



Nursery management, tree propagation and marketing

A training manual for smallholder farmers and nursery operators



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Front cover photo: (From left, clockwise) *Practical training session at ICRAF, HQ nursery; Satellite nursery training session at Mwala DEB Primary School, Machakos county and Theory training session at Machakos ATC*

Back cover photo: (From left, clockwise) *Theory training session at Mbarali, Tanzania; Pumping water with money-maker pump for community nursery water supply; Group satellite nursery and Farmer displaying packed seeds ready for sale*

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ABOUT THIS MANUAL

This publication covers the principles and practices in the production of quality and superior planting materials from seeds to seedlings grown in the nurseries. The aim of this manual is to familiarize the nursery operators, farmers and institutional nurseries with, and to get them involved in, the project techniques of propagation and establishment of small scale-nurseries.

The learning activities in this manual are presented in five different modules.

Topics covered in module 1 include sourcing and selection of seeds for seedlings or rootstock propagation, preparation of seedbed and germination medium, techniques of enhancing seed germination and sowing of seeds in the germination bed, uprooting and transplanting of germinated seeds in the nurseries.

Module 2 deals with topics on the establishment and management of nurseries. The activities include site selection and land preparation, field layout and planting techniques, seedling management, weeding and control of seedling diseases.

The concepts, principles of practising vegetative propagation and the steps with illustrations on the production of quality planting materials through various methods of asexual propagation are presented in module 3.

Module 4 deals with making of compost and mixing of the soil in the nursery. The learning activities include mixing of media and making of compost from the nursery waste.

Module 5 discusses the tree nursery as an enterprise or business.

This publication:

- Provides flexibility in planning, conducting and evaluating training courses.
- Allows trainers to formulate their own training schedule based on results from the training needs assessments.
- Can easily be adapted to suit different cultures by reviewing case studies and applying only those that are appropriate to their situations. Additional case studies can be devised based on local statistics, cultural practices and social issues.

Learning outcomes

By the end of the training, participants should be able to:

- Define a tree nursery
- Demonstrate various technologies on tree nursery development and management practices
- Outline the basic principles and criteria for evaluating seedling quality
- Mix suitable soil media for potting up seedlings and cuttings
- Germinate seeds, transplant seedlings and cuttings into pots correctly
- Understand the significance and importance of tending and checking seedlings in the nursery
- Develop entrepreneurial skills in tree seedling production

ACRONYMS AND ABBREVIATIONS

DED District Executive Director

ICRAF World Agroforestry Centre

KFS Kenya Forestry Service

MoA Ministry of Agriculture

RRC Rural Resource Centre

TFS Tanzania Forestry Service

TOT Training of Trainers

INTRODUCTION

Seedling production is one of the key steps in scaling up or domestication of any species. Each step has to be properly planned and implemented. The way seedlings are handled and managed in a nursery contributes to their survival rate after planting and their subsequent growth performance. Improving seedling quality correlates positively to their survival, growth and productivity. Seedling quality is governed by the genetic make-up of the parent trees and the physical growth of the seedlings. Several types of nurseries exist: individual or private, community or group, central or research, commercial and training nursery.

Nursery practices must be consistent and the various techniques closely integrated. If one element in the chain is lacking there will be a negative impact on seedling quality. Good quality seedlings cannot be produced without care and tending. Nursery plants need to be protected from extremes of environmental conditions until they are strong enough to withstand them. To ensure high quality of seedlings and to provide more opportunities (income, technology transfer), local people are encouraged to establish small-scale community nurseries.

The need for training of trainers and the development of training modules on nursery management and propagation techniques is important. The training should aim to train the TOTs 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 economic) and use of existing networks to disseminate technologies is vital. This may be achieved through rural resource centres (RRCs) that will allow maximum interaction of technicians, farmers and nursery operators.

RRCs serve as hubs for production and distribution of high quality tree planting materials, development and dissemination of techniques, training of nursery managers, farmers, small-scale processors and extension officers. They could also serve as collection points and marketing centres for tree products, notably quality seeds and seedlings, medicinal plant products and fruits. RRCs are normally equipped with seed storage and propagation facilities, meeting and training facilities, mother-blocks and demonstration plots. This has a multiplier effect of leading to the establishment of satellite nurseries and provision of technical backstopping to majority of stakeholders.

RRCs provide opportunities to gain insights into:

- Validation of method or practice modules
- Nursery establishment and management
- Seed source, collection, storage and germination
- Vegetative propagation (cutting, grafting and marcotting)
- How to run a nursery as a business

This manual aims to facilitate the learning process by incorporating practical activities that provide better and clearer understanding of the principles involved in nursery establishment and management and to enable participants to translate such knowledge and skills into entrepreneurial action projects. This session highlights steps in setting up of nurseries, soil mixture and mixing, pot filling and placing, sowing and transplanting of seedlings, watering, weed control, shading, nutrient and pest management and protection of seedlings from mechanical damage. It also covers technical ways of checking and evaluating the quality of seedlings.

Definitions

What is a tree nursery?

A **nursery** is a place where seedlings are propagated, managed and grown to plantable size. To ensure a good planting programme, good nursery stock is essential. Major causes of seedling mortality on-farm include the wrong size or poor health of the seedlings at the time of planting or poor health of the seedlings at the time of planting. Poor seedlings are likely to have slower growth, to be less able to compete with weeds or drought, and to be more liable to damage by insects and pests. Further, in a poor nursery, fewer seedlings will be raised from a given quantity of seed, and there will be considerable waste of money and time. After planting, the plants are immediately exposed to a harsh environment, and are more susceptible to damage from drought, grazing, fire and insects. Thus sound nursery practice is the foundation of any successful (on-farm and/or forestry) planting programme scheme.

What is a seed?

A seed is a small embryonic plant enclosed in a covering called the seed coat, usually with some stored food. It is the product of the ripened ovule of gymnosperm and angiosperm plants, which occurs after fertilization and some growth within the mother plant. The formation of the seed completes the process of reproduction in seed plants (started with the development of flowers and pollination), with the embryo developed from the zygote and the seed coat from the integuments of the ovule. All seeds have different sizes, shapes and colours.

Seeds of woody plants exhibit a great range of variation in shape, size, colour and behaviour. The most essential factor for the success of plantation is the ready availability of quality seeds. The quality of seed is responsible for the future performance of each and every seedling. Poor quality seeds may have the following problems:

- Low germination percentage
- Poor emergence
- Poor survival

- Poor adaptability to the site
- Susceptibility to disease and pests
- Poor growth
- Low productivity

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.

What is a seedling?

A seedling is a young plant that is grown from a seed. It is any young plant, especially one grown in a nursery for transplanting. Seedling development starts with germination of the seed.

What is plant propagation?

Plant propagation is the process of creating new plants from a variety of sources: seeds, cuttings, bulbs and other plant parts. Plant propagation can also refer to the artificial or natural dispersal of plants. The simplest method of propagating a tree vegetatively (non-sexually) is rooting or taking cuttings. The most common method of propagating fruit trees, suitable for nearly all species, is grafting or budding a desired variety onto suitable rootstocks.

MODULE 1: SEED SOURCES AND NURSERY MANAGEMENT PRACTICES



Standard nursery management aims at the most rapid production of healthy and quality planting materials. The success depends on the kind of materials and management practices to be employed. This module explains the various recommended practices in raising seedlings in the nurseries.

Nursery management practices cover:

- Sourcing, collection and selection of seeds for propagation
- Handling of seeds to hasten germination
- Management practices of germination beds
- Techniques of sowing the seeds in the germination beds
- Pricking out and transplanting
- Weed and pest control.

Learning objectives

By the end of this module, the participants should be able to:

- Identify the source of seeds, selection and collection
- Undertake hastening, germination and storage of seed
- Perform the standard practices of preparing a germination bed and germination medium
- Demonstrate the proper method of sowing seeds in the germination bed
- Perform the pricking out and transplanting following best practices.

Seed sourcing, collection and selection for rootstocks production

Identification of seed sourcing, collection and selection is crucial in achieving healthy and uniform-sized seedlings. For fruit rootstocks, optimum yield cannot be attained even with a favourable environment if the rootstocks used are not well adapted to environmental conditions.

The concept of proper selection is based on the following principles:

- A parent tree with desired qualities is capable of producing offspring with similar performance
- The performance of the seedlings may be predicted based on the performance of the parent materials.

Seed collection and sowing

- Always collect seeds from plus trees or phenotypically superior trees.
- A chart should be prepared in each nursery indicating the seed collection period of local or preferred tree species along with the location of such plus trees. Seedlings developed from poor or abnormal trees will never produce good trees.
- After collection, seeds should be processed carefully otherwise they may become damaged and lose viability.
- Each species requires different processing after seed collection, i.e., seeds with pulp are processed differently compared to the pods, drupes and capsules.
- Most of the seeds have short viability; therefore, sowing should be done immediately after collection and processing.



Figure 1: Seed moisture testing method before storage

A simple method of determining moisture content

- 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 13-15 per cent). On the other hand, if the jar is still dry and no salt is stuck on its sides then the seeds have



Figure 2: Stored clean seed by a seed dealer

less than 13 per cent moisture content and thus can be stored safely.

Viability test using floating method

- Fill a jar about three-quarter 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

Seed pre-treatment 1

In this trial you will try several types of seed pre-treatment of mango seeds to understand the advantage of pre-treatment.

Materials

- Local mango seeds
- 2 buckets of water
- Secateurs

Procedure

- Prepare three small seedbeds.
- Divide the 60 mango seeds into three groups of 20
- Put 20 mango seeds in a net, 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.
- Cut off a small section of the mango seed 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.
- Sow each group of seeds separately in the three different seedbeds. Check everyday and water the seedbeds when dry.
- When the seeds start germinating, record the date and number of germinated seeds in each bed as shown in table 1.

Table 1:

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

Questions for discussion

- How many seedlings germinated in each seedbed?
- How many days did it take for the seed to start germinating in each bed?
- How long did take for germination to end in each seedbed?
- Apart from the time of germination, is there any difference in the characteristics of the seedlings?
- What were the advantages and disadvantages of the different pre-treatments?

Seed pre-treatment 2

In this trial you will test several types of seed pre-treatments in several species to understand the appropriate pre-treatment for each tree species.

Materials

Seeds of some tree species e.g. *Grevillea robusta*, which the farmers would like to plant.

Procedure

- Prepare two small seedbeds.
- Divide the 200 *Grevillea* seeds into two groups of 100 seeds each.
- 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.
- Sow the two groups of seeds in two different seedbeds. Check everyday and water the seedbed when it is dry.
- When germination starts, record the date and number of germinating seeds in each seedbed.

Questions for discussion

- How many seedlings germinated in each seedbed?
- How many days did it take for the seeds to start germinating in each bed?
- How long did it take for germination to end in each seedbed?
- Apart from the time of germination, is there any difference in the characteristics of the seedlings?
- What were the advantages and disadvantages of the different pre-treatments?

Management practices of germination beds

Seeds are first germinated in the germination bed before they are planted in polybags. A well-drained area with moderate shade is an ideal site for a germination bed.

The germination bed should be established on a flat or level area near a water source within the nursery site. The best kind of germination medium is sand or light soil because germination of seeds will be faster due to aeration and seedlings can be easily pulled out during uprooting with less damage to the roots. With pure garden soil, the germination of seeds tends to be slower because the soil is too heavy and less aerated.

Sow large seeds 2cm to 3cm deep in the soil. Sow small seeds about 0.5cm to 1cm deep or broadcast and cover them with a small amount of fine soil. The beds can also be covered with thatch or a plastic sheet till the seeds germinate.

Preparing a germination bed

Materials needed

- Machete

- Garden tools (fork, shovel or mattock)
- Sand or light soil
- Hollow blocks or planks
- Shade nets, grass or banana leaves

Prepare a germination bed at most 1m wide, raised 15cm above the ground. Its length will depend on the number of seeds to be sown, size of seeds and available space.

Use wooden planks to protect the bed from erosion (figure 3).

Use any of the following materials as a germination medium:

- Fine river sand
- Decomposed sawdust (dried for at least 6 months)
- Coir dust

You can use a combination of coir dust and garden soil or sawdust and garden soil. A depth of at least 10cm is recommended.



Figure 3: Germination bed using wood planks as siding materials

Common mistakes in seed propagation

Correct sowing density

Wrong: Too dense:

- Weak seedlings, competition.
- Risk of damping off.
- Difficult to separate

Wrong: Too thin:

- Weeds sprout.
- Loss of space.

Sowing density



Correct sowing depth

Wrong: Too deep

- Seed may die.
- Seed does not germinate.
- Germination takes too long.

Wrong: Too shallow

- Seed has weak root system.
- Seed is exposed to sun.
- Birds and insects damage.

Sowing depth



Correct: Fewer seed in several batches, eases management.

Wrong: Too many seed at once

- High workload.
- Lack of planting space.
- Lack of markets.

Planning in sowing

Figure 4: Common mistakes in sowing seeds

Practices in seed handling for germination

Most leguminous seeds such as *Calliandra calothyrsus*, *Gliricidia sepium*, *Leucaena trichandra*, *Sesbania sesban* and *Faidherbia albida* have thick, hard seed coats. To hasten the germination, a mechanical means of breaking the thick seed coat before soaking in water and sowing in the seedbed must be instituted.

Materials needed

- Seeds
- Nail clipper or mechanical pliers
- Cotton bag/sack
- Hose/sprinkler
- Mulching materials
- Clean water

Activities

- Partially crack the seed coat of seeds using mechanical pliers (figure 5).



Figure 5: Nicking or partially cracking the seed coat of *Leucaena* seeds using a nail clipper

- Soak the seeds in clean water overnight (Figure 6) to enhance germination.



Figure 6: Treated seeds soaked in water overnight for optimum germination

- Sow the seeds closely on the bed surface; arrange the seeds in a single layer with the flat groove side facing downward. (Note: avoid overcrowding to prevent root distortion that may lead to difficulty in pricking out the seedlings).
- Press the seeds firmly into the seedbed until they are at the same level as the surface of the germination medium.
- Water the seedlings at least once a day.
- Mulch the bed surface with dried grass to retain seed moisture for rapid germination.
- Observe the development of the seeds in the germination bed. The seeds will start germinating within a week after sowing in case of legumes.

Selecting pricking out and transplanting of germinated seeds to polythene pots

To attain uniform growth and high survival rate in the field, select and uproot the germinated seeds carefully by hand using a dibble or hand trowel.

Materials needed

- Sprinkler
- Container with water
- Clean water
- Potted polytubes
- Watering can

Activities

- Water the germination bed first.
- Uproot the seedlings with two leaves one by one.
- Place the uprooted seedlings in a container half-filled with water to maintain turgidity and to avoid damage before transplanting to the poly pots.
- Discard retarded, deformed or diseased seedlings because they have less chances of survival.
- Bring to the area to be planted in polythene bags.



Figure 7: Pricking out germinated seedlings



Figure 8: Transplanting seedlings into polybags without coiling the roots

Watering

- Keep the seedbeds moist, not wet.
- Do not water at a fixed time each day. Water when the plants need it.
- Small seedlings require less amount of water. Large seedlings require more water more often.
- Seedlings require more water more often on windy and sunny days. Water less often when seedlings are kept in a shade.
- Moss and algae growth is an indication of excess watering. Always use clean water; dirty water may cause diseases.
- Over-watering results in weak plants and causes diseases such as root-rot and damping-off of seedlings.

Transplanting

- Water mother beds thoroughly before transplanting the seedlings.
- Always use some tools (e.g. bamboo sticks) to loosen the soil before pulling out seedlings from the beds.
- Make a deep and wide hole in the polythene bag or container for transplanting the seedlings. Hold seedlings at the base of the stem and pull it out gently from the mother beds.

- Never bend the roots and do not force the seedlings into the hole. Keep transplanted seedlings under proper shade until they have recovered.

Hardening of seedlings

In a nursery, seedlings are kept under ideal conditions; therefore hardening is essential to make them strong enough to tolerate the harsh conditions of the planting site. It is generally done by reducing the amount of watering about one month before the date of planting.

MODULE 2: ESTABLISHMENT AND MANAGEMENT OF A SEEDLING NURSERY



A standard nursery where the seeds are germinated and the seedlings are grown until they reach the appropriate age for permanent planting in the field and/or asexual propagation has to be established and managed.

The field operations and management practices of ground and polybag nurseries described in this module include the following: site selection, preparation of the nursery bed, planting of seedlings, maintenance of nursery, weed control, nursery diseases and pest control.

Learning objectives

By the end of this session, the participants should be able to:

- Describe the physical condition requirements and ecological factors to consider in the establishment and management of a nursery
- Establish a nursery
- Demonstrate the proper method of planting of seedlings
- Demonstrate the routine of nursery management practices
- Identify weeds, diseases, insect pests and other destructive organisms which could attack seedlings and perform necessary control measures

Nursery site selection

The selection of an appropriate nursery site is the most important decision for efficient production of good quality plants. The selection needs to be agreed upon at least six months before the first seed is sown. It must start from a well-defined statement of the objectives of the nursery, which must include details such as:

- Number of plants to be produced each year
- Species
- Type and size of plants

- Location of the plantations and villages to be supplied
- Expected life of the nursery

Some of the technical factors which need to be considered when establishing a nursery are discussed.

Availability of land

It is important that the site selected for the nursery has enough land to raise the number of seedlings needed, and if possible, room for expansion. A small nursery raising 20,000 plants in 4 by 6 size pots, and keeping the plants in a nursery for a year could require about 500m² of land; this includes potting beds, 20 per cent extra for losses and damage, paths between the beds, soil storage, thatched shelter, and the compost-making area. But for sloping sites the land requirement may be double the size, that is, 1000m². The size of the nursery depends on the number of plants to be produced, the time they will remain in the nursery, as well as the quality and slope of the site.

It is also important to ascertain who owns the land. If it is institutional or privately owned land it is important to formalize the use of the land by obtaining a letter from the owner agreeing to its use as a tree nursery for a defined period of time.

Water supply

A reliable and adequate water supply is always a requisite in nursery establishment. The nursery site should be located near the source of water either from a running stream or main pipe water supply to sustain rapid and healthy growth of the seedlings. The ideal situation is where there is a perennial stream at a higher level than the nursery, and fairly close to it, so that water can be diverted from the stream to the nursery in high density plastic pipes (which should be buried 15cm deep). Alternatively, a water storage tank should be installed for sustainable water supply.

Topography

The area for tree nursery establishment is preferably flat with a gentle slope to allow for drainage. Contour

terracing should be done if the slope is in excess of 2 per cent.

Size

The size of the area must be large enough to accommodate any possible expansion of the nursery.

Location

The nursery site should be located near the planting site to minimize injury in handling and during transportation. It must be easily accessible to facilitate nursery field operations and supervision. Access roads should be usable during all seasons of the year.

Soil

Deep, good-structured, easily pulverized soil is desirable. Avoid shallow soils with a hard sandstone band near the surface. A very sandy-structured soil should also be avoided because of poor moisture retention characteristics and faster leaching of plant nutrients. Soil containing too much clay has poor drainage characteristics and should not be considered in site selection.

Preparation of media

Most of the plants are multiplied on nursery beds. Solarisation is an effective and eco-friendly method of soil sterilization and it involves trapping of solar heat and energy through polythene covering. This raises the temperature of media to the level where it becomes lethal to soil micro-organisms.

Exposure to frost, strong winds and flooding

At high altitudes, sites which are particularly liable to frost damage should be avoided. Such areas include valley bottoms and other sides where the downward flow of cold night air is common due to a dense belt of trees or shrubs below the site. Other natural hazards should also be avoided. Areas threatened by landslides, subject to flooding or strong winds must be avoided.

Availability of labour

A lot of labour is required for the construction of a nursery and subsequent nursery activities. Hence nurseries should be located where labour is available. Siting a nursery on a main trail near a village will also increase awareness and enhance patronage.

Nursery design and construction

Design

The nursery design will vary according to the type of plants to be raised and topography of the land. Before construction begins, draw a sketch plan. Measurements should preferably be made with a tape, or a distance that can be paced. The plan should include:

- Fence or wall
- Internal paths
- Water tanks and distribution system
- Seedbeds
- Soil storage shelter
- Working area
- Compost-making area

Construction

The land must first be cleared of all rocks, stumps, trees and shrubs.

Fence or wall

It is necessary that all animals are totally excluded from the nursery, so a fence or wall must be built. A stone wall 1.8m high is ideal. It should be about 60cm below ground and 120cm above, when measured from the outside, and with a layer of thorny shrubs on top of it. A stone wall is effective and long lasting.

Nursery beds

Ideal size of the bed is 1m to 1.2m wide. It should not be wider than 1.2m because of the difficulty

of reaching the centre when weeding, watering or manuring. Seedbeds which are narrower than 1m are a waste of land. The length of the bed is relatively less important, though 5m to 10m may be convenient for drainage purposes. If possible, the beds should be oriented from east to west to provide better shade against the midday sun. Paths should be 50cm to 60cm wide to provide adequate working space. When the area for the beds has been levelled, protect the corners and the edges.

Other structures

A waterproof soil storage shelter is needed to store the potting mixture and to provide some working space. A large working shed as well as an office space is also required.

Materials for tree nurseries

- Seeds, soil, sand, compost
- Polypots: 8cm by 12cm, 10cm by 15cm and 12cm by 18cm
- Heavy gauge polybags for seed storage
- Wire, strings, mesh wire, nails soap

- Pens, pencils, waterproof markers
- Registers: nursery, seed and visitors
- Machete, knife, scissors, secateurs, germination trays, plant-carrying trays, soil and sand sieves, hammer
- Watering can with hoses

Activities

Setting up the polybag nursery

- Clean the area and remove all plant debris, weeds and other unwanted plants.
- Prepare polybags from the polybag sheet roll or buy the preferred size.
- Fill the perforated bags with loamy soil (compost, fine sand, top soil in a ratio of 1:1:1) or forest soil, collected from the top layer below the litter layer.
- Arrange the polybags in single rows.
- Fence the perimeters properly to ensure safety of the plants against stray animals or intruders.



Figure 9: A nursery layout showing beds with seedlings



Figure 10: Illustration of seedling arrangement in the nursery bed

Setting up the ground nursery beds

- Plough the area when there is enough moisture.
- Cultivate the land thoroughly to produce fine soil tilt and to kill existing and germinating weed seeds.
- Establish straight lines indicating planting points at a distance of plants.
- Make small holes using a dibble stick enough to accommodate the germinated seeds (figure 11).

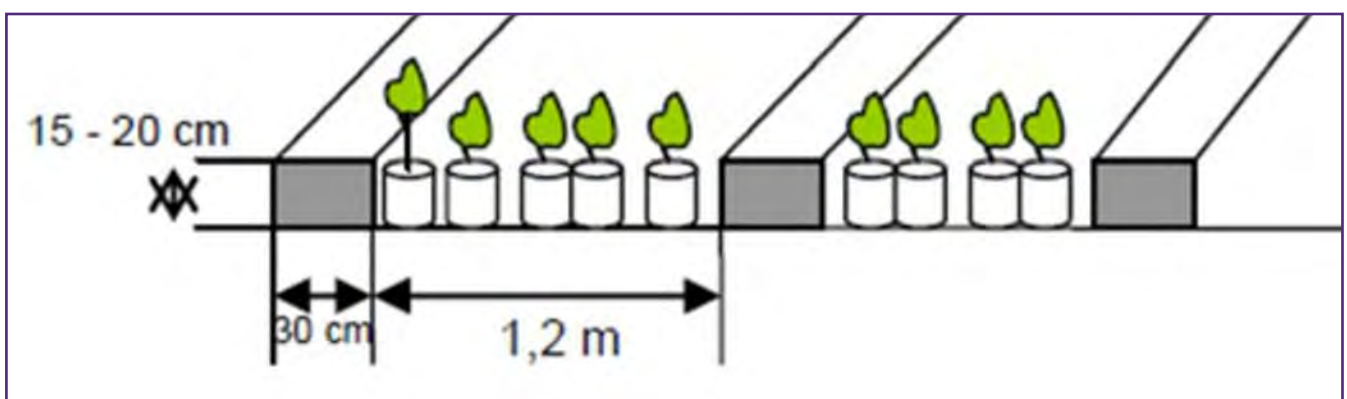


Figure 11: Ground nursery field layout illustrating the distance of planting, paths and beds

Planting of germinated seeds

Materials needed

- Germinated seeds
- Polybags
- Sprinklers/hose
- Top soil

Activities

- Carefully plant the germinated seeds in each hole for ground nursery or each bag for the polybag nursery with the radicles pointing downward.
- Cover the entire root system including the cotyledon with fine soil. Press the soil lightly to compact it around the plant.
- Water the plant as often as necessary during the dry season.

Maintenance of seedlings in the nursery

The natural fertility of the soil is continuously getting depleted with repeated cropping. With this, replenishing the soil supply of nutrients through fertilizer application is needed. Sound fertilization of seedlings provides the following advantages:

- Healthy plants
- Uniform growth of plants
- Fast growth of seedlings
- High rate of survival after field planting.

The fertilizer must be applied when the plants need it and must not be in direct contact with plants.

Materials needed

- Complete fertilizer
- Garden tools
- Weighing scale

Weed control in nurseries

Weed control in the nursery aims to minimize competition from weeds for light, water and nutrients.

Materials needed

- Knapsack sprayer
- Glyphosate herbicides
- Mulching materials

Activities

- Remove the weeds by hand, weeding at monthly intervals. Reduce the frequency of weeding as the plants grow older.
- Spray glyphosate herbicides between rows taking care not to spray other green parts of the plants.
- Use rice straw, rice hull, and sawdust as mulching materials to control weeds.

Nursery hygiene and seedling disease control

Diseased seedlings grow and develop slowly. Plants may die under severe infections. Most of the micro-organisms, insects and pests that cause diseases in the nursery live in weeds, trash and puddles. Therefore, keeping a nursery neat and clean reduces the chances of attack of common diseases. All trash, waste, polythene bags and diseased plants should immediately be removed and burnt far from the nursery.

Materials needed

- Knapsack sprayer
- Fungicides such as Benlate, Captan, Dithane M-45

Activities

- Monitor and check the occurrence of the diseases.
- Spray fungicides.

Dealing with insect pests

Common pests

Termites (*Macrotermes spp.*)

Termites form colonies at the base of the trunk. Their feeding habits are diverse. Some species prefer living in trees while others feed on dead tissues. Newly-budded plants are highly susceptible to termite attack. Affected young trees show deficiency symptoms. Termites are difficult to control when the colonies are fully developed.

Root-feeding grubs (*Leucopholis irrorata Chev.*)

Grubs live entirely in the soil. They are voracious feeders and may consume the roots of tree and cover crops. Affected young trees have yellow leaves and dying shoots, and in severe cases the trees may die.

Sucking insects such as scales, mealy bugs and aphids

The adult female of scales and mealy bugs the nymphs and adults of aphids are destructive to plants. The insects excrete honeydew, which attracts ants and sooty moulds. In heavy infestations, the shoots may die.

Materials needed

- Knapsack sprayer
- Insecticides
- Garden tools

Activities

- Monitor the presence and occurrence of the insect pests in the area.
- Practise proper sanitation in the area to control termites and sucking insects. Destroy early colonization of termites.
- Propagate seedlings using polybags to control root feeding and sucking insects.

Natural insecticides using neem seeds

Make powder of 500g dried neem seeds and soak overnight in 15 litres of tap water. Sieve twice and spray. Besides this, chilli powder and tobacco leaves powder can also be used. They generally take a little longer to repel or kill the insects, therefore, apply them as soon as the insect problem is discovered. The main advantage is that they are natural, hence safe and biodegradable. Remember the following tips while using them:

- Proper doses should be prepared by carefully reading the label or guidelines.
- Always provide protective clothing, masks, gloves and goggles to the person spraying the pesticide.
- Never mix insecticides and fungicides together in the same sprayer.
- Never eat, drink or smoke while spraying.
- Never use pesticide containers to store other things.
- Extra pesticides should be disposed of by burying them in a hole far from rivers and wells.

Planning and record keeping

Planning of a nursery should be done at community level. First visit the planting sites and discuss the reason for planting, and the species to be planted. Begin by growing local species with which the people are familiar.

Time of seed collection and sowing

One of the main constraints on nursery plans is the availability of seed. Each and every type of seed has different collecting seasons. The plan of seed collection is very essential. For every activity conducted, for instance, fruit or seed collection, sowing, seedlings transplanting; keep a record file, a



Figure 12: Drying *Faidherbia albida* pods after collection

signboard or tag placed in front of each bed or bag/ container with seeds, with the following information:

- Name of variety/type
- Place the seeds were harvested
- Date when seeds or nuts are harvested, if available or sowing
- Number of seeds or nuts sown
- Seedbed number
- planting site.
- In the absence of germination test results, assume that for every four seeds sown, only one plantable seedling will be produced; this means that the above number must be multiplied by 100/80 or 5/4.
- Find the number of seeds per gramme.
- Calculate the weight of seeds to be sown in grammes.

Planning seed supplies

- The quantity of seed required must be calculated, the sources identified, arrangements made for collection and the cost estimated.
- Prepare a table listing the number of healthy plants of acceptable size required at the

Calendar of operations

By making a comprehensive calendar that includes all activities for all species, it is easy to see how much labour and materials are needed each season. This calendar forms the basis of the budget. It also indicates when extra labour is needed and materials that cannot be obtained locally must be ordered.

MODULE 3: PRODUCTION OF VEGETATIVE PLANTING MATERIALS



Vegetative propagation

Vegetative propagation is a form of asexual reproduction in plants. Asexual propagation or reproduction from vegetative parts of the original plant, 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. It is also possible for leaves to regenerate both new roots and new shoots while a stem and a root can be grafted together to form a single plant.

Learning objectives

By the end of the session, the participants should be able to:

- Relate the concepts and principles of grafting, budding and cuttings methods of asexual propagation
- Differentiate which species and when to use grafting, budding or cuttings methods.
- Perform post grafting or budding practices in the nursery before field planting.

Practical use of vegetative propagation methods is based on two biological considerations:

- Maintenance of the physiological condition of the parent tree in the propagated part.
- Maintenance of genetic constancy. That is, the part propagated is genetically identical to the original individual.

Vegetative propagation has been widely used in breeding for, among other things:

- The establishment of clonal seed orchards
The establishment of clone banks, in which controlled pollination is effected, owing to the possibility it affords for obtaining flowers at low height.

- The propagation of special breeding material: exceptional hybrids (e.g., heterotics) that are lost through sexual reproduction and sterile hybrids.
- The propagation of selected plants on a large scale.

Its usefulness depends on, among other factors:

- The ease with which the species can be manipulated. Many species are difficult to propagate vegetatively, while others are extremely easy. This often affects production costs, both for the establishment of orchards and for large-scale production of plantation material.
- The extent to which development of the parts propagated can be controlled. In some cases the phenomenon of topophysis occurs: the development of the propagated part is influenced by the part of the tree from which it comes, e.g., lateral branches sometimes tend to grow in a horizontal direction.

There are five main methods of vegetative propagation: cuttings, layering, budding, grafting and tissue culture. Cuttings are sections taken from the tree and manipulated to root and produce shoot in an appropriate medium. Grafting and budding involve fusing of scion from a tree that has the desired traits with the rootstock.

Some of the benefits that could accrue from the application of vegetative propagation will include among others:

- Multiplying 'true-to-type' elite material
- Controlling male to female tree ratios on farms
- Propagation of seedless plants
- Avoidance of long juvenile periods control of growth form
- Combination of clones
- Economics: elimination of the juvenile phase thus shortening the time to reach the reproductive maturity.

Layers are sections of the tree which are induced to root and then separated from the mother tree to grow as new plant. Tissue culture is the manipulation of a small piece of plant part to grow as new plant under aseptic conditions.

Concepts and principles of grafting

Grafting is a technique used to unite '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:

- Reduced height for easy picking
- Good quality fruit from selected varieties
- Early fruiting after only a few years.

There are several types of grafting namely: cleft, side-veneer, bark, splice, whip, tongue, saddle and approach grafting. One of the simplest and most popular forms of grafting is described in this module. It is known as cleft grafting.

Raising rootstocks

Allow a single stem to grow for 6 to 18 months depending on the species. The technique involves 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 realised 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.

Selecting and handling 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. An alternative sterilizing solution may be prepared by mixing one part household bleach with nine parts water (by volume). However, this bleach solution can be highly corrosive to certain metals.

For best results, harvest only as much scion as can be used for grafting during the same day. Select only healthy scion that is free from insects, disease or damage. Be sure the stock plants are of good quality, healthy and true to type. If large quantities of scion wood must be harvested at one time, follow these steps:

- 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).
- Label them, recording the cultivar, date of harvest, and location of the stock plant.
- Wrap the base of the bundles in moistened tissue paper or cotton wool, place them in polythene bags and seal the bags.
- Store the bundles for short periods, if necessary cool box.

It should be noted that grafting, as well as budding, the vascular cambium of the scion or bud must be aligned with the vascular cambium of rootstock. In woody plants the cambium is a very thin ribbon of actively dividing cells located just below the bark. The cambium produces conductive tissue for the actively growing plant. This vascular cambium initiates callus tissue at the graft or bud unions to stimulate tissue growth and healing.

How to do cleft grafting

- 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.
- With a very sharp knife cut the bottom of the scions with two sloping cuts 3½cm long (A).
- 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.

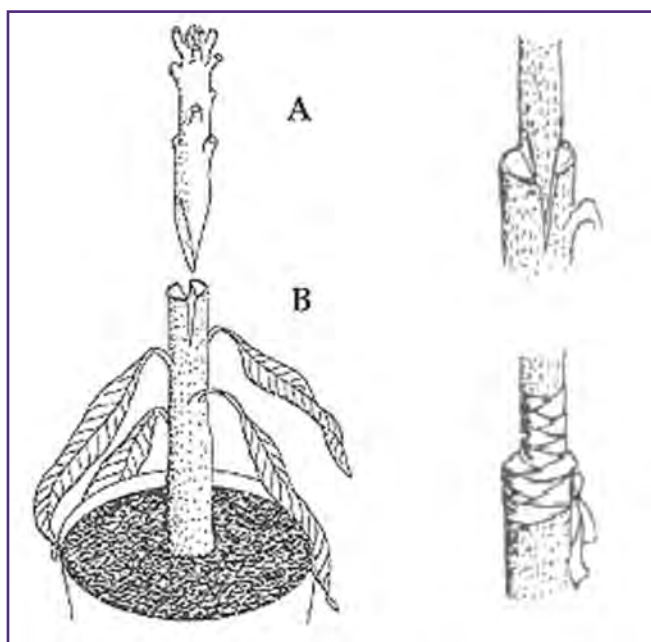


Figure 13: Top cleft grafting method

- Push the scions firmly into the rootstock cut. Leave ½cm of the cut scions outside the rootstock as shown.
- 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.
- Remove any buds which have grown below the graft.

If the graft dies, you must allow one bud to grow below the graft and wait several months before trying again.



Activity

Grafting techniques

In this trial you will try several types of grafting techniques to understand the advantages of each method.

Procedure

- Prepare grafting tools and bring root stock and scion.
- Select two types of grafting techniques and graft 5 seedlings each using same techniques (graft one inch higher than usual height so it could be grafted again in case grafting is not successful).

- Observe daily and count the number of success.
- Re-graft the unsuccessful seedlings

Concepts and principles of budding

This is a method of asexual propagation which involves inserting of a strip of bark with 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 of and requirements for 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 scion. There are two commonly used

budding techniques in tree propagation. These are T-budding and patch budding.

The principle involved in budding is the replacement of the shoot system of a plant with that of another more desirable plant. In this process, a patch of bark of the seedling plant (stock) is replaced by a patch of bark with a dormant bud (bud patch) taken from the clone

to be multiplied. The bud patch gets attached to the stock permanently and becomes part of it. The stock is then cut off above the budded portion and the grafted bud develops into a shoot exhibiting the characters of the plant from which it was taken. The new tree is a two-part tree, comprising a root system belonging to the stock plant and a shoot system contributed by the donor of the bud.

Steps in T-Budding

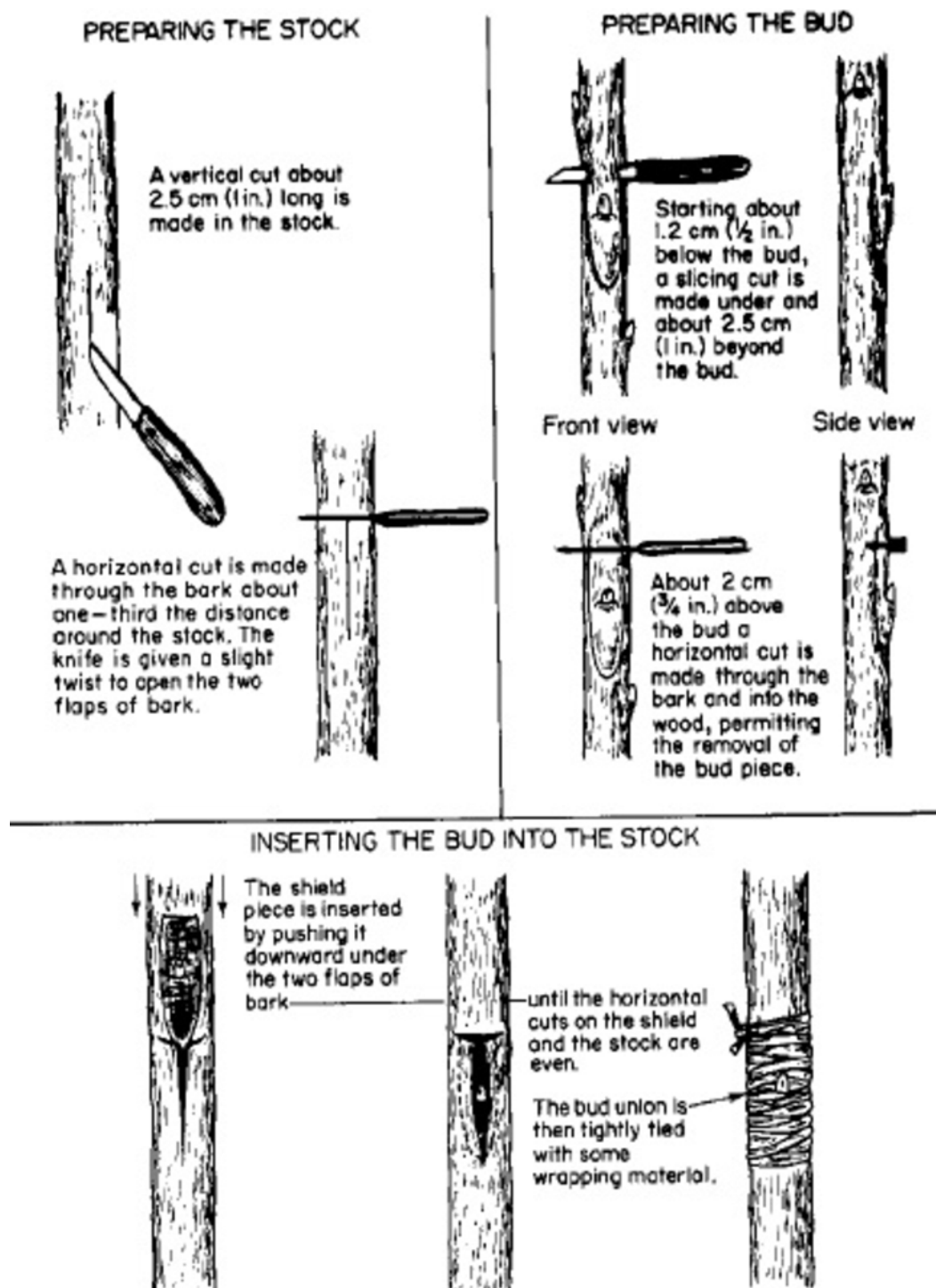


Figure 14: Steps of T-budding and patch grafting

Materials needed

- Budding knife
- Clean wiping cloth
- Budding tape wax
- Bud sticks
- Rootstocks
- Pruning shear

Activities

- Wipe the base of the seedling stock with 75 per cent ethanol
- Make 2 vertical parallel incisions at 6mm apart, 5cm long and 2.5cm to 5 cm from the ground level.
- Connect the top or bottom portion of the parallel incisions with a horizontal cut. Open the flap (figure 13) and cut the lower or upper portion leaving one half of the flap.
- Get a bud patch from a bud stick, making a similar but smaller incision on the flap of the stock.
- Slowly strip the flap having the bud eye on the middle.
- After removing the bud patch from the budstick, carefully examine the inner side for the presence of the core of the bud. Discard the bud patch, if the core of the bud is not present.
- Handle the bud patch with care so as to avoid any damage to the cambium. Always hold the edges of the bud patch without touching the cambium.
- Lift the flap and insert the bud patch immediately and hold firmly.
- After inserting the bud patch, place back the flap over it.
- Wrap the incisions with plastic tape using 0.2mm budding tape with 2cm to 3cm width

starting from the lower cut going upward.

Make sure that the edges of the tape overlap each other. During the first few turning of the wrapping, the lower end of the flap should be kept gently pressed over the bud patch, to prevent it from slipping. Tighten the wrapping to keep the cambium tissues of the seedling stocks and the bud patch in intimate contact with each other.

- Open the tape after 21 days. The budding is successful if the cambium of the seedling stocks and that of the bud patch unite. A green bud patch seen through the tape indicates successful budding. If the patch is black, then it was not successful.
- Cutback (slide cutting) the stem of the budded plants at 3cm to 5 cm from the budeye (figure 19) three weeks after budding. Apply wax to the wound of the newly cut seedlings. The buds often bear shoots at 7 to 10 days from cutting and are ready for transplanting in the field.

Concepts and principles of cuttings

This is a plant cloning technique where bare plant parts are removed from the parent tree and induced to form roots and shoots which later grow to form new plants. The plant part that is removed is called a cutting. This cutting may be referred to by the location from which it is taken. Plants can be propagated from root cuttings, leaf cuttings or stem cuttings. Typically, stem cuttings of tree species are more difficult to root.

Cutting propagation is often the preferred method for plant propagation because it is the easiest and most cost effective way to produce a clone of a particular parent plant.

Stock plant management

The conditions frequently chosen to root stem cuttings are warm, moist and shaded or at least away from dry air movement. It is important to choose cuttings that are pest- and disease-free. If appropriate, use proper and prescribed pest management tools prior to cutting.

Stock plants should be at a stage of growth most likely to have root stem cuttings. Old or mature plants are often more difficult to root than young, vigorously growing plants. Therefore, established blocks of trees and shrubs used for parent plants, known as stock blocks, will need to be replanted every 5 to 10 years. The less mature a plant, the easier it is to root a cutting from it.

Stock plants should receive balanced nutrition, usually at a moderate level for average or more difficult to root plants. When applying fertilizer to stock plants, avoid too much available nitrogen or too great an imbalance of essential nutrients. Field grown blocks of stock plants are often fertilized only once a year. However, taking cuttings from field stock is relatively easier than from root container grown plants that may require many applications of fertilizer in a year.

Propagation substrates

Stability of components with minimal decomposition during propagation is necessary as changes in particle size also change the air and water balance in the substrate. The most common components used by professional propagators are combinations of pine bark, peat moss, coir, horticultural grade perlite and washed sand. Moistening components prior to mixing and filling propagation trays or benches is a very important step in preparation of substrates. Mixing dry components creates a mixture with low aeration and poor drainage characteristics as particles fit tightly together and seal capillary channels. The effects are long lasting and have definite influence on root development and growth.

Types of cuttings

Cutting types can be described by their origin such as leaf, root or stem cuttings. They can also be described by their location on the stem such as the cuttings from the ends of stems being called terminal or tip cuttings. Cuttings from further down the stem are called secondary cuttings. Terminal cuttings often root in higher percentages than those located further down the stem due to changes in natural hormone concentrations as well as hardness.

The rooting environment

The desire to keep cuttings alive until they can root and support themselves has prompted plant propagators to develop many creative ways to provide an environment that favours rooting. Light, temperature and moisture are usually the environmental factors most often manipulated.

Light

Light can keep a stem cutting from rooting by either being too bright or too dark. Inadequate light cause defoliation of cuttings and reduces rooting percentages. More frequently, cuttings are exposed to excessive light intensities that can cause heat damage during propagation. For this reason it is common to root plants under 25 to 70 per cent shade with 50 per cent being the most common shading provided for rooting stem cuttings.

Temperature

The most effective environment for rooting different plants may vary somewhat. Most often, normal cool to warm greenhouse temperatures are maintained, depending on the needs of the individual plant, with cooler air temperatures at night than during the day. Shading is used to reduce heat build-up during bright, sunny days. Excessive high temperature causes excessive shoot growth in advance of root development and thus leads to increased water loss and death of cuttings.

Moisture

High humidity around the leaves and stems of softwood and semi-hardwood cuttings keeps the cuttings from drying out and allows normal plant functions like photosynthesis and respiration to take place without the plant wilting while new roots are forming. Under most propagation systems, roots are formed in a medium that has the proper balance of moisture and air space to allow for the development of healthy roots.

Propagating environment

Maintenance of high humidity, optimum temperature and light around the cutting is critical. High humidity may be provided by placing a flower pot, plastic bag or glass jar (figure 15a) over the cuttings or by misting the cuttings with water several times a day. Cuttings can also be placed in plastic trays covered with clear

plastic stretched over wooden hoops or wire frame (figures 15b, 16a, b & c). The plastic will help keep the humidity high and reduce water loss from the cuttings. Shade and temperature can also be manipulated by using shade net or local materials such as palm fronds, leaves or grass over the cuttings.



Figure 16a: Low tunnelling environment



Figure 16b: Small-scale rooting cutting (a) cuttings using pot, polybags, vase and (b) small bed covered tightly with transparent polythene sheet



Figure 16c: A modified low-tunnelling with planted stem cuttings

Plants with thicker or waxy leaves suffer less from low humidity than thin-leaved plants. Plants in sealed containers may require a fungicide spray to deter harmful pathogens. If you need more elaborate facilities, you can construct a small hoop frame or use an intermittent mist system.

Procedures for rooting stem cuttings

Cuttings should generally consist of the current or past season's growth. Avoid material with flower buds if possible. Remove any flowers and flower buds when preparing cuttings so that the energy can be used in producing new roots rather than flowers. Take cuttings from healthy, disease-free plants, preferably from the upper part of the plant.

The fertility status of the stock (parent) plant can influence rooting. Avoid taking cuttings from plants that show symptoms of mineral nutrient deficiency. Conversely, plants that have been fertilized heavily, particularly with nitrogen, may not root well. The stock plant should not be under moisture stress. In general,

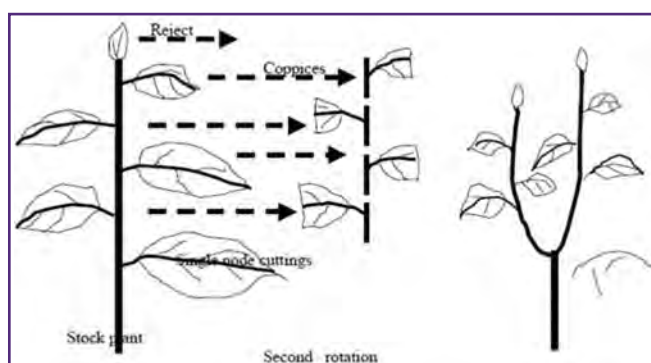


Figure 17: Schematic drawing showing shoots as cutting source and cutting the right single node cuttings

Treating cuttings with root-promoting compounds can stimulate rooting of some plants that might otherwise be difficult to root. Prevent possible contamination or damage to the entire supply of rooting hormone by taking small quantities from storage whenever required. Any material that remains after treatment should be discarded and not returned to the original container. Be sure to tap the cuttings to remove excess hormone when using a powder formulation.

The rooting medium should be sterile, low in fertility and well-drained to provide sufficient aeration. It

cuttings taken from young plants root better than cuttings taken from older, more mature plants.

Early morning is the best time to take cuttings, because the plant is fully turgid. It is important to keep the cuttings cool and moist until they are inserted in the rooting medium. An ice chest or dark plastic bag with wet paper towels may be used to store cuttings.

While terminal parts of the stem are best, a long shoot can be divided into several cuttings. Cuttings are generally 6cm to 10cm long depending on the species. Use a sharp, thin-bladed pocket knife or sharp secateurs for the preparation of cutting. If necessary, dip the cutting tool in rubbing alcohol to prevent contamination or infections.

Remove the leaves from the lower one-third to one-half of the cutting (figures 17 and 18). On large-leaved plants, the remaining leaves may be cut in half to reduce water loss and conserve space. Wounds may be created at the base of cuttings of difficult to root species.

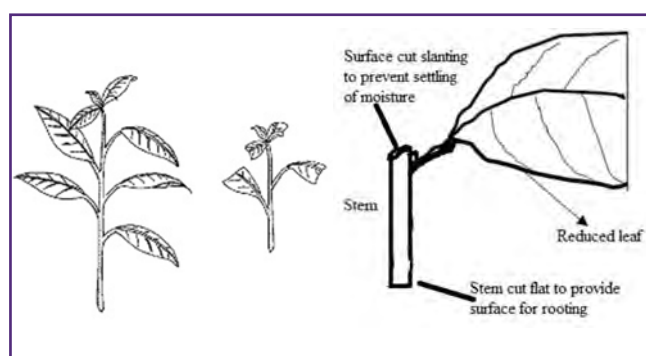


Figure 18: A stem cutting showing the slanting cut at the end of the stem with the leaf cut into half

should also retain enough moisture so that watering does not have to be done too frequently. Materials commonly used are coarse sand, sawdust, a mixture of one part peat and one part perlite (by volume), or one part peat and one part sand (by volume). Media should be watered while being used.

Insert the cuttings $\frac{1}{3}$ to $\frac{1}{2}$ half their length into the medium. Maintain the vertical orientation of the stem (do not insert the cuttings upside down). Make sure the buds are pointed up. Space cuttings just far enough apart to allow all leaves to receive sunlight.

Water the container or set-up again after setting or inserting the cuttings. Cover the cuttings with plastic and place in shaded area to avoid exposure to direct sun. Keep the medium moist until the cuttings have rooted. Rooting will be improved if the cuttings are misted on a regular basis.

Transplanting

Newly rooted cuttings should not be transplanted directly into the landscape. They should instead be transplanted into pots. Growing them to a larger size before transplanting to a permanent location will increase the chances for survival. Handle rooted cuttings by the rootball or pot, not the stem. Otherwise, roots may break off due to the weight of the media on the roots.

MODULE 4: MAKING COMPOST IN THE NURSERY



What is composting?

Composting is the breakdown of any organic material over time through the action of micro-organisms into a crumbly, dark, soil-like product in which none of the original material can be easily identified. Various organic waste materials produced by farming such as husk, effluent, vegetable waste, stubble and so on can be used to produce compost.

There are many benefits of using compost including:

- Increasing organic carbon protection of soil from erosion
- Increasing soil structural stability
- Improving soil moisture holding capacity
- Increasing water infiltration and reducing water runoff addition of nutrients (as slow release)
- Enhancement of growth of a wide range of soil organisms.

There are three distinct phases in composting. These include:

- Hot phase
- Cool down phase
- Maturation phase

During the hot phase the digestive processes of the micro-organisms cause the temperature of the compost pile to increase. Internal temperatures of 130°-140°F are routinely reached. These temperatures are sufficient to kill some disease organisms and weed seeds.

During the cool down phase fungi become more active in the compost processes. This is when stems, stalks and other tough fibrous materials are broken down.

The maturation phase begins after the compost has cooled down. In some instances worms move into the compost breaking down some of the materials and mixing the compost. The compost is ready to use as soon as most of the original material is no longer recognizable.

Nutrient supply and types of organic material

Organic materials are substrates for bacteria, fungi and other micro-organisms involved in composting. Compost is the end product of these digestive processes.

Compost that is suitable for growing seedlings requires a mixture of dry dead materials with living green materials. Dry dead materials are consumed slowly and contain high levels of carbon but low levels of nitrogen. Living green materials are consumed quickly and contain low levels of carbon but high levels of nitrogen. If there is too much nitrogen in the compost, some of it will turn to ammonia that will be lost.

The balance of carbon-rich dead materials and nitrogen-rich green materials is referred to as the carbon/nitrogen ratio. The optimum carbon to nitrogen ratio is about 30 to 1. Grass, animal manure and fresh green plants are high in nitrogen. Leaves, brush, sawdust and wood chips are all good sources of carbon. Blending these carbon sources with nitrogenous materials can provide a satisfactory carbon to nitrogen ratio.

Size of compost pile

A desirable size of a compost pile for a non-mechanized operation is 2.5m wide and 1.5m high. If the pile is much larger, then air circulation will not be sufficient to ensure the speedy decomposition of the organic materials. On the other hand, if they are too small, compost piles will not develop the heat required for speedy decomposition. Compost piles should not be less than 1m by 1m.

Particle size

Reducing the size of the organic material prior to composting increases the surface area available to micro-organisms. Reducing particle size also improves the internal structure of the compost pile which makes controlling aeration and moisture easier.

Size reduction can be mechanized with power choppers, shredders or hammer mills. A small gasoline-powered shredder can process up to 7m/

hour of organic materials. This could process enough compost for a nursery that produces one million seedlings a year.

Available oxygen

Most micro-organisms active in composting require oxygen to live. These micro-organisms are considered aerobic. The carbon dioxide produced during decomposition needs to be removed. If enough oxygen is not available, anaerobic micro-organisms will thrive and slow the decomposition as well as produce a bad smell.

Oxygen will move into the pile if it is loose and there is plenty of space between particles, like when straw is mixed in the pile. These factors have been quantified and are considered the basic requirements for accelerated compost production.

Compost making

Typically, compost should be made in pits – a pit that is 2m long by 1m wide and 1m deep will produce enough compost for up to 8000 small polythene tubes.

The first layer in the bottom of the pit is 10cm of forest soil. The second is 10cm of leaves or grass which should be compacted by walking on top of it. The third is 10cm of manure. Except for the first layer, each layer should be watered with three cans of

water before adding the next layer. These layers are then repeated in the same order until the pit is full. Normally, there will be three layers of each material in a 1 metre deep pit. The compost pit should be completed with a final 10cm layer of soil which is compacted by walking on it, and the finished compost heap should be the same level as the surrounding ground.

Good quality compost should take about 8 weeks; macadamia husk can take up to 12 weeks. It is very important not to use compost before it is ready as beneficial organisms will not have established, and nitrogen will have been temporarily taken by the decayed organisms and be unavailable to plants.

When the compost is ready it has the following distinct characteristics:

- Smell: nice and earthy, with no bad (sour or rotten) smells
- Feel: moist and earthy, not wet and sloppy or dry and powdery
- Appearance: original organic materials are not distinguishable. Pile contains dark soil-sized particles
- Temperature: pile stops getting hot.
- C:N ratio: between 15:1 and 30:1

The composting process takes longer if there is:

- Insufficient water, or
- Too much carbon-rich material

Testing compost maturity

Immature (unfinished) compost may stunt or kill plants. There are several simple tests to determine compost maturity before using compost as a growing media or incorporating compost into a potting mix. Two tests will be examined:

- Plant germination in compost
- Plant germination in compost extract



Figure 19: Compost making from farm

Plant germination in compost

This simple test consists of germinating spinach directly in the compost.

- Fill two pots with the compost to be tested.
- Moisten each pot thoroughly.
- Plant 50 spinach seeds in rows in each pot.
- After 7-10 days count the number of seeds that have germinated.
- If 75 per cent or more of the seed sprout and grow, then your compost is mature and ready to use.

Plant germination in compost extract

This test consists of germinating legume seeds on paper towels that have been moistened with a liquid extracted from the compost to be tested and with water for a control.

Making the compost extract

- Measure $\frac{1}{2}$ cup of compost.
- Put this compost into a 1-litre jar with a lid.
- Measure $1\frac{1}{2}$ cup of clean water, and add this to the compost in the jar.
- Secure the lid onto the jar and shake it. Allow this mixture to soak for 2 hours.
- After 2 hours, strain the contents of the jar through a cheese cloth then filter into a clean jar.
- Divide the test seeds into six groups of ten. Two groups will be treated with water and will serve as controls. Four groups will be treated with the compost extract.
- Make six stacks of paper towels or filter papers (if available). Moisten four stacks of the towels or filter paper completely with the compost extract. Moisten two stacks of the towels or filter paper with water.

- Drain off any excess moisture.
- After moistening the paper towels or filter paper, place 10 seeds on each of the stacks.
- Fold the paper towels over the seeds or cover with filter paper.
- Place the folded paper towels into a re-sealable plastic bag.
- Place the bags with the seed in a dark space at room temperature.
- After 24 hours remove the paper towels from storage and count the number of seeds that have germinated. Record this number and repeat this process each 24 hours for a total count (72 hours).

Home composting methods

Home composting depends on traditional or small scale simplified composting technologies at low cost. (E.g., simple pit method, heap method, bins, rotating drums). But each method uses the same scientific principle though it differs in procedures and equipment. Suitable home composting systems may differ from place to place depending on environmental, economic and social conditions of the people. In East Africa, space limitation has been a critical issue for many local authorities and this has crippled the implementation of home composting programmes.

Common home composting systems

- Heap method
- Pit method
- Traditional basket methods
- Rotating drums
- Composting bin systems

MODULE 5: THE NURSERY AS A BUSINESS



Launching the nursery business

Starting a nursery business is an exciting and complex process and it can be personally and financially rewarding — if you take the time and make the effort to learn the business and develop a closely reasoned and comprehensive business plan. Success in the nursery business isn't just 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.

This module provides a guide in exploring the current market to readers with the necessary tools on how to do market research and gather necessary data and to incorporate those using the marketing mix in preparing a sound marketing plan.

Learning outcomes

The participants should be able to:

- Define marketing management and its basic concepts
- Describe the micro and macro environment of the product/enterprise
- Identify the business threats and opportunities in the market
- Discuss tools that will aid the sellers in identifying enterprise position in the industry.
- Explain the marketing mix and its implications to marketing techniques and strategies.
- Prepare a simple marketing plan

Whatever the reasons for starting the nursery business, there are a number of things one should know and resources that should be available. First, success in the nursery business requires expertise in all phases of plant production, from propagation to post-harvest handling.

To be successful, one needs to be conversant with handling both employees and finances marketing

and sales. Finally, all business ventures—including the nursery business—require a capital investment to cover the cost of land, equipment, buildings, supplies, labour and stock, in this case the initial purchase of plants for propagation and growing to salable size.

If experienced and having strong knowledge of plants and plant culture, purchasing an existing business or starting a new one are logical options.

If case of limited or no experience, this can be gained by working for a reputable grower. Many well established nurseries are always looking for good help as full-time, part-time or even seasonal employees.

Deciding to start a nursery is only the first of many decisions to be taken. Objective decisions on all the factors affecting the operation of a business have to be made and a business plan developed.

Critical risks or situation analysis

Critical risks for our tree nurseries are separated into two segments:

Natural disasters and new competition

Natural disasters like drought can be managed by expanding water storage capacity. Pests and diseases can be controlled by constant inspection of plants and application of the required treatments. The risk of opening a new tree nursery in our community can affect our sales. Because of this possible competition we will put extra money into advertising. With regard to evaluating the project as a whole, the following strengths, weaknesses, opportunities and threats have been identified:

Evaluation of enterprises (SWOT analysis)

Activities

Participants should be able to list problems they encountered. An exercise to identify their strengths, weaknesses, opportunities and threats should be undertaken.

Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis

GROUP SWOT

STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> • Land and labour • Quality of products • Existing customers • Availability of the required equipment • Experience in growing trees • Experienced staff with a broad range of skills and experience 	<ul style="list-style-type: none"> • Lack of technical support • Lack of knowledge • Lack of good transport/communication • Lack of support/interest from the local community • Lack of water resources • Lack of finances • Uneven sale
OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> • Availability of labour • Availability of seedlings • Market for seedlings • Opening up new markets in other communities • Join a tree nursery association in the community to gain more knowledge/skills • Deforestation 	<ul style="list-style-type: none"> • Unpredictability of demand • Unpredictable climate • Natural disasters e.g., drought, floods • Disease outbreaks • Financial crisis • Policy changes • Increased competition • Inability to sustain long-term investments to enable self-sufficiency • Isolated site leading to the risk of vandalism and security problems

Product market expansion grid

	Current market	New market
Current product	MARKET PENETRATION STRATEGY <ul style="list-style-type: none"> • Encourage more customers to use the product • Attract competitors buyers to switch brand • Attract non-users 	MARKET DEVELOPMENT STRATEGY <ul style="list-style-type: none"> • Identify new market for product • Identify needs of buyers that can be served by your product • Sell in new location (local or abroad)
New product	PRODUCT DEVELOPMENT STRATEGY <ul style="list-style-type: none"> • Develop new product feature • Improve product quality • New technology 	DIVERSIFICATION <ul style="list-style-type: none"> • Develop product for different customers • New product for current customer • Create new business unrelated to the present one

The Ansoff approach on the other hand will help one detect possible opportunities for expansion. The Ansoff Approach or Product Market Expansion Grid basically helps you identify opportunities for your product. For example, in a current market what can you do with your existing product if you wish to sell more? You can use promotional activities to attract buyers to switch to your brand or you can attract non-users to use your products.

There is a market but we have no idea how big it is. Promote your product among consumers through information dissemination, advertising and other promotional activities that can help you penetrate the markets.

Developing a business plan for the nursery

A nursery business plan will help to determine the type, market, location, site, design and size of 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.

A business plan should cover the following information:

- A description of the business: name, location
- Business objectives and activities with time frames. The objectives must be SMART Current performance analysis
- Marketing plan
- Production plan
- Financial plan/needs/projections and balance sheet.

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 nursery formats:

- Landscape nurseries which grow plants for retail sales and for their in-house landscape service
- Retail nurseries which include small nurseries and garden centres that grow plants on

limited acreage for strictly retail sales to the homeowner and to landscape contractors

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

In deciding on the type of nursery business, one begins to define the type and form (rooted cuttings, seedlings, liners, container grown, field-grown seedlings, or a combination) of nursery stock to be grown. Many of these nurseries operate on less than a quarter acre of land.

Licensing, permits and regulations

It must be checked with the local authority if a licence is required. For example, a nursery business in the municipal council must pay annual nursery licensing fees and be subject to council inspections. The costs of licensing and any other authority-mandated certifications must be included in the operational costs.

Defining competition

Knowing the competition in the business is essential in developing a marketing strategy. Understanding what other growers are producing for the market will help to develop a better position for products and services. By developing a competitive analysis one can find out the kinds of products that will sell, along with pricing strategies and promotions that are necessary for keeping the customer interested.

In the corporate world, to get the edge over competitors one must have a product or service that others perceive as different from everything else offered, while also fulfilling the wants and needs of consumers better than any other product or service. In the nursery industry there is no difference. In order to successfully develop a niche, one must determine what makes them better than other products. Product quality, selection, lowest price and fastest service are what should define your nursery.

Defining the 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, balled and potted, or container grown seedlings).

Each nursery owner must analyze and organize his or her own marketing channels, develop a sales programme, 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 KFS 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 anticipate future preferences on the types and number of plants to grow
- Promote plants that you or other colleagues consider outstanding.

Marketing strategy

Marketing strategy is based on becoming an option for contractors and the general public to fill their plant and agroforestry needs and must include performance in the following areas:

- Customer service
- Knowledgeable staff
- Affordable prices
- Great location
- Quantity and quality of plants, seedlings, trees and saplings

Sales strategy

Factors that influence primary sales:

- Excellent customer service
- Exceptional product knowledge
- Large and varied offer of trees and saplings
- Good location
- Good quality of saplings
- Affordable prices

What product mix?

After evaluating the environment and identifying the opportunities for the business one can now start strategizing by identifying the target market and delivering the product needed. Marketing of any business can be broken down by using the 4 Ps -- Product, Price, Promotion and Placement.

Product

One of the most frequently asked questions is: “What should be grown?” This can be answered through a market survey.

Product development

This will involve:

- Idea generation
- Idea screening: what will it cost to produce? Is it a viable business? Is there 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.

Price

What should the price be? First and foremost, 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, several questions must be asked:

- What are customers willing to pay?
- Are all costs covered; where is the break even?
- What does the competition charge?
- 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 labour, materials and advertising. Fixed costs are incurred **whether products are sold or not**, such as rent, equipment and utilities. Following is a list of formulas used throughout business in determining the production cost. If after using these models the selling price is found to be more than that of competitors, ways must be found to lessen costs of production or accept less profit without affecting the overall quality of the product.

Assume that a nursery has determined there is a market for *Grevillea robusta* seedlings. The cost of materials is KShs 3.00 (KShs 2.50/plant + .50/pot & media) per plant. It takes ½ hour of labour to maintain each plant until ready for sale, with a labour rate of KShs 6.00/hour. Overhead is fixed at KShs 2.00 per plant.

Formula 1

Materials + overhead + labour (production time x hourly wage) divided by number of units = selling price per unit

Example: KShs 3.00 + KShs 2.00 + KShs 3.00/
1 plant = KShs 8.00 per plant

Formula 2

Materials + overhead + labour + profit divided
by 1 unit = selling price per unit

Example: KShs 3.00 + KShs 2.00 + KShs 3.00
+ KShs 2.50 /1 plant = KShs 10.50 per plant

In this example an absolute decision is made about how much profit you want from each unit sold. Profit, labour and overhead do not change.

From these examples one can see how different factors affect pricing. These are only models to find production costs; they do not take into account factors such as market price trends that affect pricing. You must be aware of constant changes in the market such as over-saturation and availability that will affect the bottom line.

Promotion

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.

Activity

Which promotional media is most effective to capture your attention? Rank the different promotional media below from 1 (least effective) to 10 (most effective).

Types of promotional media	Rank
Television	
Radio	
Internet	
Magazines	
Newspapers	
Telephone	
Pamphlets	
Posters	
Word-of mouth	
House-to-house	

Placement

Now that the product is ready for sale, priced, and consumers know that it exists, how do they get it? This is known as placement of the product, or getting the goods to the customer when and where they want it (distribution). Distributing the product can represent from 10-50 per cent of the final price of the product in shipping and freight situations.

Often businesses such as nurseries do not have the resources to individually deliver the product to the consumer. A nursery therefore relies on channels of distribution already established by wholesalers, retailers, distributors, brokers and cooperatives. A nursery can produce the best quality plants, 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 its 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.

Other Ps in marketing

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

Marketing mix

You have to remember; whatever type of market you decide to serve constraints are always present. Problems from both micro- and macro- environment affect the strategies you will employ in your marketing activity, it should not be ignored, but rather given utmost importance and factored-in before a decision is made.

Activity: Evaluation

Form a group, identify a product you wish to market, through a face-to-face interview (using marketing mix as a guide in questioning) with the group members do a market research, analyze its potential using the different strategies identified and make a marketing plan.

Activity: Phases of development

Phase 1: Pre-establishment

Phase 2: Establishment (current)

Phase 3: Expansion/diversification

Phase 1: Self-sponsored

Activities:

Market research

- Establish relationship with extension and research system

- Determine varieties
- Determine price
- Establish contacts with NGOs, farmers' associations and schools
- Plant a seed plot for two seasons and sell seed

Phase 2: 2-3 years

Activities

- Register business
- Open bank account
- Take orders

Phase 3: After 3 years

Activities:

- Introduce new crops and varieties
- Purchase new/larger equipment
- Obtain loan
- Expand market

Simple marketing plan for tree seeds

Tree seeds marketing plan	
Category	Strategy
Target market	
Positioning statement	
Offering to customers	
Pricing strategy	
Place of distribution	
Product sales strategy	
Promotional strategy	
Marketing research	
Any other component of your marketing plan	

Nursery business prospectus

Checklist

By this point, you should have a good idea of the many factors involved in starting a nursery operation. This publication has discussed many factors that affect the starting of a nursery business. The following checklist should help you prepare the kind of organized, comprehensive business you'll need before you can arrange financing.

- Size of operation
- Location
- Type of operation (products to be offered)
- Assets
- Cost of equipment and employees (number and type)
- Market (source and dependability)
- Estimated returns
- References (from other business operators and community leaders)

FEEDBACK



Module feedback

This form can be modified to suit the needs of the community.

Tell us a little about yourself:

I am a	My commodity area is:
Farmer _____	Field crops _____
Agricultural officer _____	Fruits and berries _____
Forester _____	Nursery stock _____
Nursery operator _____	Other _____
Industry rep _____	
Extension educator _____	
Other _____	

Let us know what you think

1. What part of the workshop was most interesting for you?
2. What part of the workshop was most valuable to you?
3. What two new ideas would you like to try on your farm or in your business?
4. Do you feel you understand nursery establishment and management—and how to use it— better now?
5. What other information should be included in this module?
6. What other topics would you like us to cover in future modules?
7. Do you think the time you have spent at this workshop is worth it?
8. How do you want us to work or collaborate with you?
9. After how long do you think we should visit you and see whether the technology you have learnt is working?

Questions that should guide the trainer feedback reporting

1. Training objectives:

2. Describe courses/subjects covered during the training: (Please use extra pages if required or training plan is attached).

Date: _____

Location: _____

No. of participants: _____ (*attach list of participants*) **Trainers:** _____

3. Major achievement:

Results of training evaluation

4. Comments about training:

5. Propose how the knowledge and skills gained from the course can be utilized to further improve the effective delivery of services and achieve the goals and objectives of the organization (please use extra pages if required).

Attachments

1. Training plan
2. List of participants
3. Results of training evaluation
4. Photos
5. Others: _____

ANNEX: SAMPLE PROGRAMME OF A WORKSHOP ON NURSERY MANAGEMENT AND TREE PROPAGATION TECHNIQUES

Date/time	Module	Facilitator
11/06/2012	Registration and going through the programme activities	
12/06/2012	Introduction	
0800-0930	Welcome remarks	
	Objectives setting	
	Nursery as a business	
0930-1030	Importance of nursery in agroforestry	
1030-1100	Tea break	
1100-1300	<p>Selection of plus trees</p> <p>Sources of tree seed</p> <p>Identification and seed collection</p> <p>Tree seed processing and proper seed storage at community level</p> <p>Seed procurement, multiplication and distribution</p> <p>Simple pre-sowing treatment procedures</p> <p>Practical: Moisture testing before storage and pre-sowing treatments</p>	
1300-1400	Lunch	
1400-1420	Introduction to extension	
1420-1630	<p>Tree nursery establishment and management</p> <p>Compost making, substrate selection and mixing</p> <p>Containers and how to fill</p> <p>Watering frequency and shading</p>	
1630-1700	Tea break	
13/06/2012		
0800-1030	<p>Seed germination techniques</p> <p>Nursery management: weeding, pest and disease prevention control in the nursery and hardening</p> <p>Common nursery practices: both good and bad</p>	
1030-1100	Tea break	
1100-1300	Vegetative propagation e.g., grafting, cuttings, etc	
1300-1400	Lunch break	
1400-1630	Practical on vegetative propagation in the nursery	
1630-1700	Tea break	

Date/time	Module	Facilitator
14/06/2012		
0800-1030	Recap of previous sessions How to think like a business person/manager	
1030-1100	Tea break	
1100-1300	Nursery profitability: What determines pricing of seedlings How to calculate profit/gross margin Marketing strategies	
1300-1400	Lunch	
1400-1630	How to attract customers through extension Basic agroforestry knowledge Basic extension/ communication method	
1630-1700	Tea break	
15/06/2012		
0800-0930	Networking with other nursery (associations) Networking with source of knowledge	
0930-1300	Fill the feedback questionnaires Closing ceremony and awarding of certificates to participants	
1300-1400	Lunch break	

FURTHER READING

Gregorio NO, Herbohn JL, Harrison SR. 2010. Guide to Quality Seedling Production in Smallholder Nurseries. Leyte, Philippines 44 pp.

Leakey RRB, Newton AC (eds) 1994. Tropical Trees: the Potential for Domestication and the Rebuilding of Forest Resources. HMSO, London.

Wiesman Z, Jaenicke H. 2002. Introduction to Vegetative Tree Propagation. In Janenicke H, Beniest J (eds) Vegetative Tree Propagation in Agroforestry. Training Guidelines and References.

Wightman KE. 1999. Good Tree Nursery Practices: Practical Guidelines for Community Nurseries. International Centre for Research in Agroforestry. Majestic Printing Works: Nairobi, Kenya.



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