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# A COMPARATIVE ACCOUNT OF THE DISTRIBUTION OF BIOMASS AND CARBON STOCK IN DIFFERENT DIAMETER CLASSES OF *MACHILUS GAMBLEI* GROWN ON SERICULTURE-BASED AGROFORESTRY SYSTEMS OF ASSAM, NORTHEASTERN INDIA.

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**ABSTRACT:**

This study aimed to evaluate the biomass and carbon stock distributed in different diameter classes of *Machilus gamblei* King ex Hook.f. (Syn. *Persea bombycina* (King ex Hook.f.) Kosterm.of family Lauraceae.. The study was conducted in Tupia, located in the North Bank Plain agro-climatic zone of Assam. In this investigation, the mean above-ground biomass (AGB) in different diameter classes was estimated to range between 4.11±0.98 $tonha^{-1}$ and 26.02±3.18 $tonha^{-1}$, below-ground biomass (BGB) between 1.02±0.04 $tonha^{-1}$ and 6.50±1.42 $tonha^{-1}$ and litter - biomass (LGB) ranged between 0.62±0.03 $tonha^{-1}$ and 3.90±1.38 $tonha^{-1}$. More than 65% of the total biomass contributed by the above-ground parts was recorded in the present investigation.

**KEYWORDS:**

BIOMASS, AGROCLIMATIC ZONE, RANGED, DIAMETER CLASS.

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## 1. INTRODUCTION

The term agroforestry is an aggregation of various land use systems where different plant types like woody perennial trees, shrubs, bamboo, and grasses are planted in the same unit of land. It is a dynamic and ecologically sound natural resource management system (Baliton et al,2020). Agroforestry provides socio-economic and environmental benefits to the land user. The direct tangible benefits of the agroforestry system include supply of food, fodder, fuel wood, craft and construction materials, and medicines. It also reduces the anthropogenic pressure on natural forests (Nair *et al*., 2009). Agroforestry offers unique opportunities to combine the adaptation and mitigation objectives of global warming and climate change, (Sharma *et al*., 2015). It also provides several ecosystem services like biodiversity conservation, carbon stock and sequestration, enrichment of soil nutrients, and improvement of air and water quality (Jose, 2009).

Different agroforestry systems have different potentials of carbon sequestration and assessment of this potential is useful to plan appropriate strategies to reduce and stabilize $CO_2$ emission or to increase carbon sink. The woody perennial agroforestry vegetation was found to be the most effective source of carbon pool, as it can store a higher percentage of carbon in the form of vegetation biomass (Singh and Lal, 2000). *Machilus gamblei*. King ex Hook. f. (Syn. Persea bombycina (King ex Hook.f.) Kosterm. of family Lauraceae has gained considerable importance in traditional agroforestry plantations in Northeastern India due to its high value from the point of view of the sericulture industry (Seth, 2000). Its leaves have mainly been used as the primary food for *Antherea assama* Westwood, the silkworm that produces golden silk called 'Muga' (Choudhury, 1983). Muga silk is very specific to Assam and a few geographical pockets of North East India. It is found nowhere in the globe and specified as the Geographical Indicator (GI) of the region accorded in 2007 (Anonymous, 2014). Though having a high economic value of *Machilus gamblei*, little is known about its ecological services to humankind. Since a woody perennial plant planted in an agroforestry system serves the same ecological role as that of forest trees (Negas *et al.*,2013), *Machilus gamblei* as a woody perennial plant, has promising potential to sequester atmospheric carbon in plants as well as in soil (Devagiri *et al*.,2013). Estimation of the sequestered carbon in the form of plant biomass in *Machilus gamblei* agroforestry is the need of the hour for proper evaluation of its role as a carbon sinks. The present endeavor was, therefore, taken to estimate the biomass and carbon stock in *Machilus gamblei* agroforestry system in different agroclimatic zones of Assam, Northeastern India.

## 2. MATERIALS AND METHODS

### 2.1 STUDY AREA

This study was carried out in Tupia (26.77⁰E to 26.79⁰E and $92.15^0$N to $92.93^0$N) which is located in the North Bank Plain agroclimatic zone of Assam, India. The site falls in sub-tropical climatic zone and the climate is mostly warm and temperate. The average annual rainfall was recorded to be 184.5mm while the average temperature was $24.4^0$C. The soil is mostly alluvial in origin. (Bhagabati et al. 2001).

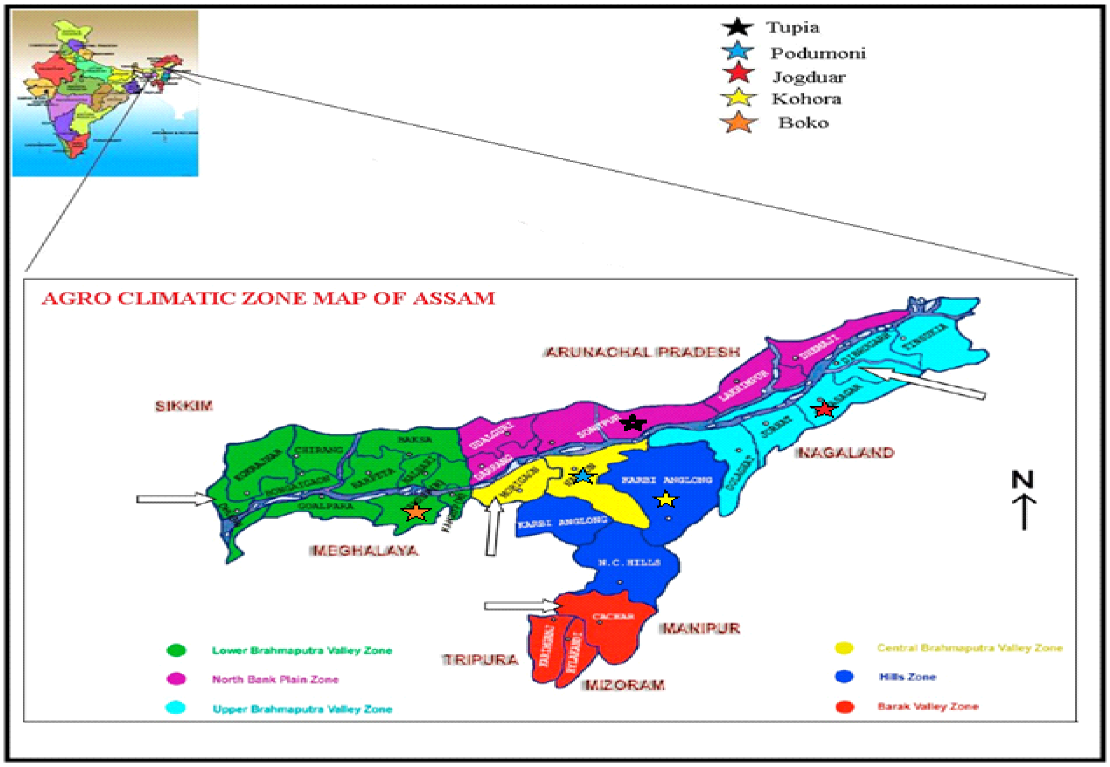


**FIGURE1- AGROCLIMATIC ZONE MAP OF ASSAM (ADOPTED FROM THE DEPARTMENT OF AGRICULTURE, GOVT. OF ASSAM)**

## 2.2 DETERMINATION OF WOOD DENSITY

The wood density of *Machilus gamblei* in the present study was determined using a selective harvesting technique following Yadav et al. (2015). In this investigation samples of stem measuring 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 was achieved. The volume of the wood samples was then obtained using water displacement methods following Das et al. (2015). The wood density was calculated as woven dry weight divided by volume.

## 2.3 BIOMASS SAMPLING

In the present investigation, twenty-one sample plots of 10mx10m size were laid down randomly in the 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 trees' average DBH (Diameter at Breast Height) was measured 1.35 meters above the ground using diameter tape with ±1mm error level and placed in different diameter classes. The plant height was measured using a hypsometer. The bole volume was calculated using the formula V=πr *h, where r is the radius of the stem and h, is the plant height. Finally, bole volume is multiplied by its wood density to get the bole biomass in kg (Kale et al. 2004). The formulae proposed by IPCC (2006) and REDD are used to estimate below-ground biomass. 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 of 0.50 (Anonymous, 2006).

## 2.4 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 analyses.

## 3. RESULTS

## 3.1 WOOD DENSITY

In the present study, the mean wood density was recorded as 0.48±0.07gm/cm for the studied plant *Machilus gamblei*. Wood density obtained in this study was found almost within the range of the values of the species. published by the UN Food and Agricultural Organization (www.worldagroforestry.com).

## 3.2 DBH, PLANT HEIGHT, AND PLANT VOLUME:

Observations on DBH and plant height of the study sites are presented in Table 1. The site had four DBH classes viz. >5-10cm>10-15cm, >15-20cm and >20-25cm. The average tree height was found to be maximum (12.36±2.48m) in >15-20cm DBH class followed by >20-25cm DBH class (11.28±1.96m) and >10-15cm DBH class (10.29±3.21m) respectively. The mean minimum height was recorded as 8.83±1.85m from >5-10cm DBH class. The plant volume was found to be ranged from 0.067±0.014m³ to 0.391±0.018m³. The mean maximum volume was calculated to be 0.391±0.018m³ in >20-25cm DBH class followed by >15-20cm (0.275±0.112m³) and >10-15cm DBH class (0.145±0.067m³) respectively. However, the mean minimum volume was calculated as 0.067± 0.014m³

**TABLE 1- PLANT HEIGHT (M) AND PLANT VOLUME (M³) IN DIFFERENT DIAMETER CLASSES IN THE STUDY SITE:**

| No. | DBH Class (cm) | Tree count | Average Plant height(m) | Average Plant volume(m³) |
|---|---|---|---|---|
| 1 | >5-10 | 118 | 8.83±1.85 | 0.067 ±0.014 |
| 2 | >10-15 | 201 | 10.29 ±3.21 | 0.145 ±0.067 |
| 3 | >15-20 | 182 | 12.36±2.43 | 0.275±0.112 |
| 4 | >20-25 | 124 | 11.28 ±1.96 | 0.391 ±0.018 |

### 3.4 ABOVE GROUND BIOMASS AND CARBON STOCK

Above ground biomass estimated in the present study is presented in Table 2 and represents above-ground biomass and carbon stock distribution in different diameter classes. The mean above-ground biomass was found to be ranged from 4.11±0.988 tonha$^{-1}$ (>5-10cm) to 26.02±3.18 tonha$^{-1}$ (>15-20cm) across different diameter classes. The average carbon stock in the above-ground biomass of *Machilus gamblei* plant ranged from 2.06± 0.04(>5-10cm) tonha$^{-1}$ to 13.02±1.42 tonha$^{-1}$ (15-20cm). The diameter class >15-20cm contributed a maximum (36.91%) to the total plant biomass and carbon stock followed by the>20-25cm diameter class (35.76%) and >10-15cm diameter class (21.49%) respectively. The total above-ground biomass and carbon stock for *Machilus gamblei* plantation from the study site was estimated as 70.49 tonha$^{-1}$ and 35.25 tonha$^{-1}$ respectively.

**TABLE 2- ABOVE-GROUND BIOMASS AND CARBON STOCK IN DIFFERENT DIAMETER CLASSES OF *MACHILU GAMBLEI* IN THE STUDY SITE**

| DBH Classes. (cm) | Above ground biomass (tonha$^{-1}$) (V*D) | Carbon stock (tonha$^{-1}$) | Percentage (%) |
|---|---|---|---|
| >5-10 | 4.11±0.988 | 2.06±0.04 | 5.83 |
| >10-15 | 15.15±2.87 | 7.56±0.53 | 21.49 |
| >15-20 | 26.02±3.18 | 13.02±1.42 | 36.91 |
| >20-25 | 25.21±1.95 | 12.61±0.92 | 35.76 |
| **Total** | **70.49** | **35.25** | **100** |

Data mean of three replicates ± SD

### 3.5 BELOWGROUND BIOMASS AND CARBON STOCK:

The distribution of belowground biomass and carbon stock in different diameter classes of *Machilus gamblei* plantation from the study site is presented in tabular form in Table 3. The belowground biomass was found to be ranged from 1.02±0.04 tonha$^{-1}$(>5-10cm) to 6.50±1.42 tonha$^{-1}$ (>15-20cm) and the carbon stock in the belowground biomass ranged from 0.51±0.05 tonha$^{-1}$(>5-10) to3.25±0.67 tonha$^{-1}$ (>15-20cm). The DBH class >15-20cm and >5-10cm contributed maximum (37.52%) and minimum (5.88%) belowground biomass and carbon stock in *Machilus gamblei* plantation respectively. The total belowground biomass and carbon stock for *Machilus gamblei* plantation from the study site was estimated to be 17.33 tonha$^{-1}$ and 8.66 tonha$^{-1}$ respectively.

**TABLE 3- BELOWGROUND BIOMASS AND CARBON STOCK IN DIFFERENT DIAMETER CLASSES OF *MACHILUS GAMBLEI* IN THE STUDY SITE.**

| DBH class(cm) | Belowground biomass (tonha$^{-1}$) | Carbon stock (tonha$^{-1}$) | Percentage (%) |
|---|---|---|---|
| >5-10 | 1.02±0.04 | 0.51±0.05 | 5.88 |

| | | | |
|---|---|---|---|
| >10-15 | 3.78±0.53 | 1.89±0.32 | 21.82 |
| >15-20 | 6.50±1.42 | 3.25±0.67 | 37.52 |
| >20-21 | 6.03±0.92 | 3.02±0.93 | 34.87 |
| **Total** | **17.33** | **8.66** | **100** |

Data mean of three replicates ± SD

### 3.6 LITTER BIOMASS AND CARBON STOCK:

Litter biomass and carbon stock distribution in different diameter classes of *Machilus gamblei* plantation from the study site are presented in tabular form in Table 4. The litter biomass was found to be ranged from 0.62±0.03 tonha$^{-1}$ (>5-10cm) to 3.90±1.38 tonha$^{-1}$ (>15-20cm) and the carbon stock from 0.31±0.05 tonha$^{-1}$(>5-10cm) to 1.95±0.67 tonha$^{-1}$(>15-20cm). The DBH class >15-20cm contributed maximum (36.89%) litter biomass and carbon stock followed by > 20-25cm (35.76%) and >10-15cm (21.48%) DBH classes respectively. The minimum litter biomass and carbon stock (5.87%) were recorded from the >5-10cm DBH class. The total litter biomass and carbon stock for *Machilus gamblei* plantation from study site 2 was estimated as10.57 tonha$^{-1}$ and 5.29 tonha$^{-1}$ respectively

**TABLE 4-LITTER BIOMASS AND CARBON STOCKS IN DIFFERENT DIAMETER CLASSES OF *MACHILUS GAMBLEI* IN STUDY SITE**

| DBH class(cm) | Litter biomass (tonha$^{-1}$) | Total carbon (tonha$^{-1}$) | Percentage (%) |
|---|---|---|---|
| >5-10 | 0.62±0.03 | 0.31±0.05 | 5.87 |
| >10-15 | 2.27±0.36 | 1.13±0.32 | 21.48 |
| >15-20 | 3.90±1.38 | 1.95±0.67 | 36.89 |
| >20-25 | 3.78±0.92 | 1.89±0.93 | 35.76 |
| **Total** | **10.57** | **5.29** | **100** |

Data mean of three replicates ± SD

Figure 1-Total biomass and carbon stock in different diameter classes of *Machilus gamblei* plantation in study site (Vertical line on bar ± SE)

Figure 2- Regression plots and line of fit on the data from study site

## 4. DISCUSSION

Result of the present study revealed that plant biomass of *Machilus gamblei* directly proportionate to respective diameter class as reflected in the regression analysis (Figure 2). 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) in different diameter classes was estimated to be ranged in between 4.11±0.98 tonha$^{-1}$ and 26.02±3.18 tonha$^{-1}$, below ground biomass (BGB) between 1.02±0.04 tonha$^{-1}$ and 6.50±1.42 tonha$^{-1}$, litter - biomass (LGB) ranged between 0.62±0.03 tonha$^{-1}$ and 3.90±1.38 tonha$^{-1}$. Interestingly more than 65% of the total biomass was contributed by the above ground parts in the study site. 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 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. ( Negash et 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). In the present study maximum carbon stock was recorded from the diameter class >15-20cm, followed by the diameter class>20-25cm and the diameter class >10-15cm(Figure 2.. 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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