therefore, this study aims to establish the base line information for carbon sequestration potential of fast growing multipurpose tree species.

Materials and methods

The present study was carried out on three tree species namely *Acacia auriculiformis*, *Cassia Siamea* and *Eucalyptus hybrid* in three different location i.e. Deoghar district in sub zone IV, Ranchi district in sub zone V and East Singhbhum in sub zone VI of Jharkhand, India. The total analyses of plant sample were done in the laboratory of phyto-chemistry lab of Faculty of Forestry, BAU, Ranchi. Jharkhand state is categorized by undulating topography. However, the state where the experiments were conducted is almost plain with minor slopes but surrounded by rugged topography with serrated hills and hillocks. The study was carried out in three districts. The area falls in the tropical region (humid to sub humid) with an average annual rainfall varies from 1200 to 1400 mm. The elevation of the study area falls between 443 m of sub zone IV to 625 m of msl in sub zone VI.

Dry ashing method is used for estimating carbon percent in trees 0.10 gm of oven dried sample is placed in silica crucible and burnt in a muffle furnace for two and a half hours. The ash content the inorganic elements in the form of oxides, left after burning was weighed and carbon content is calculated by using following equation.

$$\text{Ash (\%)} = \frac{\text{W3-W1}}{\text{W2-W1}} \times 100$$

Where,
W1 = Weight of crucible
W2 = Weight of oven dried sample + crucible
W3 = Weight of ash + crucible

Results

The experiment results obtained during the course of investigation are summarized as follows:

Carbon content in tree species (bole)

The carbon sequestration (kg C/tree/year) of bole of three tree species viz. *Acacia auriculiformis*, *Cassia siamea* and *Eucalyptus hybrid* in three different sub zones of Jharkhand is presented in Table 1. Perusal of data has indicated that maximum carbon sequestration of bole obtained by *Eucalyptus hybrid* (31.56kg C/tree/year) followed by *Acacia auriculiformis* (16.76 kg C/tree/year) whereas the minimum carbon sequestration of bole obtained by *Cassia siamea* (14.72 kg C/tree/year). Among the sub sub-zone the maximum carbon sequestration of bole was found in sub zone V (22.07 kg C/tree/year) followed by sub zone IV (20.75 kg C /tree/year) and the least carbon sequestration of bole has found in sub zone VI (20.22 kg C/tree/year). Statistical analysis revealed that among species *Eucalyptus hybrid* has highly statistically significant than other two species whereas *Acacia auriculiformis* has significant than *Cassia siamea*. Among sub zones, sub zone V has highly significant than other two sub zone where sub zone VI and sub zone VI are at par to each other.

Table 1. Carbon sequestration (kg C/tree/year) of bole in four year tree species.

Species	Agro-climatic Sub zone			Mean
	IV	V	VI	
Acacia auriculiformis	16.57	17.38	16.32	16.76
Cassia siamea	14.82	15.10	14.23	14.72
Eucalyptus hybrid	30.85	33.73	30.10	31.56
Mean	20.75	22.07	20.22	21.01
		S.Em (±)	**CD 5%**	
Tree species		0.276	0.586	
Agro climatic sub zone		0.276	0.586	
Tree species × Agro climatic sub zone		0.479	1.015	
CV%		3.946		

Carbon content in tree species (above ground component i.e. bole, branch, leaf and bark)

The carbon sequestration (kg C/tree/year) of above ground component (bole, branch, leaf and bark) of three species *viz.*, *Acacia auriculiformis*, *Cassia siamea* and *Eucalyptus hybrid* in different sub zones is presented in Table 2.

Perusal of data has indicated that the maximum above ground carbon sequestration obtained by *Eucalyptus hybrid* (38.96 kg C/tree/year) followed by *Acacia auriculiformis* (27.43 kg C/tree/year) whereas the minimum above ground carbon sequestration, obtained by *Cassia siamea* (23.90 kg C/tree/year). Among the sub zone, the maximum above ground carbon sequestration was found in sub zone V (31.82 kg C/tree/year) followed by Sub zone IV (29.69 kg C/tree/year) and the least above ground carbon sequestration has found in Sub zone VI (28.79 kg C/tree/year). Statistical analysis revealed that among species *Eucalyptus hybrid* has statistically significant than other two species whereas *Acacia auriculiformis* has significant than *Cassia siamea*. Among sub zones, sub zone V has highly significant than other two sub zone whereas sub zone IV has significant than sub zone VI.

Table 2. Carbon sequestration (kg C/tree/year) of above ground component in four years tree species.

Species	Agro Climatic Sub zone			Mean
	IV	V	VI	
Acacia auriculiformis	27.20	28.72	26.36	27.43
Cassia siamea	23.70	25.07	22.94	23.90
Eucalyptus hybrid	38.15	41.66	37.08	38.96
Mean	29.69	31.82	28.79	30.10
		S.Em (±)	**CD 5%**	
Tree species		0.282	0.598	
Agro climatic sub zone		0.282	0.598	
Tree species × Agro climatic sub zone		0.488	NS	
CV%		2.811		

Carbon content in tree species (root)

The carbon sequestration (kg C/tree/year) of root of three tree species viz. *Acacia auriculiformis*, *Cassia siamea* and *Eucalyptus hybrid* in three sub zones of Jharkhand is presented in Table 3.

Perusal of data has indicated that the maximum carbon sequestration of root obtained by *Acacia auriculiformis* (2.62kg C/tree/year) followed by *Cassia siamea* (2.14 kg C/tree/year) whereas the minimum carbon sequestration of root, obtained by *Eucalyptus hybrid* (1.24 kg C/tree/year). Among the

sub zone, the maximum carbon sequestration of root was found in sub zone V (2.11 kg C/tree/year) followed by sub Zone IV (1.99 kg C/tree/year) and the least carbon sequestration of root has found in sub Zone VI (1.90 kg C/tree/year). Statistical analysis revealed that among species *Acacia auriculiformis* has statistically significant than other two species whereas *Cassia siamea* has significant than *Eucalyptus hybrid*. Among sub zones, sub zone V has highly significant than other two sub zone whereas sub zone IV and sub zone VI are at par to each other.

Table 3. Carbon sequestration (kg C/tree/year) of root in four years tree species.

Species	Agro Climatic Sub zone			Mean
	IV	V	VI	
Acacia auriculiformis	2.63	2.75	2.47	2.62
Cassia siamea	2.11	2.23	2.08	2.14
Eucalyptus hybrid	1.21	1.35	1.16	1.24
Mean	1.99	2.11	1.90	2.00
		S.Em (±)	**CD 5%**	
Tree species		0.041	0.087	
Agro climatic sub zone		0.041	0.087	
Tree species × Agro climatic sub zone		0.071	NS	
CV%		6.170		

Table 4. Total carbon sequestration (kg C/tree/year) in four year tree species.

Species	Agro Climatic Sub zone			Mean
	IV	V	VI	
Acacia auriculiformis	29.84	31.47	28.82	30.04
Cassia siamea	25.82	27.30	25.02	26.05
Eucalyptus hybrid	39.36	43.01	38.24	40.20
Mean	31.67	33.93	30.69	32.10
		S.Em (±)	**CD 5%**	
Tree species		0.283	0.599	
Agro climatic sub zone		0.283	0.599	
Tree species × Agro climatic sub zone		0.490	NS	
CV%		2.642		

Total carbon content in the trees (above ground + below ground component)

The total carbon sequestration (kg C/tree/year) of three tree species *viz. Acacia auriculiformis, Cassia siamea* and *Eucalyptus* hybrid in three different sub zones of Jharkhand is presented in Table 4.

Perusal of data has indicated that the maximum total carbon sequestration obtained by *Eucalyptus hybrid* (40.20kg C/tree/year) followed by *Acacia auriculiformis* (30.04 kg C/tree/year) whereas the minimum total carbon sequestration, obtained by *Cassia siamea* (26.05 kg C/tree/year). Among the sub zone, the maximum total carbon sequestration was found in sub zone V (33.93 kg C/tree/year) followed by Sub zone IV (31.67 kg C/tree/year) and the least total carbon sequestration has found in Sub zone VI (30.69 kg C/tree/year). Statistical analysis revealed that among species *Eucalyptus hybrid* has statistically significant than other two species whereas *Acacia auriculiformis* has significant than *Cassia siamea*. Among sub zones, sub zone V has highly significant than other two sub zone whereas sub zone IV has significant than sub zone VI.

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