

The Republic of the Union of Myanmar  
Ministry of Environmental Conservation and Forestry  
Forest Department



Study on Growth Responses from Different Thinning Grades Applied to  
*Pterocarpus macrocarpus* kurz. (Padauk) Plantation



Yan Myo Naing, Staff Officer  
Thein Saung, Staff Officer  
Aung Maw Oo, Assistant Director  
Forest Research Institute

December, 2015

အသက် (၂၃) နှစ်သား ပိတောက်စိုက်ခင်းတွင် ပင်ကြပ်နှုတ်ခြင်းအပေါ် ကြီးထွားနှုန်းတုံ့ပြန်မှုအား  
ပဏာမလေ့လာခြင်း

ရန်မျိုးနိုင်၊ ဦးစီးအရာရှိ  
သိန်းဆောင်၊ ဦးစီးအရာရှိ  
အောင်မော်ဦး၊ လက်ထောက်ညွှန်ကြားရေးမှူး  
သစ်တောသုတေသနဌာန

အကျဉ်းချုပ်

မြန်မာနိုင်ငံတွင် ၁၉၈၀ ခုနှစ်မှစ၍ သဘာဝတောများ၏ ပျက်စီးမှုကိုကာမိစေရန် သစ်တောစိုက်ခင်းတည်ထောင်ခြင်းအား အကောင်အထည်ဖော် ဆောင်ရွက်လျက်ရှိပါသည်။ ပိတောက် သစ်မျိုးသည် စီးပွားဖြစ်စိုက်ပျိုးသော စိုက်ခင်းများတွင် ဦးစားပေး သစ်မျိုးအဖြစ် အပါ အဝင်ဖြစ်ပြီး သစ်တောဦးစီးဌာနမှ စိုက်ပျိုးထားသော ပိတောက်စိုက်ခင်းများတွင်လည်း ပင်ကြပ်နှုတ်ရန် အရွယ် ရောက်ရှိနေပြီဖြစ်ပါသည်။ သို့ရာတွင် မြန်မာနိုင်ငံတွင်ယနေ့တိုင် သစ်မာသစ်မျိုးစိုက်ခင်းများအနက် ကျွန်းသစ်မျိုးစိုက်ခင်းအတွက်သာ ပင်ကြပ်နှုတ်ဇယား တည်ဆောက်ထားရှိပြီး ပိတောက်သစ်မျိုးနှင့် ကျန်သစ်မာသစ်မျိုးများအတွက် ပင်ကြပ်နှုတ် ခြင်းနှင့်ပတ်သက်သော အချက်အလက်များမရှိသေးပါ။ ထို့ကြောင့် ပျဉ်းမနားမြို့နယ်၊ တောင်ညိုကြိုးဝိုင်း၊ အကွက်အမှတ် (၅၇) တွင် ၁၉၈၆ ခုနှစ်၌ တည်ထောင်ထားသော ပိတောက်စိုက်ခင်းအား စမ်းသပ်စိုက်ခင်းအဖြစ် ရွေးချယ်၍ ကျွန်းစိုက်ခင်း ပင်ကြပ်နှုတ်ဇယားအား အခြေခံ၍ ပိတောက်စိုက်ခင်းများတွင် စိုက်ပျိုးပြုစုပင်ကြပ်နှုတ်နည်း (Silvicultural Thinning) အပေါ် ကြီးထွားနှုန်း တုန်ပြန်မှုများအား ပဏာမလေ့လာရန် ရည်ရွယ်၍ ဤလေ့လာမှုအားပြုလုပ်ခဲ့ခြင်းဖြစ်ပါသည်။ ဤလေ့လာမှုအရ အပြင်းစား ပင်ကြပ်နှုတ်ခြင်း (D grade) သည် ပိတောက်စိုက်ခင်း ပင်ကြပ်နှုတ် ခြင်းအတွက် သင့်လျော် မှုရှိကြောင်းတွေ့ရှိခဲ့ရပါသည်။ သို့သော် ပိတောက်စိုက်ခင်း ပင်ကြပ်နှုတ်ဇယား တည်ဆောက်နိုင်ရန် ဆက်လက်၍ ပင်ကြပ်နှုတ်ခြင်းနှင့် ပတ်သက်သည့် လေ့လာမှုများအား ဆောင်ရွက်သွားသင့်ပါကြောင်း ဤလေ့လာမှုအရ အကြံပြုပြောကြား အပ်ပါသည်။

## **Study on Growth Responses from Different Thinning Grades Applied to *Pterocarpus macrocarpus* kurz. (Padauk) Plantation**

Yan Myo Naing, Staff Officer  
Thein Saung, Staff Officer  
Aung Maw Oo, Assistant Director  
Forest Research Institute

### **Abstract**

In Myanmar, a large-scale reforestation/restoration program had been implementing by Forest Department since 1980s in order to supplement the natural forests, and to compensate for the deforestation. From 1996 to 2010, the total area of commercial plantations (both pure and mixed plantations) reached to 541,781 ha representing 56% of the total planted areas. *P. macrocarpus* is the one of the three major species extensively planted by Forest Department of Myanmar. Although there are information regarding thinning in Teak (*Tectona grandis*), there have been no information concerning which thinning intensity should be practiced for the *P. macrocarpus* plantation which need to conduct silvicultural thinning, consequently to support the management of plantations in Myanmar. Therefore this study aimed to support the preliminary information for the management of these species plantations based on the applications of thinning responses from different thinning intensity or thinning grades. The study was conducted in *Pterocarpus macrocarpus* plantation which was established in 1986. Data collection was conducted two times; first time was in 2009 before thinning and second was in 2014 after thinning in divided six plots. Comparison of the responses from different thinning grades was conducted by using SPSS.16 Statistical Software to explore the best thinning grade for the surveyed plantation. This study highlighted that the D grade thinning should be applied to Padauk plantations to get the best growth response in term of DBH. Moreover, MAIs in the plots which were applied the thinning were better than MAI of the Control plot. This study suggests that the follow-up study should be carried out in term of height, DBH, Volume, CAIs, and MAI to understand the growth performance more and more. Furthermore, this study highlighted that In order to explore the growth and yield table, further investigations should be carried out in the Padauk Plantations.

**Key words:** Reforestation program, Commercial plantation, Thinning grades, Growth, Yield table

**Contents**

	Page
စာတမ်းအကျဉ်း	i
Abstract	ii
1 Introduction	1
2 Objectives	2
3 Materials and Methods	2
4 Results and Discussions	4
5 Discussion	9
6 Conclusions and Recommendations	9
References	10
Acknowledgement	
Table of contents	
List of Tables	
List of Figures	

**List of Tables**

		Page
Table 1	Profile of the plantation conducted survey	2
Table 2	Thinning Grades applied to each plot and the area of the sample plot	2
Table 3	Number of trees in each plot before thinning and after thinning	3
Table 4	Number of trees which were randomly selected from each grade	3
Table 5	Distribution of the number of trees according to DBH Class in 2009	4
Table 6	Distribution of the number of trees according to DBH Class in 2014 (5 years after thinning)	5
Table 7	Sample trees which were randomly chosen and their DBHs in each thinning grade	6
Table 8	MAI in DBH (cm) per ha	6
Table 9	Periodic mean annual increment from Control Plot	7
Table 10	Variance of DBH in each plot by applying different thinning grades	7
Table 11	LSD Values for mean DBH differences	8
Table 12	DMRT Values for mean DBH Comparisons	8

**List of Figures**

	<b>Page</b>
<b>Figure 1</b> Distribution number of trees according to GBH Class in 2009 before thinning	4
<b>Figure 2</b> Distribution of the number of trees according to DBH Class in 2014 (5 years after thinning)	5

# Study on Growth Responses from Different Thinning Grades Applied to *Pterocarpus macrocarpus* kurz. (Padauk) Plantation

## 1. Introduction

In Myanmar, forest resource is one of the most important contributors to the livelihood of people and the national economy as well. There are many different forest types in Myanmar as a result of being great variation in rainfall, temperature, soil and topography. By forest resource assessment (FRA, 2010), Myanmar's forests are being experienced not only deforestation but also forest degradation because of many reasons such as agricultural conversion, fuel wood consumption, charcoal production, commercial logging and plantation development (Leimgruber *et al.* 2005) and other activities such as urbanization and infrastructure developments and the forested area was decreased from 58% of the country's total land area of 676,577 km<sup>2</sup> in 1990 to 47% in 2010.

In order to supplement the natural forests, and to compensate for the deforestation, the Forest Department of Myanmar has been implementing a large-scale reforestation/restoration program that began in 1980s, and about 30,000 ha of forest plantations have annually been formed since 1984. From 1996 to 2010, the total area of commercial plantations (both pure and mixed plantations) reached to 541,781 ha representing 56% of the total planted areas. Commercial plantations are mainly composed of three species, namely: Teak (*Tectona grandis*), Pyinkado (*Xylia xylocarpa*) and Padauk (*Pterocarpus macrocarpus*). The *T. grandis* plantation constituted 424,743 ha (44% of the total planted area) while the *X. xylocarpa* and *P. macrocarpus* constituted 67,101 ha (7% of the total planted area) and 16,645 ha (2% of the total planted area), respectively (Forestry in Myanmar, 2011).

*P. macrocarpus* is the one of the three major species extensively planted by Forest Department of Myanmar. *P. macrocarpus* wood is up to the standards for use in high-grade furniture making, including surface board, furniture structure requiring high strength. Besides, *P. macrocarpus* also yields a red sap that can be used for dyes. *P. macrocarpus* has beautiful form, sweet-smelling flowers and can be planted for landscape adornment, shade trees in streets.

In promoting plantation programs, it is important that all plantations should produce maximum volume of good-quality timber in short rotations. Although growth and yield of the plantations need to be conscientiously managed to enhance stand quality and promote wood production. Tending operations such as thinning is typically used to increase production of usable-sized trees (Zeide, 1993). Thinning can encourage the development of crown growth and volume growth as well (Piotto D *et al.*, 2003). Paying attention on choosing thinning grades became one of the important factors to get the maximize production from plantation in less time. Moreover depending on thinning grades trees diameter growth is also vary. Although there are information regarding thinning in Teak (*Tectona*

grandis), but there have been no information concerning which thinning intensity should be practiced for the *P. macrocarpus* plantation which need to conduct silvicultural thinning, consequently to support the management of plantations in Myanmar. Therefore this study aimed to support the preliminary information for the management of these species plantations based on the applications of thinning responses from different thinning intensity or thinning grades.

## 2. Objectives

- (1) To study the growth responses from different thinning grades for Padauk Plantation
- (2) To explore the best thinning grade for Padauk Plantations
- (3) To recommend the further study of Padauk Plantations

## 3. Materials and Methods

### 3.1 Study area description

The study was conducted in *Pterocarpus macrocarpus* plantation which was established in 1986. This plantation was situated in the compartment (57) of Taung Nyo Reserved Forest, Pyinmana Township, Nay Pyi Taw Region and besides of the Mandalay-Nay Pyi Taw new Express Road. At the time of conducting the study in this plantation, the age of this plantation was 23 years and it was time to practice the silvicultural thinning. The following Table 1 shows the profile of the surveyed plantation.

Table 1. Profile of the plantation conducted survey

No.	Planted species	Area (Hectare)	Spacing	established Year	Place
1	<i>Pterocarpus macrocarpus</i>	0.833	8.5 ft x 8.5 ft	1986	Compartment 57, Taung Nyo Reserved Forest, Pyinmana Township

### 3.2 Data collection and analysis

Data collection was conducted in 2009. Firstly, the plantation was divided into six plots and the different thinning operations (different thinning grades) was applied to these plots. The detailed information is as shown in Table 2.



Table 2. Thinning Grades applied to each plot and the area of the sample plot

Plot	Thinning Grade	Area (Acre)	Area ( Hectare)
1	D	0.34	0.14
2	C	0.34	0.14
3	B	0.34	0.14
4	B	0.34	0.14
5	C	0.34	0.14
6	Control	0.34	0.14

There have been no yield table for Padauk (*Pterocarpus macrocarpus*) and had only for Teak (*Tectona grandis*) in Myanmar. Therefore consideration of thinning grades for this study was based on the yield table of Teak (U Ohn, 1996). Before carrying out the thinning operation in 2009, the numbers of trees and GBH (in) in each plot were recorded. And then thinning was conducted according to the yield table. The trees removed by thinning were fork, crook, and suppressed ones. The number of trees in each plot before thinning and after thinning was as shown in Table 3.

Table 3. Number of trees in each plot before thinning and after thinning

Plot	Thinning Grade	No. of Trees (Before Thinning)	No of Trees (After Thinning)
1	D	35	19
2	C	52	28
3	B	63	24
4	B	61	38
5	C	52	24
6	Control	39	33

After thinning operation, the numbers of trees and DBH (cm) in each plot were recorded in 2014. And then to compare the responses from different thinning grades, the sampling was conducted to test the null hypothesis that the mean DBHs of each plot practiced by B grade thinning, C grade, D grade and Control (no thinning) are equal. Samples are assumed as each tree and they are randomly selected from each group. For the numbers of trees in Plot 2 and Plot 5 are altogether summed. And also Plot 3 and 4 was done as the same. The number of trees which were randomly selected from each grade was as shown in Table 4.

Table 4. Number of trees which were randomly selected from each grade

Thinning Grade	No. of Trees	Randomly selected trees
D grade	19	15
C grade	52	15
B grade	62	15
Control	33	15

And then the DBH of sample trees for each thinning grade were recorded and data analysis was conducted by using SPSS.16 Statistical Software to explore the best thinning grade for the surveyed plantation.

#### **4. Results and Discussions**

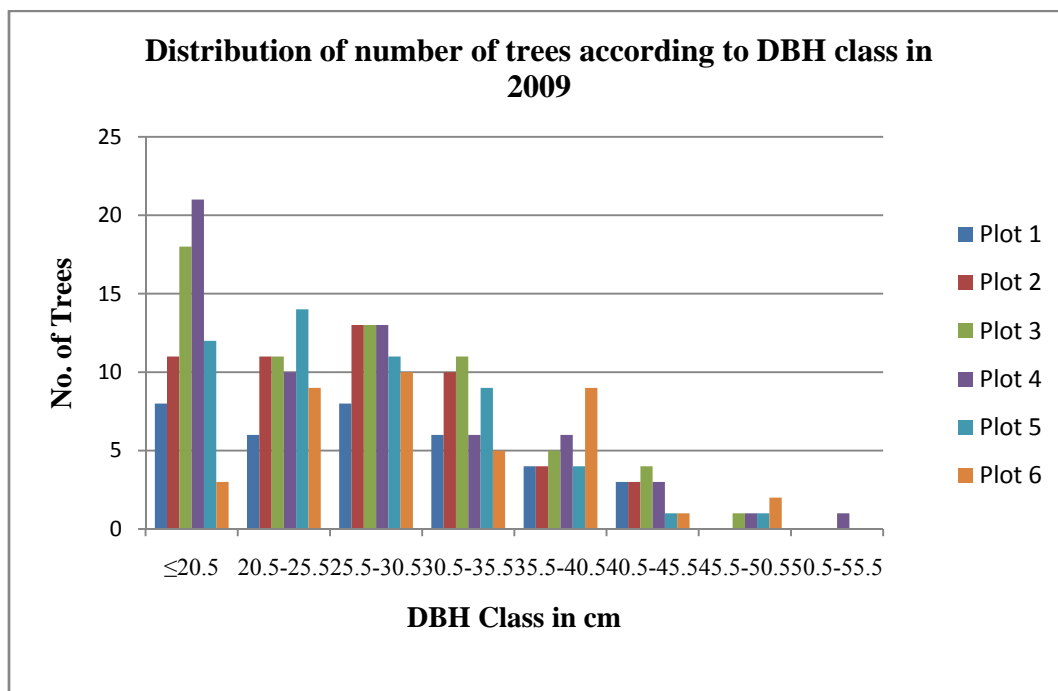
##### **4.1 Distribution of the number of trees according to GBH Class**

The distribution number of trees according to GBH Class in 2009 before thinning was as shown in Table 5 and Figure 1.

Table 5. Distribution of the number of trees according to DBH Class in 2009

DBH Class (cm)	Number of tree					
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
≤20.5	8	11	18	21	12	3
20.5-25.5	6	11	11	10	14	9
25.5-30.5	8	13	13	13	11	10
30.5-35.5	6	10	11	6	9	5
35.5-40.5	4	4	5	6	4	9
40.5-45.5	3	3	4	3	1	1
45.5-50.5	0	0	1	1	1	2
50.5-55.5	0	0	0	1	0	0
<b>Total</b>	<b>35</b>	<b>52</b>	<b>63</b>	<b>61</b>	<b>52</b>	<b>39</b>

Figure 1. Distribution number of trees according to GBH Class in 2009 before thinning

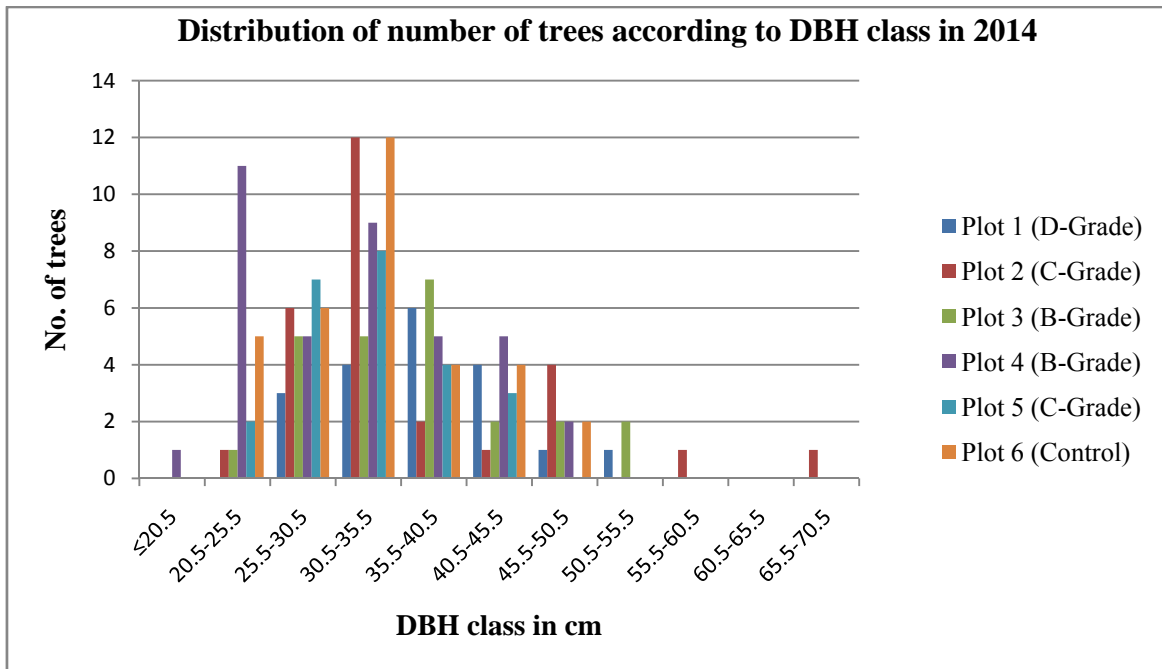


The distribution number of trees according to DBH Class in 2014 (5 years after thinning) was shown in Table 6 and Figure 2.

Table 6. Distribution of the number of trees according to DBH Class in 2014 (5 years after thinning)

DBH Class (cm)	Number of tree					
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
≤20.5	0	0	0	1	0	0
20.5-25.5	0	1	1	11	2	5
25.5-30.5	3	6	5	5	7	6
30.5-35.5	4	12	5	9	8	12
35.5-40.5	6	2	7	5	4	4
40.5-45.5	4	1	2	5	3	4
45.5-50.5	1	4	2	2	0	2
50.5-55.5	1	0	2	0	0	0
55.5-60.5	0	1	0	0	0	0
60.5-65.5	0	0	0	0	0	0
65.5-70.5	0	1	0	0	0	0
<b>Total</b>	<b>19</b>	<b>28</b>	<b>24</b>	<b>38</b>	<b>24</b>	<b>33</b>

Figure 2. Distribution of the number of trees according to DBH Class in 2014 (5 years after thinning)



The number of sample trees for each thinning grade and their DBHs were as shown in Table 7.

Table 7. Sample trees which were randomly chosen and their DBHs in each thinning grade

No. of Trees	D grade (DBH in cm)	C grade (DBH in cm)	B grade (DBH in cm)	Control (DBH in cm)
1	46.5	40.5	42.8	34.0
2	41.5	29.5	47.2	30.2
3	33.2	28.7	32.6	33.3
4	32.4	23.6	25.4	32.8
5	40.9	30.3	20.0	31.9
6	40.2	26.5	21.5	41.0
7	45.9	30.0	39.1	26.0
8	28.6	39.6	35.9	35.9

9	29.2	34.1	30.3	22.9
10	34.1	32.3	39.5	23.2
11	36.1	40.6	23.3	28.5
12	38.1	35.5	36.1	31.2
13	29.6	28.7	29.3	27.5
14	39.6	24.3	32.8	45.8
15	40.1	31.5	24.1	30.1

#### 4.2 Mean Annual Increment (MAI)

Mean annual increment in diameter at breast height (DBH) in centimeter (cm) per hectare (ha) are expressed in Table 8.

Table 8. MAI in DBH (cm) per ha

	Plot 1 (D grade)	Plot2 (C grade)	Plot 3 (B grade)	Plot 4 (B grade)	Plot 5 (C grade)	Plot 6 (Control)	Remark
MAI (DBH in cm)/ha	8.884776432	8.524981081	8.32571266	8.154856894	8.223297957	9.394347491	At the age of 23(In 2009) before thinning
MAI (DBH in cm)/ha	9.764538691	9.372896012	9.466542343	8.29789605	8.589296566	8.531553559	At the age of 28 (In 2014) after thinning

According to table 8, mean annual increment before after thinning is higher than that before thinning except in control plot. This highlighted that growth responses in plots which applied by thinning is very good and the growth responses in control plot which was not applied by thinning is very low.

#### 4.3 Periodic Mean Annual Increment (PMAI)

Periodic mean annual increment was shown in Table 9.

Table 9. Periodic mean annual increment from Control Plot

	Control Plot	Remark
Diameter/ha	216.0699923	At the age of 23(In 2009)
Diameter/ha	238.8834997	At the age of 28 (In 2014)
PMAI(DBH in cm/ha)	4.562701474	

Unfortunately, in order to know the PMAI for other plots, the data which expressed DBHs of which trees are removed during the thinning and DBH of which trees are left are not available. Therefore, it is tried to get the information about PMAI from the control plot this time. It is very important to estimate the current annual increment (CAI) and PMAI for all plots in the next time.

#### 4.4 Diameter Measurement

According to ANOVA test (Table 10), it was found that mean DBH of sample trees in each plot which was applied different thinning grades had significant difference at the significant level ( $P < 0.1$ ). According to LSD test, mean DBH of each plot applied by different thinning grades are significantly different from each other at the significant level ( $P < 0.05$ ). This was shown in Table 11. Moreover, Dunncan Multiple Range test is also applied and this can be seen in Table 12.

Table 10. Variance of DBH in each plot by applying different thinning grades

#### ANOVA

DBH(cm)	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	316.086	3	105.362	2.523	.067
Within Groups	2338.924	56	41.766		
Total	2655.010	59			

Note: One Way ANOVA test  $F = 2.523$ ,  $P = 0.067$

Table 11. LSD Values for mean DBH differences

**Multiple Comparisons**

Dependent Variable: DBH (cm)

	(I) Thinning Grade	(J) Thinning Grade	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	1	2	5.35333*	2.35984	.027	.6260	10.0807
		3	5.07333*	2.35984	.036	.3460	9.8007
		4	5.44667*	2.35984	.025	.7193	10.1740
	2	1	-5.35333*	2.35984	.027	-10.0807	-.6260
		3	-.28000	2.35984	.906	-5.0073	4.4473
		4	.09333	2.35984	.969	-4.6340	4.8207
	3	1	-5.07333*	2.35984	.036	-9.8007	-.3460
		2	.28000	2.35984	.906	-4.4473	5.0073
		4	.37333	2.35984	.875	-4.3540	5.1007
	4	1	-5.44667*	2.35984	.025	-10.1740	-.7193
		2	-.09333	2.35984	.969	-4.8207	4.6340
		3	-.37333	2.35984	.875	-5.1007	4.3540

\*. The mean difference is significant at the 0.05 level.

According to LSD test, mean DBH of thinning grade 1 (D grade) is significantly different from that of thinning grade 2 (C grade), thinning grade 3 (B grade), and thinning Grade 4 (Control).



Table 12. DMRT Values for mean DBH Comparisons

		DBH(cm)		
Thinning Grade	N	Subset for alpha = 0.05		
		1	2	
Duncan <sup>a</sup> 4	15	31.6200		
2	15	31.7133		
3	15	31.9933		
1	15		37.0667	
Sig.		.883	1.000	

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 15.000.

According to DMRT, mean DBH of plot provided by thinning grade 4 (Control) is the poorest and followed by that of thinning grade 2 (C grade). Mean DBH of thinning grade 1 (D grade) is the best and followed by that of thinning grade 3 (B grade).

## 5. Discussion

By this study it was found that growth responses in plots thinning were conducted had better responses than in control plot without conducting thinning. This finding is in substantial agreement with the finding of other studies (Piotto D et al., 2003; Ugalde, 1983; Espinosa et al., 1994; Amwteis et al., 1996; Ruiz et al., 1996). Moreover, by LSD test it was found that mean DBH trees in plot practiced thinning by grade 1 (D grade) is significantly different from that of in other plots. It meant that heavy thinning or D grade thinning had a significant impact on diameter. But Piotto D et al. (2003) pointed out that the increase in individual tree growth by thinning couldn't compensate for the fewer number of total trees per hectare and volume growth of trees by thinning as well. In this study height growth response by thinning was not explored. But regarding the height growth response by thinning, Aguiar et

al. (1995) reported that thinning practice had no influence generally on tree height for *Eucalyptus Citriodora* in Brazil and Espinosa et al. (1994) also pointed out similar result for *Pinus radiata* in Chile while Simoes (1981) highlighted that management of stand density has little effect on height growth except in very close or very wide spacing.

## **6. Conclusions and Recommendations**

According to the results, it was concluded and recommended as follows;

- (1) The D grade thinning should be applied to Padauk plantations to get the best growth response in term of DBH.
- (2) It should be noted that MAIs in the plots which were applied the thinning were better than MAI of the Control plot without conducting thinning.
- (3) To understand the growth performance more and more, the follow-up study should be carried out in term of height, DBH, Volume, CAIs, MAI, Basal area and spacing.
- (4) In order to explore the growth and yield table, further investigations should be carried out in the Padauk Plantations.

## References

- Amateris, R.L., Radtke, P.J., Burkhart, H.E., 1996. Growth and yield of thinned and unthinned plantations. *J-For.* 94 (12), 19-23
- Aguiar, I.B., Valeri, S.V., Spinelli, P., Sartori Filho, A., Pirec, C.A.M., 1995. Efeito de intensidades de desbaste sobre o crescimento em altura e diametro de *Eucalyptus citriodora* Hook. IPEF (Piracicaba) 48/49, 1-7
- Espinosa, M., Garcia, J., Valeria, O., 1994. Efecto de intensidades diferentes de raleo en el crecimiento de un rodal de pino radiate Bosque (Chile) 15 (1), 55-65
- FAO, 2010. Global Forest Resources Assessment 2010-main report. FAO Forestry Paper No 163. Rome, Italy.
- FD, 2011. Forestry in Myanmar. Ministry of Environmental Conservation and Forestry, Nay Pyi Taw, Myanmar.
- Leimgruber P et al., 2005. Forest cover change patterns in Myanmar (Burma) 1990-2000, *Environmental Conservation* 32(4), 356-364
- Piotto D et al., 2003. Growth and effect of thinning in mixed and pure plantation with native tree in humid tropical Costa Rica. *Forest Ecology and Management* 177, 427-439
- U Ohn, 1998. သဘာဝသစ်တောများနှင့်ရင်ပေါင်တန်းလာသော သစ်တောစိုက်ခင်းများ၊ မှတ်ပုံတင် အမှတ် (၂၈၅)၊ ရန်ကုန်
- Ugalde, L., 1983. Rendimiento y aprovechamiento de dos intensidades de raleo selective en *Eucalyptus deglupta* en Turrialba, Costa Rica, *Turridha* 33(2) 143-150
- Ruiz, M., Fierros, A.M., Ramirez, H., 1996. Efecto inicial del aclareo en plantaciones de *Pinus caribaea* var. *homdurensis* en la Sabana, Oaxaca. *Revista Ciencia Forestal en Mexico* 21 (80), 25-38
- Simoes, J.W., 1981. Formacao, manejo e exploracao de florestas com species de rapido crescimento. IBDF, Brasilia, P-131.
- Zeide, B et al., 1993. Selection of site trees: the combined method and its application. *Can. J. For. Res.* 23: p. 1019-1025.

### **Acknowledgement**

I would like to express my sincere thanks to Forest Department, which support the funding for this research. And my special thank go to U Win Myint, Retired Director, who tried to redesign the plantation in order to support this study. Again, my thankfulness go to U KoKoNaing, forester, for his help in the collection of data in the field for this research.