Tree Improvement Program of Teak

PROJECT COMPLETION REPORT ON TREE IMPROVEMENT OF TEAK

SUBMITTED TO

THE WEST BENGAL FOREST AND BIODIVERSITY CONSERVATION SOCIETY

BY

THE RESEARCH WING, DIRECTORATE OF FOREST
GOVT OF WEST BENGAL

PREFACE

Teak (*Tectona grandis*) is a tropical hardwood tree species in the family Lamiaceae. It is a large, deciduous tree that occurs in mixed hardwood forests. Teak wood is particularly valued for its durability and water resistance. The wood is used commercially for many economic activities like boat building, exterior construction, furniture, carving, and other small wood project.

Molecular studies show that India is one of the centres of genetic origin of teak.Kerala, Maharashtra and Madhya Pradesh are some of the prime teak growing states in India. Teak was introduced and planted in West Bengal and some North Eastern states by the British. Maharashtra and MP, being located in predominantly dry zones, they have different land races. The climatic condition of North Bengal (mostly wet condition) has similarities with that Kerala, and so some improved strains from Kerala were planted on multiple locations in the State where teak is locally found. If it is found suitable, these Teak clones could be used in the future plantation program in the State and distribution of Teak clones to marginal farmers as a supplementary source of income.

Teak Tree improvement programme was started to focus on to select most promising clones after multi-location trial in the State and to evolve superior provenances through progeny testing. We need to monitor regularly the growth pattern of all the Teak clones planted in different locations.

West Bengal Forest Research Wing has taken some good initiative regarding as Teak Tree Improvement Program which is very effective step for afforestation work by forest Department as well as for local farmers which enrich green cover of the State and is economically beneficial to the society.

Principal Chief Conservator of Forests
Research, Monitoring and Development
West Bengal

ACKNOWLEDGEMENT

Tectona grandis is a most important and valuable timber yielding tree species of South and Southeast Asia. In India, teak is distributed naturally in Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka and Kerala. Outside its natural occurrence, teak has been raised in states like Uttar Pradesh, West Bengal, Assam, Bihar, Orissa, Andhra Pradesh, Gujarat etc. This initiative is to introduce this valuable tree species in West Bengal in large scale with selected quality planting material and for this purpose this project is prepared.

The tree improvement project on *Tectona grandis* was started on 2018 funded by JICA (WBFBCP). Firstly we thank to The Principal Chief Conservator of Forests (Research, Monitoring & Development) Dr. Jose T. Mathew, IFS who first gave the proposal for doing such type of Research Work. Thanks to the Chief Project Director of WBFBCP, Sri Debal Roy, IFS who approved the project. Thanks to The Principal Chief Conservator of Forests, RMD , Shri V.K. Yadav, IFS for his kind support and permission to compile the research finding and compilation of the report. Thanks to the Additional PCCF, R&M, Smt Pratibha Raj, IFS for going through the project document and getting it approved in the Committee for Scrutiny and Approval of the final project report. Thanks to the Chief Conservator of Forests, R&D Shri D. Mallick, IFS for guidance and Dr S C Das, IFS, Chief Conservator of Forest, Soil Conservation for their support to compile the findings of the experimental work. Thanks to Shri B. Sarkar, IFS, Conservator of Forest, Research Circle, WB for guidance to the field work and data collection.

Sri T. T Bhutia, IFS and Sri K. Sarkar, IFS successfully guided the experimental part and data collection at North Bengal which is acknowledged. Smt Nabanita Sanyal, WBFS, ADFO of this Division involved herself for editing this report. Thanks to the Forest Range Officer of AFR, Arabari Research Range and Purulia Research Range under Silviculture South Division and Jalpaiguri Research Range under Silviculture North Division, who provide the growth data and good quality photographs. All the staff of Silviculture (North) Division and Silviculture (South) Division who worked hard for this project from the beginning to till end.

Divisional Forest officer
Silviculture South Division

Project Profile

1. Title of the Project:- Tree Improvement Programme of Teak (*Tectona grandis*)

2. Implementing Team

Principal Investigator	M. L Sarkar, IFS Divisional Forest Officer	Silviculture South Division
	T. T Bhutia, IFS Divisional Forest Officer	Silviculture North Division
	J. Jesper, IFS Divisional Forest Officer	Silviculture Hills Division
Co-Principal Investigator	NiladriShankha, FR Goutam Shit, FR ManideepMothey, FR Sanjay Chaki, FR JayrajBbhujel, FR	Range Officer, Arabari Range Beliatore Range Ranibandh Range, AFR Jalpaiguri Research Range Buxa-Coochbehar Research Range Kurseong Research Range
Support Staff	Sumit Chakraborty	Rathin Rana
	NemaiTudu	JaydevChoulia
	Chabilal Kami	KaluThapa
	Ratneswar Roy	

3. Project Location

Division	Range	Location
Silviculture South Division	Arabari Range	Chandmura
	Beliatore Range	Bahadurpur
	Ranibandh Range	Kadaya
Silviculture North Division	Jalpaiguri Research Range	Lataguri
	Buxa-Coochbehar Research Range	Rasik Bill
Silviculture Hills Division	Kurseong Research Range	Sukna

4. Project Commencement Date – August, 2019

5. Project Completion Date – November, 2021

6. Project Cost – 20,96,700.00

7. Funding Agency – West Bengal Forest and Biodiversity Conservation Project

Introduction

Teak (*Tectona grandis*) is one of the most widely planted and important tropical hardwoods. It is a large dominant deciduous tree found in mixed hardwood forests and is indigenous to India and the South-east Asian region. In India, teak is distributed naturally in the peninsular region below 24°N latitude and is found in Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka and Kerala. Outside its natural occurrence, teak has been raised in states like Uttar Pradesh, West Bengal, Assam, Bihar, Orissa, Andhra Pradesh, Gujarat etc. Teak has also been introduced to South-east Asia, Pacific, East and West Africa, the Caribbean, South America and Central America etc. Myanmar accounts for nearly one third of the world's total teak production. Teak is recognized as the best timber for the manufacture of door, window frames and shutters, wagon and carriage, furniture, cabinets, ships, agricultural implements, decorative flooring and wall paneling because of its moderate weight, appropriate strength, dimensional stability and durability, easy workability and finishing qualities and most appealing grain, texture, colour and figure. In view of its importance, the British attempted to raise teak plantations in different regions of India since 1841in Kerala, West Bengal etc. but no scientific strategy for its genetic improvement was evolved till recently. Later, as part of genetic improvement work, states like Andhra Pradesh, Gujarat, Madhya Pradesh, Tamil Nadu and Uttar Pradesh have also established seed orchards.

Works in West Bengal and elsewhere:-The British started raising Teak and Sal in Bamnapokri under the Kurseong Division during 1868-88 period, mainly for ship building purpose back in England. World's oldest teak plantation was raised in Kerala at Nilambur (Connolly`s Plot). So far the criteria for selection of seeds were their capacity to germinate and availability. Attempts to improve planting stock genetically were made as early as 1961 when Kedarnath and Mathews did the first selection of plus trees of teak. Sengupta (1939) reported the superiority of seeds of local origin to those from elsewhere in the region of the natural range of teak. He pointed out that Nilambur origin grows well in relatively very dry zones compared to others tested. Kadambi (1945) found that seeds of Nilambur origin were better suited for dry zones of Mysore like Shimoga. Egenti (1977) reported variation in vigour and form between provenances. According to him provenances from India and elsewhere showed clear differences in branching habit and foliage. The West African type was found inferior in bole length as compared to that of India. Grafting technique for vegetative propagation was standardized and an experimental clonal seed orchard established subsequently at Dehra Dun (Kedarnath and Venkatesh,1963).

Kerala, Maharashtra and Madhya Pradesh are some of the prime teak growing states in India. Similarly Teak is grown in West Bengal and some NE states. Depending on the climatic situation, different land races were evolved over years. Maharashtra and MP, being located in predominantly dry zones, they have different land races. Since climatic condition of North Bengal (mostly wet condition) has similarities with that Kerala, some improved strains from Kerala was tried on multiple locations in the State where teak is locally found. If found suitable, these clones could be used in the future plantation program and for distribution to marginal farmers as a supplementary source of income.

Objective of the Project:-

a. To select promising clones after multi-location trials in the State.
b. To evolve superior provenances through progeny testing of superior lines from the Plus trees developed in the State.
c. To develop suitable propagules for mass multiplication of the desirable clones for use in the forest plantations and for distribution to the general public.

Methodology:-

Kerala Forest Research Institute (KFRI), Kochi has developed some clones and five of the promising clones apparently suitable for the West Bengal Climate are being tried in different sites where teak has been traditionally growing. KFRI Clones are brought for multi location trials for its suitability in the State. In the provenance trials, progenies of selected plus trees in different zones were tried and except the material from the plus tree at Kuilapal, others were not successful and hence excluded from the trial.

a.Multi-location trials of clones

a.1. Materials:-5 no Clone brought form KFRI and one from the plus tree No PT 1 of Kuilapal, West Bengal. Total 7 treatments were done including T7 as control. Details of the five Teak provenances from KFRI, Kerala:

Sl No		No of Clones	Treatment No	Name of Clone
1.	Nilambur provenance	2	T1	Nilambur- KFRI-1
2.			T2-	Nilambur- KFRI-5
3.	Konni provenance	1	T3	Konni, KFRI-15,
4.	Wyandu provenance	1	T4	Whyanadu- KFRI-18
5.	Kulathupuzha provenance		T5	Kulathupooja KFRI - 36
6.	Kuilapal, South Bengal		T6-	Kuilapal PT-1
7.	Local seedlings, as control.		T7-	

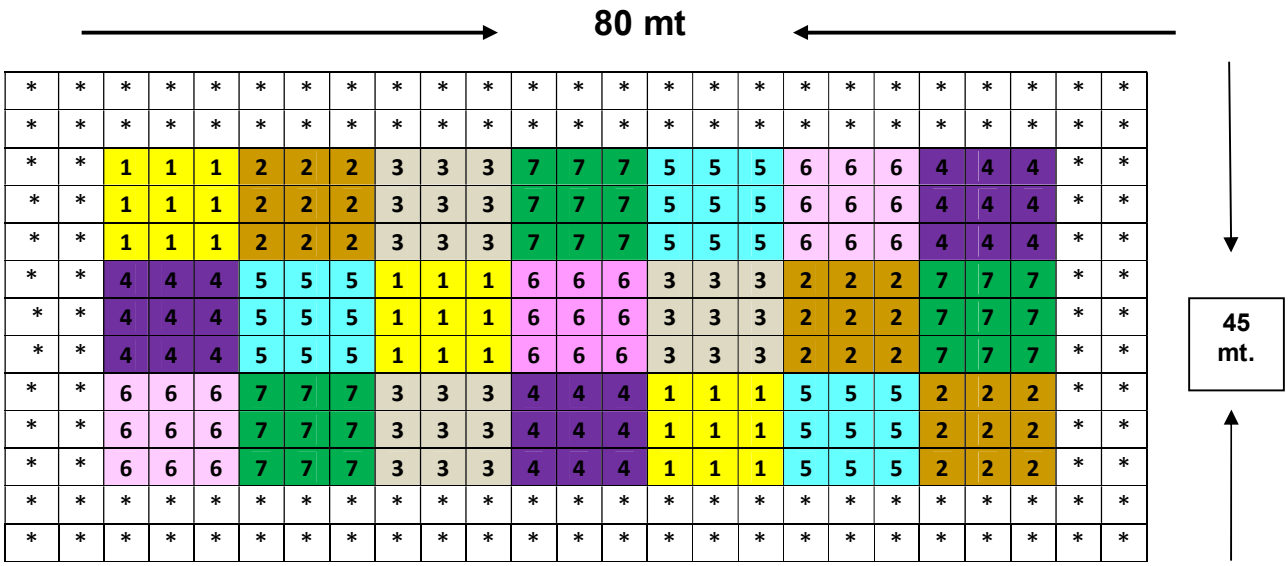
a.2. **Treatment:-**7 Treatment for each location X 5 locations.

a.3. **Location of Experiment/Trial :-**

Sl. No.	Place	Agro-climatic zone	Executing Divn.	Rainfall (cm)
1.	Sukna	Foothills(400-500m)	Silvi(Hills)	300-400
2.	Lataguri	Teraialluvium	Silvi(N)	300-400
3.	Rasik Bill(Coochbehar)	Terai alluvium	Silvi(N)	200-250
4.	Kadaya	Red soil	Silvi(S)	160-200
5.	Arabari	Lateritic soil	Silvi(S)	140-160
6.	Beliator	Alluvial soil	Silvi(S)	160 -200

a. 4. Layout of the Teak varietal trial

- No of clones/ accessions: 7 (5 clones from KFRI, 1 accessions from Forest Department and 1 control)
- No of replications: 3
- No of plants / replication: 9
- Spacing: 3m x 3 m



Details of the clones / accessions : T1 – T7 marked as 1,2,3,4,5,6,7

*** - Any accession to minimize border effect**

a.5. Data recording and analysis

Growth data of the seedlings were recorded for height and collar diameter at six months interval and these data was analyzed. Growth data recorded during December, 2020 was analyzed and compared the result with the control (T7) and among the clones, on the basis of the mean volume of the clones tried to ascertain the preliminary growth trend clone wise and location wise. The trees shall be allowed to grow till fifteen years or more to assess timber qualities etc. in which measurements are taken at yearly interval. By three to four years, an extrapolative selection could be made based on the observation of growth parameters and further testing of `general combining ability` could be studied through multi location trials.

After three to four years of study, promising clones could be selected for mass multiplication. Field measurements are to be taken every six months for the first two years and later annually to construct growth characteristics based on Age-height, age- collar girth relationships. The trees may be retained for about fifteen years for further observations on timber quality and volume production.

Interpretation of Statistical Analysis:-

For Descriptive Analysis:-

1st Column - Number of Treatment.

2nd Column - No of individual observed irrespective of replications for each treatment.

3rd Column – Mean- Average of individuals within group or within each treatment.

4th column - Standard deviation is a measure of dispersion of data from it's mean. For normally distributed population - Mean ±1SD = 68%, Mean ± 2SD = 95% & Mean ± 3SD = 99.7%

5th Column- Standard error is a measure of accuracy of a mean of any given sample from its population. SE increase means more spread, means inaccurate representation from true population.

6th Column- Confidence interval is a display the probability that a parameter will fall between a pair of value around mean, mostly measured at 95% or 99% probability level.

Minimum & Maximum - As data are recorded

Anova- Analysis of variance.

1st column- Between Group - No. of Treatment
1st column- Within Group- No. of individual recorded. Or the replication value as recorded.

2nd column - Sum of Square - Function that fits the data in best way for Anova Test.

Sum of Square $=\sum_0^n (X_1 - \bar{x})^2$ Higher SS mean higher variability.

3rd column - D.f. = Degree of freedom =(N-1)

4th column - Mean Square - Estimates the population variance, calculated by dividing the corresponding SS by the df, useful in Anova Test.

5th column -F- Value:- $\frac{\text{Variations between sample mean}}{\text{Variation within the sample mean}}$

6th column - Sig:- Significance, if the value is less than 0.01, then difference between group (Treatment) are statistically significant at 99% probability level, if the value is less than 0.05, then difference between groups (Treatment) are statistically significant at 95% probability level, and if the value is more than 0.05 then between groups difference is not significant statistically.

Post Hoc:- Duncan homogenous test :-
1st column - Treatment no.
2nd column - N- No. of individual observed with a single treatment.
3rd column- Subset for alpha=.05 or .01- When the difference between treatment is significant at 99% or 95% probability level, then further testing can be done by using different Posthoc test by choosing Duncan homogeneous subsets, which is more efficient is comparison to LSD.

5. Training of Staff and Officers

1. Consultant: The Kerala Forest research Institute, represented by Dr. Hrideek, Scientist: E and Plant breeder, who has several years of experience working in Teak, was consulted for developing the experiment design and also trained staff and Officers of the Research Wing.
2. A team from the participating Silviculture divisions (South, North and Hills respectively) had visited KFRI to have knowledge of clonal selection, clonal plantations of teak and on vegetative propagation of teak etc.

6. Deliverables

a. Promising clones could be mass-multiplied by Silviculture Divisions for forestry use.
b. Clones for distribution to the general public.
c. Setting up of Seedling seed orchards and Clonal seed orchards for Teak.

Teak Clonal cuttings

Teek Seedling from stump

Results and Discussions

- The growth data collected after one and half years of growth from five location i.e
  - Arabari
  - Beliatore
  - Kadaya
  - Lataguri and
  - Rasikbil
- Sukna trial plot was damaged more than 50% due to elephant depredation and not considered for analysis.
- The growth data was analysed and the results are given plot wise and a comparative account has also compiled.

Volume analysis report of Tree Improvement Programme of Teakfor 5 location under Silviculture (South) Division & Silviculture (North) Division

Location wise Experiment Result & inference as given below – Results of 5 plots are taken. Seedlings at Sukna Plot was damaged by wild elephant.

Treatment	Clone Name	Location
T1	KFRI-1	Arabari
T2	KFRI-5	Arabari
T3	KFRI-15	Arabari
T4	KFRI-18	Arabari
T5	KFRI-36	Arabari
T6	QAL ST 1	Arabari
T7	Local seedling	Arabari
T8	KFRI-1	Ranibandh
T9	KFRI-5	Ranibandh
T10	KFRI-15	Ranibandh
T11	KFRI-18	Ranibandh
T12	KFRI-36	Ranibandh
T13	QAL ST 1	Ranibandh
T14	Local seedling	Ranibandh
T15	KFRI-1	Beliatore
T16	KFRI-5	Beliatore
T17	KFRI-15	Beliatore
T18	KFRI-18	Beliatore
T19	KFRI-36	Beliatore
T20	QAL ST 1	Beliatore
T21	Local seedling	Beliatore
T22	KFRI-1	Jalpaiguri, Lataguri
T23	KFRI-5	Jalpaiguri, Lataguri
T24	KFRI-15	Jalpaiguri, Lataguri
T25	KFRI-18	Jalpaiguri, Lataguri

T26	KFRI-36	Jalpaiguri, Lataguri
T27	QAL ST 1	Jalpaiguri, Lataguri
T28	Local seedling	Jalpaiguri, Lataguri
T29	KFRI-1	Rashikbill, Rajabhatkhawa
T30	KFRI-5	Rashikbill, Rajabhatkhawa
T31	KFRI-15	Rashikbill, Rajabhatkhawa
T32	KFRI-18	Rashikbill, Rajabhatkhawa
T33	KFRI-36	Rashikbill, Rajabhatkhawa
T34	QAL ST 1	Rashikbill, Rajabhatkhawa
T35	Local seedling	Rashikbill, Rajabhatkhawa

Means

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Vol_cm3 * Treat	798	84.4%	147	15.6%	945	100.0%

Report

Vol_cm^3

Treat	Mean	N	Std. Deviation	Minimum	Maximum	% of Total N
1	142.93	23	79.462	8	299	2.9%
2	115.84	24	103.447	5	294	3.0%
3	91.55	22	69.348	5	293	2.8%
4	143.98	26	111.188	5	397	3.3%
5	78.51	21	70.474	2	286	2.6%
6	114.59	14	69.858	4	218	1.8%
7	46.54	25	40.703	1	153	3.1%
8	30.28	24	16.930	4	67	3.0%
9	29.13	25	18.563	5	68	3.1%
10	16.20	27	8.867	5	43	3.4%
11	12.76	26	9.078	0	33	3.3%
12	16.75	27	10.857	0	44	3.4%
13	21.39	27	10.560	7	49	3.4%
14	17.81	27	10.020	7	45	3.4%
15	35.57	27	25.905	4	97	3.4%
16	28.83	26	14.887	9	67	3.3%
17	33.73	27	24.633	8	109	3.4%
18	29.17	25	19.960	5	85	3.1%
19	40.45	26	37.521	1	123	3.3%
20	32.02	26	19.530	0	76	3.3%
21	40.67	26	48.958	1	193	3.3%
22	60.80	17	70.323	0	246	2.1%
23	37.14	20	29.864	2	100	2.5%
24	9.50	25	10.744	0	41	3.1%

25	45.18	18	45.352	1	149	2.3%
26	36.56	18	46.658	1	146	2.3%
27	76.14	26	86.211	4	322	3.3%
28	4.58	20	5.440	1	16	2.5%
29	230.72	24	395.409	4	1367	3.0%
30	53.19	19	69.155	0	264	2.4%
31	47.67	22	54.636	4	172	2.8%
32	64.34	18	93.451	1	379	2.3%
33	44.01	16	44.639	5	177	2.0%
34	368.16	21	381.524	0	1288	2.6%
35	20.20	13	10.715	6	41	1.6%
Total	61.75	798	123.505	0	1367	100.0%

One way

Descriptive

Vol_cm^3

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	23	142.93	79.462	16.569	108.57	177.29	8	299
2	24	115.84	103.447	21.116	72.16	159.52	5	294
3	22	91.55	69.348	14.785	60.81	122.30	5	293
4	26	143.98	111.188	21.806	99.07	188.89	5	397
5	21	78.51	70.474	15.379	46.43	110.59	2	286
6	14	114.59	69.858	18.670	74.25	154.92	4	218
7	25	46.54	40.703	8.141	29.74	63.34	1	153
8	24	30.28	16.930	3.456	23.13	37.42	4	67
9	25	29.13	18.563	3.713	21.47	36.80	5	68
10	27	16.20	8.867	1.706	12.69	19.70	5	43
11	26	12.76	9.078	1.780	9.09	16.43	0	33
12	27	16.75	10.857	2.089	12.46	21.05	0	44
13	27	21.39	10.560	2.032	17.22	25.57	7	49
14	27	17.81	10.020	1.928	13.85	21.77	7	45
15	27	35.57	25.905	4.985	25.33	45.82	4	97
16	26	28.83	14.887	2.920	22.81	34.84	9	67
17	27	33.73	24.633	4.741	23.99	43.48	8	109
18	25	29.17	19.960	3.992	20.94	37.41	5	85
19	26	40.45	37.521	7.359	25.30	55.61	1	123
20	26	32.02	19.530	3.830	24.13	39.91	0	76
21	26	40.67	48.958	9.602	20.89	60.44	1	193
22	17	60.80	70.323	17.056	24.65	96.96	0	246
23	20	37.14	29.864	6.678	23.17	51.12	2	100
24	25	9.50	10.744	2.149	5.06	13.93	0	41

25	18	45.18	45.352	10.690	22.63	67.73	1	149
26	18	36.56	46.658	10.997	13.36	59.76	1	146
27	26	76.14	86.211	16.907	41.32	110.97	4	322
28	20	4.58	5.440	1.216	2.03	7.12	1	16
29	24	230.72	395.409	80.713	63.76	397.69	4	1367
30	19	53.19	69.155	15.865	19.86	86.52	0	264
31	22	47.67	54.636	11.648	23.45	71.90	4	172
32	18	64.34	93.451	22.027	17.87	110.81	1	379
33	16	44.01	44.639	11.160	20.22	67.79	5	177
34	21	368.16	381.524	83.255	194.50	541.83	0	1288
35	13	20.20	10.715	2.972	13.72	26.67	6	41
Total	798	61.75	123.505	4.372	53.17	70.33	0	1367

ANOVA

Vol_cm^3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3786031.300	34	111353.862	10.150	.000
Within Groups	8371071.561	763	10971.260		
Total	1.2167	797			

Post Hoc Tests

Homogeneous Subsets

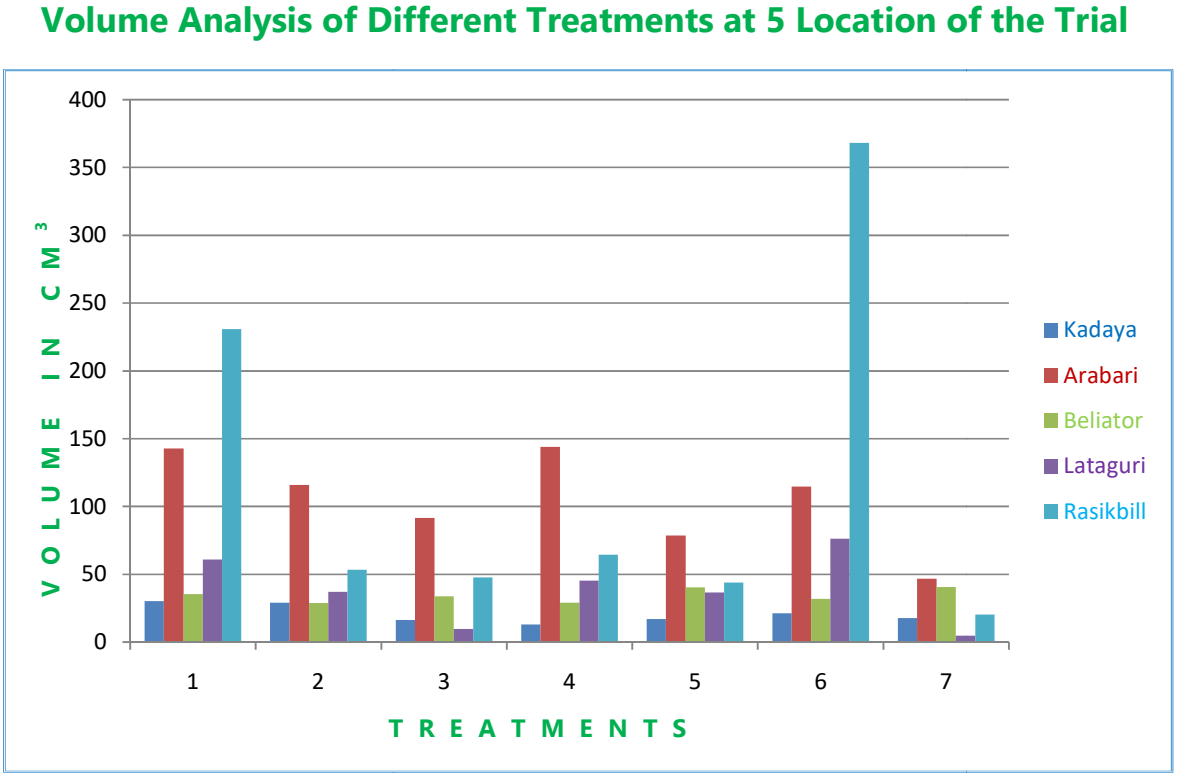
Vol_cm^3

Duncan

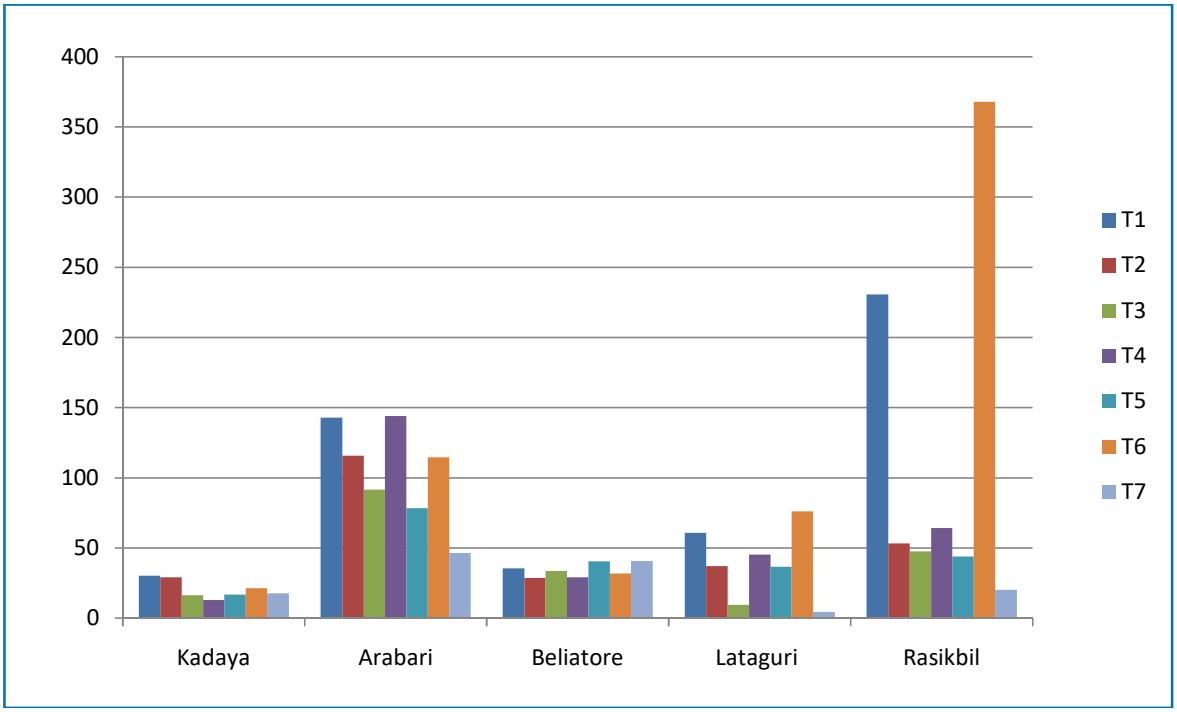
		Subset for alpha = 0.05					
Treat	N	1	2	3	4	5	6
28	20	4.58					
24	25	9.50					
11	26	12.76	12.76				
10	27	16.20	16.20				
12	27	16.75	16.75				
14	27	17.81	17.81				
35	13	20.20	20.20				
13	27	21.39	21.39				
16	26	28.83	28.83				
9	25	29.13	29.13				
18	25	29.17	29.17				
8	24	30.28	30.28				
20	26	32.02	32.02				
17	27	33.73	33.73				
15	27	35.57	35.57				
26	18	36.56	36.56				
23	20	37.14	37.14				
19	26	40.45	40.45	40.45			
21	26	40.67	40.67	40.67			
33	16	44.01	44.01	44.01			

25	18	45.18	45.18	45.18			
7	25	46.54	46.54	46.54			
31	22	47.67	47.67	47.67			
30	19	53.19	53.19	53.19			
22	17	60.80	60.80	60.80			
32	18	64.34	64.34	64.34			
27	26	76.14	76.14	76.14	76.14		
5	21	78.51	78.51	78.51	78.51		
3	22		91.55	91.55	91.55		
6	14			114.59	114.59		
2	24			115.84	115.84		
1	23				142.93		
4	26				143.98		
29	24					230.72	
34	21						368.16
Sig.		.068	.050	.051	.064	1.000	1.000

Means Plots



Comparative growth of the clones in respect of the local seedling at 5 location of the trial



Inference on Tree Improvement programme of Teak

1. **<u>At Arabari location:-</u>**

   Best Performers are clone no- Wyenadu KFRI-18 (T4) &Nilambur- KFRI-1 (T1)

   Medium performers are clone no-Nilambur-KFRI-5 (T2), Kuilapal PT-1 (T6) & Konni KFRI-15 (T3)

   Worst performers are clone no- Kulathupooja KFRI-36 (T5) & Seed origin local (T7).

2. **<u>At Kadaya (Quilapal) location:-</u>**

   Best Performers are clone no-Nilambur- KFRI-1(T1) & Nilambur-KFRI-5 (T2)

   Medium performers are clone no-Kuilapal PT-1 (T6) Seed origin local (T7).&Kulathupooja KFRI-36(T5)

   Worst performers are clones are- Konni KFRI-15(T3) &Wyenadu KFRI-18 (T4)

3. **<u>At Beliatore (Bahadurpur) location:-</u>**

   Best Performers are clone no- Seed origin local (T7) &Kulathupooja KFRI-36 (T5) &Nilambur- KFRI-1(T1)

   Medium performers are clone no- Konni KFRI-15 (T3) &Kuilapal PT-1 (T6)

   Worst performers are clones no- Wyenadu KFRI-18 (T4) & Nilambur-KFRI-5 (T2)

4. <u>At Lataguri (Jalpaiguri) Location:-</u>

Best Performers are clone no- Kuilapal PT-1 (T6), Nilambur- KFRI-1 (T1) & Nilambur-KFRI-5 (T2),

Medium performers are clone no-Kulathupooja KFRI-36 (T5) &Wyenadu KFRI-18 (T4)

Worst performers are clones no- Konni KFRI-15 (T3) & Seed origin local (T7)

5. <u>At Rashikbill (Buxa- Coochbehar) Location:-</u>

Best Performers are clone no- Kuilapal PT-1 (T6) &Nilambur- KFRI-1 (T1)

Medium performers are clone no-&Wyenadu KFRI-18 (T4), Nilambur-KFRI-5 (T2) & Konni KFRI-15 (T3)

Worst performers are clones no-Kulathupooja KFRI-36 (T5) & Seed origin local (T7)

Growth of Teak clones at Rasiknil shows best growth followed by Arabari location. All the clones planted at Lataguri, Beliatore and Kadaya are less the prior two location.

Comparative analysis of growth of Teak clone at different locations

Oneway

Descriptives

Vol_cm3

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	155	104.78	87.479	7.027	90.90	118.67	1	397
2	183	20.41	13.738	1.016	18.41	22.41	0	68
3	183	34.38	29.337	2.169	30.10	38.66	0	193
4	144	38.59	55.937	4.661	29.37	47.80	0	322
5	133	131.23	259.429	22.495	86.73	175.72	0	1367
Total	798	61.75	123.505	4.372	53.17	70.33	0	1367

ANOVA

Vol_cm3

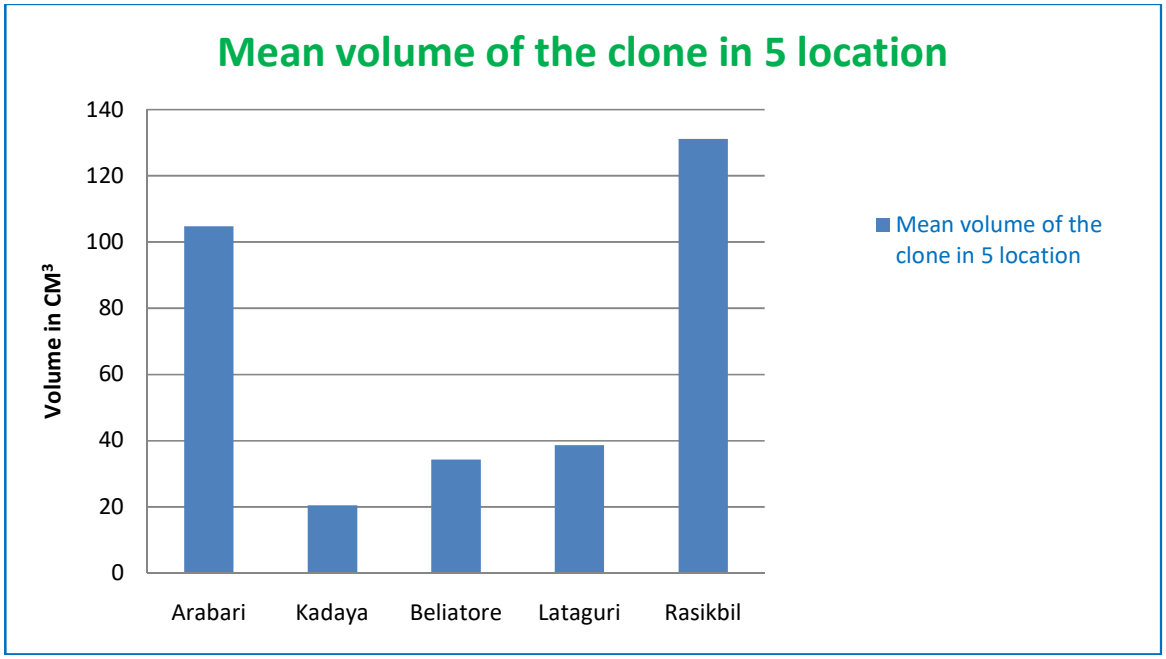
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1456125.444	4	364031.361	26.977	.000
Within Groups	1.070	793	13494.297		
Total	1.216	797			

Homogeneous Subsets

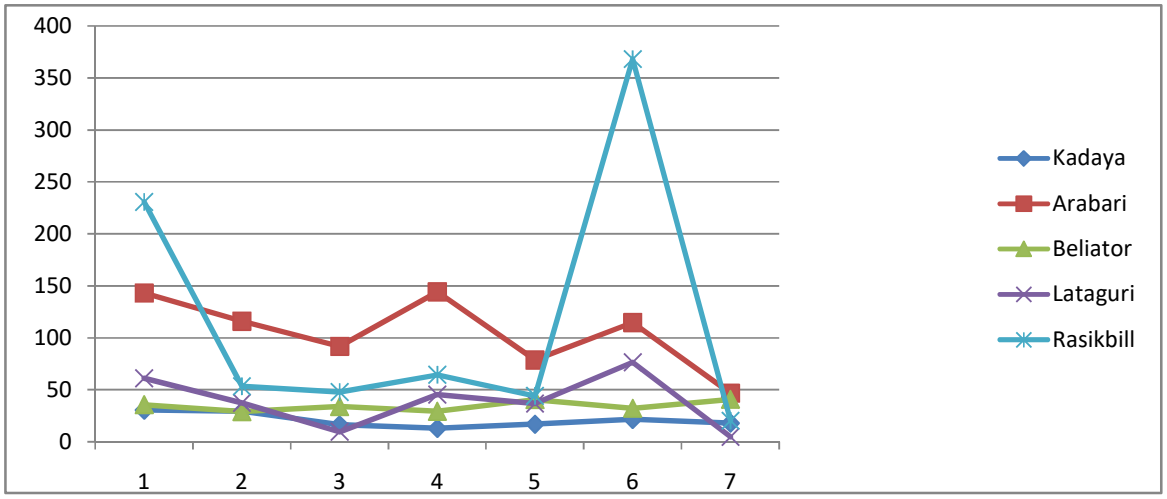
Vol_cm3

Duncan			

Loc_ID	N	Subset for alpha = 0.05		
		1	2	3
2	183	20.41		
3	183	34.38		
4	144	38.59		
1	155		104.78	
5	133			131.23
Sig.		.193	1.000	1.000



Inference:-Location wise performance of Teak seedlings for 5 locations, as per data obtained after two years of growth in terms of volume,plants at Rasikbil and Arabari are showing good growth than the other locations. Growth data for all the locations will be studied for another 3 years for making a projection of the growth of the clones and selection will be made on that basis.



Volume analysis of Teak planted atChandmura under Arabari research Range

Case Processing Summary						
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Vol_cm^3 * Ht_Dec_20	155	82.0%	34	18.0%	189	100.0%
Vol_cm^3 * CD_Dec_20	155	82.0%	34	18.0%	189	100.0%

One way

Descriptives								
Vol_cm^3								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	23	142.93	79.462	16.569	108.57	177.29	8	299
2	24	115.84	103.447	21.116	72.16	159.52	5	294
3	22	91.55	69.348	14.785	60.81	122.30	5	293
4	26	143.98	111.188	21.806	99.07	188.89	5	397
5	21	78.51	70.474	15.379	46.43	110.59	2	286
6	14	114.59	69.858	18.670	74.25	154.92	4	218
7	25	46.54	40.703	8.141	29.74	63.34	1	153
Total	155	104.78	87.479	7.027	90.90	118.67	1	397

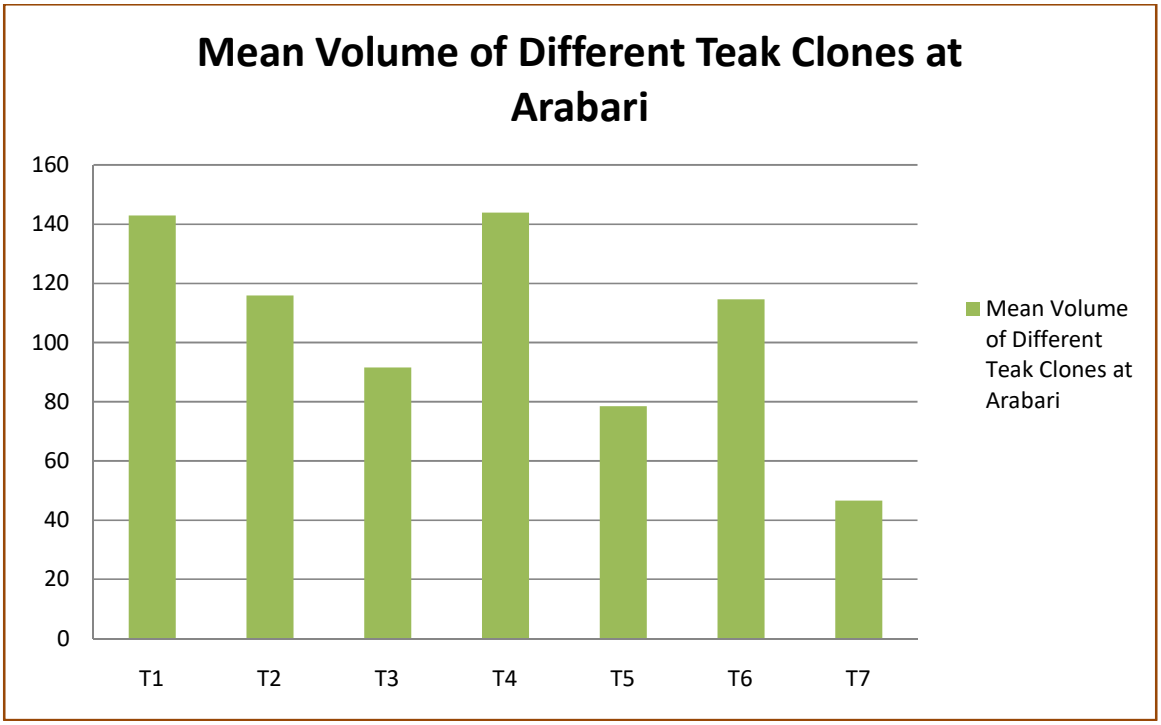
ANOVA					
Vol_cm^3					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	180865.176	6	30144.196	4.472	.000
Within Groups	997642.157	148	6740.825		
Total	1178507.333	154			

Post Hoc Tests
Homogeneous Subsets

Vol_cm^3				
Duncan				
		Subset for alpha = 0.05		
Treat	N	1	2	3
7	25	46.54		
5	21	78.51	78.51	
3	22	91.55	91.55	91.55
6	14		114.59	114.59
2	24		115.84	115.84
1	23			142.93
4	26			143.98

Sig.		.092	.180	.064

Means Plot



Inference :-

1. All the clones from Kerala, **T1** to **T5** and **T6** (Kuilapal PT-1) shows better growth in the initial stages than the seed origin Teak seedling**T7**.

2. Among the clones from Kerala,**T1** (KFRI 1 –Nilambur) and **T4** (KFRI 18 – Wyanadu) shows best performance in term of growth in the initial stage.

3. **T2** (KFRI-5Nilambur), **T3** (KFRI-15Konni) and **T6-**(Kuilapal PT-1) also shows moderate growth.

4. In its initial stage of growth, the clones obtained from cuttings of the selected material are better than the seed origin seedling of teak.

Growth data will be analyzed for 2 more years and the best performing clone will be selected for mass propagation and introduced for field trials and commercial plantations. This plot will be maintained for another 10 years to study the growth and the timber quality of the teak trees.

Teak tree volume analysis of Kadaya under Ranibandh Research Range

Means

Case Processing Summary						
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Vol_cm3 * Treat	183	96.8%	6	3.2%	189	100.0%

Report						
Vol_cm^3						
Treat	Mean	N	Std. Deviation	Minimum	Maximum	% of Total N
1	30.28	24	16.930	4	67	13.1%
2	29.13	25	18.563	5	68	13.7%
3	16.20	27	8.867	5	43	14.8%
4	12.76	26	9.078	0	33	14.2%
5	16.75	27	10.857	0	44	14.8%
6	21.39	27	10.560	7	49	14.8%
7	17.81	27	10.020	7	45	14.8%
Total	20.41	183	13.738	0	68	100.0%

Oneway

Descriptives								
Vol_cm^3								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	24	30.28	16.930	3.456	23.13	37.42	4	67
2	25	29.13	18.563	3.713	21.47	36.80	5	68
3	27	16.20	8.867	1.706	12.69	19.70	5	43
4	26	12.76	9.078	1.780	9.09	16.43	0	33
5	27	16.75	10.857	2.089	12.46	21.05	0	44
6	27	21.39	10.560	2.032	17.22	25.57	7	49
7	27	17.81	10.020	1.928	13.85	21.77	7	45
Total	183	20.41	13.738	1.016	18.41	22.41	0	68

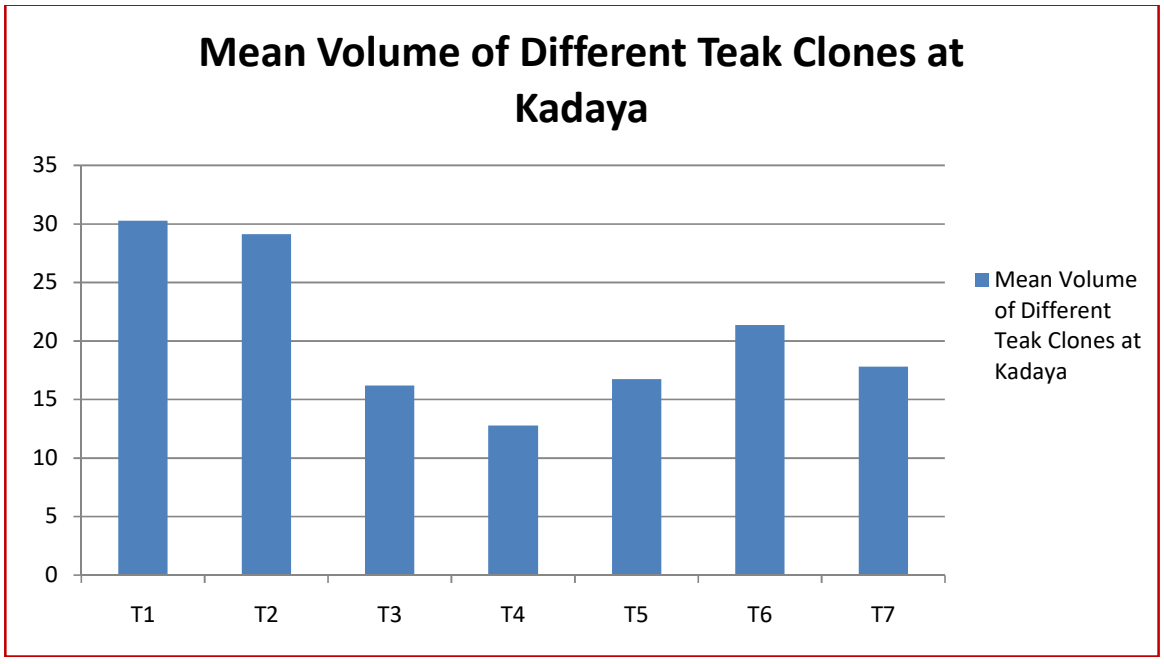
ANOVA					
Vol_cm^3					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6809.474	6	1134.912	7.253	.000
Within Groups	27540.996	176	156.483		
Total	34350.470	182			

Post Hoc Tests

Homogeneous Subsets

Vol_cm^3				
Duncan				
		Subset for alpha = 0.05		
Treat	N	1	2	3
4	26	12.76		
3	27	16.20	16.20	
5	27	16.75	16.75	
7	27	17.81	17.81	
6	27		21.39	
2	25			29.13
1	24			30.28
Sig.		.188	.175	.742

Means Plots



Inference:-

1. Clones from Kerala, **T1, T2** and **T6** (Kuilapal PT-1) from West Bengal shows better growth in the initial stages than the seed origin Teak seedling **T7**. T3, T4 and T5 are not promising in comparison to T7

2. Among the clones from Kerala, **T1** (KFRI 1 – Nilambur) and **T2** (KFRI 5 – Nilambur) shows best performance in term of growth in the initial stage.

3. In its initial stage of growth, the clones obtained from cuttings of the selected material are better than the seed origin seedling of teak.

Growth data will be analyzed for 2 more years and the best performing clone will be selected for mass propagation and introduced for field trials and commercial plantations. This plot will be maintained for another 10 years to study the growth and the timber quality of the teak trees.

Teak tree volume analysis of Bahadurpur under Beliatore Research Range

Means

Case Processing Summary						
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Vol_cm3 * Treat	183	96.8%	6	3.2%	189	100.0%

Report						
Vol_cm^3						
Treat	Mean	N	Std. Deviation	Minimum	Maximum	% of Total N
1	35.57	27	25.905	4	97	14.8%
2	28.83	26	14.887	9	67	14.2%
3	33.73	27	24.633	8	109	14.8%
4	29.17	25	19.960	5	85	13.7%
5	40.45	26	37.521	1	123	14.2%
6	32.02	26	19.530	0	76	14.2%
7	40.67	26	48.958	1	193	14.2%
Total	34.38	183	29.337	0	193	100.0%

Oneway

Descriptives

Vol_cm^3

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	27	35.57	25.905	4.985	25.33	45.82	4	97
2	26	28.83	14.887	2.920	22.81	34.84	9	67
3	27	33.73	24.633	4.741	23.99	43.48	8	109
4	25	29.17	19.960	3.992	20.94	37.41	5	85
5	26	40.45	37.521	7.359	25.30	55.61	1	123
6	26	32.02	19.530	3.830	24.13	39.91	0	76
7	26	40.67	48.958	9.602	20.89	60.44	1	193

Descriptives

Vol_cm^3

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	27	35.57	25.905	4.985	25.33	45.82	4	97
2	26	28.83	14.887	2.920	22.81	34.84	9	67
3	27	33.73	24.633	4.741	23.99	43.48	8	109
4	25	29.17	19.960	3.992	20.94	37.41	5	85
5	26	40.45	37.521	7.359	25.30	55.61	1	123
6	26	32.02	19.530	3.830	24.13	39.91	0	76
7	26	40.67	48.958	9.602	20.89	60.44	1	193
Total	183	34.38	29.337	2.169	30.10	38.66	0	193

ANOVA

Vol_cm^3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3659.811	6	609.969	.702	.649
Within Groups	152981.583	176	869.214		
Total	156641.395	182			

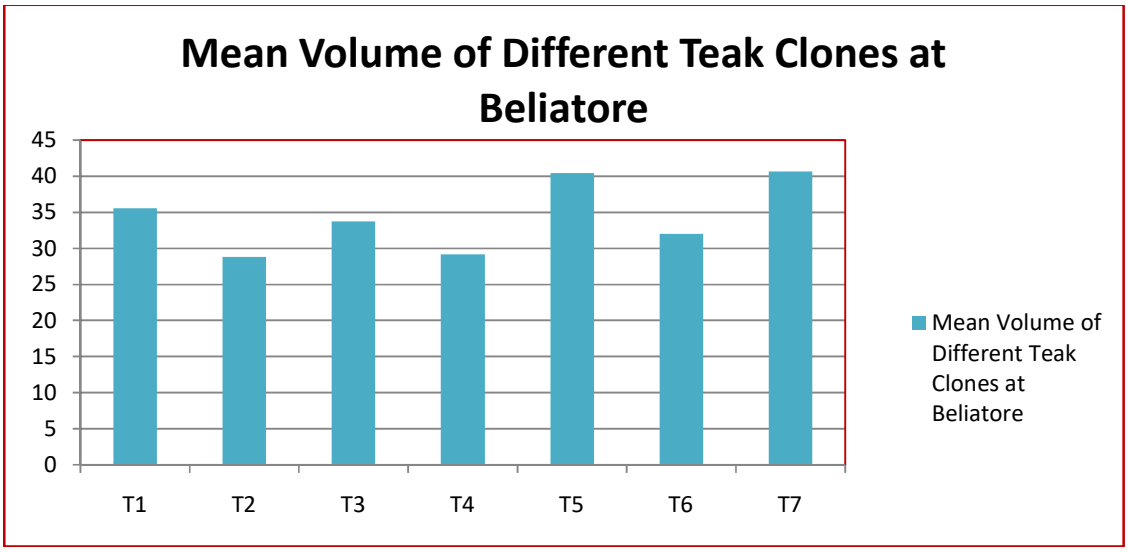
Post Hoc Tests

Homogeneous Subsets

Vol_cm3

Duncan		
		Subset for alpha = 0.05
Treat	N	1
2	26	28.83
4	25	29.17
6	26	32.02
3	27	33.73
1	27	35.57
5	26	40.45
7	26	40.67
Sig.		.219

Means Plots



Inference:-

1. All the clones from Kerala, **T1** to **T5** and **T6** (Kuilapal PT-1) are not showing better growth in the initial stages than the seed origin Teak seedling **T7**.

2. Among the clones from Kerala, **T1** (KFRI 1 – Nilambur) and **T5** (Kulathupooja KFRI-36) shows best performance in term of growth in the initial stage.

3. In its initial stage of growth, the clones obtained from cuttings of the selected material are better than the seed origin seedling of teak.

Growth data will be analyzed for 2 more years and the best performing clone will be selected for mass propagation and introduced for field trials and commercial plantations. This plot will be maintained for another 10 years to study the growth and the timber quality of the teak trees.

Teak tree volume analysis of Lataguri under Jalpaiguri Research Range, Silviculture (N) Division.

Means

Case Processing Summary						
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Vol_cm3 * Treat	143	75.7%	46	24.3%	189	100.0%

Report						
Vol_cm3						
Treat	Mean	N	Std. Deviation	Minimum	Maximum	% of Total N

1	64.60	16	70.803	1	246	11.2%
2	37.14	20	29.864	2	100	14.0%
3	9.50	25	10.744	0	41	17.5%
4	45.18	18	45.352	1	149	12.6%
5	36.56	18	46.658	1	146	12.6%
6	76.14	26	86.211	4	322	18.2%
7	4.58	20	5.440	1	16	14.0%
Total	38.86	143	56.039	0	322	100.0%

One way

Descriptive

Vol_cm^3

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	16	.515525	.1970816	.0492704	.410508	.620543	.1592	.8439
2	20	.489650	.1301735	.0291077	.428727	.550573	.2389	.6529
3	25	.313376	.1227183	.0245437	.262720	.364031	.1274	.5255
4	18	.461783	.1892790	.0446135	.367657	.555910	.1433	.7803
5	18	.468861	.3722896	.0877495	.283725	.653996	.1911	1.7994
6	26	.521191	.1819226	.0356780	.447710	.594671	.2548	.8599
7	20	.266720	.0964969	.0215774	.221558	.311882	.1433	.4777
Total	143	.430159	.2149120	.0179718	.394632	.465686	.1274	1.7994

ANOVA

Vol_cm^3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.323	6	.221	5.728	.000
Within Groups	5.236	136	.038		
Total	6.559	142			

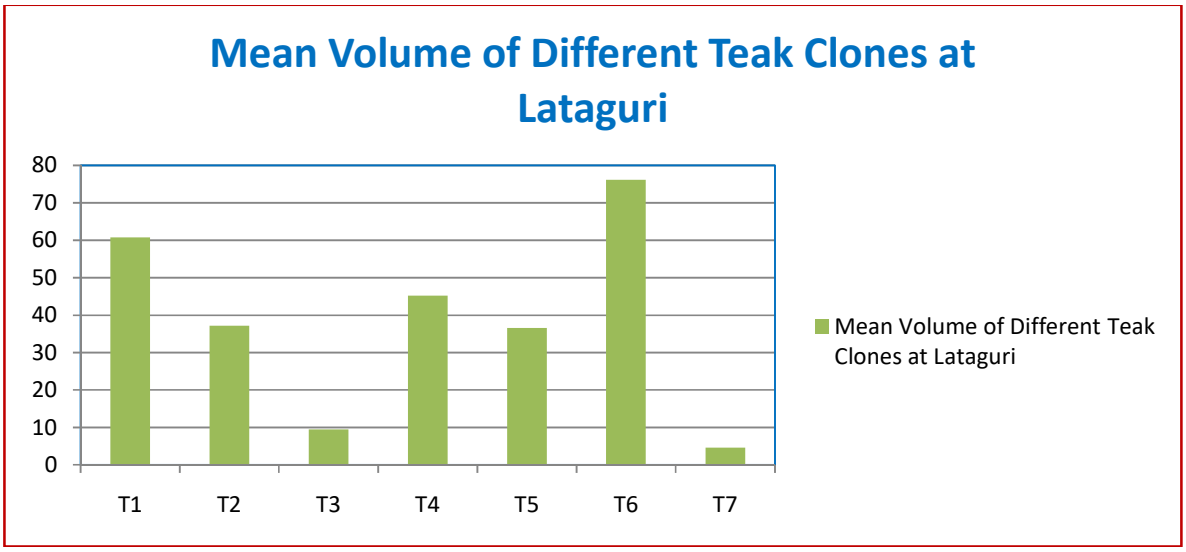
Post Hoc Tests
Homogeneous Subsets

Vol_cm^3

Duncan

		Subset for alpha = 0.05	
Treat	N	1	2
7	20	.266720	
3	25	.313376	
4	18		.461783
5	18		.468861
2	20		.489650
1	16		.515525
6	26		.521191
Sig.		.455	.405

Means Plots



Inference:-

1. All the clones from Kerala, **T1** to **T5** and **T6** (Kuilapal PT-1) shows better growth in the initial stages than the seed origin Teak seedling **T7**.

2. Among the clones from Kerala, **T1** (KFRI 1 – Nilambur) and **T4** (KFRI 18 – Wyanadu) shows best performance in term of growth in the initial stage.**T6-**(Kuilapal PT-1) from West Bengal shows best performance among all the clones.

3.**T2** (KFRI-5Nilambur), and T5 (Kulathupooja KFRI-36) shows moderate growth.

4. **T3** (KFRI-15Konni) is not promising. In its initial stage of growth, the clones obtained from cuttings of the selected material are better than the seed origin seedling of teak.

Growth data will be analyzed for 2 more years and the best performing clone will be selected for mass propagation and introduced for field trials and commercial plantations. This plot will be maintained for another 10 years to study the growth and the timber quality of the teak trees.

Volume analysis of Teak planted atRasikbil underBuxa-CoochbeharResearch Range, Silviculture (N) Division

Case Processing Summary						
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Vol_cm^3 * Treat	133	70.4%	56	29.6%	189	100.0%

Report
Vol_cm^3

Treat	Mean	N	Std. Deviation	Minimum	Maximum	% of Total N
1	230.72	24	395.409	4	1367	18.0%
2	53.19	19	69.155	0	264	14.3%
3	47.67	22	54.636	4	172	16.5%
4	64.34	18	93.451	1	379	13.5%
5	41.42	17	44.519	0	177	12.8%
6	386.57	20	381.747	3	1288	15.0%
7	20.20	13	10.715	6	41	9.8%
Total	131.23	133	259.429	0	1367	100.0%

One way

Descriptives

Vol_cm^3

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	24	230.72	395.409	80.713	63.76	397.69	4	1367
2	19	53.19	69.155	15.865	19.86	86.52	0	264
3	22	47.67	54.636	11.648	23.45	71.90	4	172
4	18	64.34	93.451	22.027	17.87	110.81	1	379
5	17	41.42	44.519	10.798	18.53	64.31	0	177
6	20	386.57	381.747	85.361	207.91	565.24	3	1288
7	13	20.20	10.715	2.972	13.72	26.67	6	41
Total	133	131.23	259.429	22.495	86.73	175.72	0	1367

ANOVA

Vol_cm3					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2188817.467	6	364802.911	6.865	.000
Within Groups	6695223.832	126	53136.697		
Total	8884041.299	132			

Post Hoc Tests
Homogeneous Subsets

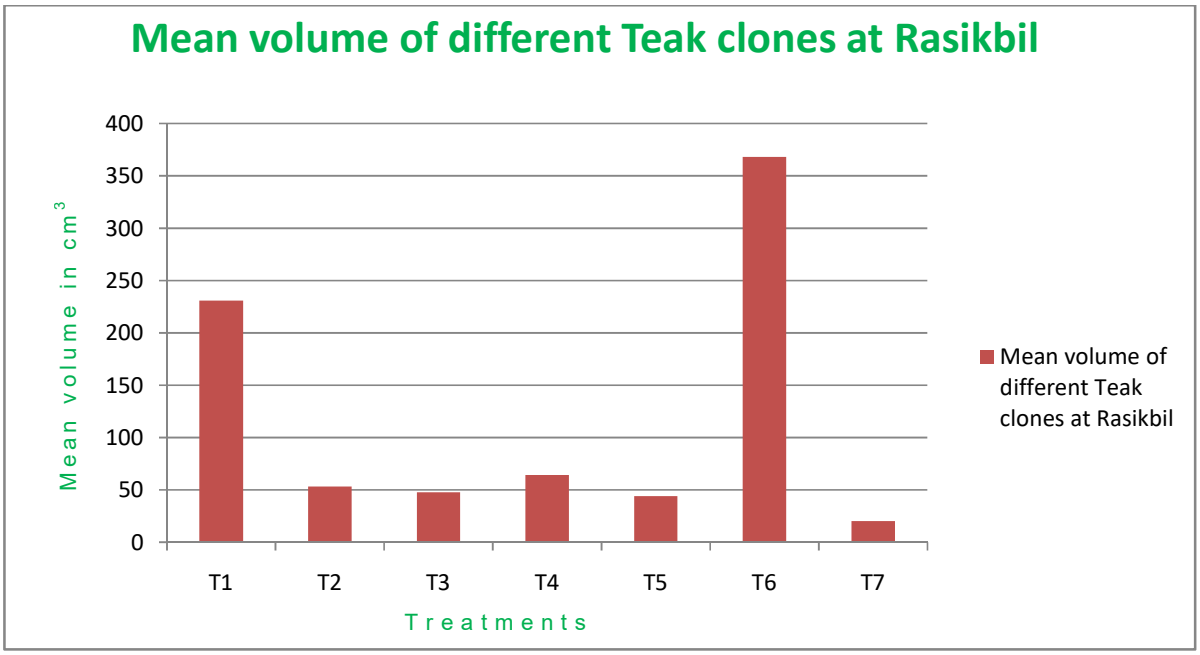
Vol_cm^3

Duncan

Treat	N	Subset for alpha = 0.05		
		1	2	3
7	13	20.20		
5	17	41.42		
3	22	47.67		
2	19	53.19		
4	18	64.34		
1	24		230.72	
6	20			386.57

Sig.		.614	1.000	1.000

Means Plot



Inference:-

1. All the clones from Kerala, **T1** to **T5** and **T6** (Kuilapal PT-1) from West Bengal shows better growth in the initial stages than the seed origin Teak seedling **T7**.

2. Among the clones from Kerala, **T1** (KFRI 1 – Nilambur) and **T6** (Kuilapal PT-1) shows best performance in term of growth in the initial stage.

3. **T2** (KFRI-5Nilambur), **T3** (KFRI-15Konni) and **T4-**(Whyanadu KFRI-18) also shows moderate growth.

4. In its initial stage of growth, the clones obtained from cuttings of the selected material are performing better than the seed origin seedling of teak.

Growth data will be analyzed for 2 more years and the best performing clone will be selected for mass propagation and may be introduced for field trials and commercial plantations. This plot will be maintained for another 10 years to study the growth and the timber quality of the teak trees.

Conclusion and Recommendation –

1. The growth of clonal seedling both from Kerala and West Bengal shows better growth than the seed origin seedling in all location based on the growth study for the first one and half year after planting.

2. Among 6 clones used in the trial, KFRI 1 and KFRI 5, both from Nilambur showing better performance than the other clones in all locations. The performance of the clone from West Bengal i.e Kuilapal PT 1 is equally good for all the locations.

3. Considering the comparative growth result, overall growth at Kadaya and Beliatore is not promising than the other locations, may be due to soil and moisture condition etc of the plot. Though the growth compared is only of one and half years and it may be improved in later stages of the study.

4. Initially KFRI 1, KFRI 5 and Kuilapal PT 1 may be selected for further testing and field trial to establish there suitability in different agro-climatic locations of the State.

5. To achieve clonal suitability and making projection of future growth and yield, growth data to be taken upto 5^{th} year from the date of planting and for this period the trial plots to be maintained as per the prescription given in the proposal.

6. To carry out the growth study, suitability of the clone and preparation of seed sources like seed orchards and clonal seed orchards, these materials (clones) to be procured and prepared. Another set of trial is required to confirm the suitability of the clones so selected and compare its performance with few more clones from West Bengal as it was proposed in the project.

7. Teak timber is one of the most valuable timber and proper selection of material will certainly help to enhance its productivity and reduce the rotation age both for forestry and social forestry plantations. So the improvement program of Teak may be continued for selection of material, its propagation and planting in commercial plantations at least for another ten years in order to achieve the objective of the trial.


Teak Clone Experimental
Pltn. at Arabari


Teak Pltn. at Arabari


Teak Clone Pltn. picture at Arabari