TEAK TREE INVENTORY AND AUDIT REPORT-2022

CONDUCTED FOR

ASIA TEAK GROUP

AT

CHON DEAN 1 (268) ESTATE

THAILAND

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2022 June

Contents

Content of Tables

Content of Figures

Content of Graphs

Executive summary

Teak plantation namely Chon Dean 1 , managed by Asia Teak Tropical Plantation was inspected by Mr.Paul Rockwood, Mr.J.M.P. Jayalath and me on 2022.5.24-25. Due to Corvid-19 travel restriction, Thailand inventory team carried out the usual inventories and auditing of the tree stocks of the plantations in 2021. All the sample data were collected throughout audit process under our close supervision in this year. Inventory data collected from the plantation was computerized. ,analyzed and prepared this report. Only the total tree number which was counted in 2020 was used for this year.

Chon Dean 01 estate

Twenty sample plots having with total sample area of 30048m^2 have been permanently setup in different locations in Chon Dean 01 estate. It is found by this study that total estimated planted area is 27.93 ha and sample plots represent 10.7 % of population. In this study, 979 trees were measured for DBH measurement. Due to unavoidable circumstance of Covid 19, Tree height measurements of small number of trees were taken. Total block tree number, good trees, tree marked for thinning and reserved tree were not taken in this year.

The average GBH of trees in the estate is 84.9cn (DBH is 27) cm. It is found that average trees per ha is 335. Details of block wise tree information are shown in table (3.4). It was observed that minor errors have occurred when counting number of trees in few blocks comparing with last year. It is absolutely negligible and acceptable in forest inventory as human errors.

After analyzing the last 10 years of DBH data (2013-2022), periodic increment for block no.8 is 1.05 cm per year and this figure for block 05 is very low as 0.44 cm per year.

Analyzing inventory tree data it is found that more than 43% of trees are having GBH more than 85 cm. (see graph 3.1-page (?) and table 3.2 and 3.2.1 (page ?). The total tree number under this category is 3932 out of 9136. Highest number (66%) of trees of this category were found in Block 8. When compare the growth rate of Blocks with previuos year, Block 3 and 5 showed slow growth in this year. This may be due to higher tree density of this two blocks (block 5-352 trees/ha) and Block 3- 375 trees/ha). These findings can be used for future planning of thinning and final mode of harvest.

When analysed the growth data (DBH) from 2013 to 2022, the periodic increment of DBH of the plantation is 0.67cm however we found that DBH increment for 2020 to 2022 is 2.31cm which means that annual increment of DBH is 1.15cm for last two years.

To get 0.8 m3 commercial log volume (11.5m length, minimum girth of 69cm at small end) , the tree needs to be with 116 cm GBH and 93 cm mid girth. At the moment, there are 34 trees which are more than 116 GBH.

These findings can be used for future planning of thinning and final mode of harvest. If we carefully and scientifically handle this valuable tree information, we will able to achieve highest turnover from these two plantations at end of felling rotation.

Finally it can be concluded that both teak plantation are healthy and good condition according to received information. There are much more potential to get more growth increment particularly for tree stem diameter for next coming years as explained with figures in this report if the plantation is maintained and managed scientifically.

1. Introduction

1.1. General Introduction of Teak (*Tectona grandis*) Plantation

Teak (*Tectona grandis* L.f.) is a highly valuable timber in International trade sought by wood industries to produce good quality furniture and wood for house construction, carving, shipbuilding and many other purposes and Teak is an important timber species for tropical forestry. Today teak is a profitable plantation crop promoted by government agencies, the private sector and farmers. Teak plantations are widely established across Indonesia, Thailand, Sri Lanka etc. in some places, they have become an inseparable part of local cultural and socioeconomic systems.

Bole form

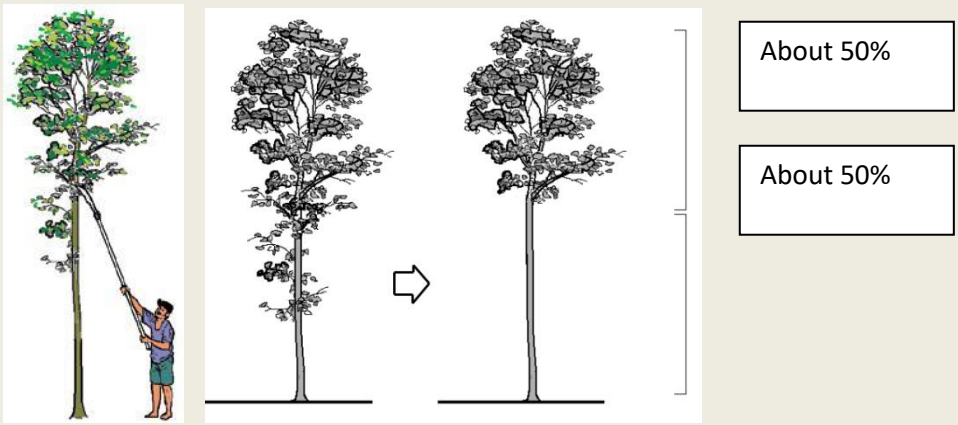
Fluting (irregular involutions and swellings) in the teak stem has been observed in a number of plantations. In some study, the mean heritability value of stem straightness was found to be 0.83, indicating that the character for stem straightness is strongly controlled by provenance and is thus genetically inherited (Kaosa-ard, 1999). Hence, fluting can be minimized if the appropriate provenance is used in breeding trials to produce plants that exhibit straight stems. The most important form characteristic determining the value of teak logs is the length of the clear bole.

1.2. Activities of teak stand maintenance

Teak grows well, grows fast, and produces high-quality timber when the land and trees are well maintained. Maintenance includes weeding, fertilizing, replanting, pruning, thinning, maintaining coppices and controlling pests and diseases.

1.2.1. Pruning

Pruning is the removal of branches which increases clear bole height and reduces knots on the main stem



Recommended height to which branches should be pruned

1.2.2. Thinning

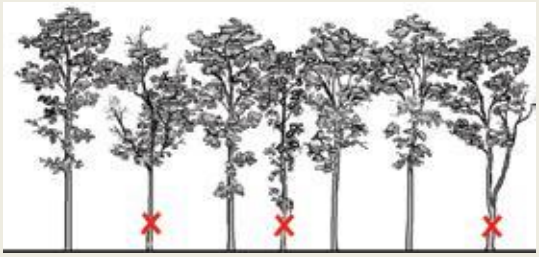
By competition for light, water and nutrients is greater in closely spaced plantations causing slower tree growth and tall, skinny stems. Thinning will encourage better growth for the good quality trees that remain.

1.3. Spacing

The spacing of trees and the number, timing and intensity of thinning strongly affect the pattern of growth and the yield of the plantation. If thinning is practiced late, growth rates decline or cease, whereas if the stand is thinned too early or too heavily, the trees have a greater tendency to produce side branches and epicormic shoots. This also reduces the potential yield of the plantation since growth is diverted from the main stem, which should be free from defects such as those caused by side branches and epicormic shoots.

Table A: Trees left after thinning based on tree height

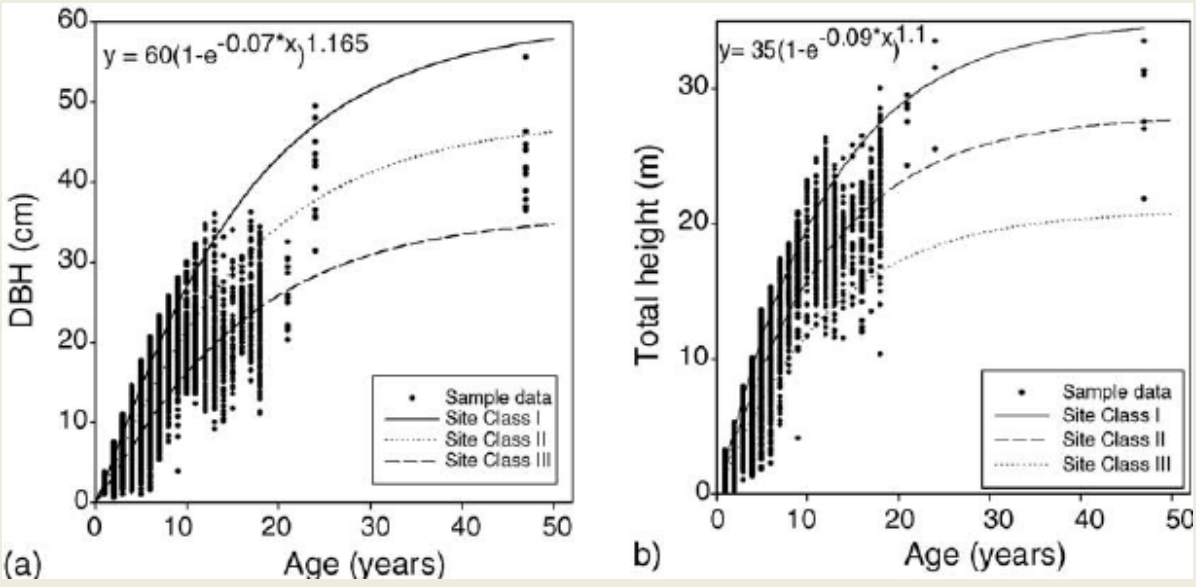
Tree height (m)	Trees remaining (trees/ha)	Age (yr) (range based on soil fertility)	Spacing (m)
11.0–13.0	1300–1500	5–11	2.5–3.0
13.5–15.5	1000–1100	7–17	3.0
15.5–17.0	800–850	10–21	3.5
17.5–21.0	500–550	15–34	4.0–4.5



1.3.1. Teak growth parameters

Height (H) and diameter at breast height (dbh) are the most important measures of tree growth and their relationship is useful in determining site-index, calculating tree volume, evaluating site –quality and predicting future growth of the stand (Jayaraman and Zakrzewski,2001).

Following growth information published by researchers can be used to develop the yield prediction table for present teak plantation of Asia Teak group.



(a) Teak growth curve : DBH against age (b)Teak growth curve : Total height against age

1.4. Positions of diameter measurement at different conditions

We followed following standard governing rules when take measurement of diameter at breast height of tree stem. Ex: clean the bole surface where we measure the stem diameter, diameter tape always correctly handled and read data carefully for reporting.

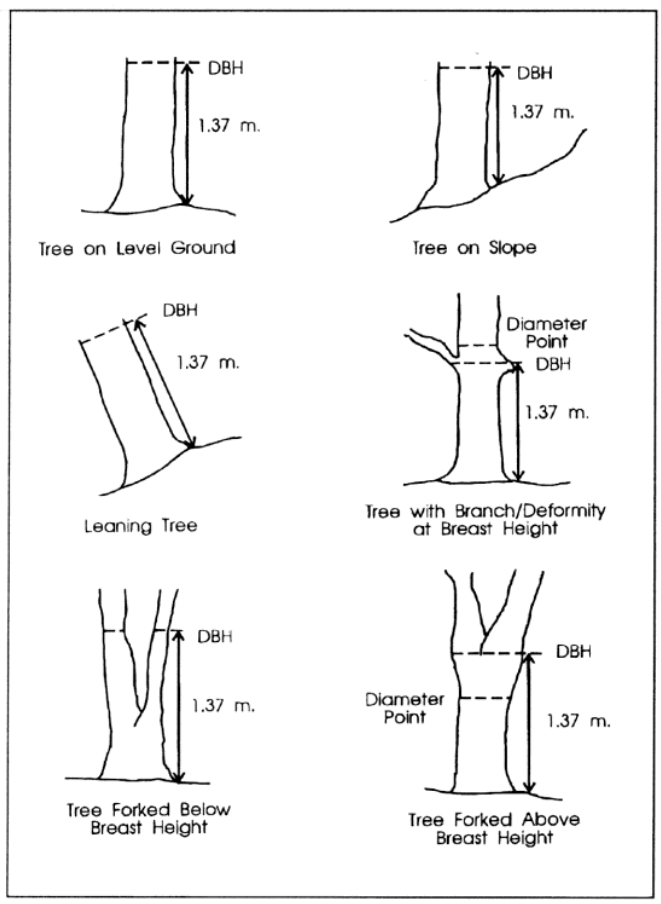


Figure: 2.1 Diameter tape used for the inventory

1.5. Tree height measurement

Height is a tree variable that is used to estimate or determine the volume of a tree. The total height is the distance between the ground and top of the tree and bole height is the distance between the ground and the Crown Point.Merchantable height: the distance between the ground and the terminal position of the last useable portion of the tree stem.Tree height is defined to be the perpendicular distance between the ground level and the top of the tree. While, Tree length is the distance between the stem foot and the top along the stem

1.5.1. Method of tree height measurement

There are two methods; one is direct method which involves using height measuring rods only for small trees. Other method we used is trigonometric principles.Sunnto hypsometer used as instrument for this purpose

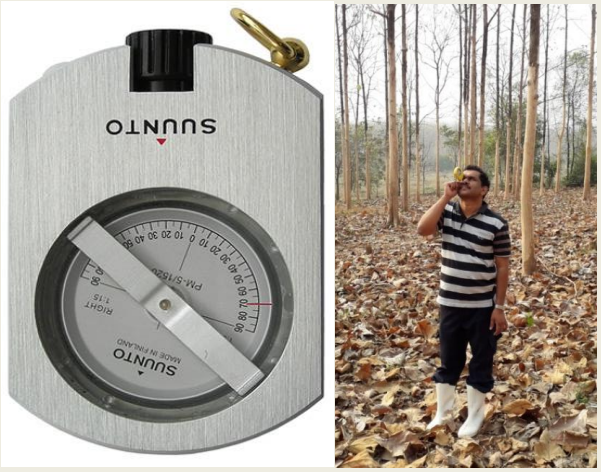
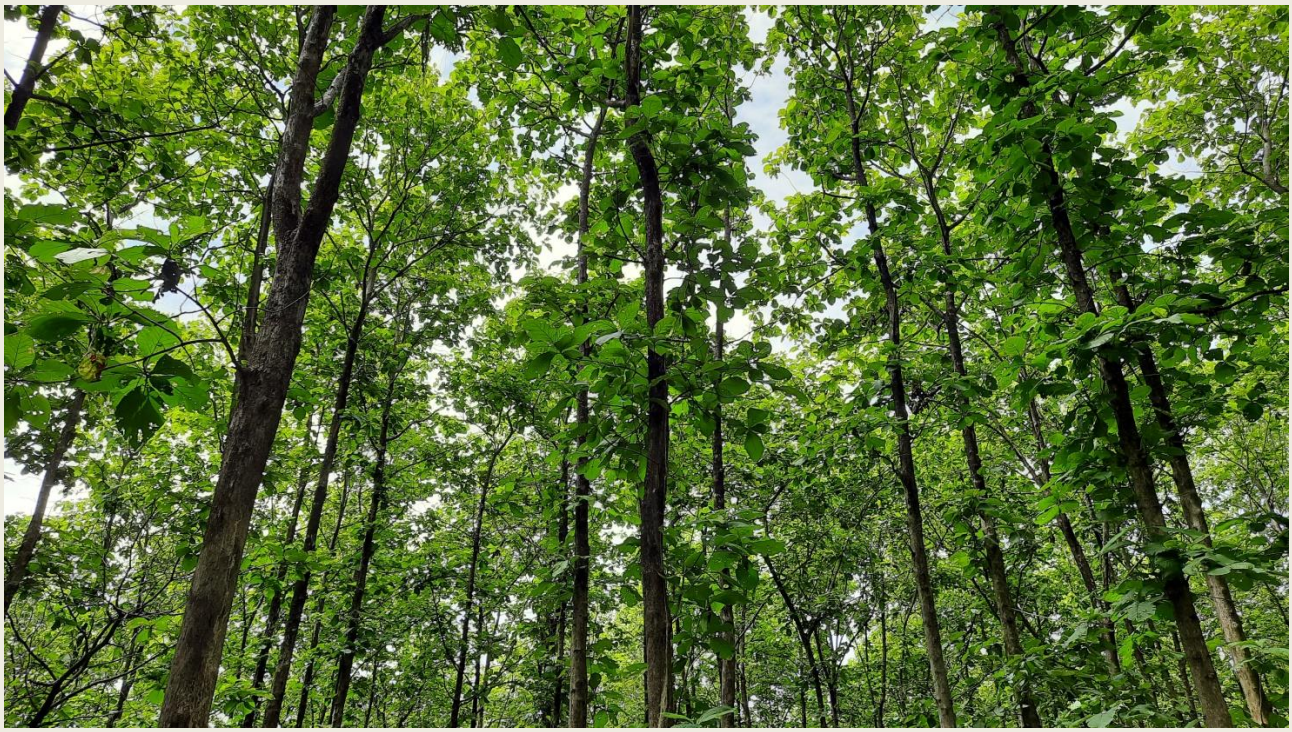


Figure 2.2. Total Tree height was measured by hypsometer, used instrument is shown in left side



Part of healthy plantation and canopy is not closed in this area

1.5.2. Plot size:

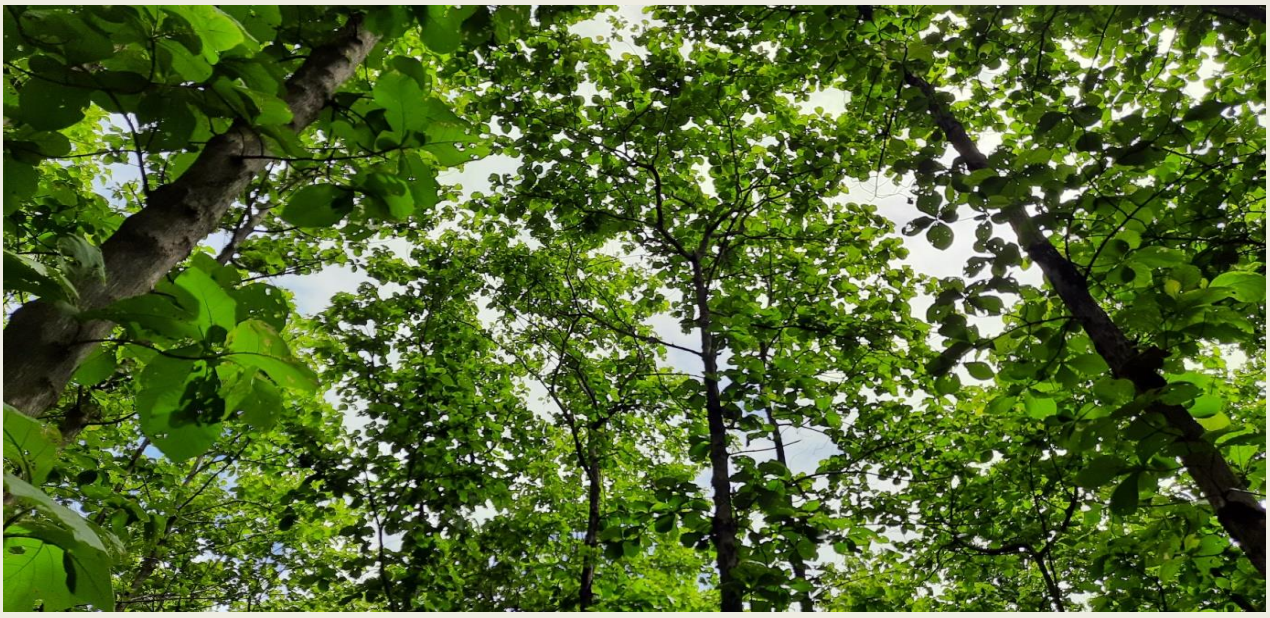
All the plots of block 01, Block 3, Block 4, Block 6, block 7 and Plot 1 of Block 8 are 40m x 40m. Plot 1 of Block 2 and Block 5 are 28m x 28m. Plot 2 of Block 8 is 40m x 32m.

Figure: Tree Girth measurement (cm) and absent of trees (x) in Chon Dean 1 plantation.

(i) 40m x 40 m =1600m2 size of plots in Chon Dean 1

Figure 2.3: example of plot

98	115	x	92	x	91	x	89	x	x
x	x	x	x	63	71	x	x	x	x
x	86	96	x	x	x	x	81	67	x
80	x	60	x	88	65	x	x	x	95
x	69	100	x	x	x	x	x	x	x
x	x	x	92	x	x	97	95	x	x
x	103	x	x	x	101	x	66	67	74
80	x	x	87	61	x	x	x	78	x
71	83	89	x	x	68	65	85	70	x
72	81	82	x	85	59	70	59	x	62



It is observed that clean bole height of average tree is around 11.5 and average height is 19-23m

2. Results of inventory of teak plantation

2.1. Estate of Chon Dean 01

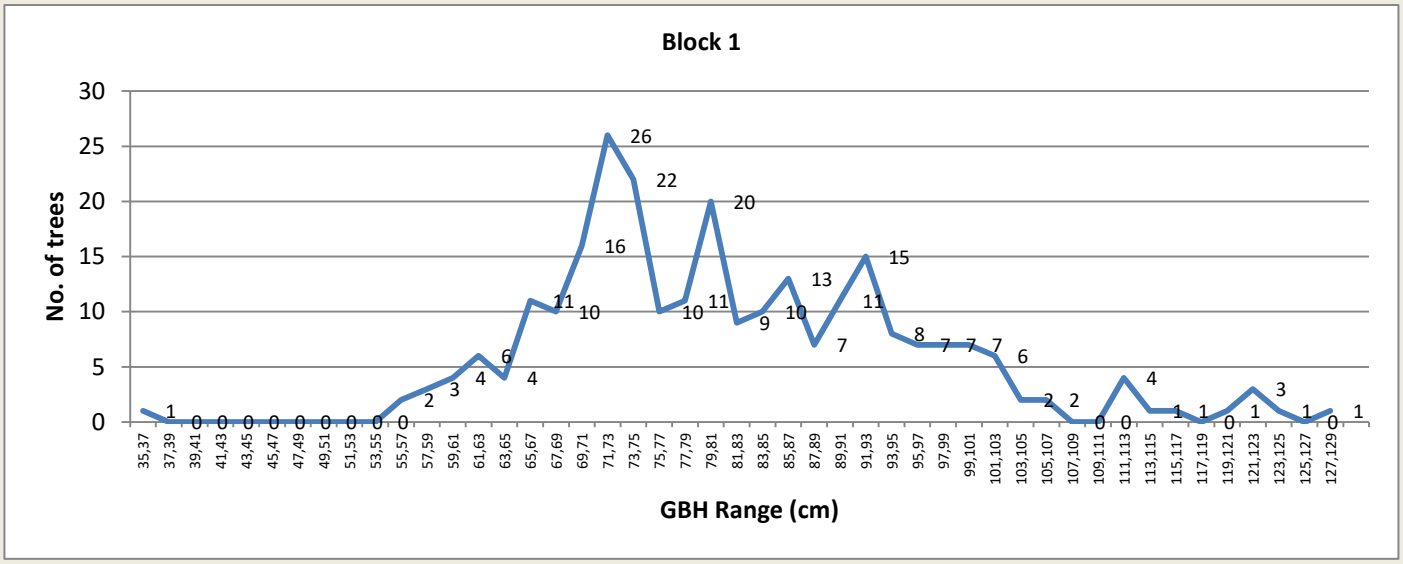
Table 2.1. Number of trees and tree mean GBH values in plots in Chon Dean 1

Plot number (P)	Block 01		Block 02		Block 03		Block 04	
	No. of trees	Mean GBH (cm)	No. of Trees	Mean GBH (cm)	No. of Trees	Mean GBH (cm)	No. of Trees	Mean GBH (cm)
1	47	87.13	28	82.25	58	80.33	56	84.7
2	52	74.73			62	82.42	44	91.65
3	53	79.81					44	87
4	47	85.7					60	82.3
5	53	83.03						
Mean	**50.4**	**82.08**	**28**	**82.25**	**60**	**81.37**	**51**	**86.41**
TOTAL	**252**		**28**		**120**		**204**	

Plot number (P)	Block 05		Block 06		Block 07		Block 08	
	No.of trees	Mean GBH (cm)	No.of Trees	Mean GBH (cm)	No. of Trees	Mean GBH (cm)	No.of Trees	Mean GBH (cm)
1	30	79.83	50	87.26	60	79.12	55	92.23
2			48	82.6	45	84.98	38	104.09
3					49	88		
Mean	**30**	**79.83**	**49**	**84.93**	**51.3**	**84.03**	**46.5**	**98.16**
TOTAL	**30**		**98**		**154**		**93**	

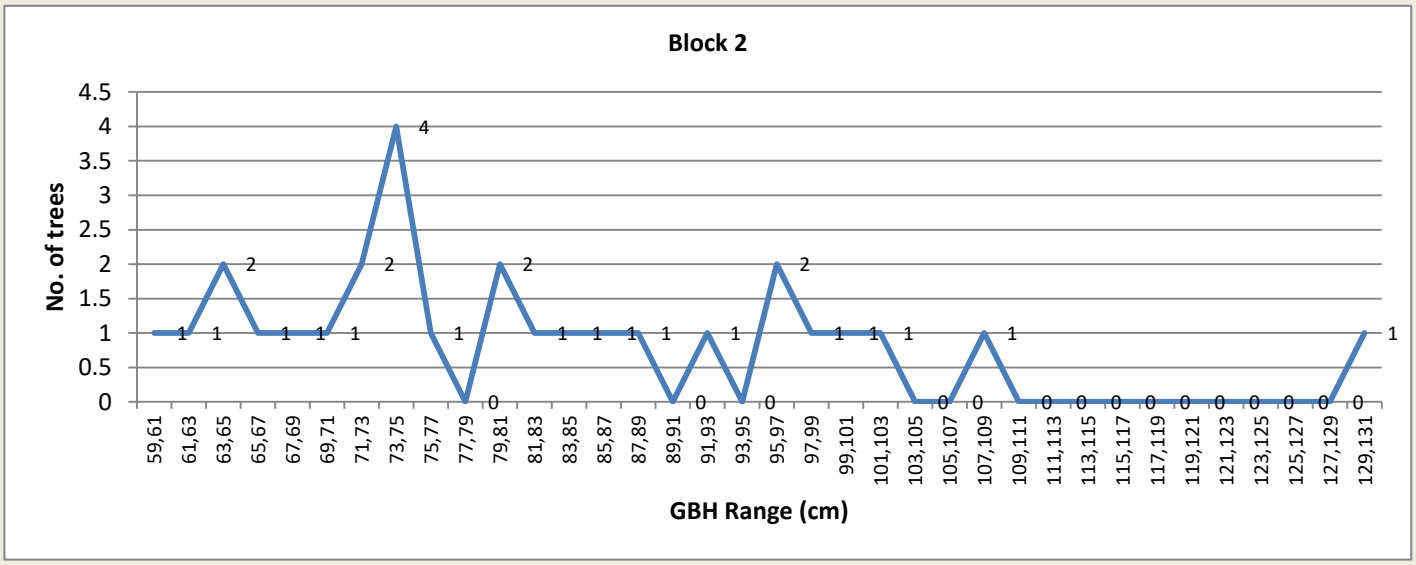
GBH measurement of teak tree is being taken by Mr.Paul Rockwood who always visits the plantation with Audit and management team.

Graph 3.1 Number of trees against to average GBH range values in Blocks in Chon Dean 1



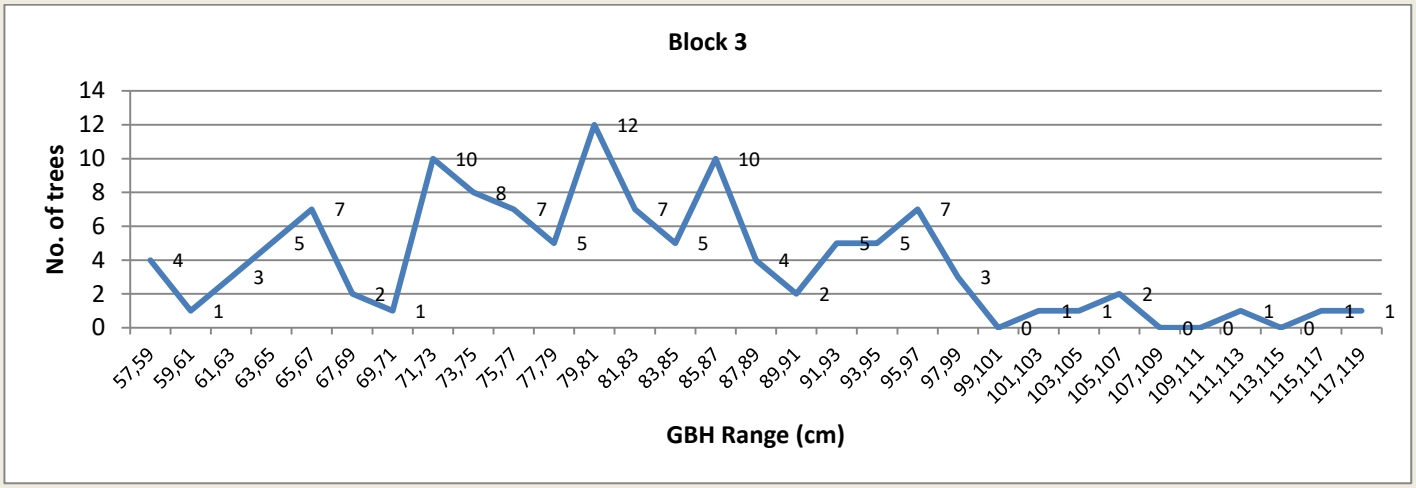
Out of 252 of trees, 97 trees are having more than 85 cm GBH.

It can be assumed that in block no.1. Out of 2735 trees, There are 1052(38%) trees having more than 85cm cm GBH category



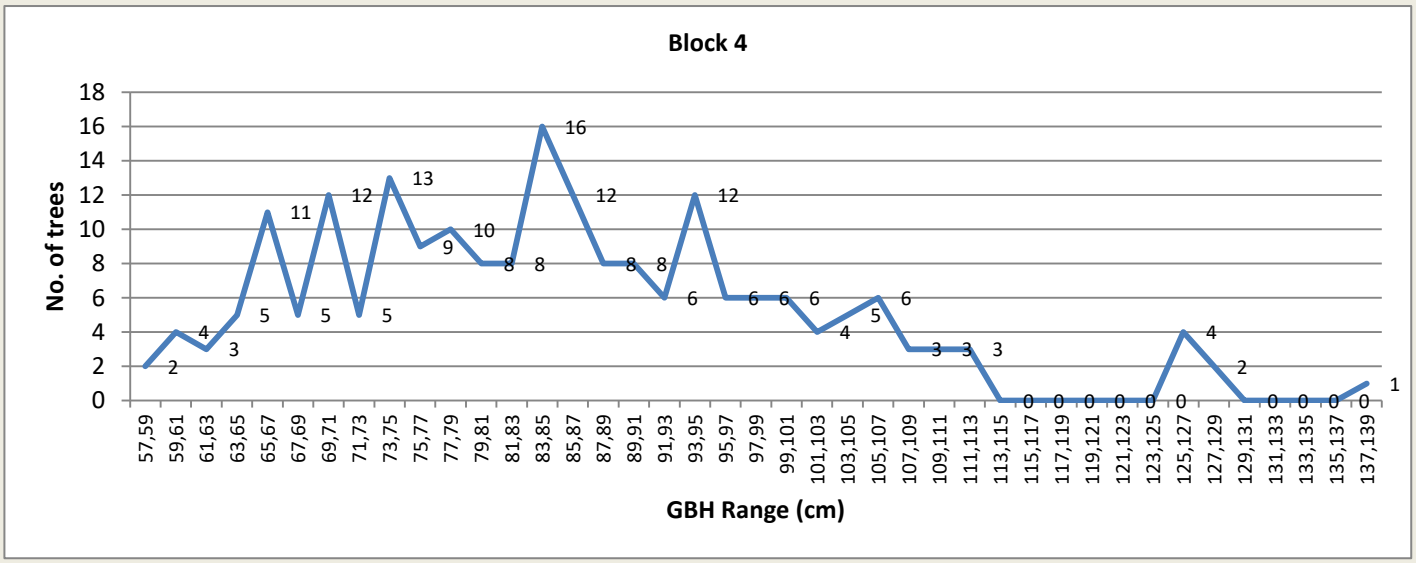
Out of 28 of trees, 10 trees are having more than 85 cm GBH.

It can be assumed that in block no.2. Out of 209 trees, There are 74 (35%) trees having more than 85 cm GBH category



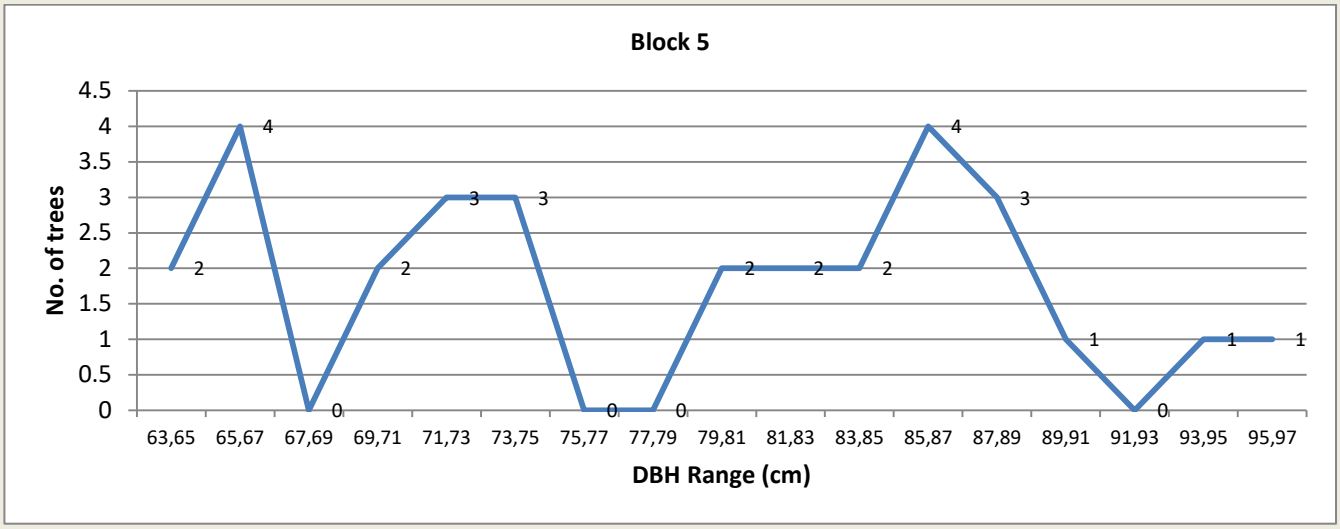
Out of 120 of trees, 43 trees are having more than 85 cm GBH.

It can be assumed that in block no.3. Out of 982 trees, There are 351 (35%) trees having more than 85 cm GBH category



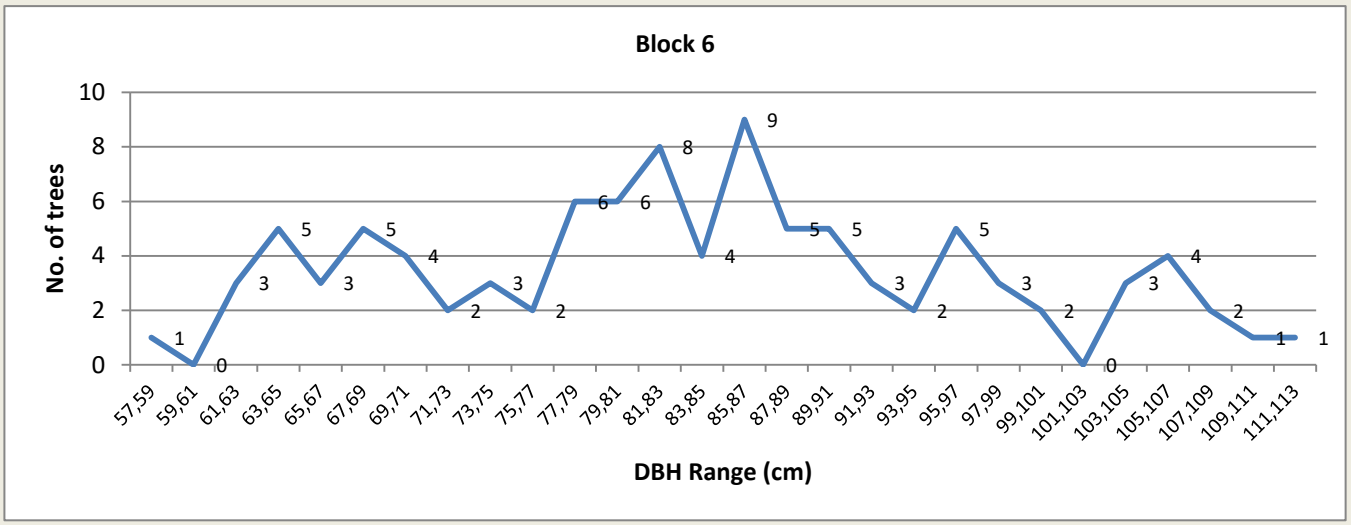
Out of 204 of trees, 95 trees are having more than 85 cm GBH.

It can be assumed that in block no.4. Out of 2026 trees, there are 938 (46%) trees having more than 85 cm GBH category



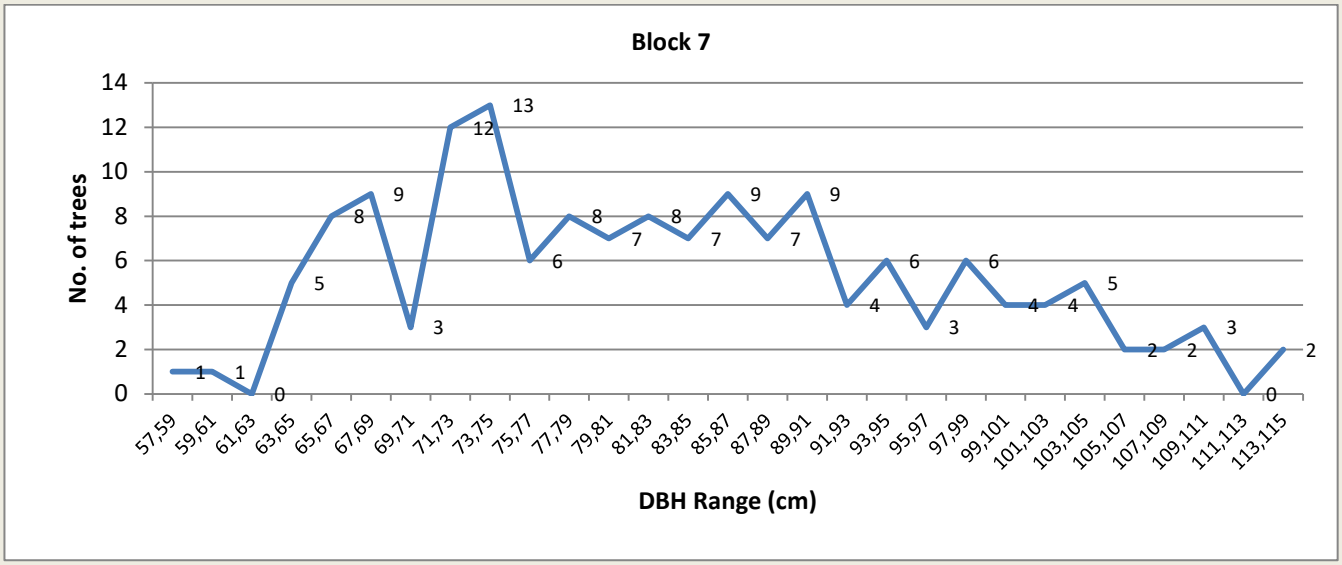
Out of 30 trees, 10 trees are having more than 85 cm GBH.

It can be assumed that in block no.5. Out of 258 trees, there are 85 (33%) trees having more than 85 cm GBH category



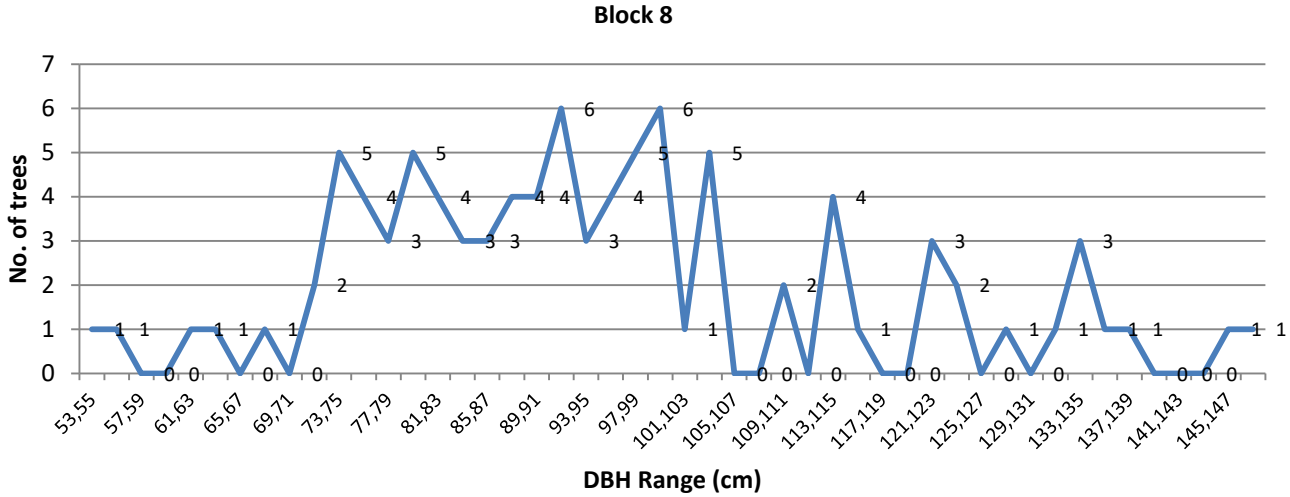
Out of 98 of trees, 45 trees are having more than 85 cm GBH.

It can be assumed that in block no.6. Out of 939 trees, There are 431 trees (45%) having more than 85 cm GBH category



Out of 154 of trees, 66 trees are having more than 85 cm GBH.

It can be assumed that in block no.7. out of 1289 trees, There are 541 (42%) trees having more than 85 cm GBH category



Out of 93 of trees, 62 trees are having more than 85 cm GBH.

It can be assumed that in block no.8. out of 698 trees, There are 460 (66%) trees having more than 85 cm GBH category

All blocks: Out of 979 of trees, 431 trees are having more than 85 cm GBH.

It can be assumed that in all blocks. out of 9136 trees, There are 4022 (44%) trees having more than 85 cm GBH category

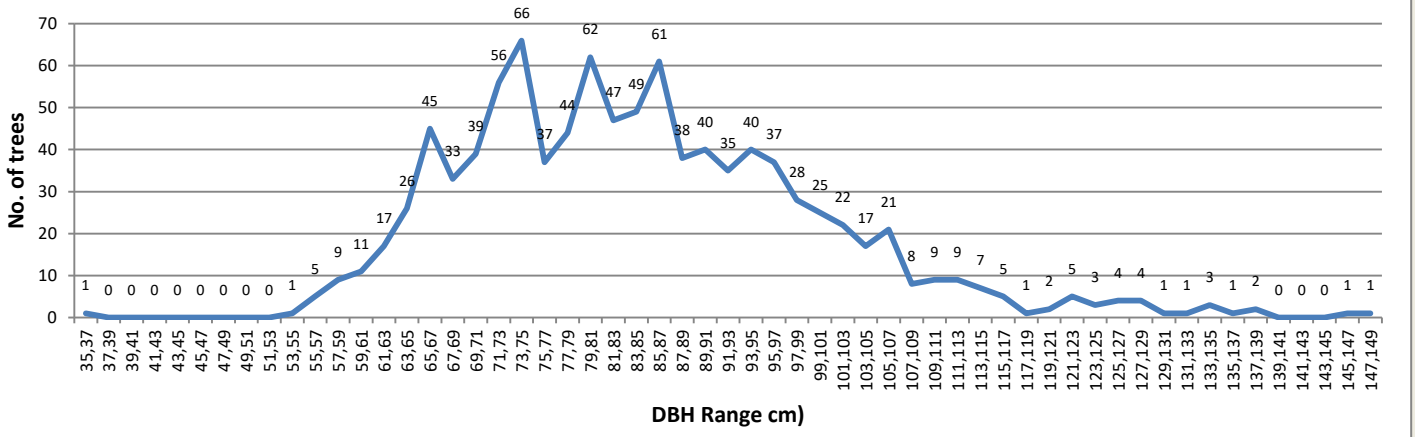


Table 2.2. Estimated number of trees having more than 85cm GBH in Chon Dean 01 teak Plantation

Estate	Block no.	Tree no. more than 66cm GBH in Blocks and its % in 2021	Ranking of bigger trees in 2021	Tree no. more than 85cm GBH in Blocks and its % in 2022	Ranking of bigger trees in 2022	No of trees for ha. In 2022
Chon Dean 01	1	2097 (76%)	5	1052 (38%)	5	315
	2	150 (72%)	6	74 (35%)	6	357
	3	807 (82%)	3	351 (35%)	6	375
	4	1616 (79%)	4	938 (46%)	2	318
	5	197 (76%)	5	85 (33%)	7	382
	6	802 (85%)	2	431 (45%)	3	306
	7	1019 (79%)	4	541 (42%)	4	320
	8	660 (94%)	1	460 (66%)	1	322
	Estate total	7348(80%) from 9136		3932 (43%) from 9136 trees		366 (average)

It seems that when no.of trees for ha is higher, the tree growth rate has slowdown in Block 5 and Block 3. This observation is correct when other factors in all the Blocks are constant.

Table 2.3. Comparison of tree parameters between year 2020 and 2021 in Chon Dean 1

Estate	Block no.	No. of Plots	Year 2021			Year 2022				
			No. of trees measured for GBH	No of trees for ha.	Average GBH (cm)	No.of trees measured for GBH	No of trees for ha.	Average GBH (cm)	Average Height (m)	Variance in GBH (cm) 2022 vs 2021
Chon Dean 01	1	5	253	316	76.3	252	315	82.08	21	5.78
	2	1	32	408	75	28	357	82.25	20	7.25
	3	2	118	368	75	120	375	81.37	22	6.37
	4	4	203	317	80	204	318	86.41	22	6.4
	5	1	30	382	75	30	382	79.83		4.83
	6	2	103	321	79.4	98	306	84.93		5.53
	7	3	153	318	76.9	154	320	84.03		7.13
	8	2	93	322	92.3	93	322	98.16		5.86
	Estate average			344	78.7		336	84.88 (27 DBH)	21.2	6.18 (1.9 cm DBH)
	Total	20	985			979				

Note: small errors found in number of tree figures between 2021 and 2022 which does not effect to mean values.

Table 2.4. Sample plots information, planted area and tree inventory data in year 2022 of Chon Dean 1 Total trees in blocks were not counted in this year . Same data of 2020 year was used.

ECstate	Estate	Block no.	Total trees in block	Estimated planted area (ha)	No. of Plots	Plots area in block (m2)	No. of trees measured for DBH in Block	No of trees for ha.	Average GBH (cm)	Average height (m)	Variance in GBH (cm) 2022 vs 2021
CCChon Dean 1	Chon Dean 01	1	2735	8.47	5	8000 (40x40mx5)	252	315	82.08	21	5.78
		2	209	0.59	1	784 (28x29m)	28	357	82.25	20	7.25
		3	982	2.65	2	3200 (40x40mx2)	120	375	81.37	22	6.37
		4	2026	6.39	4	6400 (40x40mx4)	204	318	86.41	22	6.4
		5	258	0.68	1	784 (28x28m	30	382	79.83		4.83
		6	939	2.93	2	3200 (40x40mx2)	98	306	84.93		5.53
		7	1289	4.05	3	4800 (40x40mx3)	154	320	84.03		7.13
		8	698	2.17	2	2880 (40x40+40x32)	93	322	98.16		5.86
		Total	9136	27.93	20	30048	979				
							Average	336	84.88 (27 DBH)	21	6.18 (1.9cm DBH)

Table 2.5.Thailand Teak Plantation tree count.
Comparison Tree Audit 2021-2022

(Due to covid-19 endemic circumstance, some data (good/reserved trees) were not counted in this year)

Estate Name	Block number	Geophysics count trees 2020				Geophysics count trees 2022			
		Total good trees	Marked for thinning	Reserved trees	Total trees	Total good trees	Marked for thinning	Reserved trees	Total trees were not Counted this year. Last year data was used as total
Chon Daen 1	B1	2595	39	101	2735				2735
	B2	209	0	0	209				209
	B3	946	15	21	982				982
	B4	2013	8	5	2026				2026
	B5	240	18	0	258				258
	B6	915	24	0	939				939
	B7	1244	40	5	1289				1289
	B8	653	22	23	698				698
	Total all blocks	8815	166	155	9136				9136

Table 2.6. Form factor calculation done with GBH of 102cm size felled tree. The total height and clean bole(stem) of this tree are 22m and 11.5m respectively.

1	Tree Total height with branches	22m	8 8A	Actual stem volume of 11.5m with bark based on mid girth value (79 cm). (i) first log of 5.75m with mid girth of 90cm (ii) second log of 5.75m with mid girth of 71cm Total (i) +(ii)	0.568 m3 0.37m3 0.23m3 0.602m3
2	Clean Tree stem height upto Girth of 69cm	11.5 m	9	Actual Stem volume upto 11.5m without bark based on mid girth of 79cm.	0. 477m3
3	Girth at breast height (ob)	102 cm	10	Form factor based on (8A) and its cylindrical volume (Ob) 0.602/0.95	0.633 m3
4	Mid girth of 11.5m stem (ob)	79 cm	11	Form factor based on (8) and its cylindrical volume(ob) (7) 0.568/0.95	0.59
5	Small end diameter of 11.5 m stem(ob)	69 cm	12	Form factor based on stem volume upto 11.5m (8A) and cylindrical volume of (7) height. 0.62/0.95	0.652
6	Bark thickness at one point	8-12mm	13	% of Clean stem timber volume from total volume (0.762m3) including branches which have 0.159 m3 (mid girth 41cm)	79%
7	Cylindrical volume of 11.5m length of stem based on GBH value (girth 102cm)	0.95m3			

Note : 102 cm GBH tree contains 0.762m3 wood volume in its 11.5 m long stem in which lowest mid girth of stem is 41cm., out of this 0.762m3, 79% of volume consists of log having with 79cm mid girth.

It can be assumed that in order to get 0.8 m3 volume of log ,we need 93cm mid girth of tree with 11.5m clean bole which should have 116 cm GBH.

Table 2.7. Determination of site index based on growth parameters of past years of Chon Dean 1

Chon Dean 1 plantation age is assumed as 22 years

Estate	Block no.	No. of Plots	2013 Ave. DBH (cm)	2014 Ave. DBH (cm)	2015 Ave. DBH (cm)	2016 Ave. DBH (cm)	2017 Ave. DBH (cm)	2018 Ave. DBH (cm)	2019 Ave. DBH (cm)	2020 Ave. DBH (cm)	2021 Ave DBG (cm)	2022 Ave. DBH(cm)	DBH differences from 2013 to 2022 and (Mean Increment of DBH) (cm) and periodic increment of DBH{}
Chon Dean 01	1	5	19.4	19.8	20.6	20.7	22.2	23.5	23.9	23.8	24.3	26.1	6.7 (1.18){0.74}
	2	1	17.7	18.1	19.0	18.9	21.1	22.6	23.4	23.3	23.9	26.2	8.5 (1.19){0.94}
	3	2	18.3	19.2	19.5	19.5	21.2	22.5	23.4	23.5	23.9	25.9	7.6 (1.18){0.84}
	4	4	19.4	19.5	21.3	21.5	23.3	24.7	25.3	25.5	25.5	27.5	8.1 (1.25){0.9}
	5	1	19.9	19.8	21.2	21.5	22.7	23.3	23.7	23.4	23.9	25.4	5.5 (1.15){0.61}
	6	2	19.4	18.9	20.4	20.5	22.6	23.9	24.6	24.5	25.3	27	7.6 (1.2){0.84}
	7	3	18.9	18.6	20.8	21.1	22.8	23.8	24.3	24.6	24.5	26.7	7.8 (1.2){0.86}
	8	2	19.9	22.2	24.4	24.7	27.2	28.8	29.2	29.3	29.4	31.3	11.4 (1.4){1.26}
	Estate average		19.1	19.5	20.9	21.05	23.2	24.1	24.7	24.7	25	27	5.97(1.19){0.67}

Figure 2.3: adventitious shoots need to be removed to produce knot free timber .

Figure 2.4: clean bole without branches lead to produce knot free timber which have premium price in timber market

Figure 2.5: the dolomite applied, is directly exposed to rain and easily runoff. It can be spread out into few centimeter under soil .

Figure 2.6: organic fertilizer bags have been laid on site without opening polythene bags. It is recommended to open the bags and spreading the fertilizer close to teak tree and make arrangement for preventing the washing off the fertilizer materials.

Recommendation

(1) It is recommended to prune the adventitious shoots only after required training given under close supervision. Figure 2.3 and figure 2.4 show the details.

1. **Application of soil improvement method and soil erosion prevention methods must be applied where site has steep slope. Figure 4.5.and figures 4.6 describe how organic and Dolomite need to be applied on site.**
2. **Root system of uprooted trees should be closely monitored at regular basis if termite causes for decaying of roots.**
3. **Control fire or fire lines must be properly maintained.**
4. **Average DBH increment in last two year is 2.3cm. This results show that trees exhibited significant improvement in term of wood production. If we are able to continue this trend in next five years we will be able to have trees with mean GBH of 100cm trees from this plantation.**
5. **More finding of this Audit are explained in executive summary.**

Finally it can be concluded that this teak plantation is healthy and good condition. Plantation is much more potential to get more growth increment particularly for diameter growth for next 5 years if the plantation is maintained and managed scientifically. We observed the significant tree diameter increase in last two years (2.3cm) compared with last 9 years.

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