Guidelines for Village Forest Conservation

Fostering Climate Resilient Upland Farming System in the NorthEast

Operational Guidelines, 2020

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1.0 Support to Village Forest Conservation

- The project shall support four activities under Village Forest Conservation. They include: (i) contour trenches; (ii) nursery development; (iii) planting and maintenance; and (iv) protection of water sources.

- All investments for contour trenching will have to be sourced either from Centrally Sponsored Schemes (CSS) or from other convergence sources.

- Each nursery farmer identified by the Village Forest Conservation Commiteee (VFCC)/Village Council shall be eligible to get a support for development of 0.5 ha of nursery with unit cost of Rs 50,000 for 0.5 ha (500 seedlings per VFCC/VC).

- Each VFCC/Village Council shall be eligible to get support for development of about 20 ha covering planting and maintenance at a unit cost of Rs 5,000 per ha.

- Each VFCC/Village Council shall be eligible to get support for protection of water sources with a unit cost of Rs 70,500 per site selected for water source protection. The project support will be restricted to a maximum of three sites for water source protection per village.

- The nursery development and subsequent planting and maintenance for Village Forest Conservation shall cover the following important tree species Parkiatimoriana, Michellachampaka, Gamar (Gmelina arborea), Bombax ceiba, etc . Any other tree species preferred by the Village Council can also to be included.

- The project staff at the district level shall facilitate the nursery farmers to source the seeds and seedlings from the forest department and other sources.

- The project based on the performance of the nursery farmer and also village forest conservation area to be planted and maintained by the VFCC/Village Council, may decide to increase the amount of support for nursery development during the subsequent years.

2.0 Implementation Arrangements

- The project staff to facilitate the Village Council to establish a four member VFCC comprising Village Council members with 50% participation of women.

- The Village Council with support from field staff of FOCUS shall identify village forest of about 20 ha for village forest conservation activities. The coordinates (latitude and longitude) of the boundaries of village forest area identified for village forest conservation will have to be recorded and mapped for geo tagging purposes. Any village interested in developing more than 20 ha of village forest conservation area shall seek special approval from FOCUS-PMU. The VFCC/Village Council shall establish rules on use of the village forest conservation area related to tree cutting and grazing of animals.

- The VFCC/Village council shall identify sites for water source protection with coordinates (latitude and longitude) of the site. Any village interested in taking up development of more than 3 sites for source protection activities shall seek special approval from FOCUS-PMU.

- The project staff shall facilitate the VFCC/Village Council to prepare a proposal for village forest conservation covering four activities: (i) contour trenching, (ii) nursery management; (iii) planting and maintenance; and (iv) protection of water source. The proposal shall cover cost estimate, sources of funding and contribution from the Village Council if any.

- This proposal shall be submitted to DMU for approval and the project shall facilitate the VFCC/Village Council to access funds for contour trenching from convergence.

- Upon approval of the proposal from DMU, VFCC/Village Council shall identify a farmer interested in establishing a nursery to grow seedlings for planting in the village forest conservation area. The selected nursery farmer shall have adequate land and irrigation for nursery management. VFCC/Village Council shall enter into an agreement with the nursery farmer to buy agreed quantity of seedlings at pre-determined price.

- The identified nursery farmer will be trained by DMU staff using the trained staff of the project and nursery experts.

- The project will release Rs 50,000 to the VFCC/Village Council and this fund shall be released by the VFCC/Village Council to the nursery farmer.

- Monitoring will be undertaken by DMU and field staff including - TO (LR,S&WC), TO (Horticulture/Agriculture)/SAC/VLW/VFA and with the supervision of experts from Horticulture, Forestry and Land Resources, Soil and Water Conservation of the district.

- The field staff of FOCUS shall submit a report on nursery development activities and once the planting season approaches, a request letter from the VFCC/Village Council will have to be sent to DMU to release funds for planting and maintenance. DMU shall release funds and VFCC/Village Council to purchase seedlings from the nursery farmers. VFCC/Village Council shall take up planting of the seedlings in the village forest conservation areas. VFCC/Village Council shall be responsible for maintaining the village forest conservation area.

- At the same time, VFCC/Village Council will have to be facilitated to submit an application for releasing funds for developing a site for water source protection. Upon receipt of application, DMU shall release funds to VFCC/Village Council. VFCC/Village council to complete the activities planned and submit a utilization certificate to DMU along with a completion report from field staff of FOCUS. Thereafter, based on the completion of activities of the first site for water source protection, funds for the next water source protection activity will have to be released. This shall be repeated until all approved sites have been developed.

- The unit cost per site for protection of water source is estimated at Rs 70,500. The project shall release this fund to the VFCC/Village Council and this fund shall be released by the VFCC/Village Council to the local contractor. The amount shall be released in three installments to the bank account of VFCC/Village Council.

- First Instalment of Rs 25,000 per site shall be released upon the approval of the proposals of FIGs-Village Forest Conservation by FOCUS officials. Second installment of Rs 25,000 per site will be released subject to submission of the utilization certificate for the first installment released to the FIGs-Landless and verified by FOCUS officials. Third installment of Rs 20,500 shall be released after submitting utilization certificate for the second installment and full utilization of member contribution and verified by FOCUS officials. Thereafter within 30 days of release of third installment, FOCUS officials will have to obtain a utilization certificate from the FIG-Village Forest Conservation for the amount released as third installment and file a completion certificate for the entire construction with copies of measurement book.

- Monitoring will be undertaken by DMU and field staff including - TO (LR,S&WC), TO (Horticulture/Agriculture)/SAC/VLW/VFA and with the supervision of experts from Irrigation and Land Resources, Soil and Water Conservation of the district.

- Field staff will have to monitor all the activities and submit completion certificate to the respective DMU.

CHAPTER - I

Nursery Establishment

3.0. Nursery establishment

3.1 Nursery development and practice

Developing a nursery is necessary under several conditions:

o When no nursery is within easy traveling distance;
o When there are no outside sources of seedlings; and
o When the species cannot be directly sown.

Travel time is an important consideration in determining the need for a nursery. If it is necessary to travel several hours from the nearest nursery to the planting site, the excessive travel time may result in death or poor growth of the seedling due to lack of moisture and shock. If there are no government programs or commercial nurseries to supply the desired quantity or species, it may be advantageous to establish a large nursery that supplies products region wide. In some cases, it is necessary to start a nursery because the species chosen requires special care prior to transplanting to the field.

The type of nursery is determined by the scope of the project. If the objective is to provide seedlings on an ongoing basis for various projects, or individual home plantings, it is necessary to develop a large, centrally located facility with a wide variety of plants. This type of nursery should be self-sustaining, or maintained by government funds. If the objective of the project is to provide trees for one small individual project, a temporary facility should be developed. As the project concludes, the site can be used for another purpose. Whenever possible, local materials, labor, and other resources and appropriate technologies should be used. The amount of land to be used depends on the size of the project, its goals, and the availability of land in general.

3.2 Mandatory Requirement for availing support for Nursery Development

Sl. No.	Type of nursery	Basic requirement	Infrastructure requirement
1.	Small Nursery (0.5 ha)	Selection of Site: Nurseries will be established only to produce planting material which are suitable for that agroecology. The nurseries should be well connected to road to facilitate transport. Sites exposed to strong winds and with danger of flooding or landslides should be avoided. Soil Conditions Well drained, light to medium textured fertile soils.	• Fencing Water Source (Irrigation source/ • Ponds/ Tanks/ Well/ Tube well) Energy Source (electricity or Genset) • Water lifting devices • Water distribution system • Farm machineries required for land • preparation, bed preparation and other operations • Other equipments & tools for raising seedlings Composting Unit • Watch & ward

3.3 Cost Norms

Sl. No.	Type of Interventions	Indicative unit cost per plants (Rs.)
1.	Pre-Plant activities/Land clearing/maintenance etc.	**10.00**
2.	Digging /Planting etc	**10.00**
3.	Single unit Planting material etc	**10.00**
4.	Transportation charges	**10.00**
5.	Critical inputs viz., FYM, Fert., seed treatment, PP chemicals etc	**20.00**
6.	Planting cost	**10.00**
7.	Fencing	**20.00**
8.	Maintenance (weeding+ watering etc.)	**10.00**
	TOTAL	**100.00**

Note: (i) The activity wise cost indicated above are tentative and states have the flexibility to formulate their own estimate based on local requirements subject to a maximum of Rs. 100/- per plant.
(ii) The assistance will be given in the year wise proportion of 40:20:20:20 for four years.

3.4 Total Cost Norms

Sl. No.	Type of plantations' magnitude (seedlings/ha)	Indicative total cost
1.	1000	As per actual no of plants @ Rs.100/- per plant
	TOTAL	**Rs. 1,00,000/-**

(Rupees one lakh) only

- *The amount for nursery establishment proposed in AWPB of 2020-'21 is revised and a budget of INR 1.00 lakh per hectare i.e. INR 50,000/- per 0.5 Ha / village / nursery (500 tree seedlings per nursery) is proposed since the rates of any activities are much higher as compared to that of the year 2017-'18. The budget of INR 1.00 lakh per hectare was also proposed in the AWPB 2018-'19 and was given No Objection Certificate from IFAD.*

An area of 106 hectare is allotted for the year 2020-'21.

Therefore, for execution of 106 hectares @ Rs. 1,00,000.00 per ha = Rs. 1,06,00,000.00
(Rupees one crore six lakhs) only

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CHAPTER - II

CHECK DAM
under
Protection of Water source

4.0 Protection of water sources – Check Dam

4.1 Introduction

"Check dams" are small barriers built across the direction of water flow on shallow rivers and streams for the purpose of water harvesting. The small dams retain excess water flow during monsoon rains in a small catchment area behind the structure. Pressure created in the catchment area helps force the impounded water into the ground. The major environmental benefit is the replenishment of nearby groundwater reserves and wells. The water entrapped by the dam, surface and subsurface, is primarily intended for use in irrigation during the monsoon and later during the dry season, but can also be used for livestock and domestic needs.

Check dams are built in a range of sizes using a variety of materials, including clay, stone and cement. Earthen check dams, or embankments, can easily be constructed by the farmers themselves. Masonry and reinforced cement concrete (RCC) structures, on the other hand, require some degree of advanced construction experience and monetary inputs. Earthen dams do not allow for overflow of water, in contrast to masonry and RCC structures which allow excess water to flow over the spillway.

4.2 Objectives

The main objectives of the check dams were to recharge ground water reserves and increase the availability of water for agricultural purposes and animal intake throughout the whole year.

4.3 Check dams create more employment

Check dams created more employment in the beneficiary villages by increasing the number of working days for landowners. This was accomplished by increasing access to irrigation that led to:

 Agricultural Intensification: This refers to more intensive cultivation of formerly rainfed or under-irrigated plots of land resulting in higher yields per hectare and requiring more person days of labour. Some lands that only produced only a single crop previously can now be double-cropped, adding an additional season of labour.

 Agricultural Extensification: In some beneficiary villages, formerly barren lands have now been brought under irrigation as a direct result of the water availability with the advent of check dams. Owners of this property now have additional days of agricultural employment.

4.4 Check dams reduce poverty through additional income

The check dams have helped to reduce poverty by providing additional surface and underground water leading to:

- Increased agricultural yield
- Increased income from the sale of crops
- Income from the sale of fish
- Increased revenues from livestock
- Increased growth of fodder
- Increased availability of water for processing sun hemp (a forest fibre)

4.5 Check dams improve the quality of life

The check dams have served to increase the quality of life in beneficiary communities by:

- Increasing the availability of water for domestic use
- Decreasing women's workloads
- Improving diets: Better harvests provide additional staple crops for the family's consumption. Moreover, in many places, families can grow vegetables now that they have access to check dam water, adding to the variety of foods in their diets. Lastly, families who live in the check dam catchment areas can also eat the fish, which provide an additional source of protein.

4.6 Check dams increase livelihood adaptation

- It increased the number of months when water is available: Water for agricultural and domestic use is now available for more months of the year and, in many cases, the whole year round.
- It increased the number and continuity of working days across the seasons: As a result of agricultural intensification and extensification, particularly the addition of a second growing season, there are more working days and smaller gaps of agricultural unemployment in the year for most check dam beneficiaries.
- It improved food security: Increased yields of staple crops and planting of vegetables and the addition of a second growing season has worked to increase food security among beneficiaries.

4.7 Check dams enhance natural resource base

- Recharging groundwater reservoirs and wells
- Increasing soil humidity
- Promoting growth of surface vegetation
- Capturing runoff rainwater and silt

4.8 Planning Considerations

- Check dams are usually made of stone. The center must be lower than the edges.
- Ensure that overflow areas along the channel are resistant to erosion from out- of-bank flow caused by the check dams.
- Check dams can also be constructed of logs, or pea gravel-filled sandbags. Log check dams may be more economical from the standpoint of material costs, since logs can often be salvaged from clearing operations. However, log check dams require more time and hand labor to install. Stone for check dams must generally be purchased. This cost is offset somewhat by the ease of installation.

4.9 Site selection

1. The sites must be in village conservation area or area which will help in the protection of water source of village forest conservation area.
2. The site must have a rocky or a strong foundation. Rock foundations have a very large load bearing capacity, resist erosion, and reduce permeability. A soil with a high permeability allows water to flow underneath the check dam.
3. The site must not be prone to soil erosion.
4. Where the farmers are willing to take up operation & maintenance of the structure.
5. The newly constructed structure should not have any adverse impact on the hydrological efficacy of the existing, ongoing and future major, medium, minor (flow) irrigation and minor (lift) irrigation projects.

4.10 Design & Construction Recommendations

- Check dams can be constructed of rock, sand bags filled with peagravel, or logs. Provide a sump immediately upstream.

- The rock must be placed by hand or mechanical placement (do not dump rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges. The rock used must be large enough to stay in place given the expected design flow through the channel.

4.11 Maintenance

- Inspect after each rainfall event.

- Remove sediment accumulations.

- Check structure and abutments for erosion, piping, or rock displacement. Repair immediately.

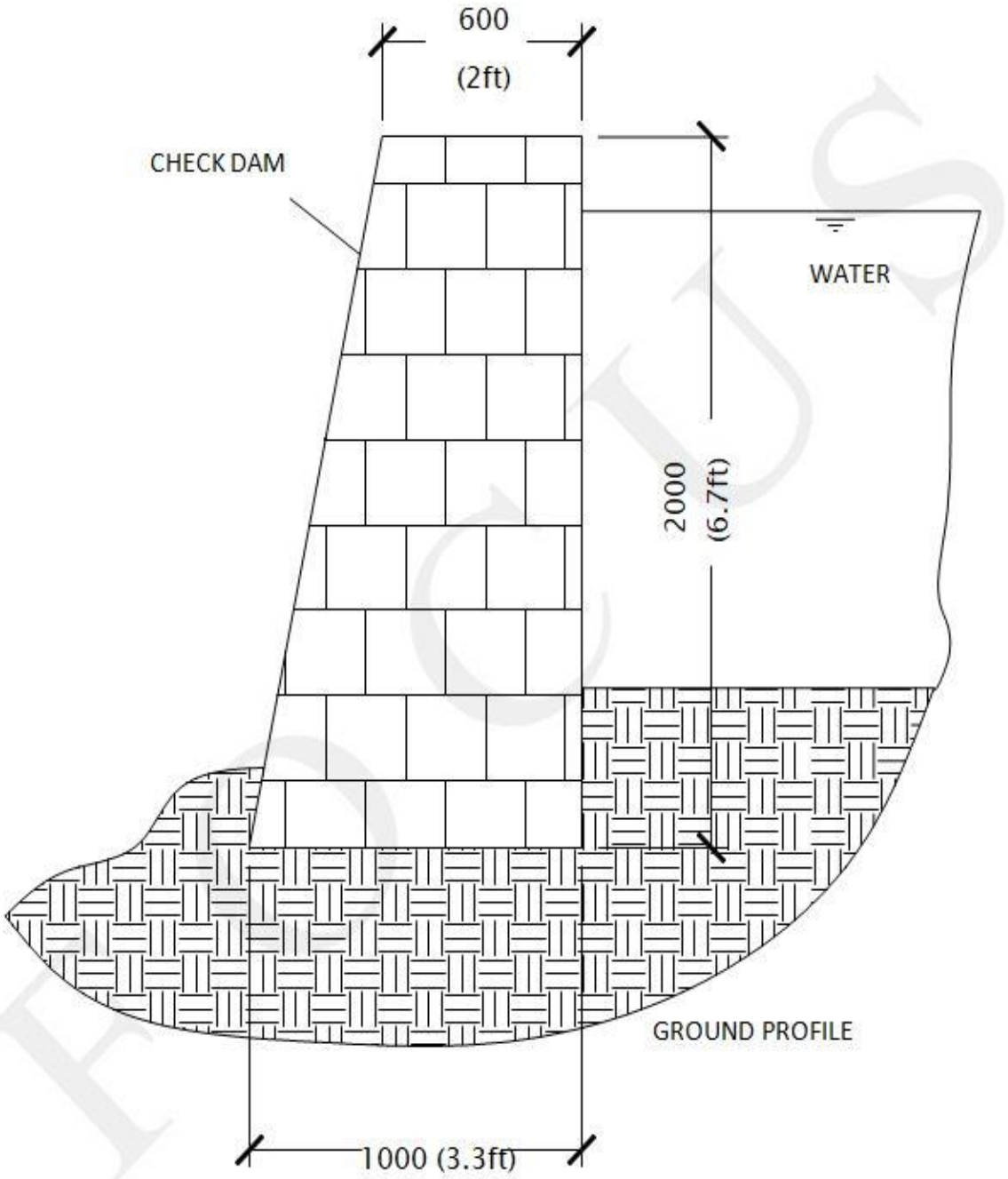
4.12 Estimate of retaining wall Check Dam

Sl. No.	Description						
1 / 2.06	Earthwork in excavation over areas (exeeding 30cm in depth,1.5m in width as well as 10sqm on plan) including disposal of excavated earth, lead upto 50m and lift upto 1.5m, disposed earth to be levelled and neatly dressed.						
	1	5	0.9	1	=	4.5	m3
	@	Rs.	411.5	per m3	=	Rs. 1851.75	
2 / 4.02	Providing and laying in position cement concrete of specified grade excluding cost of centering and shuttering - All work upto plinth level:						
	(a) 1:2:4 (1 cement :2 course sand :4 stone aggregate 20mm nominal size)						
	1	5	0.9	0.15	=	0.675	m3
	@	Rs.	8324.6	per m3	=	Rs. 5619.105	
3 / 7.01	Regular coursed rubble masonry with hard stone in foundation upto one storey above and below ground level including curing, etc. complete.						
	(a) in cement mortar 1 : 3 (1cement : 3 fine sand)						
	1	5	2	(1+0.6)/2	=	8	m3
	@	Rs.	7406	per m3	=	Rs. 59248	
4 / L/S	Steel open & close gate						
					=	Rs. 3800	
				Total	**=**	**Rs. 70518.86**	
				SAY	**=**	**Rs. 70,500/-**	
				(Rupees seven thousand five hundred only)			

An number of 300 sites is allotted for the year 2020-'21.

Therefore, for execution at 300 sites @ Rs. 70,500.00 per site = Rs. 2,11,50,000.00
(Rupees two crore eleven lakhs fifty thousand) only

4.13 CHECK DAM SECTION DRAWING



ALL DIMENSIONS ARE IN MM

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5.0 Appendix - I

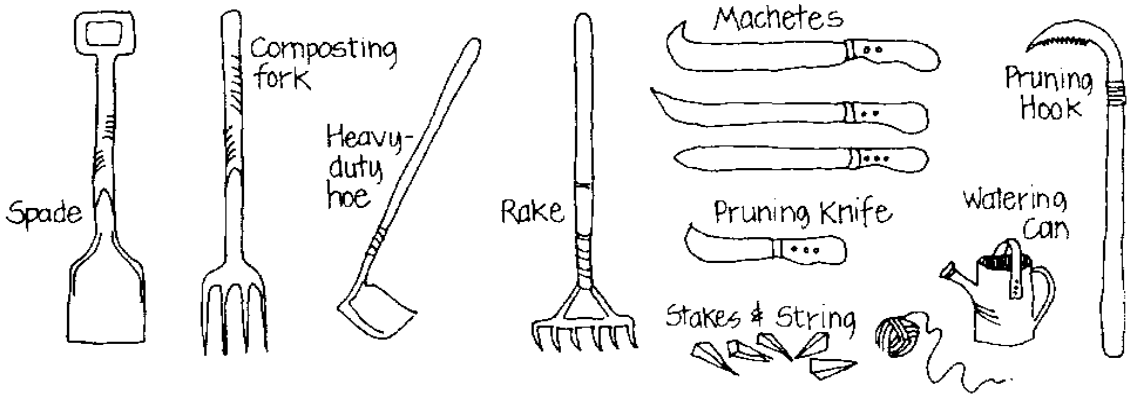
Nursery Establishment

Materials

Purchase the necessary nursery materials (fencing, construction material, tools, pots, plastic potting bags, etc.) well in advance of the planned start-up date. Early purchase of materials will avoid delays in planting or transplanting. Costs may be reduced and local acceptance increased by the use of local materials and labor and the integration of local knowledge into the design and construction work. Materials not available locally can normally be acquired from government forestry off ices or agricultural suppliers.

A list of materials could include the following: plow, hoe, rented draft animal or hand tractor, shovels, budding knife, pruning shears, pruning saw, pots (plastic bags, bamboo, clay), plastic sheets, spade, wood or wire fencing, construction materials for a shed, watering cans or hose, soil, sand, compost, and 55 -gallon drums.

Illus. 5-1 Nursery Tools



Timing

Timing is a critical factor in nursery development. Timing issues include the amount of time needed to set up, acquire materials, and make sure seedlings are ready for planting at the right time of year. An additional timing consideration is arranging labor and transportation for critical times (planting of seeds or stock, transplanting to planting sites, etc.). This planning should be done well in advance, since labor may be in short supply when workers are needed for other farming activities.

The most important time consideration is the timely planting of the seedlings. Since the survival chances of young trees depends directly on the maturity and size of the trees when transplanted, and upon transplanting at the right time of year, the timing of the project must be carefully planned.

The timing involved in seeding or placing open rooted stock or vegetatively propagated plants in the nursery must therefore be carefully considered in order to ensure that planting stock is ready at the correct time. Planting too late in the nursery will make for immature seedlings with lessened chances for survival.

Conversely, planting too early in the nursery will produce heavier seedlings that will be harder to move and transplant, and may become pot-bound.

To time the planting, the forester must know how long each species must remain in the nursery and plan nursery time to coincide with the rainy season. Other planting considerations that must be taken into account are the overall location of the nursery, soil, sunlight, and local climate. All of these can speed up or slow down the development of seedlings. To avoid having a project ruined by these factors, it is necessary to

consult local experts and records of other projects. It is important to keep good records for yourself and for those who follow.

As stated, long-range planning is crucial for successful nursery operations. It avoids shortages, waste, and lost opportunities. Along with materials, record-keeping, and timing, other considerations for nursery development include soil, water, labor, space, design and layout, light and shade, protection and maintenance, propagation methods, care of nursery plants, records, and other activities.

Soil

Good, rich soil promotes healthy development of seedlings. Before a nursery is established, the soil should be tested for its suitability with the trees to be used. Factors to be tested for include pH, nutrients (nitrogen, phosphorus, others), and overall composition.

Adjust the soil according to the needs of the plants, if possible. Adequate fertilization is especially important to open-rooted stock. For open-rooted stock, cultivate the nursery soil to the expected depth of the roots. Add nutrients and any other elements the soil is lacking at this point.

Nutrient -rich soil should be developed for nursery use by the mixing of compost, sand, and soil. A standard mix is 1/3 sand or loose soil, 1/3 clay, and 1/3 compost (see Illus. 5-2). This soil is loaded into pots or plastic bags, or used to make nursery beds. When planting in beds, it is necessary to supplement the soil mixture with additional nutrients: add a generous amount of composted animal and plant debris. A general rule is 90 kg per hectare. Continual addition of compost will ensure good soil structure.

Inorganic commercial fertilizer can be used to improve the fertility of the planting medium. However, it is expensive and may not be available. Where it is available, add commercial fertilizer containing nitrogen and phosphorus to the soil, clay, and compost mixture during preparation, or after placing the soil in the pots, plastic bags, or beds.

Illus. 5-2. Soil Mix

It is very important not to leave the soil exposed to the sun, rain, and heat of the tropics for very long, as all of these elements will deteriorate the quality of the soil. Sunlight will bake the soil, dry it out expose it to wind erosion, and kill exposed microorganisms important to plants. Rain will leach out important nutrients and, if sufficiently strong, will wash away precious soil. Tropical heat speeds oxidative reactions in the soil, further weakening the soil's ability to nurture seedlings. Protect soil at all times, especially after tilling, by mulching with grass cuttings.

Water

The cost, quantity and amount of water are important considerations in the development of the nursery. Projects can be seriously hampered if source of water becomes polluted, dries up, or is diverted for another project. To ensure the financial and technical feasibility of the nursery, the forester must assure that adequate quantities of clean water are available. Drinking quality is not necessary for plants, although a drinking supply should be allotted for workers. Overly dirty or organic water should be avoided or filtered, as slimes will gum up nozzles and valves.

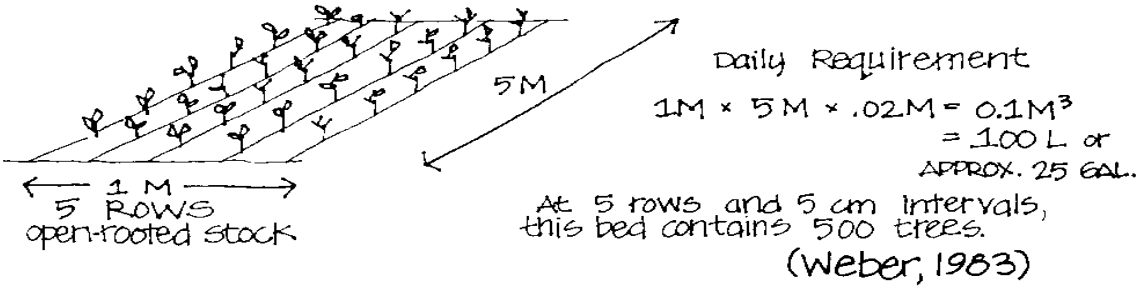
A shortage of water is a serious problem. For sites with limited water, use water sparingly. Occasionally flush seedlings with large amounts of water to remove as much salt as possible. This over-irrigation is one solution, although it may also leach nutrients out of the soil. While planning the nursery, it is important to calculate how much water will be needed on a daily basis. This will determine all water supply plans and activities. Once the daily amount is known, it is possible to determine the pumping rates and water storage needs for the nursery.

An easy and reasonably good method for determining daily needs is to measure the area to be watered (the planting beds) and multiply this by 0.02 m. This will give the amount of water in cubic meters to cover the area with a sheet of water two centimeters in height. For example, if a bed is 1 m x 5 m, the amount of water needed per day will be: 1 m x 5 m x 0.02 m= 0.1 cubic meters, or 100 liters of water. (See Illus. 5 - 3.)

If the nursery has ten beds, it will require 1000 liters of water a day. This means the nursery will need 365,000 liters of water a year, if it is producing seedlings on a continual basis. Fluctuations in this number will occur depending on number of beds in production and maturity of the seedlings. This calculation should show the amount of water adequate for most trees under most conditions. It can be less if:

o There is adequate humidity, shade, and protection from wind;
o Available water is used during the cooler parts of the day; and
o There is good water retention in the soil.

Illus. 5-3. Water Need Calculation



Under these circumstances, it might be possible to reduce water needs by up to one half. Other strategies to conserve water include sinking the pots in the ground, mulching, and constructing shade devices.

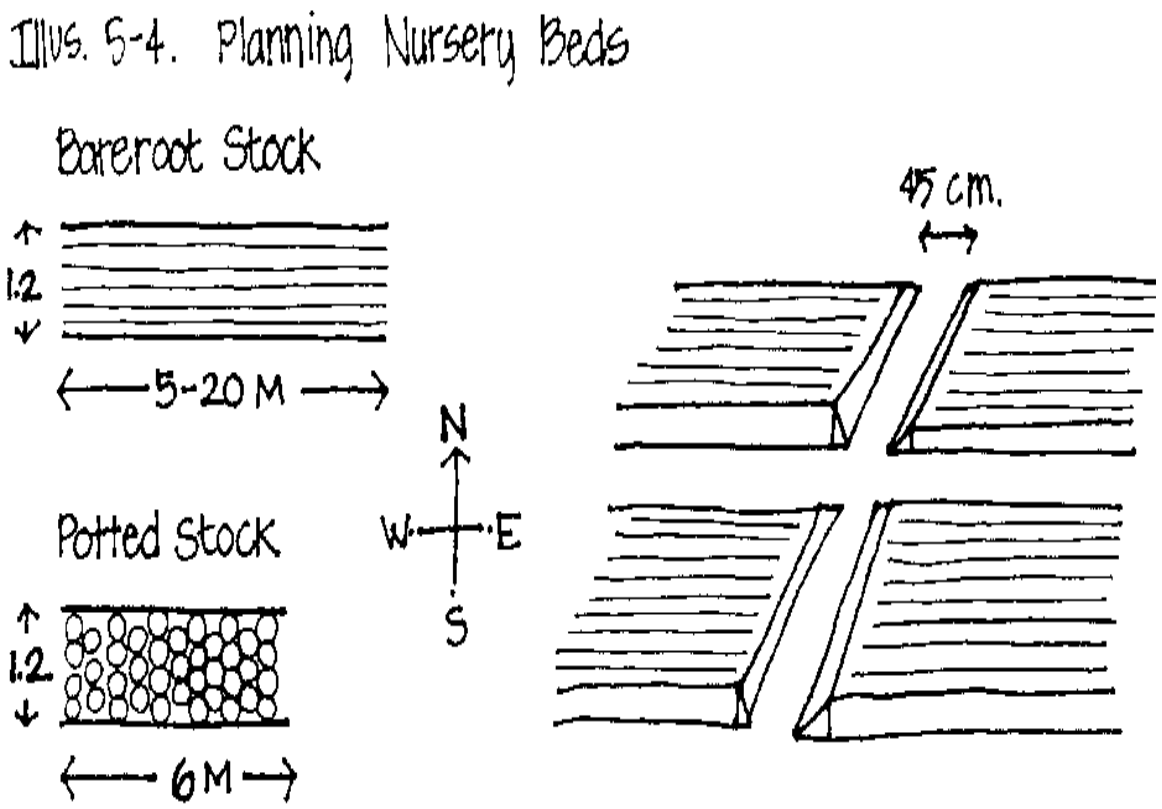
Water can become a limiting factor to nursery development. It may be necessary to carry out ground, surface, and rainwater schemes to assure an adequate supply.

Space

Space considerations are determined by the needs of the plants and the community, how much time and money is available, and how easy it will be to acquire written consent and permission for use of the land. Consider sites that allow expansion if extra room is likely to be needed or desired.

Estimating the amount of space required

First, the number of trees required by the project is determined by considering the overall project design and the capabilities and needs of the community. After determining numbers, the total space for the nursery can be calculated. As a general rule, when estimating the area needed for a nursery, use the following guidelines: for open-rooted stock, 1,000 trees need 10 square meters of space; for potted stock, 1,000 trees need 7 square meters of space.



After calculating the area, add 15-25% of the above figure to account for the miscellaneous needs of the nursery, such as extra nursery beds, walkways, roads, work sheds, firebreaks, and research areas. It may be tempting to add even more space, but doing so w ill add to the overall cost of the nursery because additional fencing, maintenance, and other items will be necessary.

A sample calculation to estimate the amount of space needed would take the following form:

A community forester decides that 800 trees per year would best suit the community's needs, resources, and capabilities. If pots are not locally available but a good site with good loose soil is available, it will be suitable for open-rooted stock.

For 800 trees, using the open-rooted method, the initial calculation is 800 x 10 sq. m = 8,000 sq. meters; 8,000 sq. m x 0.15 = 1,200 sq. meters, or 9,200 sq. m total, 8,000 sq. m x 0.25 = 2,000 sq. meters, or 10,000 sq. m. total. The size of the nursery should range between 9,200 and 10,000 square meters.

Nursery design and preparation

Good design and preparation will increase the efficiency and productivity of a nursery operation. Unnecessary deaths of seedlings can thus be avoided, which is crucial when a project requires a specified number of trees in order to be economically efficient.

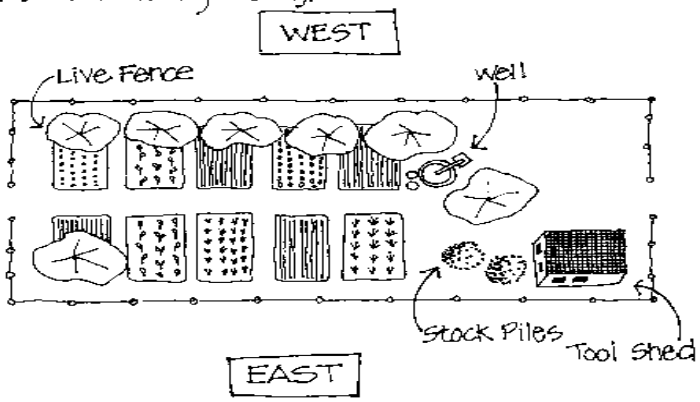
Nursery design depends on the site. Some general guidelines exist that can help in the initial stages. Draw out your design so that the best overall nursery plan can be developed, and so that alternative plans can be easily formulated. (See Illus. 5 - 5.) The size, orientation, and location of the nursery beds are important considerations. Beds should be 1.2 m in width for ease of weeding; their length will depend on the shape of the nursery. Orient the beds with the long dimension of the bed running from east to west. This orientation

allows even exposure throughout the day for the trees on both the inside and outside of the bed. If the area is level create a slight slope to facilitate surface runoff.

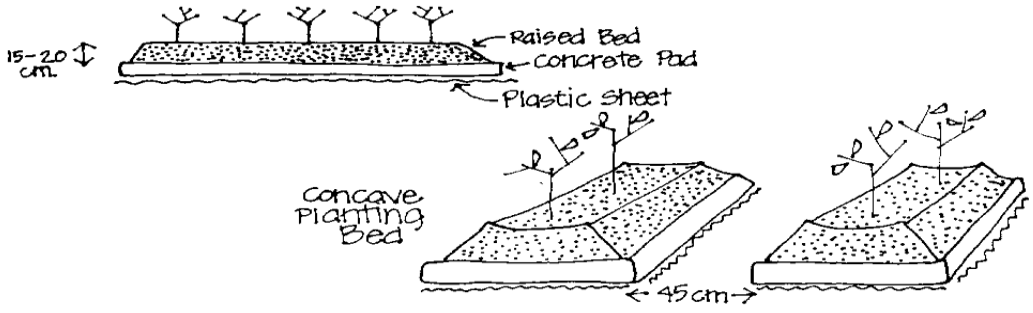
The beds should be separated by walkways that are at least 45 cm wide, allowing people with wheelbarrows easy access for weeding, pruning, and other treatment. Beds should be slightly raised above the walkways, at least 15-20 cm. This allows good root penetration and easy maintenance. A slightly concave shape is recommended for the top of the bed. This controls erosion of the sides and enhances water retention.

If the nursery is permanent and the budget allows, lay a concrete pad as a base for each of the beds. The pad will deter roots from penetrating too deeply, as well as facilitate surface runoff. Another option is to line the bottom of the beds with plastic sheets. Large fruit tree plantations use plastic bags to cover the fruit during crucial periods. When split they make excellent liners, and plantation managers are often willing to provide them free of charge. (See Illus. 5-6.)

Illus. 5-5. Nursery Design



Illus. 5-6. Planting Bed



Space should be made available for a walkway right up to each bed. This access will avoid long carries and allow quick loading of seedlings for transport. Other items to work into the design include supervisor's quarters on the site, a work and storage shed, a soil compost pile, a water supply or well, a research area, and germinating beds. The space allotted to each of these will depend on their importance to the project, their size and the size of the project, and on the availability of space.

Light and shade

Seedlings tend to be fragile following sprouting and transplanting. This is due to the immaturity of the root system, which is unable to support the seedling during times of stress. The harsh sunlight can be a serious threat to these young plants. On the other hand, seedlings require increased light as they mature in order to maximize the rate of growth. For this reason, it is best to pick a site with both shade and open areas. Protect the seedlings until they are hardier, and then move them into direct sunlight. A site with carefully placed shade trees is a good idea, although too much shade will slow the growth of seedlings, (See Illus. 5-7.) It may be possible to thin out tree cover, but no large sections of tree should be cut out if the objective of the nursery is tree conservation.

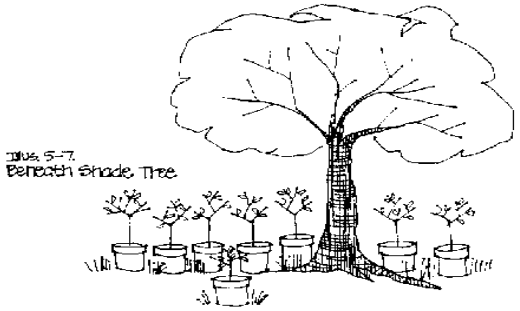
If no trees exist, shading for young seedlings may have to be constructed, especially in hot, dry areas. Use local resources, materials, and labor for the reasons listed above. Spread raised woven mats and banana and other leaves across seedlings as shading. (See Illus. 5-8.) Prior to planting, sow fast-growing tree species around the perimeter of the site.

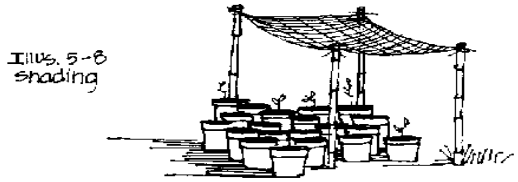
As an intermediate step between shading and full sun, seedlings in pots can be half-buried in trenches dug in the shape of nursery beds. This step limits the amount of water lost--the major form of stress caused by excess sun--yet allows full exposure to the sun much earlier, for faster growth. (See Illus. 5 - 9.)

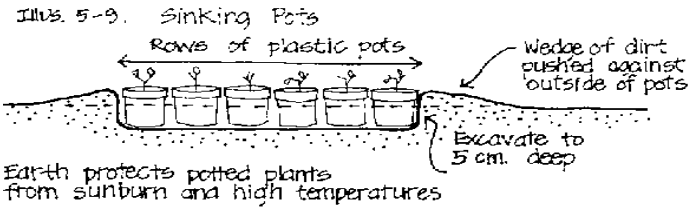
Protection and maintenance

Besides drying out, harsh sun, and the dangers to seedling growth cited above, other problems exist of which nursery managers must be aware. These include dangers from livestock, people, pests, and fires.

Seedlings have no chance for survival if they are trampled on or eaten by livestock. To protect the area from livestock, 24-hour surveillance or fencing is required. This may not seem to be so important where few livestock roam, but it may only take several animals to wipe out months of work. A combination of fencing and surveillance may be necessary if other problems include theft and pedestrian traffic.







For surveillance, people must be available and willing to work regularly. In the case of a permanent nursery, a worker may be willing to live at the site. The cost of paying workers must be considered, as it is unrealistic to hope that people will volunteer to watch the nursery for the entire time it will be operating. Food, money, shelter with land, or any other locally acceptable form of payment should be used.

Fencing is the best alternative to hiring a full time worker. The type of fencing used will depend on availability and purchase and construction costs. Cost and availability are usually linked: the cost of the fencing often depends on the type of material available.

Before deciding on the type of fencing, determine the local land use patterns. Be aware that fences may cut off a walkway or traditional grazing area of which you are unaware. Plan around customs, and ensure that change will not adversely affect area residents.

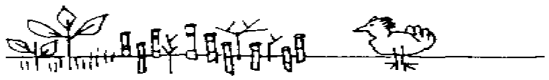
Local materials may be used entirely or in part to save money. Bamboo, wood stakes, layered branches from thorn trees, and other structurally sound materials are adequate assuming they are maintained regularly.

Design the fence to keep out all types of animals. Several wires strung four feet ok the ground may keep out large animals such as cattle and mature pigs, but it will not deter piglets or chickens. It is necessary to add thick brush or additional wire at the base of the fence to keep out piglets. Chickens are almost impossible to discourage if it is not a local practice to clip wings at birth. In this case only surveillance will work.

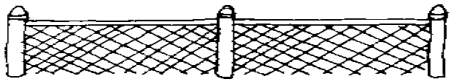
ILLUS 5-10 FENCING MATERIALS

LIVE FENCE

BAMBOO FENCE



BAMBOO OR STICK STAKES



METAL FENCE

Fire can ruin a nursery in short order. Check sites for history of fire. Know the dry season months and plan accordingly. Encircle the nursery with a firebreak, and conduct regular patrols to prevent build-up of materials that will allow the fire to pass into the nursery. If available, water should be kept on hand during dry periods to fight any small, controllable outbreaks.

Wind can dry seedlings out entirely or damage them to a point where their chances of survival are lowered. If possible, choose a site with a natural windbreak such as forests or hill slopes, or construct a windbreak. The general rule is that 2.25 times the height of the fence is the distance from the fence that is protected from the wind. Therefore, a 1 m fence will provide 2.25 m protection downwind.

Infestations can come in many forms, but the most serious ones involve insects, nematodes, fungi, and bacteria. The range of possible pests is beyond the scope of this book. Insects and diseases specific to particular species are listed in Appendix C. Local forestry extension agents can provide more information on specific insects and diseases in the area. If an infestation is suspected, institute the following procedures.

o If possible, isolate affected trees and burn the infected parts. This will limit the spread of the problem.

o Identify the pest as best you can. Drawings of insects (or photos) will help extensionists identify problems if they cannot visit the site. Most government forestry services have manuals to help identify common insects and diseases. If the pest cannot be seen, a drawing or photo of the effects on the tree(s) can also help in identification.

o Enact controls. Consult extensionists, local people, and other foresters working in the same area for information on possible controls for infestations. All possible techniques should be considered before decision(s) are made. It may be advantageous to use a powerful control, such as pesticides, or a less risky and less expensive technique such as integrated pest management. Other forms of control include wider spacing, plant diversity (this is more difficult with nurseries than in the field), and companion planting.

Propagation methods

The two methods of propagation are propagation by seed and vegetative propagation. Each has advantages and disadvantages that should be considered in planning the nursery.

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Propagation by Seed

Propagation by seed is the primary method of propagation used for tropical trees, especially fruit trees. It is a natural method that is easy to implement. It produces a seedling free of virus and with a high root/shoot ratio. Another advantage of seeds is the initial supply of food available to the seedling from the seed endoplasm.

Propagation by seed is carried out in the nursery by either sowing in pots or sowing in beds to produce open-rooted stock. It is important to decide correctly on which of these two methods to use, as the decision will have a great impact on many other aspects of the nursery and site planting. This is especially true for space, care, labor, transport, and cost considerations.

Open-rooted stock: The open-rooted stock method involves grow ing seedlings in beds and lifting them out when they are mature, with little or no soil attached. Beds can be raised 10-20 cm, or can be at ground level. Make beds of improved soil over the subsoil, or over plastic sheets or concrete pads, so as to prevent the roots from attaching to the subsoil. Open-root stock can be started from seeds in the beds, or from seedlings that are placed in the beds after initial development elsewhere. The major advantages to the open-rooted method are as follows:

o Less nursery care: open-rooted stock require less day-to-day care in the nursery because plants are not as exposed as potted stock, unless the pots are sunk in the ground. Root pruning is not necessary.
o Lower initial costs: The purchase of pots and other materials is not necessary, although other cost factors must be considered (and may favor pots).
o Lower transport weight: Plants are moved without soil, wrapped in protective covers (large leaves, etc.) which prevent them from drying out. They also take up less room, as the seedlings can be stacked atop each other.
o Less time to transplant: Open-rooted stock go into the ground faster at the planting site because they don't have to be removed from pots. This reduces labor requirements during planting.

Disadvantages of the open-rooted method:
o More nursery space needed: Open-rooted stock must be spaced farther apart, so more space is needed to grow the same number of trees. This can add to the overall cost of the nursery and its operation.
o More nursery time needed; Although they require less attention, open-rooted stock must be kept in the nursery longer because they take longer to mature to a form ready for planting. This time adds to the project cost.
o Need for good soil: Open-rooted stock is planted directly the existing soil. This soil may be improved to some degree, but reconditioning all of the soil will cost a great deal compared to the cost of producing soil for potting. Soil must be kept loose for ease of lifting, and roots must not be allowed to reach a depth where they anchor to the untilled soil.
o More root exposure during planting: Open-rooted stock are lifted out of the ground and transported directly to the site. This increases the chances of roots drying out and being damaged.

Potted Stock: A fertile soil mixture is placed in any type of available pot or container. Plastic bags, which are often available from government operated nurseries can be a substitute for regular pots. If using bags, cut holes in the bottom to provide drainage. Embed viable seed into the mixture, and at the desired age, carefully remove both the seedling and the soil ball from the pot and transplant them into the ground. The pot can be reused many times. Some pots can be planted with the tree and will decay in the ground, feeding the plant and allowing the roots to grow through. Advantages to the potted stock method are as follows:

o Soil: Good soil brought in to the nursery or developed (by composting or other methods) can be substituted for poor on-site soil.
o Seedling spacing: Seedlings can be placed closer together, requiring less overall space for the same number of plants than the open rooted method.
o Less nursery time: Potted plants develop faster and are ready for planting in less time than open-root stock.
o Ability to wait: As long as potted plants are kept watered and their roots pruned, planting can be delayed. Open-rooted stock must be planted immediately. This is important if planting could be delayed for unexpected reasons.
o Less root damage: Potted trees suffer less damage to the roots during transport and transplanting than open-rooted trees because of the protection provided by the pot.

Disadvantages to the potted method:

o Root pruning required: The roots of the potted plants must not be allowed to grow out of the pot or start spiralling inside the pot. This will lead to poor root development and hinder the trees' chances for survival. Every so often all pots should be lifted up and roots trimmed at the drain hole.
o More space needed for transport: Because pots cannot be piled on top of each other, more space is required during transport from nursery to planting site. An alternative is to outfit a truck or other transport device with shelving.
o Additional weieht during transport: Potted plants are heavier than open-root stock because of the soil. They must also be watered prior to transport to avoid drying out. This adds to the weight of the plant.
o Higher initial cost: Pots must be bought either from local crafts men (preferred) or imported from outside the community (such as plastic pots and bags). Many different pot designs are available. Pots must be ordered far in advance, as their absence will delay the entire project.

Steps in Seed Preparation: Obviously, seeds have to be gathered prior to planting and prepared in one form or another. There are four important steps to seed preparation: collection and extraction, storage, scarification, and sowing.

Collection and Extraction: There are two ways to collect seeds: order them from a seed supplier or collect them from the field. In obtaining seeds from an outside source, it order well in advance to ensure that seeds needed for the nursery or planting projects are available at the designated startup date.

Seed suppliers normally provide information on preparing their particular seed. To be on the safe side, request the information when the order is placed. Seeds purchased or received from outside sources should be fresh, reasonably dry but not dried out, and free of insects and other pests. Most government extension nurseries or private agricultural research institutes supply seeds free or at minimal cost.

If the tree species selected is available in the area, collecting is an excellent method for acquiring necessary seeds without the bother and cost of purchasing from suppliers. The best seeds come from strong, healthy parent trees which are disease free, bloom early, produce copious amounts of seeds or fruits, and in general exhibit qualities typical of the species. Groves of trees have an advantage in their greater variation in size, height, etc. Otherwise, more than one or two sources of seeds should be used to ensure a degree of variation in the parent material.

Harvest time is determined by the degree of ripeness of the fruit, which is indicated by a change in color, or by the softening of the outer tissue of the fruit and a hardening of the seed. The pod produced by most leguminous plants begins to dry out and turn brown to black. Overripe fruit may be lost to insects. One way to increase the efficiency of collection is to spread out mats beneath the trees and collect the seeds as they fall on the mat. Often the first fruits to fall will be infested with insects. Sweep them away and collect the fruits that fall next.

Seed collection can be a job the entire community can get involved in. Collect seeds as quickly as possible to avoid predation by insects and other seed-eating animals. If predation is very high, the seeds can be collected while they are still immature.

Germination rates will be lower than with mature seeds, but they may be greater overall due to the reduced predation.

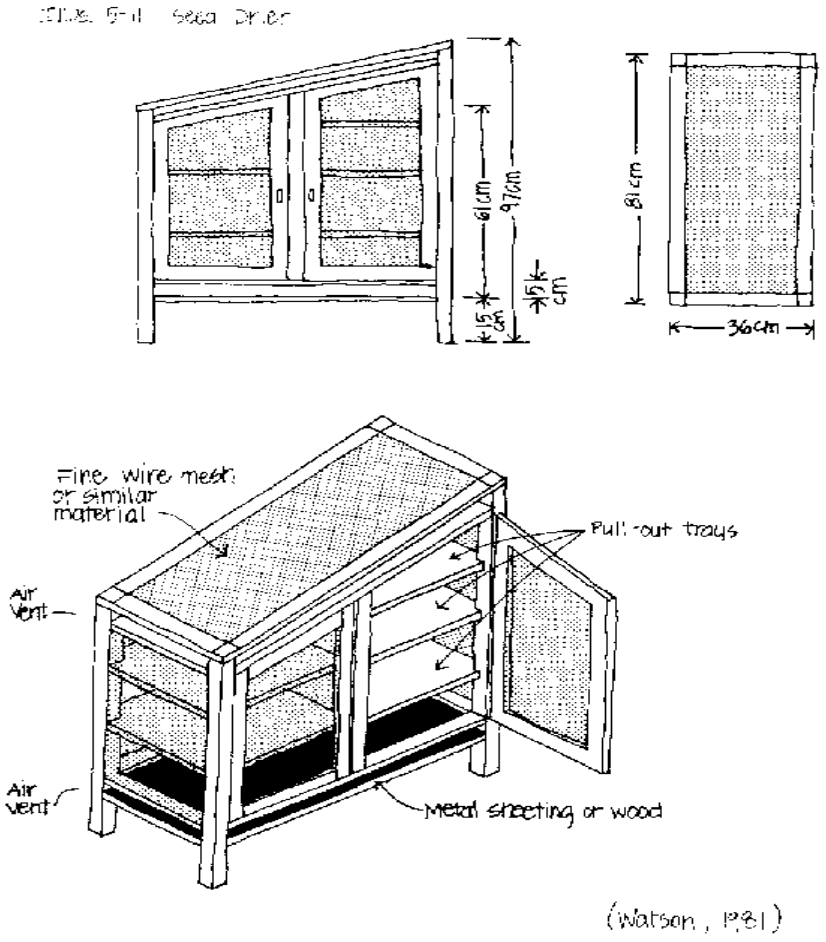
The method of extracting seeds from fruit depends on the type of fruit. Hard fruits (nuts, or stones inside soft fruits) may need to be ground using mortar and pestle or stones. Grinding can be done in bowls or on clean, hard ground. Some seeds may be released by soaking the outer shell and then drying it, causing it to crack. Soaking may also soften the shell, making it easier to pound the seed out. All pounding must be done with care so as not to damage the seed. Follow ing extraction spread the seeds on a hard, shady, dry area to facilitate drying. Do not put light- or heat-sensitive plants in the hot sun.

Seed storage

Seed storage is very important in order to keep the number of seeds needed for a project available and in good condition, especially since seeds may have to be collected and stored over a period of time until the necessary total is obtained. Seed storage is also a good way to maintain seed stocks for expansion or replacement, and to have extra seeds available for anyone interested in growing trees.

Seeds must be dried a bit before they can be stored, or they will rot. To dry them, remove all fruit from the seed. They should be air dried in the shade, as drying in the sun will overheat them and destroy their ability to germinate. Boxes that allow air circulation, such as ones with screening or other open bottoms, are good for both drying and storage. Whatever container is used, it must allow air to circulate and permit easy access to facilitate removal of spoiled seeds and rotation of seed positions. (See Illus. 5-11.)

Mark seed containers well and record their contents. Include information such as the species type, day(s) they were collected, where collected and who collected them, when storage was started, and the number of seeds in the container. Other information may include treatment of seeds, length of drying time, and germination times. Seeds must be checked frequently for spoilage, damage, and disease. Remove bad seeds, and turn the seed stock over frequently.



(Watson, P81)

Scarification

Scarification is the method by which the seed is prepared for planting and germination. Many seeds must be pretreated to stimulate germination. In most cases, the germination rate is increased with some type of preparation. The types of seeds that almost always need some kind of scarification are those with glossy, hard covers. The two most common methods are soaking in hot water and scratching. Soaking is preferred, as there is less chance of damaging the contents of the seed. For soaking, place the seeds in hot water (boiling water allowed to cool for 5-10 minutes) and let them stand for a few hours or overnight. Seeds are then ready for planting. For scratching, scratch or pound the outer layer with a knife, hammer, or stone. This allows water to reach inside the seed, stimulating germination. Some seeds may require both methods.

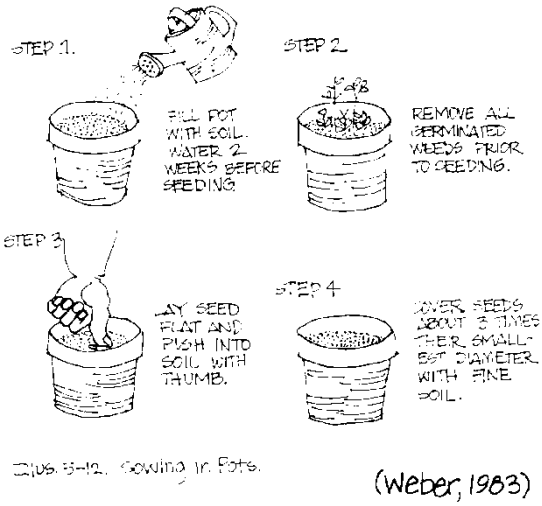
Methods of sowing

It is extremely important to sow seeds correctly, as the success of a project may depend on whether or not the seeds were planted in the correct fashion. When seeding in pots or nursery beds, it is important to prewater and weed. Two weeks before sowing, water the pots and beds every day. This distributes the water evenly and thoroughly throughout the soil and stimulates the growth of fungi and bacteria that are necessary for plant development. Daily watering will also germinate weed seeds in the soil, which can then be removed prior to sowing. This saves time and increases the survival rate of the seedlings.

Sowing in pots

Sowing in pots is a simple process. Fill pots with soil (a widemouthed funnel helps) and water two weeks before sowing. Remove all germinated weeds. Lay the tree seed flat and push it just barely into the soil with the thumb, and then cover it with soil. (See Illus. 5-12.) The depth of soil depends on the tree, but as a general rule it should be three times the smallest diameter of the seed.

The number of seeds in a pot depends on the expected germination results. If the tree species has a good germination rate, one seed is enough; otherwise two or three seeds may be necessary. To determine the rate of seed germination, place 1020 seeds between wet pieces of cloth or in a porous bag until the seeds germinate. The percent that germinate will give a good indication of the viability of the stock. This will determine the number of seeds to plant per pot.



Illus. 5-12. Sowing in Pots.

(Weber, 1983)

Open-root sowing in beds

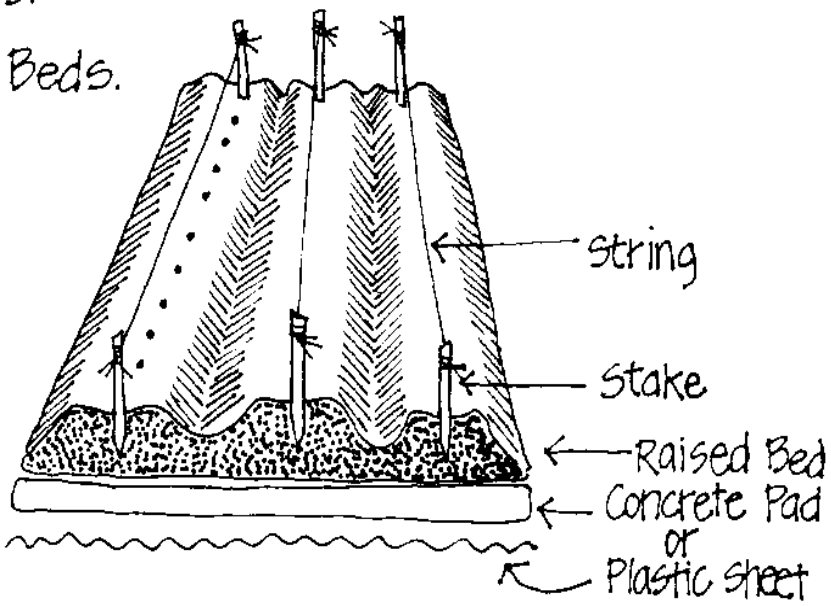
Open-root sowing in beds is similar to potted sowing, except that more seeds are planted. Again, the soil should be watered two weeks before sowing and weeded. A string stretched along the long axis of the bed helps to keep the planting straight, making cultivation and weeding easier later on. Once the seeds have germinated and the roots are well established, thin to the desired distance. It is a good rule to space the plants so the outer leaves do not overlap. This will aid in the prevention of disease. (See Illus. 5-13.)

Sowing at stake

Sowing at stake is only mentioned briefly, as it negates the need for a nursery. Some advantages exist for sowing at stake, including initial vigor and a firm beginning, less need for skilled labor and transport, and less damage to the taproot. The disadvantages to sowing at stake have to do with productivity, and in Plastic Sheet most eases they outweigh the advantages (exceptions exist, such as for Leucaena).

Illus. 5-13.

Sowing in Beds.



The disadvantages include increased difficulty in inspection due to the widespread distribution of the seedlings, holes in the planting pattern due to seedling death, predation, the difficulty of protecting and monitoring the seedlings, and the variable nature of seedling development. When nursery plantings are used, the land can be used for other means (farming, livestock) until the seedlings are ready, thus increasing its productivity. This option is not as easy to carry out when sowing at stake. Watering, weeding, and shading are also very difficult.

To sow at stake, clear and plow the site one month prior to planting. Two weeks before sowing add mulch, topsoil, ash, and compost and/or rotted manure to the soil, or to each planting hole. Place three to five seeds in each hole, 13-15 cm apart for ease of thinning. Use more seeds if the germination rate is poor. Seeds can fall victim to any number of domestic and wild animals and insects. If predation is high, individual fences of thorns or other materials may have to be used. During dry spells, it may be necessary to water each seedling. It will also be necessary to weed and thin each hole. Weed the immediate area around the plant, and use banana or palm leaves stuck in the ground to provide shade.

Vegetative propagation

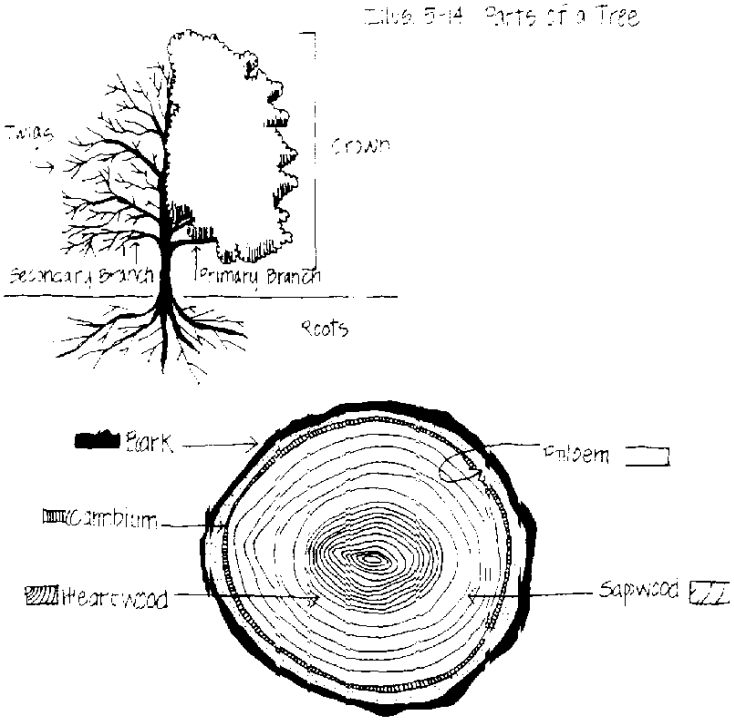
Vegetative propagation is a method by which a complete plant is reproduced from one of its parts. Vegetative propagation is generally used to replicate superior or rare tree specimens, and to shorten the time in which fruit trees reach maturity and productivity. The major types of vegetative propagation are division, marcotting and cuttings. Grafting, although not technically considered a type of vegetative propagation, is also a popular method. (For additional information of methods of vegetative propagation, see Hartman and Kester' Plant Propagation: Principles and Practices.

In order to propagate seedlings through vegetative means it is necessary to understand the crucial parts of a tree. (See Illus. 5-14.)

Division: In division, a part of the plant is stimulated to grow new roots and shoots and is then separated from the parent plant. Division is best done on plants like banana and pineapple, which naturally develop side plants or multiply by. The easiest division methods to carry out in the field are stooling and layering.

Stooling is the severe pruning of an established plant, one to two years old, and the covering of the plant base with soil. As new shoots emerge from the stump, they are covered with soil so that roots develop on the new shoots. These root/shoot parts are then removed and planted separately as new plants. (See Illus. 5-15.) The procedure for stooling is as follows:

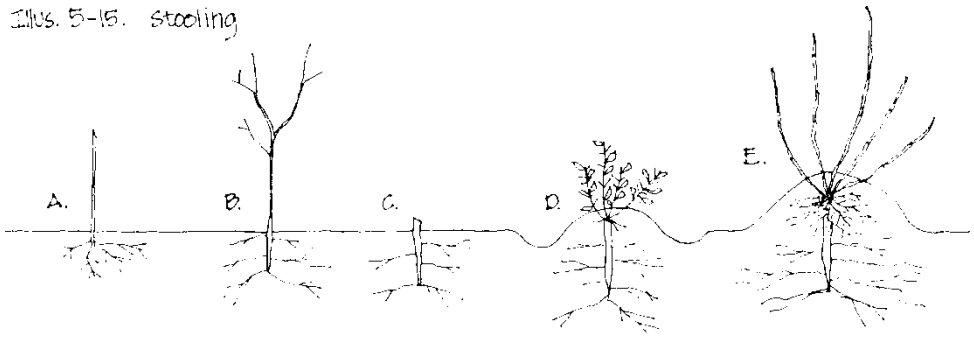
Illus. 5-14 Parts of a Tree



1. Cut down an established parent plant, about 1- 2 years after planting, approximately 2.5-5 cm above ground level. Seal the cut, not the stem, with wax or other available sealant.
2. Partially cover the emerging roots with soil, always leaving some leaves exposed. Eventually the soil should reach a height of 15-20 cm.
3. As roots develop on the individual shoots above the parent plant, collect and treat them as new plants.
4. Expose the parent plant to the original soil level to start the process again.

Hearing includes many techniques, any of which can be modified in the field. The basic technique forces the parent plant to grow close to or under the ground, covering parts of the stem with soil and causing the parent to develop new roots on the stem. The stem and roots are then removed and planted as new plants. Most layering techniques take a long time. A common form of layering is the etiolation method. (See Illus. 5-16.) The procedure is as follows:

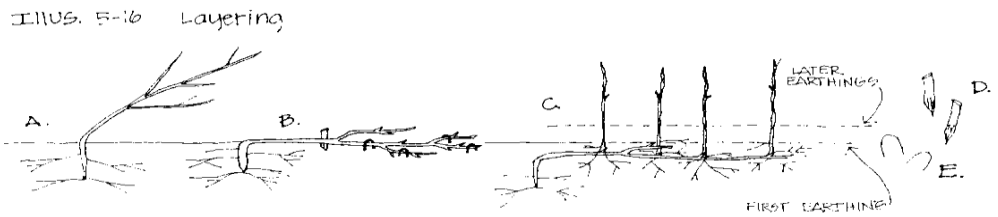
Illus. 5-15. Stooling



A= Newly planted parent. B= Established parent. C= Parent one year after planting. D= New shoots. E= Rooted shoots on the stool ready to collect.

1. Plant stock at 45 degree angles, facing the same way, 1.8 m apart.

2. After one year, peg the plants flat and cover them lightly with soil 2.5 cm deep.



A = Newly established parent. B = Established and pegged shoots on the parent C = Rooted D = Home made wooden pegs E = Wire (gauge 10).

3. When new vertical shoots form, place a heavy covering of soil (to one half the height of the shoot) on top. Maintain this depth by periodically adding new soil.

4. When the shoots mature, cut them off and plant.

Narcotting (air layering3. Marcotting is an ancient method of propagating plants. It differs from other methods used because the stem is induced to the root while still attached to the mother plant. It is practiced on many types of fruit. These include jackfruit, guava, guayabano, avocado, mango, cashew, and citrus. Marcotting is an easy, well-proven method of propagation.

For marcotting, the condition of the stem is extremely important. Young stems, such as year-old shoots, are best as they are generally the fastest growing parts of the plant. The stem should be completely girdled, not simply notched, since the flow of starch down the stem must be completely interrupted in order to promote new root development. This must be done without interrupting the flow of water upwards in the xylem or bark. Care must be taken in determining the depth of the cut. The length of the girdle is not critical, but it should range between 0.3 and 7.6 cm. Generally, the best time to start the process is 30-100 days before the rain or planting season, but timing is not a crucial factor. The procedure is summarized as follows:

1. Girdle stem (removal of a ring of bark around it) below a node 3-5 cm long. Cut to the depth of the cambium layer. After removing the ring of bark, scrape the cambium layer but not too deep to prevent healing before root formation takes place.

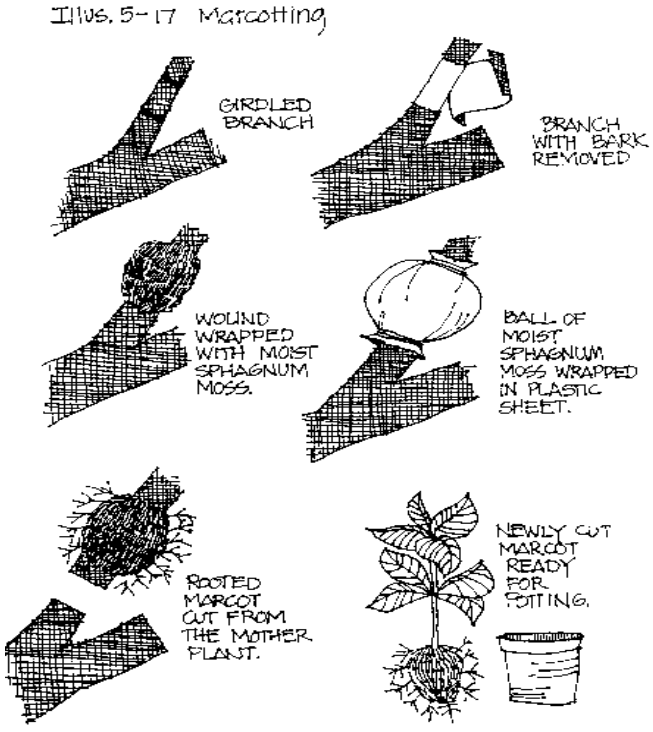
2. Cover the cut with a rooting medium and seal it with a waterretaining material such as sphagnum moss, coconut husk, sawdust or wood chips. The medium should be open in structure, allowing air and water to flow in and out of it. When roots develop, cut off the stem below the girdle and plant it as a new tree. For plants that root easily this can be accomplished in as short as one month. It may take from six to 12 months for those that are difficult to root.

3. Wrap the medium tightly with a waterproof covering that will prevent drying. It is especially important to tie the top of the cover to prevent excess water from flowing down the stem into the medium during periods of high rainfall. The rain will rot the medium and the developing roots. Polyethylene is normally used for the wrap, as it allows observation of the roots as they develop and is completely waterproof. If possible, shade the wrap to prevent overheating in the sun.

4. Remove the wrap and slowly remove the new plant by making slightly deeper cuts below the root bundle over a period of 1-2 weeks. After cutting, remove some of the leaves and place them in a nursery (in pots or as open-rooted stock) until they have developed fully and can survive field planting. (See Illus. 5- 17.)

Cuttings: The procedures for developing new plants from cuttings involve removing a part or parts of a plant and placing it in a medium in which it can mature into a complete plant. Most parts of the plant can be used, such as the root, stem, leaf, bud, leaf-bud, etc. The medium should be moist and rich, and the cutting must be protected until it is planted.

Cuttings are effective for plants whose parts quickly develop new roots, and for non-woody plants upon which division techniques cannot be carried out. Because the cutting has no parent plant to draw support from (as in layering), it is necessary to provide artificial support in the early stages of growth. Carrying out cutting techniques requires that the following criteria be met:



(Garner and Chandri, 1976)

1. The part to be reproduced must be healthy and vigorous, neither too mature nor too immature. The best cuttings are from the tops of the trees, where growth is more vigorous, the shoots are firm, and a high leaf/shoot ratio exists.

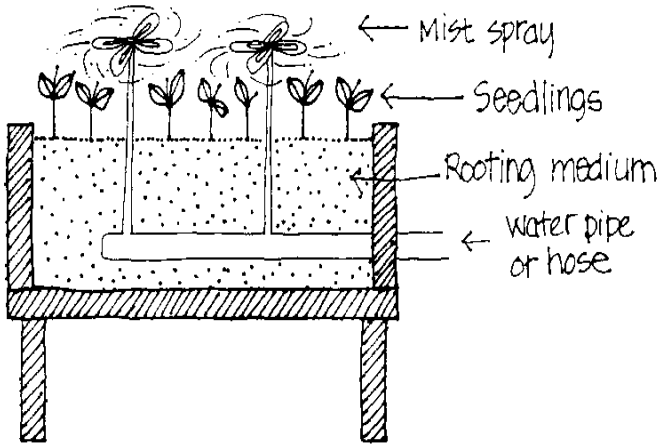
2. The treatment of cuttings is very important. Adequate temperature and aeration at the rooting end of the cutting are necessary. Water must always be available in proper amounts. When collecting cuttings, protect them from drying. The best way to do this is to collect them early in the morning, when temperatures are low and the plants are fully turgid Wrap them in moist covers until you are ready to transfer them to a planting medium. Avoid putting the cuttings in water, as many important nutrients at the base of the cutting will be washed away.

3. The planting medium should be a mixture of sand, clay, loam, moss, and/or fiber. It should be prewatered and weeded before the introduction of the cuttings, as excess competition from weeds for water will adversely affect the cuttings' chances of survival. It is also very difficult to remove weeds without damaging fragile cuttings, since their roots often intertwine. Protection from drying and the sun can be achieved by placing cutting beds in the shade, in pits or trenches, or under baskets or makeshift tents and tunnels. The planting environment must keep the plant alive and provide for the start and development of new structures. The greatest problem w ill be preventing the cuttings from drying out, especially cuttings that must develop roots.

The general rule for temperature in the medium is warm bottoms and cool tops. Keep rooting beds warm to help roots develop.

This can be achieved by warming bins or covering the soil with dark material to absorb sunlight. Warm water can also be used. To keep the tops cool, spray a fine mist of water regularly throughout the day. This will allow cooling by evaporation and help prevent the plants from losing water. Some nurseries have automatic mist machines. Every several minutes a timer activates the release of water through several nozzles strategically placed in the bed. Although this is an easy way to provide water, the system requires electricity and capital outlay. (See Illus. 5-18.)

Illus. 5-18. Mist Sprayer



4. When the new plants are mature, they must be hardened off; that is, made ready for living in a harsher environment. To do this, gradually reduce the amount of misting during development until the plant is only misted during the hottest part of the day. Shading should also be gradually reduced. Increased watering of the medium may be necessary to maintain turgidity when hardening is carried out. At this time, nutrients can be introduced to stimulate growth and complete development.

5. Move plants carefully to the nursery or planting site, and plant them as quickly as possible.

Many of the new plants developed from vegetative methods of propagation should spend a period of time in the nursery to increase their chances of survival when planted in the field. Often they must be placed in beds and treated as open-rooted stock.

Grafting

Grafting is a process of fusion between two different plants. It allows the multiplication of parts of one plant at the expense of another. Grafting is used for plants, especially woody plants and certain fruit trees, that cannot be easily propagated by division or cuttings. The objective is to use plants selected for their specific favorable properties. For example, good fruit-bearing stems from one tree may be grafted to a tree with superior root characteristics. Grafting can also be used to repair damaged trees, thus bringing them back into production quickly. Sometimes grafting is the only way to propagate a certain variety, or cultivar (cv.). Finally, grafting can be used to invigorate weak plants.

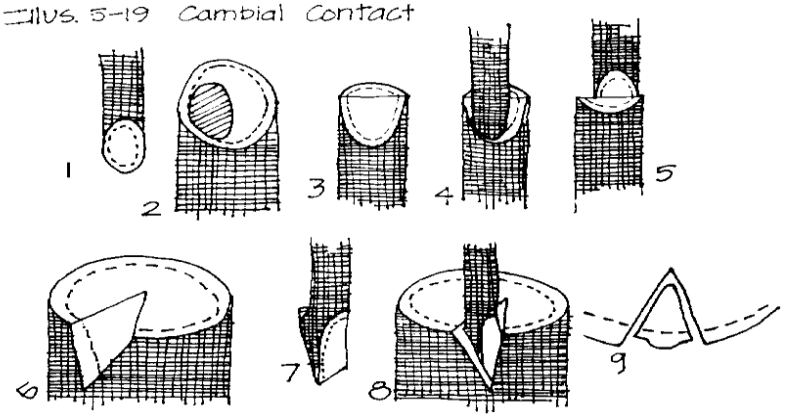
There are four requirements for successful grafting which are discussed below. They are compatibility, live parts, wounding, and anchorage.

Compatibilitv refers to compatibility between the root stock (the base plant being grafted to) and the scion (the piece from another tree to be fused to the stock). The rule is that stock and scion should be at least in the same phylogenetic family. It is better if they are in the same genus. The closer the two trees are related, the greater chance for a successful graft.

Live Parts are necessary for a successful graft. In other words, both the stock and scion must be entirely alive; attempting to use either with dead parts will hinder grafting sueeess.

Wounding is the initial step in a successful graft. The cambia of both the scion and stock are exposed, placed in contact with each other, and allowed to heal as one scar to seal the two parts firmly together. (See Illus. 5-19.) This can be difficult, since stock and scion may have different diameters, or their internal tissues may be of different sizes.

Illus. 5-19 Cambial Contact



1= Scion with thin rind. Cambium (dotted line) close to the outside of the rind. 2 = Stock with thick rind. Shading indicates cut surface of scion and limits of cambial contact. 3 = Stock prepared to achieve good apical and basal contact with scion cambium. 4 = Scion applied to stock. Note good contact at base and matching of inner rind (cambium) rather than outer rind (bark). 5=Good cambial contact at top of stock. 6 = Large stock with thick rind prepared for thin scion. 7 = Scion with thin rind. 8 = Stock and scion fitted. Note parts of stock rind outside the scion. 9 = Cross-section. Note alignment of cambia and unmatched barks.

(Hopitan, 1975)

Anchorage is necessary to make sure that the alignment of the cambia and other parts remains inteet. As with any wound, continually opening it impedes proper healing. Good anchorage keeps the seal unbroken, allowing the two parts to heal together. Anchorage is achieved by tying the stock and scion together in various ways; the cuts themselves can also be made in such a way as to hold the parts in place, as in wedge grafts. Scions can be nailed directly onto big trees. Fastening materials include natural fibers such as raffia, rubber strips and patches, and plastic strips.

Proper scion and stock selection is also important for success. Scions should be picked from shoots that have been exposed to light at the upper and outer part of the donor tree. These shoots are superior because they tend to be better developed. Also, because they are situated toward the outside, they have remained drier and freer from mildew. Avoid the apex, as its growth is too lanky. Stock should be mature plants with healthy, well-developed root growth, located in an area with space adequate for additional growth.

The basic procedures for all grafts are simple but require practice. Specific instructions for various types of grafts will follow.

1. Cut scion and stock and prepare them according to the method to be used. Strong, sharp tools are needed, such as knives, chisels, cleavers, shears, and saws. They must be kept clean. After cutting, remove the scion leaves at the base of the stem to save water until the graft has somewhat healed. It is necessary to provide cool storage for the scions if there is a long wait before the graft occurs.

2. Fit the scion and stock together, making sure the cambial layers are well exposed to each other. Anchor the parts reasonably tightly so as to prevent movement but not to inhibit growth in any way.

3. Seal the outside of the graft or wound. Many recipes for seal ant are available. They generally include mixtures of clay, wax (such as beeswax), and other materials. Local resources should be used when possible. It is also advantageous to check with local growers to find out materials that are cheap, easily available, and commonly used.

The easiest type of grafting is detached grafting. Other forms, such as approach and bench grafting, are more cumbersome and require a lot of room and time to carry out. Detached grafting, on the other hand, is simple enough to carry out with minimal tools and space. It also requires less labor per graft and is easier for mass production of grafts. The two best types of detached grafting for community forestry work are bud and apical grafting.

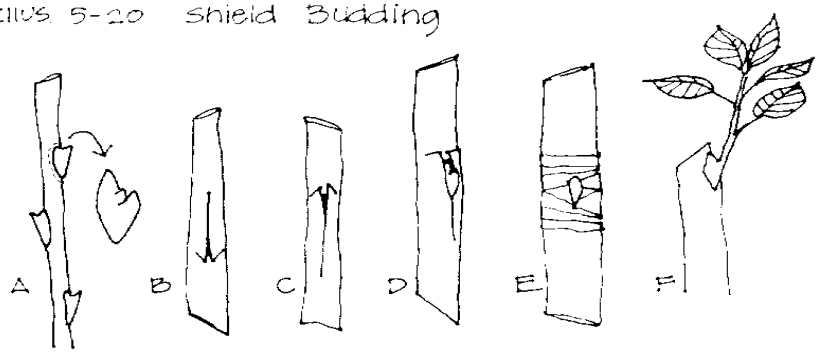
Bud grafting involves using a single bud or cluster of buds as the scion. A small amount of supporting tissue is normally included in the scion. Shield (or T-budding) and patch budding are the easiest forms of bud grafting and produce good results.

Shield budding

Shield budding is commonly used on citrus. It is a good method for stock with a flexible rind (outer layer) that is not too thick and is easily separated from the wood. The current season's growth of the donor plant provides the best scion bud-wood, as the buds are small enough for easy insertion. Buds from older growth can be used only if they are still actively growing and are not too big.

For shield budding, a good bud is removed from a branch by a shallow cut which slices out the bud and underlying cambia. (See Illus. 5-20.) Start the cut about 1-2,5 cm below the bud, pass under it, and come out about 5-7 cm above it. The part cut out behind the bud is the bud shield. It should have a sliver of wood around it for support of the cambia, yet be thin and flexible. This will assure that the scion will be able to bend around the stock's stem. A long cut provides a handle to help manipulate the scion. The handle is cut off after inserting it in the rootstock.

Illus 5-20 Shield Budding



A = Budstick with bud removed. **B** = Rootstock with inverted T cut. **C** = Rootstock with a regular T cut. **D** = Bud inserted into rootstock. **E** = Bud secured in place with a budding tape. Plastic ribbon can also be used. **F** = Root stock cut above the point of union.

(Hopitan, 1975)

Following removal of the bud, make a vertical incision about 2-3 cm long and as deep as the bark. Make a cross-cut above the vertical cut, thus forming a T-shaped cut. Peel the rind away carefully, and insert the bud into the slit made on the root stock until it is even with the cross-cut. Once the bud is set in place, tie the T-cut securely with a budding tape. Keep it covered tightly for 10 to 14 days, then unwrap and expose the bud.

Variations of the shield budding method exist and should be employed when the species or environment demand it. One variation is removing the wood from the shield. Another is the inverted T method, where the horizontal cut is on the bottom. This is used in very rainy areas to reduce the amount of rainwater entering the graft and causing rot. It may also increase the amount of nutrients available to the graft, since T-cuts with the horizontal cut on the top interrupt the food flows from the top of the stock into the scion. For the inverted T method, it is necessary to reverse the cutting stroke on the scion bud, starting just above the bud and extending the cut below the bud. It is a little more difficult to place the scion with this method.

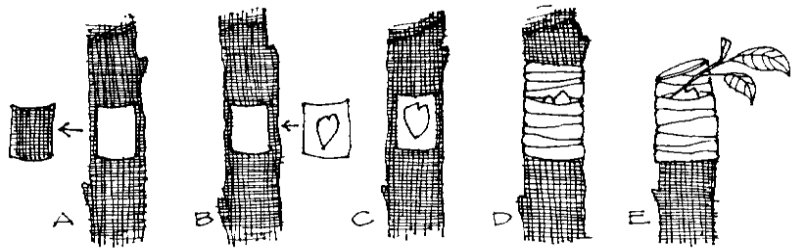
Patch budding

Patch budding is used widely on fruit trees with thick bark. Fruit tree successfully propagated using patch budding include santol, rambutan, and durian.

It is a simple process in which a rectangular patch of root stock is removed and replaced by the same size patch containing a bud from the scion. The stock and scion should be of the same age and diameter. Timing is very important; the best period to carry out the procedure is when the scion buds are just starting an active growing stage.

The procedure involves the following steps (see Illus. 5-21):
1. Make two parallel horizontal cuts, one above and one below the scion budwood. Extend the cut through the bark to the wood. Cut the root stock similarly, but make the horizontal cuts slightly farther apart than on the scion.
2. Make two vertical cuts on the scion bark, connecting the horizontal cuts and form ing a rough rectangle. Remove the piece containing the bud. Make a single vertical cut in the root stock and peel the bark back. Slowly insert the scion while peeling back the bark, taking care not to damage the bud.
3. When the scion is fully inserted, make a second vertical cut in the rootstock to remove the loose bark and provide a tight fit. No edges of bark should be exposed.
4. Tie the scion patch to the root stock. It may be necessary to seal the edges of the patch and to shade the bud with a leaf tied above the patch.

Illus. 5-21 Patch Budding

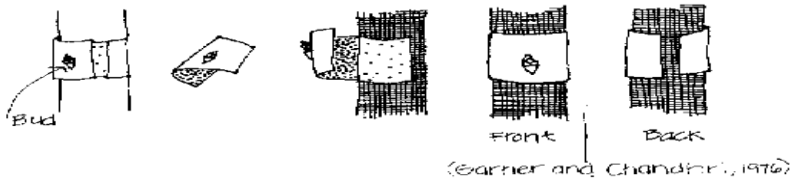


A = Rectangular bark removed from rootstock B = Rectangular bark with bud removed from the scion C = Bark with bud placed to the root-stock D = Bud secured in place with budding tape. Plastic ribbon can also be used E = Rootstock cut above the point of union. (Hopitan, 1975)

Other buddings

Other patch budding methods include flute, ring, and chi-D budding. Flute budding is just an extended patch, using up to 7/8 of the diameter of the scion and stock. It is used when a strong anchorage is necessary (see Illus. 5-22). Ring budding is similar, except the scion and stock are completely girdled down to the wood. Both these methods require parallel horizontal and vertical cuts, and the above procedures can be followed. Chip budding is convenient in anchoring and cutting (see Illus. 5 - 23). It involves a thick chip being cut out of both stock and scion. The method provides excellent cambial contact and ease of tying. It is particularly adapted on fruit plants with barks that do not slip easily. It is also useful on grapes.

Illus. 5-22 Flute Budding



(Garner and Chandhri, 1976)

Illus. 5-23 Chip Budding

A. Scion notched below bud. B. Chip made above and down and around bud. C. Chip bud removed. D. Chip cut made in rootstock. E. Chip bud placed in rootstock. F. Scion starting to grow

(Garner and Chandhri, 1976)

Apica grafting

Apical grafting is end-to-end grafting. There are numerous ways to graft in this manner, depending on the connecting pattern used. In fact, the number of methods of apical grafting is limited only by the ingenuity of

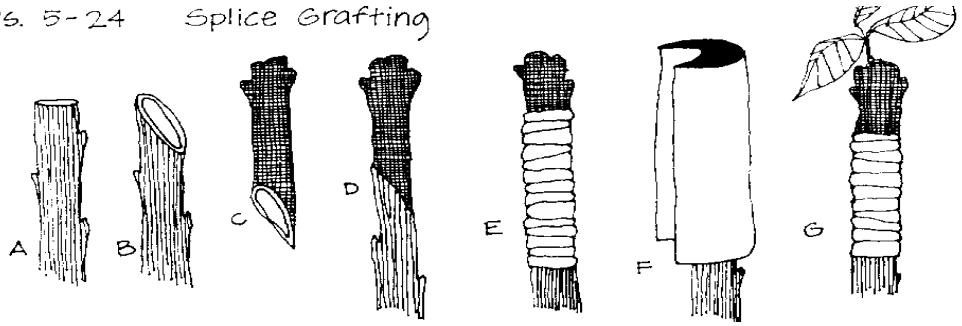
grafters and their grafting ability. It is good to remember that the same four essential requirements for any grafting technique must be met for apical grafting: compatibility, live parts, wounding, and anchorage. Apical grafting is advantageous for anchorage because the stock and scion are cut to fit tightly, and the pattern used can add to the stability of the joint.

Four apical grafting methods are especially important to tropical Pacific forestry, although many other good methods exist. Each of these leaves a lot of room for variation when necessary. The methods are splice (whir) grafting, whip and tongue grafting, wedge (cleft) grafting, and oblique wedge grafting.

Splice grafting

Splice grafting (or whir grafting) involves making single diagonal cuts that match each other in both stock. (See Illus. 5-24.) Diameters of identical size improve the bond between stock and scion. This is the easiest form of apical grafting. Its major drawback is that it is difficult to hold scion to stock when tying them together; they tend to slide apart. The procedure is otherwise simple.

Illus. 5-24 Splice Grafting



A= Rootstock cut back to the point of grafting. B= Rootstock with a slanting cut C= Scion with a slanting cut. D= Scion fitted to rootstock E= Graft secured firmly with a budding tape. Plastic ribbon can also be used. F= Scion protected with banana petiole. G= Scion starting to grow.

(Garner and Chandhri, 1976)

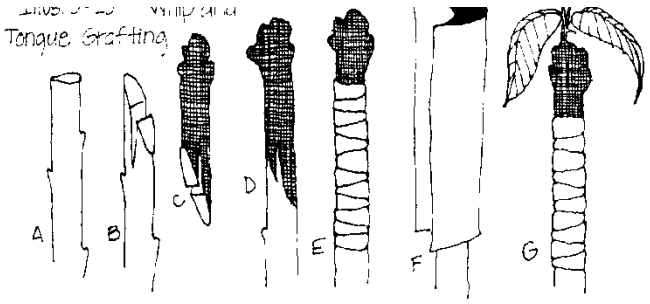
1. Make a slanting cut, as long as is convenient to manage, at the bottom of the scion. Make a cut of identical length and angle in the top of the stock.

2. Place the open surfaces of the stock and scion together so that the cambial areas are in complete contact. Tie the two parts together and seal the cut.

Splice grafts can be used when stock and scion are of unequal diameters, so long as the cambial regions have good contact. Open tissues should also be sealed, so that excess water does not penetrate the plant and cause rot.

Whip and tongue grafting

A whip and tongue graft is similar to the above method, but an extra lip of wood (the tongue) is left in the stock to stabilize the union and allow ease of tying, especially for very small stems. (See Illus. 5-25.) A matching insert is cut into the scion to allow the tongue full contact. When good, sharp tools are available, the whip and tongue graft is preferable to a simple splice graft. Its drawback is that it does not work well unless stock and scion are of the same size. The procedure is the same as that used for the splice graft except for the shape and joining of the graft itself.



A= Rootstock cut back to the point of grafting B= Rootstock showing its "tongue" C= Scion prepared with its "tongue". D= Scion inserted into the rootstock. E = Graft secured with budding tape. Plastic ribbon can also be used. F = Scion protected with banana petiole G= Scion starting to grow.

(Garner and Chandhri, 1976)

Wedge grafting and Oblique wedge grafting

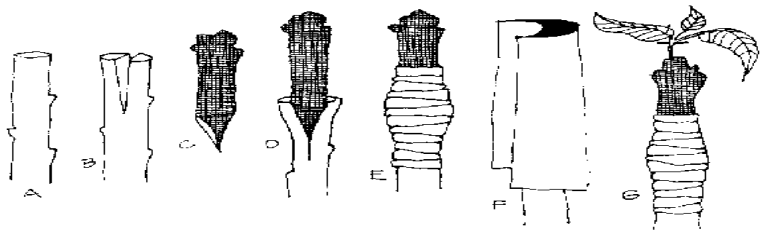
The wedge or cleft graft is a secure graft which can be used on scion that is smaller than the stock. (See Illus. 5-26.) It is also good for joining scions to roots. It is sometimes the only way to graft herbaceous (non woody) materials before they reach the woody stage. As with any grafting method, it is vital that the cambia of both the stock and scion are in good contact with each other. The procedure involves the following steps:

1. Cut the bottom of the scion in the shape of a point or wedge.
2. Cut the stock horizontally at the point of the union, and then split it at its apical (upper) edge. Place the scion in the split so that just the top of the cut surface of the scion is visible above the end of the stock.
3. When placing the scion in the split, keep at least one side of the cambia of both the stock and scion in good contact with the other.
4. Tie and seal the joint.

The oblique wedge graft is similar to the wedge graft, except that it is not carried out at the top of the stock. (See Illus. 5-27.) Instead, a wedge cut is made in the side of the stock. The scion is also cut differently; its wedge is not symmetrical (the upper side of the scion wedge is longer than the bottom) because the scion will initially emerge from the stock at an angle, somewhat like a branch, instead of as a continuation of the stem. Later the scion will straighten out. The procedure involves these steps:

1. Cut the scion as short as is manageable. Cut its base into an unequal sided wedge. The long side of the wedge is on the same side as the highest (apical) bud.
2. Cut the stock in the side at an angle no deeper than half its thickness. Open the stock at the cut, and insert the scion with the apical bud at the highest position and the long cut of the scion wedge pointing toward the center of the stock.
3. Let the stock close back on the scion, and then cut off the stock just above the scion. Seal the graft. Tying is generally not necessary.

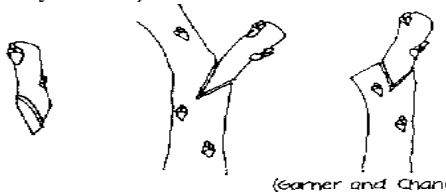
Illus. 5-26 Cleft Grafting



A= Rootstock cut back to the point of grafting B= Rootstock showing vertical incision C = Scion showing a wedge cut base D= Scion inserted into the rootstock E = Graft secured firmly with budding tape. Plastic ribbon can also be used. F= Scion covered with banana petiole G= Scion starting to grow.

(Garner and Chandhri, 1976)

Illus. 5-27 Oblique Wedge Graft



(Garner and Chandhri, 1976)

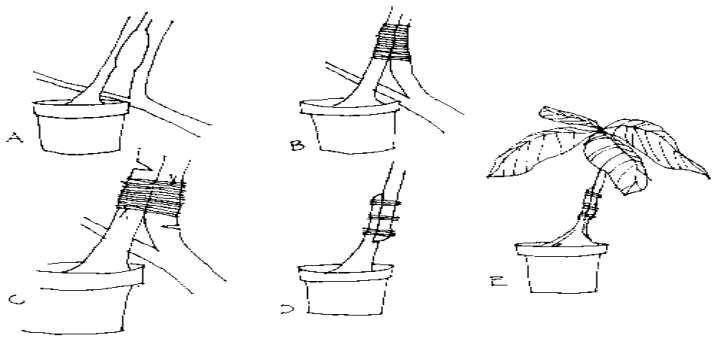
Inarching

A method of approach grafting commonly used is in arching. (See Illus. 5 - 28.) Inarching is a method of propagation in which the scion is made to unite with the root stock while they are growing independently on their own root systems. Although it can be done it near the ground, it is usually performed high on the branches where the scion stem approximates the size of the root stock. This necessitates providing the root stock with a rigid support like bamboo or wooden platforms.

To inarch, select an actively growing root stock and bring it to the branch chosen for grafting. Cut a longitudinal section about 4-5 cm long and about half its thickness. Make a similar cut on the scion then fit them together. Tie firmly with a string or cotton twine. When union has taken place, gradually cut the scion below the point of union and the rootstock above the union. Make the first cut about half the thickness of the scion stem. About a week later, make the second cut. lf after making the second cut the scion does not show any signs of wilting, cut it off completely. In arching is one of the few methods of propagation that needs little attention. Except for the regular watering of the rootstock, no other treatment is given to the inarched plants after they are tied together.

Another grafting method which deserves a quick mention is grafting to entire trees. This is advantageous if a superior cultivar is developed that takes a long time to grow to maturity. A root system of a fully developed tree can be used to propagate the scions of the new cultivar. If a tree loses most or all of its canopy yet retains a healthy root system, it is possible to rejuvenate the tree and save the well-developed root system by chopping off the tree at the trunk and inserting grafts into the stump. There are many ways to do this, and all require heavier cutting tools (such as saw, mallet, and machete) than the other methods. The major problem with these methods is the large size of the cuts, which increase the chances of infection.

Illus. 5 - 28 Inarching



A = Stock and scion showing their longitudinal cuts. B = Scion secured tightly to the rootstock with cotton twine. C = Partially cut inarched plant D = Newly cut inarched plant E = Potted inarched plant ready for planting.

(Hopitan, 1975)

Other considerations

Care of Nursery Plants

Seedlings are fragile plants and need special treatment to ensure their survival until they are established. Water seedlings with about 5 ml of water for each plant once a day, even on holidays. This will keep the soil in both pots and beds well moistened. Check pots and beds frequently for adequate moisture by spot-checking pots without seedlings that have been watered or by digging about 20 cm into the beds and making sure moisture has penetrated to that depth.

Watering: Water germinating seeds twice a day for about a month, after this the seeds should have sprouted and the roots should be developed enough to cut back to one daily watering. If seedlings wilt, go back to two waterings per day until they recover.

It is necessary to consider different soil types, climate, location, and other factors which will affect water availability. Use common sense to determine any variation in water needs over extended periods of time. Check the state of the seedlings and the soil regularly, even once a day, to maintain seedling health.

Thinning: Open-root stock must be thinned after they reach a height of 10- 15 cm. After that height root competition will lead to uneven size and poor root development. Thin seedlings to 5-6 cm apart. Use a ruler or premeasured stick to assure even spacing. It may be possible to transplant thinned seedlings into gaps that have developed due to poor germination. Doing so requires very careful handling of the seedling, however, and survival is limited. A more effective method is to reseed any holes in the beds.

Root Pruning: Pots must have drainage holes to prevent water logging. If roots are allowed to grow out of the holes and develop extensively, they w ill have to be cut off before the potted plant can be transported to the planting site. After 6-8 weeks, prune all roots extending from pots once a week, or as often as is necessary.

Protection: Extra protection from the sun may be necessary for the outer row of pots in a block. Sinking these pots w ill help reduce water loss and overheating. Remove 5 cm or more of soil from below the outer row. Sink the pots in the hole and backfill as high as possible to the top of the pot, using the soil removed.

Weeding: Weeds compete with seedlings for water and nutrients. Weed frequently in beds and pots, using care not to damage seedling roots when removing the weeds.

Soil should be kept friable. Lightly till the top of the soil to allow water and air to enter it easily. Take care to avoid damaging the roots of the seedling. Tilling may be necessary after heavy rains, as soil can become sealed by the force of the droplets and limit water and air entry.

Nursery Records

The need for accurate, daily records of nursery activities cannot be overemphasized. Records provide a history of operations, so that results of techniques and materials used can be adequately evaluated. New procedures, plant types, and other innovations can also be assessed. Records help in project planning as well. As information about the amount of labor or time needed to perform certain tasks accumulates, the data become useful for future costing and other calculations. Worksheet and pay records also prevent disagreements over wages and hours worked.

A monthly report of nursery activities is an excellent way to summarize records, plan for the next month, and explain any discrepancies between the previous month's plans and results. Support from donor is easier to obtain and maintain when activities and results are well documented.

Nursery and other project records should contain at least the following:

o Daily log of activities,
o Any technical notes, such as techniques used, pests discovered and treatments used, and methods used for spacing, watering and feeding of plants,
o Seed and plant histories (collection, treatment, growth rates, etc.), numbers of plants in beds, and success of plant types,
o Amount of time and labor needed for specific tasks, individual workers' histories, and pay worksheets, and
o Monthly report summarizing results, problems, and discrepancies of the past month, and expected results of the next month.

A well-designed project should continue to operate long after the departure of the community forester. A nursery is a long-term, ongoing affair that can be shared by a succession of foresters. The 2-4 years length of service experienced by the experts is really just enough time to initiate a project or improve on the work of predecessors. Records allow the knowledge gained by one forester to be passed on to others. This information may be invaluable.

Other Activities

If the objective of the nursery is to grow plants for a specific project, it is necessary to prepare the planting site well in advance of seedling maturity. Site preparation activities include arranging labor, digging holes, collecting mulch and fertilizers (commercial or manure, or green manure) and making them available at the site, building windbreaks and fences, arranging transportation, and other activities. These activities cannot be postponed until the trees are mature and ready for planting. Failure to prepare the site ahead of time may result in seedlings less capable of handling stress associated with transplanting. Roots may become pot-bound, open-rooted stock may anchor in the subsoil, and plants may become crowded and heavy. The optimal planting time may be missed, forcing planting during dry periods and increasing tree mortality.