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Preliminary Study on Effective Planting Techniques for Teak

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ကျွန်းစိုက်ပျိုးရာတွင်ကောင်းမွန်ထိရောက်သောနည်းလမ်းများကို ပဏာမလေ့လာတင်ပြခြင်း

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(Göttingen, Germany) ၊ တောအုပ်ကြီး
သစ်တောသုတေသနဌာန၊ရေဆင်း။

စာတမ်းအကျဉ်းချုပ်

ကျွန်းစိုက်ခင်းများကို အထူးစီမံကိန်းတစ်ရပ်အနေဖြင့် အရှိန်အဟုန်မြှင့်တည်ထောင်လျက်ရှိရာ စီးပွားရေးအရ တွက်ခြေကိုက်ပြီး ထိရောက်အောင်မြင်သည့် နည်းလမ်းများကို ရှာဖွေ ဖော်ထုတ်နိုင်ရန် လိုအပ်ပါသည်။ ဤလေ့လာမှုကို သစ်တောသုတေသနဌာနမှ စီမံအုပ်ချုပ်နေသော ငလိုက်ကြိုးဝိုင်း အကွက် အမှတ်(၉)တွင် ပြုလုပ်ခဲ့ပါသည်။ ပဏာမလေ့လာ တင်ပြခြင်းအနေဖြင့် ကျွန်းစိုက်ခင်း တည်ထောင်ရာတွင် သိုလှောင်ငုတ်တက်ဖြင့် စိုက်ပျိုးခြင်းသည် လတ်ဆတ်ငုတ်တက်နှင့် ပျိုးပင်စိုက် စိုက်ပျိုးခြင်းတို့ နှင့် နှိုင်းယှဉ်လျှင် အမြင့်ကြီးထွားမှုဌ ထူးခြားစွာကောင်းမွန်ကြောင်းကို တွေ့ရှိရပါသည်။ ရှင်သန်မှုတွင် ထူးခြားစွာကွာခြားမှုမရှိပါ။ ဤစာတမ်းတွင် အထက်ဖော်ပြပါ ကျွန်းစိုက်ခင်းတည်ထောင်ခြင်း နည်းလမ်း(၃)မျိုး၏ ရှင်သန်မှုနှင့် အမြင့်ကြီးထွားမှုများကို နှိုင်းယှဉ်တင်ပြထားပါသည်။ ထို့ပြင် ကျွန်းငုတ်တက်သိုလှောင်ခြင်း နည်းလမ်းကိုလည်း တင်ပြထားပါသည်။

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Abstract

As teak plantations are being established with increasing momentum in Myanmar as a special programme, it is felt that economically effective means and ways should be found for successful establishment. This study was conducted in compartment No.(9) of Ngalaik Reserved Forest managed by Forest Research Institute. As a preliminary step, stored stumps planting is significantly better in height growth as compared to those of fresh stumps and seedling plantings. Nonetheless survival percentages among them is not significant. In this paper, the comparisons of survival and height growth between the above mentioned three methods are also described and storage technique for teak fresh stumps is also presented.

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1. Introduction

Commencing from 1998, teak plantations are being extensively established as a special project to fulfil the socio-economic needs of the country. These plantations should be accomplished silviculturally and economically. In Myanmar, the establishments of teak plantations have been tried in several ways such as direct seeding, transplanting, fresh stump planting and stored stump planting. To find out the suitable environmentally sound technique for teak planting in a particular locality is the critical duty of the Forest Department.

In temperate countries, there have been some experiences on stump planting of Cornifer species since 70 years ago. Stumps were carefully prepared mixed with sawdust and husk, then stored in the cold chambers with the temperature ranges of -2°C and +2°C. Storage period was from 20 to 200 days and success was gained in plantation establishment. (HOCKING and NYLAND 1971, quoted in U KHIN HLAING 1982.)

In 1974, LOURIDSON and KAOSAARD also tried teak fresh stump storage using sand, husk and sawdust as buffer between the stump bundles. The stumps were stored in the concrete pits for about 5-9 months and then planted in low and high rainfall areas. It was found that the plantations developed successfully and satisfactorily. (U KHIN HLAING 1982).

As the first step, a teak plantation with different techniques including transplanting, fresh stump and stored stump planting followed by digging and fertilizer application was established in a natural forest managed by Forest Research Institute. In coming years, similar plantations will also be established again in the special teak plantation programme areas to provide applicable information and concrete data to the local staffs of the Forest Department.

2. Objectives

- to document the variation in survival percentage, growth rate and responses of teak by establishing the plantation with three different planting techniques
- to provide some useful and applicable information for the special teak plantation programme
- to present some factors relevant to raising environmentally friendly and economically successful teak plantations

3. Study Area

The study area is located in compartment No. (9) of Ngalaik Reserved Forest. It is also one of the five reserved forests managed by Forest Research Institute in Yamethin District. It is a rather flat and ploughed area with sandy clayey loam texture. It is approximately situated at 19º96' N and 95º56' E. It is situated near the fringe of dry zone and is also part of the Bago Yoma range.

3.1 Forest Type

Climate and soil are the determining factors for the formations of different forest types. According to the classification of tropical forests based on temperature and rainfall, the study area is classified as a slightly moist deciduous type. This classification (quoted in HANS LAMPRECHT, 1989) is shown in appendix III.

3.2 Climate

The study site lies within the area surrounding the central dry zone, which is influenced by tropical savannah climate with a pronounced dry period between the monsoon rains. According to the climatic data of 1970-1999, the number of rainy days is found to be around 90.

Table.1 The climatic data (monthly means) and DE MARTONNE'S aridity index of the Pyinmana Township.

Month	Jan	Feb	Mar	Apr.	May	June
Temperature (°C)	22.7	25.1	28.6	30.9	30.6	27.8
Rainfall (mm)	3.3	4.6	2.2	13.0	111.8	211.4
Aridity Index	1.2	1.6	0.7	3.8	33.1*	67.1*

Month	July	Aug	Sep.	Oct.	Nov.	Dec.	**Year**
Temperature (°C)	27.6	27.3	28.1	28.1	25.8	23.9	**26.9**
Rainfall (mm)	200.5	245.0	147.4	111.7	63.5	10.9	**1329**
Aridity Index	64.1*	78.8*	46.4*	35.2*	21.3*	3.8	**37.7**

Source: The meteorological station, Pyinmana

(*) Indicates the month with the aridity index larger than 20

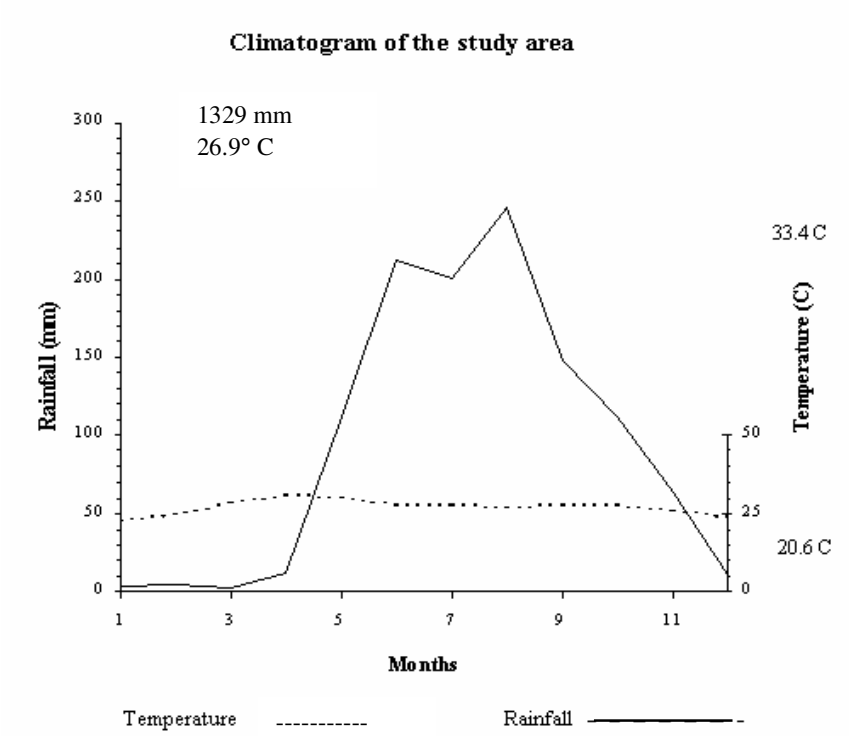

Figure 1. Climatogram of the Study Area

DE MARTONNE's Index (quoted in THAN SOE OO, 2000) is calculated by:

$a_y = N\ (mm)/T_y + 10$ (yearly)
$a_m = 12\ n/T_m + 10$ (monthly)
Below 20 = arid

Where, N (mm) = mean annual rainfall (mm)
n = mean monthly rainfall (mm)
T_y = mean annual temperature (°C)
T_m = mean monthly temperature (°C)

3.3 Soil

The soils are mostly yellow brown forest soil of tropical monsoon forests (ROZANOV, 1965 qouted in BENDER 1983), and belong to the group of Xanthic Ferralsol (F.R.I Yezin). Soil samples of the study site were taken and analysed at Forest Research Institute. The data related to the dry weight of the soil samples are given in the table.

Table 2a. Physical properties of the soil samples of Ngalaik Reserved, Compartment No. (9). (extractable nutrient in percentage of dry weight)

Texture	Depth (cm)		
	0-10	40-50	80-90
Sand % (Average)	73.61	72.38	72.13
Silt % (Average)	13.33	13.29	12.43
Clay % (Average)	9.76	11.00	12.06
Remark	Sandy loam	Sandy loam	Sandy loam

Table 2b. Chemical properties of the soil samples of Ngalaik Reserved, Compartment No. (9). (extractable nutrient in percentage of dry weight)

Texture	Depth (cm)		
	0-10	40-50	80-90
pH	6.05	6.09	6.14
P %	0.000161	0.000123	0.000126
Total N %	0.0447	0.0503	0.0535
K %	Not Available	Not Available	Not Available
Organic matter % (Av)	3.30	3.33	3.38

4. Material And Methods

4.1. Site selection

The site was selected in the abandoned fallow area of slightly flat plain. Experimental plot covered 4.3 ac in Compartment No. (9) of Ngalaik Reserved Forest.

4.2. Experimental Design

Split Plot Design with four replications was adopted for the experiment. Following lists are materials for the experiment:

- Potted seedling (P)
- One year old fresh stump (F) and,
- Stored stumps from one year old seedling (S)

Another two treatment factors, digging and fertilization were also applied to the young seedlings. Treatment plots were laid down according to the design employed and one block consisted of three plots for each treatment. Each treatment included 49 trees with 9' x 9' spacing. Treatment plots were detached 18' wide so as to avoid mixing the plots and to differentiate one treatment plot from the other. Treatment and replication number of each plot was uniquely numbered serially as shown in figure 2.

Layout

Fertilization / Digging				
	no / no	no / yes	yes / yes	yes / no
	P - -	**S** - Dig	**F** Ferti Dig	**P** Ferti -
	F - -	**P** - Dig	**S** Ferti Dig	**F** Ferti -
	S - -	**F** - Dig	**P** Ferti Dig	**S** Ferti -

Replication I

Fertilization / Digging				
	yes / no	yes / yes	no / no	no / yes
	F Ferti -	**S** Ferti Dig	**P** - -	**F** - Dig
	P Ferti -	**F** Ferti Dig	**S** - -	**P** - Dig
	S Ferti -	**P** Ferti Dig	**F** - -	**S** - Dig

Replication II

Figure 2: Layout of the design selected

4.3. Nursery practice

Seedlings required for the experiment were raised in the permanent nursery of the Forest Research Institute as in that of the special teak plantation programme being implemented by the Forest Department.

4.3.1 Seed collection

Teak seeds from Yanpe Reserved Forest of Taungtwingyi Township were collected to raise seedlings for the experiment.

4.3.2. Seedling

To raise the potted seedlings, teak seeds of the same provenance were used.

4.3.3. Fresh stumps

One-year-old seedlings were raised in this permanent nursery. Stump cutting was carried out one day before planting out. Seedlings reached 2-3 feet height and the diameter 0.3-0.5 inch. Stumps were cut 2-3 inches length above the root collar and 4-6 inches below it.

4.3.4.Stored stumps (Technique for teak stump storage)

One-year-old seedlings were also raised in the same nursery to store the teak fresh stumps in the pit. The cutting was made in February. That means it must be completed at the time of leaf shedding and before new shoots come out from the seedlings raised. The size of stored stumps was the same as that of fresh stumps.

These stumps were stored in bundles of 45-50 stumps in a pit of 4' x 4' x 4'. The bundles were stored layer by layer and there was a 4" thick layer of river sand between the layers of the bundles of teak stumps.

The pit was kept away from the direct sunlight and direct contact of water so as to avoid the infection of fungus. Temperature was recorded daily at 14:00 and maintained under 35°C so as to avoid extreme temperature.

4.3.5. Trial site preparation and layout of experimental design

Although the experiment was aimed to provide some applied information for the field work practiced in the special teak plantation programme, taungya cutting and burning could not be done as the selected site was an abandoned fallow land, but other operations were as in the planting schedule of taungya operation.

As mentioned above there were gaps of 18 feet width between the treatment plots. After site preparation, the design was laid down with different sizes of marked stakes. Plot pillars were set up at every corner of each treatment plots and they were blazed at the upper part of the posts facing the plot. Type of treatment and replication numbers opposite to the plot were also marked on the blaze.

4.3.6 Planting

Planting of seedlings, fresh stumps and stored stumps was completely done between 8th and 9th June 2001 according to the design selected.

4.3.7 Weeding and fertilization

Two times of spot weeding and fertilizer applications were carried out and the former was done in June and August together with patching, and the latter in June one week after planting and in October. Chemical fertilizer of N: P: K (8:16:9) was also applied two times to the plots according to the design mentioned in the publication "From seed to trial establishment" by CSIRO, Division of Forestry, Australia.

5. Results

The respective survival and growth rate of trees planted according to the design selected were recorded 8 months after planting and the data obtained were analyzed using Genstat statistics program. The results obtained are given in appendix I.

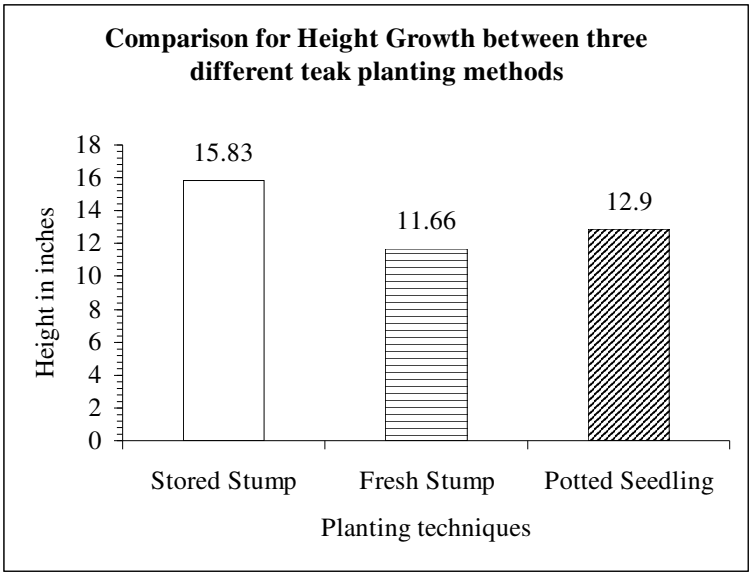

Figure 3. Comparison for Height Growth among three different teak planting methods

According to the Genstat ANOVA table (Appendix II), the standard error of mean of heights between three planting materials is 0.882 leading to an L.S.D of 0.882 $t_8 = 2.96$, and so stored stump planting is much better in height growth than that of potted seedling and fresh stump. It can also be seen clearly in the diagram (figure 3).

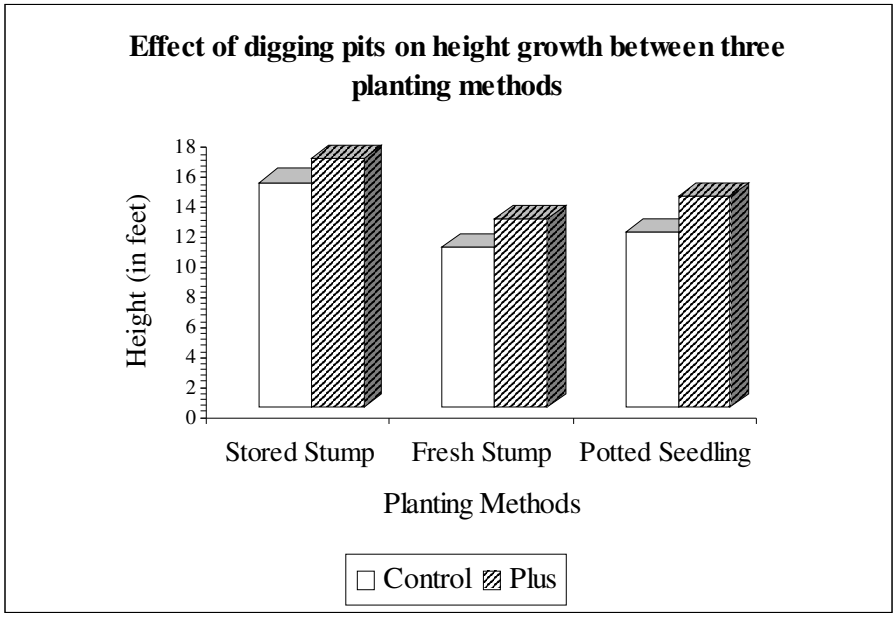

Figure 4. Comparison for Height Growth among different treatments by digging pit

Influences of digging pit and control treatment upon height growth were also tested five months after planting and statistical analysis shows no significant difference. Average height of trees planted in pits can be seen in appendix II. Again growth responses on fertilizer application among the planted are also tried and the average height of trees among the three methods is compared. It also shows no significant differences.

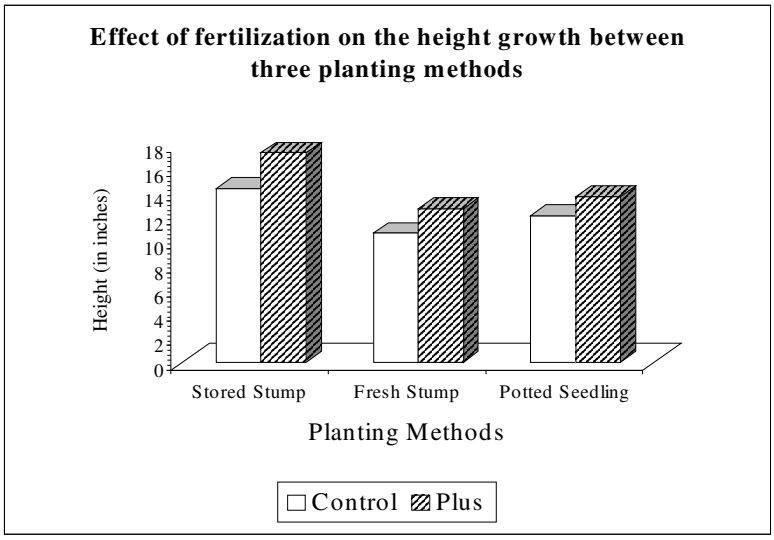

Figure 5. Comparison for Height Growth among different treatments by fertilization

Generally, it may be said that digging and fertilization may have only slightly better growth rate than that of control treatment, but no differences shown between them.

According to the Genstat ANOVA table shown in the appendix II, the standard error of difference for survival percentage between three planting techniques is 5.39 leading to an L.S.D of 18.08, $t_8 = 2.98$. Seedling planting is much better in survival percentage than that of stored stump planting. But there is no significant difference between survival percentage of seedling and fresh stump planting.

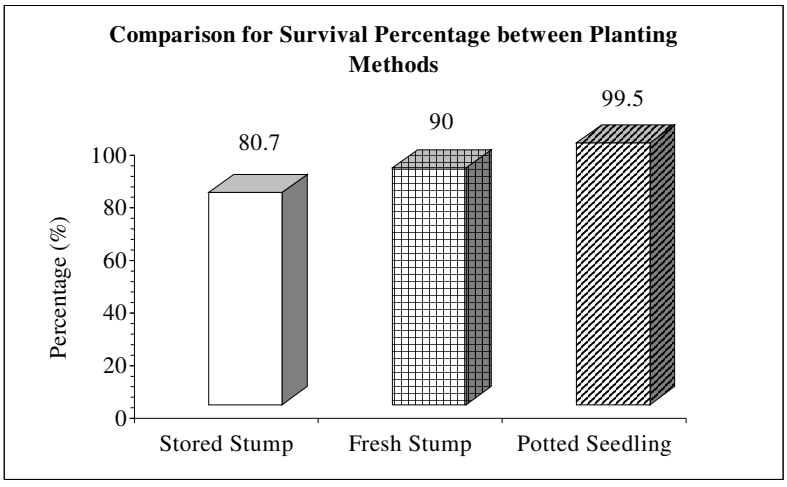

Figure 6. Comparison for Survival Percentage between different treatments on teak planting methods

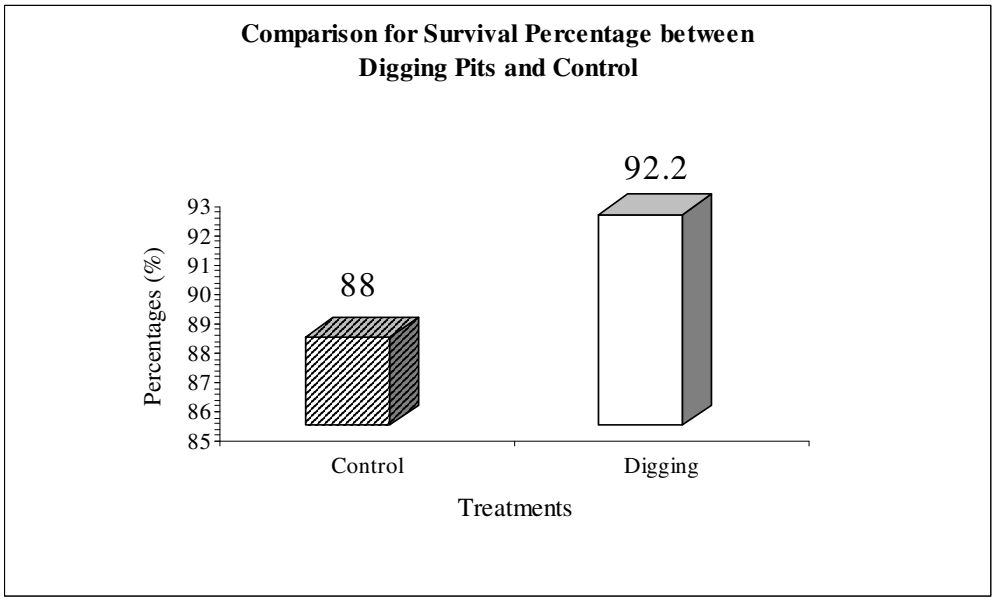

Figure 7. Comparison for Survival Percentage between digging and Control among different treatments on teak planting methods

Although planting in pits and fertilization have no significant effect on the amount of survival percentage, they seem to provide a slightly higher rate of survival for the plants. Two figures shown above represent the respective survival rate of the different materials and of digging pits and fertilization.

6. Discussion

Teak is a strong light demander and big deciduous tree species, taproot deep and stout. It can be established by direct seeding, transplanting, stump planting (fresh and stored stumps and pre-sprout stump planting). Pre-sprout stumps were prepared 4 to 6 months in advance (in or around February) and put in containers on a raised platform in shade and watered daily. These stumps after sprouting were then planted at the onset of monsoon to give satisfactory results (MISHRA 1958, quoted in TEWARI 1992).

Here, three methods, transplanting, fresh stump and stored stump plantings are tested and their respective growth and survival percent are examined so as to obtain concrete data for the establishment of successful teak plantation, both ecologically and economically. There were 4 blocks for the split plot design adopted. Of the initially adopted 4 blocks, only two were included in the data analysis because stored stumps planted in two remaining blocks were affected by fungus infection. Notwithstanding, it is very important to provide and disseminate applicable data for the special teak plantation as much as possible. Further study concerning with establishment of teak plantation will be carried out in the next year at least with four replications in other localities such as high rainfall areas and low rainfall areas to get more precise data.

(a) Potted seedling

By checking out the ANOVA tables and histogram shown above, it is very reliable on survival percentage which is the highest as compared to the other two methods. As regards height growth, it also stands in the second position being a little higher than the fresh stump and lower than that of stored stump.

In our country, seedling planting is favoured because of its high survival percentage and reducing patching cost consequently. If the site is favorable for teak with conditions such as good drainage, sandy loam soil and being native and near to the nursery, seedling planting gives satisfactory results.

Another factor to be considered is its highest transport charges. It is because one bullock cart can carry 250 - 300 seedlings at a time and two labourers will be required for loading and unloading seedlings from the nursery to the planting sites. And also one labourer can carry 20 - 25 seedlings at a time to plant. For this reason, much more labourers will be required to complete planting than those of stump planting. Comparison of total cost for planting operation is shown in the appendix 1.

(b) Fresh Stump

Usually it is suggested that fresh stump planting should be carried out in high rainfall areas because of its reliable survival percentage. In areas of lower rainfall (45" - 60") early planting is a failure. The earliest date for safe planting in areas of 80" rainfall down to 60" should be taken around 15th May i.e., a week to ten days before the normal break of rains. In the famous plantation at Nilumbur in Southern Indian early stump planting in April is normal practice and produces excellent results. (Plantation & Silviculture Lecture Note, Third Year)

In this experiment, all types of planting were completed on 8th and 9th June because climatogram of the study area showed that late May and early June were found to be with reliable shower. Therefore, survival percentage and average height growth of fresh stumps planted were 90% and 11.6" respectively at the age of 6 months. As compared to the total cost of planting operation of seedling, the cost of stump planting is much lower,

especially in transport charges. Although the initial cost of raising seedlings to prepare stumps is almost equal to that of the transplanting, seedlings germinated from dormant seeds in the seedbeds can also be used for fresh and stored stump planting in the next year. But it is not totally reliable and may provide seedlings enough only for patching.

(c) Stored Stump

If teak stumps can be stored properly, stored stump planting gives satisfactory results as compared to that of fresh stump planting and transplanting. Because of fungus infection, mismanagement in storage can lead to the poorest survival percent. Its survival percentage is found to be down to 33% (U Mehm Ko Ko Gyi et. al 1983) under unfavorable conditions. For stumps which had been stored properly and carefully planted at the right time, very high survival percentages were observed; 94.5% on ridge, 96% on slope and 96% on rather flat plain respectively. The results of comparison of heights and survival percentages between transplanting, fresh stump planting and stored stump planting observed by U KHIN HLAING (1982) are shown in table 3.

Table 3: Comparison of survival and height between different planting techniques

Planting Technique	Ridge Top		Ridge Slope		Flat plain	
	Mean Ht (ft)	Survival %	Mean Ht (ft)	Survival %	Mean Ht (ft)	Survival %
Seedling	1.7	97	2.5	97	2	98.5
Fresh Stump	1.35	63	1.6	64	1.7	71
Stored Stump	3.1	94.5	3.2	96	4.1	96

Source: U KHIN HLAING (Director-Plantation, 1982)

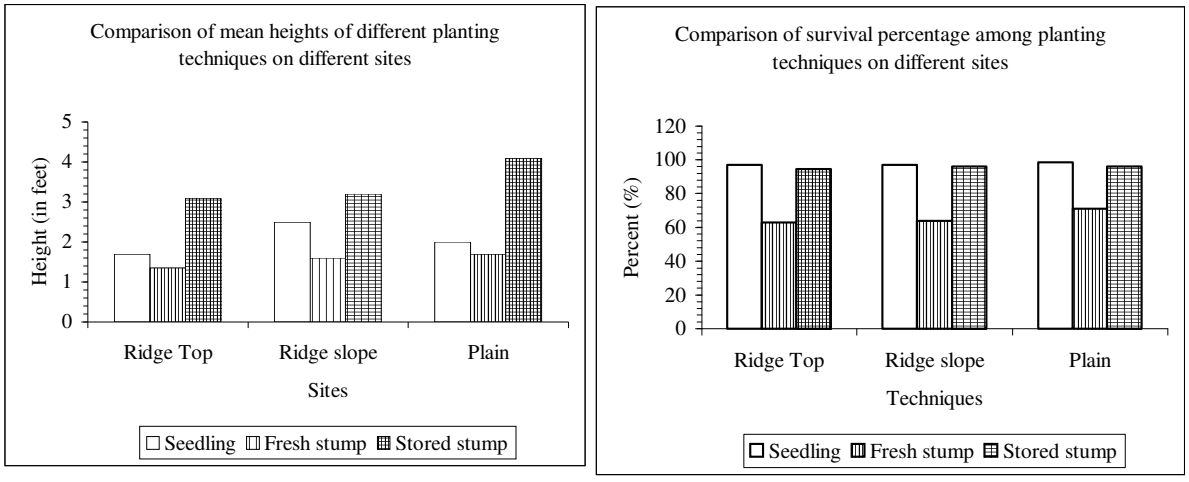

Figure 8: Comparison of height growth and survival percentage among three planting techniques on different sites.

According to the table and diagram shown above, it can be clearly seen that stored stump gives higher growth rate as compared to that of fresh stump and seedling plantings. Its survival is also found to be very satisfactory. Proper management of teak stump storage is essential to protect fungus infection. Its height growth can suppress weed at the year of establishment and reduce the weeding costs. It can compensate the cost for preparing and storage of teak stumps. Stored stumps, if survived and established, show best height growth as compared to that of any other planting sources.

7. Conclusion and Suggestion

Seedling should be planted where the site is near to the nursery. Although its initial cost for raising at nursery is more or less equal to stump planting, transport charge is much higher than stump planting. Therefore, seedlings should be raised only for the purpose of patching because of its reliable survival percentage.

Fresh stump should be planted where the rainfall is high. The drier the site, the lower its survival percentage. In this experiment, its survival percentage is found to be satisfactory as the site selected is a rather flat plain with sandy loam. At the time of planting, 8th and 9th June, soil was moist enough after the break of rain. The climatogram for a particular place should be set up before planting operations begin. The condition of local climate in accord with rainfall and its patterns, temperature and relative humidity of a particular site is the prerequisites for planting operations, especially for fresh stump planting.

As discussed above stored stump planting gives the best height growth and can overcome weed competition. But, the controversial point for stored stump planting is fungus infection when the stumps were not properly stored in pits. To find out means and ways for proper techniques of stump storage is critical. After achieving the best method, teak plantation should be established by using stored stumps because of its best height growth and satisfactory survival percentage on different site conditions. (See table 3)

"This method is not widely used in Myanmar. Stored stump planting has the following advantages as compared to the other two planting techniques i.e., transplanting and fresh stump planting.

- ☞ Getting enough time to carry out plantation operations starting from seed collection to planting
- ☞ Better growth and higher survival percentage than that of the other two methods because more starch and sugar for tree growth have been stored in stump before sprouting
- ☞ Higher resistance to drought as compared to fresh stump, consequently it can be planted in slightly low rainfall areas." **(အောင်မြင်သောစိုက်ခင်းတည်ထောင်ရန် အကြံပြုတင်ပြချက်၊ ဒုတိယအကြိမ်၊ ၂၀၀၁ မတ်လ)။**

This study is just a preliminary step and further similar studies will be carried out in different localities with different rainfall conditions.

Appendix I

Establishment Costs for Teak Experimental Plot under Different Planting Methods

Calculations for all the planting methods were made for 9' x 9' spacing

1. Planting with potted seedlings

Seedlings required for experimental plot	=	784
27% surplus for patching and damages caused during transportation, etc.,	=	212
		996
Therefore, seedlings needed for experimental plot	=	1000
Cost for making one seed bed = 1 x 100	=	100 Kyats
[(25' x 4') seed bed can be completed by one man/day]		
Cost for using bamboo for transplant bed = 1 x 100	=	100 Kyats
Cost for teak seed pretreatment and raising at nursery (one man/day/seed bed) = 1 x 100	=	100 Kyats
Cost for sand needed for one seed bed (50 cu ft/seed bed) = 1 x 400	=	400 Kyats
Cost of teak seed for one seed bed = 3 x 62.5	=	187.5 Kyats
(3 Pyi of seed can be sown in one seed bed)		
Required soil mixture by volume for (1000) seedlings		
3.14 x 1.5/12 x 1.5/12 x 7/12 x 1000	=	28.62 cu ft
20% surplus	=	5.724 cu ft
Required soil mixture	=	34.34 cu ft

Soil mixture ratio = 6 forest soil: 1 sand: 2 manure by volume

$$\text{Forest Soil} = \frac{34.34 \text{ x } 6 \text{ x } 600 \text{ Kyats}}{9 \text{ x } 100} = 137.36 \text{ Kyats}$$

$$\text{Soil} = \frac{34.34 \text{ x } 1 \text{ x } 800 \text{ Kyats}}{9 \text{ x } 100} = 30.52 \text{ Kyats}$$

$$\text{Manure} = \frac{34.34 \text{ x } 2 \text{ x } 1300 \text{ Kyats}}{9 \text{ x } 100} = 99.20 \text{ Kyats}$$

Cost of soil mixture 267.08 Kyats

Cost for filling soil mixture into the plastic bags (500 bags/1 man/day)

$$\frac{1000 \text{ x } 100 \text{ Kyats}}{500} = 200 \text{ Kyats}$$

Appendix I

Cost of watering the seed bed	= 1500 Kyats*
Cost of transplanting ……= 1000 x 100/500	= 200 Kyats
(500 seedlings/man)	
Cost of watering teak seedlings, patching, weeding and cutting (1 bed/1 man/ 3 months) = 1 x 3 1500	= 4500 Kyats
Cost for purchasing thatch for shading: 20 Nos. of thatch for transplant bed (25' x 4') are needed 20 x 10	= 200 Kyats
Cost for plastic bags (3" x 7") 1000 x 0.75 Kyats	= 750 Kyats
Total cost for preparing 1000 seedlings	= 8504.58 Kyats
Say, for one potted seedlings	= 8.50 Kyats
Charge for hiring the carts to transport the seedlings to the site to be planted (6 carts followed by two labourers for loading and unloading the seedling bags)	
700 Kyats x 6 carts	= 4200 Kyats
12 labourers x 100 Kyats	= 1200 Kyats
Cost for planting (8 labourers x 100 Kyats)	= 800 Kyats
Total cost for transporting and planting 1000 seedlings	= 6200 Kyats
Say, for one potted seedlings	= 6.2 Kyats
Therefore, total charge for preparing and complete planting of one seedling	**= 8.50 + 6.2 Kyats**
	= 14.70 Kyats

2. Stump Planting

Number of stumps required for experimental plot	= 1568
27% surplus	= 424
	= 1992 (say 2000)
Total number of stumps both for fresh and stored stumps	= 2000 stumps
One seed bed (25' x 4') can produce 200 stumps	
Cost of making nursery bed ----------10 beds x 500	= 5000 Kyats
Cost of sowing = 5 x 1 x 100 (two beds/1 man/day)	= 500 Kyats
Cost of teak seed = 20 Pyis x 62.50	= 1250 Kyats
Cost for watering & weeding of one year old seedling	
(1500 x 1 labor x 6 months)	= 9000 Kyats

* A man can water at least 10-12 transplant beds daily.

Appendix I

Cost of preparing 2000 stumps (13 labourers x 100 Kyats/day)	= 1300 Kyats
Cost of 2000 stumps until preparation	= 17050 Kyats
Cost of one stump	**= 8. 52 Kyats**
Cost of transportation by cart (1 x 700 Kyats)	= 700 Kyats
Cost of planting (8 men* x 100 Kyats)	= 800 Kyats
Total cost of transporting and planting for 2000 stumps	= 1500 Kyats
Cost of one stump	= 0.75 Kyat
Cost of one stump (Production + planting)	**= 9.27 Kyats**

3. Stored Stump Planting

Cost of routine stump (one year old) planting	= 9.27 Kyats
Cost of digging a pit (3' x 3' x 3½')	= 500 Kyats
Shed Construction	= 500 Kyats
(40) Thatch x 10 Kyats	= 400 Kyats
Cost of bamboo and posts (2 men/day)	= 200 Kyats
Cost of sand (50 cu ft x 800 Kyats) (800 Kyats in 100 cu ft)	= 400 Kyats
Cost for putting in and taking out the stumps (2 men/day)	= 400 Kyats
Cost of storage 1000 teak stump in the pit	= 2400 Kyats
Cost for storage of one stump	= 2.4 Kyats
Cost of one stored stump (production + storage + planting)	**= 11.67 Kyats**

* One labourer can at least plant 250 stakes in one day.

Appendix II

Identifier	Minimum	Mean	Maximum	Values	Missing
v[1]	9.20	13.46	20.00	24	0
v[2]	60.00	90.08	100.00	24	0 Skew

Identifier	Values	Missing	Levels
repl	24	0	2
mainpl	24	0	4
subpl	24	0	3
dig	24	0	2
ferti	24	0	2
material	24	0	3

Analysis of variance

Variate:v[1]; ht-height in inches

source of variation	d.f	s.s.	m.s.	v.r.	F pr.
repl stratum	1	86.792	86.792	13.04	
repl.mainpl stratum					
Pit	1	22.504	22.504	3.38	0.163
Ferti	1	28.952	28.952	4.35	0.128
pit.ferti	1	0.086	0.086	0.01	0.916
Residual	3	19.966	6.655	2.14	
repl.main.subpl stratum					
Material	2	73.319	36.695	**11.78****	**0.004**
material.pit	2	0.492	0.246	0.08 ns	0.925
material.ferti	2	1.896	0.948	0.30 ns	0.746
material.pit.ferti	2	3.501	1.750	0.56 ns	0.591
Residual	8	24.895	3.112		
Total	23	262.403			

** highly significant at 1% level

ns not significant

* MESSAGE: the following units have large residuals

repl 1	mainpl 1	subpl 3	2.15	s.e	1.02
repl 2	mainpl 1	subpl 2	- 2.15	s.e	1.02

***** Tables of means *****

Variate: v[1]; ht- height in inches

Grand mean 13.46

dig	None	plus
	12.49	14.43

ferti	None	plus
	12.36	14.56

Appendix II

material	stored stump	fresh stump	potted
	15.83	11.66	12.90

dig	No	no	plus	plus
ferti	No	plus	plus	no
	11.33	13.65	15.47	13.65

dig material	No	plus
stored stumps	15.03	16.62
fresh stumps	10.70	12.61
potted	11.75	14.05

ferti material	No	plus
stored stumps	14.35	17.30
fresh stumps	10.64	12.68
potted	12.10	13.70

dig.ferti material

dig	No	no	plus	plus
ferti	No	plus	no	plus
stored stumps	12.95	17.10	15.75	17.50
fresh stumps	9.90	11.50	11.37	13.58
potted	11.15	12.35	13.05	15.05

*** Standard errors of differences of means for height***

Table	Dig	ferti	material	dig.ferti
rep	12	12	8	6
d.f.	3	3	8	3
s.e.d.	1.053	1.053	0.882	1.489
LSD $_{(0.01)}$	8.78	8.78	2.96	8.70
LSD $_{(0.05)}$	4.78	4.78	2.03	4.74

	dig material	ferti material	dig.ferti material
rep	4	4	2
s.e.d.	1.465	1.465	2.072
d.f.	8.46	8.46	8.46

Except when comparing means with the same level(s) of

dig	1.247
d.f	8
ferti	1.247
d.f	8
dig.ferti	1.764
d.f.	8

Appendix II

Analysis of variance

Variate:v[2]; sur-survival in percentage

source of variation	d.f	s.s.	m.s.	v.r.	F pr.
repl stratum	1	704.2	704.2	11.45	
repl.mainpl stratum					
Pit	1	104.2	104.2	1.69	0.284
Ferti	1	88.2	88.2	1.43	0.317
pit.ferti	1	181.5	181.5	2.95	0.184
Residual	3	184.5	61.5	0.53	
repl.mainpl.subpl stratum					
Material	2	1406.3	703.2	**6.05***	**0.025**
material.pit	2	122.3	61.2	0.53^{ns}	0.610
material.ferti	2	30.3	15.2	0.13 ^{ns}	0.879
material.pit.ferti	2	309.0	154.5	1.33 ^{ns}	0.317
Residual	8	929.3	116.2		
Total	23				

* significant at 5% level

^{ns} not significant

***** Table of means *****
Variate:v[2]; sur-survival in percentage
Grand mean 90.1

dig	none	plus
	88.0	92.2

ferti	none	plus
	92.0	88.2

material	stored stump	fresh stump	potted
	80.7	90.0	99.5

material dig.ferti

dig	no	no	plus	plus
ferti	no	plus	no	plus
	92.7	83.3	91.3	93.0

dig material	stored stump	fresh stump	potted
none	79.0	85.0	100.0
plus	82.5	95.0	99.0

ferti material	stored stump	fresh stump	potted
none	84.0	92.0	100.0
plus	77.5	88.0	99.0

Appendix II

dig.ferti material

dig	No	no	plus	plus
ferti	No	plus	no	plus
stored stumps	90.0	68.0	78.0	87.0
fresh stumps	88.0	82.0	96.0	96.0
potted	100.0	100.0	100.0	98.0

*** Standard errors of differences of means for survival percent***

Table	Dig	ferti	material	dig.ferti
rep	12	12	8	6
d.f.	3	3	8	3
s.e.d.	3.20	3.20	5.39	4.53
$LSD_{(0.01)}$	18.69	18.69	18.08	26.45
$LSD_{(0.05)}$	10.18	10.18	12.42	14.41

	dig material	ferti material	dig.ferti material
rep	4	4	2
s.e.d.	7.00	7.00	9.90
d.f.	10.78	10.78	10.78
Except when comparing means with the same level(s) of			
dig	7.62		
d.f	8		
ferti		7.62	
d.f		8	
dig.ferti			10.78
d.f.			8

Appendix III

Climax forest formations in the tropical belt.

General characteristics: Daily thermal regime: daily and annual average fluctuate between 28° and 10°C according to elevation. Occurrence of occasional frost only in high montane forests.

Nomenclature	Physiognomy	Climate a = aridity index acc. to DE MARTONNE T_a = mean annual temperature N_a = mean annual precipitation
1. Moist ever green forests	Evergreen, 3- to multistoried, rich in tree species	No more than 1 month a< 20, N_a> (T+14) cm
a Low elevation	Multistoried, cauliflory. buttresses	Hot (T_a ca. 22-28°C;) N_a> 1800 mm
b. Montane	Generally 3-storied, few buttresses	Temperate (T_a ca. 14-22°C;) N_a> 1400 mm
c. High montane (cloud forest)	3- storied, very rich in epiphytes, tree ferns	Moderately cool and moist (T_a ca. 10-14°C;) N_a> 1200 mm
2. Moist deciduous forests	± many periodically deciduous species, 2-3 storied, rich in tree species	Max. 4 months a < 20, Min. 6 months a > 40: N_a between (T+14) cm and 2 1/2 (T+140 cm)
a. Low land	Rainy season: appearance ± the same as moist evergreen forests	Hot (T_a ca. 22-28°C)
b. Montane	Dry season: at least the upper storey is semi-deciduous, few buttresses, fewer epiphytes	Termperate (T_a ca. 14 - 22°C)
3. Dry deciduous forests	Periodically bare for longer periods, 1-to 2-Dornen-storied, ± poor in species, xeromorphous structure	The length and intensity of the dry season is more decisive than the temperature 6-8 months a < 20, ca. 3 months a> 40 N_a< 2(T + 14) cm

Comments: 1. Although the tropical forest is determined by broad-leaved trees, conifers occasionally occur in all formations (mainly due to extreme soil conditions), in particular Southeast Asia and Central America. Most widespread genera are, among others:

1a: *Agathis, Dacrydium, P. caribacea, P merkusii*

1b: *Abies, Agathis, Araucaria, Cupressus, Dacrydium, Pinus, Podocarpus*

2a: *Callitris, Pinus*

2b: Up to the tree line *Abies, Cephalotaxus, Cunninghamia, Juniperus, Pinus, Podocarpus*

2. Apart from climatic formations, edaphic forest types also occur, e.g. gallery, peaty, fresh water swamp forest, mangrove etc.

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