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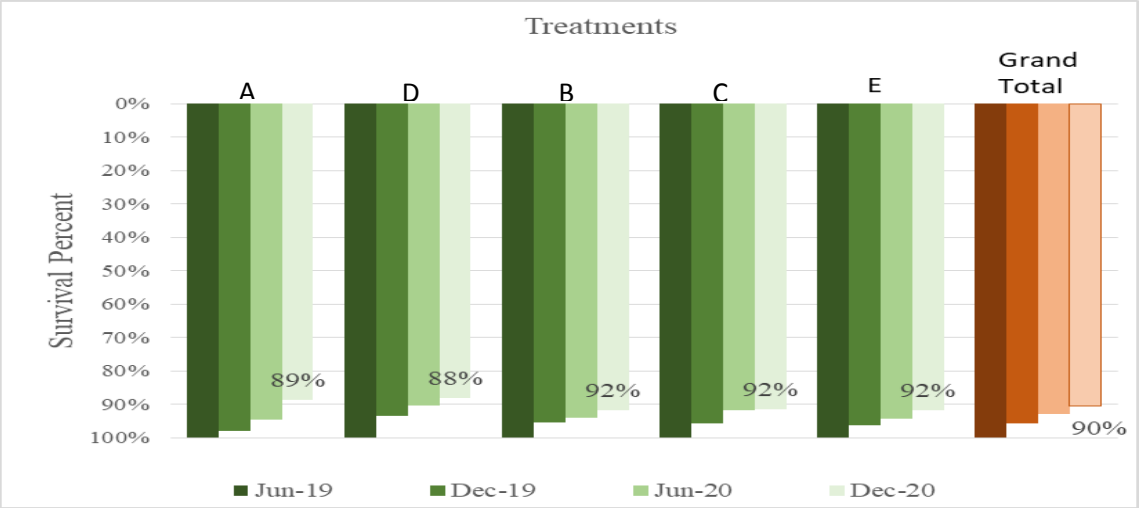
Forest Department

Effects of site preparation on growth of teak plantation



Dr. Yu Ya Aye
Assistant Director
Forest Research Institute, Forest Department

Dr. Zar Chi Hlaing
Staff Officer
Forest Research Institute, Forest Department

Khaing Wut Hmone
Staff Officer
Forest Research Institute, Forest Department

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Contents

List of Figures

List of Tables

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Yu Ya Aye[1]*, Zar Chi Hlaing[2], Khaing Wut Hmone[2]

[1]Assistant Director, Forest Silviculture Section, Forest Research Institute
[2]Staff Officer, Forest Silviculture Section, Forest Research Institute

Abstract

Establishment of plantations requires some degree of site preparation and early maintenance to ensure high survival and rapid initial growth rates. But concerns have been raised as to whether intensive site preparation might have a negative effect on the long-term productivity of a stand. Likewise, nursery practices have effect on the vigor of seedlings and the success of their transplantation in the field. In order to investigate the long-term effects of different site-preparation and nursery practices on growth performance of teak, the research plantation was established in 2019. Five site-preparation treatment were performed and seedlings from different nursery practice (polybag and pot-tube) are used. At the end of the second year growing season, teak growth responses showed significantly different among site preparation treatments. Treatment C (Slash and burn) resulted in better performance of teak raised by polybag and treatment D (slash and burn with complete plowing) showed better performance of teak raised by pot-tube. Among different site preparation treatment, clear-felled treatment (slash and burn, slash and burn with complete plowing) shown better performance than strip plowing, strip burning and spot clearing treatment. The growth (height) of teak raised by Polybag shown significantly higher than the growth of teak raised by pot-tube. This study evaluated the second-year growth performance of teak plantation. Continuous assessment need to conduct in order to identify the effect of site preparation and nursery practices on teak growth.

Keyword: site-preparation, teak plantation, nursery practices, growth performance

*****Corresponding author: yuyaaye@gmail.com

မြေနေရာပြုပြင်ခြင်းဖြင့် ကျွန်းပင်များ ကြီးထွားမှုအပေါ် သက်ရောက်မှုအား လေ့လာခြင်း

ဒေါက်တာယုယအေး၊ လက်ထောက်ညွှန်ကြားရေးမှူး
ဒေါက်တာဇာခြည်လှိုင်၊ ဦးစီးအရာရှိ
ခိုင်ဝတ်မှုံ၊ ဦးစီးအရာရှိ
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

စိုက်ခင်းမြေနေရာပြုပြင်ခြင်းသည် စိုက်ခင်းစတင်တည်ထောင်သည့်နှစ်တွင် စိုက်ပင်များ ရှင်သန်မှုနှင့် ကြီးထွားမှုအပေါ် များစွာအကျိုးသက်ရောက်မှု ရှိပါသည်။ အဆိုပါ ပြုပြင်ခြင်းကြောင့် စိုက်ခင်းအပေါ် ရေရှည်အကျိုးသက်ရောက်မှုများကို လေ့လာရန် လိုအပ်လျက်ရှိသည်။ ထို့ပြင် စိုက်ခင်း၏ အပင်များ ရှင်သန်အောင်မြင်မှုသည် ပျိုးဥယျာဉ်တွင် ပျိုးပင်များ ပျိုးထောင်စဉ်က အသုံးပြုခဲ့သော နည်းလမ်းများအပေါ်တွင် မူတည်လျက်ရှိသည်။ စိုက်ခင်း မြေနေရာပြုပြင်ခြင်းနှင့် ပျိုးထောင်ခြင်း နည်းလမ်းများကြောင့် ကျွန်းစိုက်ပင်များအပေါ် အကျိုးသက်ရောက်မှုကို ရေရှည်လေ့လာရန် ရည်ရွယ်၍ ၂၀၁၉ ခုနှစ်တွင် မြေနေရာ ပြုပြင်နည်းအမျိုးမျိုးဖြင့် စမ်းသပ်ထားသော ကျွန်းသုတေသနစိုက်ခင်းကို တည်ထောင်ခဲ့ပါသည်။ ပျိုးအိတ် ဖြင့် ပျိုးထောင်သော ကျွန်းပျိုးပင်နှင့် pot(tube)ဖြင့် ပျိုးထောင်ထားသော တစ်နှစ်သား ကျွန်းပျိုးပင်တို့ကို မြေနေရာပြုပြင်ခြင်း နည်းလမ်း(၅)ခုဖြင့် စမ်းသပ်စိုက်ပျိုးခဲ့ ပါသည်။ ၂၀၂၀ ခုနှစ် ဒီဇင်ဘာလ တိုင်းတာချက်များအရ ပျိုးအိတ်ဖြင့်ပျိုးထောင်သည့် ကျွန်းပင် သည် ယာခုတ်မီးရှို့သည့် စမ်းသပ်ကွက်တွင် ကြီးထွားနှုန်း အကောင်းဆုံးဖြစ်ပြီး pot-tubeဖြင့် ပျိုးထောင်သော ကျွန်းပင်သည် ယာခုတ်မီးရှို့ ထွန်ယက်သည့် စမ်းသပ်ကွက်တွင် ကြီးထွား နှုန်း အကောင်းဆုံး ဖြစ်ကြောင်း တွေ့ရပါသည်။ မြေနေရာပြုပြင်ခြင်းများ နှိုင်းယှဉ်ပါက အပြောင်ရှင်းသည့်နည်းဖြင့်ဆောင်ရွက်သည့် ယာခုတ်မီးရှို့နှင့် ယာခုတ်မီးရှို့ ထွန်ယက်သည့် စမ်းသပ်ကွက်များသည် လိုင်းအလိုက်ထွန်ယက်ခြင်း၊ လိုင်းအလိုက်မီးရှို့ခြင်း၊ စိုက်ပင် ပတ်လည် အပြောင် ရှင်းခြင်း ဆောင်ရွက်သည့် စမ်းသပ်ကွက်များထက် ကျွန်းပင်ကြီးထွားနှုန်း ပိုမိုကောင်းမွန်ကြောင်း တွေ့ရပါသည်။ စမ်းသပ်ကွက်များ အားလုံးတွင်ပျိုးအိတ်ဖြင့် ပျိုးထောင်ခဲ့သည့် ကျွန်းပင်သည် pot-tube ဖြင့် ပျိုးထောင်ခဲ့သောကျွန်းပင်ထက် ကြီးထွား နှုန်း ပိုမိုကောင်းမွန်ကြောင်းတွေ့ရပါသည်။ ဤစာတမ်းသည် သုတေသနစိုက်ခင်း ဒုတိယနှစ် တွင်

တိုင်းတာရရှိသော အချက်အလက်များအား တင်ပြထားခြင်းဖြစ်ပြီး စိုက်ခင်းမြေနေရာ ပြုပြင်ခြင်းနှင့် ပျိုးထောင်ခြင်းနည်းလမ်းများကြောင့် ကျွန်းပင်များအပေါ် ရေရှည်အကျိုး သက်ရောက်မှုများကို ဆက်လက်လေ့လာသွားမည် ဖြစ်ပါသည်။

Effects of site preparation on growth of teak plantation

1. Introduction

Reforestation is needed globally to help restore degraded sites, combat desertification, protect watersheds, and provide forest products. Myanmar's Forest Department has practical experiences in program-based reforestation activities start from 1979. FD continued reforestation and afforestation activities by its national budget. Between 1981 and 2016, totally 885,638 ha (about 2.19 million acres) of different types of forest plantations were established. Although Myanmar has already developed a significant extent of forest plantations, inspections conducted in 2010 has revealed that 55.98 % of the established plantation failed due to various reasons. Moreover, FRA (2015) has reported that Myanmar is the third-most deforested country in the world. In response to address deforestation and forest degradation issue, FD has developed and been implementing "Myanmar Reforestation and Rehabilitation Program (MRRP) (2017-18 to 2026-2027)". Plantation establishment is one of the main activities in MRRP program since forest department plan to establish 637,542 acres (state-owned plantation and private plantation) during the MRRP (10) years period. Mass production of forest tree seedlings is necessary to fulfill the targeted plantation establishment.

Appropriate nursery and tree planting technologies are vital for successful afforestation and reforestation. Nursery planting pots have been reported as one of the main factors affecting the successful development of seedlings (Dominguez-Lerena et al. 2006; Poorter et al. 2012). Nursery practices have effect on the vigour of seedlings and accordingly on the success of their transplantation in the field (Oliet et al. 2009; Del Campo et al. 2010). Extensive research suggests that nursery operations play a significant role in seedlings quality and outplanting performance (liu *et al.* 2000, Gao *et al*. 2007, Li GL *et al.* 2012). Reforestation and restoration success in developing countries could be vastly improved with a readily available and cheap alternative to modern nursery containers (Khurram et al. 2017).

Now-a-day, polybags are more commonly used in nursery. Start from 2017, modern nursery container, pot-tube, was initiated in Myanmar. Pot-tube seedlings offers several benefits such as being able to be transported considerable distance and being easy and quick to plant. Aung. et al (2018) recommended that pot-tube seedlingss should be used instead of plastic bag seedlings to reduce plastic wastes in forests, transportation cost and planting cost. However limited study is conducted the growth performance of pot-tube seedlings after transplanting in the field. This study attempt to investigate the growth performance of pot-tube seedlings and poly bag seedlings after transplanting in the field.

Establishment of plantations requires some degree of site preparation and early maintenance to ensure high survival and rapid initial growth rate (Smith et al. 2012). Normally, tree plantation establish in degraded forest land. The sites were clear-felled during the winter. During the following summer, slash (tops and branches) was piled and burned. The slash and burn with subsequent replanting is used in establishment of plantation in Myanmar. This system is widely used in plantation establishment and produced good stand-establishment results for decades. But clear fell and burn may alters environmental conditions

such as microclimate, soil hydrology, and soil fertility. Consequently, a clear cut, with its changing dynamics, is not always a friendly environment for newly planted seedlings (Grossnickle, 2000). Thus, concern has been raised as to whether different site preparation might have different growth performance of tree species. The present study was therefore designed to investigate the long-term effects of different site-preparation methods on growth performance of teak seedlings by pot-tube and poly bag.

2. Objectives

- To explore the effect of different site preparation practices on the growth of teak plantation
- To analyses the growth performance of pot-tube seedlings and poly bag seedlings after transplanting in the field

3. Materials and Methods

3.1. Study area and method

The present study was designed to investigate the long-term effects of different site-preparation treatments on productivity and determine any possible interactions with tree species and site fertility. In the 2019, Teak research plantation with a randomized block experiment was established at Ngalike Reserve Forest, Ottayathiri Township, Naypyitaw. Five site-preparation methods were performed and seedlings from different nursery practice (pot-tube and polybag) are used.

The pot-tube size was 5 inches x 1.5 inches. Pot tube media is mainly composed of Coir (up to 65%) and other ingredients such as peat, rice husks, carbonized rice husks, peat moss, gypsum, cow dunk, sphangum peat moss, *Hydrilla verticullata*. The polybag size was 7 inches x 3 inches. The soil media was composed of a mix of local soil, manure and sand with the proportion 3:2:1 with 3 parts local soil, 2 parts sand and 1 part manure.

The different site-preparation treatments were used in the experiment: (A) strip plowing (B) strip burning (C) control (i.e conventional slash and burn method) (D) slash and burn with complete plowing (E) clearing the planting spot. Treatment A, Strip plowing, was carried out in strips of 4 m, where treated 2 m and untreated 2 m strips alternated. Treatment B, Strip burning, was carried out in strips of 4 m, where treated 2 m and untreated 2 m strips alternated. Treatment C, Control plots (i.e conventional slash and burn method), the sites were clear-felled during the winter. During the following summer, slash (tops and branches) was pile and burn known as slash and burn method. Slash and burn method was used in plantation establishment in Myanmar. Treatment D, complete plowing plots were treated by plowing the whole plot area after slash and burn. Treatment E, zero burning and clearing 1 squared meter at the planting spot. Treatment A and treatment E are zero burning plot. All treatments were replicated three times. In strip-plowed plots seedlings were planted in the middle of the strip. In all treatment, the tree are planted with the spacing 4 m x 4 m.

Growth (DBH, height) will measure every year for a long term assessment on impact of site preparation. In this paper, the second year's growth response of two types of seedlings under five site preparation were analyzed. Growth (height) were measured during the first years after establishment. Every six months, tree growth were re-measured at the level of individual trees.

3.2. Statistical analysis

One way analysis of variance (ANOVA) was used to test the different among the site preparation. Post-hoc test was used to know the significant of one way ANOVA. Tukey's HSD test was performed for post-hoc comparisons between treatments mean at the 95% probability level ($P<0.05$). Differences in average tree height per container type (polybag and pot-tube) in each site preparation trial were assessed using independent sample t-test.

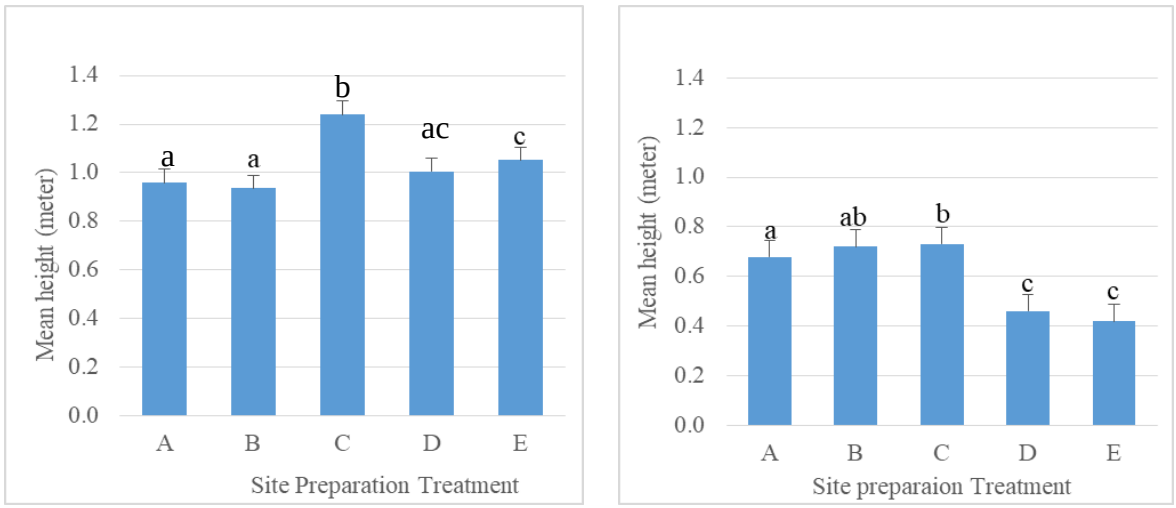
4. Results

The present study was designed to investigate the long-term effects of different site-preparation methods on productivity and determine any possible interactions with different planting stock. Besides, growth responses differ among different planting stocks and polybag seedlings are used in current reforestation program indicating a need for additional research for improved understanding alternative planting stock. Every six months, tree growth were re-measured at the level of individual trees.

4.1. Effects of site preparation on different planting stocks

Growth of planted tree (Dec 2019)

Growth (height) were measured during the first years after establishment. Among five site preparations, treatment-C (slash and burn) resulted in better growth performance in polybag seedling. In polybag seedling plot, teak growth under treatment C was highest 1.24 ± 0.03 meter, follow by treatment E (1.05 ± 0.03), treatment D (1.00 ± 0.03), treatment A (0.95 ± 0.03) and treatment B (0.93 ± 0.02). Based on the Tukey's HSD, treatment C is significantly higher than other treatment. The growth of the pot-tube teak were within the ranges 0.42 ± 0.01 and 0.73 ± 0.02. In pot (tube) teak seedling plot, treatment C (slash and burn) is significantly higher than other treatment.

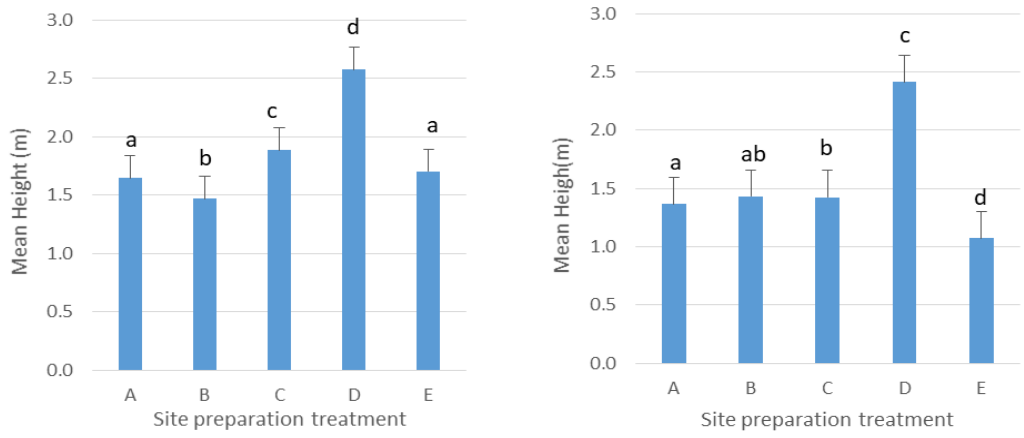


(a) (b)

Figure 1 Growth (height) of teak raised by polybag (a) and Pot-tube (b) under different site preparation (Dec 2019)

Growth of planted tree (July 2020)

In polybag seedling plot, mean growth of teak varied from 1.34 ± 0.03 meter to 2.35 ± 0.05 meter. The highest growth was recorded in treatment D (slash and burn with complete plowing) followed by treatment C, treatment E, treatment A and treatment B. In pot-tube seedling, tree growth was found highest in treatment D (2.20 ± 0.06) followed by treatment B (1.30 ± 0.03), treatment C (1.30 ± 0.03), treatment A (1.24 ± 0.03) and treatment E (0.98 ± 0.03). As evaluated by Tukey's HSD, treatment D showed significant difference among other treatment.



(a) (b)

Figure 2 Growth (height) of teak raised by polybag (a) and Pot-tube (b) under different site preparation (July 2020)

Growth teak (Dec 2020)

In polybag seedling plot, mean growth of teak varied from 2.33 ± 0.05 meter to 2.93 ± 0.06 meter. The highest growth was recorded in treatment C (slash and burn) followed by

treatment D, treatment E, treatment A and treatment B. In pot-tube seedling, tree growth was found highest in treatment D (2.58 ± 0.08) followed by treatment C (2.39 ± 0.06), treatment B (2.36 ± 0.06), treatment A (2.17 ± 0.05) and treatment E (1.83 ± 0.06). As evaluated by Tukey's HSD test, treatment D showed significant difference ($P < 0.05$) among other treatment.

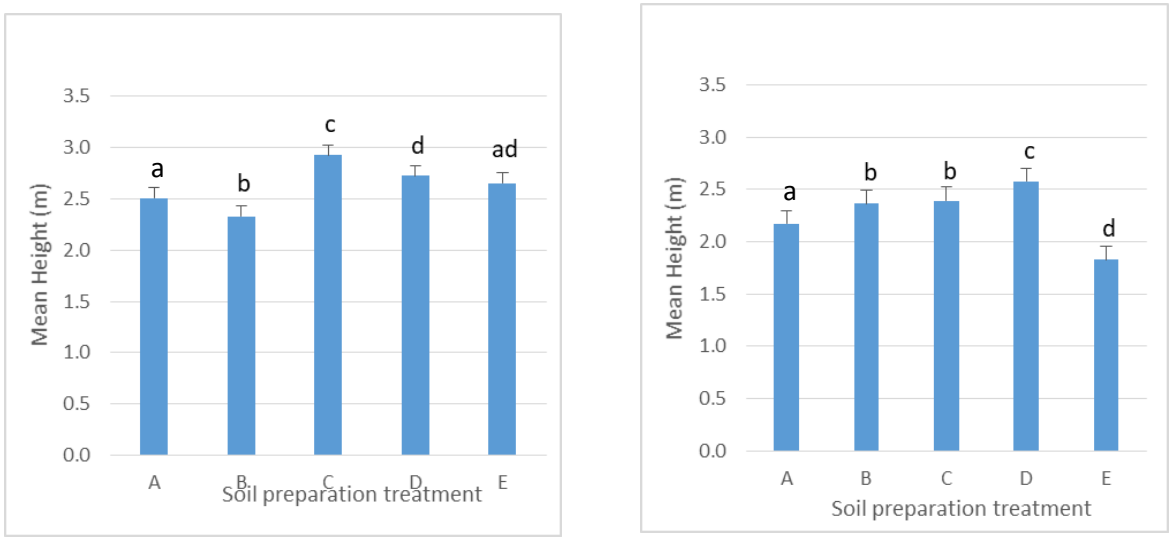


Figure 3 Growth (height) of teak raised by polybag (a) and Pot-tube (b) under different site preparation (Dec 2020)

A comparison of site preparation treatments showed significant differences in plant growth responses at both one year and two year after outplanting. At the end of the first growing season after transplantation in the field, December 2020, it was found that teak growth (height) was affected by planting stocks (Figure 3). After second year growing season, slash and burn with complete plowing (Treatment D) resulted in better performance than other treatments. Treatment D was significantly higher in growth of teak raised by polybag (2.35 ± 0.05) meter and pot-tube (2.20 ± 0.06) meter. The effects of site preparation were most evident with pot-tube plot because the teak growth (height) in treatment D was 2.20 ± 0.06 and other treatments ranged from (0.98 ± 0.03) to (2.20 ± 0.06).

Effect of site preparation on tree growth

Table 1 Tree growth by different site preparation treatments

No.	Treatment	Tree Height (m)		
		2019 Dec	**2020 July**	**2020 Dec**
1.	A	0.82 ± 0.02	1.37 ± 0.03	2.35 ± 0.04
2.	B	0.83 ± 0.02	1.33 ± 0.03	2.34 ± 0.04
3.	C	0.98 ± 0.02	1.52 ± 0.03	2.66 ± 0.04
4.	D	0.72 ± 0.02	2.28± 0.04	2.67 ± 0.05
5.	E	0.73 ± 0.02	1.27 ± 0.03	2.24 ± 0.04

After second year growing season, slash and burn treatment (2.66 ± 0.04 meter) and slash and burn with complete plowing (2.67 ± 0.05 meter) resulted in better performance of teak. The highest growth was recorded in treatment D (slash and burn) followed by treatment C, treatment A, treatment B and treatment E. Thus, clear-felled treatments (slash & burn and slash & burn with complete plowing) were the effective method for stand establishment of teak.

4.2. Growth performance of different planting stocks

Effect of different site preparation treatments on planting stocks

Based on measurement data, it was found that the planting stocks (polybag seedlings and pot-tube seedlings) effect on growth of tree in outplanting stage. At the three time interval measurement data, it was found that poly bag seedlings was significantly higher than the pot-tube in all site preparation treatments (Figure 4)**.** It may be effects of different nursery practice such as different media and different pot size at the seedling stage. The pot-tube size was 5 inches x 1.5 inches while the polybag size was 7 inches x 3 inches. The positive effect of increasing planting pot size on seedling growth was reported for many plant species (e.g. Dominguez-Lerena *et al.* 2006; Dumroese *et al.* 2011). Our results confirm with Abera. *et al* 2018 statement. He stated that seedlings raised in large pots would be better developed and produced in a shorter time than seedlings raised in pots of smaller size. He also mentioned that better seedling performances in larger pots is due to the availability of more growing space, enabling the early development of root to escape drought, favorable condition for the success of transplantation in the field. Moreover the effect of media might be one of the factor the growth performance of tree. Some studies have reported significant growth differences under different soil mixes; for example, Fekadu et al. (2011) used different levels of manure, sand and local soil in a highland area but reported significant differences among the treatments. In this study, pot-tube media is mainly composed of Coir (up to 65%) and other ingredients and polybag media composed of local soil, manure and sand.

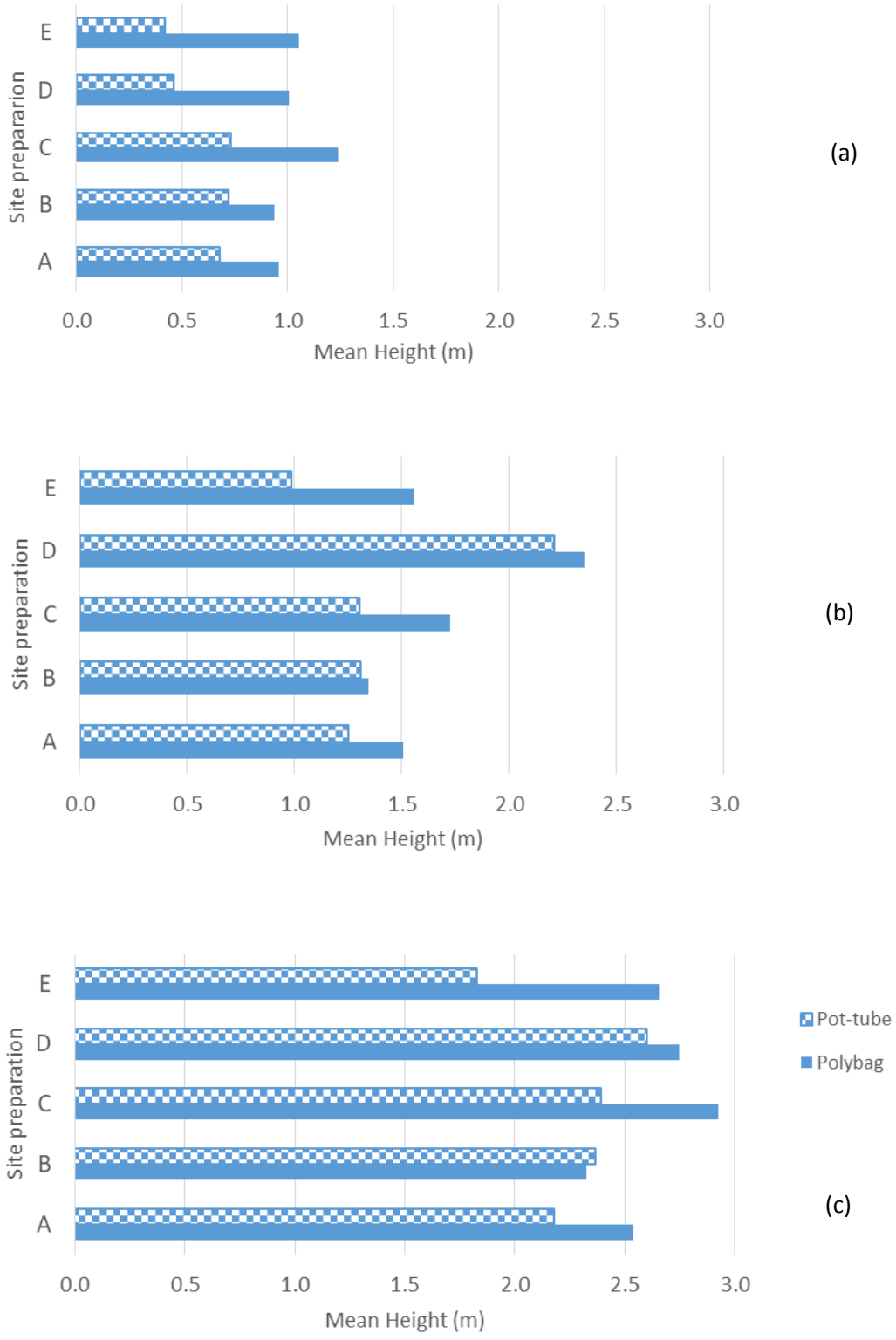


Figure 4. Growth of different planting stock at each measurement (a) 2019 Dec, (b) 2020 July (c) 2020 Dec

Comparison on growth performance of different planting stocks

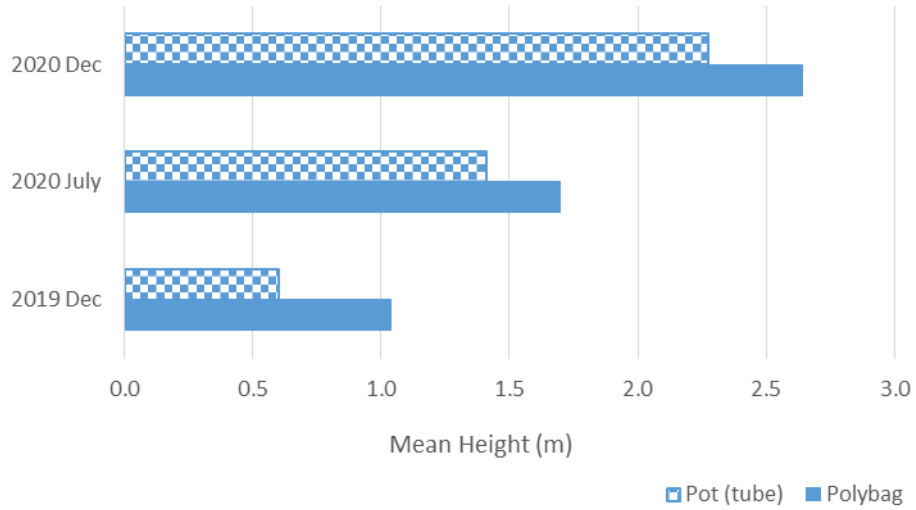


Figure 5. Growth response of different planting stocks

Base on measurement data, it was found that poly bag seedlings was significantly higher than the pot-tube. There was almost threefold growth performance within one year of the plantation with both planting stocks (Figure 5). This study observed that polybag seedling provided better growth performance (1.04 m in 2019 December, 1.70 m in 2020 July and 2.64 in 2020 December) than pot (tube) seedling (0.06 m in 2019 December, 1.41 m in 2020 July and 2.27 in 2020 December). After the first year growing season, 2019 Dec, the growth of teak raised by polybag was significantly higher than teak raised by pot-tube. The height of the polybag seedling was twofold higher than the pot-tube seedlings. But between 2019 Dec to 2020 Dec, poly-bag seedlings was observed about threefold growth performance within one year while pot-tube seedlings was almost fourfold growth performance within one year. It was found that the growth performance of polybag teak was better the first year growing season but in the second year growing season, the growth performance of pot-tube teak was better.

4.3. Survival of planted tree

The survival percentage is around 90 % in all site preparation treatment if the different planting stocks are not considered. At the current condition of December 2020, the treatments (B, C and E) have better survival percent than the treatments (A and D) (Figure 6). This study consistent with other studies. Site preparation increases survival and that higher mortality occurs in the first years following planting (Johansson *et al.* 2013). And Wallertz *et al.* (2018) stated that the effect of site preparation was not only related to increase survival but it also positively affected individual trees. But Smith *et al.*, (2013) mentioned that based on trial research, the final survival, basal area and volume were not affected by land preparation. This study indicated that site preparation was not effect to survival percent of different planting stock (polybag seedlings and pot-tube seedling) (Figure 7).

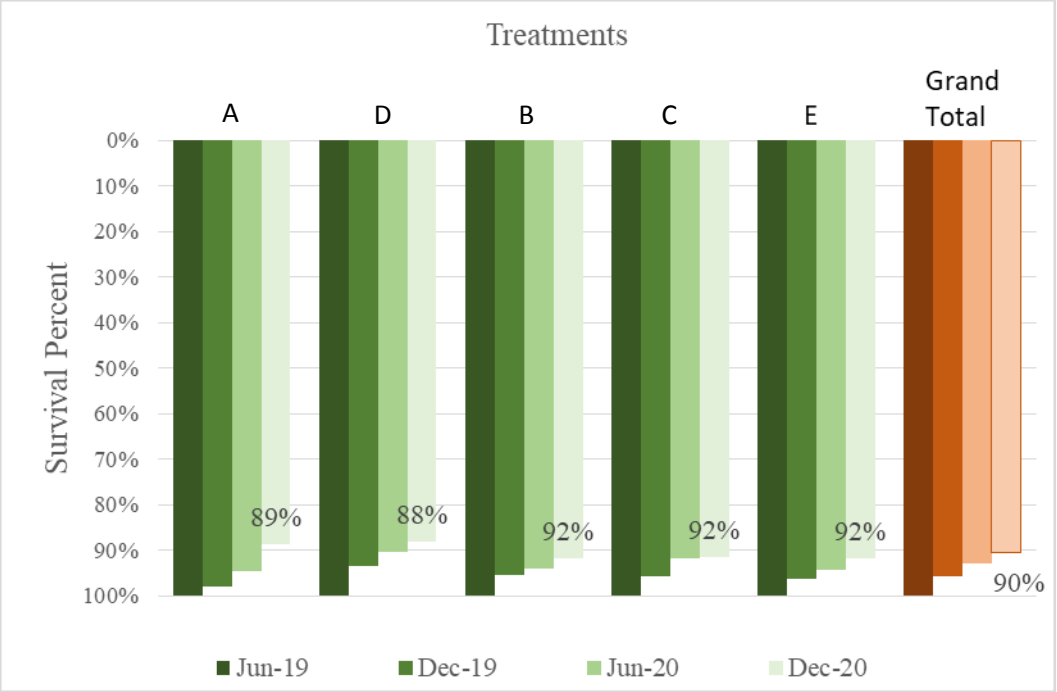


Figure 6. Survival percent of planted tree in different site preparation treatment

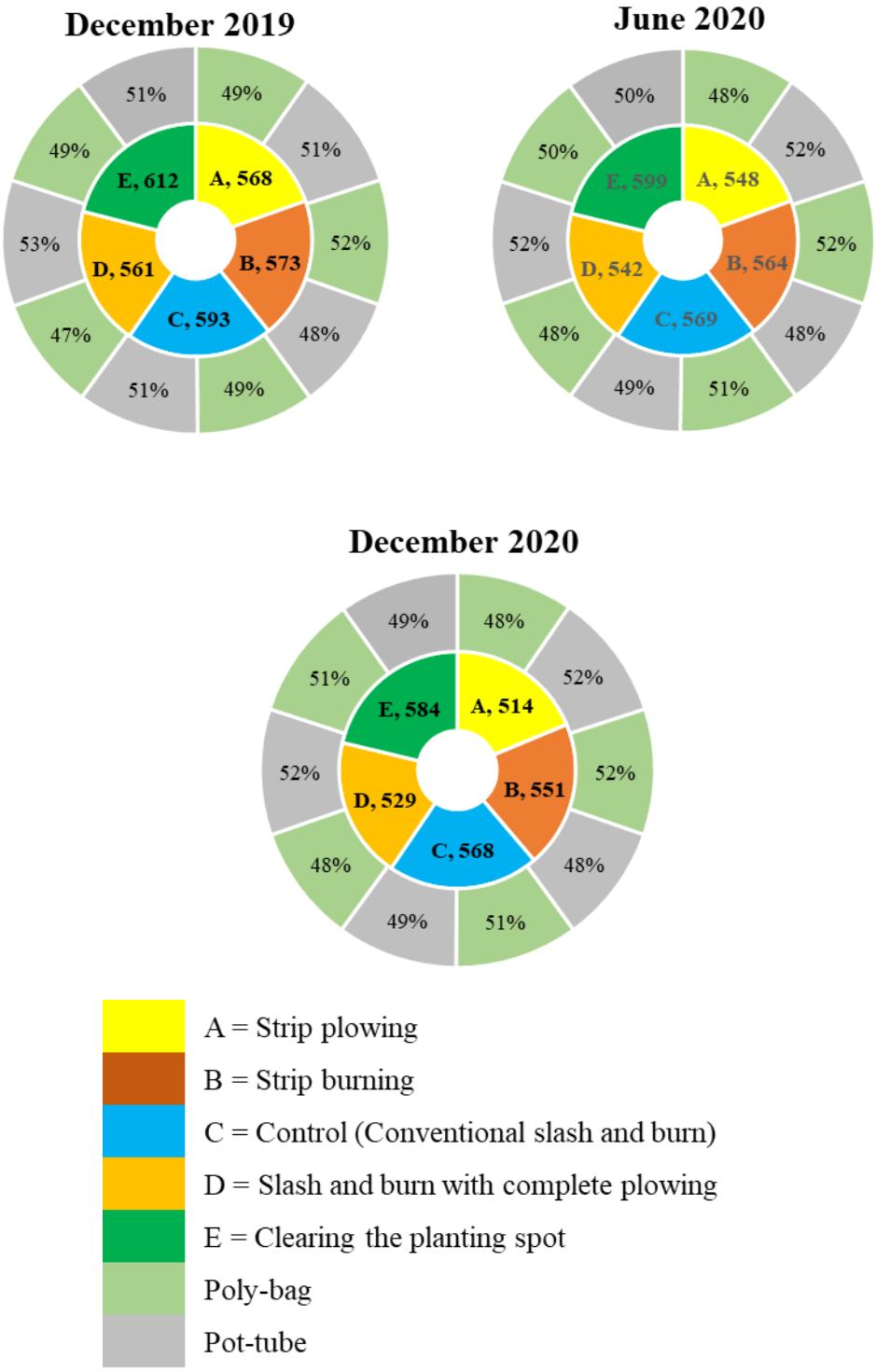


Figure 7. Survival percent of planted tree based on different planting stocks

5. Discussion

Site preparation improved plant survival and growth at the early stage of plantation. Site preparation may lead to multiple interactions among soil physical and chemical properties that affect plant survival and growth. But, site preparation for reforestation or afforestation is difficult to implement accurately, although it is easier if topography does not vary greatly (Lui 2016). However, the benefits of site preparation appear to be more obvious in the early years of growth, and they often decrease over time, with growth rates coinciding with non-prepared sites by the end of the rotation (Passauer, 2013 and Fox, 2005). The study investigate the effect of site preparation such as strip plowing, strip burning, slash & burn, slash & burn with complete plowing and clearing the planting spot. After second years growing season, teak growth (height) in slash and burn plots and slash and burn with complete plowing plots showed significantly higher than other plots. Thus, clear-felled treatments (slash & burn and slash & burn with complete plowing) were the effective method for stand establishment of teak. It may be due to the fact that cleared-fell and burning treatment reduce the ground vegetation. The result supports the statement of Karlsson (2002), he mentioned that site preparation promotes the early establishment and growth of crop trees by reducing competition from ground vegetation (Karlsson, A 2002). Moreover, the planted tree might less compete with weed and get sufficient light. It corresponds with Liu (2016) findings. He found that, in the clearing site, the trees growth well because they outcompeted other trees for light. Several studies indicated that tree growth releases mostly take place during the juvenile phase because of competition for light (Brienen, 2006 and De Ridder 2013).

When the site preparation methods categorized into burning and without burning, the burning plots (slash & burn, slash & burn with complete plowing) provided the better growth performance. Because slash & burn and slash & burn with complete plowing treatments cleared undesirable ground vegetation before plantation establishment and provide favorable condition for teak seedlings. This study result is comparable with Miller (2009) statement. He stated that various site preparation treatments should applied at stand initiation to reduce competing vegetation and improve crop tree growth. Mahmud's stated that zero burning is an environmentally friendly technique which helps safeguard the environment from air pollution. But in this study, teak growth in burning plots provide better than no burning plots. In case of survival rate, this study indicated that site preparation was not effect to survival percent of planted tree.

This study also examined the growth response of different planting stocks (polybag seedlings and pot-tube seedlings). In each site preparation treatment, different teak planting stocks were planted. After second years of transplanting in the field, it was found that the teak growth was affected by planting stocks**.** The growth of teak raised by polybag was significantly higher than teak raised by pot-tube. Seedlings container type may be one of the factors that effect on tree growth in outplanting phase. The container size are different polybag seedlings (7 inches x 3inches) and pot-tube seedlings (5 inches x 1.5 inches). Jacobs (2017) found that the container types showed a few different the plant growth responses at both in nursery and one year after outplanting. But Khurram S et al. (2017)'s report that in the outplanting phase, container type did not impact seedlings height and diameter growth of

tree species. Although the first year following planting represents the critical establishment period, one or two year may have been insufficient to observe treatment effects, Grossnickle (2005).

At the time of planting, in June 2019, one year old seedlings raised by different nursery practice (polybag and pot-tube) were planted in all experimental plot. After two years going season, polybag seedlings growth was higher than pot-tube seedlings after transplanting in the field. In all site preparation treatment, the growth of teak raised by polybag was significantly higher than teak raised by pot-tube. It might be due to the seedlings height different at the time of plantation establishment. Even though this study used one year old seedlings, the height of poly bag seedlings was much higher than pot-tube seedlings at the time of planting. In term of annual growth increment, polybag seedlings resulted in almost threefold height increment within one year while pot-tube seedlings resulted in almost fourfold height increment. The mean annual growth rate of different planting stocks are 1.60 m/years for polybag seedlings and 1.67 m/year for pot-tube seedlings. Hence the growth rate of pot-tube seedlings was comparable the polybag seedlings. If the annual growth rate of different planting stocks are similar, this result would suggest that use of pot-tube as an alternative container type in production nurseries for incorporation into reforestation and restoration programs.

6. Conclusion

Forest restoration projects have become increasingly common around the world and planting trees is almost always a key component. Low seedlings survival and growth may result in restoration failures and various site preparation practice are important tools used to help counteract this. Site preparation often results in improved seedlings survival and growth. Site preparation may lead to multiple interactions among soil physical and chemical properties that affect plant survival and growth. Limited research to date on site preparation and plantation performance has been conducted. Slash & burn are usually use in restoration program indicating a need for additional site preparation research to provide recommendation in reforestation program. Site preparation should be implemented carefully because they can have large impacts on the environment. Different site preparation may lead to multiple interactions among soil physical and chemical properties that affect plant survival and growth. In order to investigate the long term effect of site preparation on the growth of teak, the research plots were established in 2019. Five site preparation treatment were performed and seedlings from different planting stocks (pot-tube and polybag) are used. After second year growing season, slash and burn resulted in better performance of teak raised by polybag and slash and burn with complete plowing showed better performance of teak raised by pot-tube.

This study also observed that tree growth was affected by different planting stocks. Based on three times measurement (2019 December, 2020 July and 2020 December), it was found that the growth of teak raised by polybag was significantly higher than teak raised by pot-tube. If compare teak height growth between 2019 Dec and in 2020 Dec, polybag seedlings resulted in almost threefold height increment within one year while pot-tube seedlings resulted in almost fourfold height increment. Mean annual growth (height) rate of

teak raised by polybag was 1.60 m/year and teak raised by pot-tube was 1.67 m/year. This study provide the evidence to suggest that use of pot-tube as an alternative container type in production nurseries for incorporation into reforestation and restoration programs since pot-tube seedlings offers several benefits such as being able to transported considerable distance and being easy and quick to plant. Many developing countries are concurrently facing severe environmental problems that can be ameliorated by planting trees in restoration projects (Bewket W. et al 2005). In addition to providing an effective means to produce high quality seedlings for reforestation, use of pot-tube as nursery containers will reduce consumption of plastic and provide a commendable alternative for waste management. But seedlings producers should consider how pot-tube could be incorporated into their existing facilities, available resources, and seedlings handling and storage methods and it is recommended that further research on cost benefit analysis, forester's perception and long term effect on plantation should be conducted. Further comparative studies of different species in different region are needed for a deeper understanding of the effect of planting stocks after transplanting in the field.

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