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Comparative Study on Shoot Formation and Productivity of Teak (*Tectona grandis* Linn.f.) Planted in Hedge Garden

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ကျွန်းခန္တာပိုင်းမျိုးထုတ်ဥယျာဉ်မှအညွန့်ထွက်ရှိမှုနှင့် အမြစ်ထွက်ရှိမှုအားနှိုင်းယှဉ်လေ့လာခြင်း

တင်တင်မူ၊ လက်ထောက်သုတေသနအရာရှိ
ဖြူဖြူနှင်း၊ သုတေသနလက်ထောက် ၂
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

တည်ထောင်ထားသော ကျွန်းခန္တာပိုင်းမျိုးထုတ်ဥယျာဉ်မှ အမြင့်ပေ (၃)မျိုးဖြင့် ဖြတ်တောက်ပြုပြင်မှုပြုလုပ်ပေးပြီး အညွန့်ပိုင်းကိုင်းထိုးမျိုးပွား၍ ကလုန်းစိုက်ခင်းတည်ထောင်မှုကို အထောက်အကူပြုနိုင်ရန် စမ်းသပ်ခဲ့ခြင်းဖြစ်ပါသည်။ အပင်အမြင့်ပေ (၃)မျိုးဖြင့် ဖြတ်တောက် စမ်းသပ်ရာတွင် အမြင့်ပေ (၆၁)စင်တီမီတာတွင် အညွန့်ထွက်ရှိမှု ပိုမိုကောင်းမွန်ကြောင်း တွေ့ရှိရသည်။ ထိုသို့စမ်းသပ်ရာတွင် ထွက်ရှိလာသော အညွန့်ပိုင်းများအား ရေငွေ့ထိန်းခန်းအတွင်း အောက်ခံမြေအမျိုးအစားများဖြစ်သော (၁) မြေဆွေး+သဲ၊ (၂) မြေဆွေး၊ (၃)အုန်းဆံဖတ်တို့တွင် အမြစ်ထွက်ဆေး ဟော်မုန်းများဖြစ်သော အိုင်ဘီအေ၊ ဖာတီစတာ့တို့ဖြင့် စမ်းသပ်ခဲ့ရာ ဤစမ်းသပ်မှုတွင် အောက်ခံမြေမြေဆွေး+သဲ၌ အိုင်ဘီအေ ဟော်မုန်းသည် အမြစ်ထွက်နှုန်းအကောင်းဆုံး တွေ့ရှိရသည်။ စမ်းသပ်မှုပြုလုပ်သော နေရာဒေသများမှာ (၁) လက်ပံခုန် ကျွန်းခန္တာပိုင်း မျိုးထုတ်ဥယျာဉ် (အုတ်တွင်းမြို့)၊ (၂) အမျိုးသားသယံဇာတဖွံ့ဖြိုးတိုးတက်ရေး ကုမ္ပဏီလီမီတက်(ကျောက်တံခါးမြို့)၊ (၃) မြစိမ်းတောင်ညိုကျွန်းခန္တာပိုင်း မျိုးထုတ်ဥယျာဉ် (တိုက်ကြီးမြို့) တို့ဖြစ်ပြီး ရလဒ်အကောင်းဆုံးမှာ အညွန့်ထွက်နှုန်း (၉၈%)၊ အမြစ်ထွက်နှုန်း (၇၆%)များဖြစ်သည်။ ခန္တာပိုင်းမျိုးပွားနည်းတစ်နည်းဖြစ်သော အညွန့်ပိုင်းကိုင်းထိုးနည်းကို လက်တွေ့အသုံးချနည်းစနစ်အား ဖေါ်ထုတ်ဆောင်ရွက်ခြင်းဖြင့် သစ်တောစိုက်ခင်းများ တည်ထောင်ခြင်းလုပ်ငန်းများတွင် လိုအပ်သော အရည်အသွေးကောင်းမွန်သည့် ကျွန်းမျိုးကောင်းမျိုးသန့်ပင် အမြောက်အများ ထုတ်လုပ်ပွားများ ပေးစွမ်းနိုင်ရန် ရည်ရွယ်၍ လေ့လာထားခြင်းဖြစ်ပါသည်။

Comparative Study on Shoot Formation and Productivity of Teak (*Tectonagrandis*Linn.f.)Planted in Hedge Garden

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Abstract

The experiments were carried out to investigate the vegetative propagation by shoot cutting methods for establishment ofteak plantations.The experiments were conducted on shoot cuttings of 1-year-old teak stock plants grown in a Hedge Gardenat three locations.They are (1) Let-pan Khon Research Station (Oak-Twin),(2) NRDC (KyaukTakha)and (3)Mya SeinTaungNyo (Taikkyi).The cuttings were treated with different hormones of IBA (IndoleButric Acid) andFerti-stat and cultured in a moisture chamber for rooting where the relative humidity was maintained at 60-90%with maximum and minimum temperature at 25-30˚C respectively. It was observed that the rooting parameters viz., rooting and sproutingpercent, and mean number of shoots and roots per cutting were significantly influenced by the plant height position and auxin treatment. The highest numbers of roots sprouting were observed in cuttings of branches at a middle positionwhich showed the highest values of (98%) sprouting and (76%) rooting. Furthermore, the interactive effect of medium and auxin treatment on rooting and sprouting response was also found to be significant. Overall, the findings of this investigation suggest that middle branch position in hedge plants and 1000 ppm IBA can be used to induce maximum rooting and to produce high quality planting stock material for clonal forestry program of teak.

Key words: *Tectonagrandis,*Hedge Garden,Shoot cuttings, Rooting media and hormone, Rooting percent

Contents

Comparative Study on Shoot Formation and Productivity of Teak (*Tectonagrandis*Linn.f.) planted in Hedge Garden

1. Introduction

Myanmar has launched a Special Teak Plantation Program since 1998 with an annual plantation target of 8,000 ha in addition to the normal plantation scheme (Myanmar Forest Department 2000). With the private sector coming in a big way into teak cultivation in the 2010s, many intensively managed Teak plantations came into existence. Improved quality Teak seed (fruit) in sufficient quantity is prerequisite for implementing successful facilities are needed to carry of establishment plantation, out seed collection, processing and storage. Alternative to raising seedling from teak seeds in the nursery the Forest Research Institute at Yezin producing cuttings from seedling of selected individuals with desirable characteristics and developing techniques for successful rooting of cuttings from teak seedlings.

Reproduction of tree species by vegetative means is an important aspect for genetic improvement and become necessary to develop quick and economic methods of producing planting material of desired characters. These methods seem to be very useful for multiplication of species and for producing desired clones. Clone planting material is of considerable importance in the practice of forestry because it offers advantage of uniformity of growth and development by eliminating genetic differences between trees and by making immediate availability of superior individuals for plantations. On the other hand, problems like seed collection, ensuring germination and subsequent survival of young seedling for large scale a forestation programme can be circumvented by applying the macro propagation methods. The other gains obtainable through selection and propagation are multiplying the stocks which have developed resistance to insects and provide rapid growth and early flowering of trees. Teak plants can be raised using either seeds (Tewari1992) or vegetative processes (Mascaren has et al. 1993; Husen and Pal 2006). Low percent germination of seeds and production of seedlings affected by several factors (Tewari1992) are the cause of concern to most teak planters.

Considerable efforts have been made to propagated teak by vegetative propagation especially macro propagation methods like cleft grafting, budding, rooting of branch cuttings, stem cuttings and shoot cuttings. This situation has resulted in changes in the basic plantation concept of teak.

Vegetative propagation can play a key role in tree improvement programmes as a means of large-scale multiplication of superior clones or tested plus trees. Shoot Productivity of Teak Hedge Garden and formation of shoot cutting had been conducted the *Ex -situ* and *In-situ* conservation of teak to support the sustainable forest management by the ITTO project PD 270 /04 Rev.2 (F) collaborated with the Forest Department from 2006 to 2009.Teak Hedge Gardens were established of Private sectors and Forest Research Station.

In contrast to propagation by seed (where every individual genetically different from every other), asexual orvegetative propagation involves duplicating (theoretically without limit) genotypes while preserving through mitotic divisions their original genetic make-up, and consequently their individual characteristics. This is essential to ensure the transfer of traits that are under non-additive control, especially those that are of economic importance. Moreover, vegetative propagation is applicable to any individual, even those without fertile seeds, due to immaturity, unfavorable environmental conditions, or other factors. As in other tree species, multiplying teak vegetatively by cuttings is a useful research technique in addition to its obvious application to operational or production activities. Therefore the aim of the present study is to develop a technology for large-scale multiplication of selected superior mature trees.

2. Literature Reviews

Teak vegetative propagation by shoot cutting method can be practically used for establishing clonal seed orchards, avoiding risks of 'illegitimate' clones associated with clonal seed orchards traditionally produced by grafting on unselected stock. Vegetative propagation can also be used to develop timber production populations using bulk or clonal strategies, the pros and cons of which have been documented (Monteuuis, 2000). Clonal propagation by rooted cuttings from wisely selected teak 'plus' trees remains the only way to generate top grade teak timber trees in a reasonable time, counteracting the heterogeneity associated with seedling or even bulk options.

The possibility to mass clonally propagate any mature selected teak trees at reasonable cost, either in nursery or tissue culture conditions, has radically changed the prospects of teak plantations (Monteuuis,1995). The nursery techniques developed initially in Sabah (Malaysia) consist of serially propagating selected teak trees of any age by rooted cuttings under proper mist-system facilities. Average rooting rates of 70 to 80% were obtained from several thousand cuttings collected from mature teak genotypes intensively and properly managed as container grown stock plants. On average 40 rooted cuttings were produced annually per stock plant, corresponding to 600 rooted cuttings per square meter (15 stock plants per square meter). This method has been successfully transferred to various countries of South East Asia, Latin America and Africa.

The results clearly show that of juvenile 1-year-old plantings of teak root easily. It is further evident that treatment with IBA, especially with 1000 ppm concentration, the percentage of rooting and sprouting, as well as growth of roots and shoots can be increased in teak cuttings. Although, promotion of rooting by IBA in teak and other species has been well known (Husen and Pal, 2003b; Husen and Mishra, 2001; Husen, 2002), The bark portion of the wound healed up within 45 days and the entire wound zone of split cutting was overgrown by cambium and healed in about five months after the cuttings were out planted. Meanwhile, the shoot emerging from the axillaries bud had already established itself on the main shoot and, further growth of the propagules was determined by this shoot only. Thus, the growth and wood quality of the trees propagated by split cutting method would be comparable to normal cuttings. Hence, such cuttings can be successfully used for rapid mass production of juvenile clonal planting material of teak.

Traditional teak plantations, managed mostly by state organizations for harvesting in 60-80 years(Ball et al. 2000), are no longer well-adapted to the current needs of private investors looking for the best returns in the shortest possible time. For such investors, the quality and the origin of teak planting stock has become a crucial issue.

3. Objectives

(a) To evaluate the media and Hormones on shoot cutting methods
(b) To access seasonal shoot formation capacity from teak Hedge garden
(c) To support clone plantation programmes by genetically improved materials

4. Materials and Methods

4.1. Experimental site

The experiments were conducted at three locations such as (1) Letpankhon Station, Oaktwin Township (18˚ 15′ N and 96˚ 18′ E), King & Queen Company Limited, Taikkyi Township (16˚ 27′ N and 95˚ 53′ E), NRDC (Natural Resources and Development Company limited), Kyauktakha Township (18˚ 09′ N and 96˚ 36′ E) and in 2012 and 2013.

4. 2.Methods

Three different experiments were carried out at each of the above mentioned sites. The experiments are as follows;

Experiment (I): The effectiveness of different media for shoot cutting

Experiment (II): The effectiveness of hormonal treatments of growth response of rooting ability

Experiment (III): Effectiveness of site and seasonal variation on shoots productivity of Teak Hedge Garden

4.2.1Experiment (I) The effectiveness of different media for shoot cutting

4.2.1.1. Collection and preparation of shoot cutting

Healthy and free from any disease and insect pet infection materials were collected cuttings of one year plantings were selected forest in series of experiments.

4.2.1.2. Preparation of shoot cuttings

The length of young shoot cuttings are from 50 mm to 70 mm and diameter of 0.3 to 0.4 mm were collected from lateral shoots of superior teak maintained in the hedge garden. Shoots were collected early morning sand late evenings when temperature is low to minimize transpiration. The shoots were cut only with one pair of leaf and one-third for rooting experiment and placed in 5% Benlate solution (Benomyl at 500 g/kg active ingredients) for 30-45 minutes.

4.2.2. Experiment (II): The effectiveness of hormonal treatments of growth response of rooting ability

4.2.2.1. Preparation of plant growth hormones

Fifty cuttings were used with four replications in each treatment. Soaked cuttings were bundled, each with50 pieces, with the basal part at the same time and soaked in 1,000 ppm Indole-3-Buteric acid (IBA), Freti-stat solution (containing Thamine hydrochloride and chelated iron), rooting hormone for 10-30 minutes. Growth hormones treatment is to improve the rooting percentage, hasten root initiation and increase the number and uniformity of roots produced (Hartmann, 1997).

4.2.2.2. Treatment of shoot cuttings

The stock solution of hormones isprepared by dissolving (100 mgin 1 liter for 100 ppm and other concentration like 200, 300, 400 and 500 ppm etc., of each hormone in 1.5ml of absolute alcohol making it to 1,000ml with distilled water. Dipping methods were used. The fresh stock solutions were used throughout the experiment.

4.2.2.3. Preparation of media for potting

Three types of media were used. They are (1) 2:1 ratio of soil mixture and sterilized sand (2) soil mixture (3) coconut fiber. These media were sterilized under the sunlight about (1-2) days. Shoot cuttings were kept in bamboo portable chamber (10□ x 5□ x 3□) or Portable Plastic Chamber. The shoot cuttings were regularly watered. After that three to four weeks, when cuttings produced adventitious roots they were transferred, one in each polyethylene bags of (10″x 7″)in size.

4.2.2.4. Data collection and analysis

Data were recorded for rooting percentage, average number of roots per cutting and number of shoot sprouting for each experiment, and statistically analyzed using Microsoft Randomized Complete Block Design (RCBD) was applied for ANOVA table. For experiment (I) and(II).

4.2.3. Experiment (III) Effectiveness of sites and seasonal variations on shoots productivity by plants grown in Teak Hedge Garden

4.2.3. 1. Methods in fields

Comparison of shoot productivity of one year seedlings of teak plants from established Teak Hedge Garden were studied seasonally. The plants were divided into three groups depending on the different height and diameter. The plants with (3-12) cm diameter and height of (30)cm, (45)cm and (60) cmmeasured from ground levels four replications of each group of 50 plants in each location were studied.

4.2.3.2. Treatment in moisture chamber

After treatment with three types of soil mediaviz,(1) soil mixture & sand (2) soil mixture and (3) coconut fiber were put into polyethylene bags were presoaked 24 hours with tap water. The cuttings were planted in size of (7″x 3″) black polyethylene bags. The cuttings were immediately inserted about 1.0 cm in prepared media after auxin treatmentand kept in the mist chamber where the relative humidity was maintained at 60-90% with maximum and minimum day-night temperature at 25-30˚C respectively. After (45) days, the cutting were carefully removed from polythene bags (7″x 3″) and transferred to (7″x 10″) sized polythene bag sand observations were made.

4.2.3.3. Experimental design

The experiment was carried out by using Simple Completely Randomized Design (CRD) with four replications.

4.2.4. Environmental factors

4.2.4.1. Soil requirement

Teaks can be grown on variety of soils. The quality of its growth, however, depends on depth, structure, porosity, drainage and moisture- holding capacity of the soil. It develops best on deep, well drainage and fertile soils, especially on volcanic substrata such as igneous and metamorphic soil or alluvial soils of various origins. The optimal soil pH is between 6.5 and 7.5.

4.2.4. 2. Temperature and Rainfall

Teak growth best when the minimum monthly temperature is above 13˚C, the maximum monthly temperature is below 40 ˚C, optimal rainfall for teak ranges between species requires a dry of at least four months with less than 60 mm precipitation (Kaosad-ard, 1981).

5. Results and Discussions

5.1. Experiment (I): The effectiveness of different media for shoot cutting of *Tectonagrandis* Linn. f

The results showed the percentage of soil mixture, soil mixture & sand and coconut fiber they are means of comparison of original scale. The result of soil mixture &sand media was found to be better than other two media. (Table.1)

Table.1. Treatment and Media of Means for Rooting Percentage

MEDIA (M)	Treatment (T)			M-Mean
	Control	IBA solution	Ferti-stat	
Soil mixture	52.00 b	40.00 b	56.00 b	49.3333
Soil mixture and Sand (2:1)	70.00 b	76.00 c	58.00 b	68.0000
Coconut fiber	14.00 a	14.00 a	16.00 a	14.6670
T-Mean	45.00	43.00	43.00	44.0000

In a column, means followed by a common letter are not significant different at the 5 % level by DMRT.

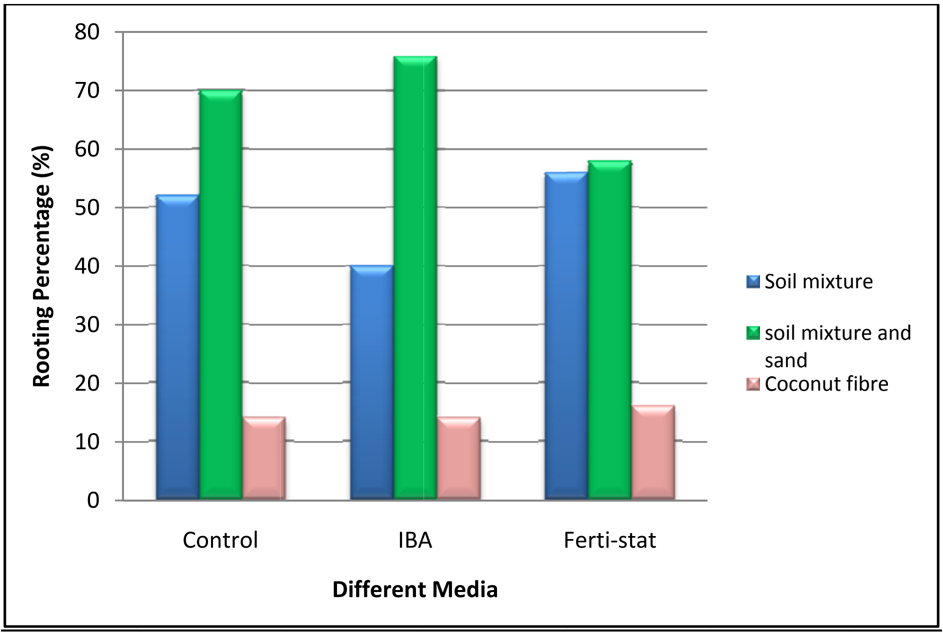

Fig 1.Treatment by different media for rooting (% means)

5.2. Experiment (II): The effectiveness of hormonal treatments of growth response for rooting ability

The result indicated that means the rooting ability by using IBA showed better than media. It was found that 1000 ppm IBA treatment gave better rooting response (76 %). Rooting occurred in control (70 %), which was (45 %) of mean average but in IBA solution and ferti-stat treatments, the rooting response was lower than that of the control which was (43 %) in each treatment.

Table.2. Treatment and Media of Means for Rooting Percentage

Treatments	Media			T- Mean
	Soil Mixture and Sand	Soil mixture	Coconut fiber	
IBA Powder	76.00 a	40.00 a	14.00 a	43.33 a
Ferti-stat	58.00 a	56.00 a	16.00 a	43.33 a
Control	70.00 a	52.00 a	14.00 a	45.33 a
M- Mean	49.33	68.00 a	14.67	44.00

In a column, means followed by a small letters are not significant at the 5 % level by DMRT.

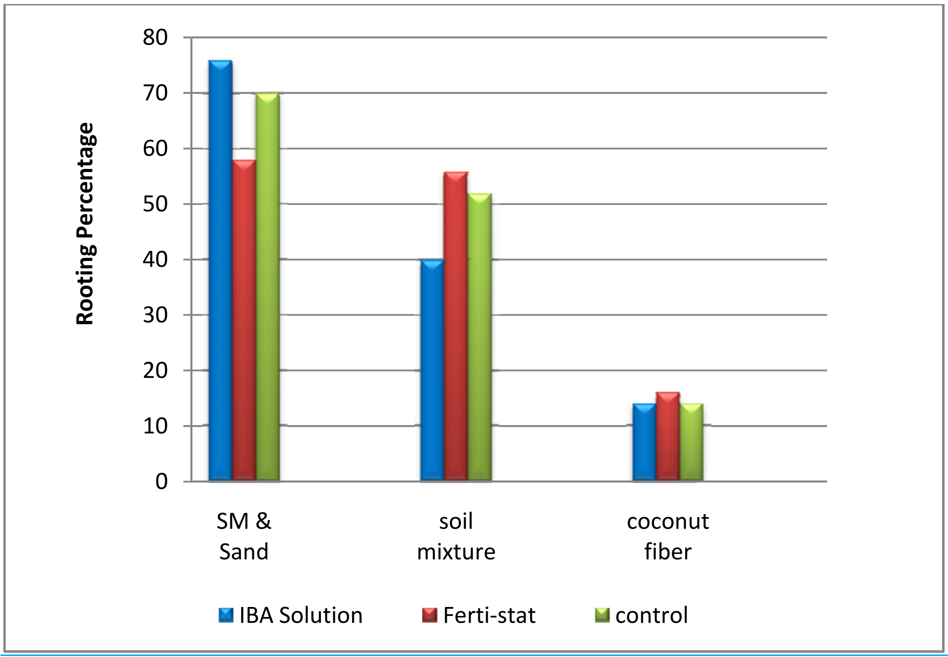

Fig 2.Response of rooting by hormonal treatments

Table.3. interactive between Treatment and Media of Means for Rooting Percentage

MEDIA (M)	Treatment (T)		M-Mean	Difference
	IBA Solution	Control		
Soil mixture	39.9800 a	48.6400 a	44.3100 a	-8.6600 ns
Soil mixture and Sand (2:1)	50.6600 a	41.3000 a	45.9800 a	9.3600 ns
Coconut fiber	34.6200 a	27.9400 a	31,2800 a	6.6800 ns
T-M	41.7533	39.2933	40.5233	2.4600 ns

ns = not significant
In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

According to the statistical analysis, there was no significance between the treatment and different media, such as soil mixture and sand (2:1), soil mixture, and coconut fiber. It was found that 1000 ppm IBA treatment gave over (50%) and better rooting response for soil mixture and sand media. Soil mixture was (40 %), followed by coconut rooting percentage (35 %) and (28 %) in untreated.

5.3. Experiment (III): Effectiveness of site and seasonal variation on shoots productivity of Teak Hedge Garden

Comparison of shoot productivity of one year old planted teak plants from established Teak Hedge Garden were studied seasonally. The plants were chosen from three groups with different heights and diameter. They are of (3-12) cm diameter and height of (30) cm, (45) cm and (60) cm from ground 50 plants per each group with four replications in each of locations were studied.

Table.4. Shoot productivity of plants height and diameter from different sites during rainy, cold season and summer season (2012-13)

Table.4. a. Shoot productivity of Oaktwin Township, in rainy season

Study site (Rainy)	plants height/diameter(cm)	shoot productivity (%)
Oak twin	60/3-12	82
	45/3-12	78
	30/3-12	31

Table.4. b. Shoot productivity of Oaktwin Township, in cold season

Study site (Cold)	plants height/diameter(cm)	shoot productivity (%)
Oak twin	60/3-12	64
	45/3-12	60
	30/3-12	23

Table.4. c. Shoot productivity of Oaktwin Township, in summer season

Study site (summer)	plants height/diameter(cm)	shoot productivity (%)
Oak twin	60/3-12	53
	45/3-12	53
	30/3-12	14

Table.5. Shoot productivity of plants height and diameter for different sites in rainy, cold and summer season (2012-13)

Table.5.a. Shoot productivity of NRDC in rainy season

Study site (Rainy)	plants height/diameter(cm)	shoot productivity (%)
NRDC	60/3-12	98
	45/3-12	87
	30/3-12	28

Table.5. b. Shoot productivity of NRDC in cold season

Study site	plants height/diameter(cm)	shoot productivity

(Cold)		(%)
NRDC	60/3-12	64
	45/3-12	62
	30/3-12	18

Table.5. c. Shoot productivity of NRDC in summer season

Study site (Summer)	plants height/diameter(cm)	Shoot productivity (%)
NRDC	60/3-12	94
	45/3-12	83
	30/3-12	14

Table.6. Shoot productivity of plants height and diameter for different sitesTaikkyi Township, in rainy, cold and summer seasons (2012-13)

Table.6. a. Shoot productivity of Taikkyi Township, in rainy season

Study site (Rainy)	plants height/diameter(cm)	Shoot productivity (%)
Taikkyi	60/3-12	78
	45/3-12	77
	30/3-12	32

Table.6. b. Shoot productivity of Taikkyi Township, in cold season

Study site (Cold)	plants height/diameter(cm)	Shoot productivity (%)
Taikkyi	60/3-12	63
	45/3-12	59
	30/3-12	19

Table.6. c. Shoot productivity of Taikkyi Township, in summer season

Study site (Summer)	plants height/diameter(cm)	Shoot productivity (%)
Taikkyi	60/3-12	80
	45/3-12	68
	30/3-12	23

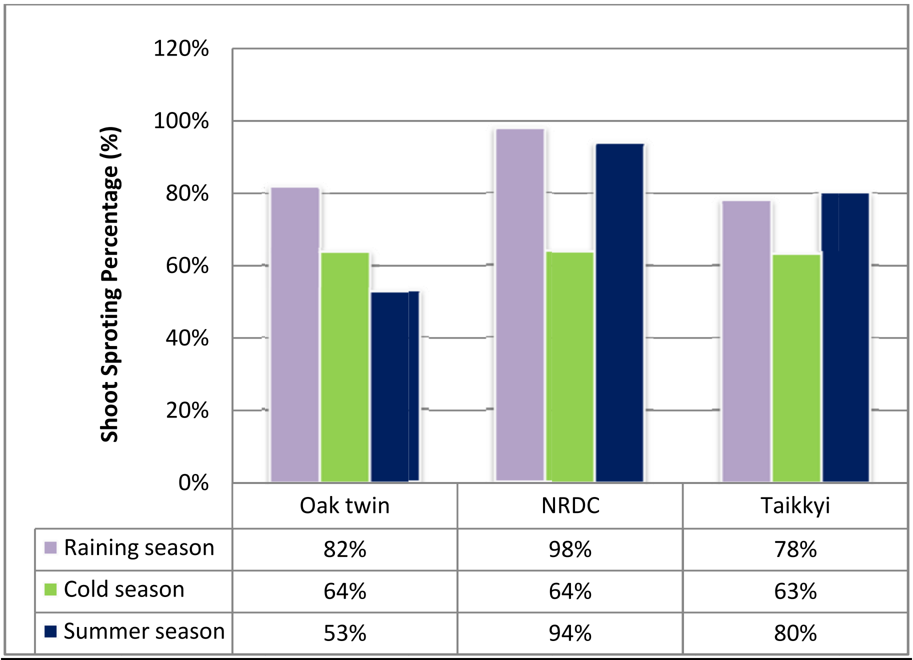

Fig 3. Effective of site variation on shoots productivity base on the plant diameter (3-12) cm and height (60) cm

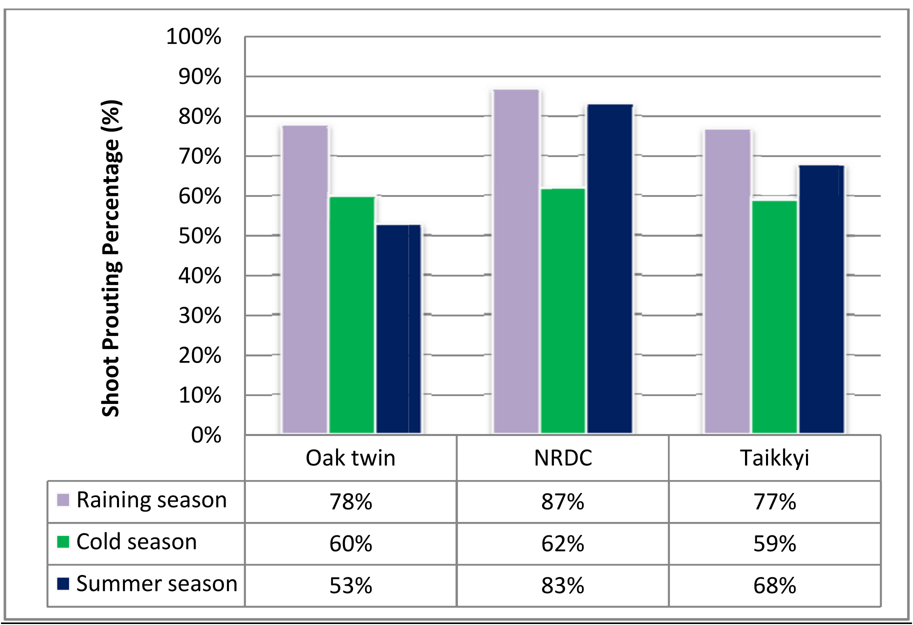

Fig 4.Effective of site variation on shoots productivity base on the plant diameter (3-12) cm and height (45) cm

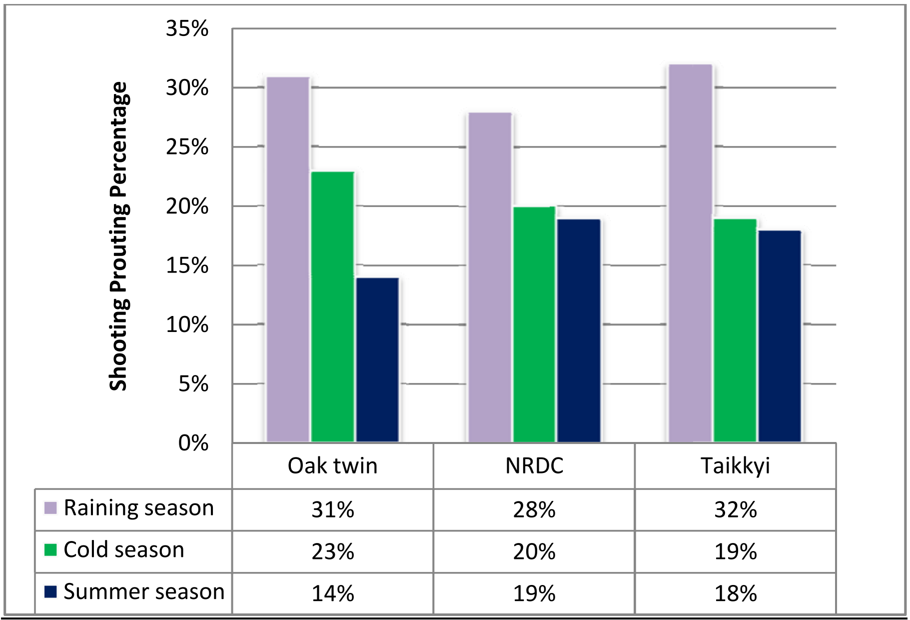

Fig5.Effective of site variation on shoots productivity base on the plant diameter (3-12) cm and height (30) cm

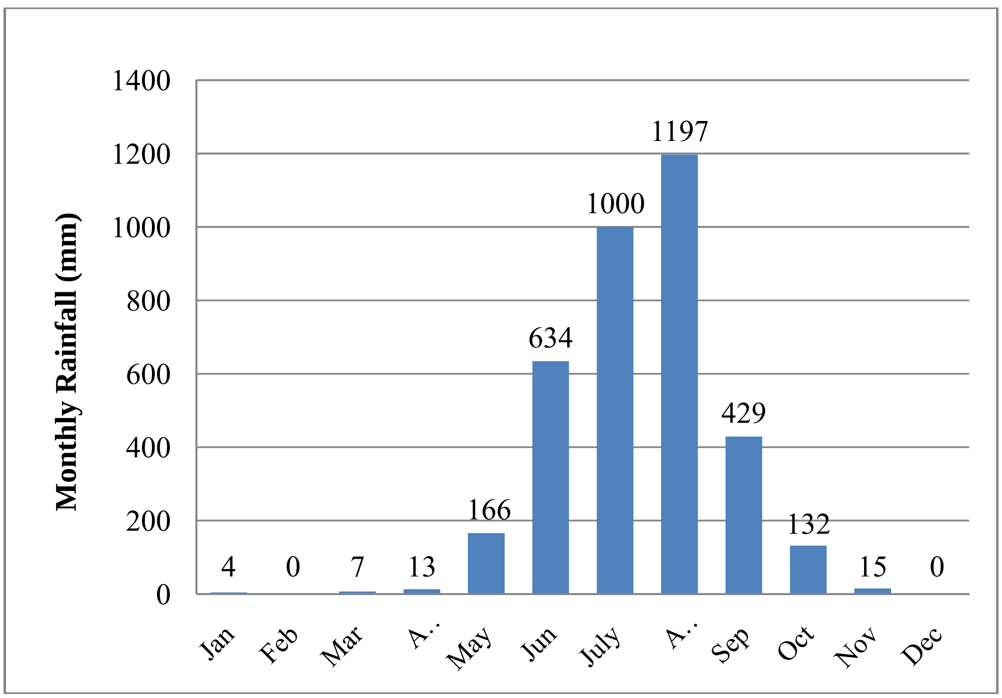

Fig 6. Monthly Rainfall of Bago Division in 2012

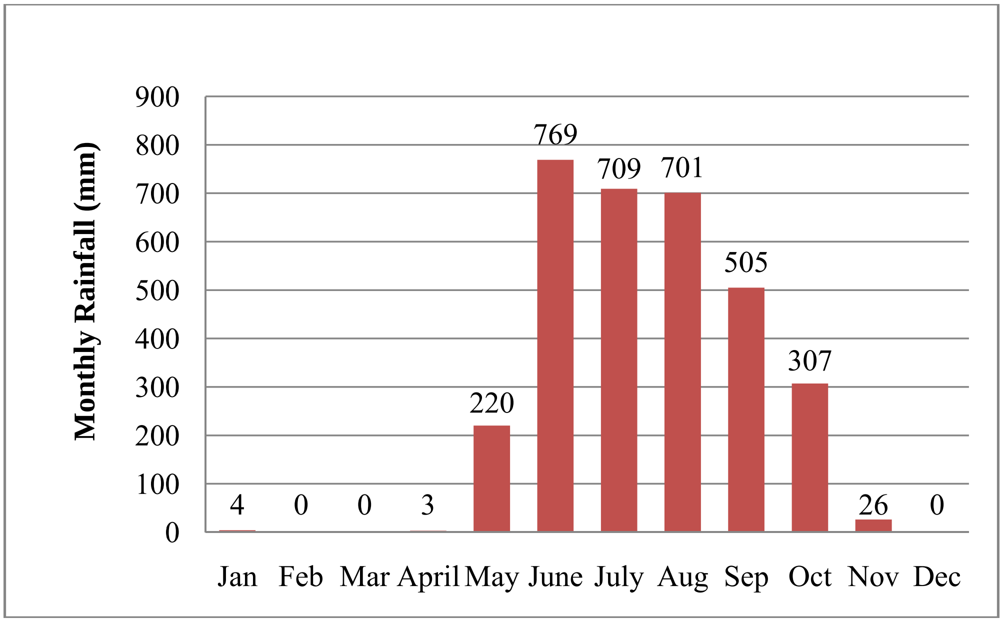

Fig 7. Monthly Rainfall of Bago Division in 2013

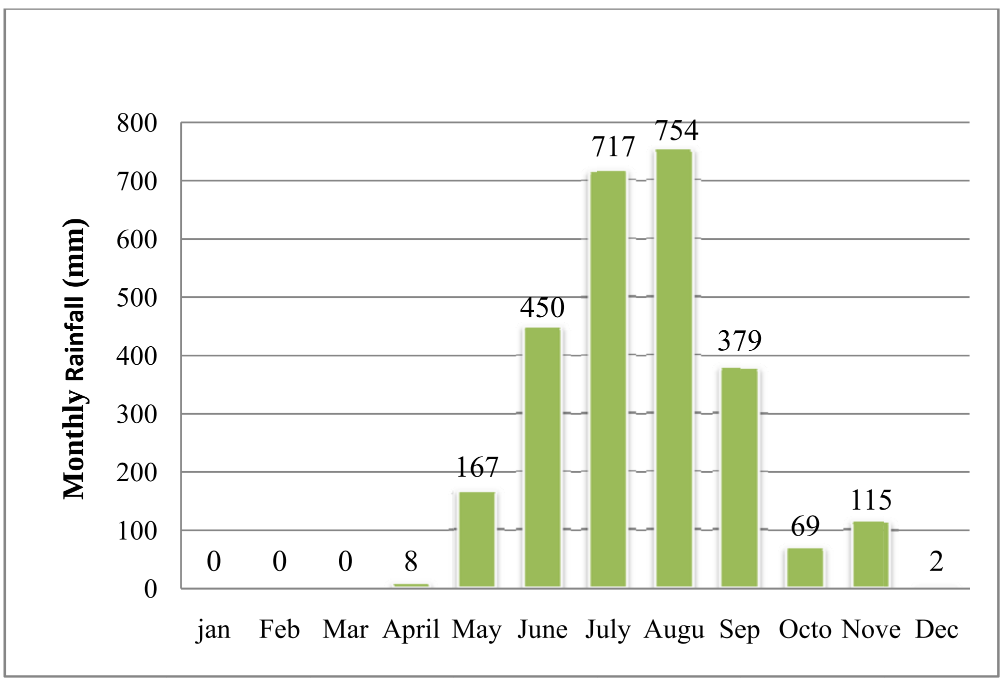

Fig 8. Monthly Rainfall of Rangoon Division in 2013

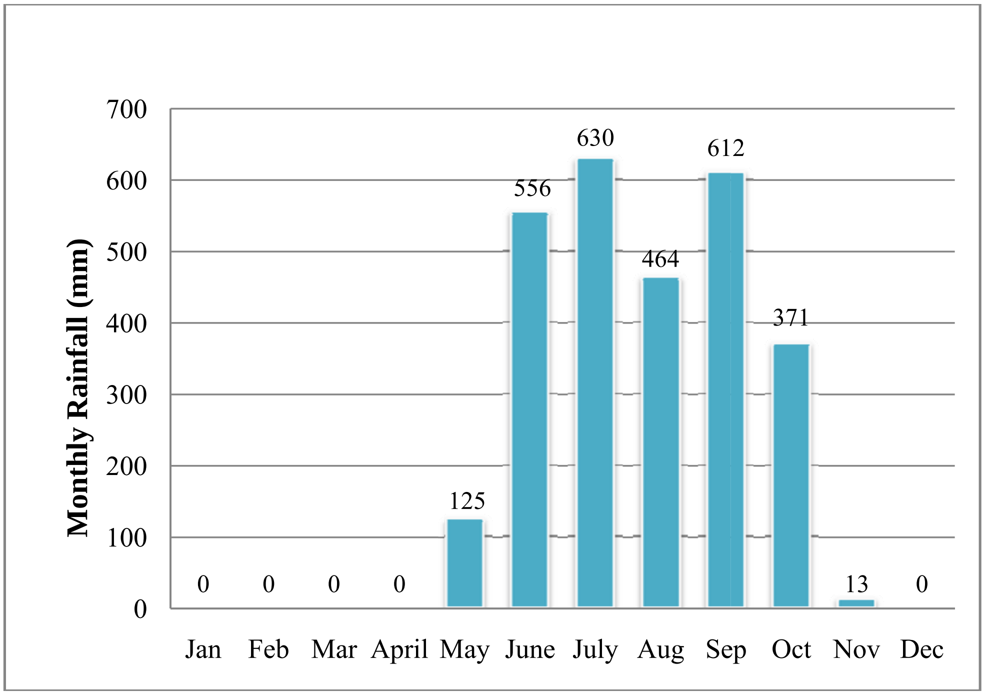

Fig 9. Monthly Rainfall of Rangoon Division in 2013

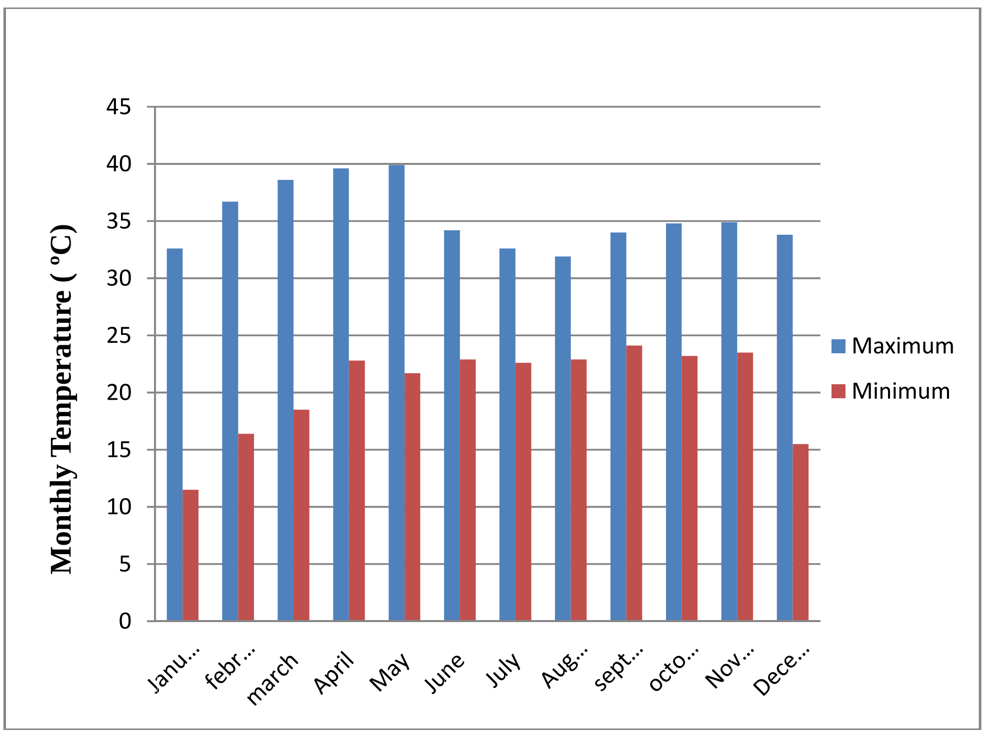

Fig10. Monthly Temperature of Bago Division in 2012

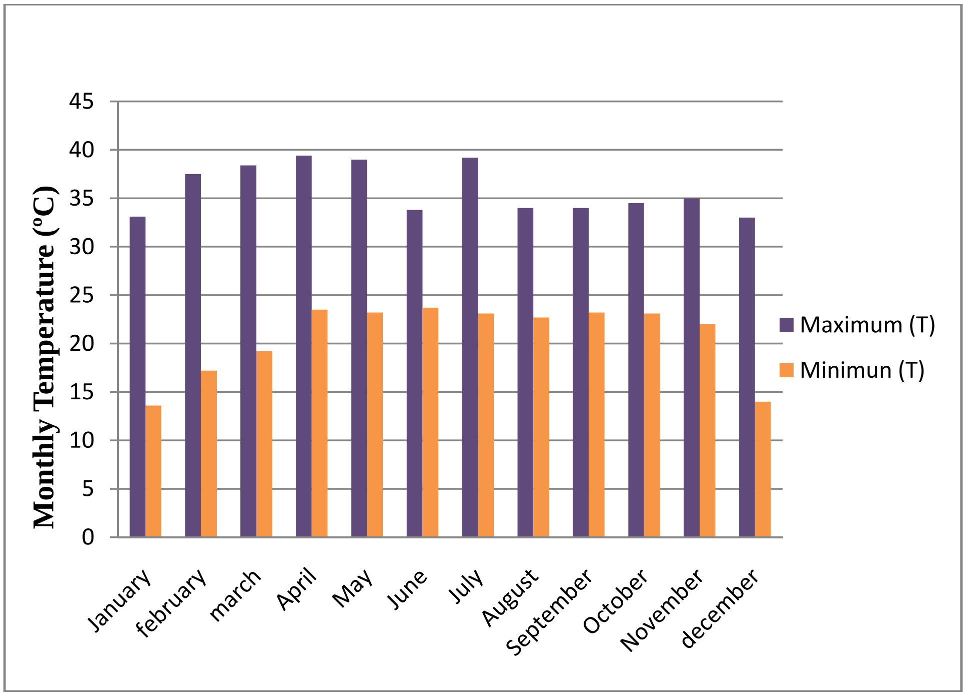

Fig 11. Monthly Temperature of Bago Division in 2013

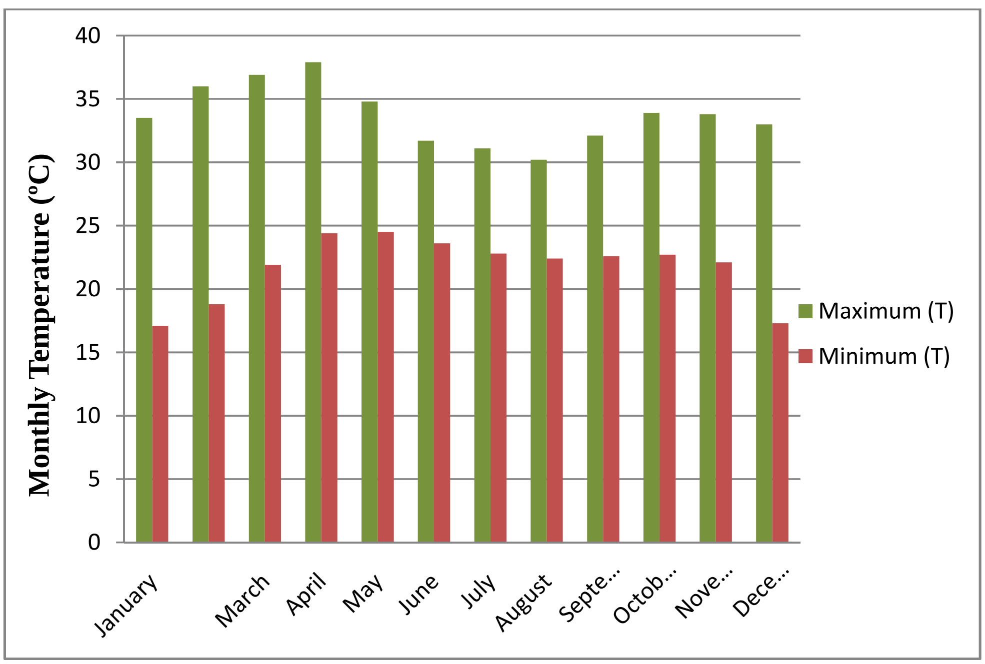

Fig 12. Monthly Temperature of Rangoon Division in 2012

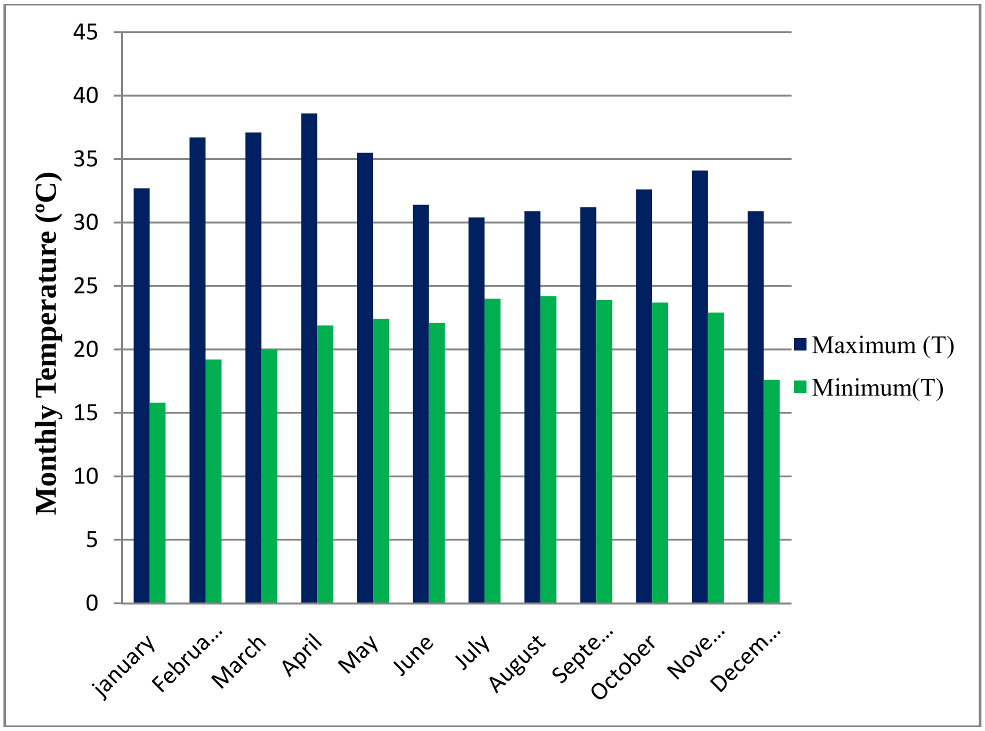

Fig 13. Monthly Temperature of Rangoon Division in 2013

6. Discussions

Juvenile sources should be used for cutting to carry out mass production of teak. The Juvenile shoots on a hedged donor plant has an important effect on rooting and sprouting response of teak cuttings. Cuttings taken from the middle position have the highest and followed by apical and basal positions respectively. In most tree species rooting ability of cuttings has been reported to increase from apical to basal part of the crown/shoots which has been attributed to accumulation of carbohydrates at the base of shoot (Hartmann et al. 1997). However, there are many deviations from this general trend. For example, in *Triplochitonscleroxylon*, rooting percentage of cuttings from different node positions was found to decline basic petally (Leakey and Mohammed 1985). Cuttings originating from the apical position of shoots of *Miliciaexcelsa* (Ofori et al. 1997), *T.scleroxylon* (Leakey 1983) and *Naucleadiderrichii* (Matin1989) displayed higher rooting percentages than those taken from the basal portions. Results of present study indicate that cuttings of branches originating from the middle position of teak displayed higher rooting percentage. And a similar result was obtained in *Dalbergiasissoo* (Husen 2004). Therefore, it is evident from these findings that optimal branch positions for the best rooting percentage vary with the plant species. The affect of position on rooting may becaused by variation in the physiological status of shoot/cutting tissues on stock plant sresulting in occurrence of gradients along the stem axis in the cellular activity or on the level of assimilates or growth regulators or on the level of lignifications etc. (Hartmann et al.1997).

Among the auxin treatments generally, application of IBA Hormone maximally promoted rooting percentage for cuttings, which were taken from the middle position while it was less effective in cuttings taken from the other positions. The effect of auxin in promoting rooting of cuttings is well known (Nanda 1970; Hartmann et al.1997; Husen and Mishra 2001; Husen2002a, b; Husen2003; Husen et al. 2003a, b, and c; Husen and Pal 2006; 2007), while very little information is available on the effectiveness of auxin in relation to the branch position, especially when the cuttings were taken from the hedge garden (Husen, 2004).

Teak growing countries use of rooted cutting and micro- propagation from clone propagated teak trees have been produced and planted by private since the 1990s. The superiority of such planting material compared to seedlings has led to increasing interest in this technology from both private investors and eager to maximize returns in a reasonable Time. The calcium content of the soil is also an important factor, calcium deficiency in the soil results in stunted growth of teak (Kaosa-ard, 1981).

The present study highlighted the importance of potting media and auxin treatment for maximum rooting response in teak cuttings The findings of this investigation suggest that cuttings from the middle position of plants height and treated with 1000 ppm IBA gave maximum rooting.(Table.2,Figure.2.) Therefore, this can be utilized to produce quality plantlets for planting stock improvement program of teak. However, further physiological/ biochemical investigations are still needed in this species to understand the detailed mechanism of this rooting response.

According to results, among the three types of media and Hormones treated, such as soil mixture and sand (1: 2), soil mixture and coconut fibers. The Soil mixture and sand(2:1) and 1000 ppm IBA solution gave the highest percentage of rooting.

7. Conclusions and Recommendations

7.1. Conclusions

According to the results and indications of the study the following conclusions can be made; Cuttings from one year old teak plants which are from selected good quality materials (tree) and grown in Teak Hedge Garden are appropriate for propagation of clones for plantation purposes.

Middle portions i.e.about30-60 cm from ground gave the best in response to shoot proliferation and rooting in cuttings. Hormone treatment with 1000 ppm of IBA gave the best result for shooting and rooting soil mixture & sand than soil mixture and coconut fiber media.

Temperature in moisture chamber of 25-30 ˚C gave the best results. Concerning locality and seasons of one year old teak plants grown in teak Hedge Garden of improvement, there are different between sites and seasons.

(a) In Oaktwin plants with 60 cm in height and diameter of 3-12 cm and in rainy season are suitable for propagation.
(b) In NRDC plants with 60 cm in height and diameter of 3- 12 cm in rainy season are suitable for height / diameter/ season

(c) Taikkyi plants with 60 cm in height and diameter of 3-12 cm in rainy season are suitable for height/diameter/season.
(d) In all the different sites percent of shooting is not much different to rainy season as late summer is also a sprouting season for plants and winter is the dormant time for many plant species.
(e) The sites companies are all along the best teak growing area, i.e. Bago Yoma range, the results indicate the same.

7.2. Recommendations

The following recommendations would be appropriate;

Further study on comparison of top, middle and basal shoot positions, different constriction labels of plant growth hormones and base on young planting of Hedge garden is recommended. Establish Hedge garden near the systematically established Seed Production Areas (SPAs) or Teak seed orchards. This kind of study should be repeated in different localities of various ecological zones. Confirm the position: basal, middle or top of the sprouted plants in Hedge Garden which would give) the best results concerning shooting and rooting. Confirm also shooting and rooting to be used from different producers of hormones for their authenticity. Should be tested the fertilizer treatment in Hedge Gardens to compare with natural condition. Note here in this study effect of different sites or shooting is given and to share the technique with other relevant institutions.

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Plate

Plate 1, 2. Shoot sprouting based on the one year planting

Plate 3, 4. Shoot seedlings produced after 45 days

Plate 5, 6. Planted shoot in the bamboo potable plastic chamber

Plate 7,8.Developed shoot and root formation

Plate 9, 10.Preparation of Teak Hedge Garden and planting in Moist Chamber

Plate 11, 12. Successful rooting position (45 – 60) days

Plate 13,14. Young Shoots planted in different media

Plate 14, 15. Hardening plants under the Nursery shade

Appendix

Analysis of variance of rooting percent of control

SV	DF	SS	MS	F
Media (M)	2	8173.3	4086.7	13.62**
Error	12	3600.0	300.0	
Total	14	11773.3		

CV = 38.2%, ** = Significant at 1% Level.

Analysis of variance of rooting percent of IBA Hormone

SV	DF	SS	MS	F
Media (M)	2	9693.3	4846.7	23.84**
Error	12	2440.0	203.3	
Total	14	12133.3		

CV = 32.9%, ** = Significant at 1% Level.

Analysis of variance of rooting percent of ferti-stat Hormone

SV	DF	SS	MS	F
Media (M)	2	5613.3	2806.7	7.14**
Error	12	4720.0	393.3	
Total	14	10333.3		

CV = 45.8%, ** = Significant at 1% Level.

Analysis of variance of rooting percent of different media

SV	DF	SS	MS	F
Treatment	8	23520.0	2940.0	9.84**
Treatment (T)	2	40.0	20.0	<1
Media (M)	2	21973.3	10986.7	36.76**
T xM	4	1506.7	373.7	1.26 ns
Error	36	10760.0	298.9	
Total	44	34280.0		

CV = 39.3%, ** = Significant at 1% Level; ns = not significant

Analysis of Variance on rooting percentage of different plant growth hormones in different media

Sources	Rooting percentage			
	DF	SS	F- value	CV%
Control	2	8173.3	13.62**	38.2%
IBA	2	9693.3	23.84**	32.(%
Fer-start	2	5613.3	7.14**	45.8%
Media	2	2197.3	36.76**	39.3%
Treatment x media	4	1506.7	1.26ns	-

*=Significant at 5% level, ** = Significant at 1% level, ns = not significant