ESTIMATION OF DIAMETER AT BREAST HEIGHT OF SHISHAM (*DALBERGIA SISSOO* Linn.) FROM STUMP MEASUREMENTS

by

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Summary. *Diameters of shisham trees were measured at 6 inches (15 cm) interval from ground level upto breast height 4.5 feet (1.37 metres). Each set of diameters had a strong linear correlation with diameter breast height. Separate straight line regression equations were developed using sets of diameters at different heights as independent variables and diameter breast height as dependent variable. Estimations of diameter breast height were done from these equations against diameters ranging from 5 to 40 inches (1 cm to 100 cm) at different height along the stem from ground level upto 4 feet (1.22 metres).*

Introduction. Cubical contents given in a local volume table of a species are shown against diameter breast height i.e., 4.5 feet. (1.37 metres) above ground level. In cases of illegal cutting of trees the stump is the only leftover part of the tree which can be used for estimation of volume of the cut tree. Stump heights may vary from tree to tree therefore it became necessary to develop a relationship between diameter breast height and diameter at different heights along the stem of tree.

Basic Data. Diameter measurement overbark at 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 and 4.5 feet heights above ground level were recorded with diameter tape on 223 trees of trees of shisham (*Dalbergia sissoo*) ranging in diameter breast height from 2 inch to 26 inch in different irrigated plantation. The extent of data and number of trees in each diameter class are given in table 1.

Method. Each set of diameters at different heights were separately correlated with the set of diameters at breast height. The results revealed that there was a strong linear correlation between the two in each of 8 individual cases. This led to the derivation of simple linear equations by the least square method for each set of diameters taking dbh as dependent (Y) and diameter at 0.5, 1.0, 1.5 feet etc., above ground level as independent variable (Xi, where i varies from 1 to 8). The regression equations with respective correlation coefficients are given in table 2.

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Table 1

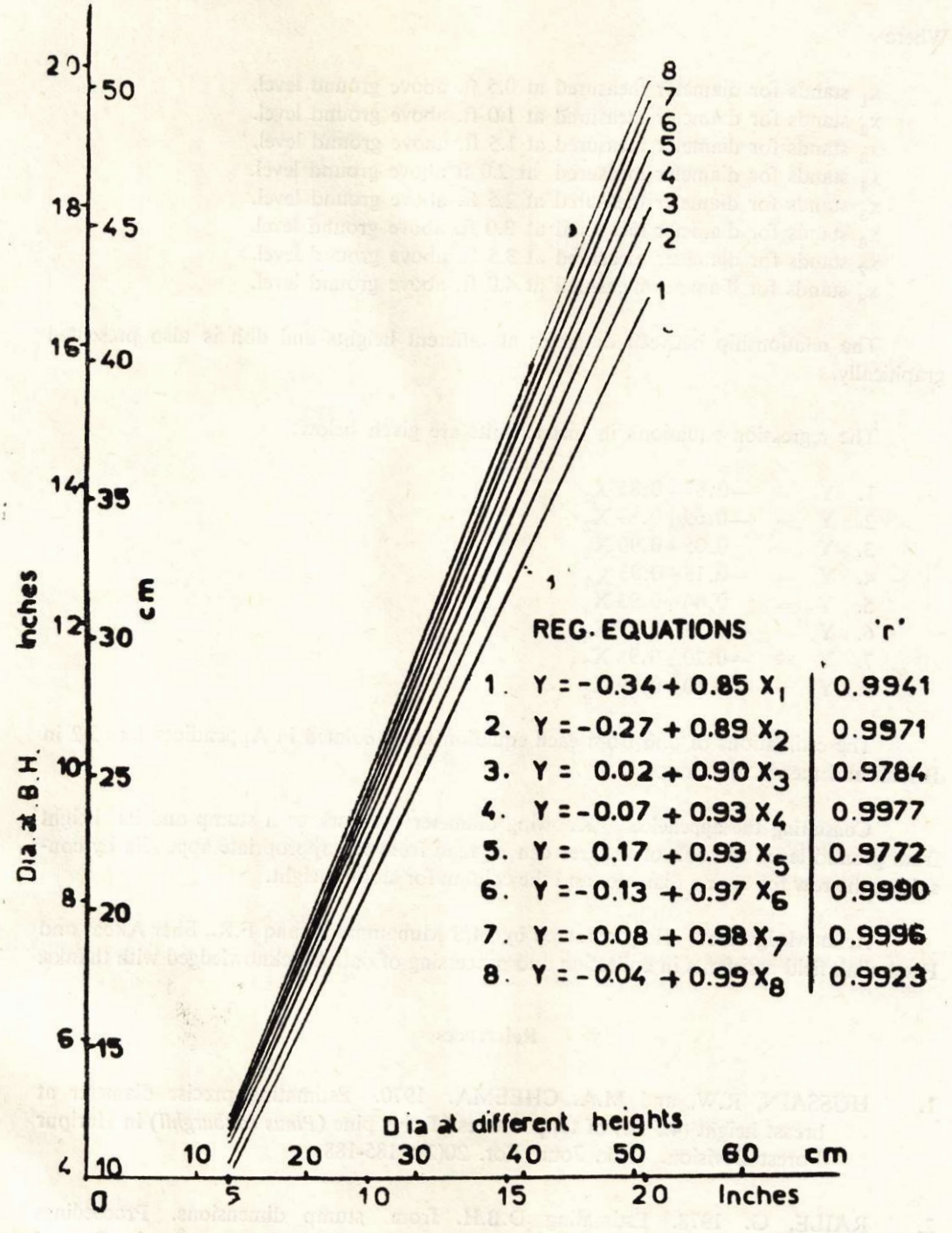
Frequency of measured trees in each diameter class.

Dia class (inch)	No. of tree	Dia. class (inch)	No. of trees
2	10	14	8
3	10	15	11
4	10	16	8
5	9	17	10
6	9	18	12
7	11	19	10
8	10	20	13
9	12	21	10
10	10	22	5
11	13	23	10
12	8	24	4
13	7	25	2
		26	1
		Total:	223

Table 2

Regression equations for estimation of dbh (Y) from diameters taken at different heights from ground level (X_i, $i = 1$ *to* 8).

S. No.	Regression equation	Correlation coefficients(y)
1	$Y = -0.34+0.85\ X_1$	0.9941
2	$Y = -0.27+0.89\ X_2$	0.9971
3	$Y = 0.02+0.90\ X_3$	0.9784
4	$Y = -0.07+0.93\ X_4$	0.9977
5	$Y = 0.17+0.93\ X_5$	0.9772
6	$Y = -0.13+0.97\ X_6$	0.9990
7	$Y = -0.08+0.98\ X_7$	0.9996
8	$Y = -0.04+0.99\ X_8$	0.9923


Dia. at B.H.
inches
cm
Dia at different heights
cm
Inches
REG. EQUATIONS
'r'
1. Y = -0.34 + 0.85 X1 | 0.9941
2. Y = -0.27 + 0.89 X2 | 0.9971
3. Y = 0.02 + 0.90 X3 | 0.9784
4. Y = -0.07 + 0.93 X4 | 0.9977
5. Y = 0.17 + 0.93 X5 | 0.9772
6. Y = -0.13 + 0.97 X6 | 0.9990
7. Y = -0.08 + 0.98 X7 | 0.9996
8. Y = -0.04 + 0.99 X8 | 0.9923

Where

x_1 stands for diameter measured at 0.5 ft. above ground level.
x_2 stands for diameter measured at 1.0 ft. above ground level.
x_3 stands for diameter measured at 1.5 ft. above ground level.
x_4 stands for diameter measured at 2.0 ft above ground level.
x_5 stands for diameter measured at 2.5 ft. above ground level.
x_6 stands for diameter measured at 3.0 ft. above ground level.
x_7 stands for diameter measured at 3.5 ft. above ground level.
x_8 stands for diameter measured at 4.0 ft. above ground level.

The relationship between diameter at different heights and dbh is also presented graphically.

The regression equations in metric units are given below:

1. $Y = -0.87 + 0.85 X_1$
2. $Y = -0.69 + 0.89 X_2$
3. $Y = 0.05 + 0.90 X_3$
4. $Y = -0.18 + 0.93 X_4$
5. $Y = 0.44 + 0.93 X_5$
6. $Y = -0.33 + 0.97 X_6$
7. $Y = -0.20 + 0.98 X_7$
8. $Y = -0.10 + 0.99 X_8$

The estimations of dbh from each equation are tabulated in Appendices 1 and 2 in British and metric units respectively.

Consulting the appendices. Knowing diameter overbark of a stump and its height from ground level, the dbh of the tree can be read from the appropriate appendix by consulting the row for stump diameter and the column for stump height.

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References

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Appendix I

DIAMETER BREAST HEIGHT ESTIMATED FROM DIAMETER STUMP HEIGHT IN BRITISH UNITS

Xi	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
	Stump Height (Feet)							
Dia (inches)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
	Diameter Breast Height (Inches)							
0.5	0.1	0.2	0.5	0.4	0.6	0.3	0.4	0.4
1.0	0.5	0.6	0.9	0.9	1.1	0.8	0.9	0.9
1.5	0.9	1.2	1.4	1.3	1.6	1.3	1.4	1.4
2.0	1.4	1.5	1.8	1.8	2.0	1.8	1.9	1.9
2.5	1.8	1.9	2.3	2.2	2.5	2.3	2.4	2.4
3.0	2.2	2.4	2.7	2.7	3.0	2.8	2.9	2.9
3.5	2.6	2.8	3.2	3.2	3.4	3.3	3.3	3.4
4.0	3.1	3.3	3.6	3.6	3.9	3.7	3.8	3.9
4.5	3.5	3.7	4.1	4.1	4.3	4.3	4.3	4.4
5.0	3.9	4.2	4.5	4.6	4.8	4.7	4.8	4.9
5.5	4.3	4.6	5.0	5.0	5.3	5.2	5.3	5.4
6.0	4.8	5.1	5.4	5.5	5.7	5.7	5.8	5.9
6.5	5.2	5.5	5.9	6.0	6.2	6.2	6.3	6.4
7.0	5.6	6.0	6.3	6.4	6.7	6.7	6.8	6.9
7.5	6.0	6.4	6.8	6.9	7.1	7.1	7.3	7.4
8.0	6.5	6.8	7.2	7.4	7.6	7.6	7.8	7.9
8.5	6.9	7.3	7.7	7.8	8.1	8.1	8.2	8.4
9.0	7.3	7.7	8.1	8.3	8.5	8.6	8.7	8.9
9.5	7.7	8.2	8.6	8.8	9.0	9.1	9.2	9.4
10.0	8.2	8.6	9.0	9.3	9.5	9.6	9.7	9.9
10.5	8.6	9.1	9.5	9.7	9.9	10.0	10.2	10.3
11.0	8.9	9.5	9.9	10.2	10.4	10.5	10.7	10.8
11.5	9.4	10.0	10.4	10.6	10.9	11.0	11.2	11.3
12.0	9.9	10.4	10.8	11.1	11.3	11.5	11.7	11.8

Xi Dia (inches)	X_1 0.5	X_2 1.0	X_3 1.5	X_4 2.0	X_5 2.5	X_6 3.0	X_7 3.5	X_8 4.0
	Diameter Breast Height (Inches)							
12.5	10.3	10.9	11.3	11.5	11.8	12.0	12.2	12.3
13.0	10.7	11.3	11.7	12.0	12.3	12.5	12.7	12.8
13.5	11.1	11.7	12.2	12.5	12.7	13.0	13.1	13.3
14.0	11.6	12.2	12.6	12.9	13.2	13.4	13.6	13.8
14.5	12.0	12.6	13.1	13.4	13.6	13.9	14.1	14.3
15.0	12.4	13.1	13.5	13.9	14.1	14.4	14.6	14.8
15.5	12.8	13.5	14.0	14.3	14.6	14.9	15.1	15.3
16.0	13.3	14.0	14.4	14.8	15.0	15.4	15.6	15.8
16.5	13.9	14.4	14.9	15.3	15.5	15.9	16.1	16.3
17.0	14.1	14.9	15.3	15.7	16.0	16.4	16.6	16.8
17.5	14.5	15.3	15.8	16.2	16.4	16.8	17.1	17.3
18.0	15.0	15.7	16.2	16.7	16.9	17.3	17.6	17.8
18.5	15.4	16.2	16.7	17.1	17.4	17.8	18.0	18.3
19.0	15.8	16.6	17.1	17.6	17.8	18.3	18.5	18.8
19.5	16.2	17.1	17.6	18.1	18.3	18.8	19.0	19.3
20.0	16.7	17.5	18.0	18.5	18.8	19.3	19.5	19.8
20.5	17.1	18.0	18.5	19.0	19.2	19.7	20.0	20.2
21.0	17.5	18.4	18.9	19.5	19.7	20.2	20.5	20.7
21.5	17.9	18.9	19.4	19.9	20.2	20.7	21.0	21.2
22.0	18.4	19.3	19.8	20.4	20.6	21.2	21.5	21.7
22.5	18.8	19.7	20.3	20.8	21.1	21.7	22.0	22.2
23.0	19.2	20.2	20.7	21.3	21.6	22.2	22.5	22.7
23.5	19.6	20.6	21.2	21.8	22.0	22.7	22.9	23.2
24.0	20.1	21.1	21.6	22.2	22.5	23.1	23.4	23.7
24.5	20.5	21.5	22.1	22.7	22.9	23.6	23.9	24.2
25.0	20.9	22.0	22.5	23.2	23.4	24.1	24.4	24.7
25.5	21.3	22.4	23.0	23.6	23.9	24.6	24.9	25.2
26.0	21.8	22.9	23.4	24.1	24.3	25.1	25.4	25.7
26.5	22.2	23.3	23.9	24.6	24.8	25.6	25.9	26.2

Xi Dia (inches)	X_1 0.5	X_2 1.0	X_3 1.5	X_4 2.0	X_5 2.5	X_6 3.0	X_7 3.5	X_8 4.0
	Diameter Breast Height (inches)							
27.0	22.6	23.8	24.3	25.0	25.3	26.1	26.4	26.7
27.5	23.0	24.2	24.8	25.5	25.7	26.5	26.9	27.2
28.0	23.4	24.6	25.2	26.0	26.2	27.0	27.4	27.7
28.5	23.9	25.1	25.7	26.4	26.7	27.5	27.8	28.2
29.0	24.3	25.5	26.1	26.9	27.1	28.0	28.3	28.7
29.5	24.7	26.0	26.6	27.4	27.6	28.5	28.8	29.2
30.0	25.2	26.4	27.0	27.8	28.1	29.0	29.3	29.7
30.5	25.6	26.9	27.5	28.3	28.5	29.4	29.8	30.1
31.0	26.0	27.3	27.9	28.8	29.0	29.9	30.3	30.6
31.5	26.4	27.8	28.4	29.2	29.5	30.	30.8	31.1
32.0	26.9	28.2	28.8	29.7	29.9	30.9	31.3	31.6
32.5	27.3	28.6	29.3	30.1	30.4	31.4	31.8	32.1
33.0	27.7	29.1	29.7	30.6	30.9	31.9	32.3	32.6
33.5	28.1	29.5	30.2	31.1	31.3	32.4	32.7	33.1
34.0	28.6	30.0	30.6	31.5	31.8	32.8	33.2	33.6
34.5	29.0	30.4	31.1	32.0	32.2	33.3	33.7	34.1
35.0	29.4	30.9	31.5	32.5	32.7	33.8	34.2	34.6
35.5	29.8	31.3	32.0	32.9	33.2	34.3	34.7	35.1
36.0	30.3	31.8	32.4	33.4	33.6	34.8	35.2	35.6
36.5	30.7	32.2	32.9	33.9	34.1	35.3	35.7	36.1
37.0	31.1	32.7	33.3	34.3	34.6	35.8	36.2	36.6
37.5	31.5	33.1	33.8	34.8	35.0	36.2	36.7	37.1
38.0	32.0	33.5	34.2	35.3	35.5	36.7	37.2	37.6
38.5	32.4	34.0	34.7	35.7	36.0	37.2	37.6	38.1
39.0	32.8	34.4	35.1	36.2	36.4	37.7	38.1	38.6
39.5	33.2	34.9	35.6	36.7	36.9	38.2	38.6	39.1
40.0	33.7	35.3	36.0	37.1	37.4	38.7	39.1	39.6

Appendix 2

DIAMETER BREAST HEIGHT ESTIMATED FROM DIAMETER STUMP HEIGHT IN METRIC UNITS

Xi Dia (cm)	Stump Height (centimetres)							
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
	15	30	46	61	76	92	107	122
	Diameter Breast Height (inches)							
1	—	0.2	0.9	0.7	1.4	0.6	0.8	0.9
2	0.8	1.1	1.8	1.7	2.3	1.6	1.8	1.9
3	1.7	2.0	2.7	2.6	3.2	2.6	2.7	2.9
4	2.5	2.9	3.6	3.5	4.2	3.5	3.7	3.9
5	3.4	3.8	4.5	4.5	5.1	4.5	4.7	4.8
6	4.2	4.6	5.4	5.4	6.0	5.5	5.7	5.8
7	5.1	5.5	6.3	6.3	6.9	6.5	6.7	6.8
8	5.9	6.4	7.2	7.3	7.9	7.4	7.6	7.8
9	6.8	7.3	8.1	8.2	8.8	8.4	8.6	8.8
10	7.6	8.2	9.0	9.1	9.7	9.4	9.6	9.8
11	8.5	9.1	9.9	10.0	10.7	10.3	10.6	10.8
12	9.3	10.0	10.8	11.0	11.6	11.3	11.6	11.8
13	10.2	10.9	11.7	11.9	12.5	12.3	12.5	12.8
14	11.0	11.8	12.6	12.8	13.5	13.2	13.5	13.8
15	11.9	12.7	13.5	13.8	14.4	14.2	14.5	14.7
16	12.7	13.5	14.4	14.7	15.3	15.2	15.5	15.7
17	13.6	14.4	15.3	15.6	16.2	16.2	16.5	16.7
18	14.4	15.3	16.2	16.6	17.2	17.1	17.4	17.7
19	15.3	16.2	17.1	17.5	18.1	18.1	18.4	18.7
20	16.1	17.1	18.0	18.4	19.0	19.1	19.4	19.7
21	17.0	18.0	18.9	19.3	20.0	20.0	20.4	20.7
22	17.8	18.9	19.8	20.3	20.9	21.0	21.4	21.7
23	18.7	19.8	20.7	21.2	21.8	22.0	22.3	22.7
24	19.5	20.7	21.6	22.1	22.8	22.9	23.3	23.7
25	20.4	21.6	22.5	23.1	23.7	23.9	24.3	24.6
26	21.2	22.4	23.4	24.0	24.6	24.9	25.3	25.6

Xi Dia (cm)	X_1 15	X_2 30	X_3 46	X_4 61	X_5 76	X_6 92	X_7 107	X_8 122
	Diameter Breast Height (centimetres)							
27	22.1	23.3	24.3	24.9	25.5	25.9	26.3	26.6
28	22.9	24.2	25.2	25.9	26.5	26.8	27.2	27.6
29	23.8	25.1	26.1	26.8	27.4	27.8	28.2	28.6
30	24.6	26.0	27.0	27.7	28.3	28.8	29.2	29.6
31	25.5	26.9	27.9	28.6	29.3	29.7	30.2	30.6
32	26.3	27.8	28.8	29.6	30.2	30.7	31.2	31.6
33	27.2	28.7	29.7	30.5	31.1	31.7	32.1	32.6
34	28.0	29.6	30.6	31.4	32.1	32.6	33.1	33.6
35	28.9	30.5	31.5	32.4	33.0	33.6	34.1	34.5
36	29.7	31.3	32.4	33.3	33.9	34.6	35.1	35.5
37	30.6	32.2	33.3	34.2	34.8	35.6	36.1	36.5
38	31.4	33.1	34.2	35.2	35.8	36.5	37.0	37.5
39	32.3	34.0	35.1	36.1	36.7	37.5	38.0	38.5
40	33.1	34.9	36.0	37.0	37.6	38.5	39.0	39.5
41	34.0	35.8	36.9	37.9	38.6	39.4	40.0	40 .5
42	34.8	36.7	37.8	38.9	39.5	40.4	41.0	41.5
43	35.7	37.6	38.7	39.8	40.4	41.4	41.9	42.5
44	36.5	38.5	39.6	40.7	41.4	42.3	42.9	43.5
45	37.4	39.4	40.5	41.7	42.3	43.3	43.9	44.4
46	38.2	40.2	41.4	42.6	43.2	44.3	44.9	45.4
47	39.1	41.1	42.3	43.5	44.1	45.3	45.8	46.4
48	39.9	42.0	43.2	44.5	45.1	46.2	46.8	47.4
49	40.8	42.9	44.1	45.4	46.0	47.2	47.8	48.4
50	41.6	43.8	45.0	46.3	46.9	48.2	48.8	49.4
51	42.5	44.7	45.9	47.2	47.9	49.1	49.8	50.4
52	43.3	45.6	46.8	48.2	48.8	50.1	50.8	51.4
53	44.2	46.5	47.7	49.1	49.7	51.1	51.7	52.4
54	45.0	47.4	48.6	50.0	50.7	52.0	52.7	53.4
55	45.9	48.3	49.5	51.0	51.6	53.0	53.7	54.3
56	46.7	49.1	50.4	51.9	52.5	54.0	54.7	55.3

Xi Dia (cm)	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
	15	30	46	61	76	92	107	122
	Diameter Breast Height (centimetres)							
57	47.6	50.0	51.3	52.8	53.4	55.0	55.7	56.3
58	48.4	50.9	52.2	53.8	54.4	55.9	56.7	57.3
59	49.3	51.8	53.1	54.7	55.3	56.9	57.6	58.3
60	50.1	52.7	54.0	55.6	56.2	57.9	58.6	59.3
61	51.0	53.6	54.9	56.5	57.2	58.8	59.6	60.3
62	51.8	54.5	55.8	57.5	58.1	59.8	60.6	61.3
63	52.7	55.4	56.7	58.4	59.0	60.8	61.5	62.3
64	53.5	56.3	57.6	59.3	60.0	61.7	62.5	63.3
65	54.4	57.2	58.5	60.3	60.9	62.7	63.5	64.2
66	55.2	58.0	59.4	61.2	61.8	63.7	64.5	65.2
67	56.1	58.9	60.3	62.1	62.7	64.7	65.5	66.2
68	56.9	59.8	61.2	63.1	63.7	65.6	66.4	67.2
69	57.8	60.7	62.1	64.0	64.6	66.6	67.4	68.2
70	58.6	61.6	63.0	64.9	65.5	67.6	68.4	69.2
71	59.5	62.5	63.9	65.8	66.5	68.5	69.4	70.2
72	60.3	63.4	64.8	66.8	67.4	69.5	70.4	71.2
73	61.2	64.3	65.7	67.7	68.3	70.5	71.3	72.2
74	62.0	65.2	66.6	68.6	69.3	71.4	72.3	73.2
75	62.9	66.1	67.5	69.6	70.2	72.4	73.3	74.1
76	63.7	66.9	68.4	70.5	71.1	73.4	74.3	75.1
77	64.6	67.8	69.3	71.4	72.0	74.4	75.3	76.1
78	65.4	68.7	70.2	72.4	73.0	75.3	76.2	77.1
79	66.3	69.6	71.1	73.3	73.9	76.3	77.2	78.1
80	67.1	70.5	72.0	74.2	74.8	77.3	78.2	79.1
81	68.0	71.4	72.9	75.1	75.8	78.2	79.2	80.1
82	68.8	72.3	73.8	76.1	76.7	79.2	80.2	81.1
83	69.7	73.2	74.7	77.0	77.6	80.2	81.1	82.1
84	70.5	74.1	75.6	77.9	78.6	81.1..	82.1	83.1
85	71.4	75.0	76.5	78.9	79.5	82.1	83.1	84.0
86	72.2	75.8	77.4	79.8	80.4	83.1	84.1	85.1
87	73.1	76.7	78.3	80.7	81.3	84.1	85.1	86.0
88	73.9	77.6	79.2	81.7	82.3	85.0	86.0	87.0
89	74.8	78.5	80.1	82.6	83.2	86.0	87.0	88.0
90	75.6	79.4	81.0	83.5	84.1	86.8	88.0	89.0
91	76.5	80.3	81.9	84.4	85.1	87.9	89.0	90.0

Xi Dia (cm)	X_1 15	X_2 30	X_3 46	X_4 61	X_5 76	X_6 92	X_7 107	X_8 122
	Diameter Breast Height (centimetres)							
92	77.3	81.2	82.8	85.4	86.0	88.9	90.0	91.0
93	78.2	81.1	83.7	86.3	86.9	89.9	90.9	92.0
94	79.0	83.0	84.6	87.2	87.9	90.8	91.9	93.0
95	79.9	83.9	85.5	88.2	88.8	91.8	92.9	93.9
96	80.7	84.7	86.4	89.1	89.7	92.8	93.9	94.9
97	81.8	85.6	87.3	90.0	90.6	93.8	94.9	95.9
98	82.4	86.5	88.2	91.0	91.6	94.7	95.9	96.9
99	83.3	87.4	89.1	91.9	92.5	95.7	96.8	97.9
100	84.1	88.3	90.0	92.8	93.4	96.7	97.8	98.9