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Development of Rooted Cutting Method for Vegetative Propagation of *Aleurites montana* (Lour.) E.H.Wils.

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တန်းဆီပင် [*Aleurites montana* (Lour.) E.H.Wils.] အား ကိုင်းထိုးမျိုးပွားခြင်းနည်းဖြင့် ခန္ဓာပိုင်းမျိုးပွားခြင်းအား စမ်းသပ်လေ့လာခြင်း

ဖြူဖြူလွင်၊ တောအုပ်ကြီး
ခင်ပပရွှေ၊ သုတေသနလက်ထောက်–၂
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

အပူပိုင်းမိုးသစ်တောများရှိ အပင်များ၏ ၈၀% ကျော်မှာ အညွန့်ကိုင်းထိုးစိုက်ပျိုးခြင်းနည်းဖြင့် အမြစ်ထွက်ရှင်သန်နိုင်ကြောင်းကို စမ်းသပ်တွေ့ရှိပြီး ဖြစ်သည်။ တန်းဆီပင်၏ အညွန့်များမှ အမြစ်ထွက်ရှိ၍ အပင်သစ်တစ်ပင်အဖြစ် ရှင်သန်ကြီးထွားရန်အတွက် လိုအပ်သည့် အခြေခံအချက်အလက်များကို လေ့လာဖော်ထုတ်သိရှိနိုင်ရန်အတွက် ဤသုတေသနလုပ်ငန်းကို အကောင်အထည်ဖော်ဆောင်ရွက်ခဲ့ခြင်း ဖြစ်ပါသည်။ တန်းဆီပင်သည် အခြောက်မြန်သော အဆီတစ်မျိုး ထုတ်လုပ်နိုင်ရန်အတွက် အလားအလာရှိသော အပင်တစ်မျိုးဖြစ်သဖြင့် သုတ်ဆေးများ၊ သစ်အရောင်တင်ဆီများတွင် ထည့်သွင်းအသုံးပြုရန်နှင့် ဆေးဖက်ဝင်သော အပင်ဖြစ်သောကြောင့် ဘက်စုံသုံးအပင်တစ်မျိုးဖြစ်ပါသည်။ ဤသုတေသနလုပ်ငန်းတွင် တန်းဆီပင်အား ခန္ဓာပိုင်း မျိုးပွားရန်အတွက် အသင့်လျော်ဆုံး မျိုးပွားနည်းစနစ်ကို ဖော်ထုတ်ပြီးနောက် တန်းဆီအညွန့်ကိုင်းဖြတ်များ အမြစ်ထွက်ရှိရှင်သန်နိုင်ရန်အတွက် အသင့်လျော်ဆုံး အမြစ်အားတိုးဆေး၊ အချိန်ရာသီနှင့် နေရာဒေသတို့ကို သိရှိနိုင်ရန် စမ်းသပ်မှု (၃) မျိုးကို ဆောင်ရွက်ခဲ့ပါသည်။ တန်းဆီပင်အား ခန္ဓာပိုင်းမျိုးပွားရန်အတွက် အညွန့်ကိုင်းထိုး မျိုးပွားနည်းမှာ ရှင်သန်မှုနှုန်း အကောင်းဆုံးဖြစ်ကြောင်း စမ်းသပ်တွေ့ရှိရပါသည်။ ရှင်သန်မှု ရာခိုင်နှုန်းမှာ ၇၆% ဖြစ်ပါသည်။ တန်းဆီပင်အား အညွန့်ကိုင်းဖြတ်မျိုးပွားရာတွင် စမ်းသပ် အသုံးပြုသော အမြစ်အားတိုးဆေးများအနက် IBA အမှုန့်မှာ အမြစ်ထွက်ရှင်သန်မှုနှုန်း အကောင်းဆုံး ဖြစ်ကြောင်း တွေ့ရှိရပါသည်။ ရာသီအလိုက်အမြစ်ထွက်နှုန်းကွာခြားမှုကို လေ့လာရာတွင် နွေရာသီတွင် စမ်းသပ်ခြင်းမှ ရှင်သန်မှုရာခိုင်နှုန်း ၅၅% ရှိ၍ အကောင်းဆုံးဖြစ်ကြောင်း စမ်းသပ်တွေ့ရှိရပါသည်။ အပူပိုင်းဒေသနှင့် အအေးပိုင်းဒေသများတွင် တန်းဆီအညွန့်ကိုင်းဖြတ်များ၏ ရှင်သန်မှုအခြေအနေမှာ စာရင်းအင်းနည်းလမ်းအရ များစွာကွာခြားမှုမရှိကြောင်း စီစစ်လေ့လာသိရှိရပါသည်။ သို့သော် အအေးပိုင်းဒေသဖြစ်သော သီပေါမြို့နယ်တွင် စမ်းသပ်စိုက်ပျိုးခြင်းမှာ ပျမ်းမျှရှင်သန်မှုနှုန်း ပိုမိုကောင်းမွန်ကြောင်း စမ်းသပ်တွေ့ရှိရပါသည်။

Development of Rooted Cutting Method for Vegetative Propagation of *Aleurites montana* (Lour.) E.H.Wils.

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Abstract

More than 80% of tropical forest trees so far tested can be rooted as leafy stem cuttings in low-technology 'poly propagators' and/or under mist, grown on in a nursery and planted out just like seedlings. This research paper is carried out for exploring favorable conditions for rooting juvenile shoots of Tung Oil trees (*Aleurites montana* (Lour.) Wils). It is a very potential tree species for producing bio-fuel paints and other medicinal purposes. In this research, three experiments were conducted for investigating season, type of macro-propagation, rooting hormones and site apt for successful rooting. Leafy stem cutting was found to be the most effective method for vegetative propagation of *A. montana* and survival percentage was 76% for treatment with IBA-powder and 67.67% for control. Survival percentage of the cuttings differed among the auxins, seasons and site. The result of maximum rooting of 53.11% was obtained by treatment with IBA-powder followed by 47.44% for treatment of IBA Solution (100 ppm). Commercial Root-Fro Solution was also found more effective than other treatments and its mean survival percentage was found to be 46.22%. Highest survival rate was obtained during hot season (55%) followed by cold season (41.07%) and then rainy season (33.73%). There was no statistically significant difference among all measurements between two different sites tested. But mean survival percentage of cuttings tested at the nursery of Forest Department, Thipaw Township (62.67%) was higher than that of Yezin (50.33%). Better survival and rooting rates under favorable conditions imply that *A. montana* can be propagated vegetatively at reduced cost, thus ensuring that this technology can be adopted with minimum capital to yield expected results.

Key Words: *Aleurites montana,* leafy stem cutting, rooting hormones, seasonal variation, vegetative propagation, rooted cutting

Contents

1. Introduction

Aleurites is a small arborescent genus of plants in the tropical and subtropical regions of Asia, the Pacific, and South America, belonging to the Spurge family Euphorbiaceae. These monoecious, evergreen trees are perennials or semi-perennials. These are large trees, 15-40 m tall, with spreading drooping and rising branches.

The oil-rich seeds are produced inside a thick, woody endocarp layer and are the source of tung oil used on fine furniture. There are many *Aleurites* species which can produce Tung oil such as *Alurites montana*, *Aleurites moluccana*, *Aleurites fordii.*

Tung oil is pressed from the nuts of these Tung trees and is also known as China wood oil and nut oil. Tung oil is an ideal "binder" or "vehicle", carrying the resins and driers deep into the pores of the wood so that sealer and finish coats practically become part of the wood-drying into an armor-like yet beautiful surface.

For centuries tung oil has been used for paints and waterproof coatings, and as a component of caulk and mortar. It is an ingredient in ink and is commonly used for a lustrous finish on wood. Some woodworkers consider tung oil to be one of the best natural finishes for wood. Tung oil's ability to dry quickly and polymerize into a tough, glossy, waterproof coating has made it especially valuable in paints, varnishes, linoleum, oilcloth and printing inks.

These Tung oil producing trees are now being planted out as commercial plantations in our country especially in cooler regions. Therefore if the best quality seedlings would be produced by means of vegetative propagation because these propagation methods can produce the same genetic quality of mother tree, it is very beneficial for our country to fulfill the requirements of essential oils for industrial uses.

However, successful propagation of difficult-to-root species can be achieved if the type of cutting (hardwood, softwood, or root), date of collection (seasonal growth development), stock plant or cutting manipulation (pruning, wounding, etc.), rooting treatment (auxin type and concentration, rooting media), and greenhouse parameters (mist-bed system, supplemental lighting, temperature, etc,) are carefully considered.

Vegetative propagation methods are also very useful tools in propagating forest tree, especially for cloning of desired quality trees. Vegetative propagation methods (including rooted cuttings) will be required in order to produce clones of elite or genetically improved genotypes of *Aleurites montana* (Lour.) E.H.Wils.

Thus the objectives of this study were:

(1) To investigate the cheapest and easiest methods for vegetative propagation of Tung Oil trees (*Aleurites montana)* and

(2) To investigate various environmental factors influencing the development of shoots and roots of *Aleurites* species from shoot cuttings.

The specific objectives were:

(1) To examine the rooting ability of shoot cuttings
(2) To investigate the effect of growth regulating substances treated on cuttings in order to determine the most effective chemicals for rooting
(3) To determine the seasonal variation and site variation in growth response of cuttings

2. Materials and Methods

There were three experiments conducted in this study:

Experiment I	Study on the effectiveness of different macro-propagation methods for vegetative propagation of *Aleurites montana* (Lour.) E.H.Wils.
Experiment II	Study on effectiveness of Hormonal Treatments and Effect of Seasonal Variation on growth response of cuttings
Experiment III	Study on Effect of Site Variation on growth response of cuttings

2.1 Experiment I Study on the effectiveness of different macro-propagation methods for vegetative propagation of *Aleurites montana* (Lour.) E.H.Wils.

2.1.1 Types of Macro-Propagation Methods

In this experiment, five types of macro-propagation methods were tested for vegetative propagation of *Aleurites montana*. They were bark-grafting, cleft-grafting, budding, leafless stem cutting (Branch cutting) and leafy stem cutting (shoot cutting). The experiment was conducted with RCBD (Randomized Complete Block Design) in three replications with seven treatments (seven types of macro-propagation methods). Stem cutting methods (both leafy and leafless cuttings) were carried out in two types for each: treated with IBA-Powder and control. Misting was carried out four times a day and data for assessment of root and shoot development and environmental factors such as temperature, relative humidity were recorded weekly. The main objective of this experiment was to determine the most successful macro-propagation method for vegetative propagation of tung oil trees. Below were some descriptions of these propagation methods.

2.1.1.1 Grafting

In grafting, a scion from a genotypically superior plant is united with a stock from another plant. The stock is usually a seedling, rarely a rooted cutting or a planted air-layered branch. For a good result of grafting the root stock as well as the scion has to be in good conditions, and the two parts should be compatible. In this experiment, two types of grafting were used namely bark-grafting and cleft-grafting. The stocks used were one-year-old seedlings and the scions were collected from decease-free and mature plants. The size of the scions was 15–25 cm in length and 0.6–1.2 cm in diameter. They were taken from the upper part of the tree and they had well developed vegetative buds in a dormant stage.

Grafting can be done in the nursery in which case the stock is growing in a container. For some species grafting can take place under field conditions, provided the graft union is well protected after the grafting. In this case, grafted plants were raised in polyethylene bags and kept in plastic mist chamber where temperature and relative humidity could be controlled.

2.1.1.2 Budding

A modified form of grafting in which only a bud is inserted in the root and stem of stock is budding. The budding should take place when the plants are in active growth and the bark is easily separated from the wood. The inserted bud should be a vegetative bud and not a flower bud. In this case, one-year-old seedlings were also used as stocks and the scions were actively vegetative buds. In this experiment, patch budding was carried out.

2.1.1.3 Stem Cutting

These cuttings are severed twigs that have been placed into growing medium and encouraged to develop roots into entire plants. Propagation from stem cuttings is the most important method in forestry. In this study, sterilized sand was used as rooting medium and indole 3-butyric acid (IBA) in powder was used as rooting hormone and also control (no hormone treatment) was also tested. The shoots were planted in plastic bags of the size with (17.8x7.6 square centimeters) and the branches were planted in polyethylene bags (25.4x35.6 square centimeters) with the rooting medium as a mixture of sand, soil and cow dung in 3:2:1 ratio.

Two main types of stem cuttings used in this study were as follows.
Softwood cuttings (leafy stem cuttings or shoot cuttings) are young soft succulent cuttings with leaves (sometimes pruned). In this study, the size of the cuttings was 15-25 cm long and 0.3-2.0 cm in diameter. Shoots were collected from 18-month-old seedlings and leaves on the lower part were removed while the top pair of leaves was trimmed into size of its one-third to reduce water loss and to allow photosynthesis to take place.

Hardwood cuttings (Leafless stem cuttings or branch cuttings) are made of matured, dormant hardwood after the leaves have been shed. Tip cuttings possess terminal buds; basal cuttings are without terminal buds. Branches were collected from 5-year-old matured plants. The size of the branch tested was 30-45 cm in length and 8-12 cm in diameter.

2.1.2 Data collection and analysis

Data collection was carried out for survival percentage, temperature and relative humidity, number of shoots and roots developed, average number of roots per cutting and average size of root per cutting weekly. Data analysis was carried out using Microsoft Office Excel 2003 and Genstat Statistical Software. Randomized Complete Block Design (RCBD) was applied for analysis of variance (ANOVA) of the data collected to investigate whether there was statistically significant difference among propagation methods tested.

2.2 Experiment II Study on effectiveness of Hormonal Treatments and Effect of Seasonal Variation on growth response of cuttings

2.2.1 Preparation of cutting materials

The cuttings were collected from juvenile stem of one-year-old seedlings raised in the nursery. For each experimental unit or plot, 100 cuttings were tested. The cuttings selected were normally 15-25 cm long and 0.3-2.0 cm in diameter.

There was a requirement for critical leaf area which ensures the optimal balance between the positive effects of photosynthesis and the negative effects of transpiration. Usually one or two leaves near the tip and sometimes together with active bud were left and the base of the cutting is treated with suitable auxins before being put into sterile medium under a mist propagator. Cuttings were taken from selected seedlings in the evening to protect burning from sunlight during daytime. Then they were planted in pure sandy soils in well-drained sand boxes and raised in plastic mist chamber.

2.2.2 Rooting Media

No propagation method is going to work if the right media for growth is not used. In propagation, the air content of rooting media should be between 20 and 45 volume percent to promote root formation and growth. The volume percent in media should not drop below 15 volumes percent (Gislerod, 1983). This ensures adequate oxygen availability for the developing root systems. Increases in air within the media increases the oxygen diffusion rate (ODR). This increase is what will aid the root systems in acquiring the optimum amount of oxygen needed. The contents of media can vary for different regions and different species. Type of media used in that experiment was oven-dried sterilized sand, which was the most favorable media for rooting of Tung tree cuttings shown by the results of preliminary testing.

2.2.3 Preparation of the rooting hormones

In that experiment, different four rooting hormones were used to determine the most suitable one for rooting of stem cuttings of Tung oil trees. They were commercial rooting hormones: Ferti-Start Hormone Solution (containing Thiamine hydrochloride and chelated iron), Root-Fro Hormone Solution, IBA Powder and 100 ppm-IBA Solution. Indole 3-butyric acid(IBA) is a growth regulator; it may promote cell division in the growing stage of plant. Hence, it is mainly applied to facilitate mature, step-up output, break quiescence, and encourage germination and cultivator.

The stock solution of hormones were prepared by dissolving the weighted quantity (100 mg in 1 Litre for 100 ppm) making it to 1000 ml with distilled water to get 100 ppm-IBA Solution. For making stock solution of commercial Ferti-start and Root-Fro hormone solution, the amount of 5% of these solutions was mixed with distilled water to get 1000 ml concentration. Dipping methods were used in this experiment. These commercial rooting hormones can be obtained in the market of Myanmar.

2.2.4 Study on Effect of Seasonal Variation

In the seasonal variation experiment, the seasons were divided into three periods. The experiments were conducted in three different seasons. For hot season, the experiment was conducted during April, 2008. For rainy season, the experiment was conducted during August, 2008 and for cold season, during November, 2008.

2.2.5 Data collection and analysis

Data collection was carried out for rooting percentage (Survival percentage), average number of roots per cutting and average size of root per cutting for each plot after 45 days. Data analysis was carried out using Microsoft Excel 2003 and Genstat Statistical Software. The experiment was carried out with three replications under four hormonal treatments and under control (no treatment) for two factors: hormonal treatments as main plot factor and different seasons as sub-plot factor. Split Plot Design (SPD) was applied for analysis of variance (ANOVA) of the data collected.

2.3 Experiment III Study on Effect of Site Variation on growth response of cuttings

2.3.1 Description of study areas

In this study, to test the effects of site variation on rooting of leafy stem cuttings of tung oil trees, the experiments were conducted in two study areas: Forest Research Institute, Yezin and Forest Department, Thipaw Township of the Northern Shan State. In Forest Research Institute, Yezin, the research was carried out in mist chamber where we could control the temperature and humidity. In Forest Department of Thipaw Township, the research was conducted in small plastic mist chambers that could be made easily by nursery labors themselves. Comparison of mean monthly temperature and rainfall at two sites are shown in Figure 6.

2.3.2 Preparation of cutting materials

The size of cuttings used in this study was the same as in Experiment II. The cuttings were collected from eighteen-month-old seedlings and four-year-old plantations. All of the cuttings were treated with 100 ppm IBA-Solution as rooting hormone. Sterilized sand was used as rooting medium for all experimental units. The experiment was conducted in three replications with two treatments (two research sites).

2.3.3 Data collection and analysis

Data collection was carried out for rooting percentage, average number of roots per cutting and average length of roots per cutting for each plot after 45 days. Data analysis was carried out using Microsoft Excel 2003 and Genstat Statistical Software. Randomized complete block design was applied for ANOVA table.

3. Results and Discussions

3.1 Experiment I Study on the effectiveness of different macro-propagation methods for vegetative propagation of *Aleurites montana* (Lour.)E.H. Wils.

Of the seven different macro-propagation methods, shoot cutting method or leafy stem cutting method (treated with IBA powder) showed maximum survival rate of 76% in average followed by shoot cutting method (control) of which survival percentage of 67.67%. The results show that *A. montana* can be vegetatively propagated without treating with rooting hormone in its required optimum conditions. Rooting was not found in leafless stem cutting (Branch Cutting Method) for all experimental units.

Scion-Stock compatibility was occurred in Cleft Grafting method and its survival percentage was 32.67%. This method was easier and did not need much expertise to carry out compared to other grafting methods such as bark grafting, root grafting and budding. The results are shown in table (1) and figure (1). Shoot and root development of macro-propagation methods are shown in figure (2).

According to results obtained in ANOVA table, there is highly significant difference among mean survival percentage of different methods. The coefficient of variation is 26.1% that shows the reasonable level of precision attained in collected data on survival percentage of different propagation methods (Table 2 & 3).

3.2 Experiment II Study on effectiveness of Hormonal Treatments and Effect of Seasonal Variation on growth response of cuttings

In this experiment, there were two factors of treatment; hormonal treatment as main plot factor and seasons as subplot factor. According to ANOVA table, there is highly significant difference among hormonal treatments and also among different seasons at 1% level. But two factors interaction (hormonal treatment and seasonal variation) was not significant at 5% level (Table 8). The different hormones and seasons of the year thus had significant variations in their ability to initiate shoot and root development but there was no interdependence on each other between hormonal treatments and seasons for rooting of cuttings. The results of the statistical analysis were shown in table 6, 7 & 8.

Among the different hormones used, treatment with IBA-Powder was found to be the most effective of which mean survival percentage was 53.11% followed by 47.44% for treatment of IBA Solution (100 ppm). Commercial Root-Fro Solution was also found more effective than other treatments and its mean survival percentage was found to be 46.22% as shown in table 4 & figure 3.

Among different seasons when the experiment was conducted, highest survival rate was found during hot season (55%) followed by cold season (41.07%) and then rainy season (33.73%) as shown in table 5 and figure 4. These were rapid rooting of the cuttings by dry season resulting in almost all the cuttings rooting by fourth week of planting. Whereas in the rainy season, there was gradual rooting of cuttings up to the eight week.

Regarding to shoot development of experimental units, there was found that active pairs of shoot developed after about one week. But root development was found only after about 45 days for most cuttings and after 60 days for some. Non-survived cuttings were wilted and died within one week. Callus formation was found in some cuttings and in this experiment, it was not recognized as surviving (Figure 5). Only cuttings of which their shoots and roots developed well were counted for data collection.

3.3 Experiment III Study on Effect of Site Variation on growth response of cuttings

Tung oil tree plantations had been established extensively in Thipaw Township by Forest Department. Data collection was carried out for shoot development, root development, number of roots developed, average root length and survival percentage of cuttings tested.

For this experiment, data analysis was carried out by using Microsoft office Excel 2003 for comparison of survival percentage conducted in different sites and randomized complete block design (RCBD) was applied for statistical analysis among different measurements by using Genstat Statistical Software.

There was no statistically significant difference among all measurements between two different sites (Table 10, 11 & 12). According to the results calculated by Microsoft Office Excel 2003, mean survival percentage of cuttings tested at the nursery of Forest Department, Thipaw Township(62.67%) was higher than that of Yezin (50.33%) as shown in table 9 and figure 7. Regarding to the average root length, it was found that it was higher in Thipaw than in Yezin(Table 9 & figure 8). But for average number of roots, it was higher in Yezin than in Thipaw Township as shown in table 9 & figure 9.

4. Conclusion

The price of cuttings will inevitably be higher than that of seedlings, however, because more human handwork is needed in the production of cuttings. Vegetative propagation programs with traditional techniques of rooted cuttings have been carried out in many countries with success. A better result for survival and rooting for the control and also treated with commercial rooting hormones implies that *A.montana* can be propagated vegetatively at reduced cost, thus ensuring that this technology can be adopted with minimum capital to yield expected result. Thus, the possibility of vegetative propagation of this species may solve the problem of nonavailability of seeds as well as the requirement for genetically qualified seedlings. This will facilitate the availability of planting stock and subsequent integration of the species into the agroecosystem.

In conclusion, *A. montana* can be regenerated via single-node cuttings carrying the whole leaf, either without hormone treatment, or with even better results using low concentrations of IBA or thiamine hydrochloride solution.

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6. Tables

Table 1. Mean Survival % of Different Propagation Methods

Propagation Methods	Mean Survival %
Cleft Grafting	32.67
Bark Grafting	29
Budding	4
Branch Cutting (treated with IBA)	0
Branch Cutting (control)	0
Shoot Cutting (Treated with IBA)	76
Shoot Cutting (Control)	67.67

Table 2. TxR Table of Means for Survival % of different propagation methods based on values of arcsine transformation

Propagtion Methods	Replication I	Replication II	Replication III	Treatment total	Treatment mean
I	40.40	30.00	33.83	104.23	34.74
II	35.06	35.67	26.56	97.29	32.43
III	0	20.27	0	20.27	6.76
IV	0	0	0	0.00	0.00
V	0	0	0	0.00	0.00
VI	65.65	60	56.79	182.44	60.81
VII	48.45	51.94	67.21	167.60	55.87
Rep. total (R)	**189.56**	**197.88**	**184.39**		
Grand total				**571.83**	
Grand Mean					**27.23**

Table 3. Analysis of Variance for Mean Survival percentage of different propagation methods based on values of arcsine transformation

Source of variation (SV)	Degrees of freedom (d.f)	Sum of squares (SS)	Mean of Squares(MS)	Computed F (MST/MSE)	CV%
Replication	2	13.24	6.62		
Treatment	6	11800.48	1966.75	**38.87****	26.1
Error	12	607.21	50.6		
Total	**20**	**12420.93**			

** Highly significant at 1% level

Table 4. Mean Survival Percentage of cuttings for different hormonal treatments

Treatments	Mean Survival %
control	28.78
IBA-Powder	53.11
IBA-Solution	47.44
Ferti-start Solution	40.78
Root-Fro Solution	46.22

Table 5. Mean Survival Percentage of cuttings at different seasons

Season	Mean Survival %
Hot Season	55.00
Rainy Season	33.73
Cold Season	41.07

Table 6. Replication x hormonal treatment table of survival percentage for Experiment II

Treatments	Rep I	Rep II	Rep III	Ai
control	91.72	94.83	103.84	**290.39**
IBA-Powder	155.49	129.79	137.85	**423.13**
IBA-Solution	132.84	136.64	121.98	**391.46**
Ferti-start Solution	129	117.93	108.76	**355.69**
Root-Fro Solution	134.51	120.51	130	**385.02**
Rep total (R)	**643.56**	**599.7**	**602.43**	
Grand total (G)				**1845.69**

Table 7. Treatment x Season table of Survival % for Experiment II

Treatment	Summer	Rainy	Winter
control	110.41	90.26	89.72
IBA-Powder	169.96	124.53	128.64
IBA-Solution	158.88	111.17	121.41
Ferti-start Solution	135.58	94.44	125.67
Root-Fro Solution	145.46	109.75	129.81
Total (Bi)	**720.29**	**530.15**	**595.25**

Table 8. Analysis of Variance for Mean Survival percentage of cuttings for results of Experiment II based on values of arcsine transformation

SV	DF	SS	MS	F	CV%
Replication	2	80.51	40.255		
Hormonal Treatment (A)	4	1116.41	279.1025	**11.07****	
Major Plot Error(a)	8	201.6	25.2		20.1
Seasons (B)	2	1245.03	622.515	**21.436****	
Hormone x Season interaction (AB)	8	210.1	26.2625	**0.904**^{ns}	
Subplot Error (b)	20	580.82	29.041		
Total	**44**	**3434.47**			

** Highly significant at 1% Level
^{ns} Non-Significant

Table 9. Comparison of data recorded between two different sites

Site	Survival %	average root length(cm)	average numbers of roots
Yezin	50.33	9.43	8.67
Thipaw	62.67	10.17	6.67

Table 10. Analysis of Variance for mean survival percentage of cuttings for results of Experiment III based on values of arcsine transformation

SV	DF	SS	MS	F	CV%
Replication	2	53.8	26.9		
Treatment	1	79.4	79.4	**0.74**^{ns}	21.2
Error	2	214.0	107.0		
Total	**5**	**347.2**			

^{ns} Non-Significant

Table 11. Analysis of Variance for mean average root length (cm) of cuttings for results of Experiment III based on values of arcsine transformation

SV	DF	SS	MS	F	CV%
Replication	2	6.730	3.365		
Treatment	1	0.807	0.807	**0.29**^{ns}	17.0
Error	2	5.563	2.872		
Total	**5**	**13.100**			

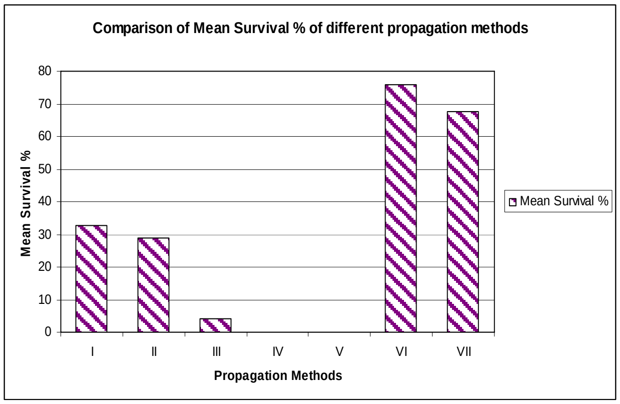
^{ns} Non-Significant

Table 12. Analysis of Variance for mean average no. of roots of cuttings for results of Experiment III based on values of arcsine transformation

SV	DF	SS	MS	F	CV%
Replication	2	5.333	2.677		
Treatment	1	6.000	6.000	**3.00**^{ns}	18.4
Error	2	4.000	2.000		
Total	**5**	**15.333**			

^{ns} Non-Significant

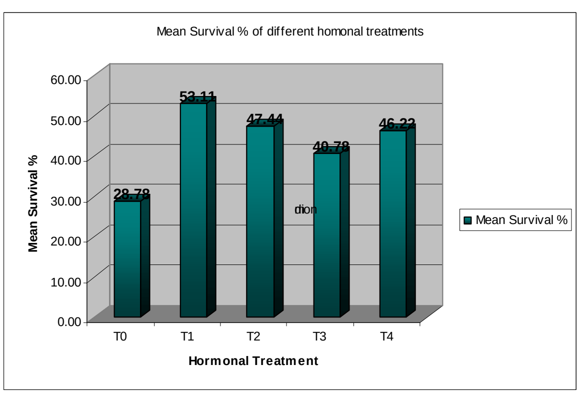
7. Figures



I- Cleft Grafting
II- Bark Grafting
III- Budding
IV- Branch Cutting (treated with IBA)
V- Branch Cutting (control)
VI- Shoot Cutting (Treated with IBA)
VII- Shoot Cutting (Control)

Figure 1. Mean Survival percentage of different propagation methods

Figure 2. Shoot and Root development of different propagation methods



To= Control
T1= IBA- Powder
T2= IBA- Solution
T3= Ferti-Start solution
T4= Root-Fro Solution

Figure 3. Mean survival percentage of different hormonal treatments

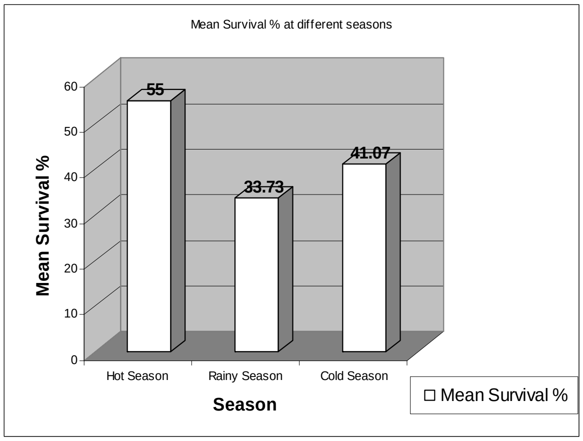


Figure 4. Mean Survival percentage at different seasons

Figure 5. Callus formation of cuttings tested

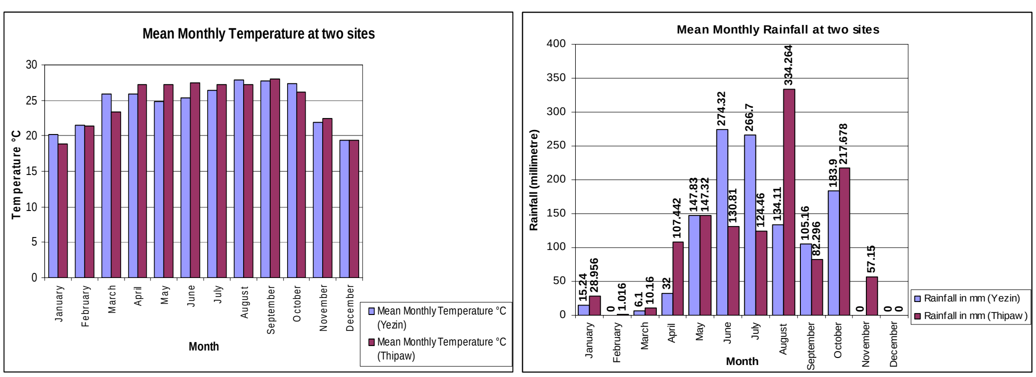


Figure 6. Mean Monthly temperature (°C) and Rainfall (mm) at two sites

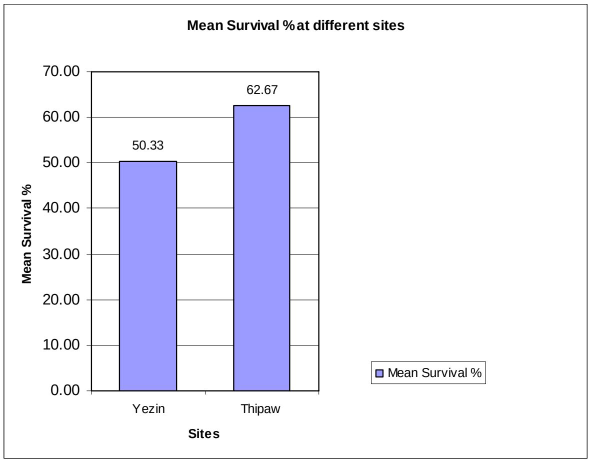


Figure 7. Mean survaival percentage at two different sites

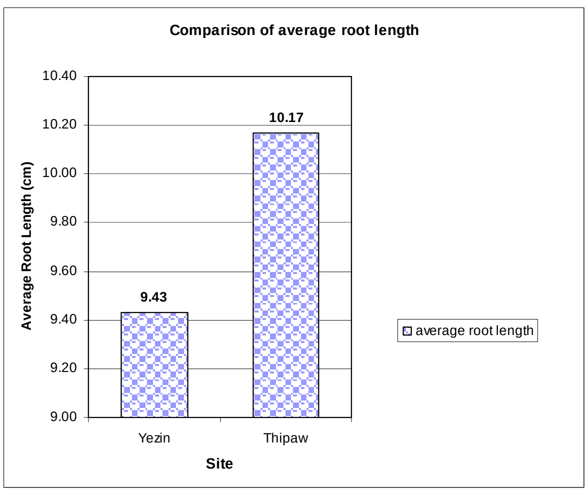


Figure 8. Comparison of average root length at two different sites

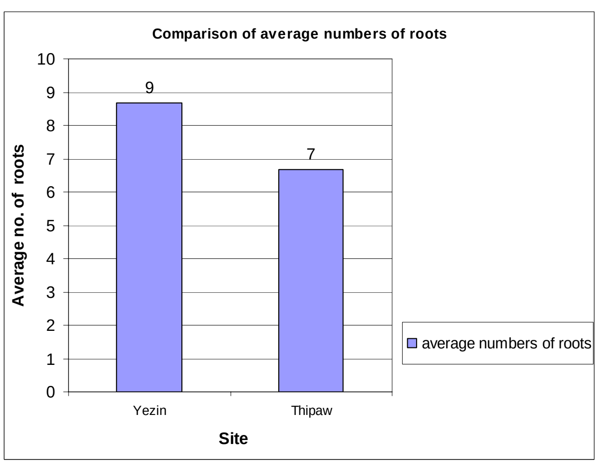


Figure 9. Comparison of average number of roots at two different sites

Figure 10. Shoot and root development of cuttings

Figure 11. Portable Plastic Mist Chambers

Figure 12. Seedlings and 5-year-old plants from which cuttings were collected