TEAK TREE INVENTORY AND AUDIT REPORT-2021

CONDUCTED FOR

ASIA TEAK GROUP

AT

CHON DEAN 1 AND CHON DEAN 224 ESTATES, PHETCHABUN PROVINCE

THAILAND

DR.NIMAL RUWANPATHIRANA

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Executive summary

Two estates of Teak plantations namely Chon Dean 1 and Chon Dean 224 , managed by Asia Teak Tropical Plantation are normally inspected by Mr.J.M.P. Jayalath, Mr.ErandaRathnamalala and me . However due to Corvid-19 travel restriction , Thailand inventory team carried out the usual inventories and auditing of the tree stocks of two plantations. All the sample data were collected throughout audit process under close supervision of them. Inventory data collected from two plantations were received to me and I analyzed the data and prepared this report. Comparing with previous year tree growth rate , relevant data, tree growth parameters collected for 2021 year are acceptable .

Chon Dean 01 estate

Twenty sample plots having with total sample area of 30048m2 have been permanently setup in different locations in Chon Dean 01 estate. It is found by this study that total estimated planted area is 27.92 ha and sample plots represent 10.7 % of population. In this study, 985 trees were measured for DBH measurement. Due to unavoidable circumstance of Covid 19, Tree height measurement , total block tree number, good trees, tree marked for thinning and reserved tree were not takenin this year.

The average DBH of trees in the estate is 25 cm. It is found that average trees per ha is 344. 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 9 years of DBH data (2013-2021), 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 80% of trees are having DBH more than 21 cm. (see graph 3.1-page (16) and table 3.2 and 3.2.1 (page 21-22). The total tree number under this category is 7348 out of 9136. This figure was 7020 in year 2020 tree inventory. These findings can be used for future planning of thinning and final mode of harvest.

Chon Dean 224 estate

Nineteen sample plots having with total sample area of 2736m2 have been permanently setup in different locations in Chon Dean 224 estate. It is found by this study that total estimated planted area is 2.56 ha and sample plots represent 10.6 % of population. In this study, 131 trees were measured for DBH measurement.Due to unavoidable circumstance of Covid 19, Tree height measurement, total block tree number, good trees, tree marked for thinning and reserved tree were not taken in this year.

The inventory (tree count data) results shows that there are 1235 trees. The average tree DBH in the estate 224 are 20.5 cm. It is found that average trees per ha is 481. Details of block wise information are shown in table 3.3 and page 21.

After analyzing the tree growth rate and other relevant factors, the age of the plantation can be estimated as approximately 15 years old.Based on that and mean DBH value for year 2021 (20.5cm) the mean increment for DBH can be calculated as 1.36cm per year. However we have DBH data only for 2018 ,2020 and 2021. Therefore it is not possible to find correct periodic increment for the plantation.

Analyzing inventory tree data it is found that more than 84.5% of trees are having DBH more than 17 cm. (see graph 3.2 in page 20 and table 3.2.in page 21). The total tree number under this diameter category has increased from 850 to1045 during the last year.

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 if the plantation is maintained and managed scientifically.

1. Introduction

1.1. General Introduction of Teak (*Tectonagrandis*) Plantation

Teak (*Tectonagrandis*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 andTeak 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

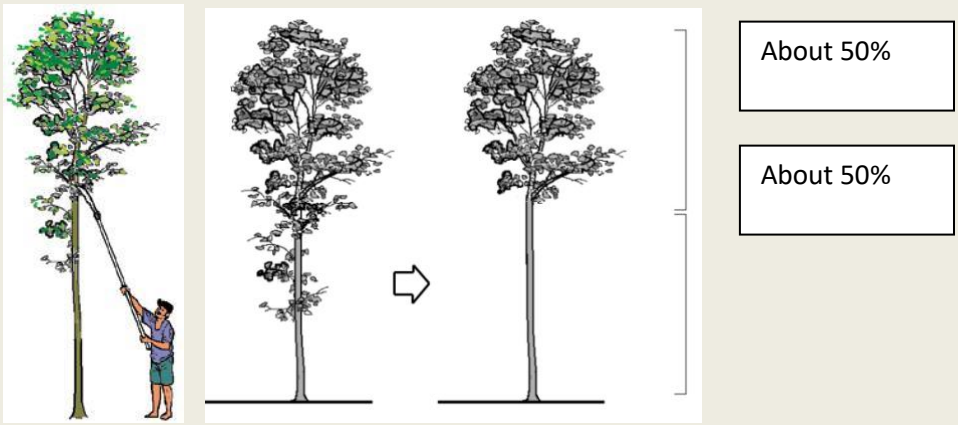
Fluting (irregular involutions and swellings) in the teak stem has been observed in a number of plantations. In some study, the mean heritability value of stem straightness was found to be 0.83, indicating that the character for stem straightness is strongly controlled by provenance and is thus genetically 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

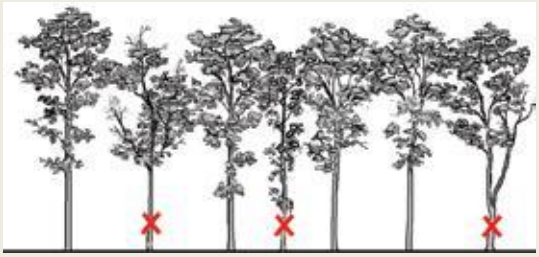
By competition for light, water and nutrients is greater in closely spaced plantations causing slower tree growth and tall, skinny stems. Thinning will encourage better growth for the good quality trees that remain.

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

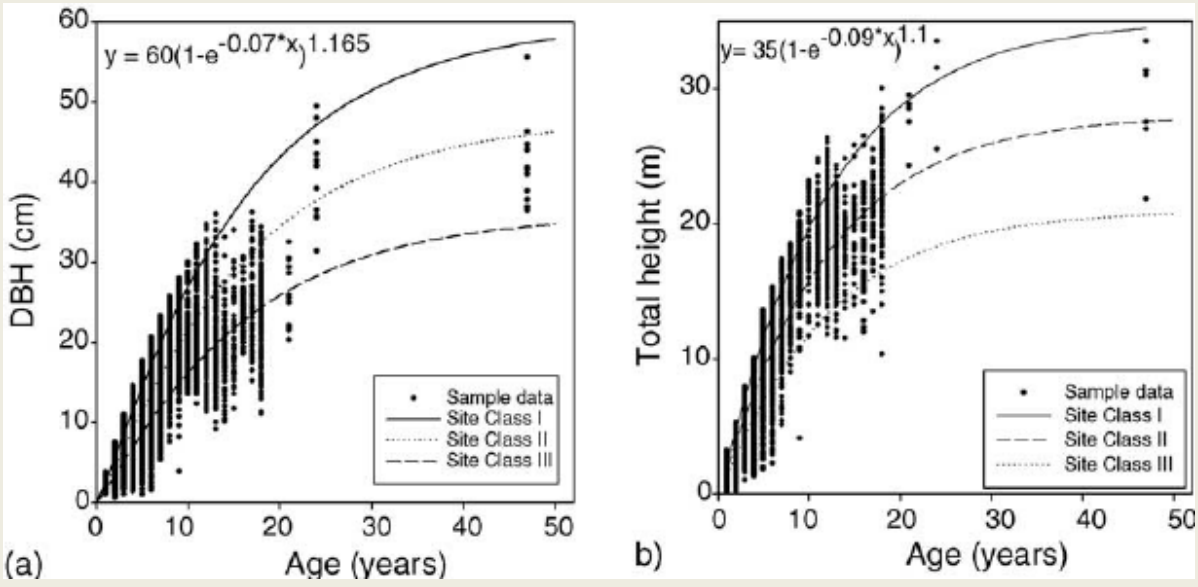
Tree height (m)	**Trees remaining (trees/ha)**	**Age (yr) (range based on soil fertility)**	**Spacing (m)**
11.0–13.0	1300–1500	5–11	2.5–3.0
13.5–15.5	1000–1100	7–17	3.0
15.5–17.0	800–850	10–21	3.5
17.5–21.0	500–550	15–34	4.0–4.5



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

Table 1. Growth parameters of Teak governed by site quality of some other countries

Site quality 19							
age	No.of stems/ha	Top height(m)	DBH(cm)	Per Tree volume (m3)	Trees volume /ha	MAI(m3/ha/year	CIA(m3/ha/year
3	1111	8	6.9	-	-	-	9.9
5	776	13.4	13.1	0.03	27.2	5.4	13.6
8	542	17.6	18.6	0.102	55.3	7.6	11.3
12	379	19.3	22.2	0.259	98.5	9.7	13.7
20	265	21.3	27.0	0.449	119.0	7.9	5.2
25	185	21.7	31.5	0.62	115.3	7.1	4.3

Table 1.1. Growth parameters of Teak governed by site quality of some other countries

Site quality 21							
age	No.of stems/ha	Top height(m)	DBH(cm)	Per Tree volume (m3)	Trees volume m3/ha	MAI(m3/ha/year	CIA(m3/ha/year
3	1111	8.3	7.2	0	0	0	11.3
5	754	14.4	14.2	0.04	30.2	6	15.1
8	512	19.3	20.5	0.15	76.8	10.4	17.8
12	347	22.1	25.5	0.310	107.6	11	12
20	236	23.9	30.7	0.619	146.3	9.7	7.8
25	160	24.3	36.1	0.85	136	8.7	4.5

Age (years)	H_0	Main crop before thinning					Crop removed					Main crop after thinning					Total crop		
		N	D_g	G	V	Hart	N	D_g	G	V	Vt	N	D_g	G	V	Hart	VT	MAI	CAI
Quality 23																			
3	8.6	1111	7.5	4.9	0	34.9	399	0	0	0	0	712	9.4	4.9	0	43.6	0	0	0
5	15.3	712	15.2	13.0	49.8	24.5	256	12.1	2.9	12.5	12.5	456	16.8	10.1	37.3	30.6	49.8	9.9	24.9
8	21.0	456	22.7	18.5	114.0	22.3	164	19.5	4.9	28.7	41.2	292	24.4	13.6	85.3	27.9	126.5	15.8	25.6
12	24.3	292	29.0	19.3	137.2	24.1	105	24.8	5.1	34.5	75.8	187	31.1	14.2	102.7	30.1	178.5	14.9	13.0
20	26.5	187	35.9	19.0	157.1	27.6	67	31.8	5.3	39.4	115.2	120	38.1	13.7	117.7	34.4	232.9	11.6	6.8
25	27.0	120	43.9	18.2	133.2	33.8											248.4	9.9	3.1
Quality 21																			
3	8.3	1111	7.2	4.6	0	36.1	357	0	0	0	0	754	8.8	4.6	0	43.9	0	0	11.3
5	14.4	754	14.2	11.9	30.2	25.3	242	9.4	1.7	6.78	6.78	512	16.0	10.2	23.4	30.7	30.2	6.0	15.1
8	19.3	512	20.5	16.9	76.8	22.9	165	15.7	3.2	17.3	24.1	347	22.4	13.7	59.5	27.8	83.6	10.4	17.8
12	22.1	347	25.5	17.7	107.6	24.3	111	21.1	3.9	24.1	48.2	236	27.3	13.8	83.5	29.5	131.7	11.0	12.0
20	23.9	236	30.7	17.4	146.3	27.2	76	28.7	4.9	33.0	81.2	160	31.5	12.5	113.3	33.1	194.5	9.7	7.8
25	24.3	160	36.1	16.4	136.0	32.5											217.2	8.7	4.5
Quality 19																			
3	8.0	1111	6.9	4.2	0	37.5	335	0	0	0	0	776	8.3	4.2	0	44.9	0	0	9.9
5	13.4	776	13.1	10.5	27.2	26.8	234	9.1	1.5	5.73	5.733	542	14.5	9.0	21.43	32.1	27.2	5.4	13.6
8	17.6	542	18.6	14.7	55.3	24.4	163	13.6	2.4	11.6	17.37	379	20.3	12.3	43.65	29.2	61.0	7.6	11.3
12	19.3	379	22.2	14.7	98.5	26.6	114	20.7	3.8	20.7	38.12	265	22.8	10.8	77.79	31.8	115.9	9.7	13.7
20	21.3	265	27.0	15.2	119.0	28.8	80	25.9	4.2	25.1	63.26	185	27.4	10.9	93.84	34.5	157.1	7.9	5.2
25	21.7	185	31.5	14.4	115.3	33.9											178.5	7.1	4.3

[a] H_0: top height (m); N: number of stems/ha; D_g: quadratic mean diameter at breast of height (cm); G: basal area (m^2/ha); V: commercial volume (m^3/ha); Vt: commercial volume accumulated in thinnings (m^3/ha); Hart: Hart–Becking index; VT: total commercial volume (m^3/ha); MAI: mean increment of volume (m^3/ha per year); CAI: current increment of volume (m^3/ha per year).

Other studies have indicated that wood density and mechanical properties are independent of growth rate or that fast-grown trees of ring-porous species have higher wood density andstrength (Harris, 1981; Bhat, Bhat and Dhamodaran, 1987; Rajput, Shukla and Lai, 1991). More recently, a study on the wood properties of fast-

grown plantation teak trees of different ages revealed that there were no significant differences in wood density, modulus of rupture (MOR), modulus of elasticity (MOE) or maximum crushing stress (Bhat, 1998). It was concluded that young trees (13 to 21 years of age) are not necessarily inferior in wood density and strength to older trees aged 55 and 65 years, and hence that the rotation age of fast-grown teak wood can be reduced without affecting the timber strength.

1.4. Forest Plantation Audit process and Objectives

Forest Audits generally assess and compliance with the forest management planning manual and the effectiveness of forest management activities in meeting the objectives set out in the forest management plan.

The specific objectives of forest Audit are to assess to what extent forest management planning activities comply with forest management plan and forest management principles. Another objective is to compare the planned forest management activities with actual activities undertaken and to remedy shortcoming identified in a previous audit. At finally the audit provide a conclusion stating whether or not the forest is being managed consistently with principles of sustainable forest management to achieve the set objectives of forest management plan. Present teak plantations need to be prepared the comprehensive forest management plan with set objectives.

1.4.1. Requirement for conducting the audit

There is sufficient or appropriate information to conduct the audit, in addition there are adequate resources and co-operation from the auditee to conduct audit process. The audit team must be independent.

1.5. Objectives of present forest inventory and Audit of Teak Plantation in Chon Dean Estate in Thailand

1. To inventory the teak plantation to get Teak tree stock and tree growth parameters.
2. To decide next silvicultural treatments such as pruning, thinning and some maintenance activities of plantation like fire lines, weeding, fertilizing based on information gathered from forest inventory and field examination.
3. To predict future tree growth,timber production and estimated timbervalue. This forecasting will help to take the remedial measures to manage the plantation efficiently to achieve the maximum benefit from the plantation.
4. To remedy shortcoming identified in a previous audit and assess the forest management activities.

2. Methodology of Forest inventory

Sound forest management depends on the quantity and quality of information available on the forest. This information is obtained from forest inventories. Forest inventory is the activity of data collection that helps generating the required information base on the forest resource within an area of interest. There are three main factors, which influence the cost of an inventory: Type of information required; Standard of accuracy; Size of area to be surveyed and the minimum size of unit area in the forest.

A good forest inventory;

a) Should be conform to the objectives
b) Should provide adequate precision
c) Methodologically sound & follow statistical sampling criteria
d) Have comprehensive transparent reporting & documentation

e) Overall credibility

In this inventory process, impotency of the above criteria is considered and followed.

2.1. The following items are recommended for conducting forest inventory and monitoring exercises

Items needed for all field inventory or assessments Field assessment datasheets (current and previous) Field vest, Plastic flagging (at least three different colors) Mechanical pencils, Sharpie permanent ink pen, Compass, Calculator, Small Ruler (metric & English), 75' or 100' Spencer tape w/dbh tape, Clinometer, Clipboard or datum,Stand map, plots mapped, Small pocket sized notebook, Digital camera,Numbered tree tags (check for numbers that have not been used) Unmarked bearing tree tags for scribing,Rebar& plastic pipes (for replacement if missing), Tree paint (spray can): orange or other bright color, First-aid kit, Water, Cell phone.

2.1.1. Temporary vs. Permanent Plots

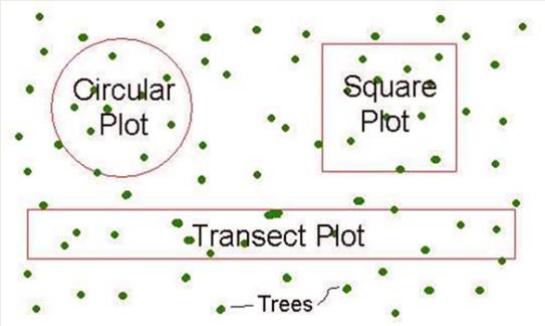
When conducting a forest inventory, most landowners install temporary plots. When the stand is re-inventoried in the future, plot locations are different. This is the simplest inventory method and is recommended for landowners who have minimal time to devote to forest inventory. Permanent inventory plots are often used on large ownerships and are the most precise method of monitoring forest change over time. To establish "permanent" plots, plot centers or corners are marked with a stake or other marker and the variables of the forest stand within the plot are re-measured through time.

Asia Teak Group audit inventory the permanent square shape plots are used and for forest management review works temporary circular plots were used.

Figure 2.1. Plot number and one corner post of square shape plot in Chon dean estate

2.2. Plotshape

In this study, square plot are used and suggested plot size based on the stocking shown bellow. However we have used 40m x 40 m square shape plots in most of time.



STOCKING RATE (STEMS/*HECTARE*)	PLOT SIZE (*HECTARES*)	RADIUS OF CIRCULAR PLOT (METRES)
100	0.2	25.2
200	0.1	17.8
400	0.05	12.6
500	0.04	11.3
600	0.033	10.2
800	0.025	8.9
1000 +	0.02	8.0

Various plot shapes

2.3. Basics of mensuration (Tree variables measurement)

(a) Diameter measurement of a single standing tree
(b) The diameter at breast height (dbh)

The standard position for diameter measurement at standing tree is at breast height. It is defined at 1.30 meter above ground in most countries. Calipers and diameter tape are the most commonly used instruments.

2.3.1. Diametertape

There are diameters tapes from which the tree diameter can be directly read. Tree diameter can also be determined from circumference measurement which can be done by diameter tape or any tape since circular tree stem shape is assumed.

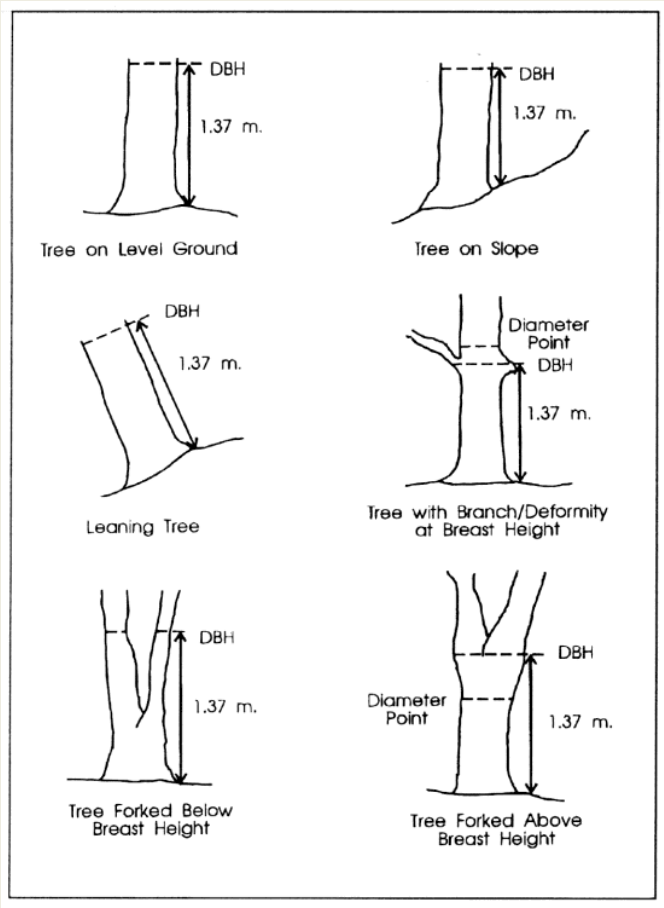
$C = 2\pi r = d; \quad d = C/\pi$

In this study, Diameter tape is used.

Figure 2.2: Diameter at breast height (1.3m) is measured by diameter tape. Inventory team follows all the standard and rules recommended in this regard.

2.4. 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.



Diameter tape used for the inventory

2.5. 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

2.5.1. 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 2.3. Total Tree height was measured by hypsometer, used instrument is shown in right side

Figure 2.4. Correct horizontal distance between tree and height observer is being positioned

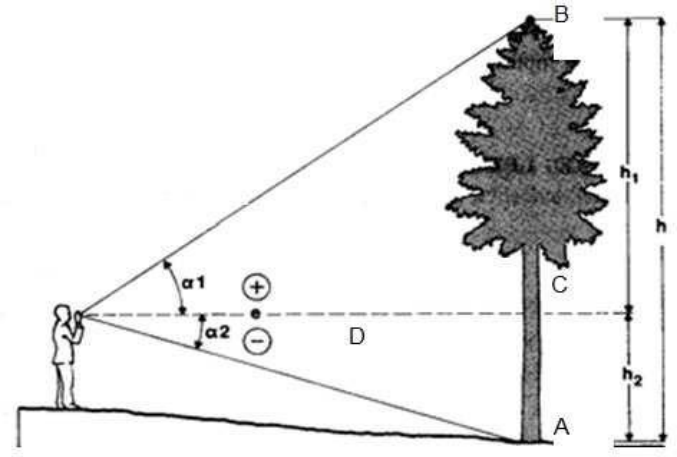
2.6. General steps for Hypsometer are bellow

Stand at a fixed horizontal distance from the base of the tree (usually 10, 15, 20, 25 meters, and so on)

a) Sight at the top of the tree and read the value ‘A’ (top reading)

b) Again sight at the bottom of the tree and read the value ‘B’ (bottom reading)
c) Then the total height of the tree is top reading ‘A’ minus bottom reading ‘B’
d) Bottom reading +ve or –ve (above and below eye level)

Height measurement can be taken using clinometers as shown figure 2.3.



tan α1 = BC / D
BC = tan α1 . D
tan α2 = AC / D
AC = tan α2 . D
AB (height) = BC + AC
AB = tan α1 . D + tan α2 . D
AB = D (tan α1 + tan α2)

Figure 2.5: *Tree height measurement on a flat terrain*

2.6.1. Plot size:

Allthe 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.Sample plot C1 B4 P3.

(i) 40m x 40 m =1600m2 size of plots in Chon Dean 1
(ii) 12m x12m=144m2 plots in Chon Dean 224

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

3. Results of inventory of teak plantation

3.1. Estate of Chon Dean 01

Table 3.1. Number of trees and tree mean DBH values in plots in Chon Dean 1

Plot number (P)	Block 01		Block 02		Block 03		Block 04	
	No. of trees	Mean DBH (cm)	No. of Trees	Mean DBH (cm)	No. of Trees	Mean DBH (cm)	No. of Trees	Mean DBH (cm)
1	48	25.9	32	23.9	57	23.5	56	25.1
2	54	22.2			61	24.3	44	27.1
3	53	23.5					45	25.5
4	49	25.1					58	24.3
5	49	24.6						
Mean	**50.6**	**24.3**	**32**	**23.9**	**59**	**23.9**	**50.75**	**25.5**
TOTAL	**253**		**32**		**118**		**203**	

Plot number (P)	Block 05		Block 06		Block 07		Block 08	
	No.of trees	Mean DBH (cm)	No.of Trees	Mean DBH (cm)	No. of Trees	Mean DBH (cm)	No.of Trees	Mean DBH (cm)
1	30	23.9	51	26.2	60	23.2	55	27.3
2			51	24.4	42	24.4	38	31.5
3					49	25.8		
Mean	**30**	**23.9**	**51**	**25.3**	**51**	**24.5**	**46.5**	**29.4**
TOTAL	**30**		**103**		**153**		**93**	

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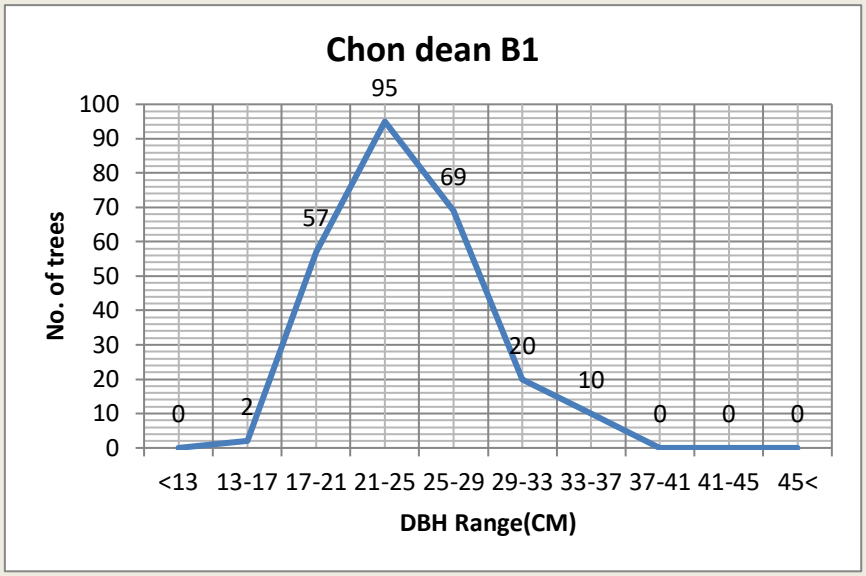
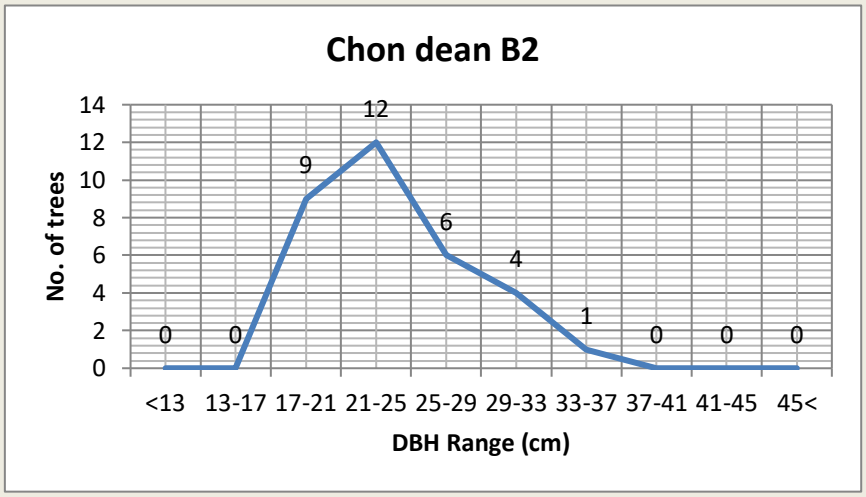
Figure 3.1: Part of view of Block 01

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



Out of 253 of trees, 99 trees are having more than 21-25 cm dbh.

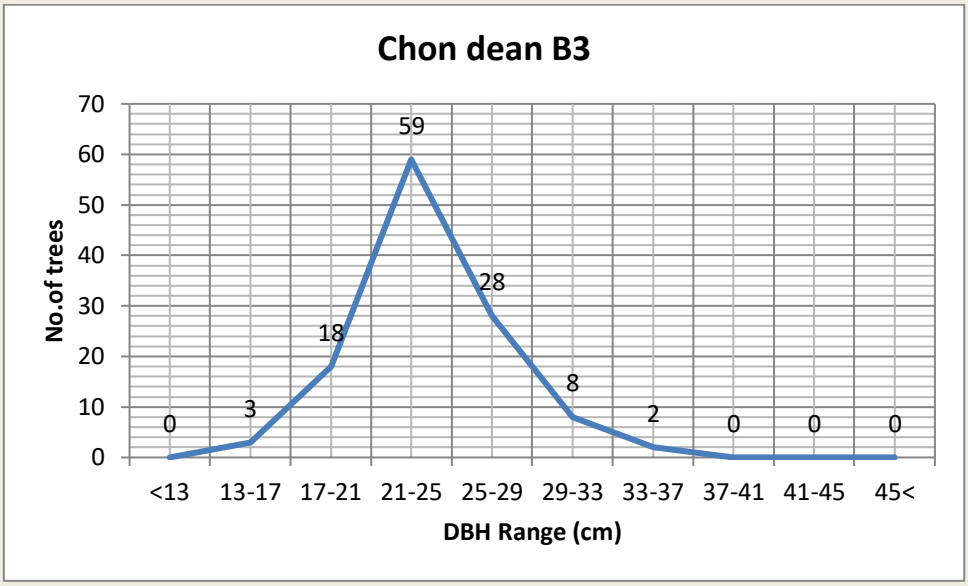
It can be assumed that in block no.1. out of 2735 trees, There are 1070 trees having more than 21-25 cm DBH category



Out of 32 of trees, 11 trees are having more than 21-25 cm dbh.

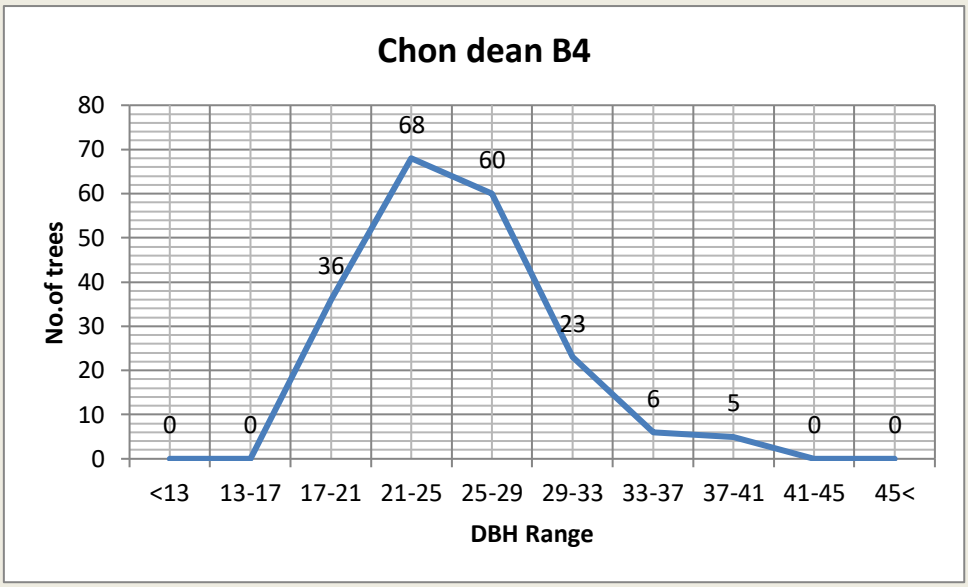
It can be assumed that in block no.2. out of 209 trees, There are 72 trees having more than 21-25 cm DBH category

Figure 3.2. Side view of Block 02 in Chon Dean 1



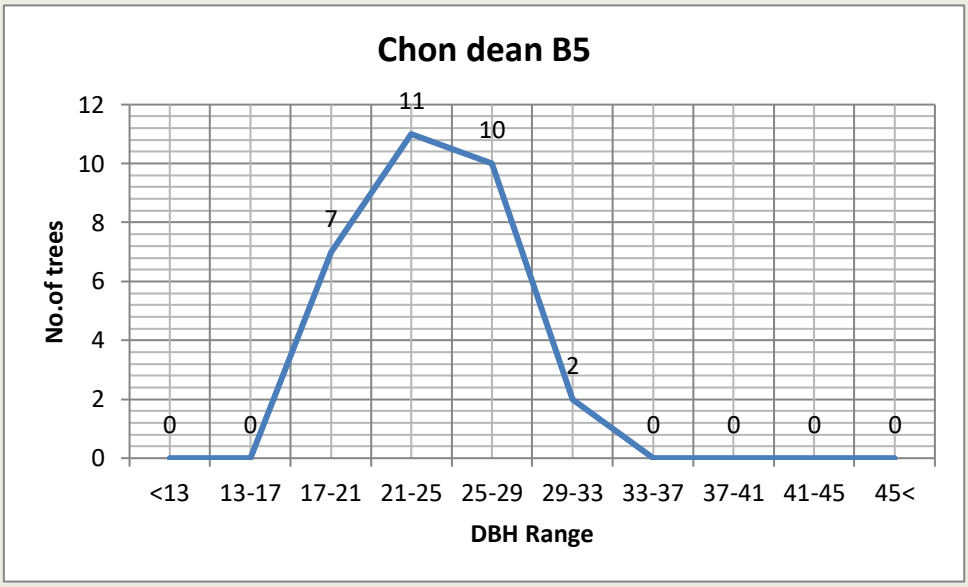
Out of 118 of trees, 38 trees are having more than 21-25 cm dbh.

It can be assumed that in block no.3. out of 982 trees, There are 316 trees having more than 21-25 cm DBH category



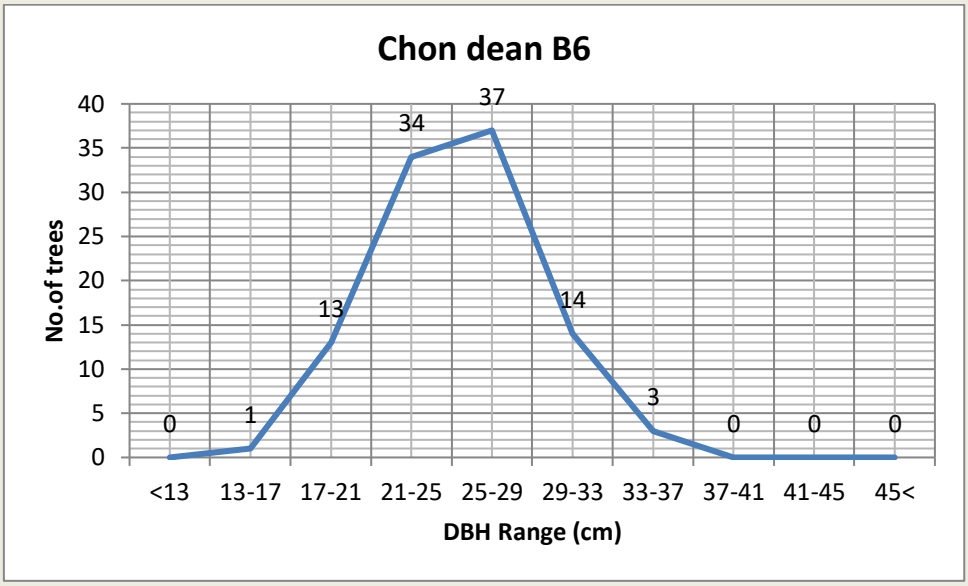
Out of 203 of trees, 94 trees are having more than 21-25 cm dbh.

It can be assumed that in block no.4. out of 2026 trees, There are 938 trees having more than 21-25 cm DBH category



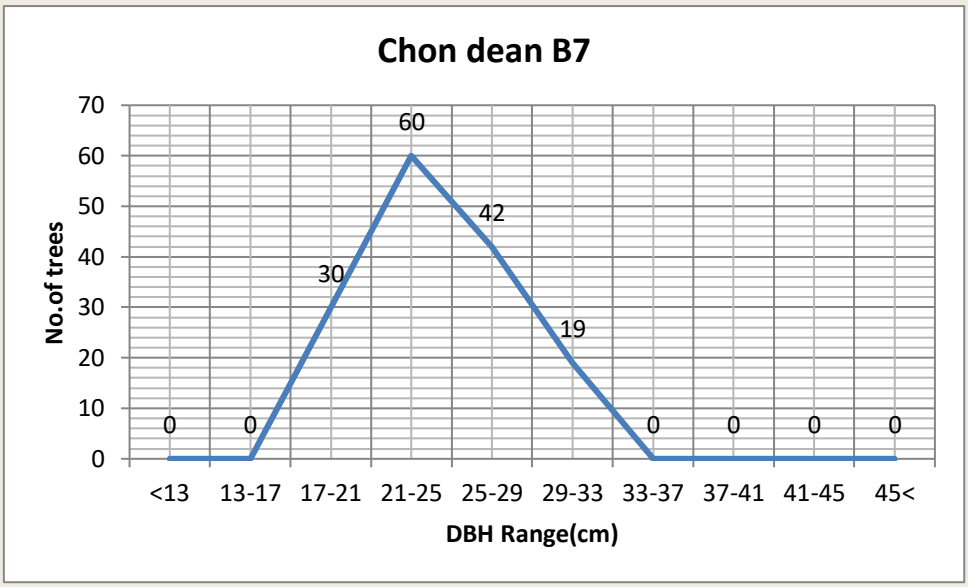
Out of 30 of trees, 12 trees are having more than 21-25 cm dbh.

It can be assumed that in block no.5. out of 258 trees, There are 103 trees having more than 21-25 cm DBH category



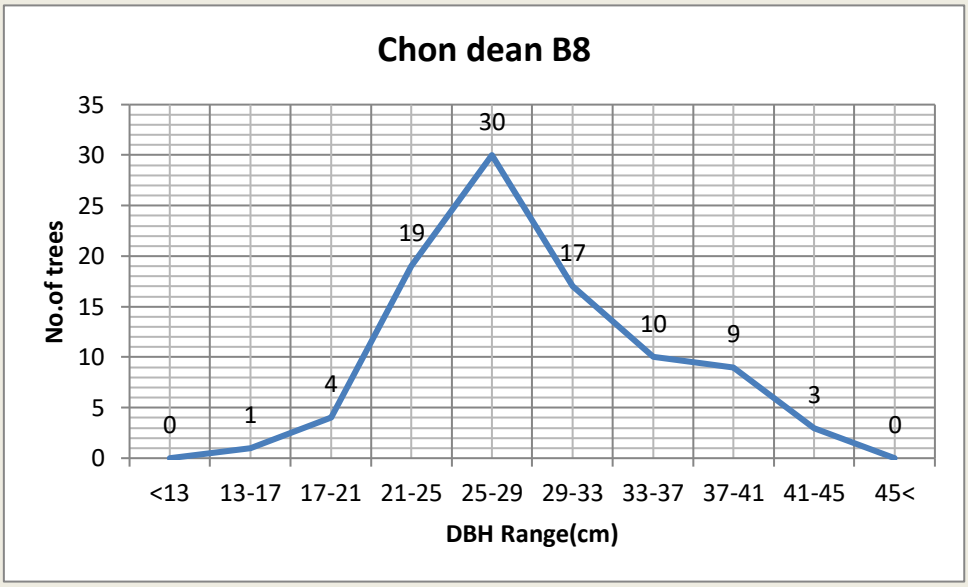
Out of 103 of trees, 54 trees are having more than 21-25 cm dbh.

It can be assumed that in block no.6. out of 939 trees, There are 492 trees having more than 21-25 cm DBH category



Out of 153 of trees, 61 trees are having more than 21-25 cm dbh.

It can be assumed that in block no.7. out of 1289 trees, There are 514 trees having more than 21-25 cm DBH category



Out of 93 of trees, 88 trees are having more than 25-29 cm dbh.

It can be assumed that in block no.8. out of 698 trees, There are 292 trees having more than 25-29 cm DBH category

3.2. Chon Dean 224

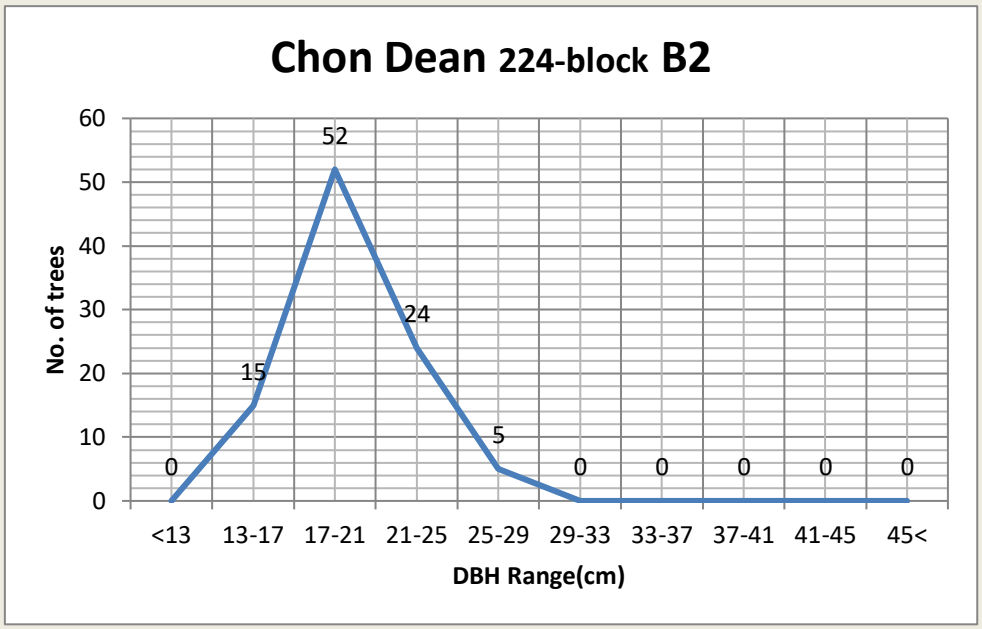
Plantation name: Chon Dean 224- Block No.B2 and Block No.B3

Figure 3.2.1. Side view of Chon Dean 224 –block no.2

Table 3.1.1. Number of trees and its mean DBH values in Chon Dean 224

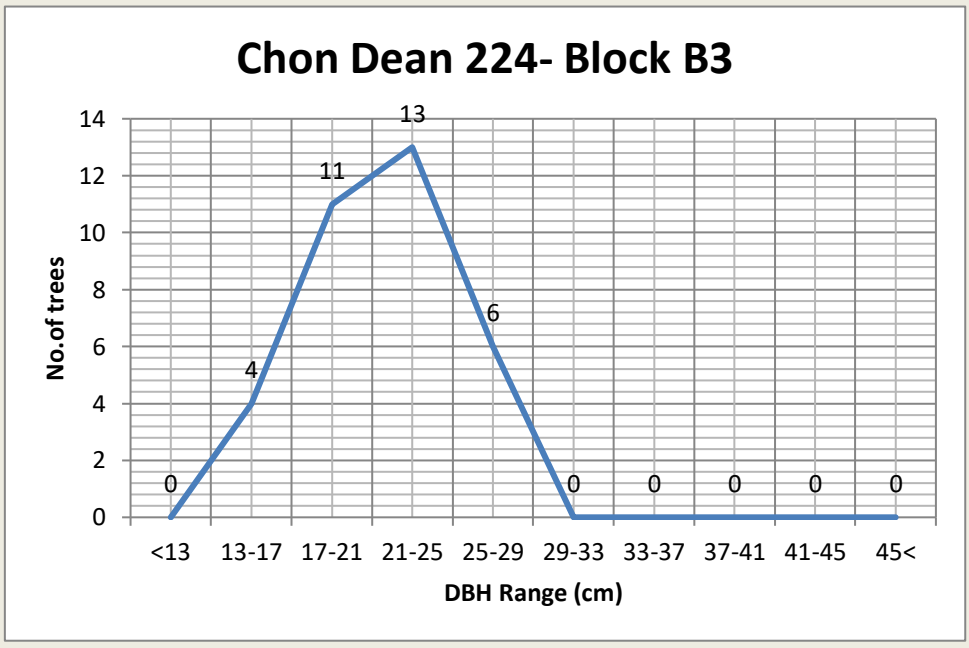
Plot number (P)	**Block B2**		**Block B3**	
	No.of trees	Mean DBH (cm)	No.of Trees	Mean DBH (cm)
1	9	17.8	8	18.4
2	6	16.9	7	23.6
3	5	21.4	7	20.9
4	8	19.5	6	21.4
5	9	19.2	7	22.2
6	**5**	**22.7**		
7	**9**	**21.3**		
8	**7**	**18.8**		
9	**8**	**19.7**		
10	**9**	**20.4**		
11	**8**	**20.8**		
12	**5**	**18.7**		
13	**8**	**19.4**		
Mean	**7.4**	**19.7**	**7**	**21.3**
TOTAL	**96**		**(35)**	

Graph 3.2 Number of trees against to mean ranged DBH values in Blocks in Chon Dean 224



Out of 96 of trees, 29 trees are having more than 17-21 cm dbh.

It can be assumed that in block no.2. out of 922 trees, There are 278 trees having more than 17-21 cm DBH category



Out of 35 of trees, 6 trees are having more than 21-25 cm dbh.

It can be assumed that in block no.3. out of 313 trees, There are 53 trees having more than 21-25 cm DBH category

Table 3.2. Estimated number of trees having more than 21cm DBH and 17cm DBH in Chon Dean 01 and Chon dean 224 teak Plantation respectively

Estate	Block no.	Larger no. of trees, more than 21cm DBH in Block and its %
Chon Dean 01	1	2097 (76%)
	2	150 (72%)
	3	807 (82%)
	4	1616 (79%)
	5	197 (76%)
	6	802 (85%)
	7	1019 (79%)
	8	660 (94%)
	Estate total	7348(80%) from 9136
		Larger no. of trees, more than 17cm DBH in Block and its %
Chon Daean 224	B2	777 (84 %)
	B3	268 (85%)
	Estate total	1045 (84.5%)

Table 3.3. Comparison of tree parameters between year 2020 and 2021 in Chon Dean 1

Estate	Block no.	No. of Plots	Year 2020				Year 2021			
			No. of trees measured for DBH	No of trees for ha.	Average DBH (cm)	Ave. Height (m)	No.of trees measured for DBH	No of trees for ha.	Average DBH (cm)	Va DI 20 20
Chon Dean 01	1	5	259	323	23.8	20.2	253	316	24.3	0.5
	2	1	28	357	23.3	19.2	32	408	23.9	0.6
	3	2	119	371	23.5	20.5	118	368	23.9	0.4
	4	4	203	317	25.5	20.3	203	317	25.5	0
	5	1	30	382	23.4	17.5	30	382	23.9	0.5
	6	2	103	321	24.5	22	103	321	25.3	0.8
	7	3	153	318	24.6	19.6	153	318	24.5	-0
	8	2	93	322	29.3	25	93	322	29.4	0.1
	Estate average		**123**					**344**	**25**	
	Total	**20**	**988**				**985**			

Table 3.3.1. Comparison of tree parameters between year 2020 and 2021 in Chon Dean 224 estate

Estate	Block no.	No. of Plots	Year 2020				Year 2021		
			No. of trees measured for DBH	No of trees for ha.	Average DBH (cm)	Ave. Height (m)	No. of trees measured for DBH	No of trees for ha.	Average DBH (cm)
Chon Daean 224	B2	14	97	481	19,2	16.6	96	476	19.7
	B3	5	35	486	21.1	20	35	486	21.3
	Estate average			**482**	**20.2**	**18.3**		**481**	**20.5**
	total	19	132				131		

Table 3.4. Sample plots information, planted area and tree inventory data in year 2021 of Chon Dean 1

Total trees in blocks were not counted due to covid epidemic circumstance . same data of 2020 year was used.

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 DBH (cm)	Variance in DBH (cm) 2021 vs 2020
Chon Dean 1	1	2735	8.47	5	8000 (40x40mx5)	253	316	24.3	0.5
	2	209	0.59	1	784 (28x29m)	32	408	23.9	0.6
	3	982	2.65	2	3200 (40x40mx2)	118	368	23.9	0.4
	4	2026	6.39	4	6400 (40x40mx4)	203	317	25.5	0
	5	258	0.68	1	784 (28x28m	30	382	23.9	0.5
	6	939	2.93	2	3200 (40x40mx2)	103	321	25.3	0.8
	7	1289	4.05	3	4800 (40x40mx3)	153	318	24.5	0
	8	698	2.17	2	2880 (40x40+40x32)	93	322	29.4	0.1
	Total	**9136**	**27.93**	**20**	**30048**	**985**			
	Aver.age						**344**	**25**	

Table 3.4.1. Sample plots information, planted area and tree inventory data in year 2021 of Chon Dean 224

Block no.	Total trees in block	Estimated planted area (ha)	No. of Plots	Plots area in block (m2)	2021				
					No. of trees measured for DBH in Block	No of trees for ha.	Average DBH (cm)	Average height appro.(m)	Variance DBH (cm 2021vs 2020
B2	922	1.92	14	2016 (12x12m x14)	96	476	19.7	16.6+	0.5
B3	313	0.64	5	720 (12x12mx5)	35	486	21.3	20+	0.2
Total	**1235**	**2.56**	**19**	**2736**	**131**				
Ave.						**481**	**20.5**	**18.3+**	

Table 3.5.Thailand Teak Plantation tree count.
Comparison Tree Audit 2020-2021

(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 2021			
		Total good trees	Marked for thinning	Reserved trees	Total trees	Total good trees	Marked for thinning	Reserved trees	Tota Cou Last used
Chon Daen 1	B1	2595	39	101	2735				27
	B2	209	0	0	209				20
	B3	946	15	21	982				98
	B4	2013	8	5	2026				20
	B5	240	18	0	258				25
	B6	915	24	0	939				93
	B7	1244	40	5	1289				12
	B8	653	22	23	698				69
	Total all blocks	**8815**	**166**	**155**	**9136**				**91**

Table 3.5.1.Thailand Teak Plantation tree count.
Comparison Tree Audit 2020-2021

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

Estate Name	Block number	Geophysics count trees 2020				Geophysics count trees 2021			
		Total good trees	Marked for thinning	Reserved trees	Total trees	Total good trees	Marked for thinning	Reserved trees	Tota
Chon Dean 224	B2	787	135	0	922				92
	B3	290	23	0	313				31

	Total all blocks	**1077**	**158**	**0**	**1235**	**1235**

Table 3.6. Form factor calculation with average size felled trees

1	**Tree Total height with branches**	**22m**	**8**	**Stem volumeupto 11m with bark**	**0.38 m3**
2	Clean Tree stem height upto Diameter 16.5cm	11 m	**9**	Stem volume upto 11m without bark	0.312 m3
3	Diameter at breast height (ob)	26 cm	**10**	Tree volume based on total height and Stem mid diameter (16.5 cm at 11m) (ob)	0.470 m3
4	Mid diameter of 11m stem (ob)	5.5m	**11**	Form factor based on (10) and its cylindrical volume(ob)(7)0.47/1.167	0.40
5	Small end diameter of 11 m stem(ob)	16.5 cm	**12**	Form factor based on stem volume upto 11m (8) and cylindrical volume of (7) height. 0.38/1.167	0.32
6	Bark thickness at one point	13mm	**13**	% of Clean stem timber volume from total volume (upto 16.5 cm diameter of 11m length)	80%
7	Cylindrical volume of total height of tree(22m)(Ob)	1.167m3			

Table 3.7. Determination of site index based on growth parameters of past years of Chon Dean 1 and Chon Dean 224

Chon Dean 1 and Chon Dean 224 plantation age is assumed as 21 years and 15 years old respectively.

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. DBH(cm)	DBH dif 2013 to 2 (Mean I DBH) (c increme
Chon Dean 01	1	5	19.4	19.8	20.6	20.7	22.2	23.5	23.9	23.8	24.3	4.9 (1.
	2	1	17.7	18.1	19.0	18.9	21.1	22.6	23.4	23.3	23.9	6.2 (1.
	3	2	18.3	19.2	19.5	19.5	21.2	22.5	23.4	23.5	23.9	5.6 (1.1
	4	4	19.4	19.5	21.3	21.5	23.3	24.7	25.3	25.5	25.5	6.1 (1.
	5	1	19.9	19.8	21.2	21.5	22.7	23.3	23.7	23.4	23.9	4 (1.1
	6	2	19.4	18.9	20.4	20.5	22.6	23.9	24.6	24.5	25.3	5.9 (1.2
	7	3	18.9	18.6	20.8	21.1	22.8	23.8	24.3	24.6	24.5	5.6 (1.1
	8	2	19.9	22.2	24.4	24.7	27.2	28.8	29.2	29.3	29.4	9.5 (1.
	Estate average											
Chon Dean	B2	14						17.2		19.2	19.7	(1.
	B3	5						19.9		21.1	21.3	(1

Estate average	**20.5**

4. Recommendation

Pruning of the adventitious shoots should be carried out only after required training given under close supervision.

1. Control fire or fire lines must be properly maintained.
2. Application of soil improvement method and soil erosion prevention methods must be applied where site has steep slope. Erosion of the soil conditions due to the harrowing carried out in the past.
3. Root system of uprooted trees should be closely monitored at regular basis if termite causes or help for decaying of roots.

Finally it can be concluded that both teak plantation are healthy and good condition. Plantation is much more potential with site to get more growth increment particularly for diameter growth for next 5 years if the plantation is maintained and managed scientifically.

DR.NimalRuwanpathirana (Ph.D., M.Sc (forestry), B.sc (Bio. Science)
Consultant for forest management and wood science