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# The capacity of carbon storage of *Litchi chinensis* Sonn. in the hot spot area of Bangladesh

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**Abstract**
*Litchi chinensis* Sonn. is cultivated as a horticultural crop in Bangladesh and it has large-scale economic important. *Litchi chinensis* is planted throughout the country in homesteads and orchards. The plantation is increasing at a geometrical rate due to its deliciousness and being more profitable. The main objective of the study was to estimate the organic carbon storage at different ages of *Litchi chinensis*. A systematic sampling method was followed for selection of plots using Global Positioning Systems (GPS). Biomass and carbon storage of trees were estimated by a non-destructive method. The average value of diameter at breast height and height were 44.97cm and 7.76 m in 10 to 40 years old trees. The highest mean annual diameter at breast height increment and the lowest mean annual height increment were 2.22m, 1.07cm, 0.59m, and 0.22m respectively. Their average values were 1.49 cm and 0.34 m in 10 to 40 years old trees. There was a positive relationship between diameter and height at different ages (r=0.96). The maximum, minimum and mean biomass and carbon storage were recorded of 813.10, 157.51, 473.75, 406.55, 78.75, 236.88 kgtree$^{-1}$ in 10 to 40 years old trees respectively. Carbon storage range from 0.08 to 0.41t C tree$^{-1}$ with an average of 0.24 t C tree$^{-1}$. The average carbon storage capacity of *Litchi chinensis* was 0.65 t Cha$^{-1}$ year$^{-1}$. Statistical analysis revealed that the biomass and carbon stock (tC/tree) varied significantly ($p<0.05$) among different ages of trees. Fruit orchards should be promoted as environment friendly economic activity in the country. It will help in sustainable agricultural development as well as contribution to climate change mitigation.

**Keywords:** Allometric Equations, Age, Diameter, Height, Biomass, Organic Carbon, Global Warming

## 1. Introduction

Carbon dioxide is the prime greenhouse gas which is emitted due to the combustion of fossil fuel and deforestation. Through several efforts have been taken worldwide to reduce carbon emissions, the increase in carbon dioxide gas concentration in the atmosphere is still alarming. The current concentration of $CO_2$ in the atmosphere is about 410 ppm and it is estimated that by 2070 the concentration of $CO_2$ will reach up to 500 ppm (IPCC, 2003) [8]. Only trees play a major role in carbon storage and act as principal sinks of atmospheric carbon which capture $CO_2$ and stored it in the form of biomass in different parts of the body. In this case, photosynthesis plays a vital role to convert carbon dioxide into carbohydrates. When trees are burnt the stored carbon in them are released back into the atmosphere. This is the natural systems of carbon maintained and is controlled by a dynamic balance between biological and inorganic processes since the beginning of the geological history of the earth.

It is impossible to reduce global warming without plantations and giving up the excess luxurious lifestyle. For this reason, developing countries emphasize to plantation program implementation and choose plant species on the basis of environmental conditions. It also should be mentioned that plantation programs are mainly implemented in two ways such as; forest plantation and horticultural plantation in Bangladesh. *Litchi chinensis* is included in horticultural plantation and is a major fruit crop in the northwestern part of Bangladesh covering the Pabna, Rajshahi and Dinajpur districts. *Litchi chinensis* is an evergreen fruit tree and it is found in most of the homesteads of the country. It is a tropical and subtropical fruit tree native to the Guangdong and Fujian provinces of China. It was introduced in Bengal during the later of the 17$^{th}$ century (Hossain, 2015) [7]. It is rapidly becoming popular among farmers in the northwestern part of Bangladesh because it is able to grow in low fertile, sandy loam soils, and adapted to dry regions. The production capacity of *Litchi chinensis* is high and helps to provide more cash than other horticultural crops.

The plant biomass is an important attribute for assessing the carbon stocks in the terrestrial ecosystems. The accurate estimation of individual trees or orchard biomass is important for the valuation of the amount of $CO_2$ that is sequestered from the atmosphere as well as changes in the carbon stock. But the estimation of organic carbon storage of *Litchi chinensis* is impossible due to the lack of proper and sufficient information still yet. Therefore, the present investigation was undertaken to estimate biomass and carbon stocks in Litchi chinensis under different ages.

## 2. Materials and methods

### 2.1 Study area

The present study was carried out to measure the carbon storage in *Litchi chinensis* orchards at Salimpur union of Ishwardhi Upzila of Pabna district in Bangladesh. The study area lies between 24°01´29″- 24°08´28″ N latitudes and 89°25´90″- 89°23´58″ E longitudes (Fig 1). The elevation of the study area is 19.10 meters above mean sea level (MSL). The study area is a tropical wet and dry with low rainfall. The maximum, minimum and mean temperature are 35°C, 25°C and 28°C respectively. Mean annual precipitation is 102.50 mm and average humidity is 63.82% and the warmest, coldest, wettest and driest months are April, January, July and December respectively (Weather Department, 2021).

### 2.2 Sites selection

The study was based on sites selection and measurement of diameter and height of trees. Field study and laboratory investigations were done from January 2021 to December 2021. Sites of the present study in the *Litchi chinensis* orchards were selected using Global Positioning Systems (GPS). There were Twelve hundred fifty-four 1254 plots (reference points or sites) distributed throughout the orchards. The plots were also situated in varying locations and different ages of orchards. The coordinates were recorded using the Global Positioning System (GPS). A systematic sampling method was used for the selection of each plot with the help of global positioning system which is recognized all over the world. (Pearson *et al.*, 2007) [10]. The study areas were established orchards and plots were 100 meters apart from each other. Four plots (20 m radius) were set at 50 m intervals from the center of each track in north-south and east-west directions. The total numbers of the plots were three hundred eight (1248). So, there were 1248 plots and 4992 sub-plots.


**Fig 1:** Map of the study area

Although the minimum sampling intensity (number of plots per hectare) required for such studies was suggested to be 1 % by Rana *et al.* (2012) [14], but 20% were taken in the present study.

### Growth and biomass measurement of tree

After laying out of the plots, the number of trees in each plot were counted and recorded. The trees were measured for height and diameter at breast height (DBH). Each tree was marked and numbered to prevent double counting. A diameter tape was used to measure the DBH (1.30 m above from the ground level) of all the trees in each plot. Height of the trees having DBH equal or greater than 5 cm was measured with a Hega- altimeter. Trees on the border was included in a plot if > 50 % of their basal area fell within the plots and excluded if < 50 % of their basal area fell outside the plot. Trees overhanging to the plots were excluded, but with their trunk inside of the sampling plots, and branches out were included. Care was taken to ensure that the diameter tape is put around the stem exactly at the point of measurement.

**Estimation of trees biomass**

A non-destructive method was used to measure the aboveground biomass of an individual tree. The model of Brown *et al*. (1989) [3] was used to determine the AGB of each tree from its height and DBH values. This method is taken to be one of the most suitable methods for biomass estimation in tropical forests (Alves *et al*., 1997; Brown, 1997; Schroeder *et al.*, 1997) [1, 2, 16].

The model for aboveground biomass is as follows.

$AGB=\exp.\{-2.4090+0.9522\ln(D^2HS)\}$

Where,

AGB is the aboveground biomass (kg),

H is the height of the trees (m),

D is the diameter at breast height (cm),

S is the wood density ($kg/m^3$) for specific species.

Wood density values of the species of the present study were obtained from Sattar *et al*. (1999) [15].

Aboveground biomass per plot, per track and per hectare were calculated by the following formulas:

AGB per plot = Summation of the AGB values of all the trees in a plot.

AGB per track = Summation of AGB values of all the plots in a track.

$$\text{AGB per hectare} = \frac{\text{Sum of AGB values of all the plots in a track}}{\text{Total area of all the plots in a track}} \times 10{,}000$$

BGB was considered to be 15 % of the aboveground biomass as suggested by Mac Dicken (1997) [9]. The formula is given below:

$$\text{BGB} = \text{AGB} \times (15 / 100)$$

The aboveground and belowground biomass was added to get the total biomass of a tree. Total biomass (TB) per plot, per track and per hectare were calculated by the following formulas:

TB per plot = Summation of the total biomass values of all the trees in a plot.

TB per track = Summation of the total biomass values of all the plots in a track.

$$\text{TB per hectare} = \frac{\text{Sum of total biomass values of all the plots in a track}}{\text{Total area of all the plots in a track}} \times 10{,}000$$

**Data analysis**

Descriptive statistics were calculated to describe biomass and carbon in trees. Analysis of variance (ANOVA) was done at different age aspects. Duncan's multiple range tests were used to determine the significance of the variation in the mean. Statistical Package for Social Science (SPSS) version 21 was used to perform these analyses.

## 3. Results and discussion

Biomass and total organic carbon were estimated on the basis of the diameter at breast height (DBH) and height (H) of *Litchi chinensis* (Sonn.). The maximum diameter at breast height and height were found 54.76 cm, 8.92 m in 40 years old and the lowest diameter at breast height and height were found 31.50 cm and 6.25 m in 10 years old trees. The average value of DBH and H were 44.97cm and 7.76 m in 10 to 40 years old trees (Table 1). The present study revealed that the highest mean annual diameter at breast height increment and the lowest mean annual height increment were 2.22cm, 1.07cm, 0.59 m and 0.22 m respectively. Their average values were 1.49 cm and 0.34 m in 10 to 40 years old trees in *Litchi chinensis*.

**Table 1:** Diameter at breast height (DBH), height (H) mean annual diameter increment (MADI) and mean annual height (MAHI)

| Years | DBH | Height | MADI(cm) | MAHI(m) |
|---|---|---|---|---|
| 10 | 22.23±0.22 | 5.92±0.14 | 2.22±0.19 | 0.59±0.06 |
| 15 | 27.42±0.28 | 6.15±0.10 | 1.82±0.21 | 0.41±0.05 |
| 20 | 31.36±0.31 | 7.45±0.07 | 1.57±0.12 | 0.34±0.09 |
| 25 | 34.46±0.19 | 7.92±0.13 | 1.37±0.10 | 0.32±0.04 |
| 30 | 37.60±0.21 | 8.30±0.16 | 1.25±0.12 | 0.28±0.08 |
| 35 | 39.25±0.29 | 8.55±0.11 | 1.12±0.16 | 0.24±0.07 |
| 40 | 42.66±0.32 | 8.92±0.14 | 1.07±-0.11 | 0.22±0.05 |
| Mean | 33.57 | 7.51 | 1.49 | 0.34 |

Several scientists (Mark Daryl and Rico, 2016) [5] observed that diameter at breast height and height influenced by age, size and types of orchards and they mentioned *Mangifera indica* attained 12.96-meter height and 32.41 cm diameter in 15 years old plantation. *Nephelium lappaceum* attained 7.33-meter height and 23.44 cm diameter in 12 years old plantation. Again, *Sandoricum koetjape* attained 16.91-meter height and 37.03 cm diameter in 32 years old planation. The growth of height and diameter were influenced by different types of species and ages. The present study revealed that there was a positive relationship between diameter and height at different ages (Fig 2). Statistical analysis indicated that the growth of diameter and height had a positive correlation (r=0.96).

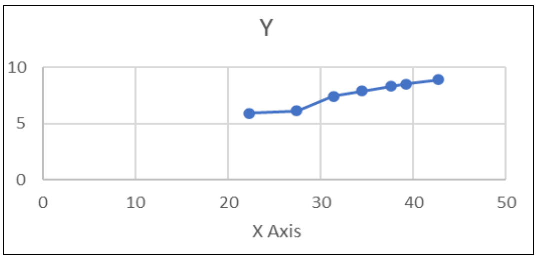


**Fig 2:** Relationship of diameter and height at different ages

The present study was conducted on *Litchi chinensis* tree species at different ages for the estimation of biomass and carbon storage. The results revealed that maximum, minimum, mean biomass and carbon were recorded at 813.10, 157.51, 473.75, 406.55 and 236.88 kgtree$^{-1}$ in 10 to 40 years old trees respectively (Table 2). The highest biomass and carbon were found in 40 years old trees and the lowest biomass and carbon were found in 10 years old trees. Statistical analysis revealed that the biomass and carbon stock (tC/tree) varied significantly (p>0.05) among the above ages trees.

**Table 2:** Above ground biomass, below ground biomass, total biomass and total carbon in different ages of *Litchi chinensis* tree species

| Years | AGB (kg tree$^{-1}$) | BGB (kg tree$^{-1}$) | TB (kg tree$^{-1}$) | TC (kg tree$^{-1}$) | TC (t/ tree) | t Cha$^{-1}$ | tCha$^{-1}$ year$^{-1}$ |
|---|---|---|---|---|---|---|---|
| 10 | 136.96±7.02 | 20.54±1.26 | 157.51±2.32 | 78.75 | 0.08 | 6.30 | 0.63 |
| 15 | 213.85±10.25 | 32.08±1.28 | 245.93±3.90 | 122.96 | 0.12 | 9.84 | 0.66 |
| 20 | 306.86±13.28 | 46.03±1.31 | 352.89±4.211 | 176.444 | 0.18 | 13.41 | 0.67 |
| 25 | 420.46±9.85 | 63.07±1.35 | 483.53±2.29 | 241.76 | 0.24 | 17.89 | 0.72 |
| 30 | 519.07±5.88 | 77.86±1.29 | 596.93±4.12 | 298.46 | 0.30 | 19.79 | 0.66 |
| 35 | 579.46±8.66 | 86.92±1.34 | 666.38±3.91 | 333.19 | 0.33 | 21.66 | 0.62 |
| 40 | 707.04±5.72 | 106.0±1.33 | 813.10±5.61 | 406.55 | 0.41 | 24.46 | 0.61 |
| Mean | 411.96 | 61.79 | 473.75 | 236.88 | 0.24 | 16.19 | 0.65 |

The present study also indicated that a total of 0.63 t Cha$^{-1}$ was found in 10 years old orchards which was the lowest and the highest amount of carbon 0.72 t Cha$^{-1}$ was found in 40 years old orchards (Table 2). The average carbon storage capacity of *Litchi chinensis* was 0.65 t Cha$^{-1}$ year$^{-1}$. The study showed that carbon storage capacity was slowly increased with the increasing of ages and this trend slowly decrease in a certain period. In the initial stages, the growth of the fruiting tree species is well and the rate of growth is slowly decrease. The whole study areas were included of planted at different ages and horticultural practice and other managements were also equal. Fruits harvesting were the main aim of these orchards and timber collection was normally less important. The horticulturists suggested that planted at 10 m ×10 m spacing and 100 seedlings per hectare. An average 80% of trees were found in the present study areas. Normally carbon storage capacity depends biotic and abiotic factors. Several scientists (Chavan and Rasal, 2010) [4] observed that carbon storage variations were present in different species in different locations of the world. Pragasan (2015) [11] reported that *Tamarindus indica, Spondias pinnata,* and *Diospyros ebenum* contained 0.51, 0.46 and 0.22 t C/tree respectively in the tropical forest of Bodamalai Hill. A study conducted on Khajura fruits orchard in Nepal (Shrestha and Molla, 2016) [18] found that carbon storage capacity in *Mangifera indica*, *Litchi chinensis*, *Psidium guajava* and *Phyllanthus emblic*a were 2.17, 2.73, 1.63 and 3.51 t/tree respectively. The present result showed that the average value was 0.24t/tree and their values were higher than the findings. Several scientist (Selvaraj *et al*., 2016) [17] observed that carbon storage ranges were 1.85 to 80.74, 2.86 to 24.45 and 9.14 to 285.68 tha$^{-1}$ of *Mangifera indica*, *Manikara zapota* and *Cocos nucifera* in 20 years old orchards. Several authors (Davagiri *et al*., 2013) [6] have reported that the total standing biomass of *Emblica officinalis, Tamarindus indica, Achras sapota, Annona reticulata and Annona squamosa* were 63.31, 67.32, 23.65, 153.00 and 135.00 Kg ha$^{-1}$ respectively. A study was conducted in Chitteri hills by Pragasan (2014) [12] and reported that *Mangifera indica* contained 1.73 tC/tree. The growth rate of *Mangifera indica* is higher than *Litchi chinensis.* The growth rate is the most important factor for increasing of biomass.

## 4. Conclusion

The results of the present study revealed that *Litchi chinensis* is cultivated mainly for fruit harvesting. It produces high-quality timber but the growth rate is slow, canopy shows mainly horizontal tendency. Its timber is used for making agricultural tools and infrastructure of houses. The cultivation of Litchi chinensis is increasing day by day due to its deliciousness and ability to provide more cash money than other crops. Besides, it is well adapted and grown in low fertile sandy loam soils whereas other tree species cannot easily sustainable. For this reason, massive plantation has been started with *Litchi chinensis* in the above environment conditions of Bangladesh. The findings of the present study will help to indicate that *Litchi chinensis* has importance in the view of environmental aspects. Fruit tree species are planted for the purpose to harvest fruits for economic benefit. In addition to direct economic benefit, fruit tree species are also contributing in carbon harvesting from the atmosphere. So, a fruit orchard is also contributing in the carbon sequestration. The findings of the present study will be helpful to establish fruit orchards for reducing global warming.

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## 6. References

1. Alves DS, Soares JVS, Amaral EMK, Mello SAS, Almeida O, Fernandes S, *et al*. Biomass of primary and secondary vegetation in Rondonia, Western Brazilian Amazon. Global Change Biol. 1997; 3(5): 451-462.
2. Brown S. Estimating biomass changes of tropical forests: A primer, FAO Forestry Paper 134 edn. Food and Agriculture Organization (FAO UN), Rome, Italy, 1997.
3. Brown S, Gillespie AJ, Lugo AE. Biomass estimation methods for tropical forests with applications to forest inventory data. Forest Science. 1989; 35(4):881-902.
4. Chavan BL, Rasal GB. Sequestered standing carbon stock in selective tree species grown in University campus at Aurangabad, Maharashtra, 2010.
5. Mark Daryl CJ, Rico AM. Carbon Sequestration Potential of Fruit Tree Plantations in Southern Philippines. International Journal of Journal of Biodiversity and Environmental Sciences. 2016; 8(5):164-174.
6. Devagiri GM, Money S, Singh S, Dadhwal VK, Patil P, Khaple A, *et al*. Assessment of above ground biomass and carbon pool in different vegetation types of south western part of Karnataka, India using spectral modeling. Tropical Ecology. 2013; 54 (2):149-165.
7. Hossain MK. Silviculture of Plantation Trees of Bangladesh. Arannayk Foundation, Dhaka, Bangladesh, 2015, 361p.
8. IPCC. Good practice guidance for land use, land-use change and forestry. Institute for Global Environmental

Strategies (IGES), Japan, 2003.
9. Mac Dicken KG. A guide to monitoring carbon storage in forestry and agro forestry projects USA. Winrock Int. Institute Agri. Development, 1997, 19-99.
10. Pearson RG, Raxworthy CJ, Nakamura M, Pterson AT. Predicting species distributions from small numbers of occurrence records: a test case using cryptic geckos in Madagascar. Journal of Biogeography. 2007; 34(1):102-117.
11. Pragasan AL. Tree Carbon Stock Assessment from the Tropical Forests of Bodamalai Hills Located in India. Journal of Earth Science & Climate Change. 2015; 6(10):314-319.
12. Pragasan LA. Carbon stock assessment in the vegetation of the Chitteri Reserve Forest of the Eastern Ghats in India based on non-destructive method using tree inventory data. Journal of Earth Science & Climate Change. 2014; 11:001.
13. Rai M, Dey P, Gangopadhyay KK, Das B, Nath V, Reddy NN, Singh HP. Influence of nitrogen, phosphorus and potassium on growth parameters, leaf nutrient composition and yield of litchi. Indian Journal of Agricultural Science. 2002; 72:267-270.
14. Rana BS, Singh SP, Singh RP. Biomass and net primary productivity in Central Himalayan forests along an altitudinal gradient. Forest Ecology and Management. 2012; 27(3-4):199-218.
15. Sattar MA, Bhattacharjee DK, Kabir MF. Physical and mechanical properties and uses of timber of Bangladesh. Report 57, Seasoning and Timber Division, Bangladesh Forest Research Institute Chittagong, Bangladesh, 1999.
16. Schroeder P, Brown S, Mo J, Birdsey R, Cieszewski C. Biomass estimate for temperate broadleaf forests of the US using inventory data. Forest Science. 1997; 43(3):424-434.
17. Selvaraj A, Jayachandan S. Thirunavukkarasu DP. Jayaraman A, Karuppon P. Carbon sequestration potential, physicochemical and microbiological properties of selected trees *Mangifera indica* L., *Manilkara zapota* L., *Cocos nucifera* L. and *Tectona grandis* L. Bioscience Discovery. 2016; 7(2):131-139.
18. Shrestha G, Malla G. Estimation of atmospheric carbon sequestration by fruit plants in mid-western terai region Nepal. Nepalese Journal of Agricultural Sciences. 2016; 14:211-215.