GROWTH PERFORMANCE OF TEAK PROVENANCE TRIALS ESTABLISHED IN BAGO YOMA: EVALUATION AT THE 5TH YEAR AFTER PLANTING

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ABSTRACT

Provided with favorable soil and climatic conditions, Bago Yoma is well known for best growth of teak, and most of the special teak plantations are situated in this region. To assist large-scale plantations with high-quality genetic materials and to find out the most suitable seed sources, four provenance trials were established in Bago Yoma region in 1998. In each trial, ten provenances throughout Myanmar were tested. The trials were evaluated in the 5th year after planting in terms of adaptability and growth (height and diameter) performance of selected provenances to the four introduced sites. The results of the comparative assessment reveal that local provenances are generally the best for Bago Yoma region. This paper also reports the best performing provenances for each trial site and suggests possible provenances to be used as alternative seed sources as well as gene sources for tree improvement programs.

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1. INTRODUCTION

Teak (*Tectona grandis* Linn. f.) is one of the most valuable timber tree species of the world. Its timber quality is manifested in its color, texture, resistances to termites, fungi and weathering and suitability for carving, furniture making, household construction etc. (Kaosa-ard, 1999). It is an all-round premier timber with many favorable properties and has been, and will continue to be, one of the most admired and precious timber tree species in the world (Gyi and Tint, 1995).

Teak is indigenous to the South and Southeast Asian regions. The species occurs naturally in India, Myanmar, Thailand and Laos PDR, covering the range of latitudes between 9º-25º30' N and longitudes between 73º- 104º 30' E (Koasa-ard, 1986). In Myanmar, teak occurs naturally in all parts of the country except in the dry zone, or in the tidal regions of the delta area or in those areas of elevation exceeding 914 m (Gyi and Tint, 1995), and teak forests in Myanmar cover 16.5 million ha out of 28 million ha of teak bearing forests all over the world (Anon., 1993).

Since teak occurs on a great variety of soils and over a wide range of locally different environments, it can display geographic differences in one or more important characteristics. Teak of the best timber quality producing cylindrical and sound logs occurs in the Bago Yoma where the rainfall varies from about 50 to 60 inches, and there are all the favorable soil and climatic conditions for best growth of teak (Kermode, 1964).

Due to the population pressure and ever increasing demand of timber for domestic uses and export, extensive teak plantations in large blocks were formed in Myanmar starting from 1972. Within a period of 50 years from 1948 to 1998, 567,650 acres of teak plantations were established (Gyi, 1993). Nowadays, Ministry of Forestry has been launching special teak plantation projects since 1998, establishing 8 000 ha of teak plantations annually, most of them are situated in Bago Yoma area.

In accelerating plantation programs, it is important that all the plantations should produce maximum volume of good-quality timber in short rotations. Although growth and yield of the plantations are largely influenced by site quality, other characteristics such as stem straightness, branching habits, etc are strongly controlled by the genetic factor. Therefore, seed and seedlings, which are used in the planting programs must be of high genetic quality, especially for the commercial

plantations. If the best genetic material available is chosen, if only good sites yielding an average of 8 m^3 /ha /year or more are selected 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 (Keogh, 1996).

Along with large- scale plantations, it is routine to implement tree improvement programs for conservation and production of superior genetic materials, e.g. establishment of seed production areas converted from natural stands or old plantations; seed orchards for mass production of improved seeds and new progenies of better genetic combinations. It is also known that, seed procurement is one of the most critical problems in the planting programs especially where there is a high demand for improved seeds. For 1000 ha of teak plantation with 3m x 3m spacing, 15 tons of seeds are necessary (Kaosa-ard, 1999).

It is inevitable for plantation managers to collect teak seeds from non-region seed sources, until at least, seed production areas and seed orchards can provide adequate seeds for large-scale planting programs. Therefore the knowledge and understanding of adaptability and performance of the various provenances at a particular region is invaluable for successful establishment of teak plantations.

This research was, therefore, aimed:

- to compare the performance of teak from various seed sources in the environment of the BagoYoma region,
- to select particular provenances for seed collection and plus tree selection to use in tree improvement programs, and
- to determine the suitable provenances, which may be used as alternative seed sources for large-scale teak plantations.

2. MATERIALS AND METHODS

2.1. Provenances and Seed Collection

The trial included ten provenances, namely, Moehnyin, Mabein, Kalay, Moemeik, Saw, Pyinmana, Padaung, Phyu, Bago and Mudon, where teak naturally occurs (Fig.1). Under the guidance of the Teaknet[3], the provenances were chosen based on their climatic data and latitudinal distribution (details shown in Appendix 1, table 1).

[3] Teaknet is the Asia-Pacific regional network for teak established in 1995.

In each provenance, 25 phenotypically superior trees were selected from natural forests according to the criteria for selecting plus trees. The seeds from selected plus trees were collected during February and March, 1997. Seed collection was made on the ground by gathering both seeds already fallen and those struck down from branches bearing mature seeds. Collected seeds from the ten provenances were transported to Forest Research Institute, Yezin and stored in the seed laboratory. In February 1998, the one - year stored seeds were raised to seedlings in the nursery of the Management and Silviculture Subdivision of FRI, Yezin.

2.2. Trial Sites and Establishment of Trials

Four trial sites were established in Bago Yoma area (Fig.1). There were two trials on the eastern aspect of Bago Yoma viz. Phyu and Oktwin townships, and two on the western aspect viz. Paungte and Paukkaung townships (details in Appendix 1, table 1). In collaboration with staff from local Forest Offices, the seedlings transported from FRI to each trial site were planted in designated plots during June and mid of July, 1998. Patching was done only in the first year of the trials. With the assistance of local offices, cultural operations such as weeding, mulching and fire protection were carried out according to the annual work plan prescribed for commercial teak plantations in Myanmar.

2.3. Experimental Design

The experimental design was a randomized complete block design with four replicates in Phyu, Paukkaung and Paungte trial sites, and three replicates in Oktwin trial site. One replicate was made of 10 plots representing 10 provenances, which were assigned randomly. Within each plot, 49 seedlings of one provenance were planted in 7 rows and 7 columns with 3m x 3m (9' x 9') spacing. The whole experimental area in each trial site comprised 1960 seedlings of 10 provenances, covering an area of 1.2 ha (3.25 Ac). But in Oktwin trial site, there were 1470 seedlings from 10 provenances planted in the plots with a total area of 0.9 ha (2.4 Ac).

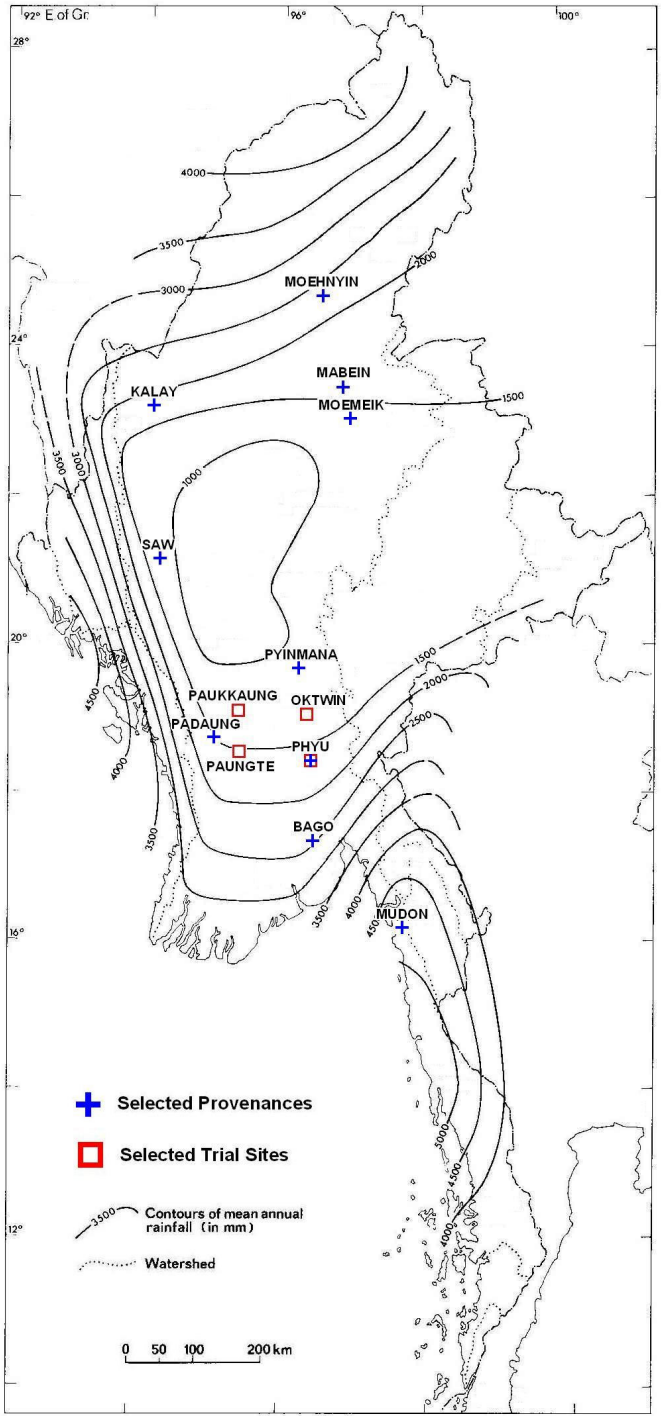


Figure 1. Location map of selected provenances and trial sites

2.4. Assessment of the Trials

In this experiment, survival counting, height and girth at 1.3m height (GBH) measurements were conducted in each trial site in order to evaluate the adaptability and growth performance of the seedlings to the environment of the introduced sites. Survival and height were recorded annually from 1998 to 2003. GBH measurements were started in 2001 when all the survived trees exceeded 2 m in height, and then converted to diameter and used for data analysis. In this paper, 2003 data set (5^{th} year after planting) was used for statistical analysis, and variables included were survival, height and diameter. Since survival rates from 2000 to 2003 were observed the same, results for survival rates represented the adaptability for the planted seedlings is also applicable to 2000 data set (2^{nd} year after planting).

Raw data for survival, height and diameter from each trial site were analyzed in FRI, Yezin. Analysis of variance (ANOVA) was carried out to test whether the variation due to the provenances was significant as compared to residual variation. The least significant difference (LSD) test was also conducted to compare the differences of the assessed parameters between any two provenances of each trial site.

3. RESULTS

3.1. Phyu Trial Site

Results from analysis of variance for survival, height and diameter in Phyu trial site revealed the existence of the variation between the tested provenances. The average survival for the provenances was not statistically different (Appendix 2.a. table 1), whereas mean height (Appendix 2.a. table 2) and mean diameter (Appendix 2.a. table 3) showed significant differences between provenances at 99% and 95% confidence limits respectively.

The survival rates of the provenances ranged from 86.2% to 94.4%. Among the provenances, Mudon showed the best survival, followed by Bago, Phyu, Saw, Pyinmana and Moehnyin provenances. Moemeik, Kalay, Padaung and Mabein had lower survival rates (Fig. 2.a).

In terms of height and diameter, Phyu, Bago and Pyinmana performed the best, followed by Padaung, Moehnyin and Mudon provenances. Moemeik, Mabein,

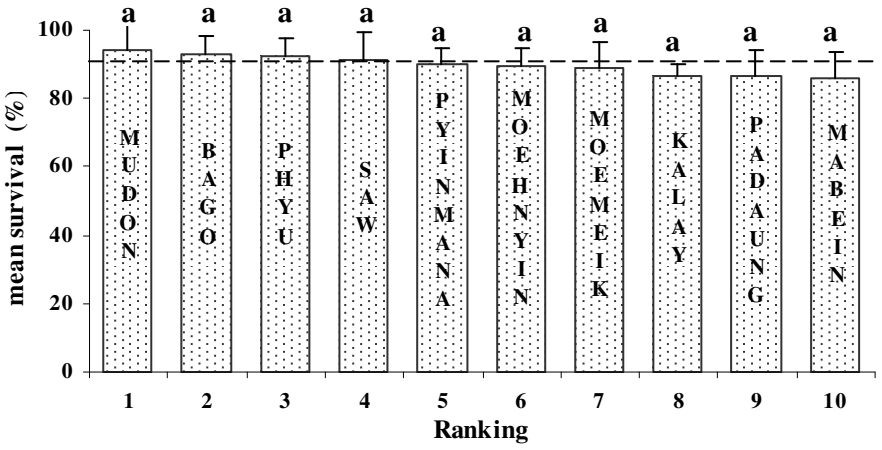
Saw and Kalay showed significantly lower values both in height and diameter (Fig.2. b & c).

Since the survival rates were not significantly different between provenances, mean height and diameter accounted for variation in the performance of the provenances. For Phyu trial site, Phyu, Bago and Pyinmana were the best in terms of growth and Moemeik, Mabein, Saw and Kalay showed the poorest growth.

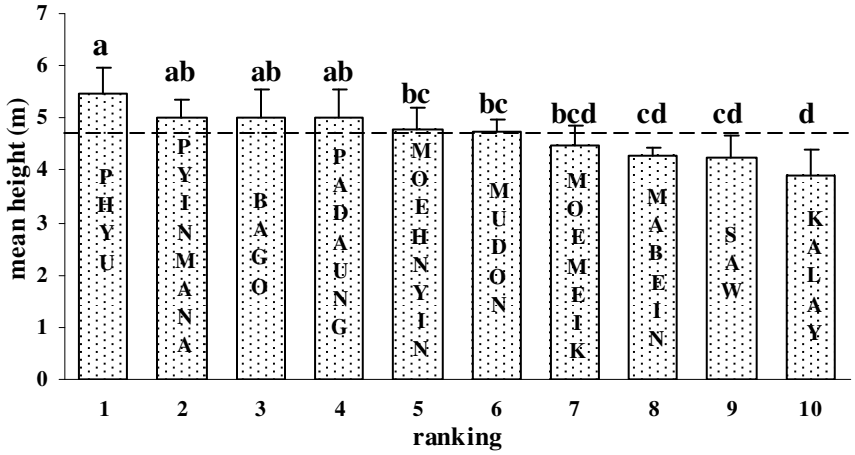
3.2. Oktwin Trial Site

The average survival for the provenances was significantly different between the provenances at 95% confidence limit (Appendix 2.b. table 1), whereas mean height and mean diameter showed no significant differences in Oktwin trial site (Appendix 2.b. table 2&3).

The survival rates of the provenances were quite variable, ranging from 68% to 91.8%. Mudon and Mabein formed a clear group of lowest survival, which were significantly different from other eight provenances (Fig. 3.a).



(a)



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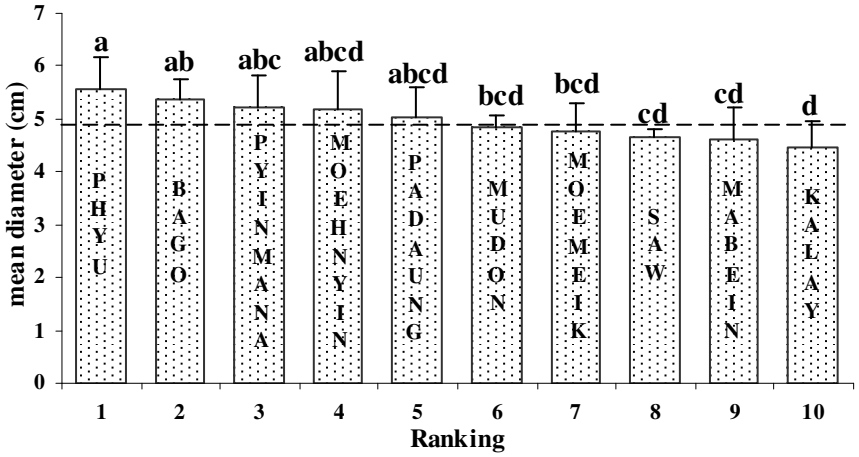
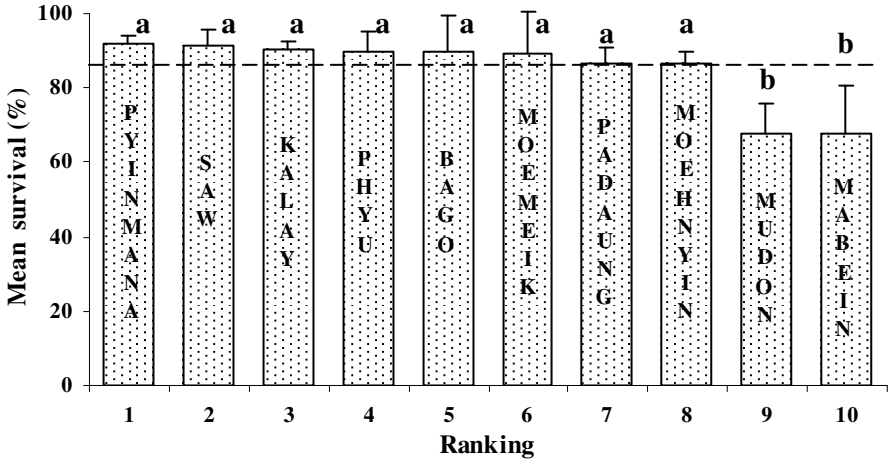
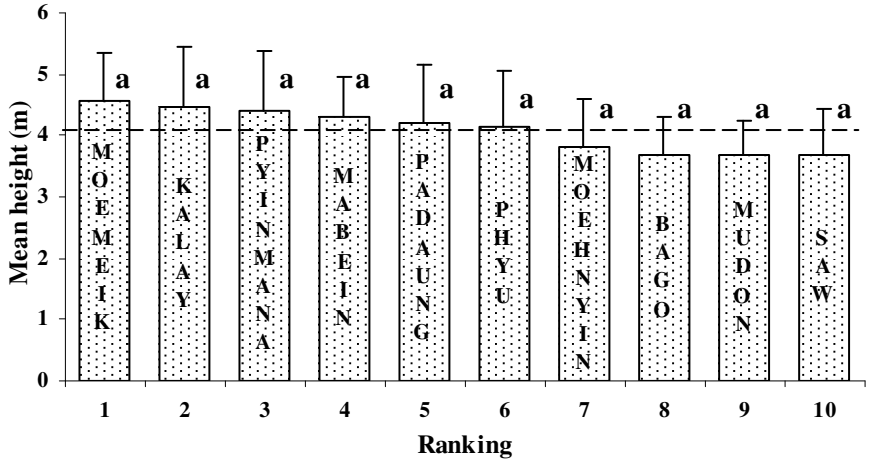


(c)

Figure 2. Comparison of (a) mean survival (b) mean height and (c) mean diameter of 10 different provenances in Phyu trial site. The dotted lines represent the grand mean. The bars with different letters indicate significant differences (P <0.05) between the provenances.


Mean survival (%)
100
80
60
40
20
0
a a a a a a a a b b
PYINMANA
SAW
KALAY
PHYU
BAGO
MOEMEIK
PADAUNG
MOEHNYIN
MUDON
MABEIN
1 2 3 4 5 6 7 8 9 10
Ranking

(a)


Mean height (m)
6
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4
3
2
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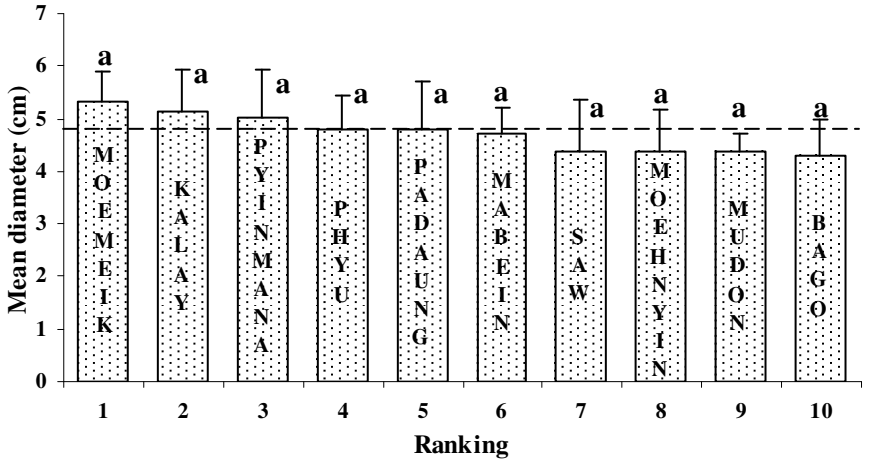
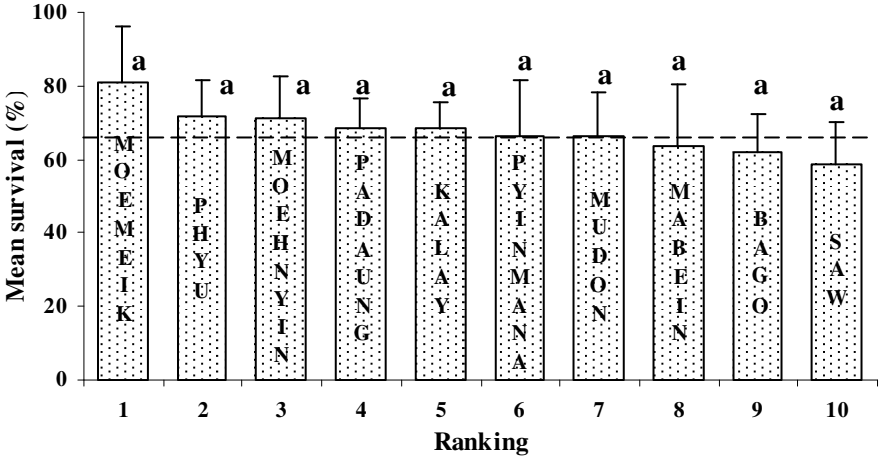
0
a a a a a a a a a a
MOEMEIK
KALAY
PYINMANA
MABEIN
PADAUNG
PHYU
MOEHNYIN
BAGO
MUDON
SAW
1 2 3 4 5 6 7 8 9 10
Ranking

(b)

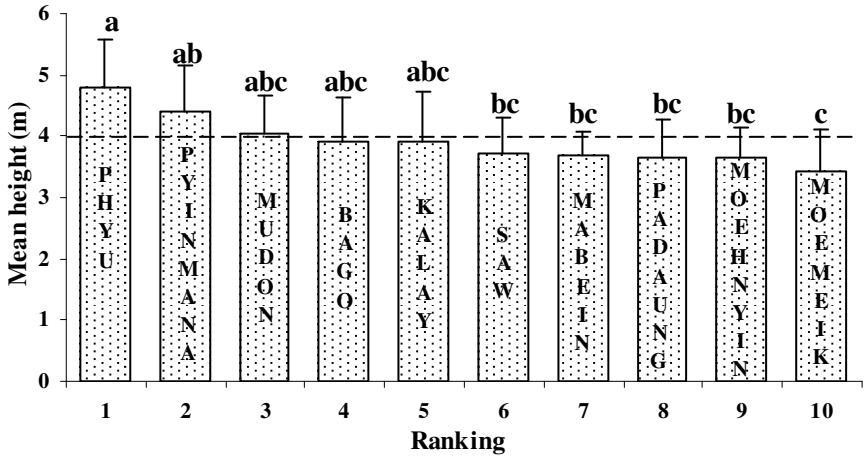


(c)

Figure 3. Comparison of (a) mean survival (b) mean height and (c) mean diameter of 10 different provenances in Oktwin trial site. The dotted lines represent the grand mean. The bars with different letters indicate significant differences (P <0.05) between the provenances.



(a)



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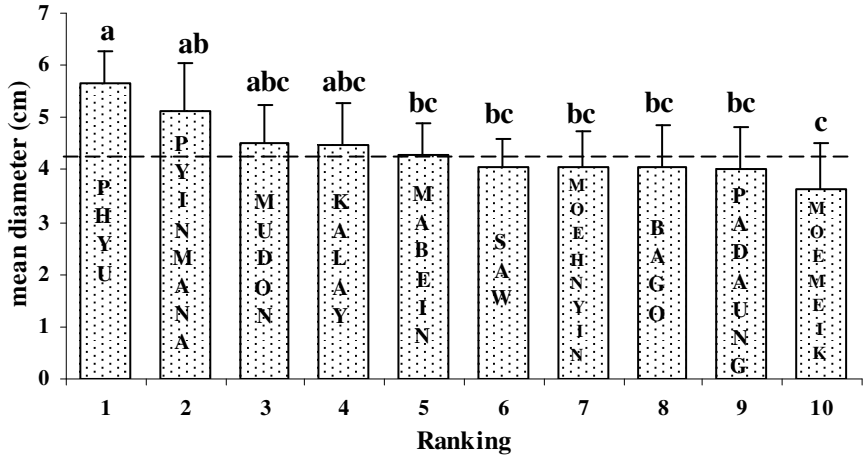
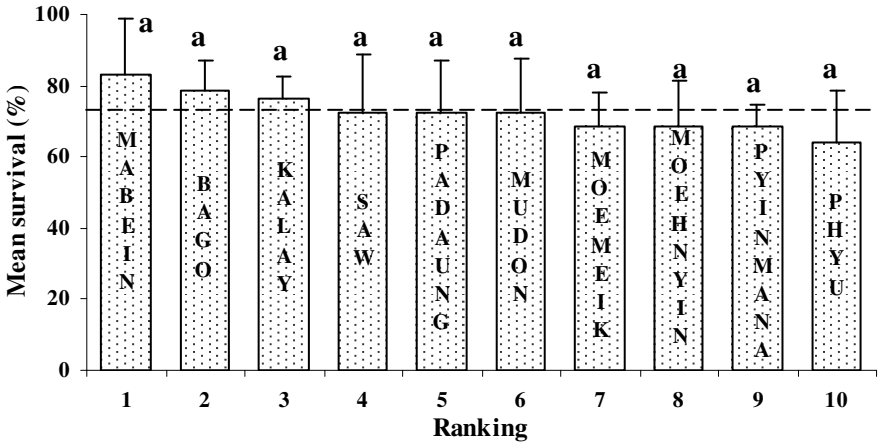


(c)

Figure 4. Comparison of (a) mean survival (b) mean height and (c) mean diameter of 10 different provenances in Paukkaung trial site. The dotted lines represent the grand mean. The bars with different letters indicate significant differences (P <0.05) between the provenances.


Mean survival (%)
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KALAY
SAW
PADAUNG
MUDON
MOEMEIK
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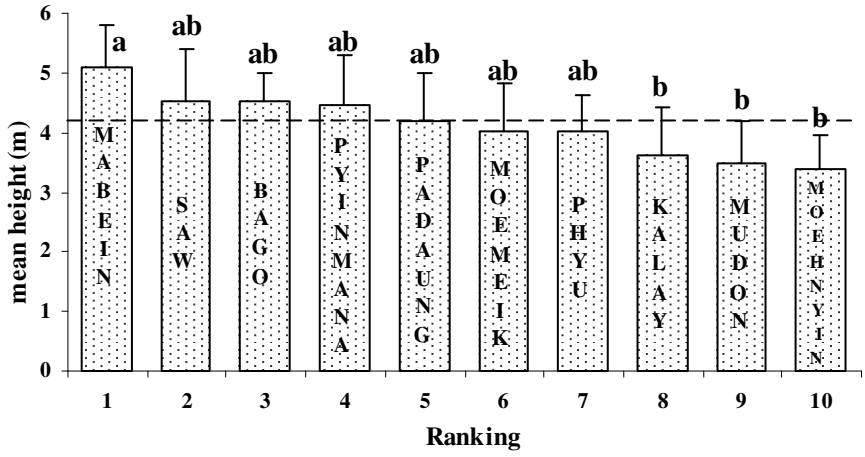
Ranking

(a)


mean height (m)
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MABEIN
SAW
BAGO
PYINMANA
PADAUNG
MOEMEIK
PHYU
KALAY
MUDON
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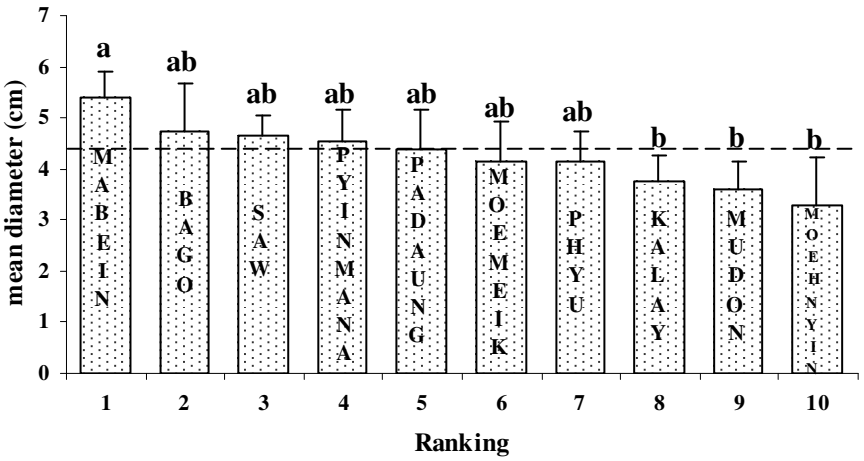
Ranking

(b)



(c)

Figure 5. Comparison of (a) mean survival (b) mean height and (c) mean diameter of 10 different provenances in Paungte trial site. The dotted lines represent the grand mean. The bars with different letters indicate significant differences (P <0.05) between the provenances.

Although there was no statistically significant difference, height and diameter seemed to have the same trend of variations between the provenances. In both growth parameters, Moemeik, Kalay, Pyinmana, Padaung and Phyu showed higher average values than Moehnyin, Bago, Mudon and Saw provenances (Fig. 3. b & c). For Oktwin trial site, adjusted by all assessed parameters, Moemeik, Kalay and Pyinmana would perform better growth than other provenances.

3.3. Paukkaung Trial Site

Results from analysis of variance for survival, height and diameter in Paukkaung trial site showed no significant differences between the tested provenances (Appendix 2.c).But the survival rates of the provenances were variable, ranging from 58.7% to 81.1%. Moemeik, Phyu, Moehnyin, Padaung and Kalay had higher survival than the rest of the tested provenances (Fig. 4. a). In terms of height and diameter growth, Phyu, Pyinmana and Mudon indicated superior performance than the other provenances while Mabein, Padaung, Moehnyin and Moemeik showed the poorest growth (Fig. 4. b & c).

For Paukkaung trial site, Phyu provenance performed the best height and diameter growth, with acceptable survival percentage.

3.4. Paungte Trial Site

Survival, height and diameter in Paungte trial site were not different between the provenances by the statistical analysis (Appendix 2.d). Among the assessed parameters, mean survivals ranged from 64.3% to 83.2%, Mabein, Bago and Kalay showing the highest values (Fig. 5. a). In height and diameter growth, Mabein, Bago, Saw, Pyinmana and Padaung formed a better group than the other provenances (Fig. 5. b & c).

Adjusted by all assessed parameters, Mabein and Bago showed superior performance among the tested provenances in Paungte trial site. Saw, Padaung and Pyinmana had lower adaptability though their height and diameter indicated higher values. On the other hand, Kalay provenance showed higher survival but the survived trees were low in height and diameter growth. In Paungte trial site, Moemeik, Phyu, Mudon and Moehnyin showed the poorest growth.

4. DISCUSSION

Because of its economic importance, teak has been planted in large scales within and outside its natural range, and provenance or seed source trials have also been tested and/or established, aiming to attain good-quality timber and superior genetic materials. Whenever provenance trials are established, the following distinct phases are commonly encountered (Burley and Wood, 1976);

- A range-wide provenance sampling phase or provenance elimination phase: at this stage, many (10-25) provenances are tested by small plots for short periods, little data on provenances and trial sites are known.
- A restricted provenance sampling phase: fewer provenances are tested by larger plot size for longer periods, increasing data on site characteristics.
- A provenance proving phase: the planting area is reckoned in hundreds of hectares, including tending operations such as pruning, thinning (eg. establishment of seed production areas, seed orchards).

There is no standard procedure or time schedule for passage through successive stages of testing. At all stages of provenance trials, evaluation is often

lengthy and expensive, and only those characters which are practically important and in which there is substantial experimental variation should be assessed. Height, diameter at breast height, survival, stem form, crown characteristics, and branch habits are assessment parameters common to most trials.

Since teak occurs on a great variety of soils, and also because of its wide and discontinuous distribution, development of numerous provenances can be expected (White, 1991). Provenance variations in wood quality, growth rate, stem form, seed morphology and germination, and other characters have substantially been reported (Nair and Mukerji, 1960; Hedegart, 1974; Keiding et al, 1986; Koasa-ard, 1993; Gyi, 1995).

In this provenance trial, ten provenances from various parts of Myanmar were tested in four trial sites situated in Bago Yoma area, and could be classified as a range-wide provenance sampling phase. Survival, height and diameter were recorded every year. And evaluation of those trials at the 5th year of the establishment indicated that there was a variation among the tested provenances in terms of survival or adaptability to introduced site and growth performance (height and diameter).

Widespread studies indicated the existence of provenance variation in teak in many characteristics. They also indicated that the comparative performance of the provenances might change with age and place (Mathauda, 1951 as quoted in Gyi, 1995). Hedegart (1971) also observed that the differences among the provenances were highly significant in the first year, but were not very clearly defined in the 3rd, 5th and 8th years. Gyi (1995) assessed the provenance trial in Pyinmana at the 3rd, 5th and 8th years after establishment and recommended that assessments of the provenance trials should be continued until more stable results were obtained.

After assessment of the four trial sites at the 2nd year of planting, Htwe (2000) reported that there were some variations in height growth among the provenances. Among the best provenances were Phyu in Phyu trial site; Moemeik, Kalay, Phyu and Pyinmana in Oktwin trial site; Phyu in Paukkaung trial site; and Mabein in Paungte trial site. In this evaluation at the 5th year of planting, the provenances performing superior height growth were observed analogous to the 2nd year results. At the 5th year after planting, Phyu provenance was still performing the best in Phyu and Paukkaung trial sites. Similarly, Moemeik, forming a group with Kalay and

Pyinmana, showed the best growth in Oktwin trial site; Mabein followed by Bago was the highest by survival, height and diameter in Paungte trial site. Therefore, these two assessments (at the 2nd and 5th years after planting) reported the same trend, indicating there was considerable stability of results in assessing the established provenance trials.

In the assessment at the 5th year, it was observed that local provenance Phyu was significantly different in Phyu trial site from other provenances and performed the best in height and diameter growth. This was consistent with some other reports. Persson (1971) worked in Tanzania, reported that the local provenance (Kihuwi) was superior to the others in volume production. Gyi (1995) also observed that the local provenance (Pyinmana) tended to be the best both in height and girth measurements in the 5th and 8th years, and concluded that local provenance was generally the best after he assessed the provenance trial established in Moeswe, Pyinmana. On the other hand, the local provenances were not always superior to the imported provenances. In many cases, they were even inferior to the imported provenances (Keiding et al., 1986).

Among the selected provenances, there were 3 local provenances from Bago Yoma area, namely, Pyinmana, Phyu and Bago. The results of this assessment revealed that Pyinmana provenance was the best in Phyu and Oktwin sites, but with poor survival in Paukkaung and Paungte sites; Phyu provenance, the best in Phyu, Oktwin and Paukkaung trials but among the poorest in Paungte trial area; Bago provenance, the best in Phyu and Paungte but poor in Oktwin and Paukkaung sites. Generally saying, Bago Yoma region provenances were suitable for the four trial sites located in Bago Yoma area, but provenances from other regions could perform the best in some trial sites, eg. Mabein provenance was the best in Paungte site and other non-region provenances were also among the best in different trial sites. No consistency was found by current data both for local and non-local provenances (Appendix 1, table 2). It can be said that the differences in vegetation type, topography, macro- and micro-climatic conditions, soil condition and aspect of the region can determine adaptability and growth performance of the tested provenances.

The results from Phyu trial site highlighted the range of some climatic conditions to be considered in selecting a suitable provenance or seed source for a particular region. In Phyu trial site, Phyu, Bago and Pyinmana performed the best growth

followed by Padaung, and Mudon provenances, indicating that all the provenances among the best were not exceeding Pyinmana in Northern and Saw in Western direction. Within this range, Mudon and Bago with high rainfall (4,628 mm and 3,180 mm) showed higher survival than Pyinmana and Padaung with low rainfall (1,238 mm and 1,028 mm respectively). Climatic conditions such as latitude, altitudinal range, maximum, minimum and annual mean temperatures, annual mean rainfall or precipitation play an important role in the stage of provenance selection (Swe, 1991). Greaves and Hughes (1976) stated that three fundamental factors that should be examined are rainfall distribution, mean annual precipitation and the temperature pattern in provenance species and provenance testing.

Climatic information of both trial sites and selected provenances will be useful for the further stages of tree improvement programs, e.g. establishment of a restricted provenance sampling phase, in which phase fewer provenances are tested by larger plot size for longer periods, increasing data on site characteristics.

5. CONCLUSION

After analyzing and adjusting the assessed parameters and available information for the four provenance trials in Bago Yoma area, we can conclude that:

- Generally, Phyu, Pyinmana and Bago are the most suitable provenances for both eastern and western aspect of the Bago Yoma region;
- in Phyu trial site, Phyu provenance is the best, followed by Pyinmana and Bago;
- in Oktwin trial site, Moemeik, Kalay and Pyinmana perform better growth than other provenances;
- in Paukkaung trial site, Phyu provenance is the best in height and diameter growth, with acceptable survival percentage; and
- in Paungte trial site Mabein and Bago provenances are the best.

Appendix 1

Detailed information of provenances

Table (1) Location and available climatic conditions of the provenances and trial sites

Provenances	Latitudes (N)	Longitudes (E)	mean temp. (°C)	annual rainfall (mm)	Eleva-tion (m)	Location of plus trees
1. Moehnyin	24° 47'	96° 22'	NA	2187	209	compt. 3, Nantpanaung RF.
2. Mabein	23° 20'	96° 40'	NA	1524	115	compt.1, Nantpaw RF.
3. Kalay	23° 47'	94° 04'	25.6	1579	152	compt.69&70,BoneRF; coupe19&22,MyithaUCF
4. Moemeik	22° 36'	96° 40'	23.9	1298	NA	NA
5. Saw	21° 15'	94° 27'	NA	1270	606	compt. 87, Letpan RF; Letpan UCF.
6. Pyinmana	19° 43'	96° 13'	27.5	1238	95	compt. 18, Naleik RF.
7. Padaung	18° 44'	95° 08'	27.6	1028	NA	coupe 122, Padaung UCF.
8. Phyu	18° 30'	96° 27'	26.0	3071	48	compt. 31, Phyuchaung RF.
9. Bago	17° 20'	96° 30'	26.8	3180	9	compt. 22&23, South Zamari RF.
10. Mudon	16° 14'	97° 43'	27.0	4628	10	NA
Trial sites						Location of trials
1. Paukkaung	18° 54'	95° 36'	NA	1261	NA	compt. 1, South Nawin RF.
2. Paungte	18° 40'	95° 30'	27.6	1184	NA	compt. 30, Bwet RF.
3. Oktwin	18° 49'	96° 24'	26.9	1929	NA	No. XVI, Khapaung PF.
4. Phyu	18° 30'	96° 27'	26.0	3071	48	No. II, Phyukoon PF.

Source: Htwe, 2000

(RF for reserved Forest, UCF for Un-classed Forest, PF for Protected Forest)

Table (2) Rankings of assessed parameters performed by each provenance in four trial sites (S for mean survival, H for mean height, D for mean diameter)

No		Phyu			Oktwin			Paukkaung			Paungte		
	Provenances	**S.**	**H.**	**D.**	**S.**	**H.**	**D.**	**S.**	**H.**	**D.**	**S.**	**H.**	**D.**
1	Phyu	3	1	1	4	6	4	2	1	1	10	7	7
2	Pyinmana	5	2	3	1	3	3	6	2	2	9	4	4
3	Bago	2	3	2	5	8	10	9	4	8	2	3	2
4	Padaung	9	4	5	7	5	5	4	8	9	5	5	5
5	Moehnyin	6	5	4	8	7	8	3	9	7	8	10	10
6	Mudon	1	6	6	9	9	9	7	3	3	6	9	9
7	Moemeik	7	7	7	6	1	1	1	10	10	7	6	6
8	Mabein	10	8	9	10	4	6	8	7	5	1	1	1
9	Saw	4	9	8	2	10	7	10	6	6	4	2	3
10	Kalay	8	10	10	3	2	2	5	5	4	3	8	8

Appendix 2

Results from the statistical analysis

(a) Analysis of variance for assessed parameters (Phyu trial site)

Table (1) Analysis of variance for mean survival (%)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	3	758.43	252.81	14.33	
Provenance	9	289.05	32.12	1.82^{ns}	0.111
Error	27	476.47	17.65		
Total	39	1523.95			

c. v % = 4.7; ^{ns} not significant

Table (2) Analysis of variance for mean height (m)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	3	4.9749	1.6583	8.21	
Provenance	9	7.4393	0.8266	4.09**	0.002
Error	27	5.4507	0.2019		
Total	39	17.8650			

c. v % = 9.6 ; ** highly significant

Table (3) Analysis of variance for mean diameter (cm)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	3	6.9287	2.3096	11.74	
Provenance	9	4.7439	0.5271	2.68*	0.023
Error	27	5.3117	0.1967		
Total	39	16.9844			

c. v % = 8.9 ; * significant at 5% level

(b) Analysis of variance for assessed parameters (Oktwin trial site)

Table (1) Analysis of variance for mean survival (%)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	2	0.83	0.42	0.00	
Provenance	9	2272.53	252.5	2.61*	0.040
Error	18	1742.88	96.83		
Total	29	4016.24			

c. v % = 11.6 ; * significant at 5% level

Table (2) Analysis of variance for mean height (m)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	2	12.0008	6.0004	8.40	
Provenance	9	3.2191	0.3577	0.50^{ns}	0.855
Error	18	12.8566	0.7143		
Total	29	28.0765			

c. v % = 20.6 ; ^{ns} not significant

Table (3) Analysis of variance for mean diameter (cm)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	2	15.8096	7.9048	9.17	
Provenance	9	3.4966	0.3885	0.45^{ns}	0.889
Error	18	15.5133	0.8618		
Total	29	34.8195			

c. v % = 19.7 ; ^{ns} not significant

(c) Analysis of variance for assessed parameters (Paukkaung trial site)

Table (1) Analysis of variance for mean survival (%)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	3	1015.7	338.6	1.41	
Provenance	9	1396.2	155.1	0.65^{ns}	0.74
Error	27	6471.8	239.7		
Total	39	8883.7			

c. v % = 22.8 ; ^{ns} not significant

Table (2) Analysis of variance for mean height (m)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	3	21.9406	7.3135	19.06	
Provenance	9	7.4393	0.8266	1.74 ^{ns}	0.127
Error	27	5.4507	0.2019		
Total	39	17.8650			

c. v % = 15.8 ; ^{ns} not significant

Table (3) Analysis of variance for mean diameter (cm)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	3	30.6065	10.2022	15.13	
Provenance	9	12.9114	1.4346	2.13 ^{ns}	0.063
Error	27	18.2071	0.6743		
Total	39	61.7251			

c. v % = 18.7; ^{ns} not significant

(d) Analysis of variance for assessed parameters (Paungte trial site)

Table (1) Analysis of variance for mean survival (%)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	3	2356.0	785.3	3.92	
Provenance	9	1123.9	124.9	0.62 ^{ns}	0.767
Error	27	5413.8	200.5		
Total	39	8893.8			

c. v % = 9.6; ^{ns} not significant

Table (2) Analysis of variance for mean height (m)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	3	15.5313	5.1771	7.24	
Provenance	9	10.5025	1.1669	1.63 ^{ns}	0.156
Error	27	19.3009	0.7148		
Total	39	45.3347			

c. v % = 20.5; ^{ns} not significant

Table (3) Analysis of variance for mean diameter (cm)

Source of variation	d. f	s. s	m.s	v.r	F pr.
Replication	3	26.705	8.902	7.94	
Provenance	9	12.013	1.335	1.19 ^{ns}	0.341
Error	27	30.284	1.122		
Total	39	69.003			

c. v % = 24.6; ^{ns} not significant

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