STUDY ON WOOD AND

BARK VOLUMES OF EUCALYPTUS TREES IN KERALA

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ABSTRACT

Based on measurements of mid-girths of billets and bole height, volume tables for Eucalyptus grandis in Grassland afforestation areas and for Eucalyptus grandis and Eucalyptus tereticornis in Industrial Plantation Circle in Kerala are presented Studies on the bark of Eucalyptus trees in these areas revealed that (1) in I. P. C. E. tereticornis has a thicker bark and a higher percentage bark volume than E. grandis and (2) E. grandis has a thicker bark and a higher percentage bark volume in I. P. C. than in grass lands .

INTRODUCTION

Eucalyptus tereticornis and Eucalyptus grandis are two exotic species that are extensively cultivated in Kerala, mainly to provide short fiber raw material for pulp and paper industry. The total extent of plantations of these species as in 1976 in the state was 32,694 hectares. The high altitude grasslands in the Peermade - Pamba region were the first to be successfully planted with E. grandis. This initial success in the grasslands encouraged the extension of Eucalyptus plantations to other parts of the state. A special Industrial Plantation Circle (I. P. C.) was formed to raise industrial wood, chiefly, Eucalyptus in the moist deciduous forests of Chalakudy and Malayattur. In the grasslands of Peermade- Pamba about 7,900 hectares are under E. grandis and under the I. P. C. about 8,800 hectares are planted with E. tereticornis and E grandis.

 Two pulp mills in the state under the private sector obtain part of their raw material from the Eucalyptus plantations in the; state. In addition a public sector newsprint factory is coming up which will also depend upon the Eucalyptus resources of the state.

OBJECTS OF THE STUDY

The objects of the present investigation were: (1) to study Over Bark Volume (Vo) and Under Bark Volume (Vu) of E. tereticornis and E. grandis and prepare volume tables and (ii) to estimate their bark volume, percentage barks volume and bark thickness.

The present system of harvesting is to mark and allot Eucalyptus areas to the industrial units in the state. The allotees fell the trees in the area, billet them and stack the billets after debarking in stacks of specified dimensions. The Forest Department measures the stacks before the wood is transported to the factory. The volume tables presented here would enable the forester to estimate the wood volume in an area before billeting and stacking. The study on bark will throw light on some aspects of Eucalyptus that has so far received little attention.

REVIEW OF LITERATURE

A number of studies for estimating the over bark and under bark wood volume of Eucalyptus (both E. tereticornis and E grandis) based on regression relationship between volume and stand and tree parameters, viz., dbh, height, age, basal area, number of stems per hectare etc. have been undertaken in the country. These studies are mostly based on recorded data from plots laid out in the various states by Forest Research Institute, Dehra Dun.

Pande and Chaturvedi (1972.) have worked out the relationship between overbark and underbark wood volume per hectare of E hybrid (E. tereticornis) and stand parameters of basal area and crop height The study was based on data from plantations in Andhra Pradesh, Bihar, Haryana, Kerala, Madhya Pradesh Tamil Nadu etc.. Chaturvedi and Venkatraman (1973) have utilized data from E. hybrid plantations in Tamil Nadu to estimate Vo and Vu of trees by means of regression relationship of tree volume to dbh and height Pande and Iain (1974) have established the relation- ship between Vo and Vu per hectare of E. tereticornis to basal area, height of crop and number of stems per hectare. The measurements were taken from sample plots in Kerala and Tamil Nadu. Chaturvedi (1976) from out of data in several permanent and temporary plots has obtained the following relationship between Vo and Vu of E. tereticorn is.

$$Vu = - 0.0014 + 0.7682 \, Vo \quad (R^2 = 0.9952)$$

Pande and Jain (1976) have worked out tree volume tables for E. grandis trees based on data from Kerala and Tamil Nadu. They obtained the following regression equations for Vo and Vu.

$$Vo = 0.037728 + 0.216865D^2H + 0039256D^2HlogA + 0003188H \quad (R2=0977)$$

$$Vu = 00345911 + 0\,211996D^2H + 0.0271027D^2HlogA + O.OO24646H \quad (R^2 = 0.969)$$

where D,H and A are the dbh, height and age respectively.

No attempt has so far been made to quantitatively estimate the volume of Eucalyptus bark. Probably because its industrial use is yet to be established in the country. Carter (1974) reported that the bark of Mannagum (E. viminalis) could possibly be pulped with wood to produce paper suitable for some purposes. Bluegum (E. globulus) and Flood gum (E. grandis) etc., have bark similar to that of Mannagum and the bark representing 15 to 20 percent of total volume can increase the total usable volume to much greater extent. The studies of Prabhu and Theagarajan (1977) have shown that E. tereticornis bark, tops and lops yielded 40 - 45 percent (on air dry weight) of oxalic acid.

STUDY AREA

The data for the present study were collected from the Kalady. Vazhachal and Kothamangalam divisions of the I.P.C. and the grassland afforestation division in the Pamba -Peermade region.

In the I. P. divisions, Eucalyptus was planted after clearfelling the moist deciduous forests of Chalakudy and Malayattur. They are high rainfall areas with an undulating terrain. The Eucalyptus areas have an altitude below 700 metres above Mean .Sea Level (M.S.L.) the soil is generally deep and loamy.

The grassland afforestation division where extensive E. grandis plantations have been raised was open grassland with tall coarse grass (mainly Typha sp.) 2 to 3 metres high. Scattered trees were also found interspaced. The soil is shallow. These areas are at high altitudes between 800-1,200 metres above M. S. L.

MATERIALS AND METHODS

During 1977 felling season measurements of bole height, over bark and underbark girths at breast height, at half bole length, and at the middle of each one-metre billet of sample trees in the I. P Circle were recorded. The girths were measured with tape Sample trees belonged to both E. tereticornis and E. grand is. Care was also taken to select adequate number of trees to represent all diameter classes. Data collected by the Working Plan party of Grassland Afforestation Division were also utilized for the present study. Here diameters were recorded by calipers and billet size was 2 metres.

The overbark and underbark billet volumes were calculated from the measurements of girth/diameter and billet size. The sum total volume of all billets constituting a tree gave tree volume.

Bark volume of a tree was obtained as the difference between its overbark and underbark volumes.

$$\text{Percentage bark Volume} = \frac{\text{Bark volume} \times 100}{\text{Over bark wood volume}}$$

If $2t_i$ is double bark thickness of the ith billet, whose middle over bark and under bark diameters are Do_i and Du_i.

$$2t_i = Do_i - Du_i$$

Bark thickness of the tree,

$$t = \frac{\sum_{i=1}^{n}(Do_i - Du_i)}{2n},$$

where n is the number of billets.

The standard errors of means were calculated. The significance of difference of means in various dbh/height classes were tested by Student's-t (Snedecor and Cochran (1968))

For preparing wood volume tables, regression model assumed was

$$\log_e V_i = a_0 + a_1 \log_e Do + a_2 \log_e H + a_3 X_i - e$$

where,

V_i = volume of the ith billet

$X_i = \frac{h_i}{H}$. h_i is the height to the midpoint of ith billet from the stump and H total bole height of tree.

Do = dbh (overbark)

a_0, a_1, a_2 and a_3 are constants to be estimated from data and e, the error term.

The significance of regression was tested by analysis of variance. The coefficient of determination, R^2 was also calculated (Snedecor and Cochran (1968))

Volume of tree,

$$V = \sum_{i=1}^{\left[\frac{H}{b}\right]} V_i, \text{ where b is the billet size and}$$

$\left[\frac{H}{b}\right]$ is the largest integer contained in $\frac{H}{b}$

All the computation work required for the study was undertaken in IBM 360/44 Computer system at Vikram Sarabhai Space Centre, Trivandrum

OBSERVATIONS AND RESULTS

Data from I.P.C and Grasslands were treated separately for purposes of analysis and presentation of results. Measurements from 80 E. grandis trees and 102 E. tereticornis trees in the I.P.C and E. grandis trees in the grasslands have been utilized for the present study. The sample trees in I.P.C belonged to 8,9 and 11 years of age and those in Grasslands belonged to ages from 10 to 17. Since adequate numbers were not available in all ages, data from trees belonging to all ages were pooled for analysis. Tables I(a) , I(b) and I(c) show the distribution of sample trees under the various height and dbh classes.

In I. P. C. the bole height of sample trees ranged from 5 metres to 24 metres and dbh from 11 cms to 30 cms. In Grasslands the range of height was 2 m. to 36 m. and that of dbh was from 6 cms. to 42 cms,

TABLE 1: DISTRIBUTION OF SAMPLE TREES

Height (m)	dbh (cm.)					All dbh
	5-10	10-15	15-20	20-25	above 25	
(a) I. P. Circle - E. grandis						
≤ 10	...	12	6	...	...	18
11—20	...	4	15	20	19	58
21—30	...	...	...	...	4	4
all heights	...	16	21	20	23	80
(b) I. P. Circle - E. tereticornis						
≤ 10	...	15	2	...	...	17
11—20	...	7	25	27	17	76
21—30	...	...	...	3	6	9
all heights	...	22	27	30	23	102
(c) Grasslands division - E. grandis						
≤ 10	25	21	3	...	...	49
11—20	1	56	54	19	8	138
21—30	...	...	29	42	24	95
above 30	...	...	...	1	17	18
all heights	26	77	86	62	49	300

VOLUME TABLES

The regression models for billet volume on which the volume tables appended are built up are given below:

(a) I. P. Circle - <u>E.</u> grandis

(i) Overbark wood volume of ith billet,

$$\log_e Vo_i = -0.47552 + 1.59953\log_e Do$$

$$- 0.02364\log_e H - 2.27499X_i$$

ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Sum of squares	Variance	Variance ratio (F) (obs)	Determination coefficient (R^2)
Regression	3	701.23657	233.745	2055.32*	0.84373
Residual	1142	129 87622	0.1137		

* Highly significant

(ii) Underbark wood volume of ith billet,

$$\log_e Vu_i = -0.15473 + 1.76420\log_e D_o +$$

$$- 0.09948\log_e H - 2.4490X_i$$

ANALYSIS OF VARIANCE

Source of variaton	Degrees of freedom	Sum of squares	Variance	Variance ratio (F) (obs.)	Determination coefficient (R^2)
Regression	3	806.64209	268.881	1585.020*	0.80635
Residual	1142	193.72729	0.170		

* Highly significant

(b) I. P. Circle - $\underline{E}$. tereticornis

i) Overbark wood volume of ith billet

$$\log_e Vo_i = 0.83347 + 1.84338 \log_e Do$$

$$\div 0.39313 \log_e H - 2.17451 X_i$$

ANALYSIS OF VARIANCE

Source of Variation	Degrees of freedom	Sum of Squares	Variance	Variance ratio (F) (obs.)	Determination coefficient (R^2)
Regression	3	822.09106	274.030	5154.031 *	0.91231
Residual	1486	79.00781	0.053		

*Highly significant

(ii) Underbark wood volume of ith billet,

$$\log_e Vu_i = 0.74696 + 1.93107 \log_e Do$$

$$\div 0.39527 \log_e H - 2.19405 X_i$$

ANALYSIS OF VARIANCE

Source of Variation	Degrees of freedom	Sum of Squares	Variance	Variance ratio (F) (Obs.)	Determination coefficient (R^2)
Regression	3	860.10156	286.700	4457.312*	0.90056
Residual	1486	95.58154	0.064		

*Highly significant

(c) Grasslands - <u>E.</u> <u>grandis</u>

(i) Overbark wood volume of ith billet,

$$\log_e Vo_i = -0.16480 + 1.52473 \log_e Do$$

$$+ 0.03252 \log_e H - 2.22532 X_i$$

ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Sum of squares	Variance	Variance ratio (F) (obs)	Determination coefficient (R^2)
Regression	3	1961.94336	653.981	7402.460*	0.88793
Residual	2803	247.63501	0.088		

* Highly significant

(ii) Underbark wood volume of ith billet,

$$\log_e Vu_i = -0.53111 + 1.50991 \log_e Do$$

$$+ 0.10300 \log_e H - 2.29971 X_i$$

ANALYSIS OF VARIANCE

Source of variaton	Degrees of freedom	Sum of squares	Variance	Variance ratio (F) (obs)	Determination coefficient (R^2)
Regression	3	2095.74756	698.582	6584.160*	0.87572
Residual	2803	297.39966	0.106		

* Highly significant

Tables II (a), II (b) and II (c) present actual average bark volume in cubic metres calculated from sample observations.

TABLE II:

AVERAGE BARK VOLUME OF EUCALYPTUS TREES
(Cubic metres)

Height(m)	dbh (cm)					All dbh
	5-10	10-15	15-20	20-25	above 25	
(a) I. P. Circle - E. grandis						
≤ 10	...	0.016	0 019	...	...	0.017
11—20	...	0.024	0.039	0.056	0.096	0.063
21—30	...	...	...	...	0.087	0 087
all heights	...	0.018	0.034	0 056	0.095	0.054
(b) I. P Circle – E. tereticornis						
≤10	...	0.014	0.034	...	...	·0.017
11—20	...	0.023	0.040	0.063	0.099	0.060
21 – 30	...	...	...	0.090	0 118	0.108
all heights	...	0.017	0.040	0.066	0 104	0.057
(c) Grasslands division - E. grandis						
≤10	0.006	0.014	0 018	...	...	0.010
11 —20	0.011	0.018	0.032	0.046	0.069	0.031
21 – 30	...	...	0.042	0.064	0.115	0.070
above 30	...	...	...	0.071	0.153	0 149
all heights	0.006	0.017	0.036	0.059	0.121	0.047

The ratio of actual bark volume to over bark wood volume expressed as percentage is defined as percentage bark volume. Tables III (a), III (b), and III (c) give mean percentage bark volume of Eucalyptus trees under various dbh and height classes in I. P. C. and Grasslands. The standard errors of the marginal means under different dbh and height classes are shown in brackets.

TABLE III :

PERCENTAGE BARK VOLUME* OF EUCALYPTUS TREES

Height (m)	dbh (cm.)					All dbh
	5-10	10-15	15-20	20-25	above 25	
(a) I. P. Circle – E. grandis						
≤10	...	21.57	18.09	...	...	20.41 (0.84)
11—20	...	24.38	21.48	16.24	14.71	17.71 (0.66)
21—30	...	...	...	...	13.98	13.98 (1.64)
all heights	... ...	22.27 (0.78)	20.51 (0.72)	16.24 (0.73)	14.54 (1.03)	18.08 (0.54)
(b) I. P. Circle - E. tereticornis						
≤ 10	...	21.96	24.12	...	...	22.21 (1.04)
11—20	...	24.01	22.95	21.08	18.74	21.44 (0.50)
21—30	...	...	...	19.75	18.72	19.07 (1.11)
all heights	...	22.61 (0.85)	23.04 (0.81)	20.94 (0.66)	18.73 (0 86)	21.36 (0.42)
(c) Grasslands division - E grandis						
≤10	23.83	20.01	19.67	...	...	21.94 (0.97)
11—20	16.15	16.34	16.52	15.90	15.44	16.42 (0.32)
21—30	...	...	13.19	13.54	12.89	13.27 (0.26)
above 30	...	...	...	9.91	11 68	11.58 (0.56)
all heights	23.56 (1.68)	17.34 (0.49)	15.51 (0.40)	14.20 (0.34)	12.89 (0.43)	15.98 (0.29)

* Figures in parentheses are standard errors.

TABLE IV:

AVERAGE BARK THICKNESS * OF EUCALYPTUS TREES

(in milli metres)

Height (m)	dbh (cm.)					All dbh
	5-10	10-15	15-20	20-25	above 25	
(a) I. P. Circle - E. grandis						
≤ 10	...	5.8	6.1	...	...	5.9 (0.24)
11—20	...	6.7	7.3	7.1	7.8	7.3 (0.27)
21—30	...	...	...	...	7.4	7.4 (0.89)
all heights	...	6.0 (0.23)	7.0 (0.33)	7.1 (0.29)	7.7 (0.60)	7.0 (0.22)
(b) I. P. Circle - E. tereticornis						
≤ 10	...	5.8	8.8	...	...	6.2 (0.35)
11—20	...	6.5	7.6	8.5	9.3	8.2 (0.19)
21—30	...	...	...	7.9	8.9	8.6 (0.49)
all heights	...	6.0 (0.22)	7.6 (0.27)	8.4 (0.26)	9.2 (0.37)	7.9 (0.18)
(c) Grasslands division - E. grandis						
≤10	4.6	5.1	5.7	...	...	4.9 (0.20)
11—20	3.7	4.2	5.2	5.8	7 0	5.0 (0.12)
21—30	...	...	4.5	5.4	6.6	5.4 (0.14)
above 30	...	...	...	4.4	6.5	6.4 (0.35)
all heights	4.6 (0.41)	4.4 (0.15)	5.0 (0.13)	5.5 (0.14)	6.6 (0.19)	5.2 (0.08)

* Figures in parentheses are standard errors.

Average bark thickness of E. grandis and E. tereticornis under various dbh and height classes are presented in tables IV (a), IV (b) and IV (c). Standard errors of marginal means are given in brackets.

DISCUSSION AND CONCLUSIONS

The regressions in all the cases are highly significant as revealed by analysis of variance, thus proving the reliability of the regression model to estimate the wood volumes.

The average percentage bark volume of sample trees were 18.08 for E. grandis in I. P. C., 21.36 for E. tereticornis in I.P.C. and 15.98 for E. grandis in grasslands division I P.C., percentage bark volume on the whole is greater for E. tereticornis than for E grandis. This is true for almost all dbh and height classes. Again, E. grandis is trees in I.P.C. have on the average higher percentage bark volume than in grasslands. The tables III (a), III (b), and III (c) also reveal that for both species and for the two regions, percentage bark volume decreases with increasing dbh and also with increasing height classes.

The mean bark thickness of the sample E. grandis trees in I.P.C. and grasslands were 6.9mm. and 5.2mm. respectively. (Tables IV (a), IV (b) and IV (c). The mean for E. tereticornis in I.P.C. worked out to be 7.9mm. The tables show that in I. P. C., the bark of E. terticornis is significantly thicker than that of E. grandis. This is true in most of the dbh and height classes. For E. grandis trees, those in I.P.C. have in general, thicker bark than in grass- lands. Again. it is clear from the tables that in both species, bark gets thicker as the trees grow in dbh and height.

REFERENCES

Carter, W.G. (1974) Growing and harvesting Eucalypts on short rotations for pulping. Aust. For . 36 (3): 214-225. --

Chaturvedi. A.N. (1976) Eucalyptus in India. Indian For. 102 (1): 57-63. -

Chaturvedi, A.N. and Venkatraman, K.G. (1973) Volume and weight table for Eucalyptus hybrid (based on the data from Tamil Nadu). Indian For., 99 (10): 599-608. -

Pande. G.C. and Chaturvedi. A.N. (1972) Stand volume, weight tables and other crop studies in Mysore Gum (Eucalyptus hybrid). Indian For. 98 (5): 286-297. -

Pande, G.C. and Jain, R.C. (1974) Basal area -volume relations for Eucalyptus grandis crops. Indian. ~ 100 (11): 670-690.

Pande. G.C. and Jain, R.C, (1976) The volume tables for
Eucalyptus grandis. Indian For. 102 (6): 362-387.

Prabhu. V.V. and Theagarajan. K.S. (1977) Utilization of Eucalyptus hybrid (Mysore Gum) bark for production of Oxalic acid. Indian For. , 103 (7):
477.479. -

Snedecor. G.W. and Cochran. W.G. (1968) Satistical methods. 6th ed. Calcutta; Oxford & IBH , 593pp.

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Over Bark Volume, Under Bark Volume and Bark Volume* of Eucalyptus grandis Trees in Industrial Plantation Circle
(KALADY, KOTHAMANGALAM AND VAZHACHAL REGIONS)

(IN CUBIC METRE)

Height (m)	dbh (cm.)											
	5	10	15	20	25	30	35	40	45	50	55	60
4	0.008	0.024	0.045	0.071								
	0 006	0.019	0.039	0.064								
	0.002	0.005	0.006	0.007								
6	0.012	0.035	0.067	0.107	0.153							
	0.008	0.027	0.056	0.093	0 138							
	0.004	0.008	0.011	0.014	0.015							
8	0.015	0.047	0.089	0.142	0 203	0.271						
	0.010	0.036	0.073	0 121	0.179	0.248						
	0.005	0.011	0.016	0 021	0.024	0.023						
10	0.019	0.058	0.111	0 177	0.252	·0.338						
	0.013	0.044	0.089	0.148	0.220	0 303						
	0.006	0.014	0.022	0 029	0.032	0.035						

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12	0.023	0.070	0.133	0.211	0.302	0.404	0.517	0.640
	0.015	0.051	0.105	0 175	0.259	0.357	0.469	0 594
	0.008	0.019	0.028	0.036	0.043	0.047	0.048	0.046
14	0.027	0.081	0.155	0.245	0.351	0.469	0 601	0.744
	0 017	0 059	0 121	0 201	0 298	0 411	0 539	0 682
	0.010	0 022	0 034	0 044	0 053	0 058	0 062	0 062
16	0 030	0 092	0 177	0 280	0 400	0 535	0 685	0 848
	0 020	0 067	0 136	0 227	0 336	0.463	0 608	0 770
	0.010	0.025	0 041	0 053	0 064	0 072	0 077	0 078
18	0.034	0 104	0 198	0 314	0 448	0 600	0 768	0 951
	0 022	0 074	0 152	0 252	0 374	0 515	0 679	0 856
	0 012	0 030	0 046	0 062	0 074	0 085	0 091	0 095
20	0 038	0 115	0.220	0 348	0 497	0 665	0 851	1 054
	0 024	0 082	0 167	0 277	0 411	0 567	0 744	0 942
	0 014	0 033	0 053	0 071	0 086	0 098	0 107	0 112
22	0 042	0 126	0 241	0 382	0 546	0 730	0 935	1 157
	0 026	0 089	0 182	0 302	0 448	0 618	0 811	1 026
	0 016	0 037	0 059	0 080	0 098	0 112	0 124	0 131

Height (m)	dbh (cm.)											
	5	10	15	20	25	30	35	40	45	50	55	60
24	0 045	0.137	0 262	0 416	0.594	0 795	1 017	1 260	1 521			
	0 028	0 096	0 197	0 327	0 484	0 668	0 877	1 110	1 366			
	0 017	0 041	0 065	0 089	0 110	0 127	0 140	0 150	0 155			
26	0 049	0 148	0 284	0 450	0 642	0 860	1 100	1 362	1 645			
	0 030	0 103	0 211	0 351	0 521	0.718	0 924	1 193	1 468			
	0 019	0 045	0 073	0 099	0 122	0 142	0 158	0 169	0 177			
28		0 159	0 305	0 483	0 691	0 924	1 183	1 465	1 768			
		0 111	0 226	0 375	0 557	0.768	1 008	1 275	1 570			
		0 048	0 079	0 108	0 134	0 156	0 175	0 190	0 198			
30		0 171	0 326	0 517	0 739	0 989	1 265	1 567	1 891	2 239		
		0 118	0 240	0 399	0 592	0 817	1 072	1 357	1 670	2 012		
		0 053	0 086	0 118	0 147	0 172	0 193	0 210	0 221	0 227		

32			0 348	0 551	0 787	1 053	1 348	1 669	2 014	2 384
			0 255	0 423	0 628	0 866	1 136	1 438	1 770	2 132
			0 093	0 128	0 159	0 187	0 212	0 231	0 244	0 252

32	0 348	0 551	0 787	1 053	1 348	1 669	2 014	2 384
	0 255	0 423	0 628	0 866	1 136	1 438	1 770	2 132
	0 093	0 128	0 159	0 187	0 212	0 231	0 244	0 252
34	0 369	0 584	0 835	1 117	1 430	1 770	2 137	2 530
	0 269	0 447	0 663	0 914	1.200	1 519	1 870	2 252
	0 100	0 137	0 172	0 203	0 230	0 251	0 267	0 278
36		0 618	0 883	1 182	1 512	1 872	2 260	2 675
		0 471	0 697	0 963	1 264	1 599	1 969	2 371
		0 147	0 186	0 219	0 248	0 273	0 291	0 304
38		0 651	0 931	1 246	1 594	1 974	2383	2 820
		0 494	0 733	1 011	1 327	1.679	2 067	2 489
		0 157	0 198	0 235	0 267	0 295	0 316	0 331
40		0.978	1 310	1.676	2 075	2.505	2 965	3 453	3 969
		0 767	1 059	1 389	1 758	2 165	2 607	3 084	3 596
		0 211	0 251	0 287	0 317	0 349	0 358	0 369	0 373
42		1 026	1 374	1 758	2 176	2 627	3 110	3.622	4 163
		0 802	1 106	1 452	1 837	2 262	2 724	3 223	3 757
		0 224	0 268	0 306	0 339	0 365	0 386	0 399	0 406

* In each cell first figure represents the over bark wood volume, second figure under bark wood volume and third figure the bark volume.

Over Bark Volume, Under Bark Volume and Bark Volume* of Eucalyptus tereticornis Trees in Industrial Plantation Circle
(KALADY, KOTHAMANGALAM AND VAZHACHAL REGIONS)

(IN CUBIC METRE)

Height (m)	dbh (cm.)											
	5	10	15	20	25	30	35	40	45	50	55	60
4	0 009	0 031	0 0 65	0 111								
	0 006	0 023	0.050	0 087								
	0.003	0 008	0.015	0 024								
6	0.011	0.040	0 084	0.142	0 215							
	0.008	0 029	0 064	0 112	0.173							
	0 003	0 011	0.020	0 030	0.042							
8	0 013	0 047	0.100	0.170	0 257	0.359						
	0 009	0.035	0 077	0 134	0 206	0.293						
	0.004	0 012	0.023	0 036	0.051	0.066						
10	0.015	0 054	0.115	0.195	0 294	0.411						
	0.011	0 040	0.088	0.153	0.236	0.336						
	0.004	0.014	0.027	0.042	0 058	0.075						

12	0.017	0.061	0.128	0 218	0 329	0.460	0 611	0.782
	0 012	0 045	0 098	0 171	0.264	0 375	0 505	0 654
	0 005	0 016	0.030	0.047	0.065	0 085	0 106	0.128
14	0.019	0 067	0 141	0 239	0 361	0 505	0.671	0 859
	0 013	0 049	0 108	0 188	0 290	0 412	0 555	0 718
	0 006	0 018	0 033	0 051	0 071	0 093	0 116	0 141
16	0 020	0 072	0 153	0 260	0 392	0 548	0 728	0 931
	0 014	0 054	0 117	0 204	0 314	0.447	0 601	0 778
	0.006	0 018	0 036	0 056	0 078	0 101	0 127	0 153
18	0 022	0 078	0 164	0 279	0 421	0 589	0 782	1 000
	0 015	0 057	0 126	0 219	0 337	0 480	0 646	0 836
	0 007	0 021	0 038	0 060	0 084	0 109	0 136	0 164
20	0 023	0 083	0 175	0 297	0 448	0 628	0 834	1 067
	0 016	0 061	0 134	0 234	0 360	0 511	0 689	0 891
	0 007	0 022	0 041	0 063	0 088	0 117	0 145	0 176
22	0 024	0 088	0 185	0 315	0 475	0 665	0 884	1 130
	0 017	0 065	0 142	0 248	0 381	0 542	0 729	0 944
	0 007	0 023	0 043	0 067	0 094	0 123	0 155	0 186

Height (m)	dbh (cm.)											
	5	10	15	20	25	30	35	40	45	50	55	60
24 ·	0 026	0.093	0.195	0 332	0.501	0 701	0 932	1 192	1 480			
	0 018	0 068	0 150	0 261	0 402	0 571	0 769	0 995	1 249			
	0 008	0 025	0 045	0 071	0 099	0 130	0 163	0 197	0 231			
26	0 027	0 097	0 205	0 349	0 526	0 736	0 978	1 251	1 554			
	0 019	0 072	0 157	0 274	0 421	0 599	0 807	1 045	1 311			
	0 008	0 025	0 048	0 075	0 105	0 137	0 171	0 206	0 243			
28		0 102	0 215	0 365	0 550	0 770	1 023	1 309	1 626			
		0 075	0 164	0 286	0 441	0 629	0 844	1 092	1 371			
		0 027	0 051	0 079	0 109	0 143	0 179	0 217	0 255			
30		0 106	0 224	0 380	0 574	0 803	1 067	1 364	1 695	2 059		
		0 078	0 171	0 299	0 460	0 654	0 880	1 139	1 430	1 753		
		0 028	0 053	0 081	0 114	0 149	0 187	0 225	0 265	0 306		

32	0 233	0 395	0 597	0 835	1 109	1 419	1 763	2 141
	0 178	0 311	0 478	0 680	0 915	1 184	1 487	1 822
	0 055	0 084	0 119	0 155	0 194	0 235	0 276	0 319
34	0 241	0 410	0 619	0 866	1 151	1 472	1 829	2 221
	0 185	0 322	0 496	0 705	0 949	1 229	1 542	1 890
	0 056	0 088	0 123	0 161	0 202	0 243	0 287	0 331
36		0 425	0 641	0 897	1 192	1 524	1 894	2 300
		0 334	0 513	0 730	0 983	1 272	1 597	1 957
		0 091	0 128	0 167	0 209	0 252	0 297	0 343
38		0 439	0 662	0 927	1 231	1 575	1 957	2 377
		0 345	0 530	0 754	1 015	1 314	1 650	2 022
		0 094	0 132	0 173	0 216	0 261	0 307	0 355
40		0 683	0 956	1.270	1 625	2 019	2 452	2 923	3 431
		0 547	0 778	1 047	1 356	1 702	2 086	2 507	2 966
		0 136	0 178	0 223	0 269	0 317	0 366	0 416	0 465
42		0 704	0 985	1 309	1 674	2 080	2 525	3 011	3 534
		0 563	0 801	1 079	1 396	1 753	2 148	2 582	3 055
		0 141	0 184	0 230	0 278	0 327	0 377	0 429	0 479

* In each cell first figure represents the over bark wood volume, second figure under bark wood volume and third figure the bark volume.

Over Bark Volume, Under Bark Volume and Bark Volume* of Eucalyptus grandis Trees in Grass Lands Division
(PAMBA - PEERMADE REGIONS)

(IN CUBIC METRE)

Height (m)	dbh (cm.)											
	5	10	15	20	25	30	35	40	45	50	55	60
4	0 007	0 020	0 037	0 058								
	0 005	0.016	0.029	0 044								
	0.002	0 004	0.008	0.014								
6	0.011	0.032	0 059	0 091	0 128							
	0.009	0 025	0.046	0 071	0.100							
	0.002	0 007	0.013	0 020	0.028							
8	0.015	0.043	0.080	0 123	0.173	0.229						
	0.012	0.035	0.064	0 099	0 139	0.183						
	0.003	0.008	0.016	0 024	0 034	0 046						
10	0 019	0 054	0 101	0.156	0 219	0.290						
	0.016	0.045	0 082	0 127	0.178	0.235						
	0.003	0.009	0 019	0 029	0.041	0.055						

12	0.023	0.066	0.122	0.189	0.266	0.351	0.444	0.544
	0.019	0.055	0.101	0.156	0.218	0.288	0.363	0.444
	0.004	0.011	0.021	0.033	0.048	0.063	0.081	0.100
14	0.027	0.077	0.143	0.222	0.312	0.412	0.521	0.639
	0.023	0.065	0.120	0.185	0.259	0.342	0.431	0.527
	0.004	0.012	0.023	0.037	0.053	0.070	0.090	0.112
16	0.031	0.089	0.164	0.255	0.358	0.473	0.598	0.734
	0.026	0.075	0.139	0.215	0.301	0.396	0.500	0.612
	0.005	0.014	0.025	0.040	0.057	0.077	0.098	0.122
18	0.035	0.100	0.186	0.288	0.405	0.535	0.676	0.829
	0.030	0.086	0.159	0.245	0.343	0.451	0.570	0.697
	0.005	0.014	0.027	0.043	0.062	0.084	0.106	0.132
20	0.039	0.112	0.207	0.321	0.452	0.596	0.754	0.925
	0.034	0.097	0.178	0.275	0.385	0.507	0.640	0.783
	0.005	0.015	0.029	0.046	0.067	0.089	0.114	0.142
22	0.043	0.123	0.229	0.355	0.499	0.658	0.833	1.021
	0.038	0.107	0.198	0.306	0.428	0.564	0.712	0.871
	0.005	0.016	0.031	0.049	0.071	0.094	0.121	0.150

Height (m)	dbh (cm.)											
	5	10	15	20	25	30	35	40	45	50	55	60
24	0 047	0 135	0 250	0 388	0.546	0 720	0 911	1 117	1 337			
	0 041	0 118	0 218	0 337	0 471	0 621	0 783	0 959	1 145			
	0 006	0 017	0 032	0 051	0 075	0 099	0 128	0 158	0 192			
26	0 051	0 147	0 272	0 422	0 593	0 783	0 990	1 214	1 452			
	0 045	0 129	0 238	0 368	0 515	0 678	0 856	1 047	1 251			
	0 006	0 018	0 034	0 054	0 078	0 105	0 134	0 167	0 201			
28		0 158	0 294	0 455	0 640	0 845	1 069	1 310	1 568			
		0 140	0 258	0 399	0 559	0 736	0 929	1 137	1 358			
		0 018	0 036	0 056	0 081	0 109	0 140	0 173	0 210			
30		0 170	0 315	0 489	0 687	0 908	1 148	1 407	1 684	1 978		
		0 151	0 279	0 431	0 603	0 794	1 003	1 227	1 465	1 718		
		0 019	0 036	0 058	0 084	0 114	0 145	0 180	0 219	0 260		

32	0 337	0 523	0 735	0 970	1 227	1 504	1 800	2 114	
	0 300	0 463	0 648	0 853	1 077	1 317	1 574	1 845	
	0 037	0 060	0 087	0 117	0 150	0 187	0 226	0 269	
34	0 359	0 557	0 782	1 033	1 307	1 602	1 917	2 251	
	0 320	0 495	0 693	0 912	1 151	1 409	1 683	1 973	
	0 039	0 062	0 089	0 121	0 156	0 193	0 234	0 278	
36		0 591	0 830	1 096	1 386	1 699	2 033	2 388	
		0 527	0 738	0 972	1 226	1 500	1 792	2 101	
		0 064	0 092	0 124	0 160	0 199	0 241	0 287	
38		0 624	0 878	1 159	1 466	1 797	2 150	2 525	
		0 559	0 783	1 032	1 302	1 593	1 903	2 231	
		0 065	0 095	0 127	0 164	0 204	0 247	0 294	
40		0 925	1 222	1.546	1 895	2.267	2 663	3 079	3 516
		0 829	1 092	1 378	1 685	1 014	2 361	2 726	3 109
		0 096	0 130	0 168	0 210	0 253	0 302	0 353	0 407
42		0 973	1 285	1 626	1 993	2 385	2 800	3.238	3 698
		0 875	1 152	1 454	1 779	2 125	2 491	2 877	3 281
		0 098	0 133	0 172	0 214	0 260	0 309	0 361	0 417

* In each cell first figure represents the over bark wood volume, second figure under bark wood volume and third figure the bark volume.