

GOVERNMENT OF MADHYA PRADESH
FOREST DEPARTMENT

TEAK

(TECTONA GRANDIS LINN.)

**GROWTH TABLES
FOR
DIFFERENT ECOLOGICAL FOREST TYPES
IN
MADHYA PRADESH**

BY

O.P. SAXENA
K.C. JOSHI & G.P. DATE

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PREFACE

The meeting of VI Advisory Committee for research of State Forest Research Institute, Madhya Pradesh in 1969 emphasised the necessity for bringing out a publication for growth behaviour of Teak in Madhya Pradesh. Stem analysis on sufficient teak stems have been conducted and growth data was obtained for about 36 forest divisions in M.P. by Working Plan Officers and State Forest Research Institute from time to time. This covered fairly wide range of ecological types and site qualities. The information was scattered in piecemeals without striking the eyes of needy foresters. In this publication such scattered information has been used as the basic data and Teak growth tables, applicable to the different ecological forests types of M.P. have been made after statistical processing and proper grouping of the data. The procedure followed in the compilation and the way of presentation of these tables is of its own kind and is open to criticism is fully realised. It is, however, believed that they will be more comprehensive as compared to the either to available references specially for M.P.

The All India yield and stand tables for plantation Teak (1959) are mostly applicable to Teak stands of plantation origin. The tables, besides being restricted in range specially for M.P. have not been prepared after grouping similar climatic Zones.

This publication presents the standard stem timber plus stem small wood (u.b.) volumes by d.b.h. (o.b.) classes for different localities in M.P. by site qualities and by ecological types. The height variable has been conveniently avoided and volume can be read directly from d.b.h. (o.b.) measurements alone. The publication also presents the statistics of growth of d.b.h. (o.b.), height and volume of a mean Teak tree by age classes, by different site qualities and ecological types. The growth figures given in the table do not profess to give more than general averages but approach to confidence limits given in Appendices 4 and 5, which have been worked out at 0.05 probability.

For proper use of the tables, specially for 5A/C1b-dry teak forest and 3B/C1c-slightly moist teak forest (other than Bastar) it is necessary to follow the following steps.

- (a) Determine ecological type of the locality where the tables have to be applied by consulting Appendix No.1.
- (b) Determine M.P. site quality class of the locality by top height/Age relationship.
- (c) If the crop is more or less of uniform age, fell about 4 to 5 trees of dominant class, if the crop is irregular for each age group starting from 5 to 15 years, 16 to 25 years, 26 to 35 years and so on fell a similar number of trees from respective dominant age classes. Before felling mark in two opposite directions the height at 4'-6' from ground level with cross marks.

- (d) Measure d.b.h. (o.b.), total height and determine total volume (standard) stem timber plus stem small wood. All measurements for volume should be underbark.
- (e) Find out averages for each of the above parameters separately for each age group.
- (f) Compare the average values determined under sub para (e) with the corresponding tabulated values given in Appendices 4 or 5 as the case may be. If the values fall within corresponding confidence limits tables can be directly applied.

The tables may be of special interest to Working Plan and Working Scheme Officers for estimation of Statistics of growth, deciding rotations, felling cycles etc. The tables may be useful for the divisional staff also for vol., estimation. However for full volume estimation allowance for branch wood timber and branch small wood (all under bark) will have to be worked out and added to the figures.

Jabalpur
1st March 1971

O.P. SAXENA
K.C. JOSHI
G.P. DATE



INTRODUCTION

THE LIMITS OF Madhya Pradesh State extend to 17°-48' to 26°-52' North and 74°-2' to 84°-24' East, latitude and longitude respectively. The total surface area of the state is 4,65,690 sq. kms. (1,71,210 sq.miles), of which about 40% i.e. 1,79,520 sq.kms (66,000 sq.miles) is under forests. The legal status of forest is as under :-

1. **Reserved forest** - 82,791 sq.kms (30,438 sq.miles) which is about 46% of the total forest area.
2. **Protected forest** - 96,827 sq.kms. (35,598 sq.miles.) which is about 54% of the total forest area.

The broad composition of the total forest area by species is as under :-

1. **Teak Forests** - 43,520 sq.kms. (16,000 sq.miles)
2. **Sal Forests** - 39,440 sq.kms. (14,500 sq.miles)
3. **Mixed Forests** - 96,658 sq.kms. (35,536 sq.miles)

However, on about 25% of the total recorded forest area, i.e. on 44,880 sq.kms. (16,500 sq.miles) either there are blanks and under stocked patches of stem density below D.4 or the forests are inaccessible for exploitation purposes.

Teak occurs over an extensive area in Madhya Pradesh. Its extreme boundaries of occurrence are given below:

1. **North** - Tikamgarh Forest Division, 25°-40' North Latitude
2. **South** - East Bastar Forest Division

(Konta Range) - 17°-45' North Latitude.

3. **East** - Sidhi Forest Division, 82°23' East Longitude.
4. **West** - Jhabua Forest Division, 74°-5' East Longitude.

It forms almost pure crops in the poor quality dry deciduous forest of peninsular India. It is indigenous to the major part of the State.

Reliable statistics about the growth trends for fixing up rotations, for assessing the cubical contents of trees of different sizes and for prescribing annual yields are essential for sound forest management. The results would be better appreciated if the statistics is made available for the different ecological types by site quality classes.

Volume tables for Teak for the former Central Provinces were compiled for the first time by Mr. V.K. Maitland in 1924. With further modifications and some more additions volume table for Teak for use in the former C.P. were compiled by Mr. Bakshi Santram in 1942. These tables were of general type having no provisions for different site qualities and ecological conditions. Data from Hoshangabad, Betul, Chhindwada, North Raipur and Balaghat Forest Divisions only were used by Mr. Bakshi Santram in compilation of his volume table. In case of Maitland's compilation the data from only Hoshangabad Forest Division were used. For these obvious reasons these tables have limited applicability to the forest of our

State. Re-organisation of States after the compilation of aforesaid tables is yet another factor which has limited the scope of their applicability in the present set up of M.P. State forests. In recent years local volume tables for Teak for South Seoni and South Chhindwada forest divisions have also been compiled. In the absence of any authentic records or tables suited to the varying requirements of the State, this publication has been brought out making use of existing stem analysis data.

The publication presents general growth trends and general volume tables for teak in Madhya Pradesh in greater detail. Teak

forest as occurring in the State have been classified into ecological types based on the revised survey of forest types of India (Champion and Seth). In each ecological type the forests have been divided according to M.P. site quality classes. The growth trends and volume table for Teak are compiled by site quality classes for every ecological type. The data was collected by different Working Plan Officers and also by the State Forest Research Institute from natural Teak forests only. The tables should thus be of general application for natural Teak forests throughout the State and in similar localities elsewhere.



ECOLOGICAL TYPES OF TEAK FORESTS IN MADHYA PRADESH

As recommended in the 'Proceedings' of All India Teak Study Tour and Symposium 1957-58 as well as adopted by Champion and Seth in their revised "Forest Types of India - 1964", the teak forests at Madhya Pradesh have been classified according to the rain fall and temperature variations. The latest working plans have also been

consulted and taken into account in distinguishing the ecological types. The divisions falling in one range of annual and having more or less the same temperature range have been grouped together to form one eco type. On this basis following types have been separated for M.P. Teak.

S.No.	Forest Types	Range of average annual rainfall in mms.
1.	3B/C1b-South Indian Moist Deciduous Forest Moist Teak Forest	1600 to 2500 mm (Approximately 61° to 100°)
2.	3B/C1c-South Indian Moist Deciduous Forest-Slightly Moist Teak Forest	1200 to 1600 mm (Approximately 46° to 60°)
3.	5A/C1b-Southern Tropical Dry Deciduous Forest-Dry Teak Forest.	900 to 1200 mms (Approximately 36° to 45°)
4.	5A/C1a-Southern Tropical Dry Deciduous Forests - VERY DRY TEAK FOREST	Below 900 mms (35°) -

The names of forest divisions falling in each of the above ecological types are given in Appendix No.1.

In order to get more precise results and

their proper applicability the forest under each of the above type, wherever available were further differentiated by M.P. site qualities as given under :

S.No.	Height class at maturity in metres	M.P. Teak site quality
1.	Over 27 Metres (over 90 feet)	I
2.	21 to 27 Metres (over 70 to 90 feet)	II
3.	15 to 21 Metres (over 50 to 70 feet)	III
4.	12 to 15 Metres (over 40 to 50 feet)	IVa
5.	9 to 12 Metres (over 30 to 40 feet)	IVb
6.	Below 9 Metres (30 feet and below)	V

The difference between an All India Teak quality and M.P. Teak quality is about 3 metres only. It seems peculiar to have separate norms for M.P. when the difference from All india quality class is so less. Moreover reference age at which the top height is to be recorded was not mentioned by Mr. V.K. Maitland when M.P. quality

classes were defined. Such a difference only causes inconvenience and extra labour in conversions as all the standard tables are based on All India basis. In the present case most of the basic data were available according to M.P. quality classes and the authors have to follow the suit in present publication.

SOURCE OF DATA

In compilation of this publication use of stem analysis data has been made which was collected by the various Working Plan Officers and was mainly compiled, computed and analysed by the statistical branch of State Forest Research Institute from time to time. In case of divisions for which stem analysis data and results were not available with the institute, growth figures have been sorted out from the latest working plans.

For purposes of stem analysis mature trees of Teak were selected keeping in view the instructions laid down under "The Silviculture Research Code Vol.3". The selection was confined to high forest areas which were managed under uniform or selection systems. It may be argued that the trees selected for stem analysis had suffered suppression at one stage or the other

during their life span. In a natural forest such conditions are obvious. The total suppression could only be avoided in case of plantations forests which had undergone regular tending operations including thinning or in converted Teak stands worked under uniform system provided timely tending operations were carried out. Unfortunately old Teak plantations of more than 20 years age are rarely available and that too in one or two divisions over very small area. Similar is the case with converted Teak stands where crops of about 30 to 40 years of age are confined to only a few divisions. Thus the results arrived at may be safely used for natural high forests.

The following is the list of Divisions for which growth data has been taken from the results of stem analysis compiled by State Forest Research Institute, Jabalpur.

S.No.	Name of the Division	M.P. quality class	No. of stems analysed
1.	Damoh	III	26
2.	Damoh	IVa	22
3.	South Seoni	II	62
4.	South Seoni	III	49
5.	North Seoni	III	46
6.	Narsingpur	III	20
7.	Jabalpur	III	25
8.	North and South Mandla	II	9
9.	North and South Mandla	III	61
10.	North and South Mandla	IVa	27
11.	Mandla (Jagmandal reserved)	II	10
12.	Mandla (Jagmandal reserved)	III	13
13.	Mandla (Jagmandal reserved)	IVa	6
14.	North Betul	II	60
15.	North Betul	III	42
16.	North Khandwa	III	50
17.	Harda	III	50
18.	Hoshangabad (excluding Bari reserved)	II	50
19.	Bari reserve (Hoshangabad)	II	15
20.	Bari reserve (Hoshangabad)	III	5

In case of following divisions growth data have been taken from respective working plans.

S.No.	Name of the Division	M.P. quality class	No. of stems analysed
1.	Indore	III	10
2.	Indore	IVa	20
3.	Indore	IVb	10
4.	Dewas	III	45
5.	Dewas	IVa	19
6.	West Bhopal	IVa	50
7.	Guna	IVa	20
8.	Guna	IVb	15
9.	Guna	V	15
10.	North, Raipur	II	15
11.	North and South Chhindwada	III	163
12.	West Bastar	II	20
13.	West Bastar	III	18
14.	East and West Bastar	II	15
15.	East and West Bastar	III	22
16.	North Balaghat	III	15

In chapter I the methods of allotting divisions to different ecological types have been discussed in detail. Grouping the total number of analysed stems from the aforesaid data according to ecological type

by site quality classes, the following is the break up of 1120 Teak trees in each type by site qualities, which is thus a fairly large number.

3B/C1c-slightly moist Teak (Bastar region)		3B/C1c-slightly moist Teak (other than Bastar-Region)			5A/C1b-dry Teak					3B/C1b Moist Teak	
II	III	II	III	IVa	II	III	IVa	IVb	V	II	III
35	56	146	169	33	60	431	131	25	15	15	5

Total number of trees analysed 1120

Though according to average annual rainfall data West Bastar and East Bastar forest divisions fall under the grouping slightly moist teak forests but on compilation of data it was observed that the height, diameter and volume figures against age classes for these two divisions far out-weighted the average growth figures for remaining forest divisions of slightly moist group. The grouping of these Bastar divisions to remaining forest divisions of this group resulted in undue enhancement of average growth figures. It was therefore

thought proper to make a sub group of these two forest divisions and separate them from remaining divisions of slightly moist Teak forests. The high growth figures in case of Bastar is attributed to a well spread of annual rainfall and deep fertile soils.

In stem analysis number of rings i.e. age forms the basis of all measurements. Every stem is divided into convenient sections and every section into decades viz. by 10 years interval and growth data recorded accordingly. Thus even though only trees of

rotation age or over are selected for stem analysis, rate of growth is obtained for the whole life of such stem. It should, therefore not be misunderstood that trees of only above one age group or height class have been actually analysed, the data is not spread over to all age and height classes of the forest. On the contrary the data is collected by every 3 metre height and 10 year age classes which in any case is not less adequate than the sample plot method of data collection for volume table compilation.

A deviation from the neither to prevalent volume table have however been injected in the present publication is so far

that the limits of standard stem timber and standard small wood could not be separated. The volume of the main bole have been calculated right upto to tip of the tree (0 cm diameter o.b.) instead of upto 5 cm. D.C.B. limit. For want of data volume or branch timber and branch small wood could not be calculated. As far as the total volume of the main bole is concerned the present method would give more accurate figures than by sample plot method. In case of Teak there is not much of branch timber. Branch small wood can be assessed as a percentage of main bole volume depending upon locality.



COMPUTATION OF DATA

Final growth figures from stem analysis results and working plans were sorted out from the existing records and these were taken as basic data. It is not necessary to give full details of method of stem analysis of individual tree and how the stem analysis results were obtained for a particular tract of a forest division. It can however be emphasised that the results of stem analysis have been arrived at by following prescribed standard methods. The growth data for individual divisions has been purposely omitted to avoid voluminous publications. The growth data for individual

divisions can be seen in the working plans of the respective divisions.

The divisions were allotted to suitable ecological type. They were then grouped according to site quality classes. In this way growth data for every ecological type and in every ecological type according to M.P. site quality classes were compiled taking age as independent variable and height, D.B.H., (O.B.) and volume as dependant variables. In this way in every eco-type by site quality classes the following number of divisions were allotted.

Ecological types	M.P. Teak site quality classes						Total
	V	IVb	IVa	III	II	I	
	No. of Divisions represented						
1. 3B/C1c-slightly moist Teak (Bastar Region)	-	-	-	3	2	-	5
2. 3B/C1c-slightly moist Teak (other than Bastar Region)	-	-	2	4	6	-	12
3. 5A/C1b-Dry Teak	2	2	6	11	1	-	22
4. 5A/C1a-Very dry Teak	-	-	-	-	-	-	-
Total	2	2	8	18	9	-	39

The number of stem analysed in each division according to site quality classes have already been given earlier in Chapter-2.

Except for the ecological type 5A/C1a and site quality I sufficient observations were available in each type.

Data for each site quality according to ecological types were averaged and mean values obtained for each dependent variable. Standard deviation was calculated for every dependent variable (Diameter, Height and vol.) for each decade in each ecological type and each site quality class. Each data was tested for its dispersion from

respective mean by the formula $M \pm 2$ where 'M' is the mean of the group and '2' the standard deviation from the mean. This showed that the probability that an individual observation will fall outside the range $M \pm 2$ approximately was 1:19 cases. It also proved that the grouping of different divisions in site quality classes was correct and the mean figures obtained could be used with 95% reliability which is quite high. None of the data was rejectable by this test except for the data of two Bastar Divisions which had to be separately grouped for the reasons stated under Chapter II. The mean figures for each of the variable under consideration i.e., D.B.H.,

(O.B.), Height and volume by ages are given in Appendix No.2. From the mean figures thus obtained (Appendix-2) harmonised and balanced smooth curves were drawn for (1) Age/Height (2) Age/D.B.H. (O.B.) and (3) Age/Volume for each type and quality class. 30 curves were drawn in this way. From these smooth curves height, D.B.H. (O.B.) and volumes corresponding to every 5th year age were read and posted on respective graph sheets. these figures are reproduced in table Nos. 5 to 7 which are discussed under Chapter No.4.

From the posted figures on the aforesaid graph sheets D.B.H. (O.B./volume and Height/Volume smooth curves were drawn taking age as common factor. From such sets of curves vol. could be read from any D.B.H. (O.B.) Finally convenient diameter

classes by 2 cms. interval were formed and volumes for the mid values of diameter classes were read out from D.B.H. (O.B.)/Vol. curves for separate types and qualities. These figures are given in table No.1 to 3 which are also discussed in Chapter 4.

In case of Bori reserve no other matching data were available from any of the forest divisions of M.P. Statistics of growth rates of D.B.H. (O.B.), Height and volume are reproduced in table No.8 from Jangles plan 1965-66, after converting the British units in to metric units. To find out the volume in different appropriate D.B.H. (O.B.) classes the volume was plotted against corresponding D.B.H. (O.B.) taking age factor as common. Smooth curve was drawn and volume read out from this curve at mid values of D.B.H. (O.B.) classes. The results are tabulated in table No.4.



TABLES AND CURVES

The tables and curves published in this records are as follows.

(i) Volume tables by diameters

Table No.	Description	Classification	Remarks
1	2	3	4
1.	Standard stem timber plus stem small wood volume under bark of a mean Teak tree in ecological type 3B/C1c - slightly moist Teak (Bastar Region)	2 cms D.B.H. (O.B.) and M.P. Teak site quality classes III and II	1. Small wood has been measured upto the tip (0 cm diameter of the tree)
2.	Standard stem timber plus stem small wood vol. under bark of a mean Teak tree in ecological type 3B/C1c - Slightly moist Teak (other than Bastar Region)	2 cms. D.B.H. (O.B.) and M.P. Teak site quality classes IVa, III & II	2. Volume is read correct to 5 cdm only.
3.	Standard stem timber plus stem small wood volume under bark of a mean Teak tree in ecological type 5A/C1b Dry Teak forest	2 cms. D.B.H. (O.B.) and M.P. quality classes V, IVb, IVa, III & II	
4.	Standard stem timber plus stem small wood volume under bark of a mean Teak tree in Bari reserves of Hoshangabad Forest Division- 3B/C1b Moist Teak Forest	2 cms. D.B.H. (O.B.) and M.P. Teak quality classes II & III combined.	

(ii) Statistics of growth of Teak by ages

5.	Statistics of growth for height, diameter and Vol. of a mean Teak tree of ecological type 3B/C1c (Bastar Region)	5 years age and M.P. Teak site quality classes III & II	D.B.H. (O.B.P) height & Volumes are dependent variables and age independent variable
6.	Statistics of growth for height, diameter and Vol. of a mean Teak tree of ecological type 3B/C1c (other than Bastar Region)	5 years age and M.P. Teak quality IVa, III & II	
7.	Statistics of growth for height, diameter and Vol. of a mean Teak tree of Ecological type-5A/C1b	5 years age and M.P. Teak quality V, IVb, IVa, III & II	
8.	Statistics of growth for height, diameter and Vol. of a mean Teak tree in Bari reserve of Hoshangabad division ecological type 3B/C1b	5 years age and Bari M.P. II & III combined quality Teak.	

Table No.1,2 and 3 give the standard stem timber volume plus standard small wood volume under bark in the rind of a mean teak tree by site quality classes in ecological types 3B/C1c, 3B/C1c and 5A/C1b respectively, by 2 cms. D.B.H. (O.B.) classes. The volume had been computed by dividing the tree length into convenient and prevalent logs of 9' and 10' lengths. Volume of these sections except the last one had been calculated by taking mid diameter of each log and on the sectional area πr^2 . The volume of the last section had been calculated by assuming that to be a cone with πr^2 basal area and height of the log as its length.

On a comparative study of table Nos.1,2 & 3 it would be seen that the difference in volume of a particular D.B.H. (O.B.) is not very significant for 2 consecutive site quality classes. The same may be the case for similar quality classes of different ecological type. Say for instance in table No.1, for the diameter class 30-32 cms. volume production for site quality class III is 500 cdm. and for site quality II it is only 480 cdm. Similarly for this very diameter class (30-32 cms.) for III quality class the volume for ecological type 3B/C1c (Bastar Region) is 500 cdm., for type 3B/C1c (other than Bastar Region) is 500 cdm., for type 3B/C1c (other than Bastar Region) 480 cdm. and for type 5A/C1b the volume is 530 cdm. as read from the table Nos.1,2 and 3 respectively. For casual reader this may sound abnormal that for a better quality class the volume is lesser than for a poorer quality class for the same D.B.H. (O.B.). Similarly this may go against his established notion that for the same D.B.H. (O.B.) volume in higher rainfall area would be more than that for the lower rainfall areas. Table No.4,5 & 6 are given

to weed out this false notion. In case of teak due to distinct annual rings, estimation of age of a tree or a crop is an easy job. The tables 4, 5 & 6 give the D.B.H. (O.B.), height and volume production by mean Teak tree at the age interval of 5 years for ecological type 3B/C1c (Bastar), 3B/C1c (other than Bastar) and 5A/C1b respectively. In each ecological type the growth figures are given by site quality classes for which data was available.

Coming to the example cited in previous para that is to the volume production at D.B.H. (O.B.) class 30-32 cms. for different site qualities and ecological types the following clarification is given. From table No.V it would be seen that D.B.H. (O.B.) 30-32 cms class is attained in about 55 years, in case of site quality III and in about 38 years in case of site quality II for 3B/C1c for Bastar Region. At these ages the height attained by the mean tree was 18.5 metres and 18.0 metres respectively. The lower age (38 years) and hence lower height (18.0 metres) resulted in lower volume production (480 cdm.) in II quality in comparison to III quality where the age taken was 55 years, height attained 18.5 metres and volume produced 500 cdm. for the same D.B.H. class (30-32 cms) for 3B/C1c (Bastar Region) type. Similar height and age variations are for other types. For any other D.B.H. class same reasons are applicable.

Since in the field the girth at b.h. is accurately measurable in comparison to diameter at B.H., a conversion table for girth to diameter is given in Appendix No.3. With the help of this conversion table girth measured in the field can be converted into corresponding diameter and the volume read directly from the table for that diameter class.

TABLE No.1

Type - 3B/C1c - South Indian moist deciduous forest/Slightly Moist Teak Forest. (Bastar Region)

Volume (Standard stem timber plus stem small wood) in the round (πr^2) under bark - by diameter classes (D.B.H. O.B.) and locality qualities to the nearest 5 cdm. for a mean tree.

Diameter class D.B.H. over bark in cms.	Locality quality class (M.P. Teak quality classes.	
	III	II
VOLUME IN cdms.		
0-2		
2-4	5	5
4-6	10	10
6-8	20	20
8-10	30	30
10-12	40	40
12-14	60	60
14-16	80	80
16-18	105	100
18-20	140	130
20-22	180	160
22-24	220	200
24-26	280	245
26-28	340	300
28-30	410	380
30-32	500	480
32-34	590	600
34-36	690	710
36-38	790	860
38-40	910	1000
40-42	1040	1100
42-44	1145	1190
44-46	1205	1270
46-48	1240	1350
48-50	1265	1420
50-52		1500

TABLE No.2

Type - 3B/C1c 'c' - South Indian moist deciduous forest/Slightly Moist Teak Forest. (other than Bastar Region)

Volume (Standard stem timber plus stem small wood) in the round (πr^2) under bark - by diameter classes (D.B.H. O.B.) and locality qualities to the nearest 5 cm. for a mean tree.

Diameter class D.B.H. over bark in cms.	Locality quality IVa	class III	(M.P. Teak quality classes. II
VOLUME IN cms.			
0-2	-	-	-
2-4	-	-	-
4-6	5	5	5
6-8	10	10	15
8-10	25	25	25
10-12	30	40	50
12-14	50	55	70
14-16	65	75	100
16-18	90	95	135
18-20	110	120	165
20-22	140	160	205
22-24	170	200	250
24-26	200	245	310
26-28	250	300	360
28-30	325	400	425
30-32	410	480	500
32-34	480	580	600
34-36		660	700
36-38		730	805
38-40		800	910
40-42		845	1020
42-44			1170
44-46			1260
46-48			1330
48-50			1395

TABLE No.3

Type - SA/C1c(b) - Southern tropical dry deciduous forest/Dry Teak Forest

Volume (Standard stem timber plus stem small wood) in the round (πr^2) under bark - by diameter classes (D.B.H. O.B.) and locality qualities to the nearest 5 cdm. for a mean tree.

Diameter class D.B.H. over bark in cms.	Locality quality class		(M.P. Teak quality classes.		
	V	IVb	IVa	III	II
	VOLUME IN cdm.				
0-2	-	-	-	-	-
2-4	-	-	-	-	-
4-6	5	5	5	5	5
6-8	10	10	10	10	10
8-10	20	25	25	25	25
10-12	30	35	35	40	35
12-14	45	50	50	55	50
14-16	60	65	70	80	75
16-18	75	85	90	100	100
18-20	95	105	125	135	135
20-22		140	170	170	170
22-24		190	215	220	215
24-26		220	250	265	260
26-28			290	340	335
28-30			320	440	410
30-32				530	490
32-34				620	590
34-36				700	680
36-38				800	800
38-40				870	900
40-42					1030
42-44					1130
44-46					1200
46-48					1250
48-50					1280

TABLE No.4

Standard stem timber plus small wood in the round πr^2 under bark by diameter classes (D.B.H.O.B.) and M.P. qualities II & III combined to the nearest 5 cdm. for a mean tree.

Type - 3B/C1b - Moist Teak Forest

BORI RESERVE

D.B.H. (O.B.) class in cms.	Volume in Cdm.	D.B.H. (O.B.) class in cms.	Volume in cdm.
0-2	-	46-48	1300
2-4	-	48-50	1490
4-6	5	50-52	1620
6-8	10	52-54	1810
8-10	20	54-56	1970
10-12	30	56-58	2150
12-14	50	58-60	2370
14-16	60	60-62	2570
16-18	80	62-64	2710
18-20	110	64-66	2850
20-22	140	66-68	3160
22-24	180	68-70	3410
24-26	215	70-72	3600
26-28	260	72-74	3820
28-30	325	74-76	4120
30-32	400	76-78	4430
32-34	465	78-80	4740
34-36	535	80-82	4820
36-38	640	82-84	4970
38-40	750	84-86	5090
40-42	850	86-88	5180
42-44	990		
44-46	1150	88-90	5250
46-48	1150		

TABLE No.5

Type - 38/C1c - South Indian moist deciduous forest/slightly moist - Teak forest (Bastar Region). Statistics of growth of a mean teak (*Tectona grandis*) tree classified by site qualities.

Age in years	M.P. quality III			M.P. quality II		
	D.B.H. (O.B.) in cms.	Height in metres	Volume in cdm (Stem timber plus stem small wood)	D.B.H. (O.B.) in cms.	Height in metres	Volume in cdm (Stem timber plus stem small wood)
10	6.0	4.6	20	9.5	6.2	30
15	9.5	6.7	40	14.0	8.8	65
20	12.0	8.8	65	18	11.2	110
25	15.5	10.6	100	22.0	13.4	180
30	18.0	12.2	135	26.0	15.4	260
35	21.0	13.8	185	29.0	17.2	400
40	23.5	15.2	250	32.0	18.9	550
45	26.5	16.5	320	34.5	20.4	700
50	29.0	17.7	410	37.0	21.8	820
55	31.5	18.8	510	40.0	23.0	970
60	34.0	19.8	630	42.0	24.1	1100
65	36.0	20.6	755	44.0	25.1	1200
70	38.0	21.4	880	46.0	25.9	1285
75	40.0	22.0	980	47.5	26.6	1355
80	40.5	22.5	1060	49.0	27.2	1420
85	43.0	23.0	1120	50.0	27.7	1460
90	44.0	23.4	1180	50.5	28.2	1500
95	45.5	23.6	1220	50.0	28.5	1530
100	46.0	23.0	1250	51.5	28.7	1550
105	46.5	24.0	1280	51.5	28.8	1555

TABLE No.6

Type - 3B/C1c - South Indian moist deciduous forest/slightly moist Teak forest (other than Bastar Region), Statistics of growth of a mean Teak (*Tectona grandis*) tree classified by site qualities.

Age in years	M.P. quality IVa			M.P. quality III			M.P. quality II		
	D.B.H. (O.B.) in cms.	Height in metres	Volume in cdm (Stem timber plus stem small wood)	D.B.H. (O.B.) in cms.	Height in metres	Volume in cdm (Stem timber plus stem small wood)	D.B.H. (O.B.) in cms.	Height in metres	Volume in cdm (Stem timber plus stem small wood)
10	5.0	3.3	5	6.0	3.4	5	6.5	4.6	15
15	8.0	5.2	20	9.0	5.1	10	9.5	6.7	35
20	11.5	7.0	40	12.0	6.8	30	13.0	8.6	65
25	14.5	8.4	60	15.0	8.4	50	16.0	10.4	115
30	17.0	9.7	95	18.0	9.8	90	19.5	12.0	175
35	20.0	10.6	125	20.5	11.2	135	22.0	13.4	245
40	22.0	11.4	160	23.0	12.5	185	25.5	14.7	325
45	24.0	12.1	195	25.0	13.6	250	28.0	16.0	415
50	26.0	12.7	230	27.0	14.7	320	31.0	17.2	500
55	28.0	13.2	280	29.0	15.7	400	33.0	18.3	620
60	29.0	13.6	325	31.0	16.6	480	36.0	19.4	730
65	30.5	13.9	370	33.0	17.4	550	38.0	20.4	850
70	30.0	14.2	415	34.0	18.2	610	40.0	21.3	950
75	32.0	14.4	450	35.5	18.8	660	42.0	22.0	1070
80	33.0	14.5	480	36.5	19.2	700	44.0	22.8	1180
85	33.0	14.6	500	37.0	19.8	730	45.0	23.5	1250
90	33.5	14.6	515	38.0	20.2	760	46.5	24.2	1300
95	34.0	14.7	520	38.5	20.6	780	47.5	24.7	1340
100	34.0	14.7	525	38.5	20.8	800	48.5	25.2	1370
105	-	-	-	39.0	21.0	815	49.0	25.6	1395
110	-	-	-	39.0	21.0	825	49.5	25.8	1410
115	-	-	-	-	-	-	50.0	26.0	1425
120	-	-	-	-	-	-	50.0	26.0	1435

TABLE No.7

Type - 5A/C1b - Southern Tropical dry deciduous forest/Dry teak forest

Statistics of growth of a mean teak (*Tectona grandis*) tree classified by site qualities

Age in years	M.P. quality V			M.P. quality IVb			M.P. quality IVa			M.P. quality III			M.P. quality II		
	D.B.H. (O.B.) in cms.	Height in metres	Volume in cdm	D.B.H. (O.B.) in cms.	Height in metres	Volume in cdm	D.B.H. (O.B.) in cms.	Height in metres	Volume in cdm	D.B.H. (O.B.) in cms.	Height in metres	Volume in cdm	D.B.H. (O.B.) in cms.	Height in metres	Volume in cdm
10	1.5	1.0	-	3.0	2.5	5	5.0	3.1	5	5.0	3.0	5	6.0	3.4	5
15	3.0	1.7	-	5.5	3.7	10	8.0	4.6	20	8.0	5.0	25	9.0	5.2	20
20	4.5	2.4	5	8.0	5.2	20	10.0	6.1	30	10.5	6.9	40	12.0	7.4	35
25	6.0	3.5	5	10.5	6.5	35	12.5	7.5	50	13.5	8.8	65	15.0	9.2	65
30	8.0	4.5	10	13.0	7.8	50	14.5	8.9	65	16.5	10.5	95	18.0	10.6	115
35	10.5	5.6	20	16.0	9.0	80	17.0	10.1	95	19.5	12.1	140	21.0	12.4	180
40	12.0	6.6	40	18.0	10.0	105	18.5	11.2	120	22.0	13.7	190	24.0	14.0	250
45	14.0	7.4	50	20.0	10.8	135	20.5	12.2	150	24.0	15.0	250	26.5	15.4	325
50	16.0	8.0	70	21.5	11.5	160	22.0	13.0	190	26.0	16.4	305	29.0	17.0	410
55	17.0	8.6	80	23.0	12.1	180	23.0	13.6	210	28.0	17.4	370	31.0	18.2	510
60	18.5	9.0	90	23.5	12.6	200	24.0	14.0	230	29.5	18.4	435	33.5	19.7	610
65	20.0	9.4	100	24.0	13.0	215	25.0	14.4	255	31.0	19.2	510	36.0	21.0	700
70	20.5	9.7	115	24.5	13.2	220	26.0	14.8	270	32.5	20.0	580	37.0	22.0	800
75	21.0	10.0	120	25.0	13.4	225	27.0	15.0	290	34.0	20.8	650	39.0	23.0	890
80	21.0	10.0	130	25.5	13.6	230	28.0	15.3	300	35.0	21.5	710	40.0	24.0	990
85							28.5	15.4	310	36.0	22.0	770	42.0	24.6	1060
90							29.0	15.4	325	37.0	22.5	810	43.0	25.4	1120
95										38.0	22.8	825	43.5	25.8	1150
100										38.5	23.2	840	44.0	26.2	1170
105										39.0	23.4	845	44.5	26.4	1190
110										39.0	23.4	850	45.0	26.6	1200

For confidence limits refer to Appendix No.5

TABLE No.8

Type 3B/C1b - South Indian moist deciduous forest/Moist Teak Forest.

Statistics of growth of a mean Teak (*Tectona grandis*) tree classified by M.P. II & III combined site qualities

Age in years	Height in metres	Bori M.P. II & III combined qualities	
		D.B.H. (O.B.) in cms	Volume in cdm. (Stem timber plus stem small wood)
10	2.4	9.1	17
15	3.6	13.5	40
20	5.5	17.0	78
25	7.2	21.0	130
30	9.1	24.6	211
35	11.1	29.0	310
40	13.4	32.2	437
45	15.2	36.0	570
50	17.1	39.9	760
55	18.6	44.0	1000
60	20.1	46.7	1288
65	21.8	50.0	1540
70	23.5	52.8	1764
75	24.7	57.0	2100
80	26.2	59.9	2431
85	27.4	64.0	2790
90	28.6	66.3	3106
95	29.8	70.0	3480
100	31.1	72.9	3822
105	32.0	76.0	4330
110	32.9	79.2	4629
115	33.8	82.0	5060
120	34.4	85.3	5405

APPENDIX No.1

Grouping of various teak divisions in Madhya Pradesh by Ecological types.

1. Type -3B/C1b Moist Teak Forests (Bori Reserve) range of average annual rainfall 1600 to 2500mm

S.N.	Name of Division	Ecological type
1.	Bori Reserve (Hoshangabad division)	3B/C1b-Moist Teak Forest

2. Type-3B/C1c-Slightly Moist Teak Forest Range of average annual rainfall (1200 to 1600 mm)

S.No.	Name of Division	Ecological type
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Group A - Bastar Region

1.	West Bastar (Bastar region)	3B/C1c-Slightly moist teak forest (Bastar region)
2.	East Bastar	—do—
3.	North Bastar	—do—
4.	South Bastar	—do—

Group B-other than Bastar Region

5.	South Seoni	3B/C1c-Slightly moist teak forest other than Bastar
6.	South Mandla	—do—
7.	South Balaghat	—do—
8.	North Balaghat	—do—
9.	Kanker	—do—
10.	Hoshangabad (Except Bori)	—do—
11.	North Raipur	—do—

3. Type- 5A/C1b- Dry Teak Forest Range of average annual rainfall (900 to 1200 mm)

S.No.	Name of Division	Ecological type
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1.	Harda	5A/C1b-Dry Teak Forest
2.	North Khandwa	—do—
3.	Indore (Except Mandsaur Sub. Division)	—do—
4.	Dewas	—do—
5.	Dhar	—do—
6.	Guna (part)	—do—
7.	North Seoni	—do—
8.	Damoh	—do—

S.No.	Name of Division	Ecological type
9.	Jabalpur	5a/c1b-Dry Teak Forest
10.	Narsinghpur	—do—
11.	East Bhopal	—do—
12.	West Bhopal	—do—
13.	Saugar	—do—
14.	South Chhindwara	—do—
15.	East Chhindwara	—do—
16.	West Chhindwara	—do—
17.	North Durg	—do—
18.	South Durg	—do—
19.	North Betul	—do—
20.	West Betul	—do—
21.	South Betul	—do—
22.	East & West Sidhi	—do—
23.	Umariā	—do—

4. Type-5A/C1a- Very dry Teak Forest Range of Average annual rainfall (Below 900 mm.)

S.No.	Name of Division	Ecological type
1.	East Kargone	5A/C1a - very dry Teak Forest
2.	Jhabua (except Kathiwara range)	—do—
3.	South Khandwa	—do—
4.	Shivpuri	—do—
5.	Guna (Part)	—do—
6.	Tikamgarh	—do—



APPENDIX No.2

Average growth figures of the divisions in M.P.

Height D.B.H. (O.B.) and volume	Age in years											
	10	20	30	40	50	60	70	80	90	100	110	120
3B/clb-Slightly moist Teak Forest (Bastar Region) M.P. Quality II												
Height in metres	6.2	11.3	15.2	18.6	21.8	24.2	25.9	27.2	28.2	28.8		
D.B.H. (O.B.) in cms.	9.1	18.4	26.6	33.4	36.3	41.0	45.7	48.0	50.4	52.2		
Volume in cdm.	21	83	257	572	828	1004	1169	1321	1455	1585		
3B/C1b slightly moist teak forest, (Bastar Region) M.P. quality I												
Height in metres	4.2	8.6	12.3	15.4	17.8	19.7	21.3	22.7	23.5	23.9		
D.B.H. (O.B.) in cms.	6.1	12.2	18.1	33.4	29.0	34.0	38.5	42.3	44.9			
Volume in cdm.	14	43	142	228	409	631	886	1149	1400	1568		
3B/C1c slightly moist Teak forest (other than Bastar) M.P. quality II												
Height in metres	3.6	8.3	12.1	14.8	17.3	19.5	21.3	22.9	24.1	25.0		
D.B.H. (O.B.) in cms.	5.6	12.7	19.5	25.9	31.4	36.4	40.4	43.9	46.8	48.8		
Volume in cdm.	12	51	142	292	500	724	962	1192	1411	1569		
3B/C1c slightly moist Teak forest (other than Bastar) M.P. quality III												
Height in metres	3.4	7.1	9.9	12.5	14.7	16.5	18.1	19.3	20.3	20.8		
D.B.H. (O.B.) in cms.	4.3	10.5	17.4	22.9	27.4	31.1	34.0	36.1	37.7	38.7		
Volume in cdm.	4	29	106	213	341	470	590	699	787	835		
3B/C1c slightly moist Teak forest (other than Bastar) M.P. quality IVa												
Height in metres	4.3	7.3	9.7	11.4	12.7	13.6	14.1	14.6	14.7	14.7		
D.B.H. (O.B.) in cms.	4.9	11.3	18.0	23.2	26.4	29.7	31.6	32.8	33.6	33.9		
Volume in cdm.	9	40	111	200	289	378	448	501	510	523		

5A/C1b- Dry teak forest M.P. quality II

Height in metres	3.1	6.7	10.6	14.1	17.0	19.5	21.9	24.0	25.8	(27.0)
D.B.H. (O.B.) in cms.	5.1	11.6	18.5	24.3	29.5	33.7	37.2	40.4	43.0	45.0
Volume in cdm.	-	36	116	252	430	622	800	976	1131	1256

5A/C1b - Dry teak forest M.P. quality III

Height in metres	3.5	7.6	11.3	14.3	16.5	18.4	20.0	21.4	22.5	23.7
D.B.H. (O.B.) in cms.	4.4	10.3	16.4	21.6	26.0	29.5	32.4	34.9	38.0	39.5
Volume in cdm.	7	31	91	191	306	428	543	652	808	872

5A/C1b - Dry teak forest M.P. quality IVa

Height in metres	3.9	6.7	9.5	11.6	13.0	14.0	14.7	15.3
D.B.H. (O.B.) in cms.	4.7	11.1	14.7	19.3	22.1	24.3	26.1	28.0
Volume in cdm.	6	33	81	138	187	231	275	310

5A/C1b Dry teak forest M.P. quality IVb

Height in metres	2.9	6.4	9.1	10.8	12.0	12.8	13.4	15.2
D.B.H. (O.B.) in cms.	4.8	11.4	15.8	18.8	21.1	23.3	25.0	-
Volume in cdm.	4	31	68	108	150	191	231	-

5A/C1b - Dry teak forest M.P. quality V

Height in metres	-	1.9	4.6	6.7	8.2	9.1	9.9	10.3
D.B.H. (O.B.) in cms.	-	2.5	8.4	12.8	15.9	18.4	20.2	21.3
Volume in cdm.	-	3	17	39	68	96	120	139

3B/C1b - Moist teak forest M.P. qualities II & III combined

Height in metres	2.4	5.5	9.1	13.4	17.1	20.1	23.5	26.2	28.6	31.1	32.9	34.4
D.B.H. (O.B.) in cms.	9.1	17.0	24.6	32.2	39.9	46.7	52.8	59.9	66.3	72.9	79.2	85.3
Volume in cdm.	17	78	211	437	760	1288	1764	2431	3106	3822	4629	5405

APPENDIX No.3

Girth/Diameter conversion table for teak (*Tectona grandis*) conversion factor d/g 0.316

Girth in cms.	0	1	2	3	4	5	6	7	8	9
Diam.in cms.	Diam.in cms.	Diam.in cms.	Diam.in cms.	Diam.in cms.	Diam.in cms.	Diam.in cms.	Diam.in cms.	Diam.in cms.	Diam.in cms.	Diam.in cms.
0	0	0.3	0.6	0.9	1.3	1.6	1.9	2.2	2.5	2.9
10	3.2	3.5	3.8	4.1	4.4	4.7	5.1	5.4	5.7	6.0
20	6.3	6.6	7.0	7.3	7.6	7.9	8.2	8.5	8.8	9.2
30	9.5	9.8	10.1	10.4	10.7	11.1	11.4	11.7	12.0	12.3
40	12.6	13.0	13.3	13.6	13.9	14.2	14.5	14.9	15.2	15.5
50	15.8	16.1	16.4	16.7	17.1	17.4	17.7	18.0	18.3	18.6
60	19.0	19.3	19.6	19.9	20.2	20.5	20.9	21.2	21.5	21.8
70	22.1	22.4	22.8	23.1	23.4	23.7	24.0	24.3	24.6	25.0
80	25.3	25.6	26.0	26.2	26.5	26.9	27.2	27.5	27.8	28.1
90	28.4	28.8	29.1	29.4	29.7	30.0	30.3	30.7	31.0	31.3

NOTE - The above table gives girth from 0 cms to 99 cms and its corresponding diameters. For girth 100 cms. and above the corresponding diameter can be obtained by multiplying the 2 digit readings by 10.

- Example -**
1. To find out the diameter corresponding 52 cms. girth, read against line of 50. figure of column headed 2. This will give 16.4 cms. diameter.
 2. To find out the diameter corresponding 125 cms girth, find out corresponding diameter (1) for 120 i.e. figures for 12, multiply by 10 (ii) add to it corresponding diameter for 5 cms girth, this comes = $3.8 \times 10 + 1.6 = 39.6$ cms. diameter.



APPENDIX No.4

Type 3B/C1c - South Indian moist deciduous forest/slightly moist teak forest (other than Bastar Region) Statistics of growth of a mean teak (*Tectona grandis*) tree classified by site qualities showing confidence limits (Reference to table no.6)

M.P. quality IVa							M.P. quality III					
Age in years	D.B.H. (O.B.) in cms	Confidence limits in cms.	Ht. in metres	Confidence limits in metres	Vol. in cdm.	Confidence limits in cdm.	D.B.H. (O.B.) in cms	Confidence limits in cms.	Ht. in metres	Confidence limits in metres	Vol. in cdm.	Confidence limits in cdm.
10	5.0	3-7	3.3	2.3-4.3	5	-	6.0	4-8	3.4	2.0-4.8	5	-
20	11.5	5-17	7.0	5.6-8.4	40	10-70	12.0	7.8-16.2	6.8	4.2-9.4	30	10-50
30	17.0	12.4-21.6	9.7	7.5-11.7	95	70-120	18.0	14.0-22.0	9.8	7.2-12.4	90	40-140
40	22.0	19.8-24.2	11.4	8.6-14.2	160	116-204	23.0	18.8-27.2	12.5	9.7-15.3	185	105-265
50	26.0	23.4-28.6	12.7	10.5-14.9	230	212-248	27.0	23.4-30.6	14.7	11.7-17.7	320	202-438
60	29.0	25.4-32.6	13.6	12.0-15.2	325	205-445	31.0	28.2-33.8	16.6	13.6-19.6	480	360-600
70	31.0	25.2-33.8	14.2	13.2-15.2	415	229-601	34.0	31.6-36.4	18.2	15.2-21.2	610	470-750
80	33.0	27.6-38.4	14.5	14.1-14.0	480	212-748	36.5	33.7-39.3	19.2	16.6-21.8	700	546-854
90	33.5	27.9-39.1	14.6	14.2-15.0	515	261-769	38.0	34.4-41.6	20.2	18.0-22.4	760	606-914
100	34.0	29.6-39.4	14.7	14.3-15.1	525	275-775	38.5	34.5-42.5	20.8	19.2-22.4	800	686-914
110							39.0	-	21.0		825	-

Note :- For other quality classes confidence limits could not be worked out for want of adequate basic data.



APPENDIX No.5

Type - 5A/C1b - Southern tropical dry deciduous forest/dry teak forest

Statistics of growth of a mean teak (*Tectona grandis*) tree classified by site qualities showing confidence limits (reference to table no.7)

M.P. quality IVa						M.P. quality III						
Age in years	D.B.H. (O.B.) in cms	Confidence limits in cms	Ht. in metres	Confidence limits in metres	Vol. in cdm.	Confidence limits in cdm.	D.B.H. (O.B.) in cms	Confidence limits in cms	Ht. in metres	Confidence limits in metres	Vol. in cdm.	Confidence limits in cdm.
10	5.0	2.4-7.6	3.1	2.3-3.9	5	0-10	5.0	2.6-7.4	3.0	1.0-5.0	5	0-20
20	10.0	5.0-15.0	6.1	3.5-8.7	30	10-50	10.5	6.9-14.1	6.9	4.3-9.5	40	20-60
30	14.5	9.5-19.5	8.9	5.7-12.1	65	25-105	16.5	13.7-19.3	10.5	7.7-14.3	95	65-125
40	18.5	12.5-24.5	11.2	8.6-13.8	120	40-200	22.0	18.6-25.4	13.7	9.7-17.7	190	90-290
50	22.0	16.0-28.0	13.0	10.6-15.4	190	90-290	26.0	22.2-29.8	16.4	12.4-20.4	305	141-459
60	24.0	18.2-29.8	14.0	10.6-17.4	230	130-330	29.5	24.9-34.1	18.4	16.0-20.8	435	241-629
70	26.0	20.0-32.0	14.8	10.8-18.8	270	110-430	32.5	27.5-37.5	20.0	16.6-23.4	580	340-820
80	28.0	22.2-33.8	15.3	11.3-19.3	300	100-500	35.0	30.0-40.0	21.5	18.1-24.9	710	420-1000
90	29.0	—	15.4	—	325	—	37.0	33.0-41.0	22.5	19.3-25.7	810	518-1102
100	—	—	—	—	—	—	38.5	34.5-42.5	23.2	20.4-26.0	840	540-1140
110	—	—	—	—	—	—	39.0	—	23.4	—	850	—

Note : For other quality classes confidence limits could not be worked out for want of adequate basic data