Nursery Management and Certification

This output is based on the research project "Enhancing livelihoods from improved forest management in Nepal" or the EnLiFT2 Project (http://enliftnepal.org/). EnLiFT2 Project (ACIAR FST/2017/037) is the second phase of the EnLiFT (ACIAR Project FST/2011/076) and is funded by the Australian Centre of International Agricultural Research. EnLiFT2 commenced in 2018 and is a collaboration between the University of Adelaide, the University of New South Wales, the Department of Forests and Soil Conservation, the Forest Research and Training Center (Government of Nepal), Forest Action Nepal, Nepal Agroforestry Foundation, and RECOFTC Nepal.

The research builds on the findings of the previous EnLiFT1 project and is based on the research project funded by Australian Centre for International Agricultural Research (ACIAR). This publication is reviewed by a number of reviewers including professionals from the Ministry of Forests and Environment (MOFE). Chapter IV-Nursery Accreditation Standards was jointly prepared by EnLiFT 2 and the Forest Research and Training Center (FRTC) of MOFE. The rating scales for the nursery standards were tested and verified in government and private nurseries. This manual was pre-tested in a training program organized by the EnLiFT2 project in collaboration with the Divisional Forest Offices of Sindhupalchok and Kabhrepalanchok districts of Nepal in April 2022. This publication is subject to an additional review process from a national project advisory group. The editors make a decision based on the reviewers' advice, which often involves the invitation to authors to revise the manuscript to address specific concerns before final publication.

ISBN: 9789937-1-4999-0

Our Cover: Division Forest Office managed the nursery at Patlepani, Sindhupalchok district. By Bishnu Hari Pandit, EnLiFT2, Agroforestry Research and Development Consultant.

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Suggested Citation

Pandit, B.H., Chapagain R, Karki, S., Acharya D., Cedamon, E., Paudel, N.S., Pokhrel, D.C, Bhatta G, Nepal, L.R, Nepal P.R, Thapa K, Pokharel Y, Ulak S and Nuberg, I. 2020. Nursery Management and Certification. Enhancing Livelihoods from Improved Forest Management in Nepal (EnLiFT2), Kathmandu, Nepal.

Contents

Acronyms

AF	Agroforestry
CFUG	Community Forestry User Group
DFO	Divisional Forest Office
DOFSC	Department of Forests and Soil Conservation
EnLiFT2	Enhancing Livelihoods from Improved Forest Management in Nepal
FAN	Forest Action Nepal
FAON	Food and Agriculture Organization of United Nations Nepal
FECOFUN	Federation of Community Forestry Users Nepal
FRTC	Forest Research and Training Center
FSLSC	Forest Seed Laboratory and Storage Center
INGOs	International Non-Government Organizations
LG	Local Government
MOFE	Ministry of Forest and Environment
NAF	Nepal Agroforestry Foundation
NAFSCOL	Nepal Agroforestry Seed Cooperative Limited
NGO	Non-Government Organization
NTFPs	Non-timber Forest Products
POMITFE	Provincial Ministry of Industry, Tourism, Forests and Environment
RECOFTC	Regional Community Forestry Center
RM	Rural Municipality
SDFO	Sub-divisional Forest Office
SQCC	Seed Quality Control Center
TISC	Tree Improvement Silvicultural Component
TOT	Training of Trainers
USDA	United States Development Agency
UUL	Under Utilized Land

Introduction

Tree nursery seedling production has been in practice for planting out in Nepal for almost a hundred years since the initiation of the Panchayat system. However, this has been a major concern across the country particularly for the Ministry of Forests and Environment (MOFE) for the effective implementation of the tree nursery program. Over the last seven years, the EnLiFT (Enhancing Livelihoods and Food Security from Agroforestry and Community Forestry in Nepal) project in collaboration with MOFE had worked with a few small to medium size tree nurseries across its project districts (Kavrepalanchowk and Lamjung). With the inception of the second phase of the project (known as Enhancing Livelihoods from Improved Forest Management in Nepal or EnLiFT2) in 2019, Sindhupalchowk district was included. A total of eight nurseries (two Divisional Forest Office-managed nurseries, one community nursery one local government-supported nursery, and four private nurseries) were supported. A major component of this Project has been to improve the quality of nursery seedlings produced in these nurseries by purchasing appropriate equipment and providing training for forestry staff, and nursery operators both from public and private sectors. While the manual is aimed at nurseries operating in Sindhupalchok and Kavre Palanchok districts, there are also numerous other GO, NGO, community, and private nurseries in Nepal which produce plants of sub-optimal quality that could benefit from improved practices. Most of the nurseries in Nepal are of a relatively small scale and are located within the Divisional Forest Offices (DFOs) or Sub-divisional Offices (SDFOs) or Community Forestry User Groups (CFUGs) or in private individual farmers that they are intended to provide service. Accordingly, they are distributed across a range of the country's agroclimatic zones. All nurseries in Nepal, but particularly those in the mountain areas, must pay careful attention to the methods employed to raise plants not only to help optimize their chance of survival after planting out but also to provide the potential for rapid and relatively uniform growth.

DFO nurseries are generally supervised by one of the senior forestry officers working in the district. Ideally, each nursery would employ a qualified and dedicated nursery manager, responsible for its planning and daily operation. Forestry Officers have a wide range of responsibilities often resulting in insufficient time available to devote to the nursery under their care. Consequently, some nurseries lack sufficient planning and qualified direction. Similar is the case for Local Government and also community-supported nurseries. The private nurseries operate in isolation and are devoted to commercial production, but have inadequate skill and knowledge for the production of good quality seedlings. Current tree nursery practice in Nepal is generally a legacy of practices developed by DFOs, which have been in place and not modified for many years. In other countries, accepted practice in forest tree nurseries has evolved greatly in recent years with improvements being made in such areas as pot and nursery structure design, growing media composition, and watering and fertilizer regimes (Quayle et al 2001; Rosetko et al 2010; Gregorio, 2010). The manner in which a plant is propagated in the nursery, and the condition of the plant when it is dispatched to the field for planting, have major influences on the survival, growth, and development of that plant in the field (Munjuga et al 2013; Pandit et al, 2020). If time and resources are allocated to raising seedlings, it can be assured that the seedlings will have the greatest possible chance of survival and rapid growth. This should be guaranteed by the commitment of related stakeholders, and adopt the best seedling production practice with the assurance of the quality of those seedlings (Pandit et al, 2020). An established seedling certification system with accreditation would pay back to the nursery owners in the long run.

Why this manual?

Seedling production is one of the key steps for expanding tree-planting activities across the country. The nursery production and plantation activities have to be properly planned and implemented. The way seedlings are produced in a nursery contributes to their survival rate after planting and their subsequent growth performance (Quayle et al 2001; Lamsal et al 2020). Improving seedling quality is positively related to their survival, growth, and productivity. Seedling quality is mostly governed by the genetic makeup of the parent trees and the physical growth of the seedlings. Several types of nurseries exist: individual or private, community or group, and DFO or Local government managed nurseries (Pandit et al 2020). Nursery practices must be consistent and the various techniques closely integrated (Lamsal et al, 2020). If one element in the chain is lacking there will be a negative impact on seedling quality. Good quality seedlings cannot be produced without proper care and management. Nursery plants need to be protected from extremes of environmental conditions until they are strong enough to endure them. To ensure the high quality of seedlings and to provide more opportunities (income, technology transfer), local people should be encouraged to establish small-scale commercial nurseries. An appropriate standard of the selected high-value tree species seedlings needs to be accredited and certified so that there won't be any problem in marketing.

The need for training of trainers (ToT) and the development of training modules on nursery techniques and standardization is important. The training should aim to train the trainers who will help in the training of other local communities. Interactive teaching techniques and practical sessions should be employed to facilitate the learning. Training of trainers in nursery management (both technical and financial) and the use of existing networks to disseminate technologies is vital. This may be achieved through Sub-divisional Forest Offices (SDFOs) that will allow maximum interaction of technicians, farmers, and nursery operators. SDFOs can serve as hubs for the production and distribution of high-quality tree planting materials as retailing, development and dissemination of techniques, and training of nursery operators, farmers, small-scale processors, and extension officers. They could also serve as collection points and marketing centers for quality seeds and seedlings of trees, Non-timber forest products (NTFPs), medicinal plants, and fruit tree species. SDFOs need to be well-equipped with seed storage and propagation facilities, meeting and training facilities, mother-plant areas, and demonstration plots. This has a multiplier effect of leading to the establishment of high qualities nurseries outside their centers and the provision of technical backstopping to many stakeholders. This office will provide opportunities to gain insights into, Validation of method or practice modules Nursery establishment and management of Seed source, collection, storage, and germination, and techniques of vegetative propagation (cutting, budding, and grafting).

Production of high-quality seedlings is critical to the establishment of healthy trees in the field. Slow development and death of tree seedlings are common to many rural development programs, which has led to many farmers losing interest in tree planting out of frustration. This loss of interest results in further deforestation and loss of valuable biodiversity which further degrades landscapes and deteriorates livelihood opportunities for people (Munjuga et al 2013; Linyunga et al 2015). Therefore, improvements in seedling quality will improve the rate of tree seedling establishment in the field and positively impact both the environment and rural livelihoods. This manual will facilitate the learning process and practices with a better and clearer understanding of the principles and

practices involved in nursery establishment and management in terms of producing high-quality seedlings and to enable participants to translate such knowledge and skills into entrepreneurial skills. This manual will help the nursery operators, farmers, and institutional nurseries familiarize themselves with, and get them involved in techniques of propagation and establishment of small scale-nurseries for the production of good quality tree seedlings.

How to use this manual?

The purpose of this manual is to provide a guide to recommended nursery practices for the propagation of quality tree seedlings, their certification, and marketing in Nepal. This publication covers the principles and practices in the production of quality and superior planting materials from both seeds and vegetative methods to seedlings grown in the nurseries and activities involved in certification nurseries and marketing of their seedlings. In the hope to make this training participatory, interactive, and collaborative, we need to confirm that there would be mutual respect, confidence-building, cooperation, and shared learning among participants and trainers. Learning occurs when participants and trainers share their experiences, knowledge, and skills (FAO & RECOFTC, 2020).

This manual consists of five modules, each of four to nine sessions (a total of 30 sessions) (Annex 5). The total hour for running all 30 sessions is 37.5. The first module is about the introduction to the training program and the establishment of a nursery. This module includes four sessions with 4.5 hours duration in total. The second module is about producing seedlings using seeds; this is the largest module in terms of time and material requirement. This has nine sessions and takes 11.5 hours. The third module is about propagation through vegetative methods and has seven sessions and 7.75 hours. The fourth module is about seedling quality maintenance and certification and has five sessions, and the time requirement is 7.75 hours. This is the core of the manual in terms of quality seedling production. The last module is about nursery enterprise development and marketing and has five sessions and requires 5.75 hours to complete all five sessions in this module.

Each of the sessions is organized in the following sequence:

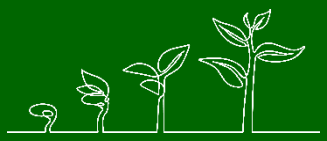
a) Title of the session
b) Objectives of the session
c) Estimated time required to run the session
d) Method used or direction to facilitate the main activities of the session
e) Materials needed
f) Reference materials including exercise sheets and handouts related to the respective session

Module I:

Introduction to the Training Manual and Nursery Establishment

Module I: Introduction to the Training Manual and Nursery Establishment

Session 1: Welcome and introduction



Objectives

At the end of the session, participants will be able to:

- Know each other.
- Formulate expectations about the training.
- Reflect on their interest in, and knowledge and views of, nursery management and certification training

Time

60 min

Method

Pair interview and plenary discussion PowerPoints, Flip chart, whiteboard, Piece of paper/ Meta cards, markers

Steps (See Reference material below if you want to use an alternative method)

- Welcome the participants and introduce the training team
- Allocate a few minutes to give the speech depending upon the presence of the main stakeholders in the training
- Divide all participants into pairs according to the presence of the participants
- Provide them a piece of paper/ meta card to each of the participants
- Give approximately 5 minutes to participants to learn their name, organization, and expectations from the training
- Ask each of the participants to introduce each other
- Summarize the expectations of the participants and present them to the plenary

Reference material:

Alternative method: Introducing each other in a gender training

AIM: Participants learn about each other and the levels of experience on gender issues in the room.

TIME: 40 min

Material needed: PowerPoints and Flip charts

Steps

1. Welcome the participants; briefly introduce yourself and other organizers of the training.
2. Ask participants to stand up and make two rows facing each other.
3. Tell participants that the person standing opposite them will be their partner in this exercise.
4. Ask participants to share with their partner general information about them-self as well as answer the following questions:
    - What are their experiences with gender issues?
    - Their reasons for joining the training?
    - What did they always want to do, but could not, because they were women/men, girls/boys?
5. Instruct participants to remember information about their partner as they will have to report on their findings in the plenary.
6. After 10 minutes ask each participant to share in the plenary what they learned about their partner.
7. Lead a discussion about the implications for individuals of the roles and responsibilities assigned to men and women.
8. Use the following questions to stimulate the discussion:
    - Do women and men have to be, or do, the things that you wrote down?
    - Can women and men do things expected of the opposite sex?
    - How do these roles and responsibilities affect life choices?

Session 2: Introduction to training objectives, learning flow and training norms

Objectives

At the end of the session, participants will be able to:

- Discuss the objectives of the training and learning flow.
- Agree on the rules and expectations of the training.
- Understand how they can participate fully and constructively.

Time

30 minutes

Method

Power point presentation, plenary discussion

Materials

Power points 2.1 & 2.2, Flip chart with training objectives, flip chart with learning flow and agenda, flip chart with rules of the training, meta cards, Post-it Notes, markers

Steps

1. Hang the flip chart with training objectives on the wall and explain each of them.
2. Go back to participants' expectations and clarify what the training will and will not cover and whether adjustments can be made to meet expectations made by participants.
3. Briefly present the learning flow and agenda for each day of the training.
4. Explain to participants that for the duration of the training, the group members must work closely together and support each other to achieve the training objectives.
5. Everyone should agree on common norms that each person will follow.
6. Hang the flip chart on the wall so that it stays visible to all throughout the training.
    - Before ending the session, take a few minutes to discuss and agree on: logistics arrangements; daily tasks for the participants to support the training course, to conduct energizers throughout the training, distributing handouts, time keeping; and feedback teams.
7. Conclude the session by allowing time for questions and clarifications.

Reference material

A. At the end of the training, participants will be able to:

- Define a tree nursery and its characteristics
- Explain the rationale for a tree nursery
- Select a suitable site for establishing a tree nursery
- Apply the various seed treatment methods
- Demonstrate various technologies on tree nursery establishment using seeds and vegetative methods.
- Demonstrate various technologies on tree nursery establishment using vegetative parts.
- Develop criteria and indicators for evaluating seedling quality and their certification.
- Identify suitable soil media and mix of soils for potting up seedlings and cuttings
- Germinate seeds, transplant seedlings and cuttings into pots correctly
- Carry out effective management practices for a tree nursery
- Develop entrepreneurial skills in tree seedling production and marketing

B. Flow of the learning process

Module 1 deals with setting the context of the training, introduction of the participants, training objectives and learning flow and training norms, topics on the establishment (Figure 1.0) of tree nursery including activities such as nursery site selection, determination of the nursery size and its layout and structures of the nursery (germination beds, potting shed, transplant shed and hardening beds). This module has four sessions.

The module 2 has basically covered the topics on seedling production through seeds (sexual propagation), seed sourcing and seed collection, preparation of seedbed and germination medium, techniques of enhancing seed germination and sowing of seeds in the germination bed, pre-seed treatment, uprooting and transplanting of germinated seeds in the transplant bed. The learning activities also include various techniques of inoculation of growing media for early growth of emerging seedlings. This module has nine sessions.

Module 3 includes the concepts, principles of practicing vegetative propagation and the steps with illustrations on the production of quality planting materials through various methods of asexual propagation (cutting, layering, division, and grafting and budding). It also includes why vegetative propagation is required, various types of cutting, layering and grafting. This has seven sessions.

Module 4 covers five sessions, the first deals about seedling quality maintenance and caring such as watering, shading, weeding and control of seedling pest and diseases. The second session deals on practical work about caring of seedlings, third is related to defining standards and criteria for nursery accreditation. The third session is about rationale of forest accreditation, accreditation body and processes. The fourth session deals about four standards and 14 **indicators** for measurement of each of the four standards.

Module 5 discusses the tree nursery as an enterprise or business. In the beginning it discusses on the prospects of establishing a nursery business using SWOT analysis. This module also covers the basic steps for establishment of nursery business and its marketing. This module has five sessions

Session 3: Nursery site selection

Objectives

At the end of the session, participants will be able to:

- Define the nursery and needs of the nursery.
- Know about the points to be considered while selecting the nursery sites.

Time

60 Minutes

Method

Powerpoint presentation, Discussion, and nursery site visit

Materials

Power points 3.1, 3.2, 3.3, and 3.4, reference materials, markers, and flip charts.

Steps

1. Allow participants 3-5 minutes to think about the definition of the nursery and the need to establish the tree nursery
2. Write down the main points of what participants say about the nursery and the benefits of the nursery.
3. In this step, ask participants one by one about the points to be considered while establishing a nursery
4. Write down the main points of what participants said about the nursery and the benefits of the nursery.
5. In this steps, ask participants one by one about the points to be considered while establishing a nursery
6. Write down each of the points expressed by the participants on the flipchart and compare it with the reference material or the handouts presented at the end of this session
7. Agree on the points based on the technical requirement for nursery site selection
8. Make arrangements for participants to visit the nearest nursery site
9. Ask each participant to make notes on the nursery focusing mainly on the 3 questions below (what is the size of the nursery bed (length & breath), types of beds that exist, and seedling quality) to be discussed in the next session.
10. Return to the training hall for the next session

Reference material

A. What is a nursery?

A forest nursery is a managed area, designated to produce tree seedlings grown under favorable conditions until they are ready for planting (Fig 1.1). It can be an informal, small-scale arrangement or a large commercial enterprise. Nurseries vary in size, facilities (supplies, tools, equipment, etc.), types of seedlings produced, and nursery operations. They also differ significantly in the quality and quantity of planting stocks produced. However, all nurseries primarily aim to produce sufficient quantities of high-quality planting stocks to satisfy the needs of seedling users. Users include the nursery owners themselves, individuals, community organizations, farmer groups, government agencies, non-government organizations, and corporate or private customers.

Figure 1.1: Typical nursery

B. Types of nursery

1. On the basis of seedling production capacity
    - Small nursery
    - Medium nursery
    - Large nursery
2. On the basis of the technology used
    - Normal/ simple nursery
    - Hi-tech nursery

3. On the basis of the time period
    - Temporary nursery (less than 10 years)
    - Permanent nursery (more than 10 years)
4. On the basis of species
    - Mixed nursery
    - Medicinal plant nursery etc.

C. Why is there a need to establish a tree nursery?

1. Flowering and subsequent seed production of most species is irregular.
2. Inapplicability of direct seeding.
3. Nurseries provide maximum care of the planting stock.
4. Take advantage of the abundance of germplasm during the seed year.
5. Best and vigorous seedlings are produced in nurseries especially when the best seeds are used.

D. Nursery Site Selection

Many factors need to be considered before setting up a new nursery or extending an existing one. Careful and thorough consideration of these factors will help ensure operations within the nursery run smoothly and systematically, and that the plants produced are of the highest quality. Careful planning will also determine whether the nursery is necessary in the first place and, if so, on what scale.

Factors to be considered

Water

Proximity to a water source (stream, spring, pond, borehole, tap, well) has a direct implication on nursery labor, which is the greatest cost in rural nurseries. It is a rule of thumb in nursery management to establish the nursery as close as possible to a water source. However, nurseries are established nearby streams, rivers, or wells, which in some areas contain contaminants that affect the quality of the water. In suspected areas, it is recommended to pass the water through a container of sand mixed with ground charcoal as a means of purifying the water. If there is a facility for a water filtering system in a nursery, this is good for seedling growth. The standard water quality is presented in Table 1.

Table 1: Water quality standard

Index	Appropriate	Remarks
pH level	6.0-7.5	< 5.5 is poor
Salinity (electrical conductivity µS/cm)	0-500	>500 is poor
Toxic ions		
Sodium (Na^-)	50 ppm*	*Upper limit
Chloride (Cl^-)	70 ppm*	
Boron (B)	0.75 ppm*	
Accessory ions		
Calcium (Ca^2+) 100 ppm	100 ppm*	
Magnesium (Mg^2+)	50 ppm*	
Sulphate ($SO4^{2-}$)	250 ppm*	
Foliar staining ions		
Bicarbonate ($HCO3^-$)	60 ppm*	
Total hardness ($Ca^{2+}Na^+$)	206 ppm*	
Iron	0.10 ppm*	

Source: Cited by Quayle et al 2001 from Landis *et al.* 1989; and, Landis *et al.* 1994

Since nurseries are established during the dry season, water availability is an important factor. Therefore, water reserve systems (water tanks, drums, dug-up wells, or a cement-constructed reservoir) are recommended to facilitate consistent quantity and regularity.

Growing media

Along with water quality, the media (potting mix) in which the plants will be grown is a very important consideration in ensuring that the seedlings are healthy and of good quality. Chapter 2 discusses in detail the process of creating appropriate growing media. When planning a nursery, ensure that all the components (soil, sand, and well-composted manure) required for the potting mix are readily available and can be readily transported to the site (Figure 1.2).

Figure 1.2: Growing media

Access to markets

Nurseries must be strategically located with respect to the needs of farmers and the communities for whom seedlings are required for planting their lands. It is important to consider the longer-term requirements of the institution involved in nursery production. In addition to internal requirements and demands for tree seedlings, there may be scope for external seedling sales. Communities, smallholder farmers, home gardeners, and even distant investors may seek quality tree seedlings in some areas. Such markets may provide a profitable sideline for some of the DFO nurseries and increase employment opportunities for the workers. Before setting up a nursery, we need to know whether there is such a demand for plants and, if so, for which species. Respective DFO needs to assure the demand of the seedlings within the district. The size of any external market may be an important factor in determining the size of a nursery.

Access to road and transport

The consideration of transport is closely related to that of the destination(s) for the seedlings. Once destinations and markets have been determined, we need to consider how far the plants will have to be transported, the quality of the roads they will travel on, and how the transport will be arranged (Figure 1.3). If the distances are excessive and/or the quality of the roads is very poor, the location of the nursery is not appropriate.

Figure 1.3: Access to transport

Availability of skilled and non-skill labors

The number of workers required for the nursery operation needs to be determined in order to establish the viability of a proposed nursery. Visit other nurseries and/or talk to other forestry officers to see how many workers are involved in the production of a particular number of plants. We need to calculate the skilled and non-skilled labor requirements for nursery tasks such as filling bags/containers, pricking out, potting up, and weeding. Once labor requirements have been determined, the availability of suitable labor in the locality must be evaluated, and also whether there is a need to employ specialist staff, or to provide special training for local workers.

Electricity

In some rural areas, a nursery can be operated without electricity. However, it is often desirable to have power for machinery, pumps, irrigation systems, and lighting based on the scale of the nursery. It is, therefore, necessary to determine whether power is available at the proposed nursery site and, if not, whether it can be easily and cheaply connected.

Arrangement for the material and equipment

The costs associated with a nursery will largely depend on the type of nursery to be established. A nursery with sophisticated equipment such as automated misting systems (Fig 1.4), heat beds, and greenhouses for vegetative propagation requires higher costs to set up than one using simple seed-propagation techniques. Decide the type and size of nursery required, and then see if there is justification for the expenditure. It is necessary to assess whether the materials such as shade cloth, green net, and irrigation equipment are available locally or need to contact suppliers in the cities. Therefore, when planning a nursery, allow plenty of time for arranging materials to ensure that they are on hand at the time of construction of the nursery.

Figure 1.4: Automated misting system

Land tenure security

This is an important consideration for establishing a nursery. Since establishing a nursery involved huge costs, therefore land tenure security is an important factor to consider.

Exposure and aspects

The nursery should be located in a place with a gentle slope (5%) or in a place that is reasonably flat. A flat or gently sloping site helps reduce soil erosion and aids in water retention but with a good drainage system. In the hills, terracing (making of large steps to accommodate nursery beds) may be required where the slope is steep and helps reduce erosion problems. South facing aspect is appropriate for good sun exposure. The nursery should be fully exposed to sunlight; should not be exposed to strong winds; and seed beds and transplant beds should be aligned in the East-West direction to maximize exposure to sunlight.

Other parameters

It is recommended to avoid the area that is prone to water erosion and landslides and at the same time, one needs to confirm that the site is well drained, and there are no disturbances of wind and extreme weather.

Session 4 Determination of nursery size and layout

Objectives

At the end of the session, participants will be able to:

- Know to determine the size of the nursery for the number of seedlings to be grown in the nursery
- To make a layout of the nursery in a given standard
- Learn about nursery structures (germination bed, polybag shed, transplant bed, and hardening bed)

Time

120 minutes

Method

PP presentation, class discussion, and nursery site visit

Materials

Power points 4.1 & 4.2.1, 4.2.2, 4.2.3 &4.2.4, flipcharts, handouts and reference materials, markers,

Steps

1. Ask some of the participants what did they see in the nursery visited a few minutes ago
2. Discuss and list the steps for determining the nursery size using **Reference material A**.
3. Confirm with the participants that they can follow these steps
4. Discuss the nursery layout design using the **reference material B**.
5. Discuss the type of structure of the nursery through the presentation slides (**Reference material C**)
6. Summarize the following points
    - How can you determine the size of the nursery?
    - What is the design of the Nursery layout?
    - What are the types of nursery structures?
7. Wrap up the session

Reference material

A. Determination of nursery size

Prior to the establishment of the nursery, one needs to consider the size of the nursery that is being planned. Obviously the greater the number of plants to be grown, the larger the area required. Visit a few well-designed, efficient nurseries, find out their growing capacity, and compare the size and layout of each site.

Steps to determine the size of a nursery

Step 1
- Measure the size of the pots or bags to be placed in the nursery.

Step 2
- Measure the area taken up by the pots or bags. For example in a standard shed of size (6mx10m = 60 M^2) for transplant beds, a minimum of 10,000 poly bags of a 4"x7" size can be placed.

Step 3
- Calculate the area assuming 50 % of seedlings (5000) are smaller size and 50% are larger size (5000) = Area required for smaller size poly pots = 30 M^2+ area for larger size poly pots = 60 M^2 = 90 M^2

Step 4
- Add 25 percent to the number of seedlings or poly pots (i.e., to allow for unexpected loss such as poor germination or death) = (90 + 25% = 112.5 M^2).

Step 5
- Multiply by 2.5 for the space between beds, seedlings, walkways and paths = 112.5x2.5 = 281 M^2

Step 6
- Estimate the size of the storage house (6x4), water tank/ reservoir (5x3), Germination bed (6x4), Hardening bed (6x4), mother plant area (10x25), and compost pits (2.5x2) and toilets (7x5) = 377 M^2 that will be needed.

Step 7
- Double this figure to allow for space between the structures (377 x2 =754M^2).

Step 8
- Add results from steps 5 and 6 to give an estimate of the total area that will be needed for the nursery (281 + 754 = 1035 M^2 = Approx. 2 *ropani*).

B. Nursery layout

The layout of a nursery should be carefully considered before any construction begins. A little time taken during the planning stage will save much time and expense later on when the nursery is operational. The layout should be arranged in such a way that the nursery operations are carried out in a logical flow in the nursery. This will save time and labor. If possible, there should be a provision for vehicle access inside the nursery or at least at the main gate of the nursery. Arrange the nursery in such a way that should drain water directly away from the nursery. This will minimize the chance of spreading any diseases to other parts of the nursery. An example of the nursery layout is illustrated in Figure 1.5:

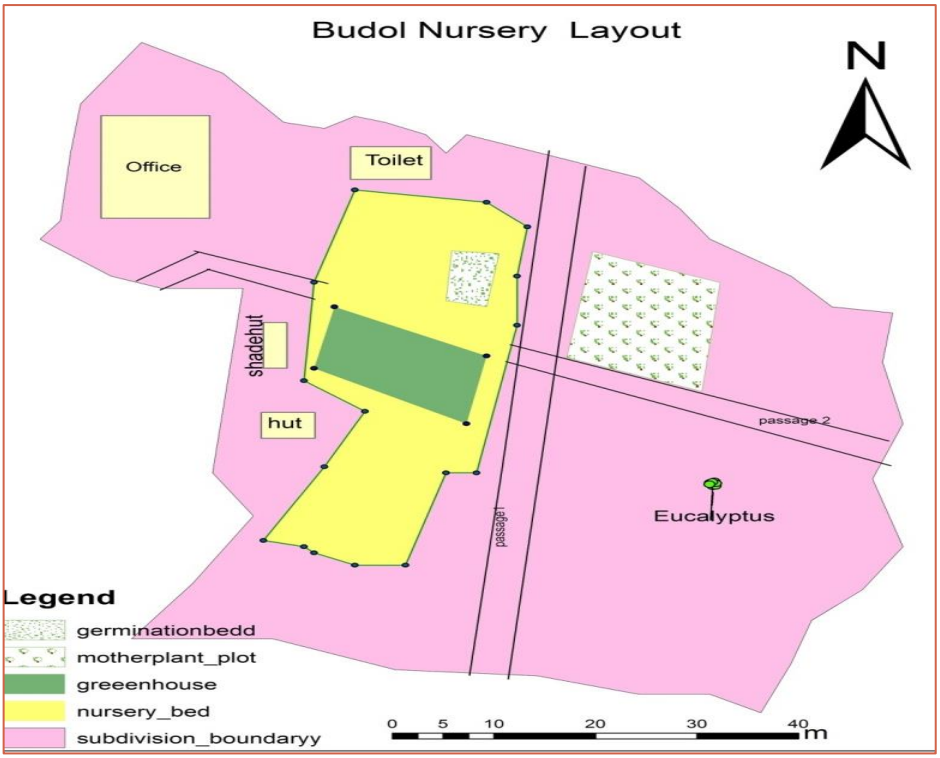


Figure 1.5: Nursery layout

C. Structures for the nursery

Mainly four types of structures are needed for the nursery. They are germination shed, potting shed, transplant shed, and hardening beds.

Germination shed/ seedboxes

Seeds are directly sown on seed boxes or on the germination shed in order to protect the seeds from too much sunlight, damage from raindrops, stray animals, and insects. Ideally, a germination shed must have plastic roofing to allow some sunlight to penetrate yet protect the seeds from being dislodged by rain (Figure 1.6).

Potting shed

Seedling containers are filled with potting media in the potting shed. A potting shed should have a roof to prevent the potting medium from getting persistently waterlogged (Figure 1.7). The floor should be dry, free of weeds, and flat for the pots to stand after filling. The area of the shed should be sufficient enough to allow the piling of the filled pots and stocking of the potting materials.

Figure 1.6: Germination shed

Figure 1.7: Potting shed

Transplant shed

Seedlings of very tiny seeds (such as *Ficus, Alnus,* or *Eucalyptus*) with less percentage of germination or with multi-embryo (Lapsi or Bakaino) grown in germination sheds or seed boxes are pricked out to individual containers inside the transplant shed. A transplant shed should have a cover either with a green net or some thatch grasses to protect the young transplants from intense sunlight but with sufficient transparency to allow some sunlight to reach the seedlings (Fig 1.8). The cover must also allow rain to pass through. However, for species with very small seedlings like Alnus, transplant sheds should have a plastic roof or dense net (75%) to prevent the seedlings from displacing due to raindrop action.

Figure 1.8: Transplant bed

Hardening bed

Seedlings must be acclimatized to the conditions of the planting site prior to planting to make them sturdy and hardened. Hardening includes exposing the seedlings to full sunlight, reduction of the frequency of watering and fertilizer application, and root pruning. In the nursery, the hardening area therefore should be free from shade to provide the seedlings full exposure to sunlight (Figure 1.9). To control the moisture available to plants, it is ideal to elevate the seedlings by placing them on a structure that prevents the pots from resting on the ground. A screen or a bed with a bamboo slat floor will serve this purpose. Aside from regulating the moisture available for seedlings, elevating seedlings will promote aerial root pruning.

Figure 1.9: Hardening bed

Module II

Propagation through seeds

Session 5 Seeds, seed sources, and their characteristics

Objectives

At the end of the session, participants will be able to:

- Define seeds and planting material
- Know various seed sources
- Know the good seed characteristics

Time

60 minutes

Method

Presentation, class discussion, and observation

Materials

Power points 5.1, 5.2 7 5.3, flipcharts, sample seed packets, and small bottles containing seeds, markers,

Steps

1. Ask participants about their knowledge of tree seeds by showing a few seed samples
2. Write down the points raised by the participants on a flipchart
3. Finalize the definition of tree seed based on discussion and **reference material A**.
4. Ask participants what they know about the sources of germplasm in Nepal (**reference material B**)
5. Discuss with participants the result due to the poor quality of seeds **(Reference C)**
6. Discuss with participants the qualities of good seeds
7. Wrap up the session with a review of all points above

Reference material

A. What is a seed?

A seed is an embryonic plant enclosed in a protective outer cover. The formation of the seed is part of the process of reproduction in seed plants. It is the product of the ripened ovule of gymnosperm and angiosperm plants, which occurs after fertilization and some growth within the mother plant (Quayle et al 2001). Seeds are of different sizes, shapes, and colors. The poor performance of trees can often be attributed to seeds that may be of poor genetic quality (Munjuga 2013). In many instances, seeds are collected by the nursery operators or other forestry personnel. However, if we want to establish high-productivity tree plantations, one needs to purchase the seed of the best genetic quality from an organization having access to reliable seed sources (Figure 2.1).

Figure 2.1: Registered agroforestry seed sale organization

B. Source of germplasm

The source of germplasm and collection methods greatly affects the seedling quality. Germplasm used in private and public nurseries in Nepal comes from sources including seed trees, seed stands, seed production areas, and seed orchards. For instance: the Tree Improvement Program (TIP) in Nepal is playing the role of conservation of genetic resources by providing seeds for various tree species. The **Department of Forest and Soil Conservation (DOFSC), Forest Seed Laboratory and Storage Center (FSLSC)** is mandated to supply the seed required for plantation activities in the country. TISC carries out the identification, registration, and management of natural seed stands of important tree species, and the establishment of breeding seed orchards from where seed or any planting material is obtained. The breeding seed orchards have been established in different parts of the country (Pandit et al 2020). The best quality seed is always a good investment. Good seed typically costs less than 1% of the total cost of forest plantation establishment (Quayle 2001; Munjuga et al 2013). The characteristics of good quality seeds of 146 species are described in a book of Gautam et al. (2018). Poor seed quality will result in:

- Low germination percentage
- Poor emergence
- Poor survival
- Poor adaptability to the site
- Susceptibility to disease and pests
- Poor growth
- Low productivity

C. Characteristics of good seeds

- Must be well-ripened, healthy, and true to type.
- Must be pure and free from inert materials, and weed seeds.
- Must be viable and have good germination capacity.
- Must be uniform in texture, structure and look.
- Must not be damaged, broken, or affected by pests and diseases.

Session 6 Seed trees and seed collection

Objectives

At the end of the session, participants will be able to:

- Know when to collect seeds of the selected species
- Learn how to keep seed collection records
- Know about the seed types, viability, pre-seed treatment method, and germination period of each of the selected species

Time

120 minutes

Method

Power points, class discussion with seed collection record, and seed collection time forms

Materials

Whiteboard, markers, tree seeds information book; seed collection records and time forms, Table 2 & 3 (PP 6.2 & 6.3)

Steps

1. Discuss and define the seed trees with participants
2. Discuss the points to be considered while collecting seeds **(Reference material A)** and write on the whiteboard
3. Participants will learn on maintaining a record of seeds collected using the format of Table (**Reference material B**) on the flipchart paper. They will be divided into different groups and each group will be asked to fill the form for at least three species.
4. List out the name of a few important common tree species to be grown in the nursery (**Ref: tree seed information book**)
5. Participants will be divided into several groups. Each group will be asked to fill the table mentioning the seed collection time, seed types, viability and pre-seed treatment method, and germination period of each listed species (**reference material C**)
6. Fill in the information in each of the respective columns of **Table 3** for 37 species**.**
7. Discuss and review all the steps above and wrap up the session

Reference materials

A. What are seed trees?

These are individual trees from which a seed or a wildling is collected. This is regarded as the most common source of germplasm in most parts of Nepal. Seed trees may be in natural forests or plantations and must have superior physical characteristics including straight and single stems, few branches, mature to produce an ample quantity of seeds and belong to the dominant or co-dominant trees in the site (Gregorio et al 2010).

Points to be considered while collecting seeds:

- Select healthy mother trees with good characteristics and vigor.
- Seeds from the fruits or flowers produced for the first time should be avoided.
- Seed should be collected only from mother trees revealing the desired characteristics.
- Trees that have straight stems may be selected for sawn timber production, crown spread for shade, quantity/ quality of fruit, and good growth rate for fruit trees and fodder production.
- Collect seeds from a large number of trees (at least 5) (Quayle 2001).
- If possible, collect seeds from a group of good unrelated trees rather than from a single well-grown specimen amongst a group of poorer plants. If a seed lot is derived from a limited number of parents, the gene pool of the resulting seedling crop will be correspondingly limited and may be susceptible to disease or have other poor characteristics.
- Do not collect from isolated trees — seeds produced by isolated trees may be self-pollinated. Seed from self-pollinated trees is inbred and will usually produce progeny of poor and/or variable vigor and form.
- Seed trees should be marked with numbers.
- Genetic identity and purity of the species should be known

How to make a record of seed collected (Annex 1)

A nursery owner or caretaker should keep a record of seeds collected and sold. This record should have information on species, date of seed collection, who collected the seeds, from which location, altitudinal range, slope/aspect, flowering, and seeding time. In the same form, seed trees details are explained such as seed tree number, height, diameter, associated species, weight of seeds collected and seed used date name of consignee, amount of seed used, amount remaining, and number of seeds per kilogram and germination percentage (Annex 1).

2. When to collect seed?

Seed collection time varies across different species in a year. Some will take a long time to ripen, and others will ripen almost overnight. Some shed their seed quickly, while others will retain the seed on the tree for months or even years. Careful observation and record keeping is therefore the key to successful seed collection. The flowering, fruiting, and seed shed habits of the various species in a particular area need to be determined and recorded so that seed collection can be efficiently programmed and opportunities will not be missed (Table 2). It is essential to ensure that the seed is ripe before collecting. The seed collection time of the 36 most commonly grown tree species in the EnLiFT2 area is presented in Table 3. In general, the seed will ripen when the fruit or pod is easy to remove from the tree; the pods are swollen; the fruit is hard and becomes dark in color (brown); the seeds are dark, rather than green, e.g. *Leucaena* seeds will be brown and *Flemingia* seed will be black.

B. Table 2: Seed collection time, seed types, viability, pre-sowing treatment and germination period (Gautam et al 2018)

Species	Seed collection time	Seed types	Viability	Pre-sowing treatment	Germination period
1. Actinidia chinensis (kiwi)	Oct-Dec	Orthodox	1 month	Washing & …	1 month
2. Alnus nepalensis (Utis)	Nov-Dec	Orthodox	>1 year	No need	2-3 week
3. Artocarpus lakoocha (baddar)	June-July	Recalcitrant	1 week	Washing	10 days
4. Bassia butyraceae (chiuri)	May-June	Recalcitrant	1 week	Washing & ….	1 week
5. Bauhinia purpurea (tanki)	April-May	Orthodox	1 year	24 hr cold w	9-30 days
6. Callistemon citrinus (kalkiphool)	Aug-Mar	Orthodox	1 year	No need	2-7 week
7. Choerospondias auxilaris (lapsi)	Nov-Mar	Orthodox	1 year	24 hr cold w	3-4 week
8. Cinnamomum camphora (kapur)	Aug-Nov	Orthodox	6 month	24 hr cold w	35-55 days
9. Cinnamomum tamala (tejpat)	May-June	Recalcitrant	1 week	Removing flesh	15-20 days
10. Coffee Arabica (coffee)	Sept-Jan	Recalcitrant	1 month	Washing	1 month
11. Citrus aurantifolia (lime)	Aug-Sept	Recalcitrant	1 month	Washing	1-2 month
12. Delonix regia (golmohar)	Mar-Apr	Orthodox	>2 year	24 hr cold w	1-4 week
13. Edgeworthia gardeneri (argeli)	Dec-Jan	Cutting	-	-	-
14. Elaecarpus sphaericus (beadtree)	Nov-Dec	Orthodox	6 month	Breaking & hot water	1-9 month
15. Emblica officinalis (amala)	Oct-Dec	Orthodox	1 year	72 hr cold w	9-30 days
16. Ficus auriculata (nimaro)	Aug-Sept	Orthodox	1 year	No need	4-5 week
17. Ficus benzamina (sami)	Apr-June	Orthodox	2 year	No need	4-9 week
18. Ficus semicordata (raikhanayo)	July-Sept	Orthodox	6 month	No need	1-6 week

19. Flemingia congesta (bhatamase)	Oct-Jan	Orthodox	2 year	Hot water	10-15 days
20. Juglans regia (Okhar)	Nov -Dec	Recalcitrant	2 year	48 hr cold w	10-60 days
21. Leucaena diversifolia (ipil ipil)	Nov-Jan	Orthodox	5 year	Hot water	10-20 days
22. Malus domestica (apple)	Dec-Jan	Orthodox	6 month	No need	1-3 months
23. Mangifera indica (mango)	July-Aug	Recalcitrant	7 days	Washing	1-2 week
24. Melia azedarach (bakaino)	Nov-Dec	Orthodox	1 year	24 hr cold w	15-45 days
25. Michelia champaca (chap)	Aug-Sept	Recalcitrant	15 days	Washing with w	10-45 days
26. Moringa oleifera (saijan)	Feb-Mar	Orthodox	6 month	24 hr cold w	20-30 days
27. Morus alba (kimbu)	Dec-Jan	Cutting	-	-	-
28. Pinus species (pine)	Nov-Dec	Orthodox	3 year	48 hr cold w	2-4 week
29. Prunica granatum (anar)	Sept-Oct	Orthodox	6 month	24 hr cold w	1-2 months
30. Persea americana (avocado)	Aug-Sept	Recalcitrant	1 week	Washing & cold	10 days
31. Prunus cerasoides (painyu)	March-Apr	Orthodox	2-3 year	No need	15-20 day
32. Pyrus communis (pear)	Dec-Jan	Cutting	-	-	-
33. Paulownia tomentosa	May-June	Orthodox	1 year	Cocopit	1-2 months
34. Saurauia nepalensis (gogan)	Mar-Apr	Orthodox	4 month	No need	3 week
35. Tephrosea spp (mendula)	Dec-Feb	Orthodox	2 year	24 hr cold w	7-10 days
36. Texus baccata (loathsalla)	Nov-Dec	Recalcitrant	6 month	Store in cold	45-80 days
37. Zanthoxylum armatum (timur)	Nov-Dec	Orthodox	2 year	Washing with W	1-6 month

Session 7: Seed extraction, drying, and cleaning according to seed types

Objectives

At the end of the session, participants will be able to:

- Learn about the seed collection methods of each of the species listed in Table 3.
- Learn about the seed extraction methods of some important species

Time

90 minutes

Method

Presentation, Class discussion, and practice on two types of seed extraction methods

Materials

PP 6.1 & 6.2, flipcharts, markers, a sample of orthodox and recalcitrant seeds with pods or fruits; Bucket, cotton cloth

Steps

1. Discuss and define the types of seeds (orthodox and recalcitrant seeds)
2. Get samples of orthodox (Ipil Ipil pods) and recalcitrant (lime fruits) for demonstration of seed extraction
3. Pods or fruits of orthodox seeds are laid out to dry on a cotton cloth and placed into paper bags and dried in the sun (**Reference material A**).
4. Fruits of recalcitrant seeds (lime or jackfruit) should be laid out on a cotton cloth or on mesh trays in the shade or placed into paper bags (**Reference material B**).
5. Request one of the participants (who knows how to extract orthodox seeds from the pods/ or fruits) to demonstrate the seed extraction method.
6. Similarly, request another participant to demonstrate the seed extraction method for recalcitrant seeds
7. Wrap up the session with a review of the above procedure

Reference material

A. Orthodox seeds

Orthodox seeds are those seeds that could be dried to low moisture content (e.g., 0.05 g H20 fresh weight. If the seed moisture content is increased by 1 % from the normal (5%–10%), the life span of orthodox seeds will be reduced by 50%. The following descriptions for extraction, cleaning, and storage of seed relate to orthodox seed which tolerates drying to low moisture content and can be stored at low temperatures. Between collection and extraction, it is very important to prevent damage to the tree through fungal or insect attack, mechanical damage, overheating, or loss of seed from the fruit/pods/capsules during transport and handling. Note that overheating of the fruit in direct sun for an extended period may cause overheating and loss of viability of the seed it contains such as coffee seeds. Once dry, fruit (pods, nuts, capsules) will often open to release the seed. In other cases, it may be necessary to break the pods with a stick or by hand such as with many legume seeds such as *Leucaena leucocephala*, *Flemingia congesta,* and *Bauhinia purpuria*. There are various methods of extracting seeds. The methods employed must be matched to the type of seed being collected and the skill of the collector. Various types of orthodox seeds are placed in a bottle container after extraction (Fig 2.2).

Figure 2.2: Orthodox seeds

These seeds will retain their viability for several years when stored in a cold place or even at room temperature because drying will let them enter a state of dormancy. Before sowing, these seeds usually require pre-sowing treatments to break the dormancy. Seeds that are very tiny such as *Paulownia, Eucalyptus, or Alnus* capsules can be placed in paper bags in a warm, dry spot. Within a few days, most of the seed will have been released from the capsules. Clean the seed through a wire sieve.

B. Recalcitrant seeds

Recalcitrant seeds cannot be dried below relatively critical moisture content (e.g., $0.30gH2Og^{-1}$) and must retain high moisture during storage and should not be stored for a longer period, only a few days or weeks. Recalcitrant seeds must be wrapped in moist cloth or paper and stored in a moist environment. Examples of this type include *Artocarpus lakoocha*, *Bassia butyraceae, Mangifera indica,* neem, jackfruit, lemon, *Michelia champaca, Castanopsis indica, Quercus* species (Fig 2.3).

Figure 2.3 Lime seed extraction

The fruit should be laid out on a cotton cloth or on mesh trays in the shade or placed into paper bags such as *Michelia champaca* seeds after extraction from the fruits, it should be washed with water and sand, then it is laid out on a paper or cotton cloth in the shade. These seeds should not be dried in the sun. The seed will lose its viability when it dries completely. These seeds lose viability once

they are dried to a moisture content below a relatively high critical value. This means that seed moisture is a critical factor in determining the viability and longevity of recalcitrant seeds. For this reason, one must first identify the seed type before prescribing a method of storage. These seeds must be stored at relatively high moisture levels (e.g., 0.30 g H20 g^{-1}). As a result, the methods, techniques, packaging materials, containers, and storage environment must be modified for the successful storage of these seeds. In the case of fleshy fruits, they should be de-pulped in warm water as soon after collection as possible. They can be put in an open shady place (not in direct sun) and stored in a cool dry place, such as an airtight container in a refrigerator. If possible, these seeds should be sown immediately in the nursery (Munjuga et al., 2013)

C. List of seed treatment methods

1. Water treatment method (hot water and cold water)
2. Stratification method (sand, soil)
3. Mechanical method (break, cut, etc.)
4. Scarification (rubbing)
5. Firing (light burn in light fire, especially for teak)
6. Chemical method (treating in sulphuric acid)
7. Weathering method (throwing hard seeds in agricultural land or fallow land)
8. Fermentation
9. Animal passing (eg. Babul by elephant)

Session 8 Determination of moisture content of orthodox seeds, viability test, and storage

Objectives

At the end of the session, participants will be able to:

- Learn how to determine the moisture content of orthodox seeds.
- Learn the techniques of the seed viability test
- Know how to store the seeds

Time

60 minutes

Method

Presentation, class discussion, and demonstrations (Moisture content determination, seed viability test, and storage methods)

Materials

PP 8.1, 8.2, 8.3 & 8.4, flipcharts, markers, sample orthodox and recalcitrant seeds for demonstration, water, jar, bottles.

Steps

1. One of the participants should be ready to demonstrate the method of how to determine the moisture content of the orthodox seeds (**Reference material A**)
2. Another participant or resource person will demonstrate the method of the seed viability test (**Reference material B**).
3. Discuss why seed storage is important for a good tree nursery (C)
4. Ask participants about the factors to be considered for seed storage (D)
5. What are the appropriate seed containers (E)
6. Wrap up the session with a review of the above five points

Reference materials

A. Method for determining moisture content in Orthodox seeds

- Fill one-quarter of the jar with salt and then add the seed sample.
- Close the lid tightly and shake the jar well
- Allow the seeds to settle for about 10 minutes

If damp salt sticks on the sides of the jar, then the seeds are too moist for storage (moisture is above 10). On the other hand, if the jar is still dry and no salt is stuck on its sides then the seeds have less than 10 percent moisture content and thus can be stored safely.

B. Simple viability test using the floating method

- Fill a jar about three-quarters way with water
- Pour seeds into the water-filled jar
- Seed separation takes place: some will float while others will sink
- Sinkers are viable while floaters are not

C. Seed storage

Seed storage is important in seedling production planning. It is because seeds are not available throughout the year so it is best to take advantage by collecting as many seeds as possible and storing them for subsequent use.

Factors to be considered while storing seeds

- Emperature
- Humidity
- Moisture content
- Light
- Insects and diseases

Of these factors, the two most important are temperature and humidity. Seeds will retain their viability for a longer period when they are stored at low temperatures and low relative humidity, placed in an airtight container, and kept in a dry and dark storage compartment (Figure 2.4).

Figure 2.4: Seed stored in different containers

D. Containers appropriate for storing seeds include:

- Sacks
- Plastic bags
- Cans
- Glass jars
- Empty bottles of soft drinks and mineral water

The containers must be filled to avoid empty space in the container which will lead to an increase in the air humidity. Whenever containers could not be filled with seeds, empty spaces can be filled with charcoal or any materials that will absorb air moisture.

Session 9: Pre-seed treatment method 1

In this method, you will try several types of seed pre-treatment methods to understand the benefits of pre-treatment. You can try this method for a variety of recalcitrant seeds such as mango, butter tree, jackfruit, avocado, coffee, etc.

Objectives

At the end of the session, participants will be able to:

- Demonstrate pre-seed treatment method for recalcitrant seeds
- Learn how to make a germination bed for sowing seeds
- Know how to plant the seeds on the seedbed

Time

60 minutes

Method

Method demonstration- Practical

Materials

Any of the local seeds (coffee beans), buckets of water and Secateurs or knife.

Steps

1. Remove the fleshy part of the coffee beans by washing them in a bucket of water or a water vessel (Figure 2.5)
2. Prepare three small seedbeds.
3. Divide the 60 coffee seeds into three groups of 20
4. Put 20 seeds in a net or in a small piece of cotton cloth, place it in a bucket of water, and put a big stone on top of it so that they do not float. Leave the seeds in water for 24 hours.
5. Cut off a small section of the seed at the end of another 20 seeds, put them in a net, and place them in another bucket of water. Put a big stone on top so that they do not float. Leave them in water for 24 hours.
6. Sow each group of seeds separately in the three different seedbeds (Figure 2.6). Check every day and water the seedbeds when dry.
7. When the seeds start germinating, record the date and number of germinated seeds as shown in Table 4:

Figure 2.5: Coffee pre-seed treatment

Figure2.6: Coffee sowing in a seed bed after treatment

Date	Bed 1 (direct sowing)	Bed 2 (one day in water)	Bed 3 (cut+ 1 day in water)
Total germination			
Total days			

Session 10: Pre-seed treatment method 2

In this method, you will test the type of seed pre-treatments in hard-coated seeds (orthodox seeds) such as Leucaena diversifolia.

Objectives

- Demonstrate pre-seed treatment method for orthodox seeds
- Learn how to make a germination bed for sowing seeds
- Know how to plant the seeds on the seedbed

Time

60 minutes

Method

Method demonstration

Materials

- Seeds of some tree species e.g. *Leucaena leucocephala* or *Flemingia congesta*, which the farmers would like to plant.
- Small water boiling vessel or "kitley"
- Cotton cloth or net
- A glass or cup

Figure 2.7: Leucaena and Flemingia pre seed

Steps

Share the following points (1-6) with the participants as to how to conduct the experiment or practical work in the field.

1. Prepare three small seedbeds.
2. Divide the 300 seeds of *Leucaena* seeds into three groups of 100 seeds each.
3. Put one group of seeds in a net, place them in a water bucket, and put a big stone on top to prevent them from floating. Leave for 24 hours.
4. Put another 100 seeds into a cup of boiled water for 3 minutes (Figure 2.7) and stir and cover with a plate after 3 minutes drain the hot water by replacing it with cold water. Keep these seeds for 24 hours.
5. Sow the three groups of seeds in three different seedbeds (Table 4). Check every day and water the seedbed when it is dry.
6. When germination starts, record the date and number of germinating seeds in each seedbed (Figure 2.8).
    - Confirm the above 6 steps with the participants and whether they can conduct the experiment in the field.

Figure 2.8: Observation of seed germination

Session 11: Seed germination media and sowing seeds in different beds

Objectives

At the end of the session, participants will be able to:

- learn how to mix the growing media (soil, compost, and sand)
- know where to sow the seeds for germination
- learn the inoculation techniques

Time:

120 minutes

Method

Presentation and practical demonstration in the field

Materials

- PPs 11.1, 11.1.1 to 4
- Spade, soil, sand, compost, sieve, and shovel for mixing growing media
- Poly pots, prepared seedboxes, and seed trays for sowing seeds in different containers

Steps

1. Follow the procedure for mixing growing media (**Reference material A**)
2. Follow the procedure for sowing seeds directly on poly-pots (**Reference material B1**)
3. Follow the procedure for sowing seeds on seedboxes **(Reference material B2**)
4. Follow the procedure for sowing seeds on a seed tray (**Reference material B3**)
5. Review all the activities above

Reference material

Seed germination is the production of a new plant from seed. Seed germination occurs when the seed embryo is viable. It begins when water and oxygen enter the seed.

A. Mixing growing media components (soil, compost, and sand) for filling pots

Once you have prepared your compost, gathered the other materials you plan to use in your growing medium, and decide the proportions of each, you should then:

Procedure for mixing media components (30 minutes)

1. Sieve the components to remove all pieces more than 5 mm in diameter.
2. Accurately measure the required amounts of each component (normally ratio is 2:1:1).
3. Mix the light ingredients first, then add the heavier ones and mix again.
4. Mix well to give a uniform consistency.
5. Keep mixing time as short as possible to avoid breaking organic matter and fiber.
6. Feel, smell, and look at the medium to make sure it is good.

B. Where to sow the seeds for germination?

- **Sowing directly in pots**: Large seeds with one embryo such as Avocado, *Leucaena, Bahunia,* and *Pinus* species, can be sown directly to pots. The germination rate is considered to be higher when we are directly planting the seeds in pots.
- **Sowing in seedbeds**: Medium to large-sized seeds that are expensive and have less germination rate such as *Juglans regia* (walnut), *Citrus lemon* (lime), Zenthoxylum armatum, and some other species that have more than one embryo such as Choerospondias axillaris, Melia azedarach is sown in seedbeds.
- **Sowing in seed boxes**: For small seeds (i.e. *Ficus, Alnus, Eucalyptus*, Paulownia) are best sown in seed boxes. If the viability of the seeds is unknown, it is best to sow the seeds in seedbeds and **seed boxes** instead of sowing them directly into pots.

B1. Procedure for sowing seeds directly in pots (30 minutes)

1. Water the pots filled with the potting medium thoroughly.
2. With the use of a dibbling stick, loosen the medium and make a small hole at the center. The size and depth of the hole should just be enough to bury the seed with a thin cover of the medium. Burying the seeds too deep will likely result in a low germination rate.
3. Place one seed in each pot and cover it with the medium (Figure 2.9).

Figure 1.9: Seed sowing directly into polybags

4. Water the pots carefully after sowing so as not to dislodge the seeds and keep the medium moist all the time.
5. Protect the newly sown seeds by covering the pots with plastic or any protective material.
6. If possible, spray the pots with insecticide to ward off insects that might consume the seeds.

B2. Procedure for sowing seeds in seed beds (Figure 2.10) - (30 Minutes)

1. Moisten the seed bed.
2. Make straight furrows across the seed bed.
3. Place the seeds into the furrows.
4. Cover the seeds with a thin layer of soil.
5. Cover the seedbed with shading material

B3. Sowing seeds in seed boxes

The advantage of sowing seeds in boxes over seed beds and direct seeding is that the germination medium can be sterilized. Sowing seeds in seed boxes involves the following steps (Figure 2.11):

Figure 2.10: seeds sowing on seed beds

Preparation of germination media for seedbeds and seed boxes

- Prepare a mixture of 60% soil and 40% river sand. The soil holds moisture while the sand promotes aeration and good drainage (Gregorio et al., 2010).
- Sterilize the germination medium by heating it over the fire at 60 degrees for full 30 minutes.
- The medium must be dampened (but not saturated) before heating. After heating, let it stand to cool down. Sieve the medium by passing through a screen to remove large clods.

B3 Procedure for seed sowing in seed boxes (30 minutes)

1. Place the appropriate medium in the seed box and level it. The box should have holes at the bottom to prevent waterlogging.
2. Spread the seeds evenly over the medium and cover them with a thin layer of the medium (Figure 2.11).

Figure 2.11: Small seed sowing in seed boxes

3. Water the seed box through the sub-irrigation method (page 27) so as not to dislodge the seeds and destroy the physical structure of the medium.
4. Place the seed box under a well-ventilated shelter.

Session 12: Inoculation of growing medium

Objectives

At the end of the session, participants will be able to:

- Demonstrate how to do rhizobium inoculation in legume seeds
- Explain and perform ***Mycorrhizae*** inoculation

Time

60 minutes

Method

Method demonstration

Materials

Inoculum (Rhizobia and Micorrizae), sugar, plate, and plate cover for inoculation

Steps

1. Divide the whole group into two, one for nodule inoculation and another for *Mycorrhizae* inoculation
2. Follow the procedure for nodules inoculation with group 1 (**Reference material A**)
3. Follow the procedure for Mycorrhizae inoculation for group 2 (**Reference material B**)
4. The leader of Group 1 will share the procedure with Group B and vice versa
5. Make cross-questions about whether the other participants can follow the procedure of inoculation as per the demonstration
6. Conclude the session

Reference Materials

A. Nodules inoculation

The roots of some tree species have special abilities to increase their uptake of nutrients and water by forming associations with other organisms.

These contain bacteria (actinomycetes) that have the ability to extract nitrogen from the air and convert it into mineral salts, which the plant can then use. Examples of plants that can form these nodules on their roots include *Acacia, Albizia,* and *Casuarina*. Besides these, some of the legume trees (such as *Leucanea leucocephala, Flemingia congesta)* are able to form a symbiotic relationship with nitrogen-fixing soil bacteria called rhizobia. The result of this symbiosis is to form nodules on the plant root, within which the bacteria can convert atmospheric nitrogen into ammonia that can be used by the plant.

Procedures for Nodule inoculation exercise (30 Minutes)

1. Collect nodules from the roots of a healthy tree in the field of the same species as to be propagated in the nursery.
2. Wash soil from nodules.
3. Place nodules in water and chop them up small pieces; an electric kitchen blender works well.
4. Mix the finely chopped nodules with water and add to the growing medium (compost or charcoal) after it has been pasteurized or sterilized. The nodules can also be chopped finely, put in a watering can, and sprinkled over the top of the seedlings.
5. Inspect the seedling roots two weeks after inoculation to see if the operation has been successful.
6. If there is no evidence of nodules, inoculate again.

B Mycorrhizae inoculation

They are special fungi that grow on the roots of some plants. These fungi form symbiotic relationships with their host plants, greatly increasing the volume of growing medium accessible to their host's roots. They do this by joining themselves to the roots of the plant and forming an extensive net of fungal hyphae through the medium. This increases the nutrient (especially P) and water uptake ability of the plant.

Procedure for Mycorrhizae inoculation exercise (30 minutes)

As each tree species may require specific mycorrhizae, these must be cultivated separately for each species. Inoculation steps are listed below:

1. Construct a special stock bed for each species; 1.0 x 1.0 m on well-drained soil.
2. Plant the bed with healthy seedlings at a spacing of 15 x15 cm (max 50 seedlings /bed).
3. Spread over the bed a bucketful of organically rich soil taken from underneath healthy adult trees of the species being grown.
4. When the nursery growing medium is being prepared, dig a few plants from the stock bed, and collect the soil from around the roots. White thread-like material may be noticed at this time; these are mycorrhizae.
5. Mix this soil with the growing medium at a ratio of 1:100, after the medium has been sterilized or pasteurized.
6. Replant the stock bed each year

Session 13: Transplanting and pricking out of seedlings and wildlings

Objectives

At the end of the session, participants will be able to:

- Learn the technique of pricking out of the small nursery seedlings to the transplant bed
- Learn the technique for wildling collection from the forest and planting in the field

Time

60 minutes

Method

Demonstration in the nursery

Materials

Small pointed stick, plate with water at the bottom, seedlings from the germination bed, soil mixture filled in pots in a transplant bed

Steps

Ask one of the participants, who is skilled to demonstrate the pricking out activity following 1-8 procedures below.

Procedure for pricking out of young seedlings

1. Water the pots and germination trays/seedbeds before lifting and planting the seedlings.
2. Prick the young seedlings early in the morning and late afternoon as the solar radiation is not so intense to damage the young seedlings
3. Lift seedlings from germination media with a flat stick and place them in a shallow bowl of water to prevent wilting.
4. Using your dibbler/flat stick (a length of round wood, about 6 mm in diameter) make a hole in the potting mix in the middle of each container.
5. The hole must be large enough for the roots to go straight down into the potting mix without bending or looping. Long roots can be lightly trimmed with sharp scissors.
6. Carefully firm the potting mix down around the roots making sure that the root collar is level with the surface.
7. Water with a soft spray immediately to make sure the young roots don't dry out and to ensure that there are no air pockets left in the potting mix around the roots. Ensure the plant is upright after watering.
8. Always label the pricked-out seedlings as you go, and finish one tray totally before moving onto the next one. Keep all seed lots separate.
    - Ask the remaining participants to perform the activity as per the demonstration
    - Make sure the participants follow the above 8 procedures correctly.
    - Conclude the session

Reference Material

A. Pricking out of the small and young seedlings

Potting or pricking out is transplanting seedlings from germination boxes and seedbeds to individual pots. This is considered as the most delicate operation of seedling production because very young seedlings are tender and improper potting will damage the root system. The following conditions should be observed during pricking out (Figure 2.12):

Figure 2.12: Pricking out of seedlings

B. Pricking out of Wildlings

Wildlings should be collected while they are still very young. Collecting old wildlings will cause severe root damage which will result in high seedling mortality, and potting old wildlings will usually result to a deformed root system such as J-rooting especially when root pruning is not carried out prior to potting.

The best time to collect wildling is early in the morning and late afternoon. If collection is done during a sunny day, wildlings should be covered to protect them from wilting. Mud packing of roots is ideal and fresh banana sheath will serve as a good packing material.

Module III

Tree improvement through vegetative methods

Session 14: Introduction to Vegetative Propagation Method

Objectives

At the end of the session, participants will be able to:

- Define the vegetative propagation method and its types
- Explain why the vegetative method of propagation is needed

Time

60 minutes

Method

Plenary discussion

Materials

Flipchart/whiteboard, markers,

Steps

1. Ask some of the participants what they know about vegetative propagation
2. Write down participants' responses on the flipchart
3. List out the various types of vegetative propagation methods on the flip chart
4. Ask any of the participants if he or she knows or has skills in any of the vegetative propagation methods
5. Review what the participants understand about the vegetative propagation method

Reference Materials

A. Vegetative propagation defined

Vegetative or asexual propagation is the production of new plants directly from vegetative parts of existing ones, not from seeds. This method is possible because every cell of the plant contains the genetic information necessary to regenerate the entire plant. Reproduction can occur through the formation of adventitious roots and shoots or through the uniting of vegetative parts by grafting or budding. Stem cuttings and layers have the ability to form adventitious roots, and root cuttings can regenerate a new shoot system.

There are mainly four types of vegetative propagation methods as follows:

1. Stem or rooted cuttings,
2. Layering
3. Division
4. Grafting and budding

B. Why the vegetative method?

- Mass reproduction of highly improved genotypes, quickly and reliably. Some trees with desirable inherited characteristics can be reproduced through mass vegetative propagation, i.e. production of improved clonal planting stock. Such as Eucalyptus, Paulownia
- To allow the production of new trees of certain species quickly Such as Pear and rose.
- Trees of some species produce seed rarely, some are seedless or their seed is difficult to store and/or does not germinate easily such as *Morus alba*, Banana.
- To produce trees that will bear fruit earlier example mango, avocado, orange, and apple.
- For maintenance of the physiological condition of the parent tree in the propagated part.
- For keeping constancy in genetic material (true to type). That is, the part propagated is genetically identical to the original individual.
- Controlling male-to-female tree ratios on farms

Session 15: Cutting method of vegetative propagation

Objectives

At the end of the session, participants will be able to:

- Learn how to make stem cuttings
- Learn how to make cutting with leaves
- Know about packaging technique of cuttings for transport and
- Identify various types of rooting hormones and their use

Time

90 minutes

Method

Demonstration on how to make cutting, discussion in small groups, and plenary

Materials

Power points 15.1, and 15.2 (15.2.1 & 15.2.2), Secateurs, knife, sickle, spade, rooting hormones (1, 2, 3), pencil size mother plant branches (mulberry, rose)

Steps

1. Discuss cutting collection methods and techniques in the plenary (Reference material A).
2. Divide the participants into two, one for stem cutting (mulberry stem) and another for cutting without leaves (Loath salla)
3. Allocate some part of the nursery area for making cutting demonstration to each of the groups
4. Assign a resource person to each of the groups for training and demonstration.
5. Demonstrate how to make cutting (without leaves- Reference material B and with leaves- Reference material C) in each of the groups by the respective resource person with the use of rooting hormones (Reference material D)
6. Select one leader to share their learning from the first group to the second and vice versa
7. Ask participants if they have any questions and wrap up the session

Reference Materials

A. Collecting cuttings

Transpiration will continue from the leaves of a cutting even after it has been removed from the parent plant. Therefore, when taking cuttings in the field, a good way to preserve them is to place them in a moistened jute bag and keep them cool.

Caution: do not pack too many cuttings together, as they will deteriorate through overheating which leads to increased transpiration. The bag should be blown up, tied off, and kept cool, preferably in a cool box with an ice pack, until it arrives back at the nursery for immediate use or storage in a refrigerator. It is even better to take and set cuttings in the cool of the early morning.

Cuttings are mainly two types, cutting without leaf and with leaf.

B. Cuttings without leaf

This method may also be used to start plants off in the nursery, where moisture, wind, and temperature may be partially controlled. If nursery soils are of good quality or appropriate materials can be added to the soils to improve their quality, it may be appropriate to propagate such cuttings in open nursery beds as 'bare-rooted' plants. After the 'stumps' have been through one nursery season they may be dug up by cutting through the roots that have formed, about 20–30 cm from the stem, with a sharp spade. They may then be planted out into the field 'bare-rooted'. The cutting should be taken longer than is necessary so that excess may then be trimmed off just before the cutting is set. Cuttings taken in the field should be about 25–30 cm long, 3–5 mm thick and have at least 6 nodes (Figure 3.1).

Procedure

- Cuttings should be taken in the dry season, normally during the dormant season, well before the growth new flush.
- The cuttings should not have actively flushing buds, as it is better for roots to form before shoots begin to grow. Older wood is better than soft, green shoots.
- The cuttings should ideally have lost their leaves naturally. If they still have leaves, they should be removed by cutting through the leaf stalks rather than tearing or putting them off.
- Leave only a few very small leaves at the tip if they are not already fallen to the ground.
- The cuttings should be 15–40 cm long and 6–30 mm thick based on the type of the species. *Brassiopsis hainla* requires bigger size cutting than *Morus alba.*

Figure 3.1: Cuttings without leaf

C. Cutting with leaves

This method may sometimes be called softwood, greenwood, semi-hardwood, ripe-wood or summer cuttings, though these terms can be misleading. This is the most common type of stem cutting used for vegetative propagation, as a wide range of species can be rooted with this method. Fewer species will root from leafless cuttings.

Procedure:

- To take cuttings from herbaceous plants, select new upper growth which has become firm. Example: *Taxus baccata* and Chinese rose can be propagated through this method (Figure 3.2).
- For woody plants take cuttings of new growth that has become hardened but not woody in texture.
- Cuttings taken from side (lateral) growth exposed to full sun appear to give better results than cuttings taken from the top. This may be due to carbohydrate storage in the lateral stems.
- A good time to take cuttings is just as the growth flush is beginning in spring, though firmed new growth taken in autumn can also be good.
- Hard, woody stems are usually not suitable for leafy stem cuttings.

D. Rooting media for cuttings

For cuttings to strike readily, the rooting medium must have specific qualities. It should be open-textured to allow free air circulation and drainage, but hold enough water to support the cuttings. Normal nursery germination media and growing media should not be used as they are usually too fine to allow adequate aeration. Also, such media often have a high proportion of organic matter which is undesirable as it may cause the cutting to rot before it initiates roots.

Suitable rooting media include coarse, angular quartz sand (washed to remove clay and silt), sterilized sand, and perlite.

A small amount of husk of coconut dust or peat (up to 20% by volume) added to these

Figure 3.2: Cutting with leaf

media will help to hold moisture and increase acidity which will encourage the formation of roots. However, too much coir or peat will hold too much water and may encourage fungal growth that can bring about stem rot.

When hand watering is used, 1 part of coir dust (or peat) to 4 parts of sand is satisfactory.

With propagation under misting systems, use 1 part coir or peat to 8–9 parts of sand.

Rooting hormones

For some species (prickly pear, pomegranate, lime), rooting is difficult and therefore some rooting hormones are recommended. Three types of root hormones are available in the markets (Figure 3.3). No. 1 is low in concentration and may be used for species that are easy to strike. No. 2 is medium strength and is appropriate for most cuttings and No. 3 is the strongest and should only be used for species that are more difficult to root.

Procedure

- Take each cutting in turn and dip the freshly cut end in hormone powder or solution.
- Shake excess powder from the cutting.
- 'Seradix' powder is a common hormone available in this region.
- The lowest strength necessary for each particular species should be used – too much hormone can be worse than none at all.
- If using a liquid (solution) preparation of rooting hormone, do not leave the cutting in the solution for more than 5 seconds as too much hormone will be absorbed and this may be deleterious.
- Gently push the cutting into the prepared hole, ensuring that the leaves are above the medium.
- Checking cuttings for roots- normally roots will be developed in a month or so depending upon the species.

Figure 3.3: Rootmax hormones

Session 16: Ground Layering

Objectives

At the end of the session, participants will be able to:

- Define different propagation methods of layering
- Learn how to produce new plants from ground layering methods

Time

45 minutes

Method

Demonstration on how to practice ground layering methods of propagation, small group learning, and plenary discussion

Materials

Secateurs, knife, mother plant for layering, stone for holding the bent ground layering branch, rooting hormones

Steps

1. Select a young vigorous stem.
2. Make a slanting cut into it and scrape the bark above the cut gently to expose the underlying tissue.
3. Apply hormone powder or liquid hormone to the cut area.
4. Stress the stem by bending it down and upwards into a "U" shape and securing it into the ground or media (Figure 3.4). If the stem is above ground level, a pot filled with growing media can be raised to the appropriate height. The cut portion should be covered with about 75 mm of soil and kept well-watered.
5. Rooting may take three months or more. Check for roots from time to time by gently scraping away the soil.
6. When roots are well established, sever the rooted stem from the plant and with soil still attached, pot up into a suitable container.
7. Water well and treat in the same manner as a potted cutting

Reference Materials

In some tree species, roots will form naturally when a branch touches the ground or a moist surface. This is natural layering. Artificial layering involves interrupting the normal flow of sap in a branch or stem and bringing that part of it into contact with damp growing media. Layerings are mainly two types, Ground layering, and aerial layering.

Ground layering

Ground layering can be done with most plants that have branches growing close to the ground. Examples include different varieties of berry fruits, litchi trees, guava and citrus lime, and lemon. We need to check over time if roots are formed on the new baby plant, but do not sever the tie between the parent and the baby until the new roots are very much established. As long as still two plants are still connected, the baby plant gets water and nutrients from the parent plant.

Figure 3.4: Ground layering

Session 17: Air Layering

Objectives

At the end of the session, participants will be able to:

- Define the air layering method of propagation
- Learn how to produce new seedlings from the air layering method

Time

45 minutes

Method

Demonstration on how to practice air layering in Citrus plant, small group learning exercise, and plenary discussion

Materials

Secateurs, knife, mother plant for layering, moss, rooting hormones, polythene, jute rope/aluminum foil

Steps

1. Conduct the demonstration first using the procedure given in the box below.
2. Ask the interested participants to perform the task as per the demonstration.
3. Make sure the participants follow the correct procedure given in the box
4. Conclude the session

Procedures for air layering

a) Carefully remove a ring of bark 12–15 mm wide from the stem of a suitable branch or side shoot. Gently scrape the exposed section to remove the soft tissue (phloem).

b) Dust the wounded area with hormone powder and pack a good quantity of wet sphagnum moss or similar material around the stem.

c) Wrap with clear polythene and secure at both ends with ties.

d) Cover the polythene completely with aluminum foil and again, tie both ends. Roots usually take three months or longer to form by this method. Progress can be checked by removing the aluminum foil and looking for evidence of roots through the polythene. Do not disturb the polythene covering.

e) When roots are well developed, cut off the rooted layer and pot up into a container. Water well and treat as a potted cutting.

Reference Material

Aerial layering

This is a form of layering in which the branch is potted or wrapped in a moist growing medium to promote root growth. Aerial layering is similar to normal layering except that the rooting takes place above the ground (Figure 3.5).

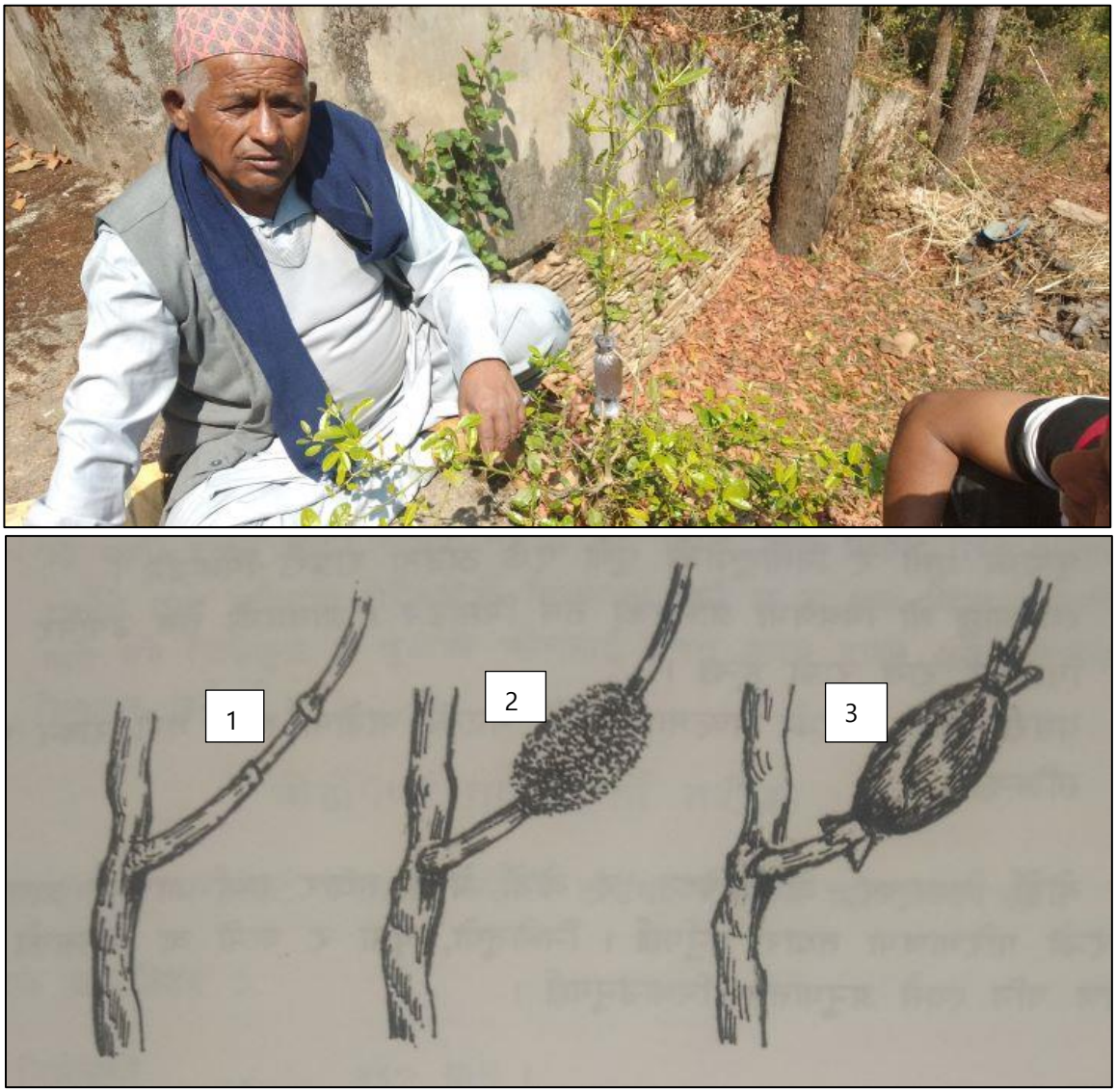


Figure 3.5: Procedure for air layering

Session 18: Producing new plants from Division

Objectives

At the end of the session, participants will be able to:

1. Define various methods of producing new plants through division
2. Learn how to get new plants from the division method of propagation

Time

45 minutes

Method

Demonstration on how to separate new plant from the parent tree (Banana, Ficus spp), small group learning exercise, and plenary discussion

Materials

Knife, mother plant for dividing plant parts, spade/khurpi, and sickle

Steps

1. Explain to the group of participants about different methods of division with some examples (See reference material)
2. Take the group to the mother plant area (either bamboo or banana garden) for exercise
3. Demonstrate how to take out the sucker or the clum from the mother plant with the help of a spade or khurpi (sickle).
4. Ask all participants one by one to practice the technique for their learning
5. Wrap up the session if you feel all know how to separate the sucker from the mother plant.

Reference Material

Division

This method involves the division of plants that are already established in the garden or in pots. Each divided part is complete with its own roots and growth buds. The division is usually done in autumn or early spring when the plants are still dormant. It is used for the production of many perennials plant species. Mainly the following five types are common for division propagation:

1. *Fibrous-rooted plants*: This method is quite common in bamboo among other species that have fibrous root systems.

2. *Woody-rooted plants*: Sometimes woody-rooted perennials will develop robust woody root systems that will be more difficult to divide than the fibrous-rooted plants. However, division is still possible and can be a useful method of increasing the number of these plants. Cut through roots with a sharp knife, secateurs, or sharpened spade to effect the division. An example includes, *Ficus* species

3. *Suckers:* A sucker is a shoot that has arisen from the root system of certain plants, such as occurs with poplars, bananas (Figure 3.6), and many bamboos. The operation simply involves digging up individual suckers, taking care to include a piece of the original root, and then replanting in the new position.

4. *Offsets*: An offset is a young plant produced alongside the parent and easily detached from it. An offset is a small, virtually complete daughter plant that has been naturally and asexually produced on the mother plant. They are clones, meaning that they are genetically identical to the mother plant. An example is daffodil bulbs, which may be separated and planted out individually.

5. *Rhizomes:* Some plants have root-like stems that grow under the ground and store food to enable the plant to survive during winter and propagate itself by vegetative means. These stems are called rhizomes. Examples of plants having rhizomes are bananas, taro, ginger, and turmeric.

Figure 3.6: Banana suckers

Session 19: Grafting

Objectives

At the end of the session, participants will be able to:

- Know various methods of grafting (veneer, side, tongue, patch, and cleft)
- Understand the advantages of grafting
- Learn how to unite the parts of plants (graft between scion and rootstock) for producing new seedlings of selected species (lapsi, walnut)

Time

120 minutes

Method

Demonstration on how to make a graft between rootstock and scion, small group learning exercise, and plenary discussion

Materials

PPs 19.1, 19.2, 19.3, 19.4 & 19.5.1-19.5.2, Knife, mother plant for scion, rootstock, plastic/polythene ribbon, jute rope, and sickle

Steps

1. Explain to the group of participants about different methods of grafting with some examples (Reference material A)
2. Ask some of the participants about the benefits of the grafting method of propagation
3. Write down the points on the flipchart about what participants say regarding the benefits of grafting
4. Explain to the group how to grow rootstock in the nursery (Reference material B).
5. Similarly explain to the group how to choose the scion from the mother plants and prepare it for grafting (Reference material C).
6. Follow the procedure about how to do side grafting in lapsi or in mango trees (Reference material D)
7. Review and wrap up the session

Reference Materials

A. Grafting

Grafting is a technique used to untie 'parts' of different plants by bringing the cambium of each into contact to grow together as one plant. The technique involves two important stages: the preparation of the grafting surfaces and the procedures for aftercare. The advantages of grafting include

- Earlier production and higher yield of fruit than trees raised from seed;
- The aerial parts of the grafted plants will be true to type (they retain all the genetic characteristics of the mother tree).
- Reduced height for easy picking
- Good quality fruit from selected varieties
- Early fruiting after only a few years

There are many types of grafting including cleft, side-veneer, bark, splice, whip, tongue, saddle, and approach grafting. For any type of grafting, the principle is that one part of the plant (the rootstock) provides the grafted plant with a strong root system. The other part (the scion) provides the stem and crown, which includes the fruiting/flowering part, with desirable characteristics (such as large fruit, and good flavor).

The scion is usually a section of stem taken from the previous year's growth of the parent plant or clone. The secret to successful grafting lies in the physiological quality and compatibility of the two components, the rootstock, and the scion; the cleanliness in the operation; and the after-care provided to the freshly grafted plant.

B. Raising rootstocks

Allow a single stem to grow for 6 to 18 months depending on the species (Figure 3.7). The technique involves the formation of a union between scions taken from desirable mother trees and rootstocks that are normally young or healthy seedlings established in the nursery. If grafting is done with the right plant material, it can shorten the period between field establishment and when a tree flowers and fruits. This is important for fruit trees since early maturity means revenues can be realized more quickly by farmers. To achieve a successful graft, it is important to have healthy, actively growing rootstocks which grow well in your area, as well as scions with active (swollen) buds that have not yet opened. Normally, scions and rootstocks should be of the same diameter, in order to align cambium layers. This is required for the formation of the graft union, to allow the effective movement of the nutrients and water needed for plant growth between roots and shoots.

Figure 3.7: Raising root stock- Lapsi

C. Choosing scion

The best quality scion usually comes from shoots grown the previous season. Scions should be severed with sharp, clean secateurs or knives and placed immediately in moistened plastic bags or tissue papers. It is a good practice during the harvesting of

scions and the making of grafts to clean the cutting tools regularly. This may be done by immersing them in a sterilizing solution such as alcohol or methylated spirit.

How to choose the best quality scion?

1. Choose wood that has healthy buds that will grow into leafy shoots. Do not take scion wood that has flower buds. Most shoot buds are long and pointed while flower buds tend to be short and fat.
2. Take scion wood from trees that are healthy, with no signs of any pests or diseases, otherwise the new trees may also have the pest or disease. For this reason, it is best to choose parents from which to collect the scion wood during the growing season.
3. Choose plants that have the desired characteristics as these will be carried with the scion wood.
4. For plants that produce fruit, take scion wood from plants that are already bearing fruit to avoid lengthy delays until the grafted plants first start to bear fruit.
5. If the buds have begun to grow, it is too late to use the wood for grafting.
6. For most types of grafting, choose scion wood that is one year old. This is the wood that grew in the previous season. For budding, choose wood from the current season's growth.

Preparation of scion and handling (Figure 3.8)

1. Cut all scions to a uniform length, keep their basal ends together, and tie them in bundles of known quantity (for example, 50 scions per bundle).
2. Label them, recording the cultivar, date of harvest, and location of the stock plant.
3. Wrap the base of the bundles in moistened tissue paper or cotton wool, place them in polythene bags, and seal the bags.
4. Store the bundles for short periods, if necessary cool the box.

D. How to do side grafting?

1. Harvest scions from the desired mother tree and cut them about 15cm long. Remove all the leaves carefully. The scions should be the same thickness as the rootstock stem (Figure 3.9).
2. With a very sharp knife cut the bottom of the scions with two sloping cuts 3½cm long (A).
3. Cut off the top of the rootstock about 30cm above the soil. Make one straight cut about 3cm deep in the top of the rootstock (B) to form a wedge.
4. Push the scions firmly into the rootstock cut.
5. Leave ½cm of the cut scions outside the rootstock as shown.
6. Use clear plastic tape to wrap firmly around the graft. Do not remove the tape until the scion begins to grow – showing the graft has been successful.
7. Remove any buds which have grown below the graft.

Figure 3.8: Scion selection of lapsi

Figure 3.9: Side grafting in lapsi

Session 20: Budding

Objectives

At the end of the session, participants will be able to:

- Know various methods of budding (T-budding, patch budding)
- Learn how to unite the buds (scion) of the mother plant with already growing rootstock for producing new seedlings of selected species (orange, walnut)

Time

60 minutes

Method

Demonstration on how to do T-budding in the orange tree, small group learning exercise, and plenary discussion

Materials

PP 20.1, Knife, mother plant for scion (bud), rootstock plants, plastic/polythene ribbon, jute rope, and wax

Steps

1. Explain to the group of participants about different methods of budding with some examples (Reference material A)
2. Ask some of the participants about what they know about the budding
3. Write down the points on the flipchart about what participants say regarding budding
4. Explain to the group how to do T budding in the orange tree (Reference material B).
5. Review and wrap up the session

Reference material

A. Budding definition

This is a method of asexual propagation that involves inserting a strip of bark with a bud from the branch of the desired clones to the stem of the seedling stocks. Budding is a form of grafting and is based on the same principles and requirements for a successful union in grafting. There are different techniques that can be used depending on bark slipping or the condition which determines the ease or difficulty of separating the bud from the wood. Similar to grafting, it uses vigorous and disease-free rootstocks and scions. It is used widely in the citrus industry for joining buds of desirable fruiting varieties to strong rootstocks such as *Poncirus trifoliate (locally called tinpate)* and the bush lemon. It is a good method to use if scion wood is scarce as numerous buds may be taken from the same amount of wood that would constitute a scion for grafting. The t-budding method is described here.

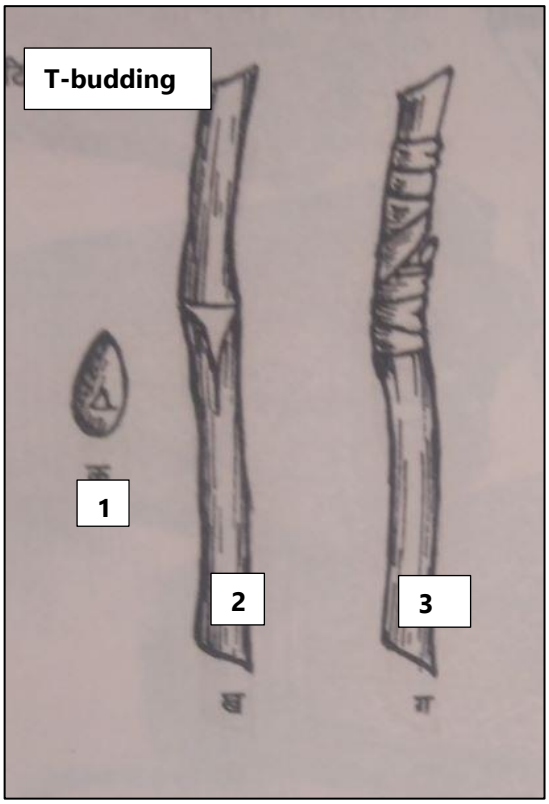


Figure 3.10: T-budding method

B. T budding

T budding is only possible when there is a strong sap flow beneath the bark that will allow the bark to be lifted away from the underlying tissue on the rootstock. This usually happens when the plant is actively growing, from the end of winter (when the weather begins to warm up) to the start of the following winter. Since the buds must be dormant but the rootstocks actively growing, the best time may be late summer.

Procedure:

1. Cut a firm, plump bud from the selected plant.
2. Make a horizontal cut through the bark on the stock plant, then a vertical cut, forming a **T**. Loosen the bark from the stem.
3. Gently ease the bud into the **T** cut (Figure 3.7)
4. Carefully bind with grafting tape/plastic film to completely cover the bud. The growing bud will eventually emerge through the film.
5. When the bud is growing strongly, remove the grafting tape and sever the sto

Module IV

Seedling quality maintenance and certification

Session 21: Introduction to seedling quality maintenance and caring of seedlings

Objectives

At the end of the session, participants will be able to:

- Understand the importance of seedling quality for a tree planting project
- Why quality seedling production is necessary?
- Who controls the seed quality system in Nepal?

Time

60 minutes

Method

Presentation, writing on meta card, plenary discussion

Materials

Flip chart, meta card, markers

Steps

1. Ask participants what they understand about quality seedlings
2. Write the points about what participants said on the flip chart and compare these points with **Reference material A**.
3. Distribute meta cards to the participants and ask them to write at least one benefit of quality seedlings.
4. Paste all these meta cards on the board and read out all the points written on these cards and compare them with **Reference material B**.
5. Ask the participants about the agencies who control the qualities of seeds (**Reference material C**)
6. Wrap up the session with learning points and reiterate some of the points from the last session

Reference material

A. Seedling quality

Seedling quality refers to the genetic and physical characteristics of a given seedling. Genetic quality relates to the genetic characteristics of the source of germplasm, while physical quality refers to the physical condition of the seedling as it is raised in the nursery (Gregorio et al. 2010). The physical quality of seedlings can be improved by good practice within the nursery but there is no fixed rule to improve seedling genetic quality. Producing seedlings of high physical quality can be carried out when the seedlings are in the nursery while raising seedlings of high genetic quality requires the application of appropriate technologies before the production of seedlings in the nursery. Improving the seedling genetic quality requires a long-term process of mother tree selection and an appropriate germplasm collection procedure.

B. Why Quality Tree Seedlings?

The quality of seedlings has a profound effect on the growth performance of planted trees (Gregorio 2010). A low-quality seedling is not worth planting because it will always produce a low-quality tree, even if it is provided with the appropriate silvicultural treatments and planted at an appropriate site. Further, the plantation maintenance cost of low-quality seedlings can be high due to high mortality and more intensive management requirement. On the other hand, high-quality seedling provides minimal plantation cost because of low seedling mortality and the less intensive management needed. In addition, the planting of high-quality seedlings provides an early return on investment because they have more rapid growth and have shortened rotation age. If farmers are concerned about choosing the best germplasm for any agriculture and forestry crops, the more that they should be more selective about the quality of tree seedlings to plant. Most crops can be harvested in a few months such that any mistake in the selection and use of germplasm can be rectified in the next cropping season. Trees, on the other hand, would require several years before they could be harvested. Thus, the mistake of planting low-quality seedlings will also take several years before this can be corrected.

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C. Who controls the quality of seeds in Nepal?

In Nepal, different seed production initiatives are being carried out on quality seed production. When the seed is to be purchased from any sources (such as Agro vet or other state departments or private companies), quality assurance is essential. With a long-term vision Nepal adopted a holistic vision for developing Nepal's seed sector included in the "National Seed Vision 2013 – 2025" (Dawadee, 2018). The leading organization for seed certification in Nepal is "The Seed Quality Control Center" (SQCC), which has been obtaining accreditation from the international community of seed certification. In the context of Nepal, seeds are properly labeled and recorded in the register and the information which should be included in the list are the species (Latin name and Nepali name), Date of collection, Place of collection, District, and Zone.

The Seeds Act was enacted in Nepal in 1988 and amended in 2012. The main objective of the Seeds Act was to promote and regulate the increased production and distribution of high-quality plant seeds and to ensure the interest of seed entrepreneurs and farming communities (the consumers of such seeds)

Session 22: Caring of seedlings for quality maintenance

Objectives

At the end of the session, participants will be able to:

- Know all the activities to be performed in order to care for and maintain nursery seedlings
- Perform all the important nursery management activities

Time

120 minutes

Method

Presentation followed by nursery visit and field operation of nine activities

Materials

Green net, straw or thatch grass, pegs, water cane, pruning knife or blade, biochar fertilizer, secateurs, hardening bed with seedlings, 1 m bamboo pole

Steps

1. Explain to the participants with a slide show of all the important activities to be performed in the nursery (**Reference material 1-9**)
2. Take the participants to the nursery site (note that if the participants' number is more than 10, divide the group into two)
3. Identify one of the participants to facilitate one of the nine nursery management activities (shading, watering, fertilizing, weeding, control of pests and diseases, root pruning, grading, culling, topping, and hardening) based on their experience.
4. Provide feedback if necessary to the selected facilitator after his or her facilitation is over
5. Allocate some time to practice the nursery activities with the remaining participants
6. Wrap up the sessions with some learning and feedback

Reference material

Nursery care and management

Nursery plants need special care in the nursery for successful establishment in the field. The amount and type of care given to plants varies across species and the age of the species in the nursery. Very young plants (germinants) require intensive care and small seedlings less care; established seedlings need hardening treatment before planting in the field.

Activities recommended:

1. Shading: Management of shade in the nursery is very important; incorrect use of shade will lead to substandard seedlings that will not perform well after planting out. A common mistake in some of the nurseries in Nepal is to provide too much shade. Heavy shade for extended periods will lead to soft, elongated, and even yellow seedlings. These seedlings are poorly adapted to harsh field conditions and will be severely stressed or die once planted out. The rule of thumb is to protect young seedlings from strong sun by starting them off in medium shade (50%), but then moving them to full sun as soon as possible to make them strong (Figure 4.1).

Figure 2.1: Green net shading

2. Watering: Poor watering regimes and practices will also lead to poor-quality seedlings. But do not make the nursery very wet. Pools of water lying around can encourage disease to spread in the nursery and are also a waste of water. Watering should be done in such a way that seedlings are not damaged and that growing media is

Figure 4.2: watering too recently germinated seedlings

not washed away (Figure 4.2). It is to remember that shade must be removed a month before planting the seedlings. This will prepare the seedlings for direct exposure to intense sunlight at the planting site. If seedlings are not accustomed to full sunlight, sun scalding of leaves will occur immediately after planting, which will result in mortality.

3. Fertilizing: The application of inorganic fertilizer may not be necessary if the potting mix contains a high amount of nutrients to support seedling growth. It is easy to scorch the seedlings, thus fertilizer application can damage the seedlings if not done correctly. If it is necessary to apply fertilizer, cheap material can be biochar-based organic fertilizer. A total of 125 gm of biochar can be

Figure 4.3: Fertilization

used in one 3"x7" size bag (Figure 4.3). The frequency of application and amount of fertilizer applied must be reduced at the time of planting the seedlings in the field. Fertilizer application must be stopped two to three weeks from planting.

4. Weeding: The importance of proper weed control in nurseries is obvious but it is often neglected. Weeds compete with seedlings for moisture, nutrients, and light. They also make the nursery look unsightly and may harbor diseases and insects. Removing weeds is easiest when they are small (Figure 4.4). Allowing weeds to become large makes the task much more difficult and may lead to seedling root damage when they are removed. Weed control and removal should be a continual task. Staff should keep watch for weeds and remove them straight away. Nursery managers must ensure that this activity is carried out by making regular inspections. The grass next to and around the nursery should always be kept short to prevent weeds from seeding with the subsequent dispersal of seeds into nursery pots.

Figure 4.4: Weeding

***5. Control of pests and diseases*:** Pests and diseases can be responsible for considerable losses of plants in nurseries if left unchecked. As with human diseases, prevention is always better than cure. Regular checking will allow fast corrective action if a disease does break out in the nursery, so that losses may be minimized. Damping off is the most common disease of seedlings in the nursery. Seedlings with damping off have rotten portions at the base of the stem causing the seedlings to topple down and die. Damping off is mostly caused by fungi, thus can be treated by applying fungicide- Capton or copper oxy-chloride. Make sure that the germination medium has good drainage to facilitate the flow of water and movement of air within the medium.

***6. Root pruning*:** Cutting roots that are coming out from the seedling container is essential to prevent the roots from penetrating into the ground (Figure 4.5). If the taproot grows deep into the ground, lifting the seedlings immediately before planting will cause severe stress to the seedlings, which will increase the risk of seedling mortality. Also, taproots penetrating into the ground will hinder the hardening process because even if water and nutrient application is reduced, the roots will continue to absorb moisture and nutrients from the soil. Root pruning can be done by cutting the roots that come out from the seedling container using a scissor or knife. If the outgrowing roots are still very young, these can be rubbed off by hands. This activity can be reduced if the seedling containers are placed on elevated beds.

Figure4.5: Root pruning

***7. Grading and culling*:** It is good practice to have even-sized plants (of the same species) grouped together in the nursery. This facilitates the management and also gives even competition between the plants for light and space. It also makes the nursery look neater and more orderly (Figure 4.6).

Figure 4.6: Grading of seedlings

Two activities are recommended:

1. Discard any diseased, malformed, or stunted seedlings. These seedlings will only take up space and time in caring for them, and will probably never achieve the quality required to ensure our planting success. The earlier sub-standard/cull seedlings are discarded, the more efficient a nursery becomes.
2. Put different-sized seedlings of each species into separate groups. Seedlings will naturally grow at different rates but eventually, the faster-growing ones may suppress the weaker ones by competing for light and deflecting irrigation water away from them. Medium and small-sized seedlings, that have been separated out, may need to be held several weeks longer before planting out (this does not apply to cull seedlings which must be discarded without hesitation).

***8. Topping seedlings*:** If the seedlings become too tall before the planting season begins, it may be appropriate to 'top' them to achieve a more appropriate shoot: root ratio. Seedlings will have the greatest chance of survival in the field if they have a low shoot: root ratio at the time of planting, that is, a lot of roots to support a given shoot size (Figure 4.7).

Figure 3: Lapsi seedling topping

Whether or not topping is appropriate will depend on the species being propagated and the subsequent plantation objectives in combination with intended silviculture. One species with which topping is used successfully on a regular basis is teak, lapsi, paulownia. For most timber species, it is necessary to avoid topping as it can encourage forking, resulting in multiple stems and branches. Only early forms of pruning can be performed.

9. Hardening off: To give seedlings the very best chance of survival in the field, it is necessary to put them through a hardening-off process as shown in Figure 1.9. Approximately three to four weeks prior to planting you should begin with the following procedure:

1. Stop fertilizing;
2. Make sure seedlings are in full sunlight (i.e. there is no shade);
3. Reduce frequency and amount of watering gradually;
4. Do not water in the morning; the idea is to make the plants stressed during the hot part of the day;
5. Wait until the seedlings wilt, then water straight away.

10. Sand and soil mixture: Along with the soil, the ratio of using compost and sand should be appropriate.

Session 23: Introduction to nursery standardization and certification

Objectives

At the end of the session, participants will be able to:

- Know what is forest nursery, simple forest nursery and high-tech nursery
- Explain the benefits of nursery accreditation and certification

Time

60 minutes

Method

Presentation, snow balling exercise, and plenary discussion

Materials

Flip chart, whiteboard, markers, and reference material

Steps

1. Explain to the participants with a slide show about the concept of nursery accreditation (**Reference material A**)
2. Ask the participants to make a note of why we need nursery seedling accreditation.
3. Divide the whole group into two and each group compile the notes from each of the individual participants.
4. Request the leader of each of the groups to present the compiled notes to the plenary
5. Get feedback from the other group and finalize the benefits of seedling accreditation (**Reference material B**).
6. Wrap up the sessions with some learning and feedback.

Reference material

A. Understanding of Nursery accreditation

In Nepal, there are many types of nurseries that do not have adequate quality assurance procedures. Species are being mislabeled and incorrect seed sources are being sold. There are pieces of evidence that some nurseries have entered the market without assurance of quality seedlings. On the other hand, why should anyone buy seedlings from an established nursery instead of a new nursery that is selling a less expensive seedling? Nursery accreditation would be one way for a reputable nursery to try to follow correct practices to distinguish itself from those that do not have quality standards. Accreditation will help the buyers to understand the quality of the products for which the nursery manager claimed his products. For example, a nursery may produce seedlings in elevated pots, which do not require root pruning, and the roots of which are not curled. Accreditation is one method that can be used to certify that the seedlings produced with inoculation (rhizobia, micorriza, azetobactors, etc) have the ability to be established properly in the new sites. Another nursery may wish to certify that their products are developed and grown for use within a particular state or region while another may wish to certify for superior timber production.

B. Benefits of accredited/ or certified nursery seedlings

- It is the basis to raise the overall industrial quality and capacity of their organization
- Seed source is known and guaranteed when we have accreditation;
- It would help to support established programs to continue good practices (keeping them in business) and serve to educate newly organized nursery businesses.
- Accreditation would encourage tighter management. If we know someone is going to observe our nursery, then we would be careful in our operation;
- Accreditation should also help achieve recognition within our own organizations that we produce quality seedlings. This, in turn, can reasonably justify training for personnel as well as having good facilities.
- Accreditation can help focus on priorities; what gets counted gets done.
- The records required by an accreditation process will prepare a nursery to address challenges observed in the nursery work. Every nursery manager has to face customer complaints from time to time. A completely documented program from seed source identity to sowing through pack and ship will put the manager in a position to answer objectively any questions raised from outside the nursery concerning seedling quality.
- It helps to maintain the availability of High-quality seeds of different tree species to the farmers through certification.
- It helps to achieve the objective of plantation
- It provides information about the place of origin and the quality of the mother plant
- It helps to know the vigor of the growth and the degree of suitability to that site of the plantation.
- It plays an important role in risk minimization

Session 24: Forest Nursery accreditation body and processes

Objectives

At the end of the session, participants will be able to:

- Know who can apply for nursery accreditation and the eligibility criteria for accreditation
- Define the members to be included in the accreditation body
- Know the seedling accreditation process

Time

75 minutes

Method

Presentation and Plenary discussion

Materials

Powerpoint presentation, flipchart, and markers.

Steps

1. Start with powerpoint presentation (Reference material A to D)
2. Get comments and feedback from the participants about the eligibility criteria (Reference material A).
3. Revise and confirm the list of members to be included in the accreditation body based on discussion (Reference material B).
4. Similarly, confirm the process of nursery Accreditation with the participants (Reference material C) and issuance of accreditation certificate-D).
5. Wrap up the session with a review and feedback from the participants.

Reference material

A. Pre-condition/ or eligibility criteria to apply for forest nursery accreditation

a) The applicant should have adequate information about seed or planting materials sources (Annex 1).

b) The applicant should have the proof of a minimum of 10,000 seedlings produced in two ropani (1000 M^2) of land annually (Annex 2)

c) Certificate of attendance to trainings, workshops, or lectures on Nursery Development and Management conducted by Forest Research and Training Center (FRTC) or Division Forest Offices (DFOs) or other agencies recognized for providing high-quality training activities;

d) Recommendation from the local government

e) Certificate of registration from the respective agencies

f) Recent Tax Clearance certificate (at least within 12 months period)

g) The nursery operator is applying the prescribed standard practices depicted in Section 6 below for nursery operation;

B. Who would participate in the accreditation program?

Any individual nursery operator, local government unit, academic institute, government including DFOs, a nongovernment organization, cooperative, corporation/ company, small and cottage industry, Forest User Groups (CFUG, LFUG), and others with existing forest nurseries can apply for nursery accreditation. In case of any forest nursery operator who is managing a forest nursery at least for the last 6 months prior to application may also apply for accreditation.

The accreditation of the nursery would be strictly voluntary and open to any nursery or seed plant wishing to participate. No one would be prevented from selling seedlings from an unaccredited nursery or seeds from an unaccredited seed plant, but the support or certifying agencies would certainly recommend the costumers buy seedlings from accreditated nurseries.

C. Accreditation body and Processes

The accreditation body is the organization that reviews the criteria and standards; and then conducts the evaluation and, finally, issues the accreditation certificate (Karrfalt, 2005). One possible accrediting body in Nepal for forest nursery accreditation could be composed of five members/ representatives of the following organizations at the local level. The last 4th and 5th members will only be invited by the DFO in case there is a need for any further information on the applicant nursery.

1. Divisional Forest Officer or officer designated by DFO- Chair
2. Sub-division Assistant Forest Officer/ designated by AFO- Member secretary
3. FRTC representative within the Province
4. Local government-related representative equivalent to officer-member
5. District Agriculture Knowledge Center - member

This committee will be named as Quality Nursery Verification Committee (QNVC) that uses the above criteria and standards (section 6) for accreditation. This committee would provide voluntary conformity assessment and accreditation services to the participant nurseries for those who applied for accreditation. This committee is an independent committee and strives to

provide services in accordance with accepted nursery practices and internationally recognized nursery guidelines. All services are provided on a cost-recovery basis with fees as nearly equal as possible to the actual cost of providing the service.

D. Accreditation process and issuance of accreditation certificate

1. The nursery owner who meets the eligibility criteria (section 5.3) can apply to the DFO for its accreditation using the format (Annex 3).
2. Application fee is proposed for NPR 1500 and the renewal charge is NPR 1000.
3. DFO in consultation with the QNVC members may form a small team (two to three members). In the case of DFO nursery, the Regional Director will form the nursery accreditation team including the representative from the Provincial FRTC office for inspections and verification.
4. The designated Team reviews the submitted documents and conducts field verification and assessment according to the prescribed rating scale of the applicant nursery to be accredited and submits the report to QNVC.
5. The applicant nursery needs to secure an average of at least 50% marks to be qualified for accreditation (Section 6).
6. The QNVC approves or disapproves the application based on the rating scales for accreditation and promptly informs the applicant.
7. The duration of accreditation will be for 1 year and renewable for another year
8. Regular monitoring of accredited nurseries shall be conducted either by the committee members or assigned technical personnel of DFO. The report will be the basis for continuous operation, suspension, or cancellation of the accreditation permit.
9. Official shields, stamps, logos, or other marks may then be used on certified nursery certificates, correspondence, advertising, and promotional material to signify that the nursery has been accredited for the claims it makes for its products.
10. DFO will issue a license to the applicant. (Note: Any nursery business within the district must pay annual nursery licensing fees and be subject to DFO inspections. The costs of licensing and any other authority-mandated certifications must be included in the operational costs of the applicant nursery).

Session 25: Forest nursery accreditation standards, criteria and Indicators

Objectives

At the end of the session, participants will be able to:

- Know about what are the basic nursery accreditation standards
- List the number of criteria and indicators approved by the Ministry of Forest and Environment Nepal

Time

150 minutes

Method

Presentation and plenary discussion

Materials

Powerpoint presentation, Nursery accreditation standards, and criteria, flipchart, and markers.

Steps

1. Start the discussion on forest nursery definition and high-tech and low-tech nurseries (Reference material A)
2. Share powerpoint presentation about the basis for accreditation of forest nurseries (B) and the criteria and indicators for forest nursery accreditation recently approved by the government of Nepal (Reference material C).
3. Divide the whole group into four main sub-groups based on the set standards
4. Explain to the participants about the standards and their criteria.
5. Give at least 30 minutes time to discuss all the indicators
6. Ask the group leader to present comments and feedback on these standards and criteria
7. Wrap up the sessions with some learning and feedback

Reference material

A. Criteria for defining a forest nursery and a high-tech nursery

Forest nursery

A forest nursery is a place where seedlings especially of forest tree species are raised either from seed or from any other part of the plant for eventual planting out. A nursery is said to be a forest nursery if: **at least 60% of the total number** of different species raised in the nursery must be tree and/or shrubs and/or fuelwood and/or fodder and/or NTFPs species such as *Terminalia belerica, Terminalia chebula, Azadirachta indica, Phyllanthus emblica, Sapindus mukorossi, Elaeocarpus sphaericus* etc. and/or ornamental tree species such as *Jacaranda mimosifolia*, *Lagerstroemia* sp. The remaining 40% of the production can be fruit, flower, or other species including medicinal and/or aromatic plants in the nursery.

High-Tech Nursery

The next step is to decide whether you are going to establish a simple locally operated nursery or a high-tech nursery. The level and types of technologies (simple seedlings are grown in a natural environment; medium-plastic and green net used and high-iron structure and sprinkle water used) differ between nursery types and investment capacities. Therefore a High-tech forest nursery is a combination of a poly greenhouse and agrinet house where the following four standards including temperature control, humidity control, light intensity control, and misting facility or micro-irrigation are fulfilled.

B. Basis for accreditation of forest nurseries

A set of four standards are developed as a basis for accreditation of forest nurseries as below:

1. Standards for human resource requirements
2. Standards for basic nursery setup and facilities
3. Standards for general seedling physical quality
4. Standards for specific seedling stock quality

A total of 14 indicators have been developed for the assessment of the quality of the forest nursery seedlings. More weightage (maximum 4 points) is given to the indicators (3, 5, 6, & 7) for the assessment of basic nursery setup and facilities followed by general seedling quality standards (Indicators- 8, 9, 10 & 12). The remaining 6 indicators (1, 2, 4, 11, 13, 14) have a maximum allocated point is 3 each. Altogether, there are 50 points of which a nursery should obtain a minimum of 25 points (50%) to pass the examination (for certification). The final results are graded as 25-30 points grade- C, 31 -40 points grade- B, and more than 40 points grade-A.

C. Standards and Criteria for Forest nursery accreditation

C.1 Standards for human resource requirement

Standards for human resource requirement is judged on the basis of individual skills/knowledge and experience in nursery operation and quality seedling production. Here four basic criteria are developed for the evaluation of human resources involved in the nursery operation and management.

1. Nursery manager and/ or supervisor should have at least a basic Diploma in forestry training to BSc or master in forestry level qualification and have one to two years of experience in nursery work supervision.

Criteria description	Points
Neither obtained an academic degree nor any nursery-related training	0
Do not have an academic degree but participated in nursery training from a recognized institute with one year of experience on nursery work supervision	1
Do not have an academic degree but participated in a month of nursery training from a recognized institute with one year of experience in nursery work supervision.	2
Completed BSc forestry, nursery training from a recognized institute & one year of experience in nursery work supervision	3

2. The nursery operator should have participated in at least one nursery related training and should have a working experience of at least three years on producing high quality seedlings

Criteria description	Points
Did not receive any nursery related training and no working experience in seedling production	0
Has participated in nursery related training and has one year working experience in forest nursery	1
Has participated in one nursery related training and has two years working experience in forest nursery	2
Has participated in at least one nursery training and has a working experience of at least three years	3

C2 Standards for a basic nursery setup facilities and outlook

3. Infrastructure: The nursery should have access to road/transport and market with enough space for tools/equipment storage, and facilities for electricity and fencing

Criteria description	Points
The nursery has space required for poly bag nursery but not for other facilities (only for nursery bed)	1
Has facility of water supply, road /transportation facilities (including the above criteria)	2
Has enough facility of water supply, and space for equipment and tool storage (Has space for equipment and tool storage room including above)	3
Has reliable facility of water supply, equipment, electricity, fencing, and market facilities (Has facilities of electricity, fencing, market, rest room including the above criteria)	4

4. Facilities- There should be the presence of necessary nursery facilities such as seedbeds seedling beds and hardening beds with soil sterilization and sieving facilities for quality seedling production

Criteria description	Points
Not having separate seeds, seedlings and hardening beds	0
Has three types of basic beds (seedbed, transplant bed and hardening bed)	1
Has soil, sand and, compost sieving facilities including the above facilities	2
Soil sterilization facility, including the above facilities	3

5. Seedling container: nursery uses different sizes of polybags and elevated trays for root training

Description	Points
Nursery uses makeshift materials (can, juice packs and plastic cups)	1
Nursery uses polybags	2
Nursery uses different sizes of polybags based on species requirements (duration-years, seedling size etc)	3
Nursery uses hiko trays (high-density plastic used in forest nurseries) or elevated containers which is used for root training	4

6. Potting mixture: nursery uses forest top-soils with drainage enhancers in the mixture

Description	Points
Pure clay soil	1
Clay soil with drainage enhancers (sand, leaf/forest peat, rice husk, sawdust) and fertilizer	2
Topsoil from forests with high organic matter	3
Top forest soil with drainage enhancers	4

7. General outlook of the nursery in terms of grading (according to the size of the polybags, age, and type of the species) and cleanliness (weeding & hoeing) seems to be appropriate, attractive and appealing.

Description	Points
Nursery lacks appropriate grading and has poor sanitation	1
Nursery seedlings are graded based on species, age, and sizes of poly pots	2
Has appropriate nursery seedling grading and good sanitation facilities	3
In addition to the above, the nursery signboard is placed in a place that can be noticed easily from the outside	4

C3 Standards for general quality seedling stocks

8. Sturdiness: seedlings should have a robust stem

Criteria description	Points
All samples have sturdiness quotient value of more than 10	1
10-16 samples have sturdiness quotient value of more than 6 but less than 10	2
5-9 samples have sturdiness quotient value of more than 6 but less than10	3
< 5 samples have sturdiness quotient value of more than 6 but less than 10	4

Note: Sturdiness quotient: It refers to the ratio of the height of the seedling in cm to the root collar diameter in mm and expresses the vigour and robustness of the seedling. A small quotient indicates a sturdy and stouter plant with a higher expected chance of survival, especially on windy or dry sites (Jaenicke, 1999). A high ratio indicates a relatively spindly (thin) seedling (Haase, 2007). The ideal value for a seedling to be considered sturdy is less than six (Jaenicke, 1999 cited by Takoutsing et al., 2013). In the prevailing context of planting materials production in Nepal's forest nurseries, the sturdiness quotient of up to 10 or less is suggested for selecting nursery stock for planting.

9. Health: Seedlings should be free from pest & diseases, no mechanical or physical injuries and no stem rottening

Description	Points
All samples (16) are affected by pests and diseases, and but no mechanical injuries	1
10-15 samples are affected by pests and diseases, and no mechanical injuries	2
5-9 samples are affected by pests and diseases, and no mechanical or physical injuries	3
<5 samples are affected by pest and diseases, and or no mechanical or physical injuries	4

Note: Any plant or seedling is said to be healthy when it is free from pests and diseases, and at the same time, it should not have any mechanical injuries and physical damage.

10. Color of foliage: The color of leaves and foliage should be dark green/ green deep color and no dark, pale-green foliage

Criteria description	Points
Almost all samples (>15) have pale green color foliage and leaves	1
10-15 samples (9) have pale green color foliage and leaves	2
5-9 samples (6) have pale green color foliage and leaves	3
< 5 samples have pale green color foliage and leaves	4

Note: Colour of foliage or leaves of seedlings is a general indicator of seedling quality and can vary by species and time of the season. Yellow, brown, or pale-green foliage indicates lower vigour than dark green foliage (haase, 2007).

11. Stem form: Good quality seedlings should have a straight stem

Description	Points
All samples (>15) have two or more stem leaders and bent shoots	0
10-15 samples have two or more stem leaders and bent shoots	1
5-9 samples have two or more stem leaders and bent shoots	2
<5 samples have two or more stem leaders and bent shoots	3

Note: Any seedlings selected for planting in the field should have straight stem and a single stem leader

12. Root form: Quality seedlings should have a well-developed root system and no evidence of root deformations

Criteria description	Points
All 16 samples have j-pot bound and curled roots and primary roots growing out from the container and penetrating into the ground	1
10-15 samples have j-pot bound and curled roots and primary roots growing out from the container and penetrating into the ground	2
5-9 samples have j-pot bound and curled roots and primary roots growing out from the container and penetrating into the ground	3
<5 samples have j-pot bound and curled root and primary roots growing out of container and penetrating into the ground	4

Note: The root system of plants can be assessed easily in bare-root seedlings and plants for stump production. A deformed

root obstructs the uptake of water and nutrients from the soil and a bent or looped primary root does not provide a strong base for the anchorage of the growing plant (Harrison et al., 2008 cited by Takoutsing et al., 2013).

C4 Standards for specific types of nursery stocks (Annex 4)

13. Container raised single year seedlings of 4″x7″ should have a min ht of 25 cm & root collar diameter 2.5 mm.

Description	Points
All 16 samples (4 samples /bed of 10 m length) fall under the minimum standard of at least 4″x7″ pot size, 25 cm ht., and root collar diameter 2.5 mm	0
Only 1-5 samples meet the minimum standard of least 4″x7″ pot size, 25 cm ht., and root collar diameter 2.5 mm	1
6-10 samples meet the minimum standard of least 4″x7″ pot size, 25 cm ht., and root collar diameter 2.5 mm	2
More than 10 samples meet the minimum standard of least 4″x7″ pot size, 25 cm ht., and root collar diameter 2.5 mm	3

14. Container raised or a large ball rooted multi- year seedlings of 5″x10″ or 14″ poly-pot size should have a min ht of 50 cm to 1 m & root collar diameter 5 mm.

Description	Points
All 16 samples fall below the min pot size of 5″, ht 50 -100 cm and root collar diameter >5 mm	0
Only 1-5 samples have min pot size of 5″, ht 50 -100 cm and root collar diameter >5 mm	1
5-9 samples have min pot size of 5″, ht. 50 -100 cm and root collar diameter >5 mm	2
>10 samples have min pot size of 5″, ht. 50 -100 cm and root collar diameter >5 mm	3

Module V

Nursery enterprise development and marketing

Session 26: Rationale for nursery enterprise development?

Objectives

At the end of the session, participants will be able to:

- Explain the concepts of the nursery business
- Know the points to be considered before establishing a nursery business
- Know the various business modalities

Time

60 minutes

Method

Presentation and Plenary discussion

Materials

Power point presentation (26.1, 26.2, 26.3), flipchart and markers, a poster showing nursery enterprise modalities.

Steps

1. Start with power point presentation.
2. Get comments and feedback from the participants on the overall presentation.
3. Agree on the concept of nursery business (**Reference material A**).
4. Discuss and agree on the points to be considered prior to establishing a nursery business (**Reference material B**)
5. Similarly, confirm the business modalities with the participants for establishing any enterprise (**Reference material C**).
6. Wrap up the session with a review and feedback from the participants.

Reference materials

A. Nursery business defined

Today, many government nurseries and also project-funded nurseries are operating voluntarily, and seedlings produced in these nurseries are distributed free of cost (Lamsal et al, 2020). Starting a nursery as a business entity is a very complex process and involves a lot of risks to run the business. It can be personally and financially rewarding if you take the time and make the effort to learn the business and develop a locally adopted business plan. Success in the nursery business isn't just about growing the plants. You must also let everyone know about the business and how your product is superior to the already available products in the trade. Before you can start off, there is some information you should keep in mind about running a nursery business. Before you start any business, you need to think about its main components as illustrated in Figure 5.1

A seed can't grow into a tree unless it starts to germinate. Similarly, even the best startup idea cannot begin to be turned into a tangible enterprise unless it is first transformed into something customers want to buy.

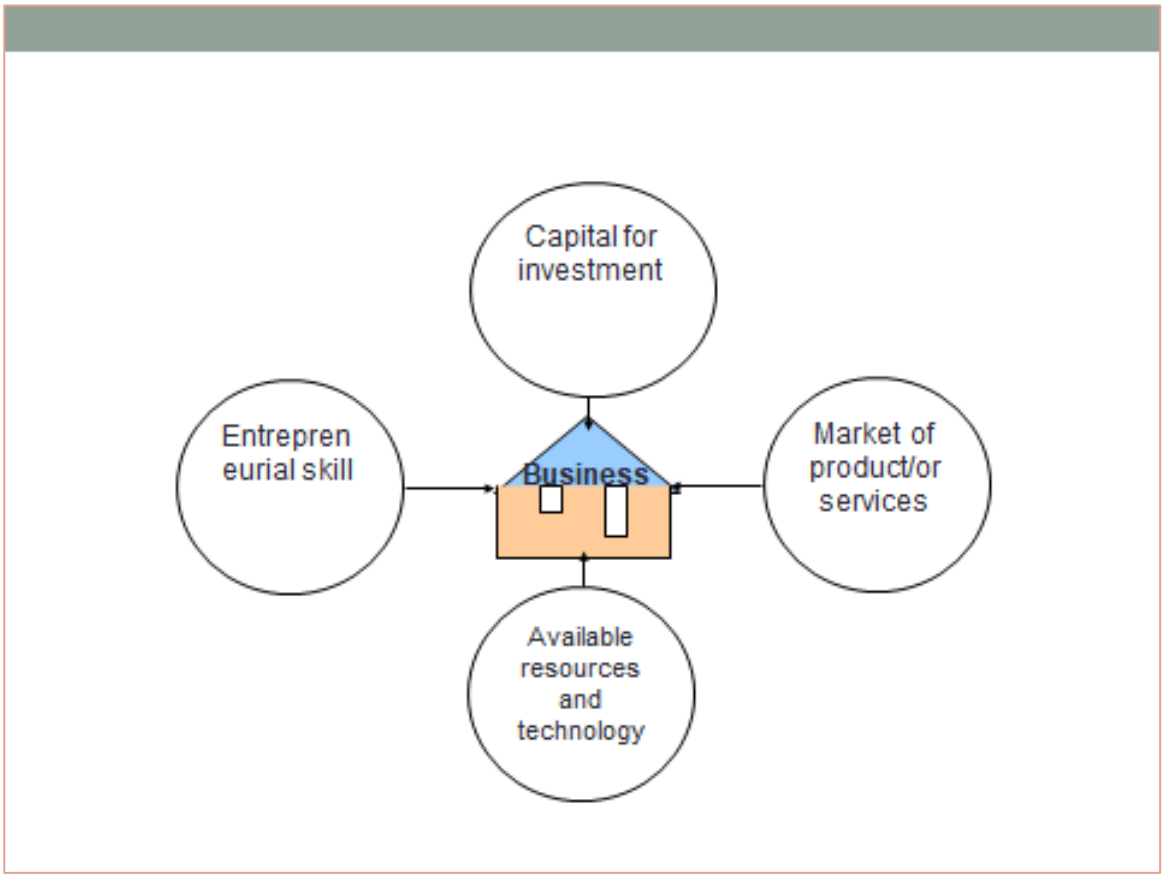

Figure 5.1: Four components of business enterprise

B. Points to consider prior to the establishment of any business

- Know your customers and what they want
- Know the supply side
- Know how to reach your customers
- Unique selling points (USPs)-how I can be different from competitors
- Understand the market
- Price that is competitive and is profitable
- Analysis of competitors - who are they, what are they doing?
- Negotiation with the customers

C. Enterprise modalities

Enterprise modalities vary based on the enterprise scale, legal personality, characteristics of membership, source of products, diversity of enterprise products and services, and external support (Pandit et al. 2008). Five types of nursery enterprise modalities are illustrated in Figure 5.2. They are public or private companies, micro or cottage industries, cooperative societies, nursery networks, and individual nursery owners.

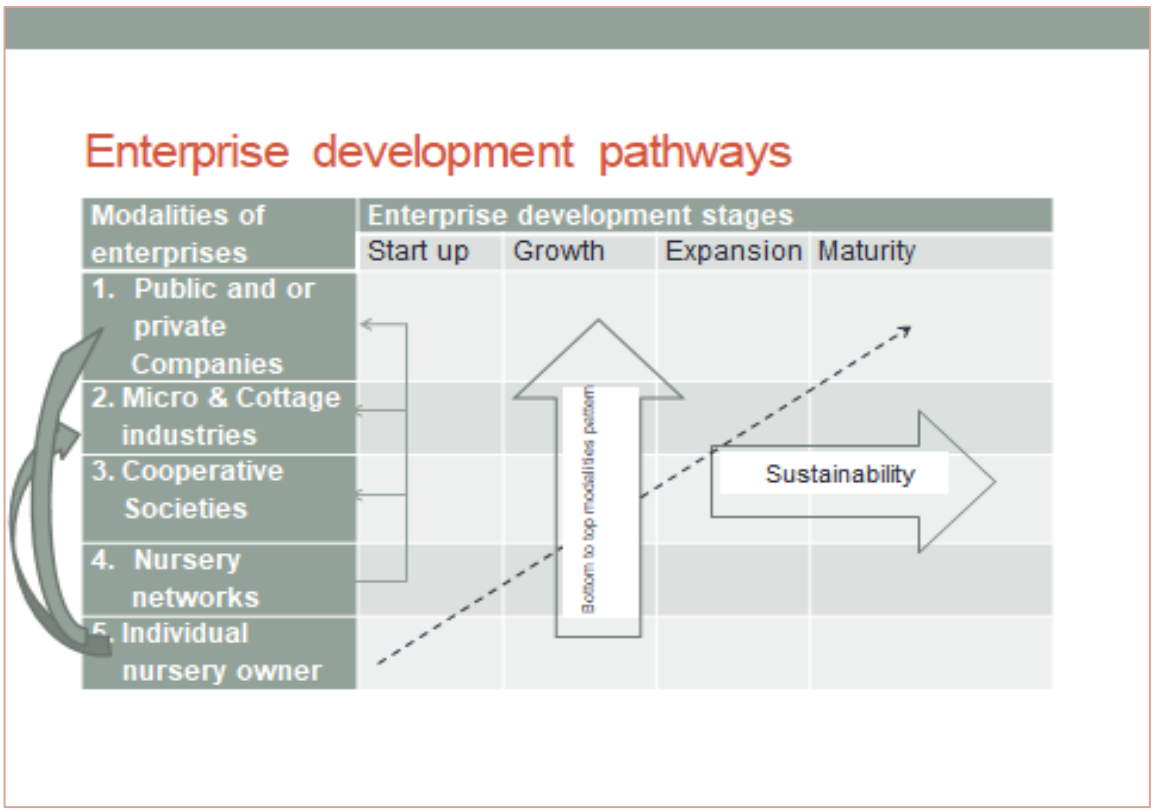

Figure5.2: Enterprise modalities

Session 27: Prospect of establishing a forest nursery: A SWOT analysis

Objectives

At the end of the session, participants will be able to:

- Know what problems are supporting and hindering their nursery business
- Make a SHOT analysis of their nurseries

Time

75 minutes

Method

Presentation, small group exercise on SWOT analysis, and plenary discussion

Materials

Powerpoint presentation, meta cards, flipchart, markers, sample business plan

Steps

1. Start with powerpoint presentation defining SWOT analysis (**Reference material A)**
2. Get feedback from the participants
3. Divide the participants into two groups based on nursery types (Government and private nurseries)
4. Select a leader from each of the groups and ask them to organize meetings in separate rooms (if possible)
5. Ask participants (within the group) to write at least one each strength (S), weakness (W), opportunity (O), and threat (T) on each of the meta-cards (Note: green card is for strength, yellow is for weakness, white is for opportunity and red for threat. One person can write as many as possible SHOTs, but only one message in one card).
6. Paste all the cards separately in the four corners of the board.
7. List all the SHOTs in the respective boxes of Table 6 (**Reference material B**)
8. Ask each of the group leaders to present their findings to the plenary
9. Vote of thanks to each of the leaders and participants and wrap up the session.

Reference materials

A. SWOT analysis

SWOT analysis is a strategic planning and strategic management technique used to help a person or organization identify strengths, weaknesses, opportunities, and threats related to business competition or project planning. It is sometimes called situational assessment or situational analysis. Strengths, weaknesses, opportunities, threats (SWOT) analysis includes an examination of both internal factors (strengths and weaknesses) and external factors (opportunities and threats) that can have an influence on the success of your enterprise (Cernusca et al.2018).

Strength: What strengths does your nursery business have that help you accomplish your goals and makes you competitive? Some of the strengths of one of the government nurseries identified by training participants of the EnLiFT project in April 2021 are presented in Table 6 (e.g. reliable seed source, enough & secured space for a nursery, availability of market for seedling sale; good location, reliable workforce, previous experience in the nursery, strong financial position).

B. Table 6: example of SWOT analysis of a government nursery

Strengths	Weakness
• Reliable seed source • South-facing slope/ land aspect • Enough and secured space for the nursery • Use of simple to hi-technology • Reliable workforce • Market availability for seedling sale • Transportation and road accessibility • Locally availability of compost manure • Availability of storehouse, compost-making area, waste pit area • Secured home for employee	• Mixed seedlings in one bed and weeds growing around the nursery • Inadequate experience in the nursery business • Insufficient finances or untimely budget • Not adequate irrigation water • Limited access to the distribution channel • Lack of consistent supply of seedlings because of the seasonality of products • Not adequate nursery equipment • No hardening bed constructed
Opportunities	**Threats**
• Exist farmers' market or cooperative that buys seedlings • Help and support from different organizations • Government services and facilities are available • Increasing interest in buying ornamental trees' seedlings (Ficus spp, bottle brush) • Can be established as a learning center • Scope for producing multiple species	• Budget not released in time and changes in policy • Increased competition from outside nurseries (market competition) • Seasonal buying trends • Transfer of employee and staff involved in nursery • Extreme climate events (snow fall in May)

Weakness: Weaknesses are areas where the nursery business can be vulnerable to competitors. What can create problems in your business? (e.g., lack of experience in the nursery business, insufficient finances, limited access to distribution channels, seasonal product). Identified weaknesses (such as lack of consistent supply of seedlings because of the seasonality of the product) can be transformed into strengths (such as building indoor facilities to extend production time).

The second part of the SWOT analysis requires you to look outside your business at issues that you cannot control but can be managed. Is there anything in the marketing of seedlings that can help or favorable (opportunity) or affect (threat) your business's ability to produce and sell seedlings?

Opportunities include a farmers market just developing in your area; a grower farmers' coop nearby the nursery; potential for buying seeds and seedlings nearby your nursery; increasing interest in ornamental tree seedlings; government support and services available, and different organizations showing interest for support.

Threats include changes in federal and state regulations, increased competition from outside nurseries, inflation, increased competition from outside nurseries, extreme climate events, seasonal purchasing trends, and frequent transfer of staff involved in the nursery.

Session 28: Business plan

Objectives

At the end of the session, participants will be able to:

- Know what is about the business plan and it content
- Develop a simple business plan based on the potential threat and opportunities

Time

75 minutes

Method

Presentation, small group exercise on Business planning, and plenary discussion

Materials

Powerpoint presentation (28.1 & 28.2), flipchart, markers, sample business plan

Steps

1. Start with powerpoint presentation by defining the business plan, its contents, and purposes (**Reference material A & B)**
2. Retain the same groups from session 28 based on nursery types (Government and private nurseries)
3. Select a leader from each of the groups and ask them to organize meetings in separate rooms (if possible)
4. Ask participants (within the group) to write a simple nursery business plan based on the contents provided earlier.
5. Ask each of the group leaders to present their business plan to the plenary.
6. Spend a few minutes for questions and answers across members of both groups.
7. If anything missing, fill in gaps in the business plan from the suggestions provided by the participants
8. Vote of thanks to each of the leaders and participants and wrap up the session.

Reference material

A. Business plan defined

A business plan is a written document that describes in detail how a business defines its objectives and how it is to go about achieving its goals. A business plan lays out a written roadmap for the firm from marketing, financial, and operational standpoints. A nursery business plan will help to determine the type, market, location, design, and size of the operation. In addition, one will establish specific details on equipment and employee requirements, operational costs, estimated pricing schemes, projected return on investment, and asset availability.

Purposes:

1. To create an effective strategy for growth
2. To determine your future financial needs and
3. To attract investors and lenders

B. Content of the business plan

1. Background
2. Vision, mission, and objectives
3. Investment plan and organizational structure (membership and staffing)
4. Resource collection
5. Production plan and value chain analysis
6. Marketing strategies (short-term and long-term)
7. Financial plan (infrastructure & machinery (fixed assets), raw material collection, labor, expenses prior to investment)
8. Financial analysis (cost-benefit ratio, breakeven point, payback period- total income/net income)
9. Collaboration and coordination
10. Social plan
11. Science and technology fit
12. Risk analysis
13. Conclusion

Session 29: Types of nursery businesses and target market

Objectives

At the end of the session, participants will be able to:

- Know the types of nursery businesses
- Identify target markets for their nursery seedling

Time

60 minutes

Method

Presentation and plenary discussion

Materials

Powerpoint presentation (29.1, 29.2 & 29.3), flipchart, markers, and question and answer.

Steps

1. Start with powerpoint presentation- types of nursery businesses and identification of target markets
2. Get feedback on the presentation from the participants
3. Spend a few minutes for questions and answers by participants in the plenary.
4. What are the types of nursery businesses? (**Reference material A**)
5. How do you identify the target markets? **(Reference material B)**
6. What would be your approach to defining market and consumers? **(Reference material C)**
7. Review the points discussed
8. Wrap up the session.

Reference material

A. Types of nursery businesses

Many nursery businesses have diversified to provide a variety of products and services to ensure rapid return on their investment. There are three basic types of nursery business (revised by Munjuga et al 2013):

1. **Producer nurseries**: Producer nurseries are those which grow plants for themselves and mostly they are meant for selling seedlings to retail and wholesale nurseries.

2. **Retail nurseries**: Retail nurseries consist of selling stock of seedlings in the communities, village, or state that it is purchased (or after minor transformations), generally to a customer base of private individuals, regardless of the quantities sold.

3. W**holesale nurseries** which include contract propagators, contract growers, producers, and distributors (re-wholesalers) of nursery stock for wholesale to other nurserymen, landscape contractors, and retail outlets.

B. Identifying the target market

Defining the market involves answering the question: Who is the customer? This question will be partially answered by the type of business you choose and the location of your operation (urban or rural). For wholesale nurseries, the type of customer will depend partly on the characteristics of the nursery location and site (e.g., soil texture, temperature) as they affect the products to be sold (rooted cuttings, liners, earth balled and potted, or container grown seedlings). Examples include the following:

1. Geographical locations- (local, national, international; rural, urban; terai, hill, mountain)
2. Demographic (Age, sex, income level, profession, marital status, religion) – (Figure 5.3)
3. Psychographic (lifestyle, perceived benefits, attitude, values, product usage)

Figure 5.3: Target market

C. Approaches to define market and consumers

Each nursery owner must analyze and organize his or her own marketing channels, develop a sales program, prepare the product for distribution, extend credit, and make collections. Possible approaches to defining your market and customers are:

- Define the types of customers within your target market based on MoA and KIS data and advice
- Determine customer preferences for products and services by investigating the local competition
- Use local and national association and government data to determine market trends and anticipate future preferences on the types and number of plants to grow
- Promote plants that you or other colleagues consider outstanding.

Session 30: Strategies for nursery seedling promotion and marketing

Objectives

At the end of the session, participants will be able to:

- Know what the marketing strategy is about?
- Know why the 4 P's are important for developing market strategies
- Investigate where to make delivery of products (plants and seedlings)

Time

75 minutes

Method

Presentation and plenary discussion

Materials

Powerpoint presentation (31.1, 31.2, 31.3, 31.4, 31.5 & 31.6), flipchart, markers

Steps

1. Start with powerpoint presentation- introducing marketing strategies and the 4 P's of marketing
2. Get feedback on the presentation from the participants
3. Spend a few minutes for questions and answers by participants in the plenary.
    - What are market strategies and the 4 P's of marketing? (**Reference material A**)
    - How do you deliver your products? **(Reference material B)**
4. Review the points discussed
5. Wrap up the session.

Reference material

A. Marketing strategies

Marketing strategy is based on becoming an option for contractors and the general public to fill gaps in seedling requirements and must include performance in areas such as customer service; knowledgeable staff; affordable prices; location and quantity and quality of plants, seedlings, trees, and saplings.

When developing marketing strategies, we need to consider 4 P's.

1. Product development

One of the most frequently asked questions is: "What should be grown?'' This can be answered through a market survey. The product development involves the following:

- Idea generation
- Idea screening: what will it cost to produce? Is it a viable business? Is there a demand for the product?
- Concept development/testing: what exactly do consumers want?
- Business analysis: what is the expected production for sustainability?
- Market testing: typical usage of a situation
- Commercialization: product launching and mass production.

Product market strategies

	Existing products	New products
Existing markets	Market Penetration Increased sales of products to current market segments, without changing the product offered. Ways of achieving this are reducing prices, and increasing promotion and distribution.	Product Development Offer of new or modified products to current market segments. Products can be, for example, increased seedling pot size or bare-root seedling production.
New markets	Market Development Identifying and developing new market segments for current products. These segments can be institutional markets, and other geographical areas, including export.	Diversification Production of new products for new markets. The level of risk increases with the number of growth alternatives because the 'change' variable increases. Example: growing in a container suitable for the transport of seedlings after hardening.

2. Place/Distribution: Finding the best way to distribute your product

- Channels of distribution
- Marketing
- Intermediary marketing (website, wholesalers, agents and shops/ retail outlets) (Figure 5.4)
- Outlet location and sales territories
- Warehousing systems
- Transportation

Figure 5.4: Retail outlets

3. Price: Setting your price to make a profit

In the beginning, nursery entrepreneurs should know what should be the price of the nursery seedlings of the species to be grown in the nursery. The price should be set high enough to generate a profit for the business, but must also be attractive to consumers. In determining the price, there are some basic questions:

1. What are customers willing to pay?
2. Are all costs covered; where is the break even?
3. What does the competition charge?
4. How much profit do you want to generate?

In determining the price, it is important to use the cost of production as the base. To determine this, divide the production cost into variable and fixed costs. Variable costs are out-of-pocket such as labor, materials, and advertising. Fixed costs are incurred whether products are sold or not, such as rent, equipment, and utilities.

Factors affecting the price of the seedlings:

- Cost-based pricing
- Competitors-based pricing
- Demand-baseded pricing
- Special prices to attract customers-discount structures
- Incentives to staff/distributors – allowances, commission, bonus
- Set different prices for changes at seasons, locations, and types of customers

4. Promotion: Creating ways to persuade customers to buy your product

Promotion strategy is everything that a person does for the customer to encourage them to purchase the product. This includes not only advertising, but also public relations and personal contact. A nursery does not only sell the plant, but the aesthetic beauty it will provide in the landscape. You need to decide what the product will do for your consumers. The concept of your promotion strategies should be to capture the attention of the public and get them to buy the product. Some of the examples for the promotion of business include:

- Advertising
- Flyers, promotion videos,
- Press release
- Television
- Radio
- Internet
- Magazines
- Newspapers
- Telephone
- Pamphlets
- Posters
- Personal contact
- House-to-house

B. Delivery of seedlings

Nursery businesses do not have the resources to individually deliver the product to the consumer (Figure 5.5). Therefore nursery promoter needs to rely on channels of distribution already established by wholesalers, retailers, distributors, brokers and cooperatives. A nursery can produce the best quality plants, and have a reasonable yet appealing price and everyone may know about it; but if the consumer is unaware, this is a recipe for failure. On-time deliveries and prompt services build the name of a business, promoting word-of-mouth advertising which is the best kind because it is free. Marketing in the nursery industry is just as important as in any other business. One cannot simply rely on people to ''just 'know'' that you are a good grower; you have to make it known. With the proper marketing strategies, it is possible to succeed in this business. Remember, growing the plants right and maintaining them is only the first step.

Figure 5.5: Delivery of seedlings

Before delivery of seedlings, one needs to know the other 4 P's in marketing

1. People: the workers must have adequate information on the products and customers.
2. Process: channel to deliver the product and service.
3. Physical evidence: portray products in shows, field days, and demos.
4. Packaging: what packaging is required; small or big? Ensure attractive packaging.

Acknowledgement

The authors acknowledge the cooperation and support provided by each of the nursery operators who provided information and updates on their nurseries for this case study. Special thanks go to Mr. Gaurab Bhatta and Mr. Krishna Bahadur Thapa, Assistant Divisional Forest Officers of Kavrepalanchowk and Sindhupalchok district, respectively for their support in providing information. This is one of the outcomes of the EnLiFT2 project funded by ACIAR.

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Annexes

Annex 1: Seed record collection

Species	Date	Collected by	Location	Altitudinal range	Slope/ aspect	Flowering	Seeding
Seed trees	No	Height	Diameter	Associated Species (if any)	Weight collected	Remarks	
1							
2							
3							
4							
5							
Seed Used							
Date	Consignee	Amount used	Amount remaining	Germination %	Seeds/kg		

Annex 2: Calculation for space requirement for 10000 seedlings

Step 1
- Measure the size of the pots or bags to be placed in the nursery.

Step 2
- Measure the area taken up by the pots or bags. For example in a standard shed of size (6mx10m = 60 M^2) for transplant beds, a minimum of 10,000 poly bags of a 4"x7" size can be placed.

Step 3
- Calculate the area assuming 50 % of seedlings (5000) are smaller size and 50% are larger size (5000) = Area required for smaller size poly pots = 30 M^2+ area for larger size poly pots = 60 M^2 = 90 M^2

Step 4
- Add 25 percent to the number of seedlings or poly pots (i.e., to allow for unexpected loss such as poor germination or death) = (90 + 25% = 112.5 M^2).

Step 5
- Multiply by 2.5 for the space between beds, seedlings, walkways and paths = 112.5x2.5 = 281 M^2

Step 6
- Estimate the size of the storage house (6x4), water tank/ reservoir (5x3), Germination bed (6x4), Hardening bed (6x4), mother plant area (10x25), and compost pits (2.5x2) and toilets (7x5) = 377 M^2 that will be needed.

Step 7
- Double this figure to allow for space between the structures (377 x2 =754M^2).

Step 8
- Add results from steps 5 and 6 to give an estimate of the total area that will be needed for the nursery (281 + 754 = 1035 M^2 = Approx. 2 *ropani*).

Annex 3: Specific standards and criteria for seven types of nursery stocks

	Polypot size, color, thickness	Height in cm/m	Root collar diameter in mm	Production period & purpose	Species and purpose
Container raised single year	3"x7" to 4"x7", black and 200 gauge	≥25 - 30 cm	≥2.5 - 3.0 cm	3 months to 1 year- for **patch or block or irregular** planting	Ipil, tanki, bakaina, lapsi, utis, pine, Flemingia, Moringa
Container raised multi- year	5"x8" or (6"-10", 10"-14"), black pots; at least 200 gauge	≥50 cm to 1 m	≥5 mm to 10 mm	2 to 4 years for urban/avenue, road side, ceremonial & canal planting	Champ, Tejpatta, kapur, timur, walnut, F religiosa, F. bengalensis, F benjamina and any fruit trees
Large ball rooted seedlings	NA	≥50 cm to 1 m	≥5 mm to 10 mm	6 months to 2.5 years depending upon the species and purpose (urban, roadside, canal and ceremonial)	Terminalia arjuna, Syzygium cumuni, Mangifera indica, Albizia lebbeck, Albizia procera etc
Stump (3-5 cm stem & 20-25 cm root portion)	Spacing in beds – 10 cm to 30 cm based on species	1 m to 2.5 m	8 mm to 25 mm	1 to 2 years	D. sissoo, T. grandis, Grewia optiva, Cassia siamea, Leucaena spp, Azadirachta indica
Cutting	5"x8" or (6"-10", 10"-14"), black pots; at least 200 gauge	15-25 cm length and 30 cm for rooted plants	8mm to 25 mm depending upon species	4- 5 months or 18 months	Populus deltoids, Daphne, Morus alba, pear, Taxus baccata
Bamboo seedlings	No of shoots or buds/ cutting = 3	≥ 1 m -2 m	≥ 4 cm diameter	18 months to 3.5 years depending on species and altitude	Abundent lateral roots with dense fibrous roots
Grafted fruit seedlings	Min 5"x8 to 10"x14" and > 200 guage thickness	≥ .5 m -1 M	≥ 10 mm	> at least > 2 years	Mango, Litchi, Orange, Avocado, Apple

Annex 4: Application form for nursery accreditation

(*To be completed by the applicant*) adopted from Grigorio *et al.* 2010

Name of the Nursery: _____

Name of the Nursery Operator/ manager: _____

Address: _____

Telephone: _____Email:_____

Enclose the following:

1. Photograph of the nursery
2. Certificate of attendance to trainings related to nursery seedling production
3. Human resource involved
4. Nursery set up and facilities
5. Land area available and production capacity
6. List of seedling species registered for production and trade
7. Source of germplasm and record keeping
8. Business permit from the local government where the business is located
9. Authenticated tax clearance
10. An accreditation/administrative fee of NPR 500.00 shall be paid to the DFO upon application for individual applicant and NPR 1,000 for cooperative, corporation, small and cottage industries, NGO, private group and academic applications.

Annex 5 Time requirement for the whole training

Module	Hour	Minutes
Module 1- Introduction to training manual and nursery establishment		
Session 1 Welcome and introduction	1	0
Session 2 Introduction to training objectives, learning flow and training norms	0	30
Session 3: Nursery site selection	1	0
Session 4 Determination of nursery size and layout	2	0
Sub-total	4	30
Module II: Propagation through seeds		
Session 5 Seeds, seed sources and their characteristics	1	0
Session 6 Seed trees and seed collection	2	0
Session 7: Seed extraction, drying and cleaning according to seed types	1	30
Session 8 Determination of moisture content of orthodox seeds, viability test and storage	1	0
Session 9: Pre-seed treatment method 1	1	0
Session 10: Pre-seed treatment method 2	1	0
Session 11: Seed Germination media and sowing seeds in different beds	2	0
Session 12: Inoculation of growing medium	1	0
Session 13: Transplanting and pricking out of seedlings and wildlings	1	0
Sub-total	11	30
Module III: Tree improvement through vegetative methods		
Session 14: Introduction to Vegetative Propagation Method	1	0
Session 15: Cutting method of vegetative propagation	1	30
Session 16: Ground Layering	0	45
Session 17: Air Layering	0	45
Session 18: Producing new plants from Division	0	45
Session 19: Grafting	2	0
Session 20: Budding	1	0
Sub-total	5	165

Module IV: Seedling quality maintenance and certification		
Session 21: Seedling quality maintenance and caring of seedlings	1	0
Session 22: Caring of seedlings for quality maintenance	2	0
Session 23: Introduction to nursery standard and certification	1	0
Session 24: Forest nursery accreditation standards, criteria and indicators	2	30
Session 25: Accreditation body and process	1	15
Sub-total	7	45
Module V: Nursery enterprise development and marketing		
Session 26: Rationale for nursery enterprise development?	1	0
Session 27: Prospect of establishing a forest nursery: A SWOT analysis	1	15
Session 28: Business plan	1	15
Session 29: Types of nursery businesses and target market	1	0
Session 30: Strategies for nursery seedling promotion and marketing	1	15
Sub-total	**5**	**45**
Total time required	**32**	**315**
Total hours calculated	**37**	**25**

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