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RESEARCH ARTICLE

Machilus gamblei (lauraceae) : A potential plant for carbon sequestration.

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Abstract: *Machilus gamblei* King ex Hook.f. (Syn. *Persea bombycina* (King ex Hook.f.) Kosterm.of family Lauraceae, has gained considerable importance in traditional agroforestry system of Assam due to its high value from the point of view of the sericulture industry. *Machilus gamblei* leaves have mainly been used as the primary food for *Antherea assama* Westwood, the silk worm that produces golden silk called "Muga". About 14,441.72 hectares of land have been used for the plantation of *Machilus gamblei* in Assam making it as the largest *Machilus gamblei* growing region of the world. Though having high economic value of agroforestry, a little is known about its ecological services to humankind. As a woody perennial plant it serves the same ecological role as that of forest trees. It has a promising potential to sequester atmospheric carbon in plant as well as in soil.

Key words: Agroforestry, Carbon sequestration, *Machilus gamblei*, Muga silk, Sericulture

Introduction

Machilus gamblei King ex Hook.f. [Syn.*Persea bombycina* (King ex Hook.f.) Kosterm] locally knownas 'Som', is one of the primary food plants of *Antheraea assama* (Westwood) the silkworm that produces muga, the golden silk. Muga is very specific to the northeastern states of India and found nowhere in the globe (Choudhury 1982; Yadav and Goswami, 1992). *Machilus gamblei* belongs to the family Lauraceae. It grows as a medium size evergreen tree with spreading branches. The young shoots are covered with simple straight hairs. Leaves are alternate with varying size and shape, upper surface is almost hairless, the lower one is slightly silky and hairy. The distribution of *Machilus gamblei* plant extends to the Khasi and Jayantia hills, along the lower Himalaya in India, from West of Nepal, and also found in Myanmar, Cambodia, Malaysia and Indonesia (Choudhury 1982).

Machilus gamblei plantation in Assam is mainly found in the form of farm forestry as well as agro forestry system. In the agro forestry system it is grown in the home gardens by rural folk but in farm forestry system plantations are mainly maintained as sericulture farm (Choudhury and Vajczikova, 2002). About 14441.72 hectares of land spreading across 22 districts have been used for the purpose plantations in Assam [Anonymous 2004] and producing about 153 metric tons of raw muga silk annually (Pandey *et al.* 2005). Apart from serving as food plants of muga silkworm, the species can contribute to biomass production, carbon sequestration and also render ecological services in nutrient fluxes.

Though having high economic value of *Machilus gamblei* little is known about its ecological services to humankind. Since a woody perennial plant planted in agroforestry system serves the same ecological role as that of forest trees (Negas *et al.* 2013).It is a woody perennial plant (Choudhury 1982), and having promising potential to sequester atmospheric carbon in plant as well as in soil (Devagiri *et al*.2013, Goswami *et al*.2013). Therefore, in the present study, estimation of the sequestered carbon in *Machilus gamblei* was done for proper evaluation of its role as carbon sinks.

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Materials and methods

Study area

This study was carried out in the Brahmaputra valley, at five different sites, located in different agro-climatic zones of Assam (21.16^{0}E to 26.77^{0}E and 85.29^{0}N to 94.18^{0}N)(table 1). The elevation of the study areas ranges from173.88ft. to 301.83ft, average annual rainfall from 2000mm to 3750mm and mean annual temperature ranges from11.2^{0}C to 35.5^{0}C (Taher and Ahmed, 2005). The valley has an undulating topography characterized by hills, hillocks, wide plains and low lying areas (Gopalkrishnan 1970). The soil types in hills and plains of the region exhibit a marked difference in compositions. The soil in plain is mostly alluvial in origin but there are laterite types of soil in some areas (Bhagabati *et al.* 2001).

Determination of wood density

In the present investigation the wood density of *Machilus gamblei* was determined using selective harvesting technique following Parthasarathy *et al.* (2007) and Yadav *et al*. (2015) where samples of stem having 5-15cm long and 1-5 cm in diameter were collected. The wood samples so collected were dried at 70^{0}C until constant weight is achieved. The volume of the wood samples was then obtained using water displacement methods following Das *et al*.(2015) and Parthasarathy *et al.* (2007). The wood density was calculated as woven dry weight divided by volume.

Biomass Sampling

In the present investigation, twenty one sample plots of 10mx10m size were laid down randomly in each of the five study sites. Trees located within a sample plot were typically of even ages and spacing. All trees within the plots were considered for measurement .The average DBH (Diameter at Breast Height) of the trees were measured at 1.35 meter above the ground using diameter tape with ±1mm error level and the height was measured using a hypsometer. The bole volume was calculated using the formula $V=\pi r^2*h$, where r is radius of the stem and h, the plant height. Finally bole volume is multiplied by its wood density to get the bole biomass in kg (Kale *et al.* 2004). For the estimation of below ground biomass the formulae proposed by IPCC (2006) and REDD$^+$ is used. 15% of above ground biomass was considered for litter biomass estimation following Archard *et al*.(2002). Total biomass was obtained by summing up the above ground, below ground and litter biomass. The carbon storage was also computed by multiplying the total biomass with the constant factor 0.50 (Anonymous, 2006).

Study sites	Agro climatic zone	Geo- coordinates	Elevation (ft MSL)
Site 1	North bank plain	26.77^{o}E to 26.79^{o}E 92.15^{0}N to 92.93^{0}N	269.02 ft.
Site 2	Central Brahmaputra valley	25.76^{o}E 8 to26.09^{o}E 85.27^{o}N to 86.35^{o}N	229.65 ft.
Site 3	Upper Brahmaputra valley	26.58^{o}E to26.05^{o}E 94.18^0 N to 94.45^{0}N	301.83 ft.
Site 4	Hill zone	25.85^{0}E to 26.60^{0}E 92.56^{0}N to 93.40^{0}N	249.34 ft
Site 5	Lower Brahmaputra valley	25.97^{o}E to 26.02^{o}E 91.23^{0}N to 91.78^{0}N	173.88 ft.

Data analysis

In the present study data exploration and analysis were carried out using IBM SPSS, version 20 and MS Excel, 2007. The level of significance was assumed to be p=0.05 for all analysis

Result

Wood density

In the present study, the mean wood density was recorded 0.48±0.07gm/cm^3 for the studied plant *Machilus gamblei*. Highest value of wood density was recorded from Site 4 (0.54 ±0.03gm/cm^3) followed by Site I (0.51±03gm/cm^3) and Site 2(0.49±0.04gm/cm^3) respectively.

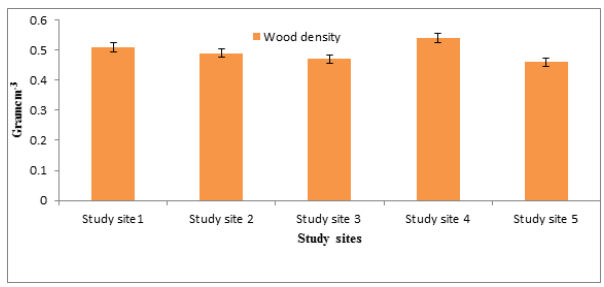

Figure 1: Wood density of *Machilus gamblei* in different study sites (Vertical line on bar ± SE)

Table 2: Statistical summary for diameter at breast height (DBH) and plant height (h) in different studied sites

Site	DBH(cm)				Height(m)			
	Mean	Min	Max	STD	Mean	Min	Max	STD
Site-1 Tupia	16.05	9.86	22.20	5.61	9.15	7.00	13.7	6.42
Site-2 Podumoni	11.37	8.19	15.43	3.11	9.64	6.61	13.02	5.34
Site-3 Jogduar	11.25	7.76	16.02	6.18	13.08	8.83	16.15	7.34
Site-4 Kohora	27.73	16.86	35.73	7.83	11.55	9.08	13.71	3.42
Site-5 Boko	13.32	7.32	19.72	6.23	11.46	9.60	13.07	4.07

(Figure1). Wood density obtained in this study was found almost within the range of the values of *Persea* spp. published by UN Food and Agricultural organization (www.worldagroforestry.com).

DBH and plant height

Observations on DBH and plant height of the study sites are presented in table 2. The results revealed that comparatively higher DBH was recorded from study site 4- Kohora with a maximum value (35.73±7.83cm) followed by study site 1- Tupia (22.20±5.61cm) and study site 5- Boko (19.72±6.23cm) respectively. However maximum plant height was recorded from study site 3 (16.15 ±7.34m) followed by study site 4 (13.71±3.42m) and study site 1 (13.7±6.42m) respectively.

Table 3: Results of the regression analysis between Biomass (dependent variable) and DBH(independent variable) of different studied sites

Site	N	Parameter estimates		Performance Criteria	
		a	b	R^2	SEE
Site I	21	-0.88	2.16	0.838	0.231
Site2	21	-5.5	4.28	0.44	0.51
Site-3	21	0.369	2.64	0.804	0.266
Site-4	21	-0.763	2.1	0.933	0.128
Site-5	21	- 1.5	2.5	0.956	0.164
Mixed data	105	1.78	1.33	0.22	0.99

Biomass and carbon stock

The results of the biomass distribution in various tree components and also the carbon stocks of different studied sites were presented in table 3. It was evident from the table that maximum biomass was recorded from study site 4-Kohora (AGB=173.85±4.60 tonha^{-1}, BGB=43.46±2.84 tonha^{-1}, LBM=26.07±1.79 tonha^{-1}**)** which was followed study site 1-Tupia (AGB=61.03±3.24 tonha^{-1}, BGB=16.15±2.37 tonha^{-1}, LBM=43.07±3.98 tonha^{-1}**)** and study site 5-Boko (AGB=51.52±2.60 tonha^{-1}, BGB=13.74±2.05 tonha^{-1}, LBM= 7.72±1.63 tonha^{-1}) respectively. Similar trend was also observed in the distribution of carbon stocks in different study sites. In the present study maximum carbon stocks was recorded from study site 4-Kohora with a carbon

Table 4: Biomass and carbon stock in different studied sites

Study site	AGB(tonha^{-1})	BGB(tonha^{-1})	LBM(tonha^{-1})	TC(tonha^{-1})
Site 1 Tupia	61.03±3.24^{a}	16.15±2.37^{a}	9.08±2.90^{a}	43.07±3.98^{a}
Site 2 Podumoni	24.96±1.65^{b}	6.45±1.09^{b}	3.78±0.98^{b}	16.96±2.13^{b}
Site 3 Jogduar	32.89±2.78^{c}	8.22±0.75^{c}	4.93±0.43^{c}	23.02±1.53^{c}
Site 4 Kohora	173.85±4.60^{d}	43.46±2.84^{d}	26.07±1.79^{d}	121.49±4.80^{d}
Site 5 Boko	51.52±2.60^{e}	13.74±2.05^{e}	7.72±1.63^{e}	36.49±2.82^{e}

Mean value ± SD, n=3, different letters within the same column indicates significant differences (One way ANOVA, $p < 0.05$)

(AGB= above ground biomass, BGB= below ground biomass, LBM= litter biomass, TC=total carbon)

sequestration potential of 121.49±4.80 tonha^{-1}. However, minimum carbon stock was recorded from study site 2-Podumoni, with a sequestration potential of 16.96±2.13tonha^{-1}.

Discussion

In the present study, the different morphological parameters i.e. DBH, plant height, plant volume etc. were varied from site to site. The mean DBH was found to be ranged from 7.32 ± 6.23 cm (Site 2) to 35.73±7.83cm (site 4) and the plant height from 6.61±5.34 meters (Site 2) to 16.15±7.34 meters (Site 3). Result of the present study revealed that plant biomass of *Machilus gamblei* directly proportionate to respective DBH as reflected in the regression analysis (table 3). Similar trend was earlier reported by Lodhiyal and Lodhiyal (2009) in *Populus deltoides,* Kaul *et al*.(2010) in *Eucalyptus tereticornis* and *Tectona grandis*.

In the present investigation a varying trend was observed in biomass production by different tree components of *Machilus gamblei.* The mean above ground biomass (AGB) was estimated to be ranged in between 24.96±1.65 tonha^{-1} and 173.85±4.60 tonha^{-1}, below ground biomass (BGB) between 6.45±1.09 tonha^{-1} and 43.46±2.84 tonha^{-1}, litter biomass (LGB) ranged between 3.78±0.98 tonha^{-1}and 26.07±1.79 tonha^{-1}. Interestingly more than 65% of the total biomass was contributed by the above ground parts in all study sites. Similar trend i.e. of having more than 65 percent of above ground biomass was shown by many of tropical agroforest trees as reported by Toky *et al*.(1989) and Lott *et al*.(2000). Below ground biomass in present investigation contributed the second largest share (25%) to the total biomass while litter biomass was the least contributor (10%) to the total biomass production in *Machilus gamblei* agroforestry. The total biomass in present study is comparable with the similar study in *Grewa optiva*, growing on the degraded lands in Western Himalaya (Verma *et al*.2014), Cacao (*Theobroma cacao*) grown in Ghana (Issac *et al*. 2007), and some other woody species grown in Brazil.(Schroth *et al*. 2002; Negash e*t al*. 2013).

The order of carbon storage in different tree components of *Machilus gamblei* were AGB > BGB > LBM. Similar result was also reported earlier by Devi and Yadava (2015); Mandal *et al*.(2016). In the present study maximum carbon stock was recorded from study site 4 (121.49±4.80 tonha^{-1}) located in Hill agro climatic zone, followed by study site 1 (43.07±3.98 tonha^{-1}) located in North bank plain zone and study site 5 (36.49±2.82 tonha^{-1}) located in Lower Brahmaputra valley zone of Assam, respectively. The present findings were higher than the carbon storage in any agricultural crops which is 23.61tonha^{-1} as reported by Murthy *et al*.(2013).

It may be concluded that with tremendous potential for carbon sequestration, the *Machilus gamblei* could play an important role in climate change mitigation in the North Eastern Region of India.

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