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Forest Department

# A Study on Teak Provenance Trial

# (Assessment in 8th Year after Planting)


Yan Myo Naing, Staff Officer
Forest Research Institute

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# မူရင်းဒေသအမျိုးမျိုး စမ်းသပ်ကွက်မှ ကျွန်းပင်များ၏ ရှင်သန်ကြီးထွားမှုကို လေ့လာခြင်း

ရန်မျိုးနိုင်၊ ဦးစီးအရာရှိ
သစ်တောသုတေသနဌာန

## အကျဉ်းချုပ်

မြန်မာနိုင်ငံတွင် ၁၉၈၀ ခုနှစ်မှစ၍ ကျွန်းစိုက်ခင်းများကို ကျယ်ကျယ်ပြန့်ပြန့် စိုက်ပျိုးခဲ့ကြသည်။ ကျွန်းစိုက်ခင်းများတည်ထောင်ရာတွင် လက်လှမ်းမှီရာ ဒေသအမျိုးမျိုး မှ ကျွန်းစေ့များကို အသုံးပြုမည့်အစား ၊ စိုက်ပျိုးရာဒေသနှင့် သင့်တော်သော မူရင်းဒေသများကို ရွေးချယ် အသုံးပြုခြင်းဖြင့် ကျွန်းစိုက်ခင်းများကို ပိုမိုအောင်မြင်နိုင်ပါသည်။ ထို့ကြောင့် ငလိုက်ကြိုးဝိုင်းနှင့် ရဲနွယ်ကြိုးဝိုင်းတို့တွင် မူရင်းဒေသအမျိုးမျိုးမှ ကျွန်းစေ့များဖြင့် တည်ထောင်ထားသော (၈)နှစ်သား ကျွန်းစိုက်ခင်းများတွင် ဤသုတေသနကို ပြုလုပ်ရခြင်းဖြစ်ပါသည်။ ငလိုက်ကြိုးဝိုင်းရှိ စိုက်ခင်းတွင် နတ်တလင်းဒေသမှကျွန်းသည် ကြီးထွားမှုအကောင်းဆုံးဖြစ်ပြီး ရဲနွယ်ကြိုးဝိုင်းရှိ စိုက်ခင်းတွင် ကန့်ဘလူဒေသမှ ကျွန်းသည် ကြီးထွားမှုအကောင်းဆုံး ဖြစ်ပါသည်။ ဤသုတေသနသည် (၈)နှစ်သား ကျွန်းစိုက်ခင်းတွင် ပထမဆုံးအကြိမ် လေ့လာခြင်းဖြစ်ရာ ကျွန်းပင်များ၏ ကြီးထွားမှုသည် အပင်၏အသက်အရွယ်အရသော်လည်းကောင်း၊ နေရာဒေသ၏ရာသီဥတုပြောင်းလဲမှုပေါ်မူတည်၍ ပြောင်းလည်းနိုင်သောကြောင့် ပိုမိုတိကျသော အဖြေများရရှိစေရန် နောက်နှစ်များတွင် ဆက်လက်၍ သုတေသနပြုလုပ်သင့်ပါသည်။

# A Study on Teak Provenance Trial (Assessment in 8th Year after Planting)

**Yan Myo Nanig, Staff Officer**

**Forest Research Institute**

## Abstract

In Myanmar, teak has been a major source of foreign exchange earnings as well as domestic uses. The Teak plantation was initiated on commercial scale since 1980s. The proper matching of seed source or provenance and planting site is essential pre-requisite for a successful teak plantation to produce higher yield with quality timber. This study was conducted in Ngalaik trial site and Yenwe trial site which was established in 2007. 8 years after planting, GBH growth was assessed among provenances. In Ngalike trial site, Nattalin provenance is the best and followed by Taungoo provenance in term of GBH. In the Yenwe trial site, it was indicated that the provenance from Kanbalu is the best and followed by Nattalin provenance. The comparative performance of the provenances might change with age and place, follow up study was recommended in order to achieve consistent results in the future.

Keywords: growth performance, plantation, seed source, *Tectona grandis*

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**A Study on Teak Provenance Trial (Assessment in 8th Year after Planting)**

## 1. Introduction

*Tectona grandis* of the family Verbanaceae is one of the most economically important tropical timber tree species. The species is native to the tropical deciduous forests of India, Laos, Thailand, Indonesia and Myanmar (Troup, 1921). Teak, classified as one of the most valuable timber species in the tropics exhibits desirable technical and decorative properties. The timber is suitable for various purposes including house construction, shipbuilding, furniture making, poles, veneer, carvings etc. The broad product suitability of the timber, its high demands, price in the international market and short rotation have triggered extensive planting programme throughout the tropics (Fofana et.al 2013).

In Myanmar, due to the rapid deforestation, large-scale plantation forestry began in 1980s although small-scale forest plantations started as early as late 1850s (Tint, 2002). In addition to the normal teak plantation scheme, Forest Department (FD) of Myanmar has launched a Special Teak Plantation Program since 1998 to maintain and increase teak production. Moreover, nowadays, FD has encouraged private sectors to establish teak plantations in large scale since 2005.

Given a plenty of planting stock for a modest scale of teak plantation, seed source or seed supply was not a concern in the past. However, by the coincidence of yearly increasing teak plantation program under the decentralized teak plantation policy, allowing private companies to grow teak, with almost extinction of mother trees and seed source area, to ensure seed supply for teak plantations has become an intense problem in recent years. More importantly, proper matching of seed source or provenance and planting site is essential pre-requisite for a successful teak plantation to produce higher yield with quality timber (Win and Yan, 2012).

In 2007, the Forest Research Institute (FRI), Forest Department, established a teak provenance trial plantation from using 8 different provenances, at Compartment No.(9), Ngalaik Reserved Forest, Tatkone Township, Nay Pyi Taw. And another teak provenance trial plantation was established by using 9 different provenances in Yenwe Reserve Forest, Kyauktaga Township. Both of them are established with the support of International Tropical Timber Organization (ITTO) under the insitu and exsitu conservation of teak. In 2015, the trial plantation was 8 year old and has not been assessed to find the different growth performances among the different provenances. Therefore, it is time to evaluate this trial plantation to explore the very important information about

growth responses of teak from different provenances. This study focused on traits to indicate growth performance rather than stem quality.

## 2. Objectives

The objectives of this study are

- To compare the growth performance of teak from different provenances
- To determine the suitable provenance, which may be used as seed source for large-scale plantation.

## 3. Materials and Methods

### 3.1 Study Area

This study was carried out in a teak provenance trial 8 years after planting. The two trial sites which was established in 2007 were selected for this study. The first trial site (Ngalaik trial site hereafter) is located in compartment No.(9), Ngalaik Reserved Forest, Tatkone township. The second trial site (Yenwe trial site hereafter) is located in compartment No.(91), Yenwe Reserve Forest, Kyauktaga township.

In Ngalaik Trial site, 8 provenances of teak seeds were used. Seedlings of the same size were selected and planted at 9 ft x 9 ft spacing. Experimental plot was designed in Randomized Complete Block Design (RCBD) with five replications in the form of blocks. Therefore each block has 8 experimental units representing 8 provenances. In each experiment unit carry 25 (5x5) plants. The layout of the experiment design and name of provenances with respective code numbers are as follows.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17 | 18 | 14 | 16 | 15 | 11 | 13 | 12 |
| 22 | 21 | 23 | 28 | 27 | 24 | 25 | 26 |
| 36 | 35 | 37 | 34 | 33 | 32 | 38 | 31 |
| 48 | 43 | 41 | 42 | 46 | 47 | 44 | 45 |
| 54 | 57 | 56 | 55 | 51 | 58 | 52 | 53 |

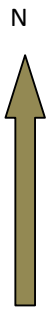


Figure 1. Layout and Design for Teak Provenence Trial Compartment 9, Ngalaik Reserve Forest, Tatkone Township, Nay Pyi Taw

**Note:**

1st Digit - Block No. (Replication)

2nd Digit - Provenence No.

No. of Provenances - 8

**(1) Nattalin**
**(2) Paukkhaung**
**(3) Kanbalu**
**(4) Oaktwin**
**(5) Taungoo**
**(6) Phyu**
**(7) Bago**
**(8) Thabeikkyin**

No. of Blocks (Replication) - 5

No. of trees per plot - 25 (5 rows and 5 columns)

Spacing - 9’ x 9’

Total no. of trees - 1000

Area - 2.82 ac (1.143 ha)

Experimental Design - RCBD (Randomized Completely Block Design

In Yenwe trial site, 9 provenances of teak seeds were used. Randomized Complete Block Design was used with five replications in the form of blocks. Each block has 9 experimental units representing 9 provenances. In each experiment unit carry 25 (5x5) plants with spacing 9 ft x 9 ft. The layout of the experiment design and name of provenances with respective code numbers are as shown in Figure 2.

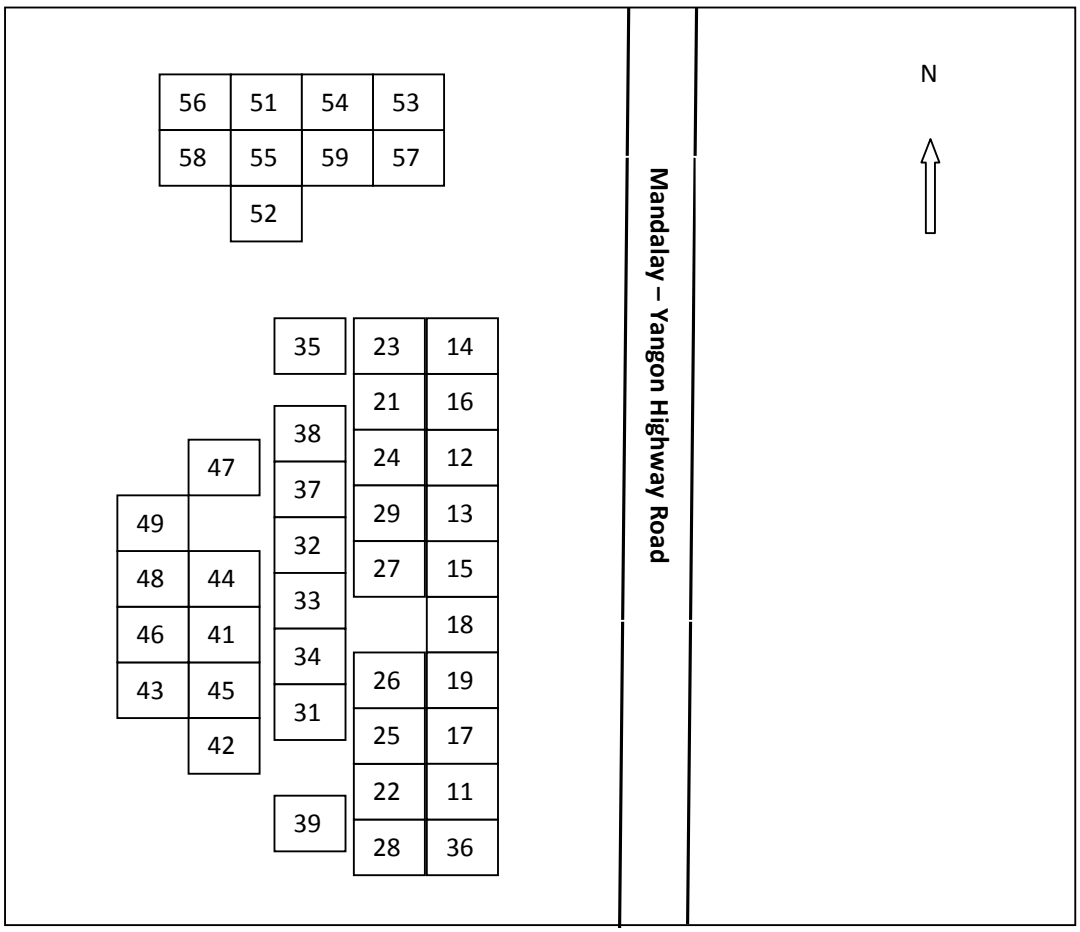


Figure 2. Layout and Design for Teak Provenance Trial, Compartment 91, Yenwe Reserve Forest, Kyauktaga Township

**Note:**

1st Digit - Block No. (Replication)

2nd Digit - Provenance No.

No. of Provenances - 9

| | | | |
|---|---|---|---|
| 1 | Nattalin | 6 | Phyu |
| 2 | Paukkhaung | 7 | Bago |
| 3 | Kanbalu | 8 | Thabeikkyin |
| 4 | Oaktwin | 9 | Kyauktaga |
| 5 | Taungoo | | |

No. of Blocks (Replication) - 5

No. of trees per plot - 25 (5 rows and 5 columns)

Spacing - 9 ft x 9 ft

Total no. of trees - 1125

Area - 3.17 ac (1.28 ha)

Experimental Design - RCBD (Randomized Completely Block Design

Cleaning undergrowth and erecting demarcation posts for each provenance according the layout design were carried out prior to make assessment for this study. For the first assessment made in January 2015, girth (GBH) measurements for each provenance were recorded and data were analyzed using SPSS 16 Statistical Software.

# 4. Results

## 4.1 Ngalaik Trial Site

### 4.1.1. Girth Measurement

For the test of hypothesis about mean GBH (Inches), the F test of the analysis of variance (ANOVA) is conducted and the result is given as in Table 1.

Table 1. Analysis of variance for GBH (Inches) measurements

| Source of Variation | Degree of Freedom | Sum of Squares | Mean Square | Computed F value | Sig. Probability |
|---|---|---|---|---|---|
| Block | 4 | 3.983 | .996 | .691 | |
| Provenance | 7 | 35.274 | 5.039 | 3.497** | .008 |
| Experimental error | 28 | 40.348 | 1.441 | | |
| Total | 39 | 79.605 | | | |

** = highly significant (significant at 1% Probability level)

According to the ANOVA of the F test, the experiment showed that the significant difference among mean GBH (Inches) of provenances was highly significant at 1% probability. Therefore, in order to find mean GBH of which provenance is different from other, LSD Test was applied. The results were given in Table 2. Moreover, for the evaluation of all possible pairs of means, Duncan' multiple range of test (DMRT) was also applied. The result of the test was given in Table 3.

According to LSD Test shown in Table 2, Nattlin Provenance is significantly different from Oaktwin and Thabeikkyin Provenances in terms of mean GBH. Means GBHs of Paukkhaung, Kanbalu, Taungoo, Phyu and Bago Provenances are also significantly different from Thabeikkyin Provenance. Oaktwin, Taungoo and Phyu Provenances differ from each other significantly in mean GBHs.

For the Duncan Multiple Range Test (DMRT), mean GBHs are ranked in order of magnitude of the value. Provenances those are designated by the same letter do not differ significantly each other at 5% level significance. There are three large groups which overlap largely. In the first group, Thabeikkyin stands the poorest followed by Oaktwin. In the second group, Bago is the poorest followed by Kanbalu, Paukkhaung and Phyu. In the last group, Nattalin is the best followed by Taungoo and significantly different from the poorest provenance, Thabeikkyin.

Table 2.The result of LSD Test in term of mean GBH

| Provenance | Nattalin | Paukkhaung | Kanbalu | Oaktwin | Taungoo | Phyu | Bago | Thabeikkyin |
|---|---|---|---|---|---|---|---|---|
| Nattalin | - | ns | ns | * | ns | ns | ns | * |
| Paukkhaung | | - | ns | ns | ns | ns | ns | * |
| Kanbalu | | | - | ns | ns | ns | ns | * |
| Oaktwin | | | | - | * | * | ns | ns |
| Taungoo | | | | | - | ns | ns | * |
| Phyu | | | | | | - | ns | * |
| Bago | | | | | | | - | * |
| Thabeikkyin | | | | | | | | - |

ns = non significance, * = significant at 5% Probability level

Table 3. Comparison of all pairs of mean GBH in DMRT

| Provenances | GBH (In) | DMRT |
|---|---|---|
| Thabeikkyin | 16.60 | a |
| Oaktwin | 17.50 | ab |
| Bago | 18.41 | bc |
| Kanbalu | 18.50 | bc |
| Paukkhaung | 18.70 | bc |
| Phyu | 19.09 | bc |
| Taungoo | 19.39 | c |
| Nattalin | 19.63 | c |

### 4.1.2. Provenance Means above and below Average

In order to have holistic view of mean comparison, mean values are subtracted from overall mean to see how much differ and whether (+) or (-) from the respective overall means at 8 years. The result for GBH measurements appear in Figure 2. In the figure, zero grid line refers to the average of all means or overall mean and provenance means are assessed whether they are above or below the average.

In comparison of mean GBHs as in Figure 2, Nattalin provenance is obviously well above the overall mean. It is followed by Taungoo, Phyu and Paukkhaunng provenances. Thabeikkyin is the poorest and followed by Oaktwin. Kanbalu and Bago are around the overall mean level.

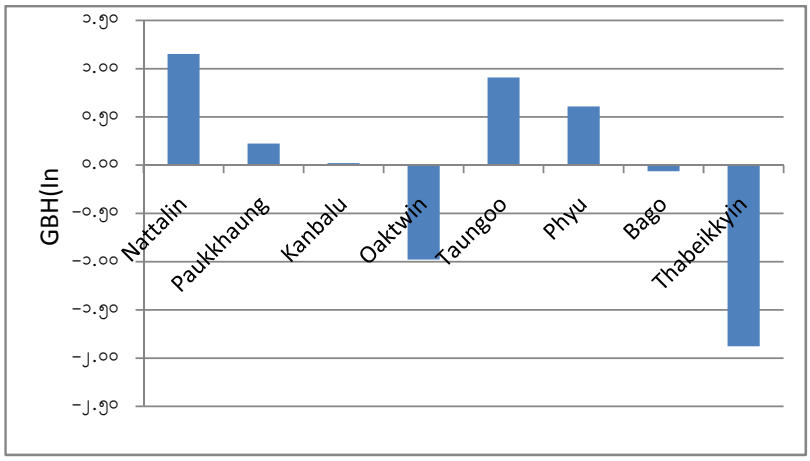


Figure 3.GBHs above and below overall mean at 8th year

## 4.2 Yenwe Trial Site

### 4.2.1. Girth Measurement

According to the ANOVA of the F test, significant ($p<.001$) differences were found among provenances (Table 4). LSD test was applied in order to identify the different among the provenances. The result of LSD test for the mean growth performance of DBH, Nattlin Provenance is significantly different from Phyu and Kyauktaga Provenances. Likewise, mean GBHs of Kanbalu Provenance is significantly different from Phyu and Kyauktaga. Other provenances likes Paukkhaung, Oaktwin, Taungoo, Phyu, Bago, Thabeikkyin and Kyauktaga are not differ each other in mean GBHs (Table 5).

Duncan' multiple range of test (DMRT) was applied to rank the mean growth performance of DBH. Different letters indicate the significant differences in mean DBH among the provenances according to Duncan's multiple range tests at 5% level of probability. The result of DMRT for the mean growth performance of DBH, over all site are presented in Table 6. Kanbalu and Nattalin are the best followed by Oaktwin, Paukkhaung, Thabeikkyin, Taungoo and Bago. The Phyu stands is the poorest followed by Kyauktaga.

Table 4.Analysis of variance for GBH (Inches) measurements

| Source of Variation | Degree of Freedom | Sum of Squares | Mean Square | Computed F value | Sig. Probability |
|---|---|---|---|---|---|
| Block | 4 | 237.49 | 59.37 | 7.44 | 0.000 |
| Provenance | 8 | 105.09 | 13.136 | 1.64** | 0.150 |
| Experimental error | 32 | 255.05 | 7.97 | | |
| Total | 45 | 597.64 | | | |

** = highly significant (significant at 1% Probability level)

Table 5. The result of LSD Test in term of mean GBH

| **Provenance** | **Nattalin** | **Pauk-khaung** | **Kanbalu** | **Oaktwin** | **Taungoo** | **Phyu** | **Bago** | **Thabeik-kyin** | **Kyauktaga** |
|---|---|---|---|---|---|---|---|---|---|
| **Nattalin** | - | ns | ns | ns | ns | *. | ns | ns | * |
| **Paukkhaung** | | - | ns | ns | ns | ns | ns | ns | ns |
| **Kanbalu** | | | - | ns | ns | *. | ns | ns | * |
| **Oaktwin** | | | | - | ns | ns | ns | ns | ns |
| **Taungoo** | | | | | - | ns | ns | ns | ns |
| **Phyu** | | | | | | - | ns | ns | ns |
| **Bago** | | | | | | | - | ns | ns |
| **Thabeikkyin** | | | | | | | | - | ns |
| **Kyauktaga** | | | | | | | | | - |

ns = non significance, * = significant at 5% Probability level

Table 6. Comparison of all pairs of mean GBH in DMRT

| Provenances | GBH (In) | DMRT |
|---|---|---|
| Phyu | 5.14 | a |
| Kyauktaga | 5.19 | a |
| Bago | 8.00 | ab |
| Taungoo | 8.48 | ab |
| Thabeikkyin | 8.68 | ab |
| Paukkhaung | 8.71 | ab |
| Oaktwin | 8.74 | ab |
| Nattalin | 9.23 | b |
| Kanbalu | 9.34 | b |

### 4.2.2. Provenance Means above and below Average

To examine how much differ from the respective overall mean after 8 years, the mean values are subtracted from overall mean. In the figure, zero grid line refers to the average of all means or overall mean and provenance means are assessed whether they are above or below the average. Kanbalu provenance is obviously well above the overall mean. It is followed by Nattalin, Oaktwin, Paukkhaung and Thabekkyin and Taungoo provenances. Phyu is the poorest and followed by Kyauktaga. And Bago is around the overall mean level.

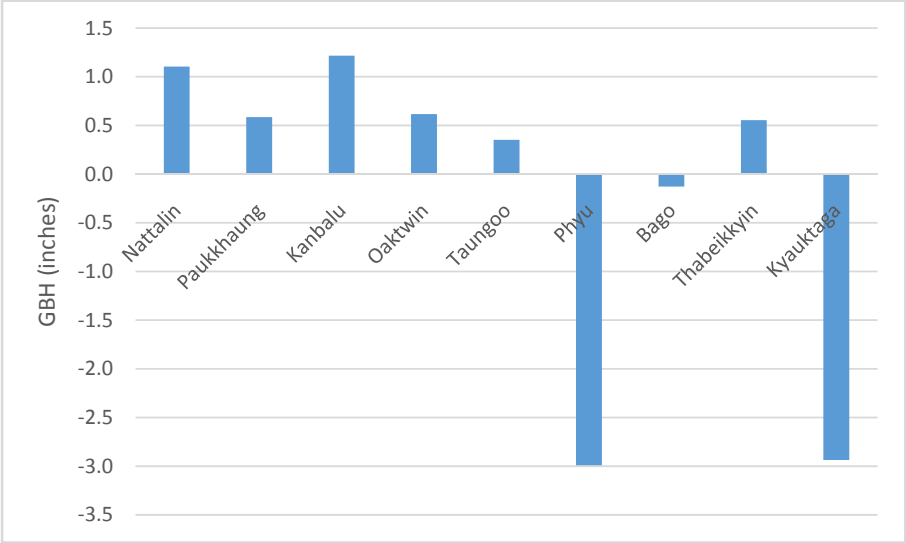


Figure 4. GBHs above and below overall mean at 8th year

## 5. **Discussion**

This study was conducted at a point of time, 8 years old of the provenance trial. The results from this study are different from that of the previous studies conducted in 8 years old of provenance trial by Gyi (1995). In that study, although it is statistically failed to detect significance in mean differences, the local provenance is the best in growth performances. This study showed the significant results in terms of mean GBH of the provenances. In 2009, Win and Yan conducted the assessment of provenances which is the same trial studied by Gyi (1995). At that time, trial plantation is 23 year old and they statistically failed to detect significance in mean differences, but Pyinmana and Taungdwingyi provenances have consistently comparative performances as the best and the poorest, respectively, as in 8 year old. They pointed out that stability of their respective growth performances on height and girth both over such a long period of 15 years (from 8 to 23 years old) supports to draw a conclusion that Pyinmana, the local provenance, is the best and Taundwingyi, the representative to drier sites, is the poorest. Similarly, Paunde also has shown stable growth performance next to Pyinmana. Local provenance is not included in the Ngalaik trial site. Though local provenance was included Yenwe trial site, the growth performance was poorer than other provenances. The result of this study was contract with Gyi (1995) and Win and Yan (2009)s' study who found that local provenance showed the best performance. Besides, Persson (1971) also found that the local provenance was superior to the other provenance in term of volume production. But, the result of this study, in Yenwe trial site, was in line with what Keiging et al., (1986)'s stated. He mentioned that the local provenances were not always superior to the imported provenances and, even, they were inferior to the imported provenances.

In Ngalaik trial site, Nattalin provenance is the best in term of GBH and followed by Taungoo provenance. But Thabeikkyin provenance is the poorest in terms of GBH for the area. In this context, it is concluded that Nattalin and Taungoo provenances should be selected for Moeswe area to establish the large-scale plantations. But Thabeikkyin should not be chosen due to the poorest response to Moeswe area. Phyu and Paukhaung provenances are also recommended for selection. Oaktwin, Bago and Kanbalu provenances should be avoided because of their poor growth responses to the Ngalaik trial site. Therefore, matching of climatic condition between the provenance, seed source, and planting site is important consideration for teak planting program. In the Yenwe trial site, it was indicated that the provenance from Kanbalu and Nattalin are better than other provenances suggesting that Kanbalu and Nattalin provenances are suitable to establish plantation for the kyauktaga area.

In the International Series of Teak Provenance Trials, with regards situations between two assessments: 7-9 years old and 17 years old, while significant mean differences of survival, health, and persistence of axis dominance disappeared, mean differences of stem form and tree size appeared significantly different (Kjaer, et al. 1995). In a situation where later assessments are significant while effect of early assessment may or may not be significant, it must be concluded that the increment/decrease has been significantly different for different provenances. The differences reflect a new genetic pattern, because the changes cannot be explained simply by differences already seen at the younger age (Kjaer, E.D. et al. 1995). The different among the provenances were highly significant in the first year, but were not very clearly defined in the 3$^{rd}$, 5$^{th}$ and 8$^{th}$ years after establishment (Hedegard, 1971). The comparative performance of the provenances might change with age and place (Mathauda, 1951 cited in Gyi 1995). Provenance trials require closed and continuous investigation on when mean differences set in and how long it will be stable. Studies on stem and timber quality are also needed for teak provenances. Much more provenance trials using potential seed sources in major plantation sites should be carried out for further understanding of teak variation. Since provenances variations effect on wood quality, growth rate, stem form, seed morphology and seed germination (Nair and Mukerji, 1960; Hedegart, 1974; Keiding et al., 1986; Koasaard, 1993; Gyi, 1995), the study on these factor are recommended for further study.

## 6. Conclusion

This study concludes as follow.

(1) According to the results from Ngalaik trial site, Nattalin and Taungoo provenances should be chosen for large scale plantation establishment in Moeswe Area. Phyu and Paukhaung provenances should be considered for second and third priority.

(2) The provenance from Kanbalu and Nattalin are better than other provenances in Yenwe trial site.

(3) This study was conducted in teak provenance trail 8 years after planting. Further study to continue this experiment was recommended in order to achieve consistent results in the future.

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