BIOMASS TABLES FOR YOUNG EUCALYPTUS GROWN IN BANGLADESH

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ABSTRACT

It is an attempt to prepare biomass tables for young trees of the three *Eucalyptus* species grown in Bangladesh. The paper gives height-diameter at breast height (dbh)-biomass, and dbh-biomass production relationships along with required tables and conversion factors.

সারসংক্ষেপ

বাংলাদেশে জন্মানো তিন প্রজাতির ইউক্যালিপটাস গাছের বায়োমাস টেবিল তৈরী করার ইহা একটি প্রয়াস। এই প্রবন্ধে গাছের উচচতা ও বুক উচচতায় গাছের ব্যাসের এবং বুক উচচতায় গাছের ব্যাসের সাথে বায়োমাস উৎপাদনের সম্পর্ক নির্ণয় করে প্রয়োজনীয় টেবিল তৈরী করা হয়েছে। তা ছাড়া গাছের সবুজ বায়োমাস বিভিন্ন প্রয়োজন-উপযোগী বায়োমাসে রূপান্তর করার গুণক প্রদান হয়েছে।

INTRODUCTION

Eucalyptus camaldulensis, E. tereticornis and *E. brassiana* proved to be the three best *Eucalyptus* species so far tried for general purpose in Bangladesh (Davidson *et al.* 1985a). The best provenances of these species are now being planted on the denuded hills and in fuelwood shortage areas. An opportunity was available to study the aerial biomass production at the stand age of five years at two sites—Charkai (Dinajpur) and Charaljani (Tangail). The biomass production per hectare has been estimated and reported by Davidson *et al.* (1985b). In this paper an attempt has been made to prepare biomass tables for the mean tree of a stand.

MATERIALS AND METHODS

Species elimination and provenance trials of *Eucalyptus* species were tried at

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Charkai and Charaljani along with other sites in 1978 (Davidson *et al.* 1985a). A brief description of some environmental factors for the two sites are given in Table 1. Planting was done at a spacing of 0.9 m x 0.9 m with 1.2 m border from plot to plot and block to block. The plots were of 23.8 m^2, while the blocks were of 1,951 m^2. Twenty five seedlings were planted at each plot. The plantation was replicated thrice at each site. In 1983, when the experiment attained an age of five years, the trees were felled and measured for diameter at breast height, total height and green biomass. The distribution of the trees are given in Table 2 and Table 3.

Table 1. Some environmental factors for the two experimental sites (Davidson *et al.* 1985a)

Factors	Charkai (Dinajpur*)	Charaljani (Mymensingh*)
Rainfall		
Mean Annual Rainfall (mm)	1,660	2,253
Period of maximum rainfall	May—Oct.	Apr.—Oct.
Period of minimum rainfall	Nov.—Apr.	Nov.—Mar
Temperature (^{0}C)		
Mean annual temperature	25.2	25.3
Mean annual maximum temperature	30.8	30.1
Mean annual minimum temperature	19.7	20.5
Relative huminity (%)		
Maximum	87	92
Minimum	64	72
Soils		
p^H	5.0–5.5	4.7
Texture	Clay	Clay Loam

**nearest meteorological station*

Table 2. Geographic distribution of sample trees

Species	Charkai	Charaljani	Total
E. camaldulensis	90	66	156
E. tereticornis	55	35	90
E. brassiana	24	24	48
Total	169	125	294

Table 3. Dbh–Height class distribution of sample trees

	Height class (m)								
Dbh class (cm)	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	Total
19.0	–	–	–	–	–	1	–	–	1
17.0	–	–	–	–	–	2	1	1	4
15.0	–	–	–	–	–	2	2	–	4
13.0	–	–	–	1	11	24	4	–	40
11.0	–	–	1	9	26	14	–	–	50
9.0	–	–	10	43	4	1	–	–	58
7.0	–	12	46	15	–	–	–	–	73
5.0	7	41	8	–	–	–	–	–	56
3.0	5	3	–	–	–	–	–	–	8
Total	12	56	65	68	41	44	7	1	294

Diameters at breast height (dbh) of the standing trees were measured using steel diameter tape. Then the trees were felled leaving 10 cm stump. Total length (height) was measured. From each plot 2–4 representative sample trees were selected for biomass measurement. Each selected tree was divided into two parts–the stem with bark-on including big branches and the leaves including small branches and twigs. The stem and the branches were cut into 2–4 metre billets and weighed using a spring balance. Leaves, twigs and small branches were weighed on a spring balance, a table model with a flat pan on top. 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. Air-dry weights of these samples were taken after six months storage in shade. Then the samples were oven-dried to a constant weight. Extrapolation was done to find out conversion factors to estimate the airdry and oven-dry weights.

DATA COMPILATION

The data were ploted in various ways to select the suitable relationships of biomass on dbh and total height. It was observed from the plotted data that there was limited difference between species or provenances on sites for biomass on diameter at breast height and total height. This means that the relationships of biomass production for individual tree of different sizes for different provenances of the three *Eucalyptus* species at the two sites mentioned were similar (Davidson *et al.* 1985b) Therefore, the following 15 equations were tested for the pooled data to find out statictically the best fitting equations :

1. $B=a+b\ D$
2. $B=a+b\ D+c\ D^2$
3. $B=a+b\ D^2$
4. $B=a+b\ D^2\ H$
5. $B=a+b\ D+c\ H+d\ D^2\ H$
6. $B=a+b\ D^2+c\ DH+d\ D^2\ H$
7. $Ln\ (B)=a+bLn\ (D)$
8. $Ln\ (B)=a+bLn\ (D)+cLn\ (H)$
9. $B/D^2=a+b/D^2+c/D$
10. $B/D^2=a+a+b/D$
11. $B/D^2=a+a+b/D^2\ H$
12. $B/D^2=a+b/D^2\ H+c\ H/D^2+d\ H$
13. $B/D^2\ H=a+b/D^2\ H+C/H+d/D^2$
14. $B/D^2=a+b/D^2+c\ H/D+d\ H$
15. $B/D^2\ H=a+b/D^2H+c/H+d/D$

Where :

B=total aerial green biomass per tree, kg

D=diameter at breast height, cm

H=total height, m

The regression models of best fit were chosen comparing various parameters describing the regressions, including high coefficient of determination, high F-value and

minimum mean square error. The models of best fit were for one-way, Model No. 7 (Table–4) and for two-way, Model No. 8 (Table–5).

The equations of best fit were found out for biomass on diameter at breast height, and biomass on diameter at breast height and total height. These equations were also transformed for biomass on girth at breast height (gbh) and biomass on (gbh) and total height. Hence, the best regression equations are :

$$\text{Ln}\,(B) = 2.39602\ \text{Ln}\,(D) - 1.3933$$

$$\text{Ln}\,(B) = 2.39602\ \text{Ln}\,(G) - 4.136$$

The best two-way regression equations are :

$$\text{Ln}\,(B) = 1.81492\ \text{Ln}\,(D) + 0.85007\ \text{Ln}\,(H) - 2.228$$

$$\text{Ln}\,(B) = 1.81492\ \text{Ln}\,(G) + 0.85007\ \text{Ln}\,(H) - 4.306$$

Where :

D is diameter at breast height, cm

H is total height, m

B is total aerial green weight (biomass), kg/tree

G is girth at breast height, cm

One-way and two-way tables are shown in Appendices I, II and III

Table 4. Analysis of variance for one-way biomass table

Source of Variation	df	S. S.	M. S.	F-value
Regression	1	231.420	231.42	5293.25
Residual	292	12.766	0.0437	
Total..	293	244.186		

Standard error=0.209. $R^2 = 0.948$

Table 5. Analysis of variance for two-way biomass table

Source of Variation	df	S. S.	M. S.	F--value
Regression	2	233.816	116.908	3280.44
Residual	291	10.371	0.0356	
Total...	293	244.187		

Standard error = 0.18878, $R^2 = 0.9575$

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, and main stem including big branches from total above ground green biomass (Table 6).

Table 6. Conversion factors for different transformed forms of biomass.

	Conversion factor
For totals	
Oven-dry : Total biomass	0.447
Air-dry : Total biomass	0.524
Stem wood: Total biomass	0.820
Leaves and twigs : Total biomass	0.180
Leaves and twigs	
Air-dry : Green biomass	0.506
Oven-dry : Green biomass	0.414
Main stem	
Air-dry : Green biomass	0.530
Oven-dry : Green biomass	0.467

CONFIDENCE LIMIT

Sample trees used in developing the aerial total biomass over bark functions had diameter and height class distribution as given in Table 3. Since, all the computer generated biomass tables have a similar format, in some tables few to many values shown are well outside the range of the original data boundaries. Hence, extrapolation in the table 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 of 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)

REFERENCES

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Appendix 1. Total aerial green biomass based on dbh and gbh for young eucalypts grown in Bangladesh

Dbh (cm)	Biomass (kg/tree)	Gbh (cm)	Biomass (kg/tree)
1.00	0.25	3.00	0.22
2.00	1.31	6.00	1.17
3.00	3.45	9.00	3.09
4.00	6.88	12.00	6.16
5.00	11.74	15.00	10.51
6.00	18.17	18.00	16.27
7.00	26.29	21.00	23.54
8.00	36.20	24.00	32.42
9.00	48.00	27.00	42.99
10.00	61.79	30.00	55.33
11.00	77.64	33.00	69.53
12.00	95.64	36.00	85.64
13.00	115.86	39.00	103.75
14.00	138.37	42.00	123.91
15.00	163.24	45.00	146.18
16.00	190.54	48.00	170.36
17.00	220.33	51.00	197.30
18.00	252.67	54.00	226.26
19.00	287.62	57.00	257.55
20.00	325.23	60.00	291.24
21.00	365.56	63.00	327.35
22.00	408.67	66.00	365.95
23.00	454.59	69.00	407.08
24.00	503.40	72.00	450.78
25.00	555.12	75.00	497·10

Appendix II. Total aerial green biomass in kilograms/tree based on dbh and height for young eucalypts grown in Bangladesh

Dbh (cm)	Height (m)										
	4	6	8	10	12	14	16	18	20	22	24
1	0	0	1	1	1	1	1	1	1	1	2
2	1	2	2	3	3	4	4	4	5	5	6
3	3	4	5	6	7	7	8	9	10	11	12
4	4	6	8	9	11	13	14	16	17	18	20
5	6	9	12	14	17	19	21	23	26	28	30
6	9	13	16	20	23	26	29	32	36	39	41
7	12	17	22	26	30	35	39	43	47	51	55
8	15	22	27	33	39	44	50	55	60	65	70
9	19	27	34	41	48	55	61	68	74	80	87
10	23	32	41	50	58	66	74	82	90	97	105
11	27	38	49	59	69	79	88	98	107	116	125
12	32	45	57	69	81	92	103	114	125	136	146
13	37	52	66	80	94	107	120	132	145	157	169
14	42	59	76	92	107	122	137	151	165	179	193
15	48	67	86	104	121	138	155	171	187	203	219
16	54	76	97	117	137	156	174	193	211	229	246
17	60	85	108	131	152	174	195	215	235	255	275
18	66	94	120	145	169	193	216	239	261	283	305
19	73	103	132	160	186	213	238	263	288	312	336
20	80	114	145	175	205	233	261	289	316	443	369
21	88	124	158	192	224	255	286	316	345	374	403
22	96	135	172	208	243	277	311	343	376	407	439
23	104	146	187	226	264	301	337	372	407	442	475
24	112	158	202	244	285	325	364	402	440	477	514
25	121	170	217	263	307	350	392	433	474	514	553

✓ *Data boundary*

Appendix III. Total aerial green biomass in kilograms/tree based on gbh and total height for young eucalypts grown in Bangladesh

Gbh (cm)	Height (m)										
	4	6	8	10	12	14	16	18	20	22	24
3	0	0	1	1	1	1	1	1	1	1	1
6	1	2	2	2	3	3	4	4	4	5	5
9	2	3	4	5	6	7	8	8	9	10	11
12	4	6	7	9	10	12	13	14	16	17	18
15	6	8	11	13	15	17	19	21	23	25	27
18	8	12	15	18	21	24	27	30	33	35	38
21	11	16	20	24	28	32	36	40	43	47	50
24	14	20	25	31	36	41	46	50	55	60	64
27	17	25	31	38	44	50	56	62	68	74	80
30	21	30	38	46	53	61	68	75	83	90	96
33	25	35	45	54	64	72	81	90	98	106	115
36	29	41	53	64	74	85	95	105	115	125	134
39	34	48	61	74	86	98	110	122	133	144	155
42	39	55	70	84	98	112	126	139	152	165	178
45	44	62	79	96	112	127	143	158	172	187	201
48	49	70	89	107	125	143	160	177	194	210	226
51	55	78	99	120	140	160	179	198	216	235	253
54	61	86	110	133	155	177	198	219	240	260	280
57	67	95	121	147	171	195	219	242	265	287	309
60	74	104	133	161	188	214	240	266	290	315	339
63	81	114	146	176	206	234	263	290	317	344	371
66	88	124	158	192	224	255	286	316	345	374	403
69	95	135	172	208	242	276	310	342	374	406	437
72	103	145	186	224	262	299	335	270	404	439	472
75	111	156	200	242	282	322	360	398	435	472	508
78	119	168	215	259	303	345	387	428	468	507	546