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Comparative Study on Provenances Variation of Burmese Rosewood (*Dalbergia oliveri* Gamble ex Prain) in Myanmar

Tin Tin Mu (Assistant Research Officer)
Swe Swe Win (Research Assistant-2)
Dr. Mu Mu Aung (Rresearch Officer)
Forest Research Institute

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မြန်မာနိုင်ငံရှိ မျိုးရင်းဒေသအလိုက်ပေါက်ရောက်သော တမလန်းသစ်မျိုး၏ ကွဲပြားခြားနားမှုနှင့် ရှင်သန်ကြီးထွားမှုကို နှိုင်းယှဉ်လေ့လာခြင်း

တင်တင်မူ (လက်ထောက်သုတေသနအရာရှိ)

ဆွေဆွေဝင်း (သုတေသနလက်ထောက်-၂)

ဒေါက်တာမူမူအောင် (သုတေသနအရာရှိ)

စာတမ်းအကျဉ်း

တမလန်းသစ်မျိုး(*Dalbergia oliveri* Gamble ex Prain) သည် ပဲမျိုးရင်း (Family: Fabaceae) တွင် ပါဝင်သော သစ်မျိုးဖြစ်ပြီး စီးပွားရေးအရ အလွန်အရေးပါသော သစ်မျိုးဖြစ်ပါသည်။ မြန်မာနိုင်ငံတွင် *Dalbergia* မျိုးစု၀င် မျိုးစိတ်ပေါင်း ၄၃ မျိုး သဘာဝ အလျောက်ပေါက်ရောက်လျက်ရှိသည်ဟု **A Checklist of Trees, Shrubs, Herbs and Climber** (Kress *et al.*, 2003) တွင် မှတ်တမ်းတင်ထားရှိပြီးဖြစ်ပါသည်။ ယခုအခါ အလွန်အကျွံခုတ်ယူ၍ တရားမဝင်ခိုးထုတ်ရောင်း၀ယ်မှုကြောင့် အန္တရာယ်ကျရောက်နေသော အနီရောင်ဇယားတွင်ပါဝင်ပြီး ထိန်းသိမ်းကာကွယ်မှုအဆင့်အနေဖြင့် Endangered (IUCN 2.3) Red List of Threatened Species မျိုးသုန်းပျောက်ကွယ်တော့မည့် အပင်မျိုးစိတ်လည်းဖြစ်ပါသည် (Nghia, 1998 and UNEP-WCMC, 2014)။ ဤသုတေသနကို မျိုးရိုးဗီဇထိန်းသိမ်းခြင်းနှင့် မျိုးကောင်းမျိုးသန့် ပျိုးပင်ငယ်များ ထုတ်လုပ်ပွါးများပြီး သစ်တောစိုက်ခင်းများတည်ထောင်ခြင်း လုပ်ငန်းရပ်များတွင် နည်းပညာများ အထောက် အကူပြုပံ့ပိုးပေးနိုင်ရန် ရည်ရွယ်၍ ဆောင်ရွက်ခဲ့ခြင်းဖြစ်ပါသည်။ ဤစာတမ်းတွင် မြန်မာနိုင်ငံတွင်

သဘာဝအလျောက်တမလန်းပေါက်ရောက်သည့် မျိုးရင်းဒေသ (၅) ခုမှ မျိုးစေ့များ စုဆောင်း၍ သန့်စင်ခြင်း၊ သိုလှောင်ခြင်း နည်းစနစ်၊ သစ်မျိုးစေ့များအား ပြုပြင်မှု ပေးနည်း အမျိုးမျိုးဖြင့်အပင်ပေါက်ရာခိုင်နှုန်း စမ်းသပ်လေ့လာ မှတ်တမ်းတင် ဆောင်ရွက် ခဲ့ပါ သည်။ ဤသုတေသန လေ့လာချက်မှ အောင်မြင်သော စိုက်ခင်းများ ထူထောင်ရာတွင် မျိုးရိုးဗီဇ ကောင်းမွန်သော မျိုးစေ့၊ ပျိုးပင်များရရှိနိုင်သော နည်းပညာရပ်ကို ကူညီပံ့ပိုး ပေးနိုင်မည် ဖြစ်ပါသည်။

Comparative Study on Provenances Variation of Burmese Rosewood (*Dalbergia oliveri* Gamble ex Prain) in Myanmar

Tin Tin Mu (Assistant Research Officer)

Swe Swe Win (Research Assistant-2)

Dr. Mu Mu Aung (Research Officer)

Forest Research Institute

Abstract

Dalbergia oliveri Gamble ex Prain (Tamalan), a member of the family Fabaceae, which is economic important timber species in Myanmar. According to the Checklist of Myanmar by Kress et al., (2003), 43 species of *Dalbergia* are naturally distributed in Myanmar. In current situation, it is regarded as IUCN Red list of Threatened species of Plants (Nghia, 1998). Due to its economic value, *D. oliveri* is facing serious depletion by illegal harvesting, illegal trading. To help improve this situation, this research to develop appropriate procedures for seed collection, pretreatment, germination suggested that the seeds of *D. oliveri* collected from 10 plus trees located five study sites. It was found that the effects of four pretreatment methods were not significantly differenced at $p \leq 0.05$ on the seed germination recorded. The overall, high genetic quality seed was obtained from seed sources that match the planting site, have a good outcrossing rate which was be managed to promote increase seed production. The results of the present study confirm that the seeds of *Dalbergia oliveri* Gamble ex Prain from all provenance can germinated in all experimental periods. The study revealed the existence of considerable variation among provenances with respect to seed morphological characters, germination and seedling growth of *Dalbergia oliveri*. This research would be provided with the increase in the establishment of rehabilitation and reforestation programme and consequently the need to know more about the quality seed and healthy growth of seedlings.

Keywords: *Dalbergia oliveri*, Pretreatment, Germination, Storage, Threatened species

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1. Introduction

Myanmar is geographically located in the Southeast Asia with the total land area of 676,577 km^2. It is richly endowed with diverse habitat types and natural resources, culture and traditions. More than 42% of the country's total area is forested. Therefore, Myanmar has abundant forest resources, but it increases the daily demand and exploits social valuable new varieties. Consequently, the economic species are gradually depleted in Myanmar. *Dalbergia oliveri* Gamble ex Prain (Tamalan), a member of the family Fabaceae, order Fabales is one of popular timber species because of its unique wood properties and the value of its wood (Anon, 1956). It is native to South-East Asia and occurred naturally in the Indian Peninsula, Myanmar, Northern Thailand and Northwestern Laos along the northern Thai border (Troup, 1921 and Kaosa-ard, 1977).

The common names of *Dalbergia oliveri* are Burmese Rosewood, Asian Rosewood, and Myanmar: Tamalan. Synonyms are *Dalbergia laccifera* Laness and *Dalbergia prazeri* Prain. According to the Checklist of Myanmar by Kress et al., (2003), 43 species of *Dalbergia* are naturally distributed in Myanmar. This species was widely distributed in Dry Upper Mixed, Lower Upper Mixed, Moist Upper Mixed, Deciduous Dipterocarpus or Indaing Forests and Dry Forests in Myanmar.

Dalbergia oliveri is a deciduous tree growing to 30 m in height and with an open, spreading crown. Young trees are fairly shade tolerant, but older trees prefer a sunny position and very slow growing tree. It is pollinated by insects. It is suitable for light (sandy), medium (loamy) and heavy (clay) soils and prefers well-drained soil. It can grow in semi-shade (light woodland) or no shade. It prefers moist soil.

*Dalbergia oliveri*is highly valued for its red lumber used in making quality furniture, cabinet, luxury, art and handicrafts as well as the handles of agricultural implements among others. It has an attractive veined structure and is easy to polish. The heartwood is a dark red-brown; the sapwood white. The wood is close-grained, hard, heavy, and resistant to the attacks of termites. It is used both with crops and as an industrial plantation species (Sheikh

1988). The species flowers abundantly and regularly from four year old, good rooting of cutting has led to their use as the most common method of propagation (Sheikh, 1988 and White, 1990). The selection criteria are wood yield and quality, but with consideration given also to folder and honey properties. The most successful tree improvement programs are those in which the proper seed sources and provenance are used (Tin Htun, 1995). Nowadays, it is regarded as an endangered species due to overharvesting.

1.1 Problem Statement

Dalbergia oliveri is one of the important timber species in Myanmar. It is useful and valuable species and it is genetically needed to improve seeds. In current situation, it is regarded as IUCN Red list of Threatened species of Plants (Nghia, 1998). Due to its economic value, *Dalbergia oliveri* is facing serious depletion by illegal harvesting, illegal trading and higher demand from China. The number of remaining individual trees is very low, and these are disappearing on a local level. In many areas of its natural range, mature and large sized trees are rarely to be found.

The species is facing the possibility of extinction if no effective protection measures are taken (CTSP, 2001). In 2002, the second CTSP meeting on the Forest Gene Conservation Strategy defined *Dalbergia oliveri* as a priority species, and one that is in need of immediate conservation Interventions and appropriate protection. It is, therefore, urgently needed to conserve and restore the sustainable use this species in the long term, through stricter conservation measure such as establishing forest plantations, enrichment planting, species wise inventory, law enforcement of illegal trade and logging, etc. However, efforts to regenerate the species on a large scale have been few and limited.

In this context, knowledge of seed biology is crucial for establishing plantation and proper handling including storage of seeds. The term ‘seed’ usually refers to the unit extracted from the fruit and handled as a unit during storage, pre-treatment and sowing. Seed handling encompasses a series of procedures beginning with selection of the best quality of seed source, through collection, processing, storage, pretreatment to germination. Each link of this chain implies a potential risk of losing seed, and any link in the process is of equal importance (though not necessarily equally sensitive). If a seed dies due to careless handling during collection or processing, even the best storage conditions will not bring it back to life. If a seed dies during storage, the whole preceding effort is wasted. In Myanmar, there is a

lack of information or, perhaps, a lack of knowledge about *Dalbergia oliveri* at different stages of growth and development.

Dangasuk et al., 1997 state that the variations in seed morphological characteristics, germination and seedling growth among provenances of the same species have been reported for many forest trees. Variation among the provenances might also be attributed to genetic differences caused by the adaptation of different provenances to diverse environmental conditions (Ginwal et al., 2005) and soil types (Elmagboul et al., 2014). Variability studies are also needed for higher productivity and future breeding work. Information on morphological variation in seed characteristics amongst the provenances of a species has been reported to be useful for tree improvement programs (Singh et al., 2010). A study on seed morphological, germination and early seedling traits of the different provenances of *Dalbergia oliveri* at nursery stage will help evaluate the suitability of certain provenances.

According to Shu et al., 2012, a major decision in forest management is the selection of seed sources for reforestation and plantation establishment to ensure a successful crop. Screening and selection of suitable seed sources was important to emphasize for providing quality planting material. It will also help in providing planting materials and seed source for mass afforestation or tree breeding strategy and to encourage increased cultivation and domestication of the species. Although, in our country, none of the studies have been carried out intraspecific variation in germination requirement among provenances of the species *D. oliveri* has been studied.

2. Objectives

The present study is carried out with the following objectives:

(a) To assess the seed viability and amount of seed production from individual tree related to provenance.
(b) To compare growth rate from different part of sprouts and which treatment can provide for long-tern storage method.
(c) To provide some technical information for establishment of forest plantations.

3. Materials and Methods

3.1 Seed Sources

In this study, the effects of different pretreatment methods on the germination of *D. oliveri* seeds from five provenances were examined. The experiment was carried out at the

Forest Seed Center of Forest Research Institute, Yezin. The seed of the *D. oliveri* to conducted the experiment were collected from five provenances such as (1) Moeswe, Pyinmana Township, Mandalay Division (19º 43' N and 96º 13' E), (2) Popa Township, Mandalay Division (25º 56' N and 55º 16' E), (3) Bamouk Township, Sangaing Division (21°30' N and 94°97' E),(4) Kyauksae Township, Mandalay Division (23°45'N and 97°00' E), and (5) Gangaw Township,Magway Division (18° 50' N and 22° 47' E). The experimental periods was from 2017 to 2018 (two years).

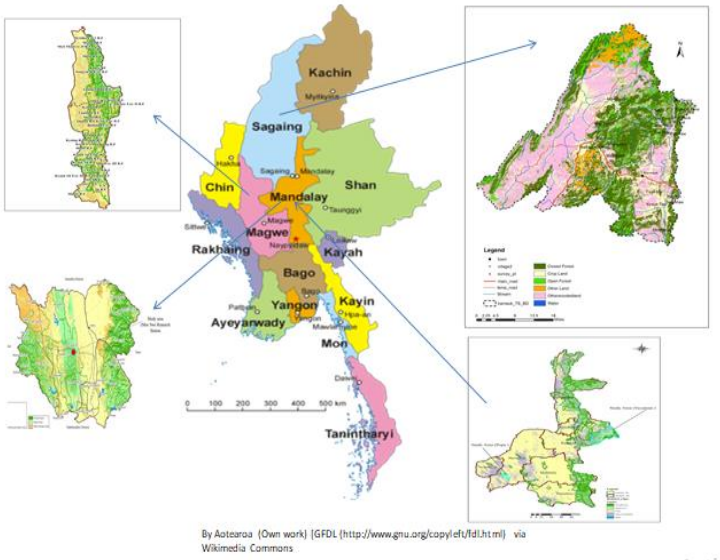

Figure1**.** Study sites

3.2 Seed Collection and Processing (cleaning)

The flowering period of *D. oliveri* species is March and April and the fruits are ripening at the end of June-November (CTSP, 2001). The fruits are legume and generally produce 1-2 seeds (CTSP, 2001). The maturity of seed can be recognized when the pod is changed to dark brown color. The fruits need to be collected as soon when it starts to mature in order to avoid the damage from insect attacks.

In this study, 10 plus trees which situated approximately at the reserved forests from five provenances were selected to collect the seed. The seeds of *D. oliveri* were collected from the middle of January to February. These plus trees were selected criteria on free from pet and disease, infection and clear bole height, steam persistent, stem straightness and branch size seeds collection were done February 2017, 2018.The collected fruits were carried from individual trees and transported to the Seed laboratory of Forest Research Institute (FRI) for processing. The fruits (pods) were collected and put in gunny bags or filled. And

then, the collected pods were dried in direct sunlight for two days. The seeds from the dried pods were extracted manually. The extracted seeds were dried in the sun for one day before storage. The seeds were tested for moisture content by subjecting a sample weighing. The moisture contents obtained were used as the initial moisture contents for the experiment. The cut-testing was also used to assess the quality of seed before carried out the experiment and store in order to provides an indication of the proportion of empty, poorly developed or insect-infested seeds. The pure seeds were then again dried in the sun for 2-3 days. The seeds were then stored in the storage room as possible. The peel can be extracted from the seeds in order to separate the good seeds from inert materials.

Table 1.Take a representative sub-sample of seeds.

No	**Collection size**	**Cut-test sample**
1	> 5,000 seeds	50 seeds
2.	1,000 - 5,000 seeds	20 seeds
3.	500 - 1000 seeds	10 seeds
4.	< 500 seeds	Do not cut-test

Sources; Kew, Technical Information Sheet-14

3.3 Seed moisture content determination and desiccation process

The high adjustable automatic temperature oven method ISTA, seeds was used to determine the moisture content of the seed both initially and subsequently during adjustments. Approximately 5g of 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 103 ºC (±2 ºC) for 17h. At the end of each exposure period, the seeds were cooled for 45 minutes inside a desiccator and reweighed.

Moisture content (MC) of the seed was expressed on a fresh weight basis. In order to adjust the moisture contents from the initial levels to the targeted storage levels, combination of cool air and silica gel methods was used. In silica gel drying methods, sub-samples of seeds in porous cloth bags were placed on blue silica gel, coved and placed in germination chamber set at 15% relative humidity and 200°C. Five lots of seeds were desiccated in silica gel until the target moisture contents of 6.0%, 8.0%, 10.0%, 12.0% and 18.0% were attained.

During desiccation, moisture contents were checked by frequent weighing and calculating moisture contents by using the formula:

Seed weight at desired MC= initial weight of seed X (100-intial MC)/ (100-desired MC)

3.3.1 Number of seeds per unit volume and unit weight

Collected fruits (seeds) were measured for their sizes, weight and number per tin /pyi /Kilogram.

Condensed milk tin (CMT) which is very commonly used as a measuring unit in Myanmar was used as a standard unit in determining the number of seeds per unit volume.

Seed lot of each of the tested species was first divided down repeatedly until seed sample of the volume required is approximately reached. Assessment of the number of seeds per CMT was replicated ten times and the average was calculated.

Similarly, seeds of each provenances tested were sampled and the number of seeds per kilogram was assessed. One kilogram of seeds was weighed on an electrical precision balance and the number of seeds was counted. The process was repeated ten times at least.

Table 2. Number of Fruits per (pyi) seeds per unit weight (kilogram), unit volume (CMT).

1.	1 pyi = 270 -275 fruit	1 CMT = 1575 seeds (1 CMT is equivalent to 320 cubic centimeters.)
2.	1 kg = 7315-7325 seeds	1000 seeds = 138.47-138.52 gm

Table 3. Yield fruits of number of plus tree from study sites.

Produced Fruits of individual tree from seed sources											**Total**	
No of Tree	1	2	3	4	5	6	7	8	9	10	Puyi (1 Pyi = 270)	Fruit
1.Moeswe	3	15	5	3	6	2	7	9	2	2.5	54.5	14,987.5
2.Popa	6	2	1	5	4	3	2	5	7	3	38	10,260
3.Banmouk	8	20	4	5	12	9.5	11	16	26	18	129.5	34,967
4. Kyaukse	13	24	8	5.5	1.5	4	14	22	6	2	100	27,000
5. Gangaw	6	2	1	5	4	3	2	5	7	3	38	10,260

3.4 Seed storage

Five samples of 2500 seeds for each MC were put in a bottle and tightly closed. All five MC regimes were replicated in air condition seed storage room at (17°C-25°C) maintained. Two samples for each provenance of Moisture content% (MC) treatment were taken to determine if seed MC changes occurred during storage. Samples were tested. Germination tests were performed by using four replicates of 25 seeds for each moisture contents for corresponding storage temperature. Germinated seeds were scored daily for up to 7 weeks. Seeds were considered as normally germinated when the radicle protruded to 2–3cm. Moisture content was determined periodically to the desired storage levels. Seed moisture status is important in maintaining seed longevity in storage. (Kew, Technical Information Sheet, 2014)

Preservation of seed with initial quality until it is needed for planting. The seeds are considered to be in storage from the moment they reach physiological maturity until they germinate or until they are thrown away because they are dead or otherwise worthless. The entire storage period can be conveniently divided into following stages as physiological maturity until harvest until processed and stored in a storage room (cold room). The ability of seed to tolerate moisture loss allows the seed to maintain the viability in dry state. After harvesting the seeds are either stored in a cold room or in transit. During the old age days, were used the seeds, in little quantity, but introduction of high yielding varieties for necessitated the development of storage techniques to preserve the seeds. The seed storage is maintenance of an acceptable capacity for germination and emergence, it can only be accomplished by reducing the rate of deterioration to the degree required to maintain an acceptable level of quality for the desired period.

3.5 Seed Pretreatment Methods

To assess the germination percentage and germination value of *D. oliveri* seed from five provenances, five pretreatment methods were used such as:

Pretreatment 1- Control (without pretreatment)

Pretreatment 2- Soaking in cold water for one day

Pretreatment 3- Soaking in boiling water for five minutes

Pretreatment 4- Partial scarification (seeds *D. oliveri*) were clipped slightly with secateurs (or) scissor.

D. oliveri seeds were tested in Seed laboratory room of Forest Seed Center. For germination assessment, 400 pretreated seeds and 100 control seeds giving a total of 500 seeds were then placed in Petridis (glassware) with pure tissue paper.

3.6 Germination Test

In germination experiment, all pretreated and control seeds were germinated in 61cmx 61 cmx 15cm Petridis containing pure tissue. The germinated seeds were counted daily and the marked. The Petridis were watered twice a day. Watering was done with fine spray once at 9 am and another at 3 pm. And then the germinated sprouts are picked and transplanted in nursery. The growth of the seedlings transplanted were measured and recorded at per month basic.

3.7 Measurement Variables and Data Analysis

Germination percentage and germination value of the *D.oliveri* Gamble ex Prain seeds were measured. STATISTICA for Windows (Version 10.0, Statsoft, Inc., Tulsa, USA) was used to analyze the relationships between pretreatments methods and germination percentage of the *D. oliveri*. Gamble ex Prain Complete Randomized Block Design (CRBD) was applied for ANOVA table. All of the graphs were plotted in Microsoft Excel 2013.

4. Results

The present study was carried out to test the hypotheses: (I) the germination percentage of *Dalbergia oliveri* seeds vary with the seed sources (or) provenance, (2) storage duration affects the seed germination and (3) the effect of different pretreatment methods on the germination percentages of the study species. In present study, the effects of four different storage duration (after 1 month, 5 month, 7 month and 12 month) and four pretreatment methods on the seed viability of *Dalbergia oliveri* Gamble ex Prain from four provenance (Banmouk, Gangaw, Kyaukse, and Moeswe) were assessed.

4.1 Effects of different storage duration on the seed viability of *Dalbergia oliveri* (2017)

The results showed that, *Dalbergia oliveri* seeds from all provenances can germinate all the storage duration. In Banmouk provenance, the highest germination percentage of the

species (67%) was obtained at 7 months storage duration and after 7 month, the germination percentage of the species was decreased (Figure 1). In Gangaw provenance, the germination percentage (59%) was the highest which is at the 1 month and the germination percentages of the species were gradually decreased with the increased in storage duration (Figure 1). In Kyaukse provenance, the germination percentage of the species (64%) was the highest at the first month and then, the germination percentages were decrease to 50% germination (Figure 1). At the first month, the germination percentage of the *Dalbergia oliveri* Gamble ex Prain from Moeswe provenance was the lowest (42%) and the highest germination percentage (90%) was attained at the 5 months storage time. After 5 months of storage, the germination percentage of the species was obviously decreased to (77%) (Figure 1).

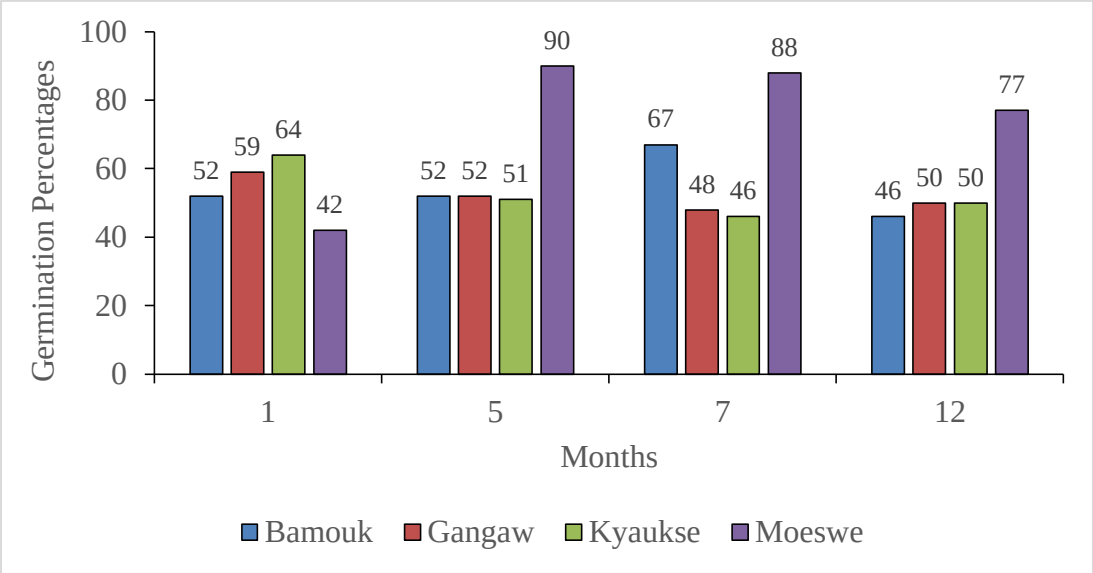

Figure 2. Seed Viability of *Dalbergia oliveri* from four provenances at four storage duration (2017)

The results revealed that, the seed viability of *Dalbergia oliveri* collected from Banmouk and Moeswe provenances obtained the highest germination percentage at the storage duration of 7 month, and then the germination percentages were gradually decreased. In Gangaw and Kyaukse provenances, the germination percentages of the seeds were the highest at 1 month storage duration and the germination percentages were obviously decreased after 7 month storage duration. In comparison between provenances, the germination percentages of *Dalbergia oliveri* from Moeswe provenance get the highest at all time and followed by Banmouk, gangaw and Kyaukse provenances.

4.2 Effects of different storage duration on the seed viability of *Dalbergia oliveri* (2018)

In 2018, the viability of *Dalbergia oliveri* seeds from five provenances (Banmouk, Gangaw, Kyaukse, Moeswe and Popa) was tested in three storage duration (1 month, 5 month and 9 month) after the collection of seeds. The results showed that, the highest of the germination percentage of the species was the highest at 5 month after the collection of seeds and then the germination percentage of the species was decreased gradually.

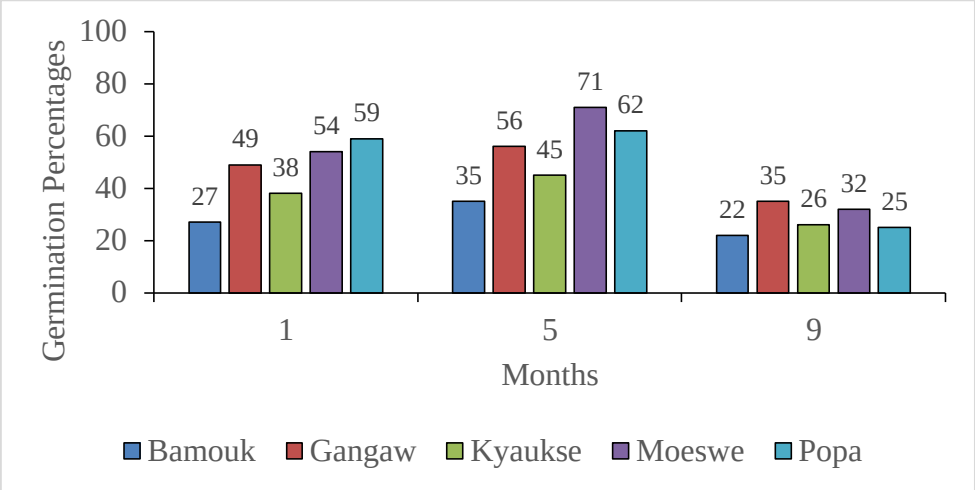

Figure 3. Seed Viability of *Dalbergia oliveri* Gamble ex Prain from five provenances at three storage duration (2018)

In Banmouk provenance, the highest germination of the species (35%) was occurred at 5 month storage time and then, the germination percentage was decreased to (22%) (Figure 2). In Gangaw provenance, the germination percentage (56%) was obtained the highest at 5 month storage duration and the germination percentages of the species were gradually decreased to (35%) with the increased in storage duration. (Figure 2). In Kyauke, the highest germination percentage of the species was related to 5 month storage duration, after that the germination percentage was decreased to (26%) (Figure 2). The highest germination percentage of *Dalbergia oliveri* Gamble ex Prain in Moeswe provenance (71%) was obtained after 5 month and the lowest germination percentage (32%) was related to 9 month storage duration (Figure 2). At 5 month storage duration, the germination percentage of *Dalbergia oliveri* Gamble ex Prain seeds in Popa provenances was the highest (62%) and the lowest (25%) was after 5 month storage duration (Figure 2).

The results obtained from this study, at 5 month storage duration, the highest germination percentages of *Dalbergia oliveri* Gamble ex Prain seeds collected from all provenances were recorded, and after 9 month storage duration the germination percentages were obviously decreased. In comparison between five provenances, the ranking of provenance with respect to the highest germination percentages were in the order of Moeswe, Popa, Kyaukse, Gangaw and Banmouk provenance (Figure 2).

4.3 Effects of different pretreatment methods on the seed germination of *Dalbergia oliveri* (2017)

The results obtained from this study showed that, the effects of four pretreatment methods on the seed germination of the species were not significantly different at $p \leq 0.05$. In Banmouk provenance, the highest germination percentage of the species (69%) was related to soaking in cold water for one day pretreatment methods and the lowest (54%) was at control (without pretreatment) (Figure 3). Under controlled condition, the germination percentage of *Dalbergia oliveri* Gamble ex Prain seed from Gangaw provenance was the lowest (52%) and the highest germination was attained at the pretreatment soaking in cold water for one day pretreatment method (Figure 3). In soaking in cold water for one day treatment, *Dalbergia oliveri* Gamble ex Prain seed from Kyaukse provenance had the highest germination percentage (60%) and the lowest (53%) was recorded at the control and soaking in boiling water for five minutes treatments (Figure 3). In Moeswe provenance, the germination percentage of the species was the highest in partial scarification treatment (87%) and the lowest (58%) was related to soaking in boiling water for five minutes methods (Figure 3).

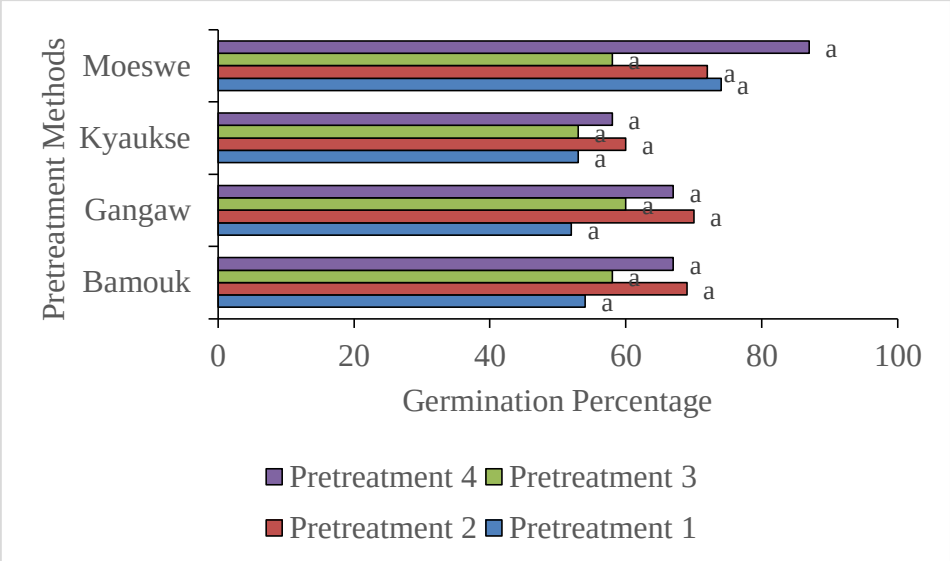

Figure 4. Effects of four pretreatment methods on the seed germination of *Dalbergia oliveri* Gamble ex Prain (2017)

Means are shown for each variable. Means with different letters were statistically significant at $p \leq 0.05$ (Tukey HSD test).

In 2017, the seed of *Dalbergia oliveri* from three provenances (Bamouk, Gangaw and Kyaukse) had the highest germination percentage at soaking in cold water for one day and, only in Moseswe provenance, the germination percentage was the highest with partial scarification treatment. The results obtained from this study revealed that, the seeds germination of *Dalbergia oliveri* with pretreatment had better result than control (without pretreatment).

4.4 Effects of different pretreatment methods on the seed germination of *Dalbergia oliveri* (2018)

The results showed that, the germination percentages of the *Dalbergia oliveri* seed from four provenances was not significantly affected ($p \leq 0.05$) by pretreatment methods, with the exception of germination percentage from Gangaw provenance. However, the germination percentage of species varies with the pretreatment methods.

In Banmouk provenance, the highest germination percentage (31%) was recorded at soaking in cold water for one day and the lowest (28%) at control and soaking in boiling water for five minutes treatments (Figure 4). In Gnagaw provenance, partial scarification treatment had the highest germination percentage (64%) and soaking in cold water for one day treatment had the lowest germination percentage (43%) (Figure 4). The highest germination percentage of *Dalbergia oliveri* Gamble ex Prain from Kyaukse provenance was related to soaking in cold water for one day treatment which was (43%) and the others pretreatment methods had the lowest germination percentages (36%) (Figure 4). In Moeswe and Paopa provenances, the highest germination percentages of the *Dalbergia oliveri* Gamble ex Prain (78% and 72%) were recorded at partial scarification treatment and the lowest (50% and 45%) were related to soaking in boiling water for five minutes treatments (Figure 4).

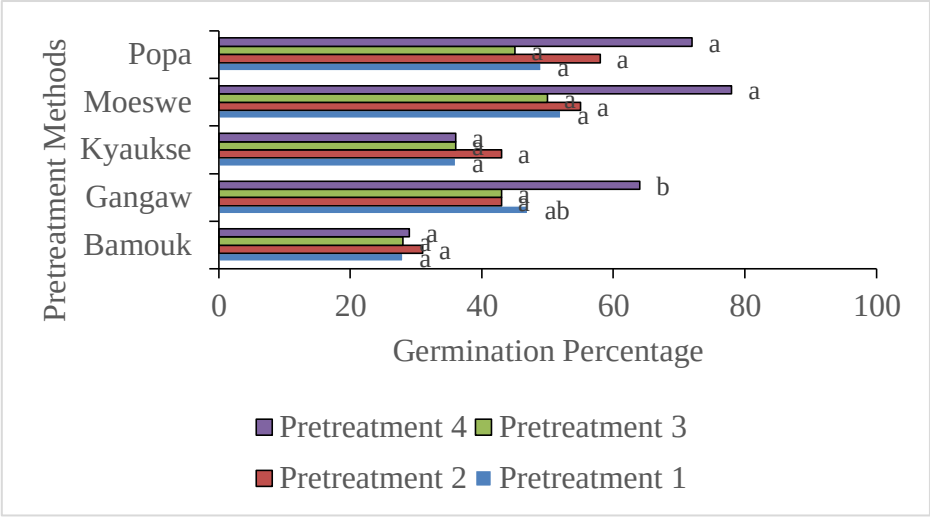

Figure 5. Effects of four pretreatment methods on the seed germination of *Dalbergia oliveri* Gamble ex Prain (2018)

Means are shown for each variable. Means with different letters were statistically significant at $p \leq 0.05$ (Tukey HSD test).

In 2018, the highest seed germination percentages of *Dalbergia oliveri* collected from three provenances (Gangaw, Moeswe and Popa) were related to partial scarification treatment and, the germination percentages of Banmouk and Kyaukse provenances were related to soaking in cold water for one day. The results revealed that, the seeds of *Dalbergia oliveri* with pretreatment had better germination percentages than control (without pretreatment).

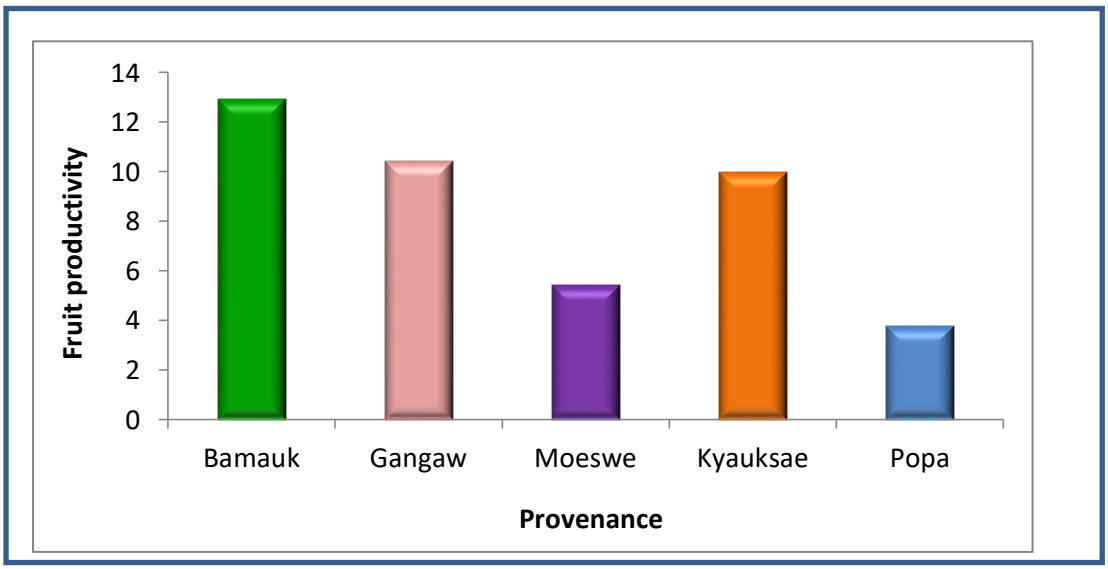

Figure 6. Different lower case letter indicate the significant differences at $p \leq 0.05$.

The results obtained from this study, at 5 month storage duration, the highest germination percentages of *Dalbergia oliveri* Gamble ex Prain seeds collected from all provenances were recorded, and after 9 month storage duration the germination percentages were obviously decreased. In comparison between five provenances, the ranking of provenance with respect to the highest germination were in the order of Moeswe, Pop, Kyaukse, Gangaw and Banmouk provenance in 2017-2018 (Table 3) (Figure 5).

5. Discussion

The results obtained from this study highlighted that, the effects of different storage duration and different pretreatment methods on the seed germination percentages of *Dalbergia oliveri* Gamble ex Prain collected from five provenances showed large variations.

The results obtained from this study, at 5 month storage duration, the highest germination percentages of *Dalbergia oliveri* Gamble ex Prain seeds collected from all provenances were recorded, and after 9 month storage duration the germination percentages were obviously decreased. In comparison between five provenances, the ranking of provenance with respect to the highest germination were in the order of Moeswe, Pop, Kyaukse, Gangaw and Banmouk provenance in 2018 (Figure 2).

Fredrick. C. et al., 2015 reported that, provenances displayed highly significant differences in seed germination capacity of the study species at $p \leq 0.05$. According to Singh et al., 2006, the seeds of a single species collected from different provenances differ in viability, germination, growth and biomass performance of the seed and seedlings. Yilmaz and Aksoy, 2007, also stated that the germination percent and/or seed viability gradually declines with increase in storage duration. Therefore, the results of the present study were in accordance with the findings of the previous works.

In the present study, the variation in germination percentage of the *Dalbergia oliveri* Gamble ex Prain seeds collected from different provenance could be by the following factors. According to Gutterman (2000), the germination of seeds can be influenced by maternal factors, such as position of the seed in the fruit/tree, the age of the mother plant during seed maturation, as well as environmental factors such as day length, temperature, light quality, water availability and altitude. Causes of such variability might be generally attributed either to (a) genetic characters of source population/plant (Shu et al., 2012), or (b) impact of mother plant environment (Singh et al., 2010). Variation in seed and seedling traits among and within sources could suggest that selection among sources might result in rapid genetic gain for the traits (Dhillon and Khajuria 1995).

5.1 Effects of different pretreatment methods on the germination percentage of *Dalbergia oliveri*

In 2017, the highest germination percentage of *Dalbergia oliveri* seed collected from three provenances (Banmouk, Gangaw and Kyaukse) were related to soaking in cold water for one day treatment and, only in Moseswe provenance, the germination percentage was the highest with partial scarification treatment. The results obtained from this study revealed that, the seeds of *Dalbergia oliveri* Gamble ex Prain with pretreatment methods had better germination percentages than control (without pretreatment). In 2018, the seed of *Dalbergia oliveri* Gamble ex Prain from three provenances (Gangaw, Moeswe and Popa) had the highest germination percentage at partial scarification treatment and, the germination percentages of Banmouk and Kyaukse provenances were related to soaking in cold water for one day treatment.

Many authors stated that the germination of the forest tree species varied among the different seed pretreatment methods. The results obtained from this study confirmed that, the seeds of *Dalbergia oliveri* Gamble ex Prain with partial scarification treatment and soaking in cold water for one day pretreatment methods treatment had better germination percentages than control (without pretreatment) and soaking in boiling water for five minutes pretreatment methods.

The seed coat is the restricting force for the imbibition of water into seed and this is a process necessary for seed germination. In this study, partial scarification of *Dalbergia oliveri* Gamble ex Prain seeds could increase the entry of water and exchange of gases into seeds and thus result in enzymatic hydrolysis and transforming the embryo into a seedling and the reason for higher germination percentage. Ayisire et al. (2009) reported that, the permeability of water and oxygen into seed is improved by nicking the seed coat and this is in agreement with the results of the present study. Tropical Plants Database (2018), mentioned that the seeds of *Dalbergia oliveri* Gamble ex Prain may benefit from scarification before sowing in order to speed up germination. Soaking in cold water for one day method was the second best seed pretreatment method, producing higher germination percentage of *Dalbergia oliveri* Gamble ex Prain seeds from different provenance. Saw C. Doo. (1981), stated that the seed of *Dalbergia oliveri* Gamble ex Prain with 24 hours soaking prior to sowing give faster germination. Moreover, Pingali and Biswanger (1984), also reported the increase in the germination of seeds of *Acacia senegal* by soaking in water at room temperature for 12-24 hours.

6. Conclusion and Recommendation

The results of the present study confirm that the seeds of *Dalbergia oliveri* from all provenance can germinated in all experimental periods. The study revealed the existence of considerable variation among provenances with respect to seed morphological characters, germination and seedling growth of *Dalbergia oliveri*. It also showed that the germination percentage of the seeds (1) varies amongst the provenance; (2) is affected by the storage period, and (3) pretreatment methods. It further confirms that 5-7 month is the best/effective storage duration for the seeds of *Dalbergia oliver* that retains seed viability for the longer period than other storage durations. The best three provenances recommended from this study based on germination for integration into agrarian systems within this region are Moeswe, Kyause and Popa because they had high germination percentages. A combination of different pretreatment methods, especially partial scarification and soaking in cold water for one day were the best methods to improve seed germination and growth of *Dalbergia oliveri*. According to the indications of this study, further research on the yield of Individual Trees of different Provenances and seasons should be made. Further study, on comparison of seedling size, different medium ration, related with moisture content (MC) and storage time and fertilizer treatment. In this study, effect of different pretreatment methods is given and to share the technique with other relevant institution.

7. Acknowledgements

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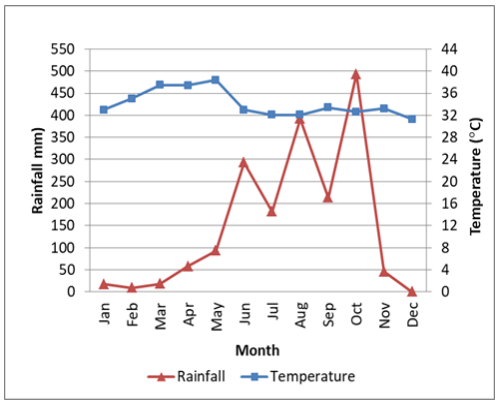
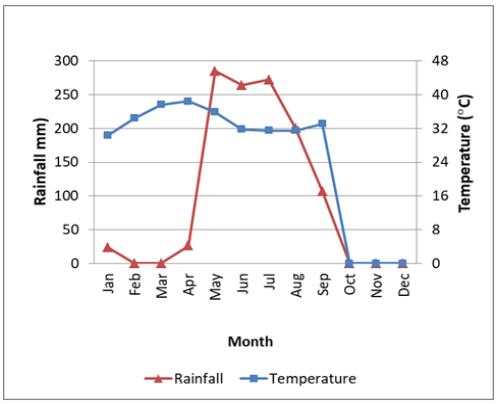
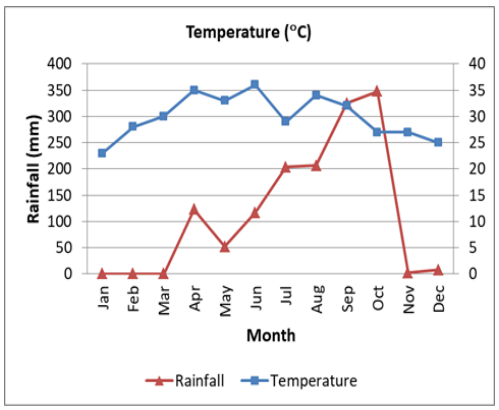
Appendix-I

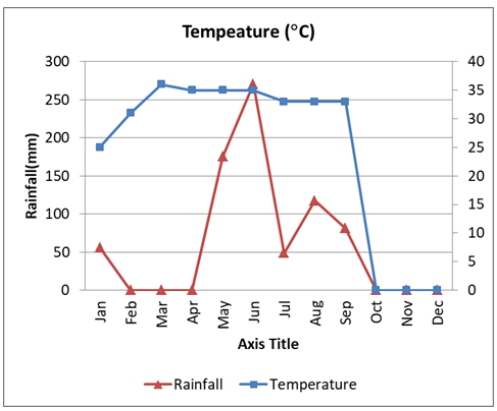
Monthly Rainfall and Temperature of Pyinmana Township (2017-2018)



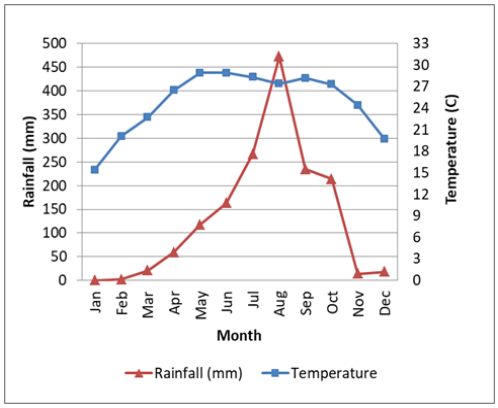


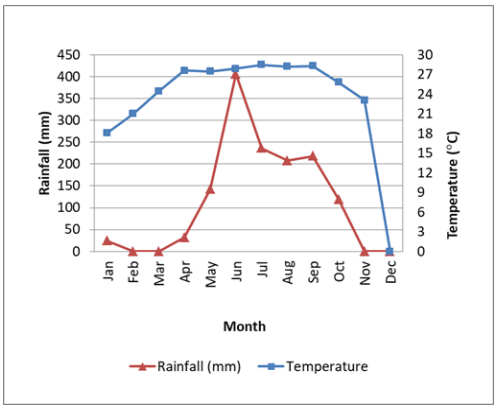
Monthly Rainfall and Temperature of Popa Township (2017-2018)



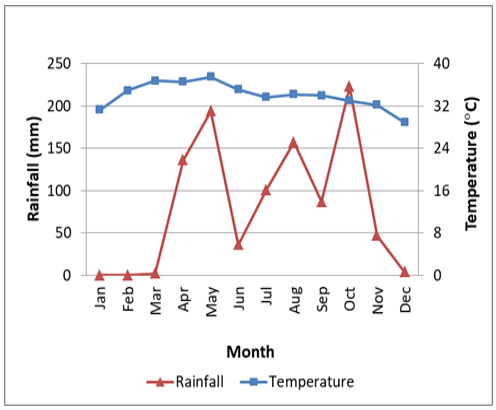


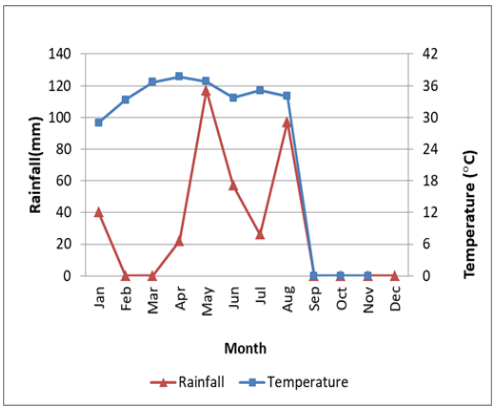
Monthly Rainfall and Temperature of Banmouk Township (2017-2018)



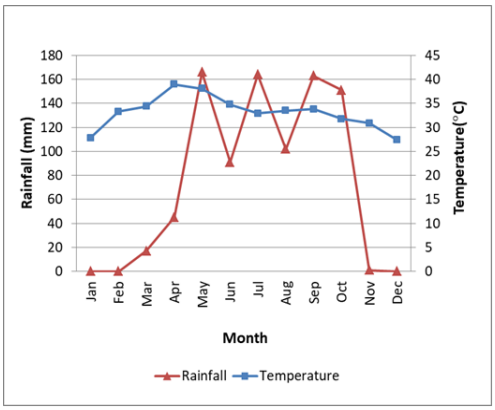


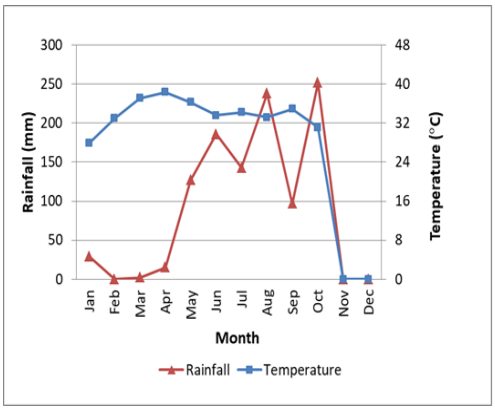
Monthly Rainfall and Temperature of Kyaukse Township (2017-2018)





Monthly Rainfall and Temperature of Gangaw Township (2017-2018)



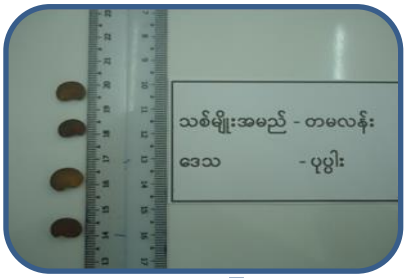


Appendix-II

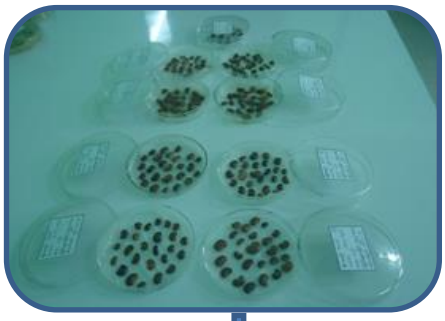
Plus tree selection of *D. oliveri*

Selected Plus tree of Reserved Forest

Seed colletection and processing



Measurement and recorded in seed size



Preparation of pretreatment of seeds for Experiment

Measurement of seedling in the Nurserv

Measurement of seedling in the Nursery