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Assessment of Teak (*Tectona grandis* Linn.f) Provenance Test in the Bago Yoma Region, Myanmar

By

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ပဲခူးရိုးမတွင်တည်ထောင်ထားသောဒေသစုံ ကျွန်းစမ်းသပ်ကွက် အပေါ်လေ့လာခြင်း

အုန်းလွင်၊ ဒုတိယညွှန်ကြားရေးမှူး
သစ်တောသုတေသနဌာန၊ ရေဆင်း

စာတမ်းအကျဉ်း

ဤစာတမ်းတွင် မြန်မာနိုင်ငံအတွင်း ကျွန်းပေါက်ရောက်သော သစ်စေ့မူရင်းဒေသ(၁၀)ခုမှ ကျွန်းမျိုးများ၏ ယေဘူယျကွဲပြားသော မျိုးရိုးလက္ခဏာများကို လေ့လာပြီး ပဲခူးရိုးမဒေသ ကျွန်းစိုက်ခင်းများ ထူထောင်ရာတွင် အသင့်လျော်ဆုံး သစ်စေ့ဒေသကို ဆုံးဖြတ်ပေးနိုင်ရန် လေ့လာ ဖေါ်ပြထားပါသည်။ မြန်မာနိုင်ငံအတွင်း သဘာဝကျွန်းတောများပေါက်ရောက်သော နေရာဒေသ များကို ခြုံငုံမိစေရန် မူရင်းဒေသ(၁၀)ခုမှ ကျွန်းစေ့များ စုဆောင်းပြီး ပဲခူးရိုးမဒေသ၌ ၁၉၉၈–ခုနှစ်တွင် စမ်းသပ်စိုက်ခင်း(၄)ခု တည်ထောင်ခဲ့ပါသည်။ ၇–နှစ်သားအရွယ်တွင် ၎င်းတို့၏ ကြီးထွားမှု၊ ပြင်ပလက္ခဏာများနှင့် ပထဝီရာသီဥတုအပေါ် တည်မှီနေမှုများကို လေ့လာ စူးစမ်း ခဲ့ပါသည်။ စါရင်းအင်းပညာအရ ခြားနားချက်များက ၎င်းတို့၏ အမူအကျင့် လက္ခဏာများသည် ဒေသမျိုးနှင့် စိုက်ပျိုးနေရာများအကြား ၅%တွင် အပြန်အလှန် ဆက်သွယ်မှု ရှိကြောင်း ဖေါ်ထုတ် ပြသခဲ့ပါသည်။ ယေဘူယျအားဖြင့် အမူအကျင့်ပြင်ပလက္ခဏာများ အကြား အပေါင်းလက္ခဏာ ဆောင်သော အပြန်အလှန်ဆက်သွယ်မှုရှိကြောင်း တွေ့ရှိခဲ့ရပါသည်။ အဆိုပါ အမူအကျင့် လက္ခဏာများနှင့် ပထဝီရာသီဥတုများ၏ ဆက်သွယ်မှုအပေါ်လေ့လာချက်အရ ကျွန်းတွင် ဂေဟအနေအထားအပေါ် ကွဲပြားခြားနားမှုရှိကြောင်း ညွှန်ပြခဲ့ပါသည်။ ကျွန်းတွင်ပြင်ပလက္ခဏာ အမူအကျင့်များသည် လတ္တီကျူဒ်နှင့် အနုတ်လက္ခဏာဆောင်သော အပြန်အလှန်တုံ့ပြန် ဆက်သွယ်မှုရှိခဲ့ပြီး လောင်ဂျီကျူဒ်နှင့် (က) ရွက်အုပ်အမြင့်၊ ပင်စည်လုံးအမြင့် တို့၏အချိုး၊ (ခ)ရွက်အုပ်အချင်း၊ (ဂ) ဘေးကိုင်းများ၏ ချဉ်းကပ်ထောင့်၊ (ဃ)အရွက်များ ပိုမိုတည်မြဲမှု တို့အကြား အပေါင်းလက္ခဏာဆောင်သော ဆက်သွယ်မှုရှိကြောင်း ထုတ်ဖေါ်ပြသခဲ့ပါသည်။ ယခု လေ့လာသော စာတမ်းတွင် ကျွန်းပင်များ၏ ပြင်ပလက္ခဏာ အမူအကျင့်များသည် ပျမ်းမျှ အပူချိန်နှင့် အရေးပါသော ဆက်သွယ်မှု မရှိကြောင်းတွေ့ရှိရပါသည်။ ကြီးထွားမှု နှင့် ရွက်အုပ် အချင်းသည် ပျမ်းမျှမိုးရေချိန်နှင့် အပေါင်း လက္ခဏာဆောင်သော တုံ့ပြန်ဆက်သွယ်မှု ရှိခဲ့ပါသည်။ စိုက်ပျိုးသော နေရာနှင့် သစ်စေ့မျိုးရင်းဒေသ တို့၏ ပထဝီမြေမျက်နှာပြင်အရ အကွာအဝေးနှင့်ကြီးထွားမှုအကြား အနုတ်လက္ခဏာဆောင်သော ဆက်သွယ်မှုရှိခဲ့ကြောင်း တွေ့ရှိရပါသည်။ ရလာဒ်များက ဖေါ်ပြသည်မှာ ကျွန်းတွင် လတ္တီကျူဒ် လွှမ်းမိုးသော ပြင်ပပုံသဏ္ဍာန် ကြီးထွားမှု အပေါ် ပျမ်းမျှမိုးရေချိန်တို့က ကန့်သတ်ထားကြောင်း မှတ်ယူနိုင်ခဲ့ပါသည်။ ယှဉ်ပြိုင် နှိုင်းယှဉ် စူးစမ်းလေ့လာချက်အရ ဒေသရင်း ကျွန်းမျိုးများသည် ယေဘူယျအားဖြင့် ပဲခူးရိုးမဒေသ စိုက်ခင်းများအတွက် အကောင်းဆုံးသစ်စေ့ ဒေသများဖြစ်ကြောင်း အကြံပြုတင်ပြခဲ့ပါသည်။

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Abstract

This report describes the general pattern of genetic variation among ten teak (*Tectona grandis* Linn. f.) provenances in Myanmar and contributes to determine the most suitable seed sources for the plantation program in Bago Yoma region. Seeds of ten provenances were collected to cover the whole teak natural distribution in Myanmar and planted at four trial sites in Bago Yoma region in 1998. 7 years after planting, variation was assessed for growth, morphological characters and their correlation with geoclimatic factors. The ANOVA revealed significant differences in most of the traits measured among provenances, trial sites and a significant provenance x site interaction at the five percent level. A positive significant ($p<0.01$) correlation was found among most of the traits. And the regression analyses between all traits and geoclimatic factors indicated the existence of ecoclinal variation in teak. Most of the traits were negatively correlated with the latitude and a positive significant correlation was found between longitude and C/B ratio, crown-diameter, average branch angle and leaf-remain. There was no significant correlation found between mean temperature and any other traits in this study. Growth traits and crown diameter were positively correlated with the mean annual rainfall. A negative correlation was found between the geographical distance and growth traits. Results suggested that the latitudinal pattern of teak genetic variations in growth performance was attributed with the limit of mean annual rainfall and the comparative assessment indicated that local provenances were generally best and could be suggested as suitable seed sources for the plantation program in the Bago Yoma region.

***Keywords**: ecoclinal variation, geoclimatic factor, growth traits, local provenances, morphological traits, pattern of genetic variation, provenance test, seed source, Tectona grandis*

Contents

1. Introduction

In Myanmar, teak from the natural forest has been a major source of foreign exchange earning as well as domestic uses for many years. However, due to long time harvesting and unavoidable human interventions, forest degradation is being experienced with decreasing production in teak. Forestry sector is, therefore, faced with the challenging mission to restore its degraded forests and enhance the existing natural stock of teak not only by natural means but also artificial innovations (Dah, 2004). In order to sustain production of the timber, the formation of teak plantation was consequently initiated on commercial scale since 1980s.

In fact to produce the tree with good growth and stem form, among other factors, seed requirement for quality and quantity is a primarily necessity in a plantation program. Seed supply from existing seed orchards and seed production areas is too few to meet the annual requirement. Seeds from natural forests and old plantations were therefore practically used in plantation program without clear instruction for seed movement to the planting site.

For that reason, further study on the selection of provenances with outstanding performance to a given site is urgently needed for the successful implementation of plantation programs in Myanmar. In order to solve the regarding problems, the main objectives of this study were set up to describe the teak growth performance and to select the suitable provenances of seed sources for plantations in Bago Yoma region.

2. Materials and Methods

2.1. Study area

This study was carried out in a teak provenance trial 7 years after planting. For the provenance test, 10 provenances were selected from the entire natural teak distribution within the country and planted at four trial sites in the Bago Yoma region where favorable soil and climate condition exist together with good accessibility. The two trial sites under the *Oak-twin* and *Phyu* townships are located on the eastern side of Bago Yoma region and the other two in the *Paungte* and *Pauk-kaung* townships are on the western side. Geoclimatic data (latitude, longitude, temperature, rainfall and average distance from seed source to planting sites) of the provenances and trial sites are shown in Table 1 and Figure 1.

Table1. Geoclimatic data of provenances and trial sites

Code		Latitude (°N)	Longitude (°E)	Mean temp (°C)	Annual Rainfall(mm)	Distance to trial site (km)
Provenance						
P1	*Pyinmana*	19° 43'	96° 13'	27.5	1631	119.2
P2	*Kalay*	23° 12'	94° 04'	25.6	2032	594.52
P3	*Bago*	17° 20'	96° 30'	26.8	3448	109.9
P4	*Phyu*	18° 30'	96° 27	26.0	3071	49.64
P5	*Mudon*	16° 14'	97° 43'	27.0	4697	351.4
P6	*Padaung*	18° 44'	95° 08'	27.6	1028	115.44
P7	*Moemeik*	22° 36'	96° 40'	23.9	1298	431
P8	*Saw*	21° 15'	94° 17'	25.6	1270	325.6
P9	*Moehnyin*	27° 47'	96° 22'	24.8	2187	667.04
P10	*Mabein*	23° 20'	96° 40'	27.2	1524	530.56
Trial Site						
S-1	*Phyu*	18° 28'	96°27'	26.0	3071	
S-2	*Oak-twin*	18° 49'	96°15'	26.9	1929	
S-3	*Paungte*	18° 36'	95°37'	27.6	1184	
S-4	*Pauk-kaung*	18° 52'	95° 44'	28.2	1261	

Source: Htwe, 2000.

2.2. Measurement

All trees were measured for diameter at breast height (DBH) and total height to calculate the volume as growth performance. In addition, each tree was examined for a number of morphological characteristics such as C/B (Crown height and Bole height) ratio, number of branches per meter, crown diameter and average branch angle of lower-branches for stem quality, apart from percent of leaf-remain on the tree during leaf- shedding season.

2.3. Experimental Design

The provenance test was laid out in a Randomized Complete Block Design with four replicates in S1, S3 and S4 trial sites and three replicates in S2 trial site. Each plot originally consists of 49 trees (7 rows x 7 columns) with 2.7 m x 2.7 m spacing. In order to minimize the edge effect, the inner 7 trees in each plot of the provenance were randomly chosen for measurement.

2.4. Data Analysis

Data analysis compared traits with the main interest on growth performance (DBH, height, and volume) and geoclimatic variation of provenances.

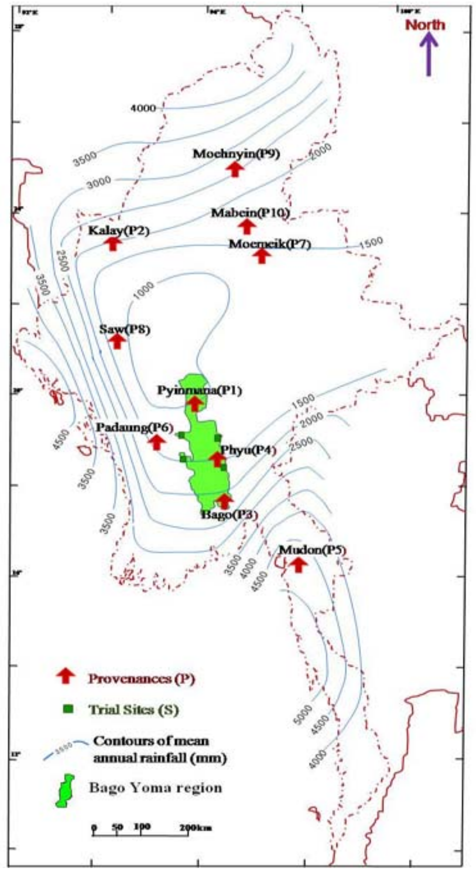

Figure 1. Location map of provenances and trial sites (Min and Lwin, 2004)

2.4.1. Analysis of Variance (ANOVA)

Two-way ANOVA was applied to investigate variation of provenances over all sites, within site and their interaction. The statistical models for each site and over all sites are given as follows.

Model for each trial site: $\boldsymbol{X_{jk} = \mu + R_j + P_k + RP_{jk} + \varepsilon_{jk}}$

Where: X_{jk} = the value of the trait (e.g. height) of the j^{th} replication in k^{th} provenance, $\boldsymbol{\mu}$ = the over all mean, $\boldsymbol{R_j}$ = the effect of j^{th} replication, $\boldsymbol{P_k}$ = the effect of k^{th} provenance, $\boldsymbol{RP_{jk}}$ = the interaction effect of j^{th} replication of the k^{th} provenance and $\boldsymbol{\varepsilon_{jk}}$ = the within plot error

Model for over all sites: $\boldsymbol{X_{ijk} = \mu + S_i + R_{j(i)} + P_k + SP_{ik} + RP_{j(i)k} + \varepsilon_{ijk}}$

Where: X_{ijk} = the value of the trait in plot of j^{th} replication of k^{th} provenance at the i^{th} site,

$\boldsymbol{\mu}$ = the over all mean, $\boldsymbol{S_i}$ = the effect of i^{th} site, $\boldsymbol{R_{j(i)}}$ = the effect of j^{th} replication at the i^{th} site, $\boldsymbol{P_k}$ = the effect of k^{th} provenance, $\boldsymbol{SP_{ik}}$ = the interaction effect between i^{th} site and k^{th} provenance,

$\boldsymbol{RP_{j(i)k}}$ = the interaction effect of j^{th}replication at the i^{th}site with k^{th} provenance and $\boldsymbol{\varepsilon_{ijk}}$ = the within plot error.

Duncan's multiple-range test (DMRT) was applied to rank the performance of provenances and trial sites. Simple regression analysis was also used to detect the relationship between traits and geoclimatic factors. All statistical analyses were performed using Genstat 9.0, SPSS 12.0 for Windows, SAS for windows (SAS Institute Inc., USA), and Microsoft Excel 2003.

3. Results

3.1. Provenance variation for growth and morphological traits over all Sites

For all traits, significant (p<.001) differences were found among provenances, trial sites and a significant provenance x site interaction (Table 2).

Table 2. ANOVA for all traits over all sites showing their mean square values and significant difference level (n=1050)

Source of variation	d.f.	DBH	Height	Volume	C/B ratio	no. of Branch /m	Crown Diameter	Angle	Leaf-remain
Prov	9	92.424***	103.531***	0.0276***	0.253***	1.041***	0.504***	921.922***	0.137***
Site	3	140.780***	233.801***	0.0438***	0.512***	5.586***	1.088***	3819.197***	4.349***
Prov-Site	27	43.280***	64.516***	0.0140***	0.123***	0.470***	0.252***	523.357***	0.153***
Within plot error	900	4.5597	4.4166	0.0012	0.03280	0.103	0.0369	139.7184	0.0153

(***) indicates significant differences at p<0.001

The results of DMRT for the mean growth performance of DBH, height and volume over all sites are presented in Table 3 (a-c).

In diameter, the P4 was the best followed by P3 and P5. And the P4 and P3 were the best in both height and volume growth followed by P5 and P1 while P2, P6, P8 and P10 were poorest among the provenances. The best provenances such as P4, P3, and P1 were local sources of Bago Yoma region except P5 from the southern most region and P9 from the northern marginal region. The better performance of the marginal provenances could be attributed to the similar annual rainfall in the area which favored the growth.

There are many contradictories on the "local is best" in provenance test (Wright, 1976) but they generally give an acceptable result (Kjaer and Foster, 1996). This is in contrast to the finding of Kjaer *et al.,* (1995) who reported that teak plantations in *Ghana*, Africa based on seed imported from *Kerala* in western India can grow 30 percent faster than the teak plantations from the local landrace seed source.

The result of this study is in agreement with the result of the oldest teak provenance trials in India consisting four provenances tested at *Topslip, Tamil Nadu* which indicated the local provenance to be the best (Kumaravelu, 1993 cited by Subramanian *et al* 1994). Gyi (1995) reported on the first teak provenance trial at *Pyinmana*, Myanmar that the local provenance (*Pyinmana*) was observed to be the best for both DBH and height measured at the age of 5 and 8 years. According to Coster and Hardjowasono (1935) cited by Suhaendi (1998), the result from the 25-years old teak provenance test in Indonesia with provenances from five countries (India, Burma (Myanmar), Thailand, Laos and Indonesia) showed that local sources from Java variety showed equal growth to the best of exotic provenances. Moreover for other species, Subramanian *et al.,* (1992) studied on *Eucalyptus grandis* provenance trial (17 exotic provenances from Australia and local seed sources) to identify suitable provenances for a general plantation program in India and reported that the four local provenances were found to be the best. This is in addition to the compatibility with the result of Kyaw (2003) who suggested that Taungoo (local area of Bago Yoma region) stand shows a diameter-height growth superior to the other stands of all species as well as teak whilst Kanbulu (northern) shows poor performance.

With regard to the performance of diameter and volume, *Pauk-kaung* trial site was found as the best among others and *Phyu* site was observed as the best for height performance. The *Paungte* site was found to be poorest in all growth traits among others. This could be explained by the fact that heterogeneity of geoclimatic condition exists among trial sites in the Bago Yoma region.

Table 3. Result of DMRT for growth traits (DBH, height, volume) over all sites

(a) DBH

Prov	Mean DBH	Duncan's grouping*
P4	10.17	a
P3	9.65	ab
P5	9.42	ab
P1	9.15	bc
P9	8.69	cd
P7	8.26	de
P8	8.07	de
P6	7.73	ef
P2	7.71	ef
P10	7.41	f

(b) Height

Prov	Mean Height	Duncan's grouping*
P4	9.92	a
P3	9.70	a
P5	8.64	b
P1	8.60	b
P9	7.98	c
P6	7.68	cd
P7	7.61	cd
P2	7.49	cd
P10	7.25	d
P8	7.08	d

(c) Volume

Prov	Mean Volume	Duncan's grouping*
P4	0.046	a
P3	0.041	a
P5	0.033	b
P1	0.031	bc
P9	0.027	cd
P7	0.026	cde
P8	0.022	def
P2	0.021	def
P6	0.021	ef
P10	0.018	f

*$p<0.05$ significantly different

Table 4. Result of DMRT for growth performances of provenances among four trial sites

(a) DBH

Site	DBH	Duncan's grouping*
S-4	9.43	a
S-2	9.01	b
S-1	8.35	c
S-3	7.81	d

(b) Height

Site	Height	Duncan's grouping*
S-1	8.83	a
S-4	8.71	ab
S-2	8.44	b
S-3	6.86	c

(c) Volume

Site	Volume	Duncan's grouping*
S-4	0.034	a
S-2	0.032	a
S-1	0.032	a
S-3	0.019	b

*p<0.05 significantly different

3.2. Relationship between Traits and Geoclimatic Factors

The purpose of estimating the regression models was to determine to what extent the traits of provenances being expressed are related to geoclimatic variations (Table 5). In this study all provenances chosen were located within 11.5˚ differences in latitude and about 3.5˚ in longitude.

Table 5. Simple correlation (r) between all traits and geoclimatic factors (n = 10)

	DBH	Height	Volume	CB ratio	Branch/m	Crown	Angle	Leaf remain
Latitude	(-).567	(-).651(*)	(-).637(*)	(-)0.309	0.439	(-)0.493	(-).449	(-)0.294
Longitude	0.528	0.465	0.547	0.716(*)	0.071	0.724(*)	.696(*)	0.723(*)
Temp	0.103	0.235	0.145	0.338	(-)0.356	0.160	.353	(-)0.063
Rainfall	0.726(*)	0.701(*)	0.803(**)	0.589	0.090	0.671(*)	.600	0.590
Distance	(-).680(*)	(-).778(**)	(-)0.681(*)	(-)0.398	0.364	(-)0.624	(-).534	(-)0.434

The pair(s) of variables with positive correlation coefficients and
(-) indicates inversely correlation between two components,
(*), (**): Correlation significance at the 0.05 level and 0.01 level (2-tailed) respectively

3.2.1. Latitude

A negative relationship between most of the traits and latitude, except for branch per meter of the main stem, was found in this study. Height and volume growth were negatively correlated (p<.05) and the DBH was moderately correlated (p<0.1) with latitude (Table 5).

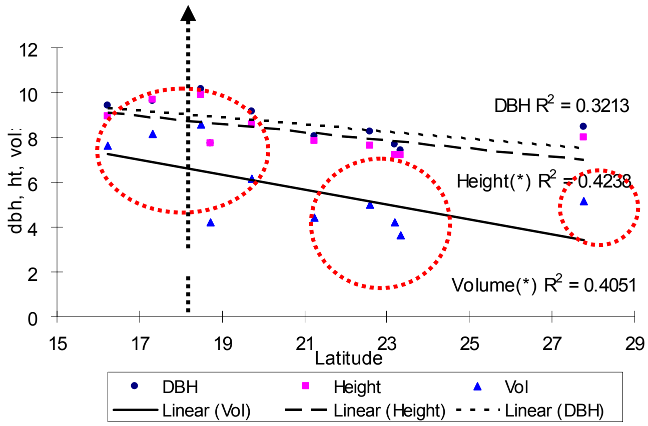

Figure 2. Relationship between latitude and DBH (cm), height (m), and volume (5000 cm^3)

Figure 2 indicates that none of the provenances from the northern region were in the top-four in the ranking of growth performance as also shown in Table 3 (a-c). The latitudinal variation of all provenances revealed that provenances from the southern region generally had better growth than those from the north (Figure 2).The result exhibited that growth performances of the provenances were decreasing with the increase of latitude until 27˚ N, but there was a little increase in growth of P9 from the northernmost marginal area of teak distribution where the average annual rainfall was similar to the trial sites.

This result is generally supported by Bhat and Priya (2004) who studied the varied relationship between growth-structure-property (quantitative and qualitative) of three 65 year-old major teak provenances tested in Western *Ghat,* India. They found that a geographical trend of increasing mechanical strength was associated with a greater cell wall percentage at the southern geographic location within a range of 9˚ to 15˚S. Similar observations were reported on other species. Roberd, *et al* (1990) studied on fifth year heights of white ash provenances and pointed out the presence of northern and southern ecotypes. Hyun (1981) reported that there was a moderate north-south trend of genetic variation in growth rate of black spruce (*Picea mariana* (Mill) B.S.P.) seedlings and superior growth rate of southern sources appears to be advantageous.

3.2.2. Longitude

Positively significant (p<.05) correlations were found between the traits such as C/B ratio, crown-diameter, average branch angle and leaf-remain, and longitude in addition to nearly significant (p<0.1) correlation with volume trait even though the provenances were within the narrow range of longitude (94° 04' to 97° 43' E) (Table 5). When provenances were selected from the eastern part of trial sites, the C/B ratio, crown diameter, and average branch angle showed greater amount of value, in addition to better growth performance (Figure 3).

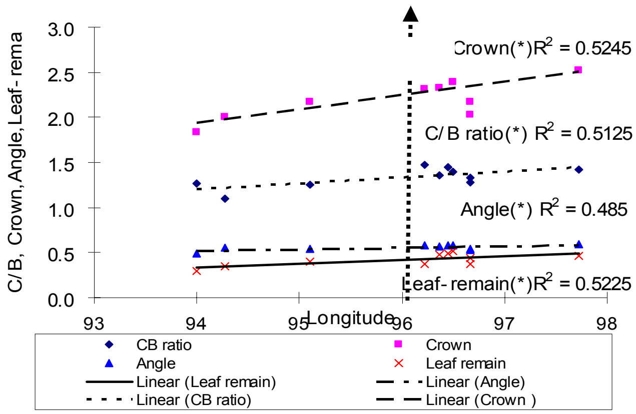

Figure 3. Relationship between longitude and traits (C/B ratio, crown diameter, branch-angle, and leaf-remain)

The present result is in agreement with the result of the study in teak provenance trials consisting of 30 provenances established in 1966 at *Huey Tak* in Thailand where there was a pattern of east-west clinal and also, to some extent, north-south differences in genetic variation of teak (Graudal, e*t al*., 1999). Another observation in six Thai and Laos teak provenances tested under the international teak provenance trial at *Pha Nok Khao* in Thailand supports a trend towards difference between eastern and western provenances based on the multivariate analysis (Graudal, e*t al*., 1999).

3.2.3. Temperature

There was no significant correlation found between temperature and any other traits (Table 5). It could be due to favourable temperature for growing teak and narrow variation in the mean annual temperature among the provenances selected (23.9˚ to 27.6˚C), and also among trial sites (26.0˚ to 28.2˚C) considering the minimum and maximum temperature limits for teak (from 9˚ to 41˚ C (FAO, 1991)).

3.2.4. Rainfall

A positively significant (p<.01) correlation was found between mean annual rainfall and volume and a significant (p<.05) with DBH, height and crown diameter (Table 5).

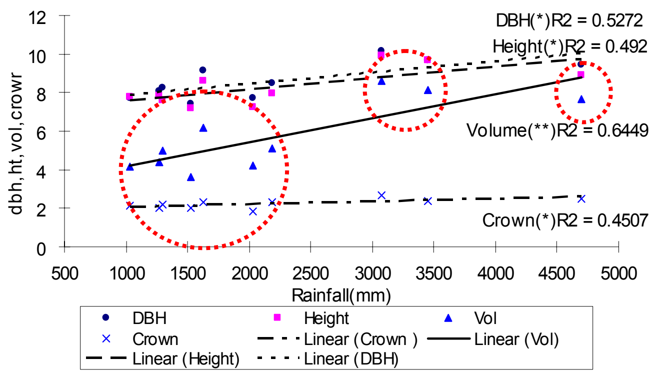

Figure 4. Relationship of rainfall with DBH (cm), height (m), volume (5000 cm^3), and crown diameter (m)

Figure 4 indicates that performance of growth increased together with the annual rainfall, but it gradually leveled off when rainfall exceeds its optimum limit of 3500 mm for teak. The annual average rainfall between 3000 to 3500 mm was best for the growth of teak. This result is supported by previous observation that rainfall of 1300-3800 mm is optimal for teak growth. The annual growth of teak is known to be dependent on the rainfall and the soil moisture availability at the beginning and the end of the monsoon season (Troup 1921 cited by FAO, 1991). Moreover this result is compatible with the finding of Kyaw (2003) who reported that relationship between rainfall and natural teak growth shows that teak has periodic growth and a marked seasonal growth rhythm and correlation analyses revealed that tree growth is mainly driven by May-October precipitation of the current year.

3.2.5. Distance between Provenances and Trial Sites

A negatively significant (p<.01) correlation was found between distance and height and a negative significance (p<.05) with DBH, and volume (Table 5). Figure 5 generally indicates that provenances close to the trial site perform better in growth than those far from the trial sites. This result is supported by Lauridsen and Olesen (1994) reporting that the shorter the distance between the trial sites and the area where seeds of the provenance collected, the greater the survival, growth and health. But the result may need to be confirmed by a further experiment with scatter distribution of trial sites along the geographic scale.

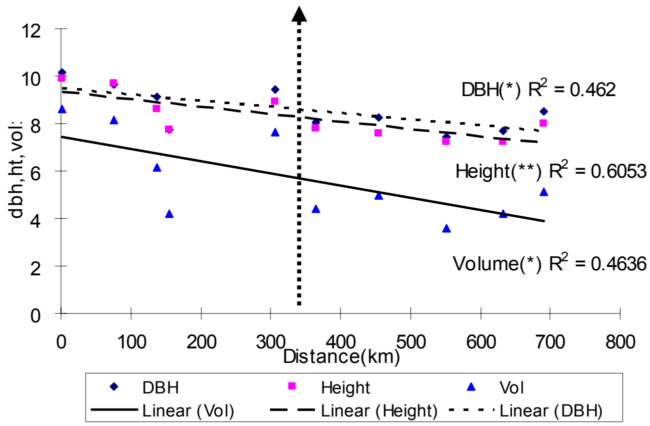

Figure 5. Relationship of distance with DBH (cm), height (m), and volume (5000 cm^3)

To examine the distance effect on growth performance, the regression line could be divided into two at the centre about 350 km from the seed-origin as shown in figure 5. The result revealed that the provenances from the left-side of the division line would indicate better growth compared to provenances of the right-side which showed poorer growth. Thus, considering for seed transfer movement within 300 km to planting site of Bago Yoma region would be proposed.

This result, from the conservation point of view, is supported by Campbell (1979) and McKay *et al* (2005) cited by Bower and Aitken (2008) stating that movement of seeds from their collection site to other environments may increase the risk of mal-adaptation which could reduce the success of plantation projects, and gene flow from maladapted planted trees into adjacent native populations could negatively affect adaptation to local conditions. Thus, seed transfer guidelines must be carefully applied to minimize the risk of maladaptation and to increase survival and growth in forestry plantation programs.

4. Recommendations

For further development of tree improvement program in Myanmar, there should be a great effort to continue this experiment for the third phase or further in mature ages to achieve consistent results in the future. More trial sites should be designed in the future program to cover entire geoclimatic distribution pattern of teak species. For further conservation purpose, as deforestation occurs, there is an urgent need for provenance collections as well.

5. Conclusion

Assessment of teak (*Tectona grandis* Linn.f) provenance trials at the 8th year after planting indicated that there was a significant variation in all traits of the tested provenances and also significant correlation between growth traits and the geoclimatic factors. The results of the comparative assessment revealed that local provenances (P4, P3 and P1) and the southernmost provenance (P5) generally showed better growth performances at the Bago Yoma region. Thus, provenances from southern region generally performed better in this region than those from the northern regions. The study found out that growth was highly influenced by the most favorable annual rainfall, but declined when rainfall exceeded the maximum limits of teak (3500 mm). In addition, provenances close to trial sites generally performed better than those far from trial sites. It would serve as a general guideline for seed transfer of teak in Myanmar.

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