BIOMASS TABLES FOR *ACACIA MANGIUM* GROWN IN THE PLANTATIONS IN BANGLADESH

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LATIF, M.A. & HABIB, M.A. 1994. Biomass tables for *Acacia mangium* grown in the plantations in Bangladesh. Biomass tables were prepared for *Acacia mangium* grown in the plantations in Bangladesh. Equations were selected to estimate the green weight of the whole tree, weights of the stem, branch and leaves including twigs. Diameter at breast height (D), green biomass weight (B) and height (H) relationships were determined. It was observed that the logarithmic function to the base e gives a good fit model. Conversion factors were also determined to estimate the air-dry and oven-dry weights of the biomass components.

Key words: Biomass table - *Acacia mangium* - Bangladesh

LATIP, M.A. & HABIB, M.A. 1994. Jadual-jadual biojisim untuk *Acacia mangium* yang ditanam di ladang-ladang di Bangladesh. Jadual-jadual biojisim telah disediakan untuk *Acacia mangium* yang ditanam di ladang-ladang di Bangladesh. Persamaan-persamaan telah dipilih untuk menganggarkan berat hijau keseluruhan pokok, berat batang, dahan dan daun termasuk ranting. Kehubungan diameter aras dada (D), berat biojisim hijau (B) dan tinggi (H) telah ditentukan. Fungsi logaritma berasaskan e diperhatikan memberi model yang cukup sesuai. Faktor-faktor penukaran juga ditentukan untuk menganggarkan berat keringan udara dan berat keringan ketuhar komponen-komponen biojisim.

Introduction

Acacia mangium Willd. (mangium) is a promising fast-growing multipurpose tree species of the family *Leguminosae.* It is indigenous to northern Australia, Papua New Guinea and eastern Indonesia (Anonymous 1980). The species was first tried in Bangladesh in 1979. Subsequently, a provenance trial was established in 1983 and suitable provenances for Bangladesh were selected (Zashimuddin *et al.* 1983). Since then the species has been planted in Bangladesh.

The initial plantations are by now 6 - 9 years old. Therefore, an attempt was made to study the growth and yield of the species in Bangladesh and as a first attempt, the present biomass tables were prepared.

Materials and methods

Mangium is being planted at a spacing of 1.5. × 1.5 m to 2.7. × 2.7 m in general. It was known from field observations that most of the trees of the older plantations fall within the diameter at breast height (Dbh) range of 5 - 20 cm. This range was divided into three 5-cm Dbh classes and an attempt was made to collect data of at least 30 trees from each class. Larger trees were also included whenever available. Trees having average to better stem form in a plantation were selected at random for data collection.

Diameters at breast height (Dbh) of the standing trees were measured first by diameter tape. Then the trees were felled leaving 7-10 cm stump and total length (height) was measured. Each selected tree was divided into there parts: the stem with bark on, the branches, and leaves + twigs. The stem and branches were cut into 2 - 4 meter billets and weighed using a spring balance. 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. Small samples of green leaves including twigs and branches were also taken, weighed,bagged and labelled for the same determination. Air-dry weights of these samples were taken after six months storage in the shade. Then the samples were oven-dried to constant weight. Extrapolation was done to determine conversion factors to estimate the air-dry and oven-dry weights. The Dbh-height class distribution of the sample trees is given in Table 1.

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

Dbh class (cm)	5	7	9	11	13	15	17	19	Total
5-10	7	10	13	6	3				39
10-15		1	3	19	15	4			42
15-20				9	24	11		1	45
20-25						4	2		6
Total	7	11	16	34	42	19	2	1	132

The collected data were summarized to obtain the above ground total green biomass of a tree, weight of the stem, branches, leaves+twigs, stem+branches and branches + leaves +twigs for 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^2H (1)

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

where

D is diameter at breast height, cm,
H is total height, m,
B is total green weight (biomass) of the component, kg/tree,
log is to the base e.

The above mentioned six components of biomass and their transformations given in (1) were regressed with all the independent variables, Dbh and height and their transformations given in (2) and best relationships were selected by the step-wise regresssion techniques. All the 15 models used to develop the volume equations (Latif & Islam 1984) were also tried where biomass values were considered in place of volumes. The regression models of best fit for each type were then chosen comparing various parameters describing the regressions, including high coefficient of determination, high F-value and minimum mean square error (MSE).

Validation of the selected models: Data were also collected from 35 sample trees representing all the Dbh and height classes for the purpose of validation of the provisionally selected models. The actual biomass values of these trees were collectively compared with the corresponding ones predicted by the selected models. The comparisons were made with the help of the absolute deviation percentage, paired t-test, chi-square and 45 degree line tests (Islam *et al.* 1992).

Results and discussions

Regression models were selected for estimation the above ground green biomass of the whole tree, the stem, the branches, leaves + twigs, branches + stem and branches + leaves + twigs. The selection and validation statistics are given in Table 2.

Table 2. Selection and validation statistics of best suited regression equations for estimating biomass produced by individual trees of mangium in Bangladesh

	Selection statistics			Validation statistics			
	R^2	MSE	F-ratio	Absolute deviations (%)	t-value	slope (degre)	MSE
Total 1	0.9795	0.0193	5262.8	0.3	0.09	43.9	295.77
Total 2	0.9772	0.0185	2761.4	0.7	0.26	43.0	283.91
Stem 1	0.9553	0.0431	2776.3	3.8	0.99	43.0	333.40
Stem 2	0.9584	0.0397	1511.8	4.6	1.21	41.5	332.48
Branch 1	0.4090	0.3084	49.8	3.2	0.27	40.0	16.49
Branch 2	0.4114	0.3030	26.5	1.4	0.11	40.0	16.99
L&T 1	0.8054	0.1524	538.0	2.9	0.48	40.1	39.97
L&T 2	0.8356	0.1298	327.8	1.1	0.16	40.0	36.22
S&B 1	0.9751	0.0211	5092.5	2.0	0.69	44.0	236.62
S&B 2	0.9818	0.0153	3532.0	3.0	1.03	42.2	213.70
BL&T 1	0.8266	0.1142	619.7	8.8	2.00	43.4	31.42
BL&T 2	0.8268	0.1138	313.6	9.5	2.00	44.6	36.28

Where,
1 = Equation derived for one-way (Biomass-Dbh)
2 = Equation derived for two-way (Biomass-Dbh-height)
Stem = Main stem up to top end diameter of about 2.0 cm overbark
Branch = Branches with diameter approximately more than diameter of 3.0 cm
L & T = Leaves + twigs
S & B = Stem+branch
BL & T = Branch+leaves+twigs
Total = Green weight of the above ground whole tree including stem,branches, leaves and twigs excluding 7-10 cm stump

The equations of best fit were selected for estimation of biomass from Dbh, and biomass from Dbh and total height. These equations were also transformed for biomass on girth at breast height (G) and biomass on (G) and total height. The selected best regression equations are:

$$\log(\text{total}) = -1.4659 + 2.3256*\log(D)$$
$$\log(\text{total}) = -4.1281 + 2.3256*\log(G)$$

$$\log(\text{total}) = -1.7073 + 2.1922*\log(D) + 0.2331*\log(H)$$
$$\log(\text{total}) = -4.2168 + 2.1922*\log(G) + 0.2331*\log(H)$$

$$\log(\text{stem}) = -2.2782 + 2.5213*\log(D)$$
$$\log(\text{stem}) = -5.1644 + 2.5213*\log(G)$$

$$\log(\text{stem}) = -2.7344 + 2.2692*\log(D) + 0.4406*\log(H)$$
$$\log(\text{stem}) = -5.3320 + 2.2692*\log(G) + 0.4406*\log(H)$$

$$\log(\text{branch}) = -1.0896 + 1.2570*\log(D)$$
$$\log(\text{branch}) = -2.5286 + 1.2570*\log(G)$$

$$\log(\text{branch}) = -1.8261 + 0.8027*\log(D) + 0.7493*\log(H)$$
$$\log(\text{branch}) = -2.7450 + 0.8027*\log(G) + 0.7493*\log(H)$$

$$\log(\text{leaves + twigs}) = -2.5539 + 2.0876*\log(D)$$
$$\log(\text{leaves + twigs}) = -4.9436 + 2.0876*\log(G)$$

$$\log(\text{leaves + twigs}) = -1.3964 + 2.7273*\log(D) - 1.1179*\log(H)$$
$$\log(\text{leaves + twigs}) = -4.5184 + 2.7273*\log(G) - 1.1179*\log(H)$$

$$\log(\text{stem+branch}) = -1.8493 + 2.3906*\log(D)$$
$$\log(\text{stem +branch}) = -4.5859 + 2.3906*\log(G)$$

$$\log(\text{stem + branch}) = -2.4276 + 2.0709\log(D) + 0.5586*\log(H)$$
$$\log(\text{stem + branch}) = -4.7982 + 2.0709\log(G) + 0.5586*\log(H)$$

$$\log(\text{branch + leaves + twigs}) = -1.8911 + 1.9442*\log(D)$$
$$\log(\text{branch + leaves + twigs}) = -4.1167 + 1.9442*\log(G)$$

$$\log(\text{branch + leaves + twigs}) = -1.5667 + 2.1235*\log(D) - 0.313*\log(H)$$
$$\log(\text{branch + leaves + twigs}) = -3.9975 + 2.1235*\log(G) - 0.313*\log(H)$$

Where: D is diameter at breast height, cm
H is total height, m
G is girth at breast height , cm
log is to the base e

It was observed that the two-way biomass equations (biomass-Dbh-height relatioships) do not explain considerably higher percentage in comparison to one-way biomass equations (biomass - Dbh relationships). Therefore, biomass tables based on Dbh are given in Table 3. The two-way equations are given for use to estimate more accurate estimates.

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

Table 3. Biomass of individual mangium trees in the plantations in Bangladesh

		Green biomass in kg					
Dbh (cm)	G (cm)	total	stem a	leaves + twigs b	stem+ branches c	branches, +leaves +twigs d	branches e
2	6.3	1.2	0.6	0.3	0.8	0.6	0.8
3	9.4	3.0	1.6	0.8	2.2	1.3	1.3
4	12.6	5.8	3.4	1.4	4.3	2.2	1.9
5	15.7	9.7	5.9	2.2	7.4	3.4	2.5
6	18.8	14.9	9.4	3.3	11.4	4.9	3.2
7	22.0	21.3	13.8	4.5	16.5	6.6	3.9
8	25.1	29.1	19.4	6.0	22.7	8.6	4.6
9	28.3	38.2	26.1	7.6	30.1	10.8	5.3
10	31.4	48.9	34.0	9.5	38.7	13.3	6.1
11	34.6	61.0	43.3	11.6	48.6	16.0	6.9
12	37.7	74.7	53.9	13.9	59.8	18.9	7.6
13	40.8	89.9	65.9	16.5	72.4	22.1	8.5
14	44.0	106.9	79.5	19.2	86.5	25.5	9.3
15	47.1	125.5	94.6	22.2	102.0	29.2	10.1
16	50.3	145.8	111.3	25.4	119.0	33.1	11.0
17	53.4	167.8	129.7	28.8	137.5	37.2	11.8
18	56.5	191.7	149.8	32.5	157.7	41.6	12.7
19	59.7	217.4	171.7	36.3	179.4	46.2	13.6
20	62.8	244.9	195.4	40.4	202.8	51.1	14.5
21	66.0	274.4	221.0	44.8	227.9	56.2	15.4
22	69.1	305.7	248.5	49.4	254.7	61.5	16.4
23	72.3	339.0	277.9	54.1	283.3	67.0	17.3
24	75.4	374.3	309.4	59.2	313.6	72.8	18.3
25	78.5	411.5	342.9	64.4	345.8	78.8	19.2
26	81.7	450.8	378.6	69.9	379.7	85.1	20.2
27	84.8	492.2	416.4	75.7	415.6	91.5	21.2
28	88.0	535.6	456.4	81.6	453.4	98.2	22.2
29	91.1	581.2	498.6	87.9	493.0	105.2	23.2
30	94.2	528.9	543.1	94.3	534.0	112.3	24.2

Conversion factors: 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 total above ground green biomass (Table 4).

Table 4. Conversion factors for estimation different forms of biomasses of mangium in plantations of Bangladesh

	Conversion factor
For totals	
Air-dry : Total biomass	0.461
Oven-dry : Total biomass	0.331
Stem wood : Total biomass	0.730
Leaves and twigs : Total biomass	0.183
Branches : Total biomass	0.087
Leaves and twigs	
Air-dry : Green biomass	0.353
Oven-dry : Green biomass	0.295
Main stem	
Air-dry : Green biomass	0.486
Oven-dry : Green biomass	0.340

Confidence limit: Sample trees used in developing the aerial biomasses of different forms over bark functions had diameter and height class distribution as given in Table 1. Extrapolation much outside the range of height and diameter 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 diameter of the stand should be calculated first. Then this mean may be used to read off 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 & Choudhury 1984). However, determination of diameters in classes and then estimation of biomass of each class apart would give more accurate estimate.

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