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# Study on Seed Germination Rate and Pretreatment of Native Tree Species in Zawgyi Reserved Forests of Taunggyi District, Southern Shan State

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## Abstract

Production of a sufficient number of healthy and suitable-sized seedlings plays a very important role in establishing a successful forest plantation. Seeds are a very important part of maintaining the sustainability of forest functions by providing good quality seeds and seedlings. Therefore, the study was conducted to determine the variability of seeds, seed quality, and seed germination methods of native tree species within the Zawgyi Reserved Forest, Yatsauk Township, Taunggyi District, and Southern Shan State. In this study, two methods of seed storage namely orthodox and recalcitrant were studied based on moisture content. Moreover, the germination percentage of species were also tested by using three pretreatment methods: one day soaking in cold water, two days soaking in cold water, and control. According to the results, out of the collected 60 species, there were 28 orthodox species and 32 recalcitrant species. However, germination testing was conducted only on 30 species out of 60; 16 species were orthodox and 14 species were recalcitrant. Similarly, among 16 orthodox species, only 8 species including Cheery (84 %), Kinpadi (68%), Taukkyan (81%) Laze (72%), Ziphyu (69%), Zaungbale (76%) Yamane (85%), and Tamanale (78%) have good germination rate in treatments. Out of 14 recalcitrant species, only 8 species including Te (96%), Thitcho (95%), Nabe (70%), Nayuwai (66%), Zagawa (72%), Zagaphyu (70%), Thadi (74%) and Shadone (64%) have good germination rate in treatments compared to control method. The results of this study can be applied in the establishment of rehabilitation and reforestation through using native tree species, and genetic conservation of native tree species and their habitat.

Keywords: Orthodox, Recalcitrant, Pretreatment Germination, Native species

# ရှမ်းပြည်နယ်တောင်ပိုင်း၊ တောင်ကြီးခရိုင် ဇော်ဂျီကြိုးဝိုင်းအတွင်းရှိ ဒေသရင်း သစ်မျိုးစိတ်များ၏ မျိုးစေ့များအားပြုပြင်မှုပေးခြင်းနှင့် အညောက်ပေါက်နှုန်းတို့အား စမ်းသပ်လေ့လာခြင်း

ဆွေဆွေဝင်း (သုတေသနလက်ထောက်–၂)

သစ်တောသုတေသနဌာန၊သစ်တောဦးစီးဌာန

## စာတမ်းအကျဉ်း

သစ်တောစိုက်ခင်းများ အောင်မြင်စွာတည်ထောင်နိုင်ရန် ကျန်းမာသန်စွမ်းပြီး မျိုးရိုးဗီဇ ကောင်းမွန်သောပျိုးပင်များ အလုံအလောက်ထုတ်လုပ်နိုင်ရေးအတွက် အရည်အသွေးကောင်းမွန်သော မျိုးစေ့များရရှိနိုင်ရေးမှာ အလွန်အရေးကြီးသော အခန်းကဏ္ဍမှပါဝင်ပါသည်။ မျိုးစေ့များနှင့်ပျိုးပင်များ၏ အရည်အသွေးကောင်းမွန်မှုကို ပံ့ပိုးပေးခြင်းဖြင့် သစ်တောလုပ်ငန်းဆောင်တာများ ရေရှည်တည်တံ့ခိုင်မြဲစေရန်အတွက် သစ်မျိုးစေ့များသည်အလွန်အရေးကြီးသော အစိတ်အပိုင်းတစ်ခုဖြစ်သည်။ ထို့ကြောင့် ရှမ်းပြည်နယ်တောင်ပိုင်း၊ တောင်ကြီးခရိုင်၊ ရပ်စောက်မြို့နယ် ဇော်ဂျီကြိုးဝိုင်းသစ်တောများ အတွင်းရှိ ဒေသရင်းသစ်မျိုးစိတ်တို့၏ မျိုးစေ့များရရှိနိုင်ရေး၊ မျိုးစေ့များ၏ အသီးတင်နှုန်းနှင့် အပင်ပေါက်ရာခိုင်နှုန်းတို့ကိုသိရှိနိုင်ရန် သုတေသနပြု လေ့လာဆန်းစစ်ခဲ့ခြင်းဖြစ်သည်။ ဤလေ့လာမှုတွင် သစ်မျိုးစေ့များ၏ သိုလှောင်သိမ်းဆည်းထားခြင်း နည်းစနစ်(၂) မျိုးဖြစ်သည့် ကြာရှည်သိုလှောင် ထိန်းသိမ်းထားခြင်း နှင့် ကြာရှည်သိုလှောင် ထိန်းသိမ်းမထားနိုင်ခြင်းတို့ကို အစိုဓာတ်ပါဝင်မှုအပေါ်အခြေခံ၍ လေ့လာဆန်းစစ်ခဲ့ပါသည်။ ထို့အပြင် သစ်မျိုးစိတ်များ၏ အပေါက်ရာခိုင်နှုန်းများကိုလည်း ရေအေးတွင် (၁) ရက်စိမ်ခြင်း၊ (၂) ရက်စိမ်ခြင်းနည်းလမ်းများကို အသုံးပြု၍ စမ်းသပ်ခဲ့ပါသည်။ ရလဒ်များအရ သစ်မျိုးစိတ်များစု ဆောင်းကောက်ယူခဲ့သည့် မျိုးစိတ် (၆၀)တွင် ကြာရှည်သိုလှောင်ထိန်းသိမ်းထားနိုင်သည့်မျိုးစိတ် (၂၈) မျိုး နှင့် ကြာရှည်သိုလှောင်ထိန်းသိမ်းမထားနိုင် သောမျိုးစိတ် (၃၂) တို့အား ခွဲခြားနိုင်ခဲ့ပါသည်။ ကောက်ယူရရှိခဲ့သည့် သစ်မျိုးစိတ်များထဲမှ ကြာရှည်သိုလှောင်ထားနိုင်သည့် မျိုးစိတ် (၁၆) မျိုးနှင့် ကြာရှည်သိုလှောင်မထားနိုင်သည့် သစ်မျိုးစိတ် (၁၄) မျိုးစုစုပေါင်းမျိုးစိတ် (၃၀) မျိုးကိုသာအပင် ပေါက်ရာခိုင်နှုန်း စမ်းသပ်ရန်အသုံးပြုခဲ့ပါသည်။ စမ်းသပ်

တွေ့ရှိချက်များအရ ကြာရှည်သိုလှောင်ထားနိုင်သည့် သစ်မျိုးစိတ် (၁၆) မျိုးတွင် သစ်မျိုးစိတ် (၈) မျိုးဖြစ်သည့် ချယ်ရီ (၈၄%)၊ ကင်းပတီး (၆၆%)၊ ထောက်ကြံ့ (၈၁%) လယ်ဇ (၇၂%)၊ ဆီးဖြူ (၆၉%)၊ ဇောင်းပလွေ (၇၆%)၊ ယမနေ (၈၅%) နှင့် တမလန်း (၇၈%) သစ်မျိုးတို့သည် ရေစိမ်၍ အညှောက်ဖောက်ပါက ကောင်းမွန်းသည့်ရလဒ်များ ရရှိကြောင်းတွေ့ရှိရပါသည်။ အလားတူ ကြာရှည်သိုလှောင်မထားနိုင်သည့် မျိုးစိတ် (၁၄) မျိုးတွင် မျိုးစိတ် (၈ ) မျိုးဖြစ်သည့် တယ် (၉၆%)၊ သရက်ချို (၉၅%)၊ နဘဲ (၇၀%)၊ နရွဲ (၆၆%)၊ စကားဝါ (၇၂%)၊ စကားဖြူ(၇၀%)၊ သဒီ (၇၄%) နှင့် လျှာထုံး (၆၄%) သစ်မျိုးတို့သည် ရေစိမ်ခြင်းဖြင့် ကောင်းမွန်သည့် အညှောက်ပေါက်နှုန်းများ ရရှိကြောင်းတွေ့ရှိရပါသည်။ ဤသုတေသနလေ့လာချက်မှရလဒ်များသည် ဒေသရင်းသစ်မျိုးစိတ်တို့အား မျိုးရိုးဗီဇထိန်းသိမ်းခြင်း၊ သစ်တောစိုက်ခင်းများ ပြန်လည်တည်ထောင်ခြင်းလုပ်ငန်းများနှင့် နေရင်းဒေသကို ကာကွယ်ခြင်းလုပ်ငန်းတို့တွင် များစွာအထောက်အကူပြုပေးနိုင်မည်ဖြစ်ပါသည်။

# Germination Rate and Pretreatment of Native Tree Species in Zawgyi Reserved Forest of Taunggyi District, Southern Shan State

## 1. Introduction

Myanmar is rich in natural resources thanks to its various types of forests and diverse biological resources. It is also home to some of the world's most important biodiversity resources. About 42.19% of the country's land area is still covered by forest resources (FAO, 2020). Kress et al (2003) reported that there are about 11800 plant species in the Checklist of Myanmar. Among them, 1375 species are large tree species. Nowadays the problem for the fruiting rate and quality of seeds are declining due to climate change and deforestation. Deforestation and forest degradation can lead to biodiversity loss and environmental destruction in Myanmar.

The most essential factor for a successful plantation is the readiness and availability of quality seeds. The quality of seeds is crucial for the future performance of individual seedlings. Therefore, systematic research on endangered species, native species, and economic species to conserve the genetically and commercially useful species is needed. The quality of seed and systematic forestry operations plays a vital role in sustainable forest management. Pretreatments are the conditions applied to break the dormancy of seeds before germination. Moreover, its purpose is to ensure quick and uniform germination. Methods of pretreatment are depending on strength and type of dormancy. Seed storage is the maintenance of high seed germination and vigorous form harvest until planting. It is important to get adequate plant stands in addition to healthy and vigorous plants.

In this study, a series of experiments to study the seed germination and early survival of sixty native tree species were carried out. This study aims to improve the basic knowledge of propagation techniques for various native tree species in nurseries and to identify suitable species for nursery production in the restoration of potential areas.

### 1.1 Problem Statement

Deforestation and forest degradation threaten to biodiversity preservation and the provision of ecosystem services (FAO, 2010, FAO, 2020). Nowadays, forest degradation and deforestation have declined day by day in Myanmar due to overexploitation, illegal logging, etc. On the other hand, the area of forest land is also decreasing because of agricultural expansion, dam

construction urbanization, etc. In addition, seed suppliers have limited distribution of qualified seeds to market. The quality of seed and systematic forestry operations plays a vital role in sustainable forest management. Quality seeds and seedlings are important factors in increasing yield and improving the quality of tree products for any land-use system related to tree plantings. That is why, it needs to maintain the physical, physiological, and genetic quality of seeds seed production techniques, seed testing, seed storage, and nursery techniques. There are very limited studies relating to intraspecific variation in germination requirement among the species Orthodox and Recalcitrant in Myanmar.

The Zawgyi Reserved forest is located in Southern Shan State, Taunggyi District. It is located in Yatsauk Township and covers an area of (152.736) acres. The forest cover of Shan State including Southern Shan State has been declining due to the increasing of croplands, shifting cultivation, mining, etc. The annual rate of changing forest cover in Shan State is 1.9%. (FRI, 2019). The loss of species diversity is totally dependent on the rate of deforestation. The degradation and loss of forests threaten the survival of many species and reduce the ability of forests to provide essential services (IUCN, 2021). Therefore, it can be said that the species diversity of the Southern Shan Stage can also be lost in the near future. This is also the root of conducting this study.

## 2. Objectives

The objectives of the study are:

(1) To identify Orthodox Seeds and Recalcitrant Seeds

(2) To compare the germination rate of native species with treatments

## 3. Materials and Methods

### 3.1 Seed Collection

Seed collection was conducted in the Zawgyi Reserved Forest, Southern Shan State, Taunggyi District (Figure 1). The method of seed extraction depends on the type and nature of the fruits. For example, the maturity of seed can be recognized when the seed is changed to yellow color, brown color, dark color, and red color. The fruits need to be collected as soon as they start to mature to avoid damage from insect attacks. Seeds from fleshy fruits may be removed by macerating and washing, while the seed's husks can be extracted by thrashing, de-winging, and picking by hand. In countries where facilities are available, machinery is being used for seed extraction, seed driers, seed graders, seed separators, seed

blowers, seed scarify, and sieves are some of the useful equipment for seed processing. However, care should be taken during all these activities so that seeds are not damaged.

In this study, all of the species were collected seasonally by climbing and picking with an extended pruner before the pods dehisce. The total number of species for testing was sixty native tree species of 27 different families and 45 genera.

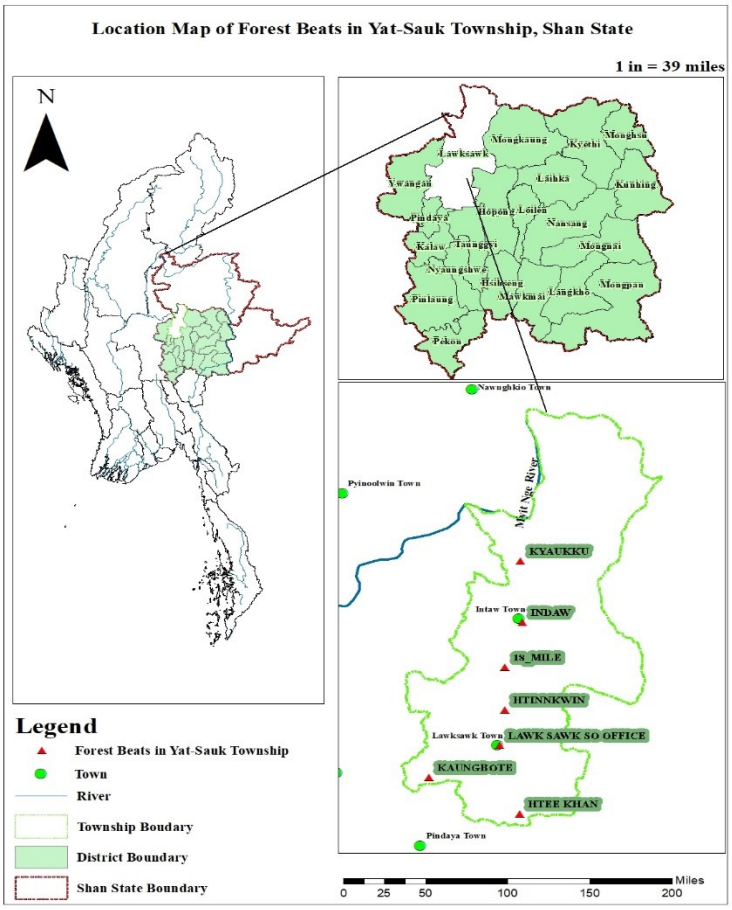


Figure1**.** Location of the study area

### 3.2 Seed Moisture Content Determination and Desiccation Process

Moisture content (MC) was determined using the standard ISTA protocol (ISTA, 2006). Two replicates of 5 g seeds were accurately weighed (to 3 decimal places) in two replicates into dry, clean, pre-weighed Petri dishes and placed into a preheated oven at 102ºC (±2ºC) for 17 hours. At the end of each exposure period, the seeds were cooled for 45 minutes inside a desiccator and reweighed. Seed moisture content was calculated on a fresh weight basis (Schmidt, 2007), as the following formula:

$$\text{Seed weight at desired MC} = \frac{\text{Initial weight of seed X (100-initial MC)}}{\text{(100 - desired MC)}}$$

### 3.3 Number of Seeds Per Unit Volume and Unit Weight

Condensed milk tin (CMT) which is very commonly used as a measuring unit in Burma (Myanmar) was used as a standard unit in determining the number of seeds per unit volume. The capacity of CMT is equivalent to 320 cubic centimeters.

Assessment of the number of seeds per CMT was replicated ten times, and the average was calculated.

Similarly, seeds of each of the species tested were sampled, and the number of seeds replicated was randomly taken and measured in grams by using an electronic digital balance. One kilogram of seed was weighed on an electrical precision balance, and the number of seeds was counted. The process was repeated five times for each.

### 3.4 Methods for Determination of Species Types

The terms orthodox and recalcitrant seed came into usage in 1973 (Dr. E. H. Roberts). The seeds used in this study were classified into two categories (orthodox and recalcitrant) based on the differences in physiological responses, which are moisture content and temperature during storage. Orthodox seeds can withstand drying down to a low moisture content of around 5% to 10% and are successfully stored at low or subfreezing temperatures for long periods. When stored at 0°C to 5°C temperature and moisture content between 6% to 10% percentage.

Recalcitrant seeds that cannot tolerate drying below relatively high moisture content (often in the range of 20% to 50% net basis) and which cannot be stored successfully for long periods. Their seeds are sensitive to low temperature and chilling damage and may die if they are stored in low temperatures. These are the most difficult groups to store even for a short period.

### 3.5 Seed Pre-treatment Methods

After all tree seeds collected in the field, the experiments were carried out at Forest Research Station (4), Yezin. Out of the 30 species tested, there are two types of tree seeds

have categorized namely orthodox and recalcitrant. The orthodox was accounted for 16 species and the remaining 14 species were recalcitrant.

The species tested were;

Pre-treatment 1- Soaked in cold water for 1 day

Pre-treatment 2- Soaked in cold water for 2 days

Pre-treatment 3- Control (without pre-treatment)

Thet-e (*Castanopsis tribuloides* (Sm.) A.DC., Nyan (*Quercus serrata* Maurrary), Thityecho (*Madhuca* sp.), Shadone (*Haberantha cerasodies* (Roxb.)Chaowasku), Nabe (*Lannea coromandelica* (Houtt.) Merr.), Naywe *Flacourtia indica* (Burm.f.) Merr.), Tawthayet (*Mangifera sylvatica* Roxb.), Zagawa (*Michelia champaca* L.), Zagaphyu (*Michelia baillonii* (Pierre) Finet & Gagnep.), Phetshat (*Colona floribunda* (Kurz) Craib), Thitswele(*Engelhardia spicata* Lechenex Blume),Taw-Thidini (*Mallotus philippensis* (Lam.) Müll.Arg.), Te (*Diospyros burmanica* Kurz), Thadi (*Protium serratum* (Wall. ex Colebr.) Engl., Kinpadi (*Sapindus rarak* DC.), Ziphyu (*Phyllanthus emblica* L.), Zaungbale (*Lagerstroemia villosa* Wall.ex Kurz), Pyinma (*Lagerstroemia speciosa* (L.) Pers.), Taukkyan (*Terminalia crenulata* Roth), Yemane (*Gmelina arborea* Roxb.ex Sm.), Cheery (*Prunus cerasoides* Koidz.), Yinsat (*Dalbergia fusca* Pierre), Tamalan *(Dalbergia oliveri Gamble ex prain),* Kathit *(Erythrina suberosa Roxb.)* Madama (*Dalbergia ovata* Graham ex Benth.), Yindike (*Dalbergia cultrata* T.S.Ralph), Chindyin (*Parkia speciosa* Hassk., Pinsein (*Docynia indica* (Colebr. ex Wall.) Decne.), Taungtama (*Melia dubia* Cav.) and Kokko (*Albizia lebbeck* (L.) Benth.) seeds were sampled and soaked in cold water for (1) day and (2) day for each treatment and one hundred seeds were germinated in a germination box with pure sand. As control group, one hundred untreated seeds were also included in the germination test. Those were watered twice a day

**3.6 Germination Test**

In the germination experiment, all pretreated and control seeds were germinated in a 61cm x 61 cm x 15 cm germination box with pure sand. The germinated seeds were counted and recorded daily. Then the germinated sprouts are picked and transplanted in the nursery. Seeds and recently germinated seedlings were planted in plastic bags of 7 x 3 cm filled with mixed soil. The growths of the transplanted seedlings were measured and recorded monthly.

### 3.7 Statistical Analysis

The present study was carried out to test the hypotheses: (I) there are differences in germination percentage among thirty tree species and different pretreatment methods influence the germination percentages of the study species. In the present study, the effects of three different germination pre-treatment methods on the seed viability of thirty species from Yatsauk Township of Taunggyi District were assessed.

To compare the mean differences between the variables, ANOVA was used to test the effect of seed pre-treatments on germination rates. Multiple comparisons of the means were tested using Tukey's HSD (Honestly Significant Difference) method ($P>0.05$). For the 30 species, seed germination rates were calculated for each treatment soaked in cold water for 1 day and soaked in cold water for 2 days and for the control. A total of 300 seeds (25 seeds, 4 replicates, 3 treatments = 300) for each of the 30 species were used in the experiment. All the statistical analyses were conducted in R (R version 4.2.1).

## 4. Results and Discussion

All of the seeds were tested to obtain their moisture content (MC) and then classified and recorded. There are two categories of seeds, namely orthodox and recalcitrant. As a result, 28 species were orthodox and 32 species were recalcitrant. All species were classified and recorded. The characteristics of the tested species were summarized in Tables 1 and 2.

The germination percentages ranged from 27% to 98%, depending on the species. Eight species had germination rates greater than 50%, and twelve species had germination rates greater than 80%, while ten species had germination rates between 27% and 49%, as shown in Tables 3 and 4.

**Table 1. List of Orthodox Seeds**

| Sr. | Myanmar name | Scientific Name | Family |
|---|---|---|---|
| 1. | Seinbanpya | *Jacaranda mimosifolia* D.Don | Bignoniaceae |
| 2. | Taukkyan | *Terminalia crenulata* Roth | Combretaceae |
| 3. | Tamalan | *Dalbergia oliveri* Gamble ex Prain | Fabaceae |
| 4. | Yindaik | *Dalbergia cultrata* T.S.Ralph | Fabaceae |
| 5. | Yinsat | *Dalbergia fusca* Pierre | Fabaceae |
| 6. | Madama | *Dalbergia ovata* Graham ex Benth. | Fabaceae |

| | | | |
|---|---|---|---|
| 7. | Thitpok | *Dalbergia cana var. kurzii* (Prain) Niyomdham | Fabaceae |
| 8. | Bonmeza | *Albizia chinensis* (Osbeck) Merr. | Fabaceae |
| 9. | Chindanyin | *Parkia speciosa* Hassk. | Fabaceae |
| 10. | Mezali | *Senna siamea* (Lam.) H.S.Irwin & Barneby | Fabaceae |
| 11. | Ywegyi | *Adenanthera pavonina* L. | Fabaceae |
| 12. | Seinban | *Delonix regia* (Bojer ex Hook.) Raf. | Fabaceae |
| 13. | Thitmagyi | *Albizia odoratissima* (L.f.) Benth. | Fabaceae |
| 14. | Kokko | *Albizia lebbeck* (L.) Benth. | Fabaceae |
| 15. | Sit | *Albizia procera* (Roxb.) Benth. | Fabaceae |
| 16. | Kathit | *Erythrina suberosa* Roxb. | Fabaceae |
| 17. | Thinwin | *Millettia pendula* Benth. | Fabaceae |
| 18. | Yethinwin | *Melliiettia macrostachya* Collett & Hemsl. | Fabaceae |
| 19. | Yemane | *Gmelina arborea* Roxb.ex Sm. | Laminaceae |
| 20. | Leza | *Lagerstroemia tomentosa* C. Presl. | Lythraceae |
| 21. | Pyinma | *Lagerstroemia speciosa* (L.) Pers. | Lythraceae |
| 22. | Zaungbale | *Lagerstroemia villosa* Wall. ex Kurz | Lythraceae |
| 23. | Taungtama | *Melia dubia* Cav. | Meliaceae |
| 24. | Ziphyu | *Phyllanthus emblica* L. | Phyllanthaceae |
| 25. | Tinyu | *Pinus merkusii* Jungh. & de Vriese | Pinaceae |
| 26. | Cherry | *Prunus cerasoides* Koidz. | Rosaceae |
| 27. | Pinsein | *Docynia indica* (Colebr. ex Wall.) Decne. | Rosaceae |
| 28. | Kinpadi | *Sapindus rarak* DC. | Sapindanace |

**Table 2. List of Recalcitrant Seeds**

| Sr. | Myanmar name | Scientific Name | Family |
|---|---|---|---|
| 1. | Lunbo | *Buchanania lanzan* Spreng. | Anacardiaceae |
| 2. | Nabe | *Lannea coromandelica* (Houtt.) Merr. | Anacardiaceae |
| 3. | Tawthayet | *Mangifera sylvatica* Roxb. | Anacardiaceae |
| 4. | Thitsi | *Gluta usitata* (Wall.) Ding Hou | Anacardiaceae |

| | | | |
|---|---|---|---|
| 5. | Shadone | *Huberantha cerasoides* (Roxb.) Chaowasku | Annonaceae |
| 6. | Thadi | *Protium serratum* (Wall. ex Colebr.) Engl. | Burseraceae |
| 7. | Chinyok | *Garuga pinnata* Roxb. | Burseraceae |
| 8. | Zinbyun | *Dillenia pentagyna* Roxb. | Dilleniaceae |
| 9. | In | *Dipterocarpus tuberculatus* Roxb. | Dipterocarpaceae |
| 10. | Thit-ya | *Shorea obtusa* Wall. ex Blume | Dipterocarpaceae |
| 11. | Ingyin | *Shorea siamensis* Miq. | Dipterocarpaceae |
| 12. | Te | *Diospyros burmanica* Kurz | Ebenaceae |
| 13. | Taw-thidin | *Mallotus philippensis* (Lam.) Müll.Arg. | Euphorbiaceae |
| 14. | Satkadone | *Mallotus nudiflorus* (L.) Kulju & Welzen | Euphorbiaceae |
| 15. | Nyanbo | *Quercus griffithii* Hook.f. & Thomson ex Miq. | Fagaceae |
| 16. | Thite | *Castanopsis tribuloides* (Sm.) A.DC. | Fagaceae |
| 17. | Nyan | *Quercus serrata* Murray | Fagaceae |
| 18. | Gon | *Castanopsis indica* (Roxb. ex Lindl.) A.DC. | Fagaceae |
| 19. | Thitcha | *Quercus brandisiana Kurz* | Fagaceae |
| 20. | Naywe | *Flacourtia indica* (Burm.f.) Merr. | Flacourtiaceae |
| 21. | Thitswele | *Engelhardia spicata* Lechen ex Blume | Juglandaceae |
| 22. | Kabaung | *Strychnos nux-blanda* A.W.Hill | Loganiaceae |
| 23. | Khadaw hmi | *Grevillea robusta* A.Cunn ex R. Br | Proteaceae |
| 24. | Sagaphyu | *Michelia baillonii* (Pierre) Finet & Gagnep. | Magnoliaceae |
| 25. | Sagawa | *Michelia champaca* L. | Magnoliaceae |
| 26. | Phetshat | *Colona floribunda* (Kurz) Craib | Malvaceae |
| 27. | Thitkado | *Toona ciliata* M.Rome. | Meliaceae |
| 28. | Thabye | *Syzygium* sp. | Myrtaceae |
| 29. | Yethabye | *Syzygium nervosum* DC. | Myrtaceae |
| 30. | Daukyat | *Putranjiva roxburghii* Wall. | Putranjivaceae |
| 31. | Thityecho | *Madhcua* sp. | Sapotaceae |
| 32. | Thitya-ni | *Schima wallichii* (DC.) Korth. | Theaceae |

This study highlights that twenty-eight out of the sixty species had orthodox seeds which could potentially be stored in an air-conditioned room. In contrast, thirty-two species could be classified as recalcitrant according to (Dr. E. H. Roberts (1973) and Wyse and Dickie (2017). In this study, the seeds of recalcitrant species were sensitive to desiccation and completely or substantially lost viability when stored, even for very short periods. They were, therefore, classed as recalcitrant (Waiboonya 2017).

However, recalcitrant species generally tend to disperse their seeds during the rainy season (Daws et al., 2005). In the present study, proper and authentic modeling of seed germination is required to improve forest tree species propagation. This result finding will provide for a tree rating system for selecting native species for nursery production and forest restoration. Variations in the germination of seeds concerning provenances have been reported in many native forest tree species, such as *Albizia lebbek* and *Shorea robusta* (Kumar and Toky, 1993).

### 4.1 Effects of Different Pretreatment Methods on Orthodox and Recalcitrant Seeds Germination

This study showed that three pre-treatment methods of orthodox seed**s** significantly affected germination in 11 out of 16 species ($p<0.05$), while no significant difference was observed in the remaining 5 species at the 0.05 significance level (Table 3). For species such as *Dalbergia oliveri*, *Sapindus rarak, Lagerstroemia villosa, Melia dubia, Lagerstroemia speciosa, Docynia indica, and Prunus cerasoides,* seeds soaked in cold water for one or two days demonstrated significantly higher germination percentages compared to the controls (Table 3). Therefore, soaking seeds in water is recommended as a pre-treatment to enhance germination rates for these species. There was no notable difference between the one-day and two-day soaking pre-treatments for these species, except for *Prunus cerasoides*, which showed higher germination rates with two-day soaking. In contrast, for *Dalbergia cultrata* and *Dalbergia ovata*, seeds without any pre-treatment (controls) exhibited significantly higher germination rates compared to seeds soaked in cold water for one or two days (Table 3 and Figure 2). Hence, pre-treatment of soaking in water is not advisable for these species, as it may negatively affect their germination rates. According to the personal observation of researchers, most of the seedlings of Dalbergia cultrata and Dalbergia ovata are destroyed due to soaking in water because these species have thin seed coats and receive more water they needed. Moreover, the *Albizia lebbeck, Parkia speciosa*, *Terminalia crenulate, Erythrina suberos*,

*Phyllanthus emblica*, *Dalbergia fusca,* and *Gmelina arborea* seeds germination was significantly higher when soaked in cold water for one or two days compared to the controls. Therefore, soaking seeds in water is recommended as a pre-treatment to enhance germination rates for these species. *Parkia speciosa* seed germination percentage was higher even though there was no pre-treatment. The results of germination rates with pre-treatment and control for these species can be seen in Figure 1.

**Table 3. Effect of Orthodox Seeds Pretreatment methods on Percentages of Germination, (Mean±SD).**

| Sr. No | Species Name | Control (Mean±SD) | Soaking in cold water for 1 day (Mean±SD) | Soaking in cold water for 2 days (Mean±SD) | F-value |
|---|---|---|---|---|---|
| **1.** | *Dalbergia oliveri* Gamble ex Prain | 64±3.2 | 80±8.6 | 78±10.1 | 5.67** |
| **2.** | *Dalbergia cultrata* T.S.Ralph | 81±5.0 | 53±8.8 | 40±7.3 | 33.48** |
| **3.** | *Dalbergia fusca* Pierre | 66±9.5 | 78±8.3 | 82±8.3 | 4.52 |
| **4.** | *Dalbergia ovata* Graham ex Benth. | 79±8.2 | 43±7.5 | 36±3.2 | 46.97** |
| **5.** | *Albizia lebbeck* (L.) Benth. | 79±3.8 | 77±9.5 | 81±6.8 | 0.18 |
| **6.** | *Docynia indica* (Colebr. ex Wall.) Decne. | 72±25.9 | 91±2 | 95±3.7 | 2.14 |
| **7.** | *Sapindus rarak* DC. | 43±2 | 65±6.8 | 68±5.6 | 27.05 ** |
| **8.** | *Parkia speciosa* Hassk. | 95±2 | 92±8 | 92±8 | 0.15 |
| **9.** | *Terminalia crenulata* Roth | 43±8.2 | 79±5.0 | 81±3.8 | 50.81** |
| **10.** | *Lagerstroemia villosa* Wall. ex Kurz | 53±8.2 | 70±4 | 76±3.2 | 18.04** |
| **11.** | *Melia dubia* Cav. | 37±13.2 | 70±2.3 | 73±3.8 | 24.6 |
| **12.** | *Lagerstroemia speciosa* (L.) Pers. | 52±5.6 | 68±3.2 | 72±3.2 | 25.2** |
| **13.** | *Erythrina suberosa* Roxb. | 74±9.5 | 89±6.8 | 91±5.0 | 6.36* |
| **14.** | *Phyllanthus emblica* L. | 55±8.2 | 62±6.8 | 69±3.8 | 27.04** |
| **15.** | *Gmelina arborea* Roxb.ex Sm. | 66±3.2 | 84±3.2 | 85±3.8 | 30.33** |
| **16.** | *Prunus cerasoides* Koidz. | 63±3.8 | 71±3.8 | 84±3.2 | 33.7** |

***F- value or significant value from ANOVA test**

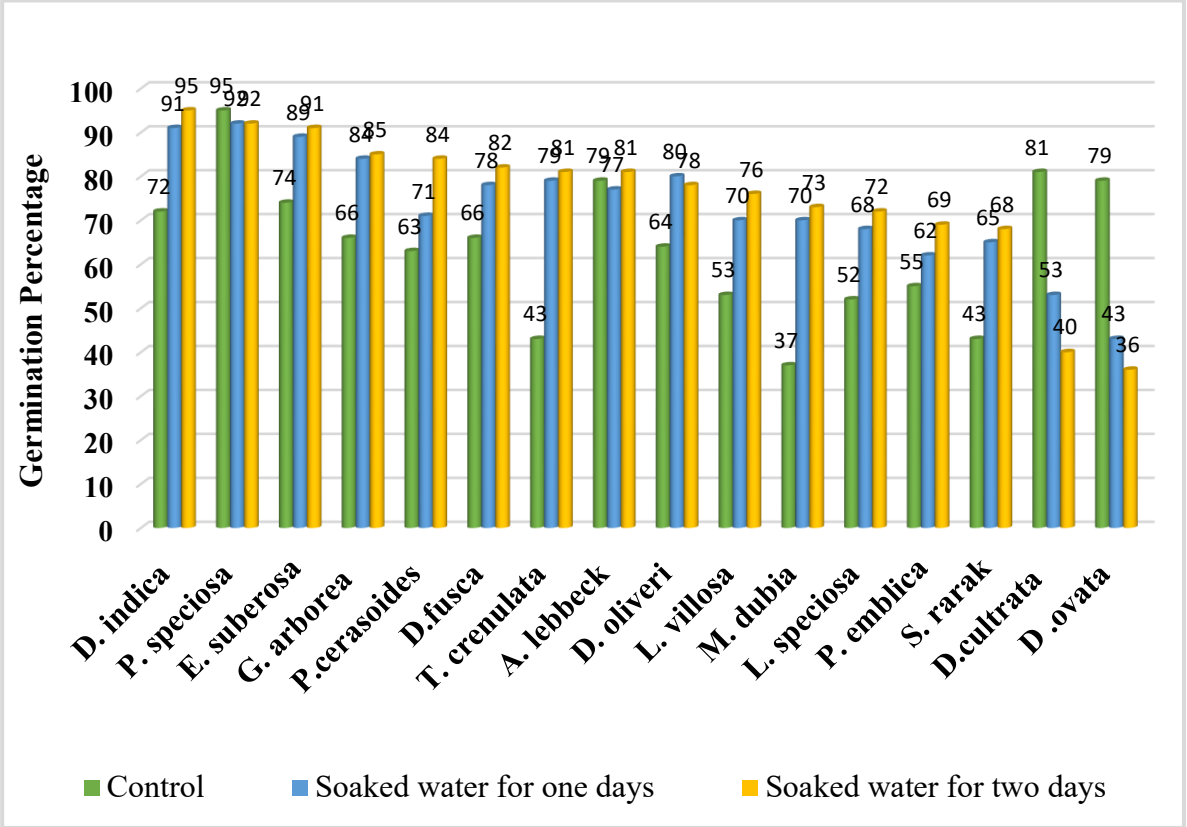


Figure 2: Effect of Different Pre-sowing Treatments on Germination Percentage (%) of Sixteen Species.

This study indicates that three pretreatment methods of recalcitrant seeds significantly influenced germination in 8 species out of 14 ($p < 0.05$). At the same time, no significant differences were observed in the remaining 6 species at the 0.05 significance level.Among these 8 species, *Madhcua* sp., *Flacourtia indica, Michelia baillonii, Michelia champaca*, *Protium serratum* and *Lannea coromandelica* exhibited significantly higher germination rates when seeds were soaked in water compared to the control, with no notable differences observed between the two soaking treatments (Table 4 and Figure 2).

A one-day soaking pretreatment is recommended for these species, except for *Lannea coromandelica,* which was better suited with two days of soaking. However, for *Castanopsis tribuloides* and *Quercus serrata*, the control group exhibited significantly higher germination rates, indicating that soaking in cool water as a pretreatment may reduce germination rates for these species. This could be due to the fact that these species have hard seed coats. Thein

and Mu (2012) also stated that the germination rate of hardshell species was not directly dependent on soaking water.

The germination percentage of *Engelhardia spicata*, *Mallotus philippensis*, *Mangifera sylvatica*, *Colona floribunda*, *Diospyro burmanica,* and *Huberantha cerasoides* soaking in cool water for one day or two days proved to be a better substrate compared to the control *Huberantha cerasoides and Colona floribunda* seeds soaked in cold water for two days, significantly higher germination rates compared to soaked in cold water for one day or controls.

**Table 4. Effect of Recalcitrant Seeds Pretreatment Methods on Percentages of Germination (Mean±SD).**

| Sr. No | Species Name | Control (Mean~SD) | Soaking in cold water for 1 day (Mean~SD) | Soaking in cold water for 2 days (Mean~SD) | F-value |
|---|---|---|---|---|---|
| 1. | *Madhcua* sp. | 72±25.9 | 91±2 | 95±3.7 | 2.14 |
| 2. | *Castanopsis tribuloides* (Sm.) A.DC. | 75±8.86 | 69±3.2 | 60±0 | 6.57* |
| 3. | *Quercus serrata* Murray | 78±7.6 | 71±3.8 | 68±7.3 | 2.58 |
| 4. | *Diospyro burmanica* Kurz | 95±2 | 94±2.3 | 96±0 | 2.25 |
| 5. | *Huberantha cerasoides* (Roxb.) Chaowasku | 32±3.2 | 50±2.3 | 67±5.0 | 88.94** |
| 6. | *Lannea coromandelica* (Houtt.) Merr. | 42±6.9 | 55±6 | 70±5.1 | 21.29** |
| 7. | *Flacourtia indica* (Burm.f.) Merr. | 27±6.8 | 58±12.4 | 66±5.1 | 22.33** |
| 8. | *Michelia baillonii* (Pierre) Finet & Gagnep. | 41±13.2 | 67±8.8 | 70±2.3 | 7.25** |
| 9. | *Colona floribunda* (Kurz) Craib | 38±8.3 | 47±8.8 | 53±5.0 | 3.94** |
| 10. | *Mangifera sylvatica* Roxb. | 70±11.4 | 74±2.3 | 76±3.2 | 1.75 |
| 11. | *Michelia champaca* (L.) Baill. ex Pierre | 49±2 | 67±8.8 | 72±3.2 | 18.81** |
| 12. | *Protium serratum* (Wall. ex Colebr.) Engl. | 44±4.6 | 69±5.0 | 74±5.1 | 42.27** |
| 13. | *Mallotus philippensis* (Lam.) Müll.Arg. | 56±5.6 | 62±4 | 64±3.2 | 3.54 |

| | | | | | |
|---|---|---|---|---|---|
| 14. | *Engelhardia spicata* Lechen ex Blume | 60±5.6 | 64±3.2 | 66±5.1 | 1.61 |

***F- value or significant value from ANOVA test**

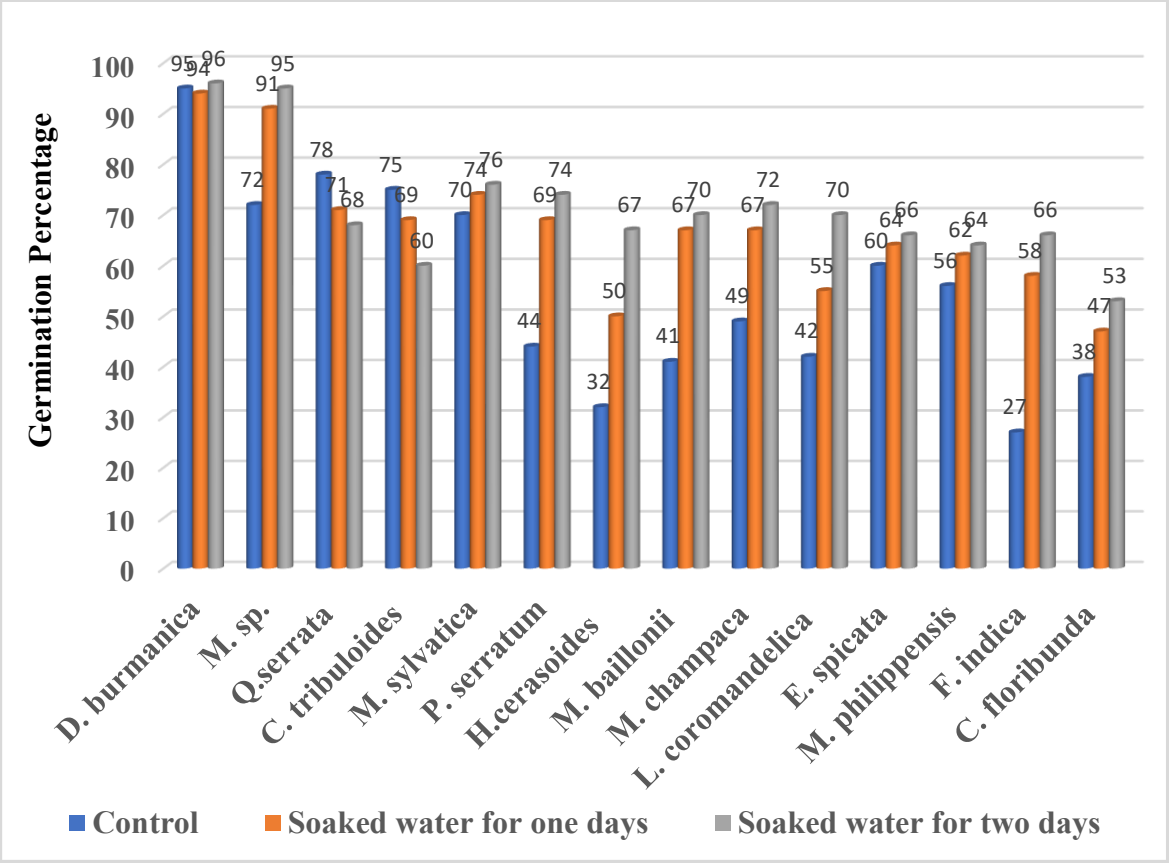


Figure 3: Effect of Different Pre-sowing Treatments on Germination Percentages (%) of Fourteens Species (Recalcitrant).

This section presents the implications drawn from our results. Pretreatment is typically undertaken shortly before sowing because pretreatment and germination are often interlinked. This study also examined the germination percentage of the seed pretreatment methods and seed conservation techniques for forest plantation establishment.

## 5. Conclusion and Recommendation

According to the result, there are 28 species that were orthodox, and 32 species that were recalcitrant out of 60 species Both orthodox and recalcitrant species are recommended to be planted in city forests with the limitation that the seeds should be properly processed. The viability of orthodox seeds could be maintained for long storage periods at low

temperatures, whereas recalcitrant seeds are difficult to store for long periods and lose their viability in a short time. The main challenge for recalcitrant seeds is their short lifespan and for some species, the irregularity of flowering and fruiting periods which do not occur annually.

The results of the present study confirmed that the seeds of thirty species have a good germination rate in all experimental treatments compared to the control group. It means that different pretreatment methods should be applied before seed distribution to nurseries for plantation.

The limitation of the study is the seed storage methods of tree species. In further studies, it should mainly focus on seed storage methods among different tree species.

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