# BIOMASS TABLES FOR MINJIRI (*CASSIA SIAMEA LAM.*) GROWN IN THE PLANTATIONS IN BANGLADESH

**M. A. Latif**
**M. A. Habib**

## ABSTRACT

Minjiri (*Cassia siamea Lam.*) is a promising fast growing tree species indigenous to Bangladesh and is included in the plantation programme. An attempt has been made to prepare the biomass tables for the species. The biomass equations were selected to estimate the green weight of the whole tree, weights of the stem, the branches, leaves and twigs, branches and stem; branch, leaves and twigs. The diameter at breast height (D) - biomass and D-height - biomass relationships were determined. It was observed that the logarithmic function to the base "e" gives a good fit model. The conversion factors were also determined to estimate the air-dry and oven-dry weights of the components.

## সারসংক্ষেপ

মিনজিরি একটি দ্রুত বর্ধনশীল প্রজাতির গাছ। বাংলাদেশে বনায়নে এই প্রজাতির গাছ লাগানো হয়। ইহার বায়োমাস টেবিল তৈয়ার করার একটি প্রচেষ্টা নেয়া হয়েছে। মাটির উপরের সম্পূর্ণ গাছ, কাণ্ড, প্রধান শাখা প্রশাখা, ছোট শাখা প্রশাখা ও পাতা, কাণ্ড ও প্রধান শাখা প্রশাখা এবং সকল শাখা প্রশাখা ও পাতা - এই ছয়টি ভাগের সবুজ বায়োমাস নির্ণয় করার জন্য সমীকরণ বাছাই করা হয়। বুক উচ্চতায় গাছের ব্যাস ও মোট উচ্চতার সহিত বায়োমাসের সম্পর্কের সমীকরণ নির্ণয় করা হয়। সবুজ বায়োমাস হতে রোদে শুকানো এবং ওভেন ড্রাই বায়োমাস নির্ণয় করার জন্য রূপান্তর উৎপাদকও বাহির করা হয়।

## INTRODUCTION

Minjiri (*Cassia siamea Lam.*) is being cultivated for fuelwood in plantations in many tropical countries. The tree grows rapidly in full sunlight and may be harvested for fuel within a few years (Anon. 1980). It is medium to large ever green tree with a dense crown and smooth bark.

Its dense wood having specific gravity of 0.6 to 0.8 makes an excellent fuel. The tree coppices rapidly and continues to coppice well for four or five rotations. It grows fast and produces a large quantity of small-sized wood suitable for fuel. Timber is suitable for furniture and cabinet making. It may be planted as a windbreak. It may be also used for reforesting the denuded hills and cutover areas.

The plant is indigenous to Bangladesh and is in the plantation programme. The trees of the older plantations have been started felling. But, there is no table to estimate the biomass of the felled trees. Therefore, the necessity of the biomass tables for minjiri was felt urgently and an attempt has been made to prepare the present tables.

## MATERIALS AND METHODS

There are scattered plantations of minjiri all over Bangladesh. The species is generally planted at a spacing of 1.8 m x 1.8 m. It is known from the field observations that a maximum number of the trees

*M. A. Latif, Divisional Officer and M. A. Habib, Field Investigator, Bangladesh Forest Research Institute, Chittagong*

fall within the dbh range of 5-20 cm. This range was divided into three five centimeter dbh classes (5-10, 10-15 and 15-20) and data of at least 30 trees from each class were collected. Larger trees were also included whenever available. The trees having average to better stem form in a plantation were selected at random for data collection.

The diameters at breast height (dbh) of the standing trees were measured by a diameter tape. Then the trees were felled leaving 7-10 cm stump and the total length (height) was measured. Each selected tree was divided into three parts - the stem with bark on, the branches, and leaves and twigs. The stem and the branches were cut into 2-4 meter billets and weighed using a spring balance. The leaves, twigs and small branches were tied into suitable bundles and weighed with the same spring balance. A small billet of the stem was removed from a position at about 30% of the tree height in the stem, weighed and labelled for determination of dry weight. The small samples of green leaves including twigs and branches were also taken, weighed, bagged and labelled for the same. The air-dry weights of these samples were taken after six months storage in a shade. Then the samples were oven-dried to a constant weight. Extrapolation was done to find out conversion factors to estimate the air-dry and oven-dry weights. The dbh-height class distribution of the sample trees are given in Table 1.

**Table 1. Diameter at breast height and height class distribution of the sample trees**

| dbh class (cm) | 6 | 8 | 10 | 12 | 14 | 16 | 18 | Total |
|---|---|---|---|---|---|---|---|---|
| 5 - 10 | 9 | 26 | 6 | 5 | | | | 46 |
| 10 - 15 | | 4 | 12 | 13 | 10 | 2 | 1 | 42 |
| 15 - 20 | | | 4• | 11 | 6 | 7 | 2 | 30 |
| 20 - 25 | | | | | | 1 | 1 | 2 |
| Total | 9 | 30 | 22 | 29 | 16 | 10 | 4 | 120 |

The data were summarized to obtain the six component biomasses - above the ground total green biomass (total), weights of the stem (stem), branches (B), leaves and twigs (LT), stem and branches (SB) and branches, leaves and twigs (BLT) for the individual tree. The following original and transformed variables were used to select the best suited regression models :

Dependent variables : B, log (B), $B/D^2$ and $B/D^2$ H ...(1)

Independent variables : D, $D^2$, H, $D^2$ H, DH, log(D), log(H), $1/D^2$, 1/D, $1/D^2$ H, $H/D^2$ and H/D ...(2)

Where : D is diameter at breast height (dbh), cm

H is total height, m

B is total green weight (biomass) of the component, kg/tree

These six components of biomasses and their transformations given in (1) were regressed with all the independent variables, dbh and height and their transformations given in (2). The best relationships were selected by the step-wise regression techniques. The 15 models used earlier (Latif and Islam 1984) were also tried where biomasses were considered in place of volumes. The regression models of the best fit for each type were then chosen comparing various parameters describing the regressions, including the high coefficient of determination, high F-value and minimum mean square error.

### Validation of the selected models

Data were also collected from 30 sample trees representing all the dbh and height classes for the purpose of validation of the provisionally selected models. The actual biomasses of these trees were collectively compared with the corresponding biomasses predicted by the selected models. The comparisons were made with the help of the absolute deviation per cent, paired t-test, chi-square and 45 degree line tests (Islam *et. al.* 1992).

## RESULTS AND DISCUSSION

The regression models were selected for estimating the six component biomasses : above ground green biomass of the total tree (total), the stem (S), the branches (B), leaves and twigs (LT), branches and stem (SB) and branches, leaves and twigs (BLT). The selection and validation statistics are given in Table 2.

**Table 2. Selection and validation statistics of best suited regression equation for estimating biomass produced by individual tree of minjiri in Bangladesh**

| | Selection statistics | | | Validation statistics | | | |
|---|---|---|---|---|---|---|---|
| | $R^2$ | MSE | F-ratio | Absolute deviations (%) | t-value | slope (degre) | MSE |
| Total 1 | 0.9728 | 0.0232 | 4144.0 | 0.4 | 0.22 | 44.9 | 145.55 |
| Total 2 | 0.9777 | 0.0189 | 2566.9 | 1.3 | 0.79 | 44.5 | 125.25 |
| Stem 1 | 0.9665 | 0.0313 | 3343.2 | 1.4 | 0.58 | 45.4 | 165.35 |
| Stem 2 | 0.9722 | 0.0257 | 2048.1 | 2.4 | 1.06 | 44.9 | 141.23 |
| B 1 | 0.5707 | 0.3528 | 86.4 | 2.0 | 0.30 | 39.7 | 35.93 |
| B 2 | 0.5855 | 0.3355 | 47.6 | 3.3 | 0.45 | 39.3 | 43.04 |
| LT 1 | 0.7614 | 0.1568 | 370.2 | 0.3 | 0.05 | 39.2 | 31.89 |
| LT 2 | 0.8209 | 0.098 | 412.3 | 1.1 | 0.16 | 39.9 | 40.70 |
| SB 1 | 0.9641 | 0.0339 | 3113.4 | 0.8 | 0.38 | 45.0 | 150.68 |
| SB 2 | 0.9785 | 0.0201 | 2658.7 | 0.9 | 0.45 | 44.3 | 152.36 |
| BLT 1 | 0.8098 | 0.1641 | 494.0 | 7.2 | 1.58 | 40.2 | 59.21 |
| BLT 2 | 0.8115 | 0.1613 | 252.8 | 6.3 | 1.38 | 39.8 | 60.46 |

Where, 1= Equation derived for one-way (Biomass-dbh)

2= Equation derived for two-way (Biomass-dbh-height)

Total 1= Green weight of the above ground whole tree including stem, branches, leaves and twigs excluding 7-10 cm stump

Stem = Main stem upto top diameter of about 2.0 cm overbark

B= Branches with diameter approximately more than 3.0 cm

LT= Leaves and twigs

SB= Stem and branch

BLT= Branch, leaves and twigs

The equations of the best fit were selected for estimating biomass on dbh (D), and biomass on dbh and total height. These equations were also transformed for biomass on girth at breast height (G) and biomass on (G) and total height. Hence, the best fitted regression equations are :

log (total 1) = -1.5851 + 2.4855* log (D)
log (total 1) = -4.4303 + 2.4855* log (G)

log (total 2) = -2.0847 + 2.1723* log (D)+0.5141* log (H)
log (total 2) = -4.5714 + 2.1723* log (G)+0.5141* log (H)

log (stem 1) = -2.1442 + 2.5917* log (D)
log (stem 1) = -5.1110 + 2.5917* log (G)

log (stem 2) = -2.7095+2.2372* log (D)+0.5817* log(H)
log (stem 2) = -5.2705+2.2372* log (G)+0.5817* log(H)

log (B 1) = -2.2732 + 1.9752* log (D)
log (B 1) = -4.5343 + 1.9752* log (G)

log (B 2) = -3.2955 + 1.3142 * log (D) + 1.0521* log (H)
log (B 2) = -4.7999 + 1.3142 * log (G) + 1.0521* log (H)

log (LT 1) = -2.1219 + 1.9299* log (D)
log (LT 1) = -4.3311 + 1.9299* log (G)

log (LT 2) = -0.6183 + 2.8726* log (D) - 1.5471* log (H)
log (LT 2) = -3.9067 + 2.8726* log (G) - 1.5471* log (H)

log (SB 1) = -2.0512 + 2.6006* log (D)
log (SB 1) = -5.0282 + 2.6006* log (D)

log (SB 2) = -2.9256 + 2.0525* log (D) + 0.8996* log (H)
log (SB 2) = -5.2752 + 2.0525* log (D) + 0.8996* log (H)

log (BLT 1) = -2.5173 + 2.281* log (D)
log (BLT 1) = -5.1284 + 8.281* log (G)

log (BLT 2) = -2.9974 + 1.98* log (D) + 0.494* log (H)
log (BLT 2) = -5.264 + 1.98* log (G) + 0.494* log (H)

It was observed that the two-way biomass equations (biomass-dbh-height relationships) do not explain considerably higher percentages in comparison to one way biomass equations (biomass-dbh relationships). Therefore, the biomass tables based on dbh are given in Table 3. The two-way equations are given for use by the interested persons.

The biomass equations for each of the six component biomasses were derived independently. The component prediction are not additive (Kozak 1970). This means, for example, that the predicted weight of stem plus the branches may not be equal to the predicted values for stem and branch. To overcome this limitations, the biomasses are calculated for individual components as well as for combination of the components (Hawkins 1987).

## CONVERSION FACTORS

The conversion factors (F) were computed to estimate the total air-dry biomass, total oven-dry biomass, weight of leaves including twigs and small branches from the total above ground green biomass (Table 4).

## CONFIDENCE LIMIT

The extrapolation appreciably outside the range of height and dbh indicated by the stand table should only be done with caution. These biomass tables should not be used to estimate the biomass of an individual tree in a stand. The mean height and mean dbh of the stand should be calculated first. Then this mean may be used to read the mean tree biomass. The mean tree biomass should be multiplied by the number of stems in a stand to get the total biomass of the stand (Davidson and Choudhury, 1984).

Table 3. Biomass of individual minjiri tree grown in the plantation in Bangladesh.

| | | Green biomass in kg | | | | branches, | |
|---|---|---|---|---|---|---|---|
| Dbh (cm) | Gbh (cm) | total | stem | leaves & twigs | stem & branches | leaves & twigs | branches |
| 2 | 6.3 | 1.1 | 0.7 | 0.5 | 0.8 | 0.4 | 0.4 |
| 3 | 9.4 | 3.1 | 2.0 | 1.0 | 2.2 | 1.0 | 0.9 |
| 4 | 12.6 | 6.4 | 4.3 | 1.7 | 4.7 | 1.9 | 1.6 |
| 5 | 15.7 | 11.2 | 7.6 | 2.7 | 8.5 | 3.2 | 2.5 |
| 6 | 18.8 | 17.6 | 12.2 | 3.8 | 13.6 | 4.8 | 3.5 |
| 7 | 22.0 | 25.8 | 18.2 | 5.1 | 20.3 | 6.8 | 4.8 |
| 8 | 25.1 | 36.0 | 25.7 | 6.6 | 28.7 | 9.3 | 6.3 |
| 9 | 28.3 | 48.2 | 34.8 | 8.3 | 39.0 | 12.1 | 7.9 |
| 10 | 31.4 | 62.7 | 45.8 | 10.2 | 51.3 | 15.4 | 9.7 |
| 11 | 34.6 | 79.4 | 58.6 | 12.3 | 65.7 | 19.1 | 11.7 |
| 12 | 37.7 | 98.6 | 73.4 | 14.5 | 82.4 | 23.4 | 13.9 |
| 13 | 40.8 | 120.3 | 90.3 | 16.9 | 101.4 | 28.0 | 16.3 |
| 14 | 44.0 | 144.6 | 109.4 | 19.5 | 123.0 | 33.2 | 18.9 |
| 15 | 47.1 | 171.7 | 130.9 | 22.3 | 147.1 | 38.9 | 21.7 |
| 16 | 50.3 | 201.6 | 154.7 | 25.3 | 174.0 | 45.0 | 24.6 |
| 17 | 53.4 | 234.4 | 181.0 | 28.4 | 203.7 | 51.7 | 27.7 |
| 18 | 56.5 | 270.1 | 209.9 | 31.7 | 236.4 | 58.9 | 31.1 |
| 19 | 59.7 | 309.0 | 241.5 | 35.2 | 272.1 | 66.6 | 34.6 |
| 20 | 62.8 | 351.0 | 275.8 | 38.8 | 310.9 | 74.9 | 38.2 |
| 21 | 66.0 | 396.3 | 31.0 | 42.7 | 353.0 | 83.7 | 42.1 |
| 22 | 69.1 | 444.8 | 353.1 | 46.7 | 398.4 | 93.1 | 46.2 |
| 23 | 72.3 | 496.8 | 396.3 | 50.9 | 447.2 | 103.0 | 50.4 |
| 24 | 75.4 | 552.2 | 442.5 | 55.2 | 499.5 | 113.5 | 54.8 |
| 25 | 78.5 | 611.2 | 491.8 | 59.8 | 555.5 | 124.6 | 59.4 |

**Table 4. Conversion factors for estimating different forms of biomasses of minjiri trees in plantations of Bangladesh**

| | Conversion factor |
|---|---|
| For totals | |
| Air-dry : Total biomass | 0.526 |
| Oven-dry : Total biomass | 0.404 |
| Stem Wood : Total biomass | 0.734 |
| Leaves and twigs : Total biomass | 0.126 |
| Branch : Total biomass | 0.140 |
| Leaves and twigs | |
| Air-dry : Green biomass | 0.512 |
| Oven-dry : Green biomass | 0.397 |
| Main stem | |
| Air-dry : Green biomass | 0.528 |
| Oven-dry : Green biomass | 0.405 |

## REFERENCES


Annon 1980. Firewood crops. Shrub and tree species for energy production. National Academy of Sciences. Washington D. C. : 120-121

Davidson, J. and Choudhury, J. H. 1984. Guide for using tree volume tables in TREE VOLUME TABLES FOR FOUR SPECIES GROWN IN PLANTATIONS IN BANGLADESH. Bulletin No. 2. Inventory Division, Bangladesh Forest Research Institute, Chittagong : 1-24

Latif, M. A. and Islam, M. N. 1984. Tree volume tables for Syzygium grande (Wt.) Wald. (dhakijam) in TREE VOLUME TABLES FOR FOUR SPECIES GROWN IN PLANTATIONS IN BANGLADESH. Bulletin No. 2. Inventory Division, Bangladesh Forest Research Institute, Chittagong. 25-57

Kozak, A. 1970. Methods for ensuring additivity of biomass components by regression analysis. For. Chron. 45 : 1-3

Hawkins, T. 1987. Biomass and volume tables for *Eucalyptus camaldulensis, Dalberzia sissoo, Acacia auriculiformis* and *Cassia siamea* in the central Bhabar-Terai of Nepal. Oxford Forestry Institute occasional paper no. 33. Nepal/UK For. Res. Proj., Dep. For. Kathmandu, Nepal. 43 pp