



**Government of the Union of Myanmar
Ministry of Forestry
Forest Department**



**Comparative Performance of Teak (*Tecona grandis*)
Provenance in Special Teak Plantations
Particularly in Bago Yoma**

U Thein Htwe
B.Sc. (Forestry), Staff Officer
Forest Research Institute
April, 2000

Acknowledgements

I'm grateful to U Khin Maung Oo, Deputy Director and U Win Maung, Assistant Director of Forest research institute for their encouragement and interest in this study.

I'm also thankful to my close friend U Nyi Nyi Kyaw, and U Chit Hlaing Win for their proper guidance and technical inputs in this study.

All people who have helped me in various ways and I thank them especially Saya U Saw C. Doo, Saya U Saw Kelvin Keh and Saya U Myo Kywe of Institute of Agriculture for sparing a considerable amount of their time and paying close attention to this paper.

Special thanks are given to former co-ordinator of Teaknet, Saya U Mehm Ko Ko Gyi, for his encouraging us to conduct this research work.

မူရင်းဒေသအမျိုးမျိုးမှ ကျွန်းသစ်မျိုးအား အထူးကျွန်းစိုက်ခင်းစီမံကိန်းဧရိယာ
(ပဲခူးရိုးမ)တွင် စိုက်ပျိုး၍ ရှင်သန်ကြီးထွားမှုကို နှိုင်းယှဉ်လေ့လာခြင်း။

ဦးသိန်းထွေး၊ B.Sc. (For.) ၊ ဦးစီးအရာရှိ
သစ်တောသုတေသနဌာန၊ ရေဆင်း။

စာတမ်းအကျဉ်းချုပ်

ကျွန်းစိုက်ခင်းများ တည်ထောင်ရာတွင် လက်လှမ်းမှီရာ ဒေသအမျိုးမျိုးမှ ရရှိလာသော ကျွန်းစေ့များကို အသုံးပြုမည့်အစား၊ စိုက်ပျိုးမည့်ဒေသနှင့် သင့်တော်သော မူရင်းဒေသများကို ရွေးချယ် အသုံးပြုခြင်းအားဖြင့် ပိုမိုအောင်မြင်သော ကျွန်းစိုက်ခင်းများဖြစ်လာနိုင်ပါသည်။ ဤစာတမ်းတွင် မြန်မာနိုင်ငံအတွင်း ကျွန်းပေါက်ရောက်သော ဒေသ(၁၀)ခုမှ ကျွန်းမျိုးစေ့များကို စီးပွားရေးစိုက်ခင်းများ၏ ဗဟိုအချက်အချာဖြစ်သော ပဲခူးရိုးမဒေသတွင် ယှဉ်ပြိုင်စိုက်ပျိုး စမ်းသပ်ခဲ့ရာ ပဲခူး ရိုးမ၏ အရှေ့ဘက်ခြမ်းတွင် ထူးခြားမှုမရှိသော်လည်း အနောက်ဘက်ခြမ်းတွင်မူ ဖြူးနှင့်မဘိန်း မူရင်း ဒေသများသည် ကြီးထွားမှု (အမြင့်) အကောင်းဆုံးဖြစ်ကြောင်း တွေ့ရှိခဲ့ရပါသည်။

Comparative Performance of Teak (*Tectona grandis*) Provenance in Special Teak Plantations Particularly in Bago Yoma

U Thein Htwe, B.Sc (For.), Staff Officer
Forest Research Institute, Yezin.

Abstract

Successful teak plantation depends on the selection of correct provenance. In the study, seeds from (10) provenances of Myanmar were tested in the eastern and western aspects of Bago Yoma for their performance, especially in height growth. The results indicated that there were no significant differences among provenances which are tested on the eastern aspect of Bago Yoma, however, provenances which are tested on the western aspects, especially the Phyu and Mabein provenance, showed better performances in height growth.

Contents

	Page
Acknowledgement	i
Abstract	ii
1. Introduction	1
2. Literature review	1
3. Materials and Methods	3
3.1 Provenances and provenance region	3
3.2 Selection of plus tree	5
3.3 Seed collection	6
3.4 Trials and trial region	6
3.5 Site selection	7
3.6 Planting	8
3.7 Post - Planting Maintenance	8
4. Method	8
4.1 Experimental design	8
4.2 Layout	8
4.3 Field measurement and data collection	9
5. Results	10
5.1 Phyu trial site	10
5.2 Oaktwin trial site	11
5.3 Paungta trial site	12
5.4 Paukkaung trial site	13
6. Discussion	14
7. Conclusion	15
8. Appendix	
9. References	

1. Introduction

Teak (*Tectona grandis*) is an all around premier timber with many favourable properties and has been and will continue to be one of the most admired and precious timber tree species in the world. (Dr. Kyaw Tint, 1999)

The total area of natural teak forests is 27.9 millions hectares in the four indigenous countries, India, Myanmar, Lao and Thailand and more than half of the area lies in Myanmar. Moreover, Myanmar is the top exporter of teak timber in the world market, and is therefore noted for her large natural teak forests and precious timber, "Teak".

Due to agricultural encroachment, illicit cutting extension of pasture land, practicing of shifting cultivation, and excessive utilization of fire-wood and charcoal, the natural teak forests area as well as its density decline.

Thus, the sustained teak timber production from natural teak forest may become endangered. However, the demand for teak never decreases and therefore in order to relieve pressure on the remaining natural forests and to fulfil the timber demand to some extent, there is an urgent need for establishing extensive teak plantations. Being the case, one cannot totally depend on natural forest for teak timber production.

The objective of this study is to investigate the best performance of teak among the provenance, in Bago Yoma, "Home of teak". Selection of correct provenance is essential to successful plantation establishment.

2. Literature Review

In its natural state, teak is indigenous to only four countries ie India, Myanmar, Lao and Thailand, and in order to extend and expand the teak resources, extensive teak plantations were established.

Not only indigenous countries but also in other parts of the world, such as East Africa and Latin America, because of its excellent qualities, teak plantations had been established for some years.

In 1990, teak constituted only 5% (estimated at 2.2 million hectares) of the reported total area under tropical plantations, of which more than 90% was located in Asia, mainly Indonesia, India, Thailand, Bangladesh, Myanmar and Sri Lanka (Pandey-90).

It was in 1700 that the first teak plantation was established in Myanmar. It was situated in Paletwa township, Chin State. (Dr. Kyaw Tint 1999). It was started with the aims of compensating the loss or mortality of teak in natural forest. Planting sites selected were poor and small in scale (Thein Lwin 1994). From 1896 to 1941, about 91,250 Acs of teak plantation had been established. (Dr. Kyaw Tint, 1999).

Around the year 1934, there were some conflicts between foresters on the formation of teak plantations with regard to soil erosion and insect attack (Thein Lwin, 1994). The following remarks show the different problems of pure teak plantations arising from different foresters.

"Although teak is an excellent timber, it is a bad forester, it does not improve the soil [like Pyinkado (*xylia dolarbriformis*)] and its leaves do not readily form humus. It should never be forced on unwilling localities" i.e. it should never be grown on unsuitable sites (Baden-Powel, 1874).

The aim of the Burma Forest Department, according to Dr.Brandis is therefore not to grow pure teak forests. Pure or nearly pure natural teak forests are rare, and where they are found, their condition is not satisfactory. (Brandis, 1881).

Blanford (1921) gave the warning that teak should be planted with caution and he still believed that there may be great danger in creating large extents of practically pure teak.

"Furthermore, pure teak is soil depleting as well as soil deteriorating, being a voracious soil or mineral consumer, with its big leaves inducing splash and sheet erosion; there is little or no undergrowth beneath it" (Champion,H.G 1936).

It is no simple matter to replace a good, vigorous mixed natural crop of many component species with a "crop of necessary" planted in blocks of single species there by destroying or changing the fauna, flora and ecology of the forest eternally destroying the biodiversity or genetic pool of the forest. (Waston, 1923)

Serious gully formation occurs in 84 out of 124 sample plots of teak plantations or about 64% of all teak plantations studies, while sheet erosion occurs in 8 out of 124 sample plots or 6.45%, about 34 sample plots or about 27% of the teak plantations have some gullies. Only about 2.5% of the teak plantations are found free of soil erosion. (Soe Myint, Kyaw Htun and Professor Chit Hlaing, 1999).

It is true that there are many objections to large scale plantations and monoculture system. Everyone is right on one's own view. In Myanmar, the socio-economic factors of almost all the local communities totally depend on natural forests. They still get all they need from natural forests.

The destruction of tropical forests is largely due to poverty of the forest dependent communities and the destruction of tropical forests mutually makes the forest dependent communities poor. Then an endless circle goes on.

In order to get over this crisis, There's one and the only way to follow: to establish teak plantations in suitable places. This does not mean to substitute plantations for natural forests but to fulfil the timber demand to some extent and to find means and ways for improving the declining natural forests.

Due to the population pressure and ever increasing demand of timber for domestic and foreign uses, starting from 1972, extensive plantations in large block therefore were formed. (Ko Ko Gyi, 1991). From 1948 to 1998 i.e. within a period of 50 years, 567.650 acres of teak plantations were established. (Dr. Kyaw Tint. 1999).

Keogh (1996) pointed out that teak could provide a very useful plantation species if adequate attention was paid and site selection was taken a good care. In addition, he said that plantations could be more suitable than natural forests for large and regular supplies of wood pulp and sawn timber.

Under the guidance of the Minister for Forestry, Special Teak Plantation Project was launched by the fiscal year 1998-99. Up to now, 20.000 acres of teak plantations had been established in the six centers of Special Teak Plantation Project Area, namely Sagaing, Magway, Yangon, Mandalay, Ayeyarwady and Bago division. (Dr. Kyaw Tint 1999)

But it is important that all of teak plantations need to be environmentally friendly as much as is possible and to use shorter rotation, with more volume production per acre per year. As such there is great need for marking proper site selection, using the best genetic materials.

If the best genetic material available is chosen; if only good sites, yielding an average of 8m³ / ha/ year or more are accepted for planting, and if the best known methods of management are employed for teak plantations of the future, an abundance of good quality timber will be available. (Ramond. M.Keogh, 1996).

In accelerating plantation programs, there are many disappointing teak plantations throughout the world. These are mainly based on poor quality genetic material (Ramond. M. Keogh 1996). Almost all the plantations were established by seedlings of none-region. At present, there is no concrete tree improvement program here. The most successful tree improvement programs are those in which the proper seed sources and provenance are used (Tin Htun, 1995). Careful selection of seed provenance determines key economic factors, notably stem straightness (Ramond .M. Keogh 1996).

Seed collection for provenance trial was initiated in 1981 and fruit and seedling characteristics were studied (Ko Ko Gyi et,al, 1984). It was found that:-

- (a) Variation exists in fruit weight, fruit diameter, seed shape, number of seeded fruits, germination, number of seedlings produced per 100 fruits, shoot/root ratio and relative height growth.
- (b) Variation among the provenance was not related to neither latitude, rainfall nor temperature.

Provenance trial comprising of 10 provenances was established in Pyinmana Township in 1982. This is a low rainfall area with an average annual rainfall of 1372mm. In 1983, another trial was made in Oaktwin township where the average annual rainfall is 2032 mm. Here, only 16 provenance were included due to the insufficiency of seed collected.

In both trials, seeds collected in 1981 were used. the design applied (i.e. RCBD) were also the same. Although statistical analysis has not yet been carried out, recent height and girth measurements indicated that variation exists among the provenances studied, but they were not critical.

In this study, (10) provenances where teak naturally occurs were selected. Seeds were collected in 1997 from (25) healthy and normal mother trees. Bago Yoma was chosen as trial region because it's known as "Home of teak". There were two trials on each side of Bago Yoma, the eastern and western aspect, altogether (4) trials. In order to compare teak's performance among the provenances, trial plantations were established there and the differences among them were studied and discussed here.

If one provenance gives timber of superior quality or size than others then clearly that particular provenance should be selected for seed collection and plus tree selection for tree breeding work. The value of provenance trial is indisputable, but the process is lengthy

3. Materials and Methods

3.1 Provenances and Provenance regions

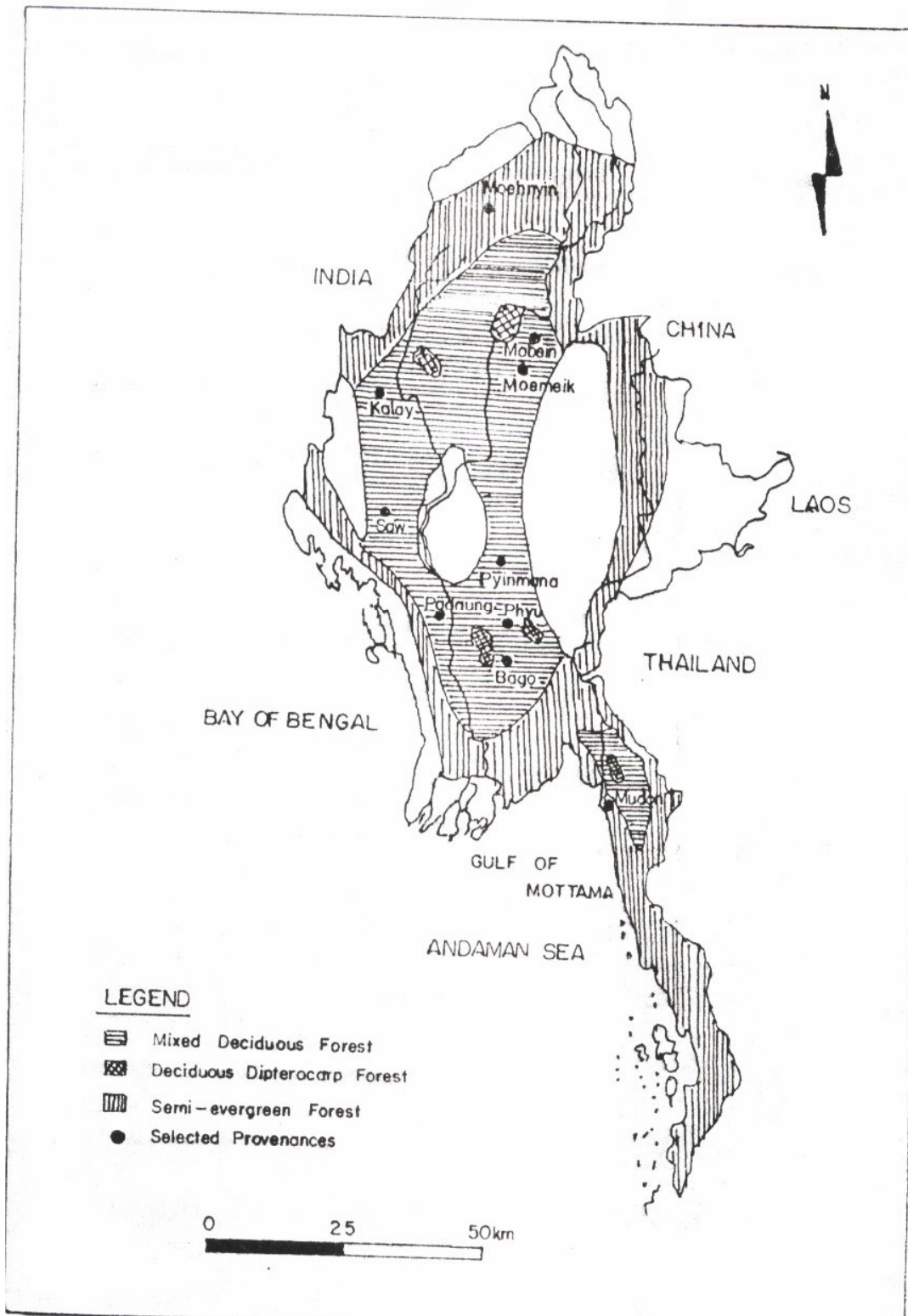
Under the guidance of TeakNet, collection of seed for this investigation was carried out from (10) provenances within Myanmar where teak naturally occurs: Saw, Pyinmana, Kalay, Mudon, Moehnyin, Bago, Padaung, Moemeik, Mabein and Phyu. Provenances to be tested using climatological data and their latitudinal distribution as a basis. Details are shown in figure I.

No	Provenance	Latitude (N)	Longitude (E)	Elevation (m)	Mean temp.(c)	Annual Rainfall (mm)	Provenance Region
1.	Pyinmana	19°43'	96°13'	95	27.6	1631mm	Yemathin District Mandalay Division
2.	Kalay	23°12'	94°04'	152	not available	2032mm	Kalay District Sagaing Division
3.	Bago	17°20'	96°30'	9	32.3	3448mm	Bago District Bago Division
4.	Phyu	18°30'	96°27'	48	32.0	3071mm	Taungoo District Bago Division
5.	Mudon	16°14'	97°43'	10	31.2	4697mm	Mawlamyaing District
6.	Padaung	not available	not available	not available	not available	1028mm	Mon State Prome District Bago Division
7.	Moemeik	22°36'	96°40'	not available	not available	not available	Kyaukme District Northern Shan State
8.	Saw	21°15'	94°17'	606	not available	1270mm	Gangaw District Magway Division
9.	Moehnyin	27°47'	96°22'	209	not available	2187mm	Myitkyine District Kachin State
10.	Mabein	23°20'	96°40'	115	not available	1524mm	Kyaukme District Northern Shan State

Source: Department of Meteorology

Figure I. List of provenance collection sites and their allocation to provenance region

Map of Myanmar Showing the Selected Provenances



3.2 Selection of plus tree

Plus trees were selected from natural forests only and not from plantations. The girth at breast height of selected tree was 3 feet and above and they were sound trees. Suppressed trees, forked trees, crooked trees, dead and moribund trees and trees with poor stem form were all rejected. 25 trees were selected for each provenance. The position of selected plus trees in reserved forest or un-classed forest are shown in figure II in details.

No	Township	Reserved (or) un-classed Forest	Compartment or Coupe	Average		Remark
				height (ft)	girth (ft)	
1.	Pyinmana	Ngaleik Reserved Forest	Compartment (18)	115.12'	6' 8"	16 trees from compt (22), 9 trees from (23)
2.	Kalay	Bone Reserved Forest Myittha U.C.F	Compartment (69),(70) Coupe XIX and XXII	100.68'	6' 6"	
3.	Bago	Southzamari Reserved Forest	Compartment (22), (23)	76.81'	4' 9"	
4.	Phyu	Phyuchaung Reserved Forest	Compartment (31)	113.44'	6' 4"	
5.	Mudon	not available	not available			
6.	Padaung	Padaung un-classed Forest	Coupe (122)	56.9'	4' 1"	
7.	Moemeik	not available	not available			
8.	Saw	Letpan Reserved Forest	Compartment (87)	103.76'	7' 5"	
9.	Moenhyin	Nantpanaung Reserved Forest	Compartment (3)	77.24"	5' 5"	
10.	Mabein	Nantpaw Reserved Forest	Compartment (1)	94.4'	6' 7"	

Figure II. Source of Plus trees and seed collection date.

3.3 Seed collection

Almost all of the seeds were collected from February to March 1997. Both collection of fallen-seeds on the ground and collection by striking the branches of bearing mature seeds with a pole to the ground were used. Bags of seed were transported to Forest Research Institute in the mid of July and were stored in seed laboratory, Silvicultural section. In February, 1998, viability of seeds was tested there and raised seedlings in the nursery of Silvicultural section, Forest Research Institute. Details are shown in Figure III.

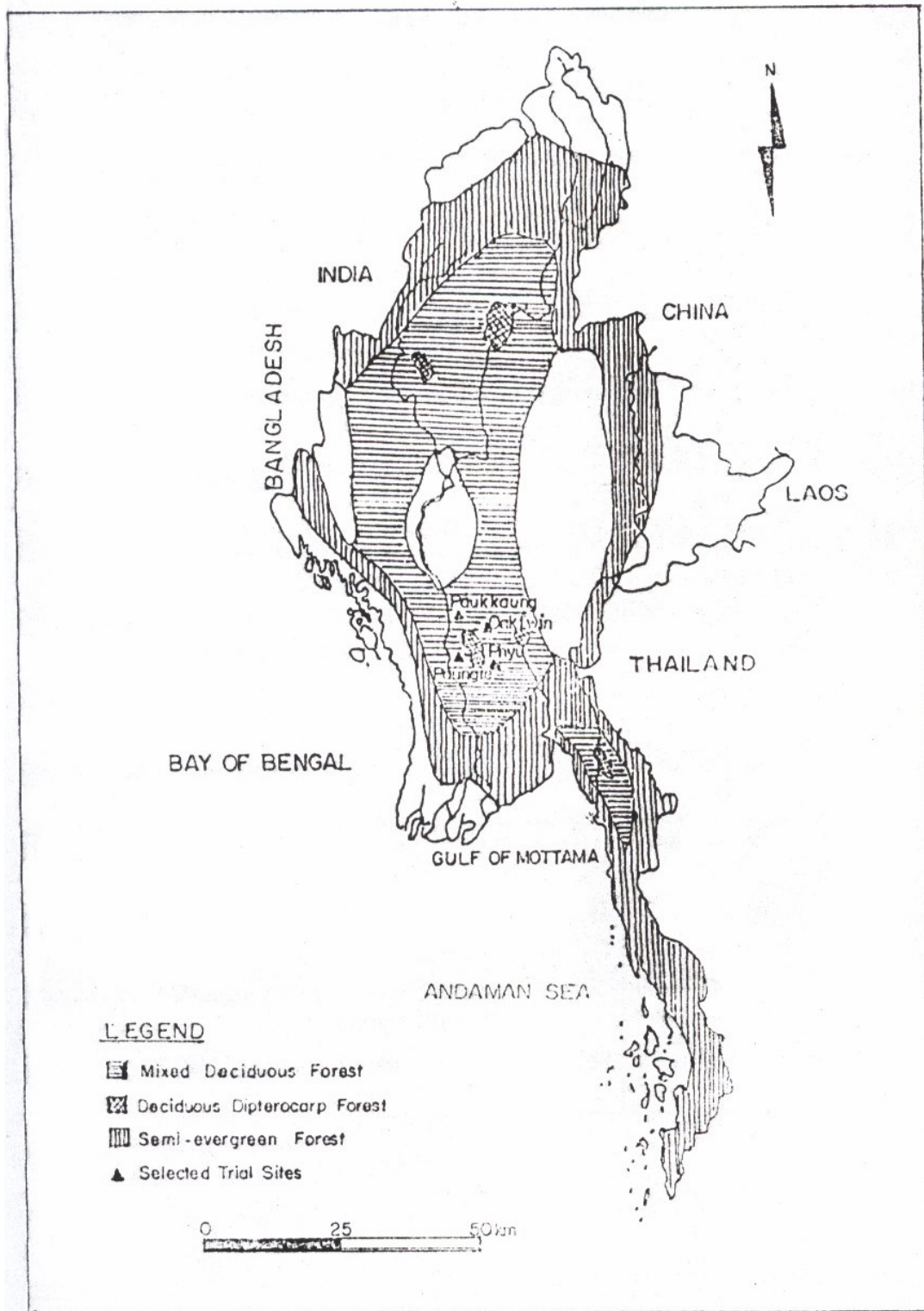
No.	Provenances	Date of Seed Collection
1.	Pyinmana	From 10.3.97 to 29.3.97
2.	Kalay	From 8.3.97 to 2.4.97
3.	Bago	From 28.3.97 to 29.3.97
4.	Phyu	From 4.2.97 to 12.3.97
5.	Mudon	Not available
6.	Padaung	From 22.3.97 to 26.3.97
7.	Moemeik	Not available
8.	Saw	From 25.3.97 to 30.3.97
9.	Moehnyin	From 23.3.97
10.	Mabein	From 25.3.97 to 27.3.97

Fig III. Provenance and seed-collection date

3.4 Trials and trial region

Bago Yoma is a concentrated area for commercial plantations as well as special teak plantation project area. Moreover, there are many natural teak forest but its best growth is in the Bago Yoma. Teak of the best timber quality producing cylindrical and sound logs occurs in the zone of the Bago Yoma where the rainfall varies from about 50-60 inches (Karmode, 1964). There are all the favourable conditions (i.e. Soil, climate) for growing teak in the Bago Yoma. That is why Bago Yoma Region was selected for trial region. Four trials were established there, two trial sites on each side of Bago Yoma, on western aspect, Paungte and Paukkaung township and on eastern aspect, Oaktwin and Phyu Township. Details are shown in figure IV.

Map of Myanmar Showing the Selected
Trial Sites



Trial No	Trail Region	Site name	Latitude (N)	Longitude	Mean Tempt. (C)	Annual rainfall (mm)	Elevation (m)
1.	Eastern aspect of Bago Yoma	Phyu	18 °30'	96°27'	32.0	3071	48
2.	Eastern aspect of Bago Yoma	Oaktwin	not available	not available	not available	not available	not available
3.	Western aspect of Bago Yoma	Paungte	not available	not available	not available	936	not available
4.	Western aspect of Bago Yoma	Paukkaung	not available	not available	not available	1261	not available

Source: Department of Meteorology.

Figure IV. Location of trials and trial region

3.5 Site Selection

This operation was carried out in May,1998, collaborating with the staffs from Forest Research Institute and local forest department staffs. All the sites lied within the area of teak special plantation project. Sites were selected to represent both aspects of Bago Yoma as much as possible. Details are shown in figure V.

Trail No	Township	Site	Selection date	Forest Division
1.	Phyu	Phyukoon Protected forest No(II)	From 9.5.98 to 10.5.98	TaungOo Forest Division
2.	Oaktwin	Khapaung Protected forest No(XVI)	- ` -	- ` -
3.	Paungte	Bwet Reserve Forest Comp (30)	From 21.5.98 to 24.5.98	Prome Forest Division
4.	Paukkaung	South Ngawin Reserved Forest Comp(1)	- ` -	- ` -

Figure V. Operation of Site Selection

3.6 Planting

Collaborating with staffs from local Forest Department, planting operation was carried out from June to mid of July, when there was regular rainfall. Method of planting used for this experiment was transplanting of seedlings taken from the nursery of Forest Research Institute. Before planting on trial sites, seedling of each provenance were tied with threads of different colour plastic so that it was easy to distinguish the provenance from one another. The planting was done with allocation of provenances at random. Data about planting operation are shown in figure (VI)

Trial No	Township	Date of planting	Planting material
1.	Phyu	From 23.6.98 to 30.6.98	Seedling
2.	Oaktwin	From 23.6.98 to 26.6.98	- ` -
3.	Paungte	From 26.6.98 to 29.6.98	- ` -
4.	Paukkaung	From 4.7.98 to 13.7.98	- ` -

Figure VI. Date of planting

3.7 Post - planting maintainance

Cultural operations such as, weeding, fire protection were done by local Forest Department Staffs according to annual work plan for commercial plantation in Myanmar.

4. Method

4.1 Experimental design

Experimental design adopted in this research is Randomised Complete Block Design.

4.2 Layout

The experimental area is divided into four replications (Blocks) so as to minimize the experimental error. Within each replicate, there are 10 plots. The whole experiment, therefore, consists of (40) plots. (49) trees (7 rows x 7 columns) with (9 x 9) feet spacing were planted in each experimental plot. Thus, the whole experimental area is made of (1960) seedlings. The experimental units are grouped into 4 blocks of 10 units each such that units within blocks are as uniform as possible. Then, the 10 treatments are assigned at random to the units within each block, such that each treatment occurs once and only once in each block. Details are shown in figure VII A and VII B.

1	5	3	4	6	9	8	10	2	5
3	9	7	5	4	2	1	6	8	10
4	8	6	5	1	3	9	7	10	2
8	6	3	4	9	1	7	5	2	10

Figure VII A.

No of seedlings per plots	Plots per Block (Replicate)	No of seedlings per Block (Replicate)	Replications or Blocks	Total	
				Seedling	Area (Ac)
49	10	490	4	1960	3.25

Figure VII B. Experimental Design

4.3 Field Measurement and Data Collection

4.3.1 Assessment of individual trees within plots

Measurement of individual tree within plots was carried out 3 times, in 1998, 1999 and in 2000 at 6 month interval. Data that was collected were growth in height. At the time of planting, data of average height of all provenances were taken. Measurement on single tree basis was started in 6 months after planting. At the time of the data collection, the trees were numbered in a row continuously as in figure (VIII) and the field orientation (an arrow pointing towards North) was noted. If another recording system is used or if data collection for the next time is made the field orientation was noted as above.

1	2	3	4	5	6	7
14	13	12	11	10	9	8
15	16	17	18	19	20	21
28	27	26	25	24	23	22
29	30	31	32	33	34	35
42	41	40	39	38	37	36
43	44	45	46	47	48	49

↑
North

Figure VIII. System to number individual trees within a plot

Trial No	Township	Date of assessment	Item of assessment
1	Phyu	17-12- 98 22-6- 99 13-1-2000	Growth in height
2	Oaktwin	15-12- 98 18-6- 99 15-1-2000	Growth in height
3	Paungte	18-12- 98 8-8- 99 28-1-2000	Growth in height
4	Paukkaung	20-12-98 4-8-99 26-1-2000	Growth in height

Figure IX. Timetable of assessment

5. Results

The operation of assessment of growth in height was carried out 3 times in 1998, 1999 and in 2000. But, due to no statistically significance among provenances, data collected in 1998 and 1999 would not be shown here. Data collected in 2000 were assessed here.

Analysis of variance was done by using Data plus and Irritate Statistical Software. For each trial site, rankings of growth in height are given below with provenance means followed by a common letter are not significantly different at 5% level by DMRT.



Photo (1) Teak Provenance Trail in Phyu Township



Photo (2) Teak Provenance Trail in Oaktwin Township

5.1 Phyu Trial Site

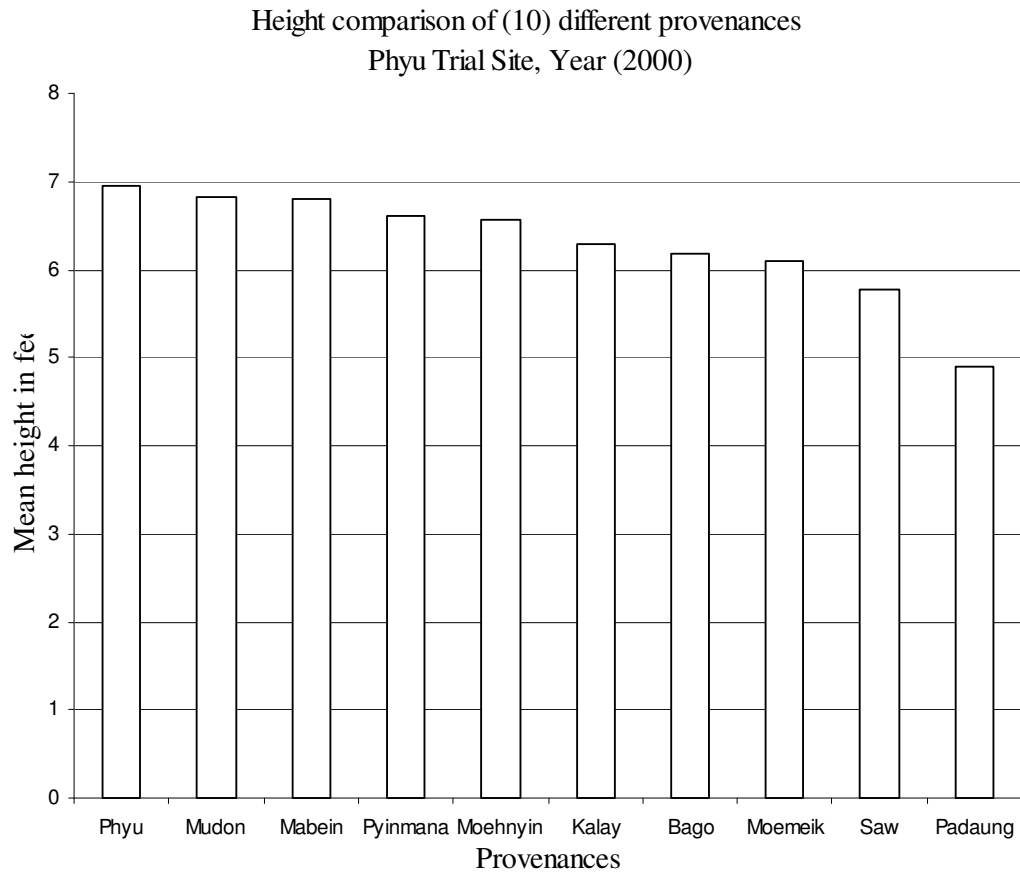
Table of Provenance (T) means for height (feet), Jan. 2000
(Av. over 4 Reps.)

Provenance	Ranks	Means
Phyu	1	6.962 a
Mudon	2	6.833 a
Mabein	3	6.800 a
Pyinmana	4	6.602 a
Moehnyin	5	6.558 a
kalay	6	6.280 a
Bago	7	6.178 a
Moemeik	8	6.095 a
Saw	9	5.778 a
Padaung	10	4.908 a

Mean

6.299

Rankings of growth in height on Phyu Trial Site shows that there is no significant difference among provenances.

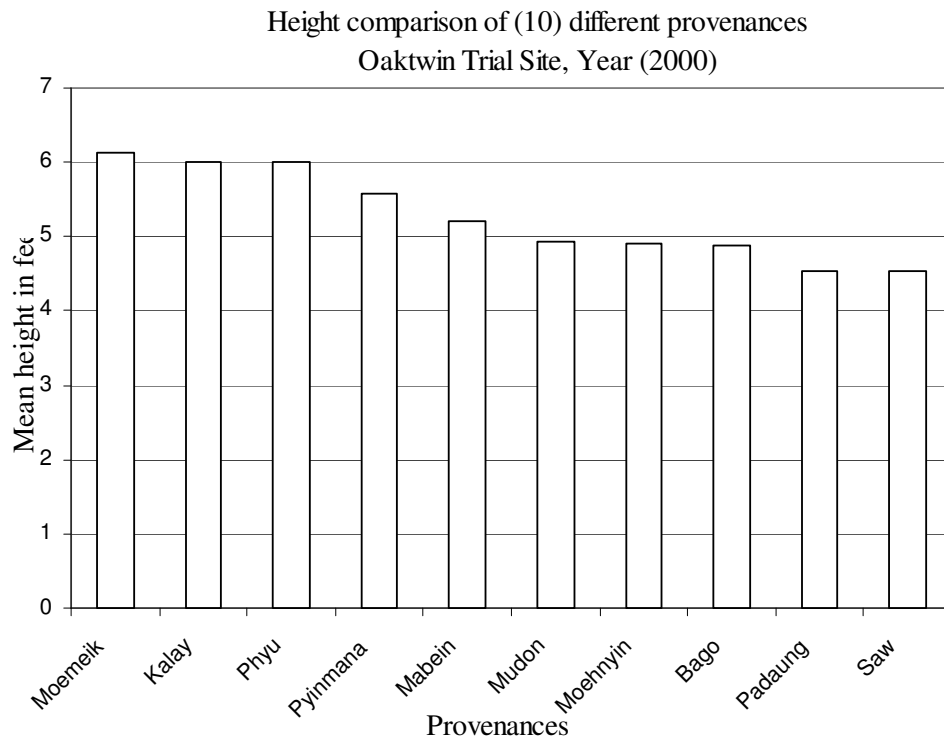


5.2 Oaktwin Trial Site

Table of Provenance (T) means for height (feet), Jan. 2000
(Av. over 3 Reps.)

Provenance	Ranks	Means
Moemeik	1	6.123 a
Kalay	2	6.013 a
Phyu	3	6.013 a
Pyinmana	4	5.587 a
Mabein	5	5.203 a
Mudon	6	4.937 a
Moehnyin	7	4.913 a
Bago	8	4.890 a
Padaung	9	4.537 a
Saw	10	4.523 a
Mean		5.274

Rankings are shown above with provenance means following common letter are not significant different. Therefore, we can definitely say that there is no statistically difference among provenances.



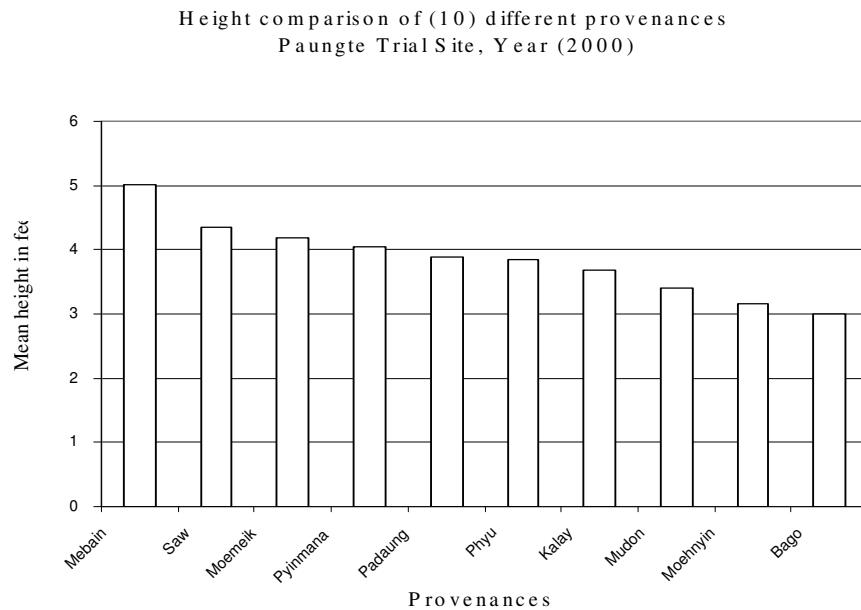
5.3 Paungte Trial Site

Table of Provenance (T) means for height (feet), Jan. 2000
(Av. over 4 Reps.)

Provenance	Ranks	Means
Mebain	1	5.020 b
Saw	2	4.355 ab
Moemeik	3	4.178 ab
Pyinmana	4	4.039 ab
Padaung	5	3.885 ab
Phyu	6	3.855 ab
Kalay	7	3.683 ab
Mudon	8	3.408 ab
Moehnyin	9	3.153 ab
Bago	10	3.010 ab
Mean		3.864

With reference to rankings shown above, there are significant differences between some provenance. Thus we can say generally. for Paungte site, Mabein

provenance is the best growth in height among provenances where Bago provenance is the lowest among them.



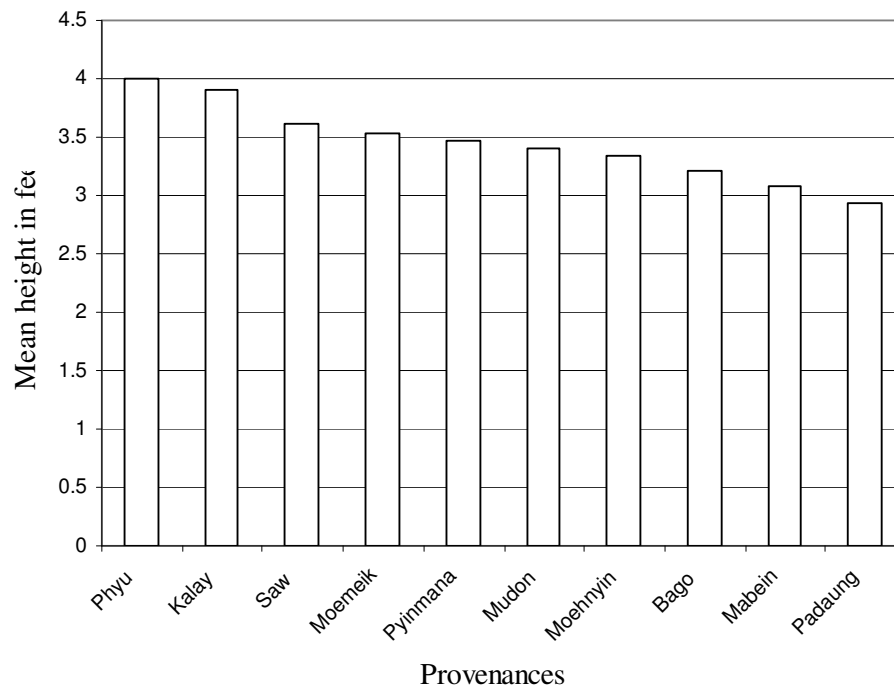
5.4 Paukkaung Trial Site

Table of Provenance (T) means for height (feet), Jan.2000
(Av. over 4 Reps.)

Provenance	Ranks	Means
Phyu	1	4.005 c
Kalay	2	3.898 bc
Saw	3	3.618 abc
Moemeik	4	3.528 abc
Pyinmana	5	3.470 abc
Mudon	6	3.398 abc
Moehnyin	7	3.338 abc
Bago	8	3.208 abc
Mabein	9	3.078 ab
Padaung	10	2.933 a
Mean		3.447

Ranking above show that there are definite differences between some provenance and therefore, we can say that Phyu provenance is the best growth in height where Padaung provenance is significantly the poorest.

Height comparison of (10) different provenances
Paukkaung Trial Site, Year (2000)



6. Discussion

In this paper, results show that there is no significant difference among the provenances in term of mean height and it seems that it is too early to decide which provenance is the best growth in height due to data collected from 2 - years old plantation. The provenance to be tested were selected using climatological data and their latitudinal distribution basis and therefore, I'm sure that there will definitely be some differences among them at one time.

There are many objectives on formation of provenance trial from establishment of seed production Area to Seed Orchard. One of the objectives of formation of provenance trial is to make an investigation on the genotype of species and therefore in some places, there may be the difference of phenotype within a species due to microclimatic changes. The ultimate aim is to conserve the genetic materials and thus, we need to make more concrete research. Because of perennial crop, there is a great need to be patient and to make field measurement and data collection timely.

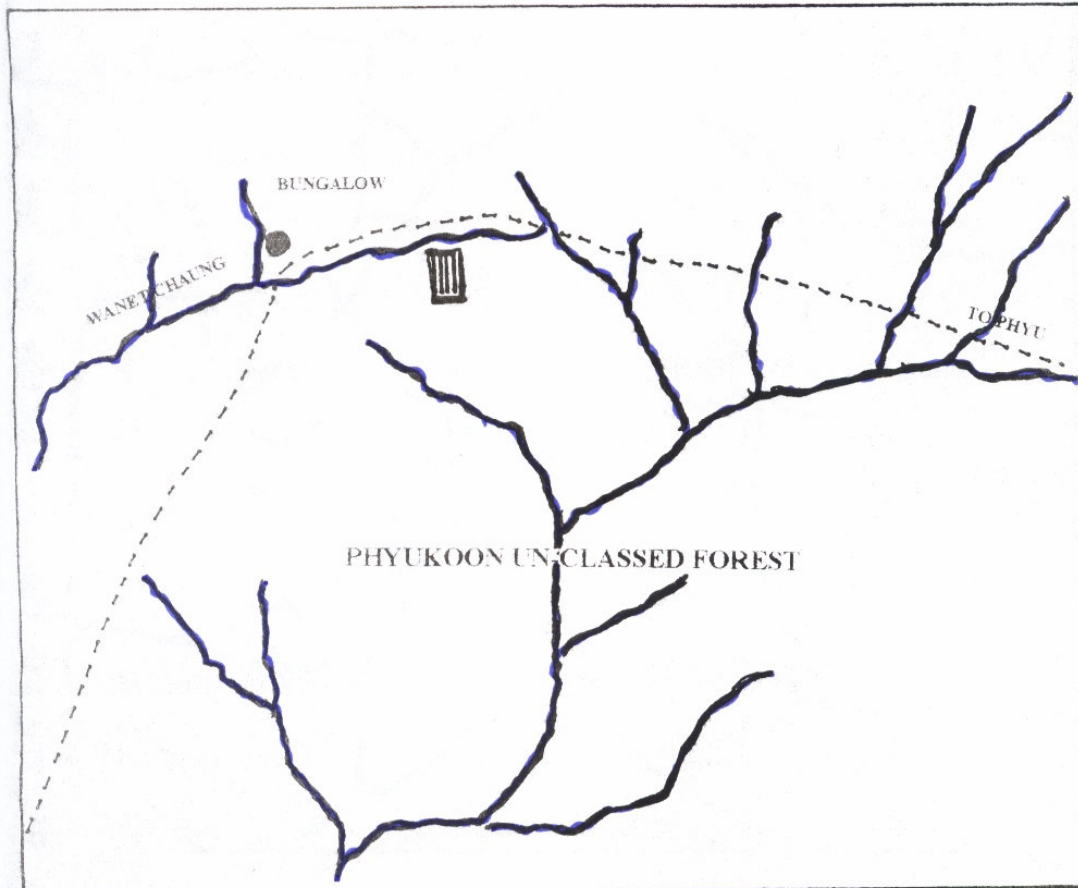
7. Conclusion

Even though there are no definite differences, among provenances in respect to growth in height, according to rankings, that are shown above for each trial site, it is concluded that;

- (a) at Phyu trial site, Phyu provenance is the best and the poorest is the Padaung provenance,
- (b) in Oaktwin, Moemeik provenance is the best where Saw gives the poorest growth in height,
- (c) in Paungte trial site, Mabein provenance is the best where as Bago is the lowest and,
- (d) in Paukkaung trial site, Phyu provenance is significantly the best following by Kalay, Saw as in rankings where the poorest is the Padaung,

Location map of Teak Provenance Trial
Phyu-kon Un-classed Forest, Coupe (X1)
Phyu Township, Taung-ngu District.

Scale: 4 inches= 1 mile



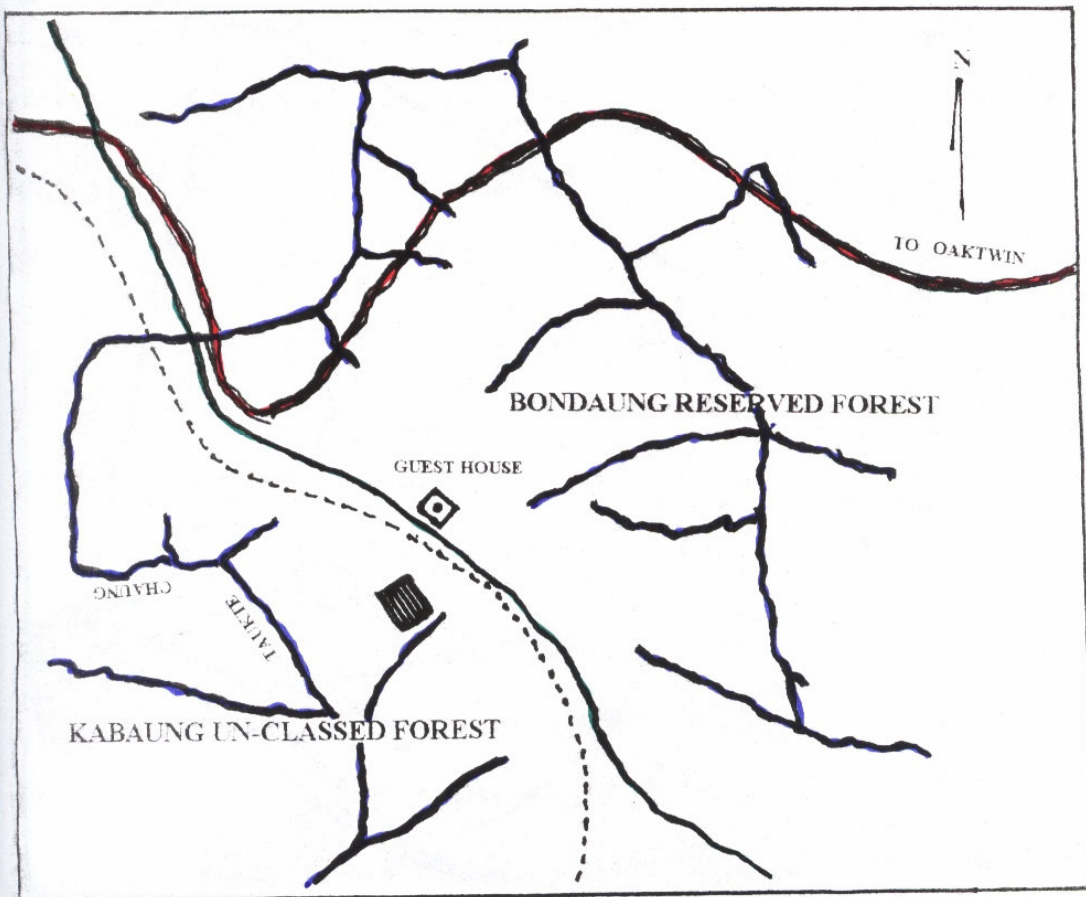
References

Reserved Boundary
Compartment Boundary
Streams
Extraction Road
Trial



Location map of Teak Provenance Trial
Ka-paung Un-classed Forest, Coupe (XVI)
Oak-twin Township, Taung-ngu District.

Scale: 4 inches= 1 mile



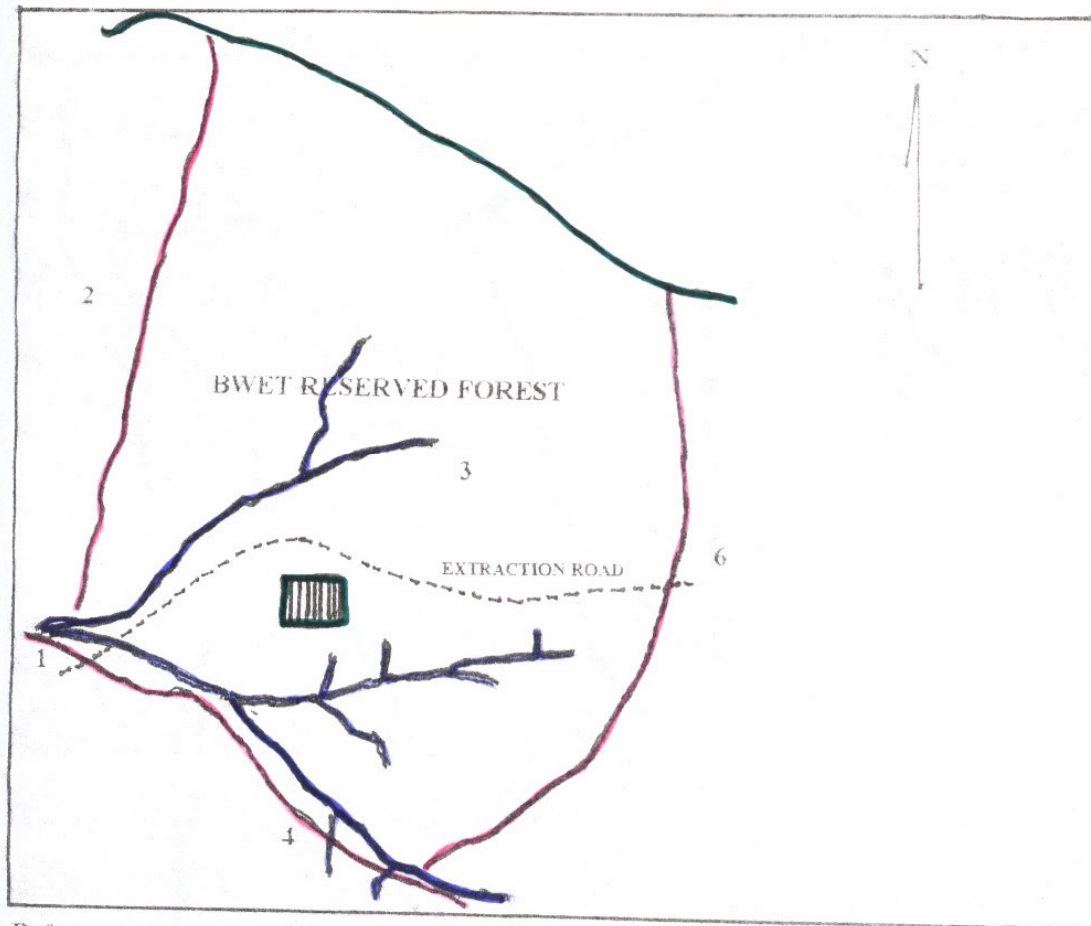
References

Reserved Boundary
Streams
Extraction Road
Trial



Location map of Teak Provenance Trial
 Bwet Reserve Forest, Compartment (3)
 Paun-te Township, Pyi District.

Scale: 4 inches = 1 mile



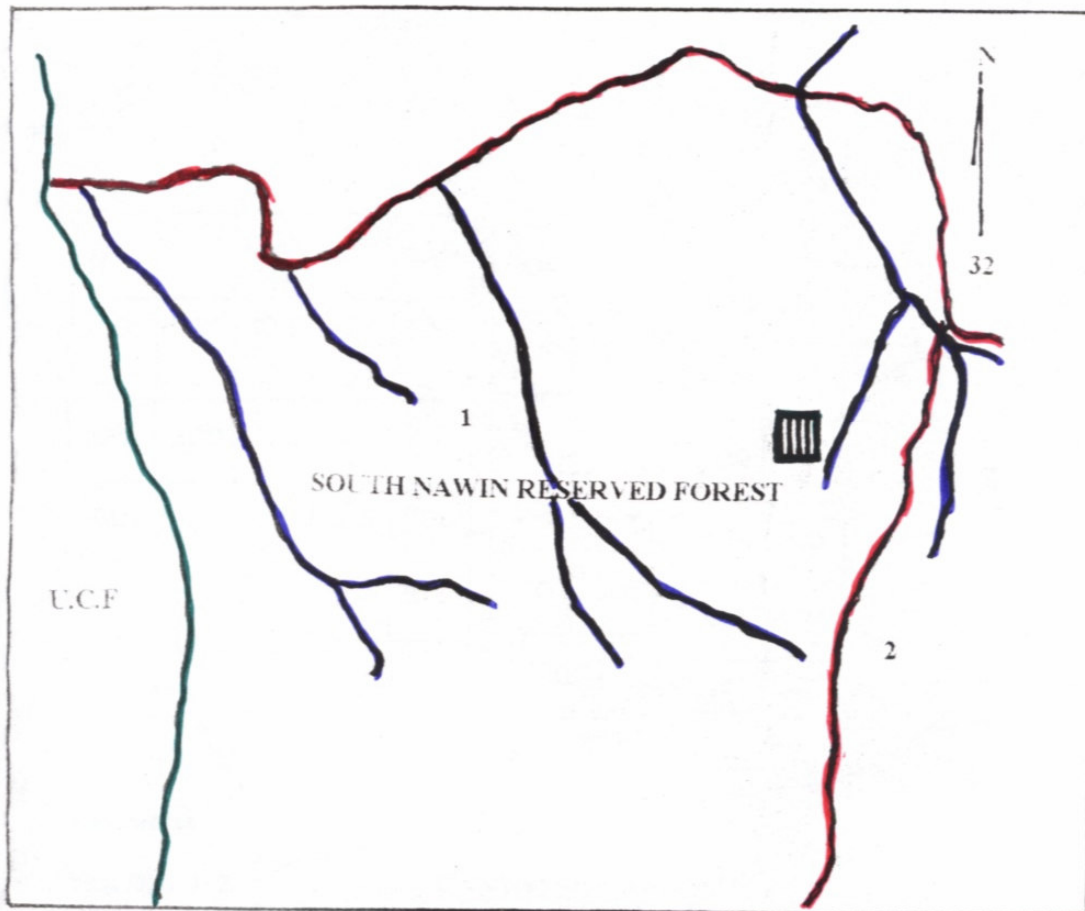
References

Reserved Boundary
 Compartment Boundary
 Streams
 Extraction Road
 Trial



Location map of Teak Provenance Trial
 South Nawin Reserve Forest, Compartment (1)
 Pauk-kaung Township, Pyi District.

Scale: 4 inches = 1 mile

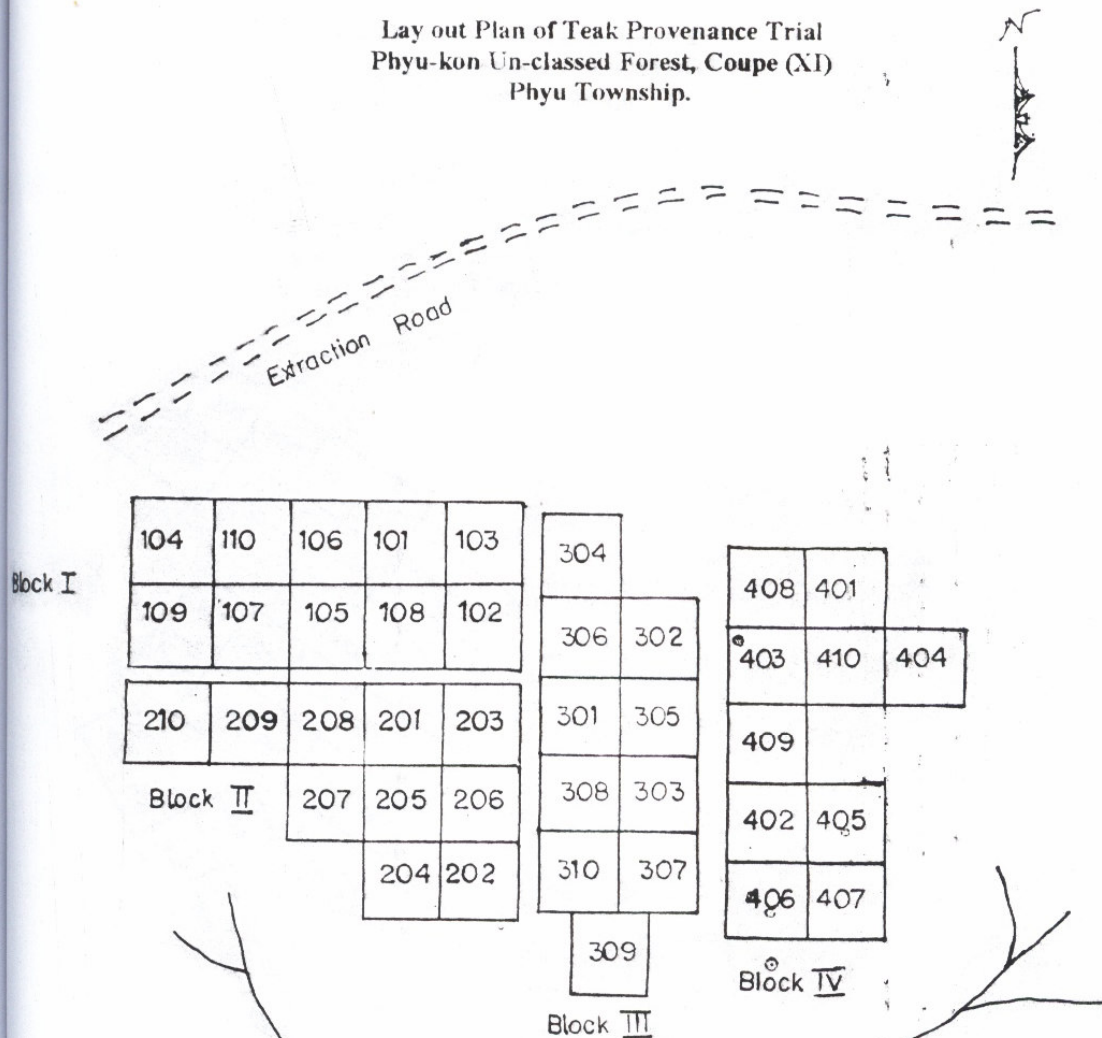


References

Reserved Boundary
 Compartment Boundary
 Streams
 Trial



Lay out Plan of Teak Provenance Trial
Phyu-kon Un-classed Forest, Coupe (XI)
Phyu Township.

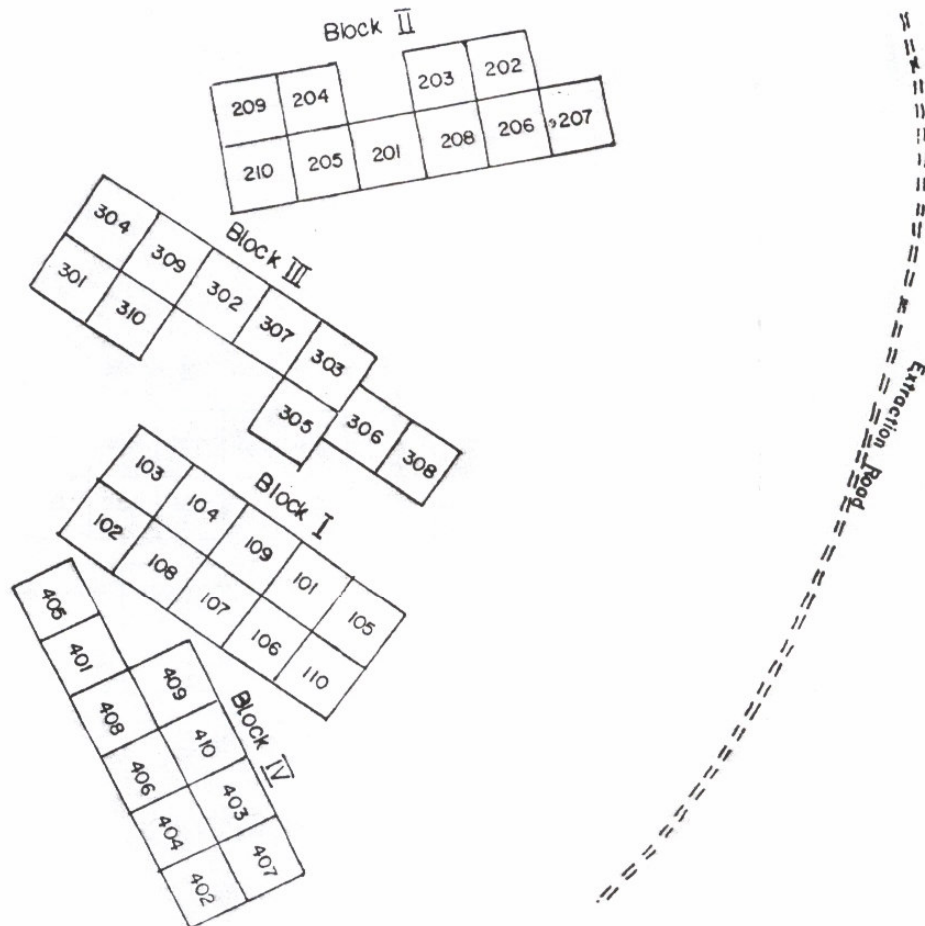


References

First Digit 1, 2, ... Block (or) Replicate Number
Second & Third Digit 01, 02, ... Provenance Code Number

Code No.	Provenance	Code No.	Provenance
01	Pyin-ma-na	06	Pa-daung
02	Kalay	07	Moe-meik
03	Bago	08	Saw
04	Phyu	09	Moe-Hnvin
05	Mu-don	10	Ma-bein

**Lay out Plan of Teak Provenance Trial
Ka-paung Un-classed Forest, Coupe (XVI)
Oak-twin Township.**



References

First Digit 1, 2, ... Block (or) Replicate Number
Second & Third Digit 01, 02, ... Provenance Code Number

Code No.	Provenance	Code No.	Provenance
01	Pyin-ma-na	06	Pa-daung
02	Kalay	07	Moe-meik
03	Bago	08	Saw
04	Phyu	09	Moe-Hnyin
05	Mu-don	10	Ma-bein

**Lay out Plan of Teak Provenance Trial
Bwet Reserve Forest, Compartment (3)
Paung-te Township.**

Block II

208	206	207	201	209	210
204	203	205	202		

Block III

307	304	303	306	302
310	308	301	305	309

103	110	106	109	101
104	102	107	105	108

Block I

410	408	407	405
401	406	409	404

Block IV

References

First Digit 1, 2, ... Block (or) Replicate Number
Second & Third Digit 01, 02, ... Provenance Code Number

Code No.	Provenance	Code No.	Provenance
01	Pyin-ma-na	06	Pa-daung
02	Kalay	07	Moe-meik
03	Bago	08	Saw
04	Phyu	09	Moe-Hnyin
05	Mu-don	10	Ma-bein

**Lay out Plan of Teak Provenance Trial
South Nawin Reserve Forest, Compartment (1)
Pauk-kaung Township.**



Block IV

406	403	407	401	408	402	405	409	404	410
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Block III

302	306	303	304	301	308	309	305
						307	310

204	201	210	206	205	207	203	208	202	209	Block II
102	105	103	104	108	109	106	110	107	101	Block I

References

First Digit 1, 2, ...

Block (or) Replicate Number

Second & Third Digit 01, 02, ... Provenance Code Number

Code No.	Provenance	Code No.	Provenance
01	Pyin-ma-na	06	Pa-daung
02	Kalay	07	Moe-meik
03	Bago	08	Saw
04	Phyu	09	Moe-Hnyin
05	Mu-don	10	Ma-bein

Appendix I (a)

Data on individual selected plus trees

Name of provenance Mabein, Kyaukme District

No	height (ft)	Girth of breast height (ft)	Quantity of seed collected (pyi)	Date of collection		
				day	month	year
1.	90'	7' 4" 8	8	25	3	97
2.	85'	6' 11'	6	`	`	`
3.	102'	7' 7"	9	`	`	`
4.	89'	5' 0"	3	`	`	`
5.	75'	5' 11"	5	`	`	`
6.	100'	6' 7"	6	`	`	`
7.	85'	6' 0"	6	`	`	`
8.	80'	6' 8"	7	26	3	97
9.	120'	7' 4"	6	`	`	`
10.	80'	6' 2"	5	`	`	`
11.	115'	6' 3"	5	`	`	`
12.	100'	6' 8"	7	`	`	`
13.	80'	5' 6"	4	`	`	`
14.	119'	6' 5"	3	`	`	`
15.	110'	7' 3"	6	`	`	`
16.	130'	7' 6"	5	`	`	`
17.	90'	8' 6"	8	27	3	97
18.	110'	7' 9"	7	`	`	`
19.	100'	8'	8	`	`	`
20.	75'	5'	3	`	`	`
21.	80'	6' 11"	7	`	`	`
22.	97'	6' 11"	4	`	`	`
23.	90'	5'	6	`	`	`
24.	78'	4'	2	`	`	`
25.	80'	6' 6"	4	`	`	`

Crew leader

Member

Labour

U Maung Win (DR)

U Soe Tint (Forestry), U Kyi Win (Forester)

Thaung Yi, Thaung Shein, Htun Khaing

Kyaw Htun, Ba Htwe (Lawa village)

Appendix I (b)

Data on individual selected plus trees

Name of provenance Saw, Gangaw District

No	height (ft)	Girth of breast height (ft)	Quantity of seed collected (pyi)	Date of collection		
				day	month	year
1.	100'	6' 3"	4	30	3	97
2.	110'	7' 6'	6	`	`	`
3.	110'	7' 5"	5	`	`	`
4.	110'	7' 2"	4	`	`	`
5.	110'	7' 2"	6	`	`	`
6.	120'	7' 8"	4	`	`	`
7.	100'	6' 11"	5	`	`	`
8.	120'	7' 8"	8	`	`	`
9.	100'	6' 5"	5	`	`	`
10.	100'	6' 3"	6	`	`	`
11.	100'	7' 3"	8	29	3	97
12.	100'	6' 6"	7	`	`	`
13.	102'	7' 1"	½	25	3	97
14.	100'	8' 1"	2 (tin)	`	`	`
15.	105'	8' 2"	3 (tin)	`	`	`
16.	100'	7' 7"	11 (Pyi)	26	3	97
17.	103'	9' 9"	1½ (tin)	`	`	`
18.	100'	8' 10"	t (tin)	27	3	97
19.	101'	7' 11"	½ (tin)	`	`	`
20.	100	7' 10"	½ (tin)	`	`	`
21.	102'	8'	½ (tin)	28	3	97
22.	102'	8'	1 (tin)	`	`	`
23.	100'	7' 1"	1 (tin)	29	3	97
24.	101"	7' 2"	1 (tin)	`	`	`
25.	100'	7'	1 (tin)	`	`	`

Crew leader

U Thaung Oo (R/O), U Sein Htun (R/O)

Member

U Hla Pa (D/R),

U Myint Aung (Forester), U Ba Than (Forester)

Labour

Thaung Yi, Thaung Shein, Htun Khaing, Kyaw Htun,
Ba Htwe (Lawa village)

Appendix I (c)

Data on individual selected plus trees

Name of provenance Moehvin, Myiktyine District

No	height (ft)	Girth of breast height (ft)	Quantity of seed collected (pyi)	Date of collection		
				day	month	year
1.	79'	6' 7"	4	7	4	97
2.	96'	6' 4"	4	`	`	`
3.	72'	4' 3"	5	`	`	`
4.	88'	5' 2"	3	`	`	`
5.	86'	7' 3"	4	`	`	`
6.	76'	6'	5	`	`	`
7.	93'	6' 1"	3	`	`	`
8.	68'	5' 6"	3	`	`	`
9.	78'	6' 7"	3	`	`	`
10.	80'	4' 11"	3	`	`	`
11.	72'	4' 11"	5½	`	`	`
12.	76'	5' 6"	7½	`	`	`
13.	70'	4'	6	`	`	`
14.	55'	3' 5"	3	`	`	`
15.	54'	3' 7"	3	`	`	`
16.	76'	4' 1"	8½	`	`	`
17.	81'	6' 3"	3	`	`	`
18.	58'	4'	8	`	`	`
19.	77'	5' 1"	5	`	`	`
20.	84'	6' 2"	8	`	`	`
21.	75'	6' 2"	23	`	`	`
22.	90'	6' 8"	8	`	`	`
23.	78'	5'10"	11	`	`	`
24.	73'	4' 10"	4	`	`	`
25.	96'	6' 9"	15	`	`	`

Crew leader

U Tin Myint (R/O)

Member

U Kyaw Thaung (D/R), U Thein Maw (D/R)

Labour

Ohn Mg (Thayagone village, Moehnyin Township)

Appendix I (d)

Data on individual selected plus trees

Name of provenance Bago, Bago Division

No	height (ft)	Girth of breast height (ft)	Quantity of seed collected	Date of collection		
				day	month	year
1.	82.5'	5' 2"		28	3	97
2.	92.05'	6' 6"		`	`	`
3.	74.25'	4' 2"		`	`	`
4.	84.15'	5'		`	`	`
5.	75.9'	4' 3"		`	`	`
6.	81.51'	4' 2"		`	`	`
7.	70.95'	4' 7"		`	`	`
8.	79.2'	3' 9"		`	`	`
9.	74.25'	3' 9"		`	`	`
10.	85.5'	4' 8"		`	`	`
11.	66'	3' 2"		`	`	`
12.	99'	6' 9"		29	3	97
13.	103.95'	7' 4"		`	`	`
14.	85.8'	5' 3"		`	`	`
15.	57.75'	3' 4"		`	`	`
16.	77.55'	4' 4"		`	`	`
17.	74.25'	4' 9"		`	`	`
18.	74.25'	4' 1"		`	`	`
19.	72.6'	4' 2"		`	`	`
20.	79.2'	3' 3"		`	`	`
21.	71.61'	4' 3"		`	`	`
22.	80.85'	6' 5"		`	`	`
23.	77.55'	4' 10"		`	`	`
24.	79.2'	3' 8"		`	`	`
25.	100.65'	6' 6"		`	`	`

Crew leader

U Win Bo (Forester)

Member

-

Labour

Nyunt Hlaing (Magyigon village)

Appendix I (e)

Data on individual selected plus trees

Name of provenance Pyinmana, Yamethin District

No	height (ft)	Girth of breast height (ft)	Quantity of seed collected	Date of collection		
				day	month	year
1.	130'	7' 8"		10	3	97
2.	140'	7' 11"		`	`	`
3.	145'	8' 3"		`	`	`
4.	120'	7' 8"		`	`	`
5.	100'	5' 9"		`	`	`
6.	120'	7' 10"		`	`	`
7.	100'	6'		`	`	`
8.	100'	5' 6"		`	`	`
9.	93'	5' 3"		`	`	`
10.	130'	8' 6"		`	`	`
11.	110'	6' 7"		`	`	`
12.	100'	6' 10"		29	3	97
13.	110'	5' 6"		`	`	`
14.	110'	6' 6"		`	`	`
15.	100'	6' 3"		`	`	`
16.	120'	6'		`	`	`
17.	130'	6' 7"		`	`	`
18.	120'	6' 10"		`	`	`
19.	100'	5' 4"		`	`	`
20.	120'	6' 5"		`	`	`
21.	100'	5' 5"		`	`	`
22.	130'	6' 5"		`	`	`
23.	100'	6' 3"		`	`	`
24.	110'	6' 9"		`	`	`
25.	140'	8'		23	3	97

Crew leader U Kyaw Maung (D/R)
Member -
Labour -

Appendix I (f)

Data on individual selected plus trees

Name of provenance Padaung, Pyi District

No	height (ft)	Girth of breast height (ft)	Quantity of seed collected (pyi)	Date of collection		
				day	month	year
1.	49.2'	4' 2"	2	22	3	97
2.	54.94'	3' 2"	6	`	`	`
3.	57.4'	6'	4	`	`	`
4.	63.96'	5'	7	`	`	`
5.	45.1'	3' 10"	2	`	`	`
6.	41.0'	3'	4	23	3	97
7.	59.0'	3' 4"	2	`	`	`
8.	55.76'	3'	5	`	`	`
9.	98.4'	6'	3	`	`	`
10.	47.56'	4'	3	`	`	`
11.	57.4'	5' 4"	6	`	`	`
12.	51.66'	3' 8"	2	`	`	`
13.	54.94'	3' 3"	2	`	`	`
14.	62.32'	5' 6"	4	`	`	`
15.	56.58'	3'	3	`	`	`
16.	60.68'	3' 1"	4	25	3	97
17.	69.7'	5'	3	`	`	`
18.	51.66'	3'	2	`	`	`
19.	45.92'	3'	4	`	`	`
20.	49.2'	3'	3	`	`	`
21.	50.02'	3' 3"	4	26	3	97
22.	57.4'	3' 1"	5	`	`	`
23.	68.88'	6' 4"	4	`	`	`
24.	65.6'	7'	4	`	`	`
25.	48.38'	3' 4"	3	`	`	`

Crew leader

U Kyi Win (D/R)

Member

U Maung Nyo (Forester), U Han Sein (Forest Guard)

Labour

Shwe Pain (Kyipin, village)

Appendix I (g)

Data on individual selected plus trees

Name of provenance Phyu, TaungOo District

No	height (ft)	Girth of breast height (ft)	Quantity of seed collected (tins)	Date of collection		
				day	month	year
1.	80'	4' 6"	5	4	2	97
2.	95'	4' 7"	6	`	`	`
3.	75'	3' 8"	10	`	`	`
4.	100'	9' 3"	7	`	`	`
5.	95'	4' 8"	4	`	`	`
6.	96'	5'	5	8	2	97
7.	100'	5' 5"	6	`	`	`
8.	100'	5' 2"	7	10	2	97
9.	120'	9' 6"	8	`	`	`
10.	150'	7' 10"	7	`	`	`
11.	110'	5' 9"	10	`	`	`
12.	100'	5' 7"	7	15	2	97
13.	100'	5' 6"	9	`	`	`
14.	95'	3' 9"	12	`	`	`
15.	150'	7'	10	`	`	`
16.	160'	8' 3"	5	`	`	`
17.	100'	5' 5"	7	6	3	97
18.	120'	7' 9"	8	`	`	`
19.	110'	6' 6"	9	`	`	`
20.	100'	5' 10"	9	12	3	97
21.	110'	6' 2"	10	`	`	`
22.	110'	6' 8"	8	`	`	`
23.	150'	7' 10"	10	`	`	`
24.	150'	8' 5"	9	`	`	`
25.	160'	9' 8"	6	`	`	`

Crew leader U Aye Lwin (D/R)
Member U Mya Lin (Forester),
Labour Myint Oo (Koegwa village)

Data on individual selected plus trees

Name of provenance Kalay, Kalay District

No	height (ft)	Girth of breast height (ft)	Quantity of seed collected (pyi)	Date of collection		
				day	month	year
1.	100'	5' 8"				
2.	100'	4'				
3.	99'	5' 4"				
4.	89'	4' 4"				
5.	90'	6' 1"				
6.	110'	7'				
7.	120'	4' 8"				
8.	110'	6'				
9.	110'	7'				
10.	98'	6' 3"				
11.	110'	7' 2"				
12.	110'	5' 7"				
13.	90'	7' 7"				
14.	90'	5' 8"				
15.	96'	7'				
16.	98'	7' 10"				
17.	110'	5' 8"				
18.	98'	6' 9"				
19.	98'	5' 7"				
20.	100'	6' 1"				
21.	120'	5' 8"				
22.	100'	6' 4"				
23.	92'	7' 4"	18	8	3	97
24.	90'	10'	22	`	`	`
25.	89'	10' 6"	15	2	4	97

Crew leader

U Hla Taung (1), (D/R)

Member

U Khin Swe (Forester), Htay Win (Forester)

Labour

Saipya, Myint Win, (Sinywa, Kalay Toanship)

Appendix II (a)

Analysis of variance for height (2000) Trial Site - Paukkaung

SV	DF	SS	MS	F
REPLICATE (R)	3	7.6	2.5	9.17
PROVENANCE (T)	9	4.1	0.5	1.65
ERROR	27	7.5	0.3	
TOTAL	39	19.1		

CV= 15.2%

** = significant at 1% level: ns = not significant

Analysis of variance for height (2000) Trial Site - Oaktwin

SV	DF	SS	MS	F
REPLICATE (R)	2	37.39	18.70	12.43
PROVENANCE (T)	99	10.25	1.14	<1
ERROR	18	27.08	1.50	
TOTAL	29	74.72		

CV= 23.3%

** = significant at 1% level

Analysis of variance for height (2000)
Trial Site - Phyu

SV	DF	SS	MS	F
REPLICATE (R)	3	2.8	0.9	<1
PROVENANCE (T)	9	13.6	1.5	<1
ERROR	27	53.2	2.0	
TOTAL	39	69.6		

CV= 22.3%

Analysis of variance for height (2000)
Trial Site - Paungte

SV	DF	SS	MS	F
REPLICATE (R)	3	4.2	1.4	1.02
PROVENANCE (T)	9	12.8	1.4	1.05
ERROR	27	36.7	1.4	
TOTAL	39	53.7		

CV= 30.2%

ns = not significant

References

1. Tint, Dr Kyaw, Gyi, K.K (1995): Management Status of Natural Teak Forest.
2. Keogh, Raymond, M (1996): Teak 2000.
3. Gyi, KK (1991): Teak in Myanmar
4. Gyi, KK et al., (1984) Interim report on Teak provenance trial (Seed characteristic)
5. Keh, Saw K, Aung. M (1995): A Critical review of the silvicultural treatments of the teak bearing forests of the Bago Yoma with some suggested remedial treatments.
6. Keh, S.K. (1993): The problems of natural regeneration of teak in the lower reaches of Bago Yoma particularly in the South Zamayi and North Zamayi Reserved forests.
7. ဒေါက်တာကျော်တင့် (၁၉၉၉)၊ အထူးကျွန်းစိုက်ခင်းများ၏ လူမှုရေးနှင့် သဘာဝဝန်းကျင် ထိန်းသိမ်းရေး ဆိုင်ရာ အလားအလာများ
8. FD (1995) : Management of Natural Teak Forest in Myanmar
9. Karmode, C.W.D (1964): Some Aspects of Silviculture In Burma
10. Keh. Saw Kelvin (1996): A review of the teak plantation establishment in Myanmar in the light of modern research findings; A Constructive Critique.
11. Myint S, Hyun. K, Evaluation of commercial plantations in Myanmar
Hlaing Professor C, (1999):
12. SHAH. S.A.(1999): What are sustainable forests?
13. Boyle. T, Chaiyasit. L (1992). Design, Measurement, and analysis of field Trials for Genetic analysis.
14. Lwin. T, (1994): Basis and action planing of Forest plantation in Myanmar.
15. Burley, J, Wood P.J (1976): A manual on species and provenance research with particular Reference to the tropics.
16. ဦးအုန်း (၁၉၉၆) ၊ သဘာဝတောများနှင့် ရုပ်ပေါင်းတန်းလာသော စိုက်ခင်းများ
17. Waston; H.W.A. A note on the Bago Yoma
18. Tin Tun (1995). Gene pool conservation of teak in Myanmar