



# TREE GROWING MANUAL



# ACKNOWLEDGEMENTS & DISCLAIMER

This manual is developed by the Agency For Accelerated Regional Development, for the implementation of **ADVANCING ACCESS TO INTEGRATED LIFE - SAVING ASSISTANCE AND PROTECTION SERVICES TO PROMOTE SELF - RELIANCE AND RESILIENCE FOR REFUGEES AND HOST COMMUNITIES.**

This publication was supported by IRC with funds provided by the United States Department of **Bureau** of population, refugees and **migration** (BPRM) and the contents, views, and statements of the publications produced under this Project are those of the Local Partner and must not comply with those of IRC and donors.

# About PRM Project

Uganda continues to be Africa's largest refugee-hosting nation. According to the United Nations High Commissioner for Refugees' (UNHCR) Uganda Population Dashboard as of January 2023, there was an influx of 122,780 refugees throughout 2022 fleeing war and persecution mainly from the Democratic Republic of Congo (DRC) and South Sudan. 94% of these refugees live in settlements alongside host communities in areas which are among the poorest and most underdeveloped in Uganda. The number of new refugee arrivals in Bidi bidi and Palabek settlements have continued to rise, adding strain to the already overstretched services.

Between June and August 2022, 21% of the population (857,000 people) in refugee-hosting districts experienced high levels of acute food insecurity (Integrated Food Security Phase Classification (IPC) Phase 3 and above). All locations in which the IRC operates report that food insecurity is caused by a lack of income and income-generating activities, the reduction of food rations, a shortage of agricultural equipment, inadequate land, and the effects of climate change and environmental hazards. thus, there was need to establish more farmer organizations and to strengthen the existing ones, so that more farmers can benefit from economies of scale, better prices for produce, and improved agricultural knowledge and practices.

The Agency For Accelerated Regional Development (AFARD) in consortium with IRC, WORLD VISION, and UGANET, is implementing a three -year project entitled "Advancing access to integrated life-saving assistance and protection services to promote self-reliance and resilience for refugees and host communities in Uganda", with an overall goal of Advancing the safety, wellbeing, self-reliance and resiliency of refugees and host communities in Uganda through integrated and client -centered protection, health and livelihood services.

## **Programme Approach**

The consortium delivers the program through four integrated objectives that aim to foster inclusiveness, self-reliance, resilience, and tangible pathways to durable solutions – aligning with the strategic objectives of the Uganda Country Refugee Response Plan (UCRRP) 2022-2025 and the Office of the Prime Minister's (OPM) 2021-2025 Comprehensive Refugee Response Framework (CRRF) strategic direction and expected outcomes.

AFARD implements objective 4, "Refugee and host community livelihoods and climate resilience are improved through coping initiatives to transition from aid to stability and self-reliance

through food and income security” of the program, targeting refugees and host communities. AFARD supports communities to transition from vulnerable subsistence farming methods to more resilient green farming approaches, promotes the sustainable practice of agroecology and climate smart agriculture (CSA) to increase food production and household incomes through mixed farming to feature livestock and annual systems which are capable of unlocking household capabilities to achieve food and income security.

The program’s implementation strategy applies a hybrid approach of interventions that integrate actions to increase food production and availability by addressing the input and output constraints to enhance the production, processing, distribution, and consumption of food, while simultaneously addressing the root causes that prevent low-come people from effectively participating and accessing opportunities in the market. In both cases, the program focuses on the systemic constraints at the household level and market systems through value chain upgrading to stimulate inclusive market linkages with production and off-markets.



# Introduction



There are many reasons to plant trees:

- To grow useful products for home use and consumption - for example, poles for construction purposes, fuelwood, fruit, fodder, nuts and oils.
- To grow products to sell - for example, poles, fuelwood and charcoal, sawlogs, pulpwood, fruits, oils and resin.
- To keep water and wind from carrying away soil, to improve degraded land and to maintain soil fertility.
- To create shade and shelter from high winds or just to be able to enjoy their beauty.

It may take years before seedlings planted today grow into big trees. Therefore, planting trees is for the benefit not only of those who do it but also for future generations.

## **About this Manual**

This guide contains the basic information needed to plan, organize and carry out the planting of trees by hand. There are many differences between countries and regions regarding tree species grown, the climate, the soils, the tools available, the people, traditions and other factors. Tree planting projects vary greatly in their size, methods and type of produce that will be grown. Since there is no substitute for local experience, this small booklet can only provide general information which has to be adapted to local conditions. The present manual can serve as a basis for local manuals in a number of ways:

- It draws attention to all the aspects that need to be considered in tree planting;
- It provides a range of technical solutions to choose from for local use;
- It gives an example of how the subject can be presented in a clear, easily accessible way e.g. by having a clear page lay-out, a limited text without technical jargon, a number of high-quality illustrations and the breakdown of operations into a sequence of steps.

The choice of where and what to plant depends on the purpose of the plantation, on who the land and the trees belong to and on other possible uses of the land. The first step is to find out what the needs of the local populations are. What are the benefits they expect? Who in the local community benefits from a plantation and who might not benefit from it? How will the plantation affect other land-uses like food production or grazing? What are the potential

conflicts in connection with the plantation? These factors have to be discussed until all concerned reach agreement.

These discussions are very important and should start early during the planning of the plantation. Plantation programs which will result in reduced benefits for the population are not likely to succeed. More tree planting projects fail because of problems with the people involved than because of technical mistakes. This manual deals mostly with the work to be done after the basic agreement has been reached. The list of references at the end of this booklet includes useful documents on extension and people's participation in forestry projects.

When you start the technical planning take a close look at the area. Decisions has to be made on:

- What regeneration method to use (whether to plant, rely on natural regeneration or seed directly on the site)?
- What tree species to establish (matching species to planting purpose and site)?
- Whether to plant a single tree species or a mixture of several?
- What type of planting stock to use (bare rooted, potted seedlings or stumps, small or large seedlings)?
- What planting pattern to use and how many seedlings to plant?
- When to plant?
- How to protect the seedlings?

To make the right decisions you have to get to know the area. Start by drawing a simple map of the plantation site and calculate the area available. One way of doing this is described in Technical Sheet 1. Mark variations in site conditions on the map. Information that can be of importance for further work should be written down.

## COMMON CONVERSIONS

Metrically-challenged readers might find the following conversions useful since we have used metric measurements throughout this publication.

1 mm	0.039 inch
1 in	25.4 mm
1 m	3.281 ft
1 ft	0.3048 m
1 ha	2.471 acres
1 acre	0.4047 ha
1 ha	10,000 square m

# Chapter 1

## Planning a plantation

- Where and what to plant?
- What regeneration method?
- What species?
- Mixed or single species?
- What type of planting stock?
- What planting pattern?
- When to plant?

### 1.1 What Regeneration Method to Use?

You have to decide whether to plant seedlings, to seed directly on the site or to rely on natural regeneration and coppicing.

If natural vegetation exists on the site and the main objective is fuelwood supply or soil conservation, protecting and helping the vegetation to recover might be the cheapest and quickest way to ensure reforestation. This is especially true in dry, hilly and eroded areas. The area should then be closed from grazing and micro-catchments might have to be constructed to ensure that the shoots get enough water. After a cover of bushes and small trees has been established, the less desirable competing plants should be cleared away to promote sprouting in the more valuable species.

This method might be combined with enrichment planting. This means planting seedlings in groups or lines inside a growing stand between existing trees and bushes. Shade-tolerant tree species have to be used. Enrichment planting is not likely to succeed at sites with rich vegetation where the seedlings will not be able to compete with the herb vegetation.

Direct sowing on the site is sometimes used to establish a new stand. This may be a simple way of establishing tree cover but often the increased need for site preparation and weeding make it more expensive than planting. Direct sowing can be used for species with very rapid initial growth when seeds are plentiful and cheap and germination is reliable. Species possible to establish in this way include *Acacia Senegal*, *Acacia nilotica*, *Acacia mearnsii*, *Cassia siamea* and *Neem (Azadirachta indica)*.

Where natural regeneration is not possible or too unreliable, or where the tree species that are to be established are not found in the natural vegetation on the site, trees have to be planted.

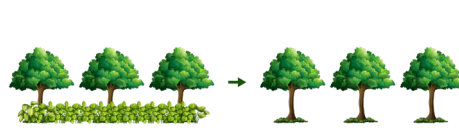
## Regeneration Methods



Coppicing



Protection from Grazing



Cleaning

## 1.2 What Species to Establish?

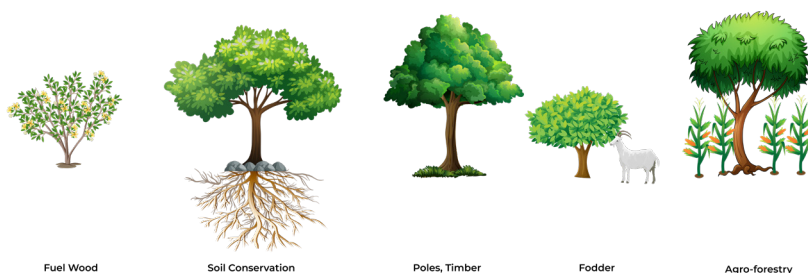
The choice of species is a most important and difficult decision to make. The choice depends primarily on three basic questions, which should be asked in the following order:

- What do the owners/beneficiaries of the project want from the plantation?
- What species are available that will produce what the people want?
- Will these species grow on the sites available?

For soil conservation, for example, fast-growing species with an extensive root system are preferable. They quickly cover and bind the soil, protecting it from rain and wind. A plantation aimed primarily at construction poles or timber will require trees with relatively heavy, durable wood and a straight stem. For fodder production, ample leaf and seed production are essential and good regrowth after coppicing and browsing. If you grow trees together with agricultural crops or to rehabilitate wasteland, leguminous varieties (for example, the Acacia family) would be a good choice because of their soil-improving ability. (Most leguminous and some other tree species can extract nitrogen from the air with the help of little nodules on their roots. They then add nitrogen to the soil when the leaves fall off). Multipurpose tree species may combine a variety of different uses.

If local, indigenous, tree species, that you know grow well in the area, are available, it may be safer to use them than to try other, exotic ones. It is essential to select species that will be able to survive the first crucial years, that will withstand the environmental conditions on the specific site and that are easy to handle both in the nursery and in the field. Good coppicing ability (i.e. putting out new shoots from the stump after cutting) may be a special advantage.

## What species to establish



Fuel Wood

Soil Conservation

Poles, Timber

Fodder

Agro-forestry

*What species are available that will produce what people want?*

### 1.3 Whether to Plant a Single Tree Species or a Mixture of Several?

A plantation may consist of only one species or a mixture of several species.

A single-species plantation is easier to handle during both the planting and the maintenance phase. Planting a mixture of species will reduce the risk of failure if a certain species does not survive or grows badly. Mixing the species may also be desirable because of site conditions or to obtain several products from the same plantation. It all depends on the purpose of the plantation.

If you choose to create a mixed plantation, you have to decide what type of mixture will be most appropriate.

When planting bigger sites, the area should be subdivided into blocks. The different blocks can then be planted with different species. This will reduce the risk of damage caused by pests, insects and fire.

A site with varying soil or moisture conditions can be utilized best if several species that are adapted to the different conditions can be selected. The species should be planted in groups on the portions of the site matching the species' site requirements.

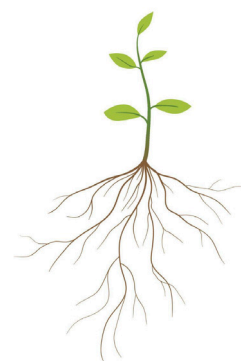
You can also create a mixture with slow-growing, valuable timber trees and faster-growing trees that will be used for fuel wood or fodder. An example is Teak (*Tectona grandis*) and Leucena (*Leucena leucocephala*). Leucena will be cut as fuelwood or fodder repeatedly until the Teak crowns form a close canopy and Leucena eventually is shaded out. In these kinds of mixtures two (or more) species are distributed evenly over the area or planted in alternate lines. There should preferably be an even mixture of light-demanding and more shade-tolerant species.

### 1.4 What Type of Planting Stock to Use?

Bare-rooted seedlings are less expensive to grow and to transport. They are however, vulnerable to drying out and mechanical injuries during transport and planting. Any weak point in the chain - nursery work/distribution/planting - can result in severe loss of the plants' availability to survive. They have to be handled with care and should be stored for as short a time possible.

**Containerized seedlings** are less sensitive, less liable to dry out, or to get injured during transport and easier to plant without damaging the roots. They often have a higher rate of survival than bare-rooted plants. They are, however, more expensive to produce. Handling and transport will also be more expensive because of the considerable weight of the earth in the pots. If no experience or information is available on the survival rate and establishment cost for the two methods, both could be tried experimentally to clarify the choice.

The seedlings should have a root system that is be-



*Bare-rooted Seedling*



*Containerized seedling*

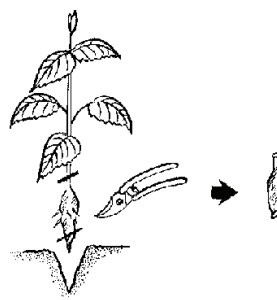
tween half the size to the size of the shoot. Big seedlings cost more to produce but are necessary for planting difficult sites. The seedlings may be separated according to quality and the seedlings of better quality used on the most difficult or inaccessible sites.

**Cuttings** are sections of roots, stems or branches that will, when placed in moist soil, grow into new plants. Cuttings can be grown into plants in the nursery. For some species they can also be planted directly on the planting site. Stumps are a special type of cutting. They consist of a short, pruned stem and a strong pruned taproot derived from nursery stock.

### Cuttings



*Branch Cutting*



*Stump*

## 1.5 What Planting Pattern to Use and How Many Seedlings to Plant?

The most commonly used planting patterns are square spacing or triangular spacing where the distance between the rows are the same as along the rows. If strip clearing or weeding are used, a rectangular pattern, where trees are closer in the rows, than between the rows might reduce labour input. For very harsh climates and on poor soils, it might be appropriate to plant in clusters.

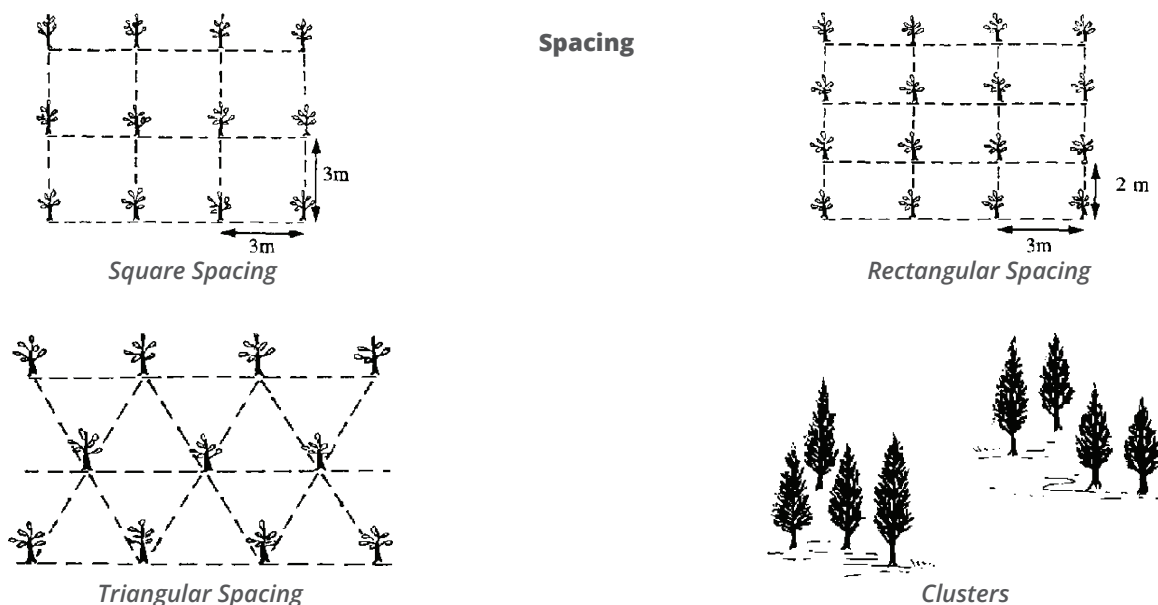
The appropriate spacing varies with the site, the purpose of the plantation and the species chosen. It is also a compromise between expected yield and the cost of establishing the plantation. Wider spacing (more than 3x3 m) is preferred:

- For fruit trees;
- When planting on agricultural or grazing land;
- To reduce the cost of planting;
- In arid areas to avoid competition for water and nutrition;
- To reduce the number of thinnings (if the aim of the plantation is large diameter timber).
- Closer spacing (3x3 m or closer) is preferred:
- To avoid expensive replacement planting;
- To give early soil cover;
- When weed competition needs to be suppressed by early tree canopy closure;
- For slow-growing species when aiming for good quality sawlogs, i.e. small branches/knots;
- When there is a market for smaller dimension wood from thinnings;

For fast-growing species such as Willows and Eucalyptus, when using short rotation to produce mostly smaller dimension wood (e.g. for fuel).

On dry sites most trees are now planted with an average of 3 or 4 metres between trees (i.e. 1100 or 625 trees/ha, respectively). On fresh sites in tropical highlands and in temperate cli-

mates a spacing of 2 square metres (i.e. 2500 trees/ha) is common. The table on the following page can be used when calculating how many seedlings will be needed for a site.



### Calculating the number of seedlings needed

If you know how many plants you want to plant per hectare, you can calculate the square spacing using the formula:

$$\sqrt{10,000 / \text{number of seedlings per ha}} = \text{Square Spacing (m)}$$

If on the other hand you know what spacing you want, you can calculate the number of seedlings needed using the formula:

Spacing between lines (m)	Spacing within lines (m)	Space per seedling (m <sup>2</sup> )	Seedlings per hectare
1	1	1	10000
2	2	4	2500
2.5	1.6	4	2500
3	3	9	1111
4	2	8	1250
4	4	16	625
10	10	100	100

### 1.6 When to Plant?

Planting should be completed early in the rains in as short a time as possible. The trees must be given time to become well established prior to the dry season. A good rule of thumb is to start planting when the soil is moist to a depth of 15-25 cm or to the bottom of the planting hole. Failures because planting is too late are more common than failures because of planting too early. In many tropical sites, the optimum planting time is two to four weeks each year. To obtain good results and avoid labour shortage in these areas considerable preparatory planning is needed. The size of the plantation might have to be adapted to the availability of labour. If dry sites cannot be planted in time, planting should be postponed until the next season.

### 1.7 How to Protect the Seedlings?

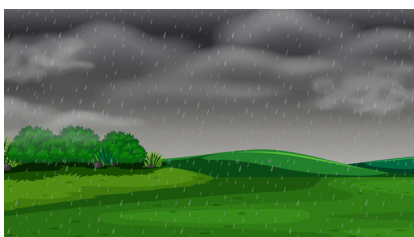
Tree seedlings may be harmed by browsing, fire, insects and diseases. The risk of damage

should be assessed and protection ensured during planning.

In most areas some sort of agreement and protection is needed to keep livestock out of the plantation during the establishment phase. Goats and sheep chew leaves and shoots and tear off the bark. Cattle can quickly destroy a plantation by trampling on the young seedlings.

Forest fires are often man-made. If the plantations benefit all members of the community, prevention of fires is mostly a matter of public relations and information. Sharing the produce of the plantation is one way of increasing the interest of the local population. Permanent guarding, fire breaks and controlled grazing or grass-cutting are also means of preventing fire. Insects and diseases are often species-specific. Species liable to damage should be avoided. Pesticides or chemically treated plants may also be used.

### *When to plant*



*Planting should start early in the rain*



*How to Protect the Seedlings*

## **1.8 The Plantation Plan**

When all decisions are made and the basic information collected, a plantation plan should be prepared. It should consist of a plantation record and a map. An example of a form to use for the plantation record is given on the opposite page.

The map is the main tool for planning (guidelines on how to draw a map are given in technical sheet 1).

If you want to create a plantation with different species mixed in groups, you have to decide where to plant the different species to best utilize the varying site conditions within the plantation area. This should be marked on the map.

Mark also access roads, suitable seedling depots (with water and shade) and where to start planting. In dry areas start the annual plantation work at the driest part of the site. This will give the seedlings as long a time as possible before the beginning of the dry season. If you have decided that the best quality seedlings, or larger holes or other special measures are needed in certain areas, this should be clearly indicated on the map.

Plantation record	
Village:	District Tiruchirappalli
Site name:	Area: 35 ha
Batcha plain Owner:	Kovali village community
Type of plantation:	Soil conservation/fodder
Previous vegetation:	Waste land with scattered bushes (Cassia and Prosopis)
Terrain:	Flat
Main soil type:	Sandy loam
Method of clearing:	No clearing needed
Risk/need for protection:	Grazing, termites
Transport:	Truck hired from Mr. Schultz
Tools required:	20 planting hoes (ordered 12.1.93)
Workdays required:	See attached workplan
Date of planting:	26 April to 20 May 1993
Nursery of origin:	Keela Kolathur village nursery
Spacing:	4x4 metres
Water conservation measures:	None
Fertilizer:	Not applied

### Common mistakes when planning

- Not enough attention to discussions on the needs, benefits and potential conflicts in connection with tree planting project. No agreement on the rights and duties of all involved, particularly concerning protection. As a result, a dissatisfied group sabotages the project (uproots trees, burns plantation or lets cattle destroy the trees, etc.).
- Species are not well suited for the purpose of plantation. Suitable local species are not utilized because there is no information in books and manuals. Local people's knowledge of sites and trees not used.
- Lack of coordination between nurseries and the plantation programme.
- Need for protection is underestimated.

# Chapter 2

The planting site should be completely prepared and ready for planting when the first rains are due. There are two reasons for this - first, because there is a rather short time interval in which the plant should be planted to get the best possible start; and second because the rainy season is the most work-intensive in rural areas and it is good to have as much work as possible done before it starts. Site preparation should give the young trees a good start and rapid early growth. The measures needed differ between different types of sites and between different types of plantations. The following measures may be taken:

- Clearing vegetation
- Ground preparation
- Marking where to dig the holes
- Digging holes
- Water conservation

## 2.1 Clearing Vegetation

On most sites trees, bushes and grass have to be cleared away to prevent them from competing with the young plants. This is very important when using light-demanding trees such as Eucalyptus, Pine or Cupressus. If more shade-tolerant species are chosen, existing trees do not have to be cleared.

Total clearing of the grass and bushes is needed on moist grassland sites and for species sensitive to grass competition, like some Eucalyptus.

On sites where ground vegetation is below one metre, it is normally sufficient to clear patches around the plants or strips along the lines of plants. The strips should be about one metre wide. Patches a radius of about 1 metre radius can be cleared with the hoe when digging the planting hole.

Between the cleared patches and strips the vegetation should be cut short, except on sites where reduction of the vegetation may result in increased erosion. There the vegetation between the cleared patches should be left as intact as possible.

Existing trees should only be removed when they seriously disturb the development of the plantation. Around water sources a vegetation belt of at least 15 to 25 metres should be pre-

served. Trees along rivers and old trees providing shade and beauty should always be saved.

### **Tools required for clearing and grass-cutting**

The type of tool used should be adapted to the land of vegetation that is being cleared.

**A brush hook** might be the best tool to use for cutting underbrush up to 20 cm in butt diameter. The weight of the brush hook is about 1.2 kg. The handle is about 0.6 m and the blade 0.2-0.3 m. The top of the blade is formed as a hook. This will protect the edge if it hits a stone. The hook also permits the worker to cut small brush with a pulling jerk. The brush hook is used with two hands.



*Brushhook*

**A machete** can be used for cutting hard-stem grasses and woody weeds. It is a long knife, also used for many other purposes, such as cutting fence posts, trimming live fences and root pruning. The machete weighs about 0.6 kg. The traditional machete has a handle of 0.1-0.15 m and a blade of 0.45 m in length.

For grass-cutting a modified model has been developed. On the grass-cutting machete the length of the handle is about 0.5 m and the blade about 0.3 m.

A grass-cutting machete is used with one hand and the long handle allows the worker to maintain an upright position. Productivity can be increased if the cutting is assisted by a wooden stick (see fig).



*Machete*

**A scythe** is useful for soft stem grasses. A scythe with a short blade (0.3 m) is chosen when the terrain is rough and the grass dense. In even terrain a longer blade (0.6 m) can be used. This will speed up the work. It takes some training to get used to the scythe, but once the technique is mastered productivity is good. The worker should stand with his back straight and feet apart.

To give power to the cutting swing, the muscles of the thighs and the back should be used. The hands are used mainly for guiding the swing, not for powering it. A well designed scythe is adjustable to individual preferences and body sizes. In the middle of the handle there is a grip for the right hand, and at the top there is another grip for the left hand (for right-handed workers).

The upper handle should reach the arm pit and the lower should be placed one underarm's length lower.



*Scythe*

A *slasher* is a double-edged tool, suitable for cutting short grass. It has only limited applications in tree planting. A slasher weighs about 0.6 kg, the length of the handle is around 0.8 m and the blade 0.05-0.1 m. Holding the slasher in one hand, the worker swings it back and forth in a sweeping motion.



*Slasher*

## 2.2 Ground Preparation

Ground preparation is needed to soften the soil, and to allow the roots to affix firmly and deeply. Since nutrients are washed out in the surface soil layer, it is also important to mix soil for the deeper layer with soil from the surface layer to guarantee availability of the nutrients needed by the seedling.

The method depends on the site and the species planted. Usually digging holes and uprooting grasses with the planting hoe about one metre around the planting hole is enough.

The work should be carried out along the contour line, not up and down the slope, otherwise rain water may start to wash away the soil and form gulleys.

In sites with crusts, hard pans or other hard soil layers it may be necessary to use mechanized soil preparation. For this a bulldozer, a sub-soiler or a scarifier drawn by a tractor can be used.



*Uprooting Grass*

## 2.3 Marking Where to Dig Holes.



It is not always necessary to mark where to dig the planting hole. A well instructed planting crew working on well cleared ground may plant without premarking the planting spots. They may space the distance using tool handles or footsteps as measures for the planting work.

Even if it is necessary to mark on the ground where to dig the planting holes, there is no need for accurate distances. It is more important to find the best planting spot available for the plant. In sites with a lot of vegetation it might, however, be preferable to plant in straight rows and with a fixed distance between the plants, since this will make it easier to find the plants

during weeding.

Determine how many handle lengths or steps should separate the trees. Then make a mark on the ground with the planting hoe. The planting spots can also be marked out by sticks or pegs.

## 2.4 Digging Holes

If the soil is not too hard, the holes might be dug in advance during the dry season. This will reduce the need for labour during the actual planting. They can also be dug at the same time as the actual planting. How to dig holes and examples of the different tools to use are described in Chapter 4.



## 2.5 Soil and Water Conservation Measures

In arid and semi-arid areas it is almost impossible to get the seedlings to survive without some water conservation measures. In high rainfall areas and on unstable soil, particularly on slopes, the soil often needs to be protected against erosion until the tree crowns shelter the site. The aim of all soil and water conservation measures is to reduce or retard the flow of surface runoff water (water harvesting). This will diminish the erosion damage and cause the water to soak into the soil, increasing the amount of soil moisture available for the seedling.

Microcatchments can be built in dry locations to trap the water around the seedlings. They vary in shape and size and are relatively small and cheap. If well constructed, they should last about five years, which will give the plants time to become well established.

Contour ridges or diguettes serve as small dams to keep water from running downhill. They consist of ridges dug out of the hill slope along the contour lines and are used in heavy soil with low permeability.

Bench terraces are series of narrow, more or less horizontal steps cut into the hillside. It is extremely important to space ridges and terraces properly. If the structures are placed too far apart, they will be washed away or broken. If they are placed too close, labour and land will be wasted.

Some guidelines of how to construct soil conservation structures are given in Technical sheet 2. However, the size, type and spacing of earthwork structures always have to be adapted to local conditions. Consult the national extension agencies for soil conservation, soil survey and forestry for more detailed advice.

## Water Conservation Structures



*Semi-Circular*



*Vee-Shaped*



*Micro-Basin*

### Common mistakes when preparing the planting site

- Insufficient site clearing and soil preparation.
- Agricultural tools are used that are not suitable for the kind of work and the soils found in tree planting.
- Tools used have handles of inconvenient size, poor shape, badly fixed and cutting edges are not regularly sharpened.
- Soil and water conservation are too sophisticated and expensive for tree planting. Water conservation measures used uniformly rather than adapted to erosion risk (bigger and more closely spaced where risk high, widely spaced or none at all where risk low).

# Chapter 3

# 3

## 3.1 Packing and Transport of Seedlings

The time between the seedlings, leaving nursery and their being planted should be as short as possible. They must be constantly protected from strong light, heat and drying out. There are small root hairs that will dry out and wither in seconds if left exposed to the sun or dry winds. The seedling should be thoroughly watered before leaving the nursery. This will provide the seedling with the largest possible reserve of water and minimize the risk of soil being shaken out of the pots during transport.

### *Containerized seedlings*

Only the containers should be held when containerized seedlings are carried. Seedlings should never be held by the shoots. Whenever possible, use boxes for transport.

Metal platforms of vehicles often get very hot, and this will burn the root tips at the bottom of the pots. Pour water over the platform and/or spread out soil, straw or twigs. It is especially important to put a thick layer over the exhaust pipe otherwise the heat may destroy some of the seedlings. If the seedlings are loaded onto carts, pickups or trucks, load densely and upright. Make sure that they do not fall over during the transport. If necessary, water the plants on the arrival at the planting site.

If a vehicle is carrying the plants, it should travel at moderate speed and the plants should be covered by a layer of grass, a mat or a tarpaulin to prevent them from being dried out by the wind.

Transport from the nursery to the planting site is often a limiting factor, slowing the progress of the planting work. Simple metal structures with several shelves, as shown in the illustration on the preceding page, can multiply the capacity of trucks and trailers several fold.

### *Packing and transport of seedlings*



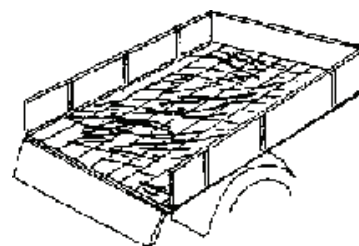
*Water seedlings before they leave the nursery*



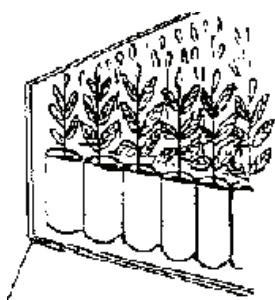
*Never pull by the shoots*



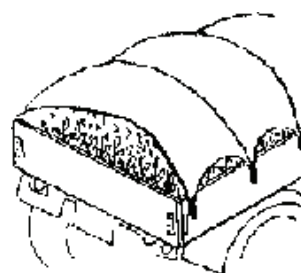
*Use trays and boxes for transport*



*Cover plants with a mat*



*Load Upright*



*Cover Plants with a Mat*

### ***Bare-rooted seedlings***

Bare-rooted seedlings have to be packaged in order for the roots to be well protected from drying out. Sacking, banana leaves, plastic bags with ventilation holes or cans may be used for packing and wrapping. To preserve moisture, the roots can be covered with wet grass, leaves, sawdust or a mixture of water and clay.

### **3.2 Storing Seedlings**

If the seedlings have to be stored a few days before planting, keep them in a dark and cool place, a cool cellar or elsewhere in the shade. If bare-rooted seedlings are packed in bags, the bags should not be opened.

Bare-rooted seedlings which cannot be planted in a few days must be healed-in close to the planting site to minimize later transport. "Healing-in" means temporarily putting bare-rooted seedlings in moist soil, under shade, until they can be used for planting. Healing-in should be avoided but it may sometimes be necessary.

*Bare-rooted seedlings*



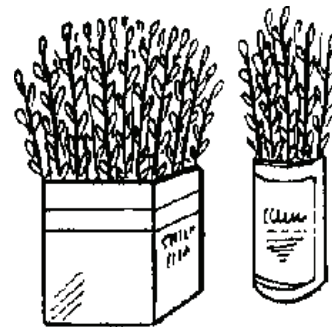
*Gunny Sacking*



*Banana Leaves*



*Polyethylene Bag with Ventilation Holes*



*Can*

*Stored seedlings*

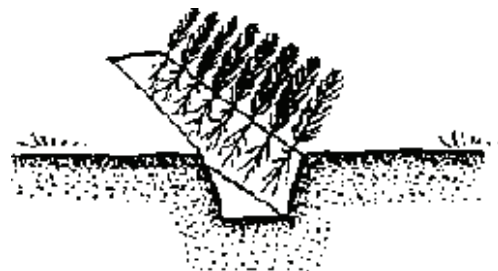
Dig a trench under a shade tree in loose, well drained, but moist soil.

Separate the seedlings from the bundles. On one side of the trench, which should be slightly sloping, arrange the seedlings individually in upright position. Cover the roots with soil taken from the opposite side of the trench, thus making room for the next row of seedlings. The roots should be covered up to, or a little above, the root collar. Firm the soil with the hands. Then place the next row of seedlings. During dry weather the seedlings have to be watered. If the location is not very shady, the seedlings should be covered by brush to discourage the emergence of shoots.

*Healing-in*



1. *Dig a Trench in the Shade*



2. *Arrange the Seedlings*

3. *Cover the Roots with Soil*4. *Firm the Soil*

### 3.3 Quality of Seedlings and Grading

You should only use seedlings of good quality. Never use seedlings left over from the year or the planting season before. Replacement is much more expensive than seedling production. Seedlings of good quality have:

- A shoot between one or two times the length of the root (or the pot);
- A sturdy, woody stem with a strong root collar;
- A symmetrical, dense crown;
- A root system with many thin roots in addition to the tap root;
- No signs of fungus or insect attack.

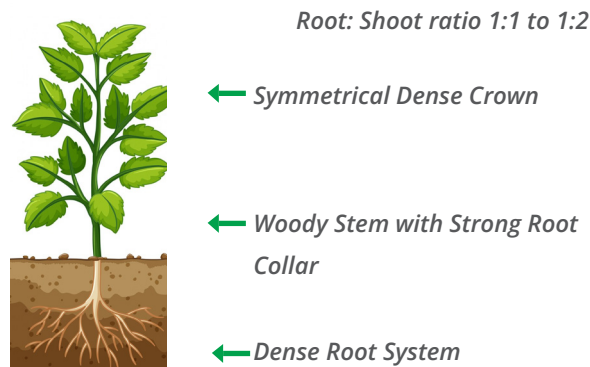
Seedlings of inferior quality should never leave the nursery. If they have, they should be rejected at planting stage. If the plantation site is varied, it may be useful to separate the plants into two or three quality classes. The best plants should be used on the most difficult or inaccessible part of the site. Second quality plants should be used on the more favourable part of the site where replacement planting is less costly.

### 3.4 Stripping and Trimming

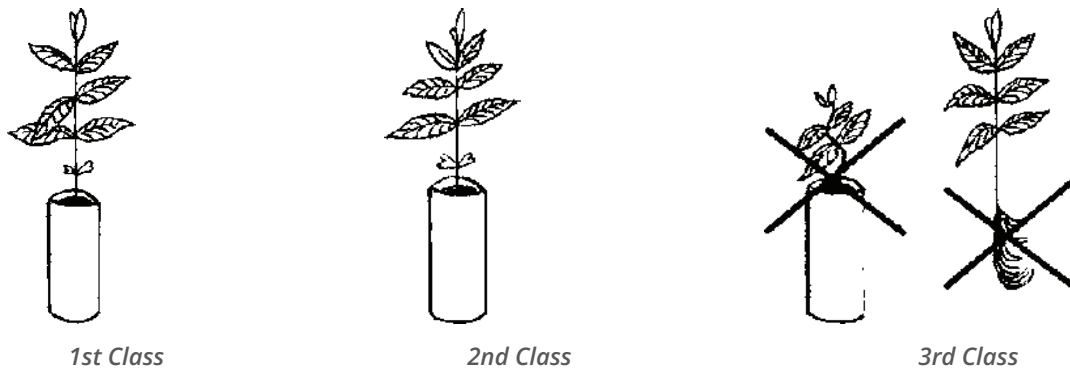
With tall, broadleaved species, young shoots and part of the foliage must be trimmed or stripped off to reduce transpiration until the roots have had a chance to reestablish their water supply function. Some species such as *Azadirachta indica* and *Khaya senegalensis* should be stripped of all leaves except for the terminal bud and two or three near it. Remove the leaves carefully. The terminal bud must not be damaged. If possible the plants should be stripped in the nursery before lifting out.

Overgrown seedlings of some broadleaved species like *Eucalyptus* can be trimmed back to the right root: shoot ratio with a pruning shear. After planting they survive much better than seedlings that are too large.

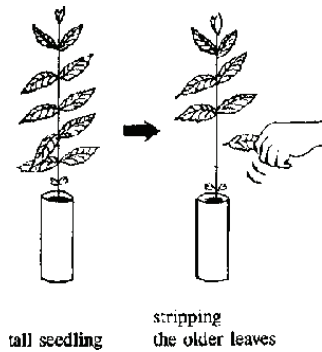
#### Good Quality Plant



### Grading

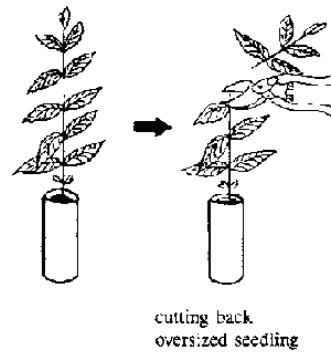


### Stripping



tall seedling      stripping the older leaves

### Trimming



cutting back oversized seedling

Figure

## 3.5 Transporting Seedlings From the Road to the Planting Site

Seedlings often have to be transported from the road to the planting site by pack animal or man. Since this is hard work, pack animals are preferable. The total weight to be carried during one day is considerable. In places where roads are sparse the seedlings may have to be transported long distances. If the planting site is large, a number of small deposit points should be set up so that hand carrying can be kept to a minimum.

### Tool required for transporting seedlings

**Yokes** are less convenient than backpacks, but it is still far easier to use one than to carry the plants with ones arms. Yokes are sticks of a suitable shape put across the shoulders. The load is suspended on strings at each end.



Yoke

### Common mistakes in handling seedlings

- Poor planting stock is not sorted out leading to low survival.
- The seedlings are pulled by the shoots, thereby breaking them and causing deformation of the future trees.
- Containerized seedlings are not transported upright and well secured. The earth-balls around the roots break up and therefore the advantage of using an expensive containerized seedling is lost at the last moment.
- Seedlings are stored too long before planting.
- Seedlings are not adequately protected against drying out.

# Chapter 4

# 4

Prior to planting, bare-rooted seedlings should stand in a mixture of water and earth/clay for a few hours and containerized seedlings should be thoroughly watered. Excessively long roots (longer than 25cm) should be pruned with a machete or an axe.

Planting consists of the following operations:

- Digging of the holes;



*Planting Gangs of Two*



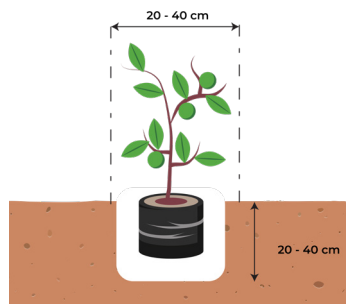
*Planting Alone*

## 4.1 Digging the Holes

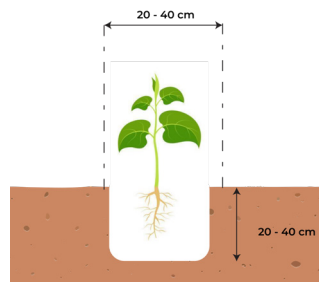
Hoe an area of about 1 square metre around the planting holes. The area should be cleared of all vegetation to eliminate competition for nutrients and water. Dig the planting holes. Holes are required for all containerized plants and for big bare-rooted seedlings. The digging can be done at the same time as planting or some weeks in advance. If holes are dug before the rainy season, labour demand will not interfere with the agricultural season and the actual planting work will be faster. Even when the holes are dug in advance, the plantation worker should bring a hoe to be able to make the holes deeper or to adjust them.

For containerized forest trees the holes should be about 20-40 centimetres in diameter and slightly deeper than the length of the container. For fruit trees the hole should be larger (up to 60 x 60 x 60 cm). The harsher the site, the deeper the holes should be.

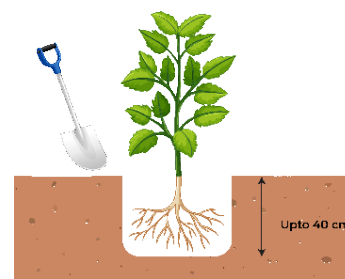
For bare-rooted seedlings make sure that the hole is deep enough to allow the taproot to hang



*Hole for Containerized Seedling*



*Hole for Bare-rooted Seedling*



*Bigger Hole for Fruit Trees*

### *Tools required for digging*

Normal agricultural tools are often not suitable for forestry work. Agricultural hoes, for example, have a wide, straight-edged blade and are heavy. They are therefore difficult to use on most tree planting sites. Suitable tools include the following:

Tools should be adapted to body sizes and for work in particular soils or terrains. The length of the handle should be adapted to the length of the worker. A hoe with a long handle is generally more efficient since it will allow work to be done in an upright standing position. When planting on a steep slope, it is preferable to use a short handed hoe to get a good work posture. Women and elderly workers should have lighter tools than fit male adults. The handle should provide a good grip, and an oval handle is preferable to a round one.

The edges of the planting hoes must be kept sharp with a file, to maintain them in good working condition. The handle should have an oval shape so that it does not twist in the hand. It should have a raised grip to prevent the hands from sliding off. Always keep the handle tightly fastened to the head.

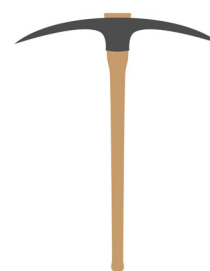
### *Tools required for digging*



*Straight Back Planting*



*Shovel*



*Pick Axe*

## **4.2 On-site Distribution of the Seedlings**

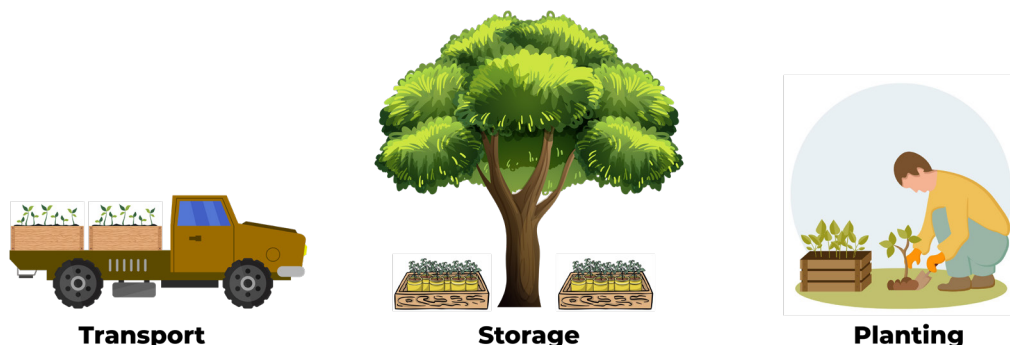
The supply of plants should be arranged so that planting is never held up for lack of plants. At the same time, the number of plants kept in temporary storage near the work site should be as small as possible.

Carrying seedlings is heavy work, especially when containerized seedlings with plenty of water-soaked earth are being carried. Appropriate tools for carrying should be available and work rotation used. Teams may change between, for example, distribution and planting work every 2 hours.

During planting, great care must be taken to ensure that the seedlings do not dry out. The roots should always be moist and never exposed to sunlight. This is especially important with bare-rooted seedlings. Seedlings whose roots are exposed to the sun for only a few minutes can already be seriously damaged and may not survive. Wet spongy material, for example grass, should cover the bottom of baskets, boxes or trays used for carrying the seedlings. With containerized seedlings the soil in the pot should always be moist at the time of planting.

If the distribution and planting of the seedlings is done by the same person, it is easier to ensure that the seedling will not dry out.

*On-site distribution of seedlings*



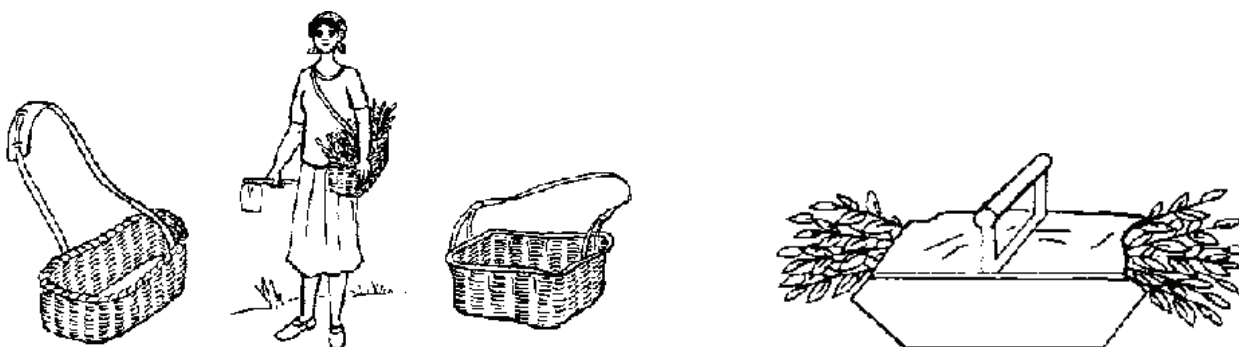
*Equipment required to distribute the seedlings on the planting site*

When plants have to be carried long distances to planting sites, back-pack carriers or yokes should be used (described in section 3.5). When carrying seedlings on the site during planting, other types of carriers are preferable.

A shoulder-carried seedling container or basket will leave the hands free for planting. The harness should have a well-padded belt and shoulder straps. They should be adjustable to allow the weight of the seedlings to be distributed between the shoulders and the hips. A more comfortable model is a shoulder harness, with the trays or bags for seedlings hooked onto it.

A plant tray or a basket carried in the hand and put down on the ground during planting can also be used. Plant trays are especially useful for bare-rooted seedlings. Moist spongy material underneath and over the seedlings will protect the sensitive bare roots from drying out.

*On-site distribution of seedlings*



*Shoulder-carried Seedling Containers*

*Plant Tray*

### 4.3 Planting

#### *Planting containerized seedlings*

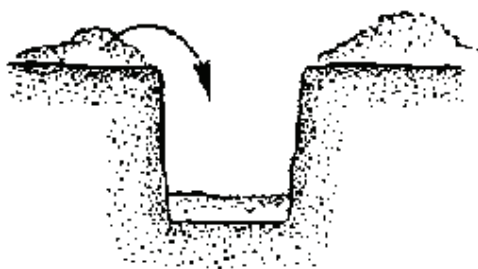
When planting containerized seedlings, fill topsoil back into the hole until the hole is as deep as the container: Cut the container open with a knife or the edge of the hoe and remove the bag. Care should be taken not to break up the earthball. Place the earthball into the planting hole, the upper part of the ball should be slightly deeper than the surrounding soil surface. Put the remaining soil into the hole until it is filled to the rim.

Firm the soil carefully with your hands or with your heel. Do not leave air pockets around the ball or the plant will dry out and die. Check that the fuming is sufficient by gently pulling the plant. The plant should rest firmly in the ground.

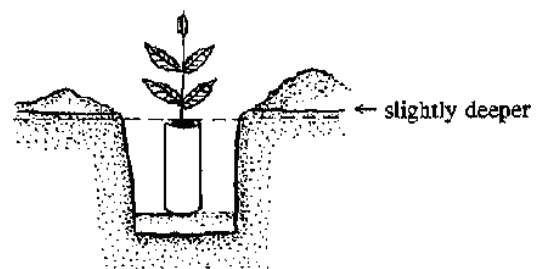
Seedlings should never be left in their containers. It will restrict the growth of the root system and cause the death of the young tree some years later.

The most critical factor for all kinds of vegetation on dry to semi-dry land is access to water. After the hole is filled, a layer of loose soil is left around the plant. Shape the loose soil into a shallow depression. This will cause the surface water to concentrate around the seedlings and they will get as much water as possible.

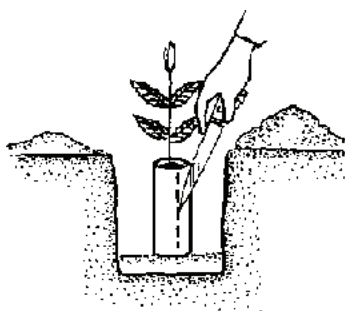
#### *Planting containerized seedlings*



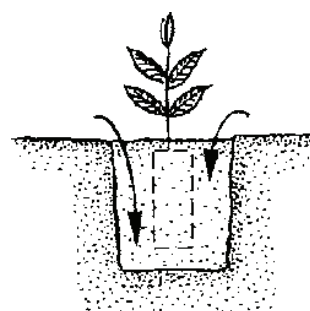
1. Fill Soil Back into Hole



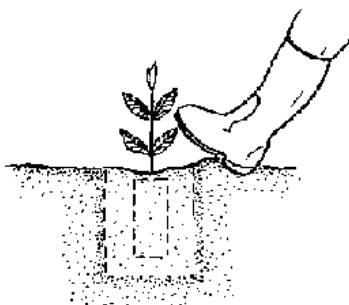
2. Place Container in the Hole



3. Cut Container Open



4. Back Fill



5. Firm Soil from Two Three Directions to remove airpockets

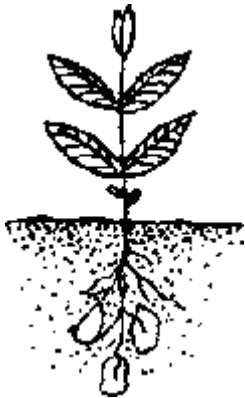


6. Make Slight Depression and Mulch

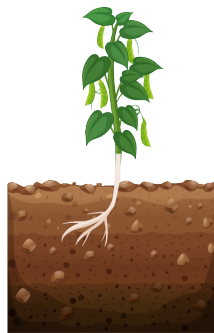
### Planting larger bare-rooted seedlings

When planting bare-rooted stock, put the seedling into the hole with the root collar 2-3 cm below ground level. The roots should be well centred. They must not be bent or curved and must never be allowed to get twisted or bent in the planting hole. If the tap root is too long it should be cut to about 20-25 cm. Put the soil back into the hole. Make sure that the seedling stands straight. At the same time sort out stones and green grass. Firm the soil with the heels or hands from two or three directions to remove air pockets. Take care not to damage the seedling.

### Planting Mistakes to Avoid



Air around roots



Bended Roots



Roots too Shallow



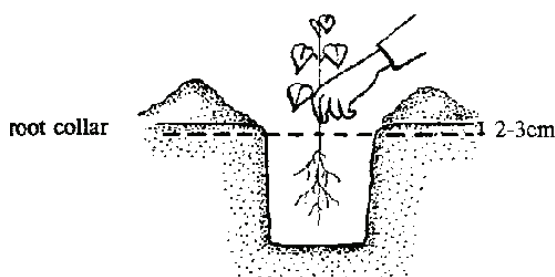
Roots out of hole



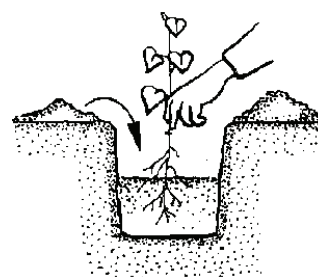
Seedling not Straight

Seedling not straight

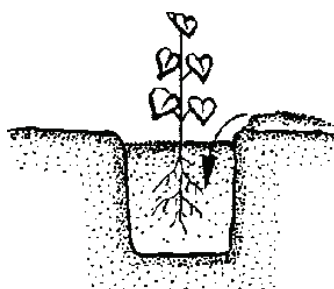
### Planting bare-rooted seedlings



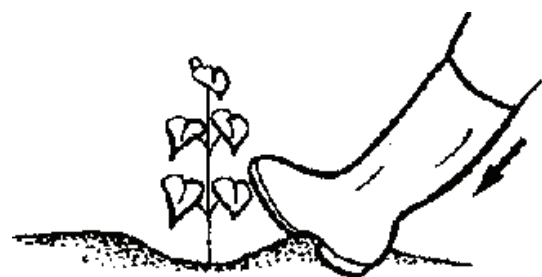
1. Hold tree with root collar 2-3cm below ground level



2. Put soil around the roots avoid air pockets



3. Fill up the hole



4. Firm soil carefully

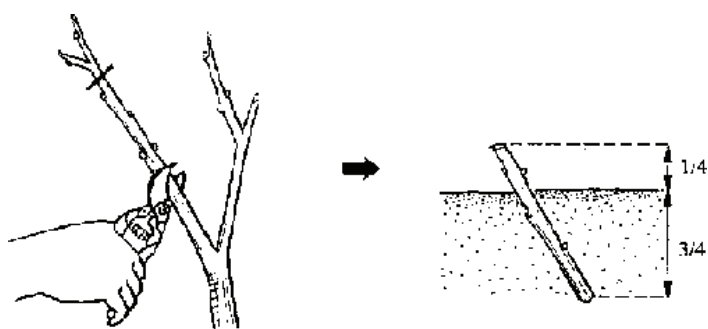
### Planting cuttings

Branch cuttings should be about 35-45 cm long with at least two leaf buds in the upper 10-15 centimetres. They should be planted in a slanting position with about 3/4 of their length in moist soil. Care should be taken that they are not planted upside down. Planting cuttings upside down will delay or prevent the rooting process.

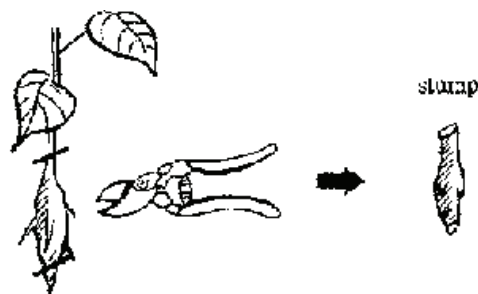
Stumps (also called root-shoot cuttings) should be 20-25 cm, about 80% root and about 20 % shoot. The diameter at the base of the stem should be between 1 and 3 cm. Stumps should be planted in a vertical position, with the root collar just at ground level.

All cuttings should be planted in premade holes. They should not be forced into the ground. Take care that cuttings are not planted upside down. Cover the upper cut with mud to protect it from direct sunshine.

### Planting cuttings

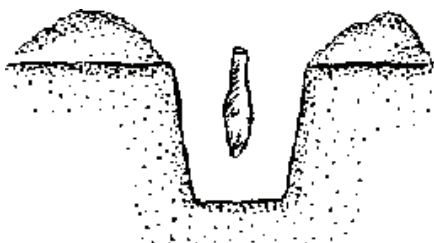


Planting Branch Cuttings

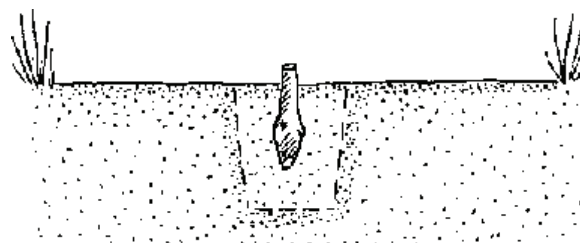


Planting Stumps

1. Prune tap root and trim lateral roots



2. Place stump in prepared hole and fill up



3. Firm soil around stump. Allow 1-2cm of shoot above ground

### Common mistakes during planting

- Planting holes made too shallow.
- Plants dry out during transport.
- The soil is not firmed enough and air pockets lead to drying out of the roots.
- Planting is carried out too late.
- Roots are damaged during planting.
- Roots are bent or twisted in the planting hole.
- Containers are left on the seedlings.

# Chapter 5

# 5

How to plant on “normal” sites has been described in the previous chapter, but the technique described has to be adapted to local conditions. It is always wise to consider local experience and to learn from previous mistakes and successes. Often the sites chosen for reforestation are those not suitable for agriculture - the difficult sites. They will require extra care. Below, some advice is given on how to adapt the general planting method to various site conditions.

## 5.1 Favourable Sites

On sites with light and soft soil where experience has shown that regeneration is easy, the less expensive bare-rooted plants can be used. Instead of actual holes simple slots in the ground suffice for planting small bare-rooted seedlings (i.e. shoots less than 25 cm). For containerized seedlings the planting holes do not need to be bigger than the container. One single worker may then complete the whole planting operation.

When little clearing of planting spots is needed or when clearing is carried out beforehand, an open-angle hoe can be used. The use of an open-angle hoe has proven to be very fast and effective. While it takes some training and practice, it permits workers to increase their productivity very significantly compared to other methods.

1. Hold the hoe in your right hand and take a number of seedlings in your left. Start with around 10. Hold the seedling bunch with two fingers and take one seedling between your thumb on one side and the index and middle finger on the other.
2. Swing the hoe upwards and let the handle slide through your hand. Gloves should be worn otherwise the handle might not glide well and you can burn your hand.
3. Thrust its blade into the ground by letting the hoe come down. The force comes from the hoe's weight rather than from the worker's effort. Just before the edge of the blade hits the ground, let the handle go, so the shock does not hit your hand.
4. Grab the hoe close to the blade, move it up and down and then outwards to open a triangular slot.
5. Place the seedling in the slot in front of the hoe's head with the root collar at the same level as the surrounding soil surface or slightly deeper. Lift the hoe from the slot.
6. Push the soil around the seedling and firm soil carefully with your foot. Then move to the next planting spot. As you get up from the last seedling planted, use the momentum of your whole body to swing up the hoe and the work cycle starts again

## 5.2 Sites with High Grass

- Use a hoe to clear a patch with a diameter of at least 1 metre around the planting hole. The grass has to be uprooted to reduce competition.
- Remove as many grass roots as possible from the soil before putting it back into the hole.
- Weed often. Use a hoe and uproot the grass around the seedling. The success of the plantation will depend on the subsequent weeding.

## 5.3 Waterlogged Sites

- Plant on mounds or ridges to improve drainage for the young plant.
- Plant at the end of the rainy season when the site has dried up sufficiently. This will give the seedlings time to become well established before the wet season starts.

### Sites with High Grass

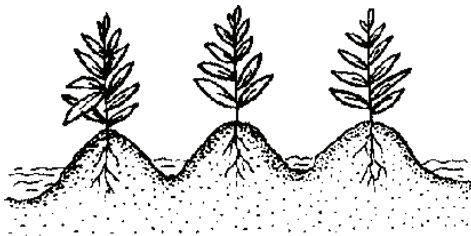


*Clear Patches*

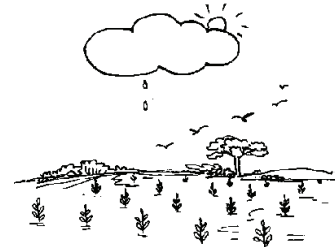


*Remove Grassroots and Weed often*

### Waterlogged Sites



*Planting on Ridges*



*Plant at the end of the rainy season*

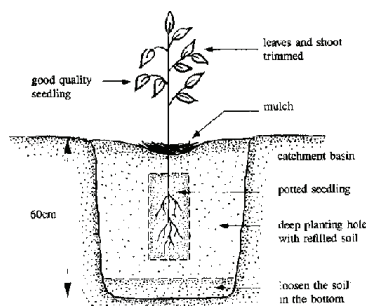
## 5.4 Dry Sites

- Prepare micro catchments (as described in Technical sheet 2).
- On dry sites it is even more important than otherwise that planting is carried out at the right time, i.e. at the beginning of the rainy season. Prepare planting holes in advance in order to complete planting as quickly as possible.
- Use seedlings of best quality with a good root system.
- Use containerized seedlings if available. They generally survive better than bare-rooted seedlings.
- With tall broad-leaved species, young shoots and part of the foliage must be stripped off, as described in section 3.4.
- Make planting holes large and deep, 60 x 60 centimetre. A large planting hole with plenty of refilled soil will help root development and thereby increase the survival rate and growth.
- Pickaxe the bottom of the holes to make it easier for the roots to penetrate.
- Form a basin around the seedling to catch as much water as possible.
- Mulching with grass and leaves around the seedlings will reduce evaporation and

prevent the surface soil from hardening.

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*Planting Technique for Dry Sites*

## 5.5 Eroding Slopes and Rocky Sites

- Determine whether soil conservation measures such as bounds or contour ridges are necessary.
- Use species with a deep, wide-spread root system and good initial growth.
- Restrict weeding to the area around the seedling.
- On severely degraded sites put a tablespoon of complete fertilizer at the bottom of the holes to provide a good start for the seedling.
- If stones are available, surround the plant with small stones.
- Avoid using vehicles that might damage the vegetation and the soil. Rainwater might otherwise wash away soil and cause erosion.
- Do not plant in a regular pattern; the seedlings should always be planted on the best available spot.
- When refilling the plant holes, remove all stones. Extra soil might be needed.

## 5.6 Steep Slopes

- On steep slopes a small horizontal platform has to be prepared where the planting hole will be dug.
- Work on a horizontal line to reduce physical effort.

## 5.7 Sand Dunes

Before starting planting on sand dunes, the moving surface must be stabilized. This can be

done as follows:

- Drive wooden stakes into the sand and tie them together with branches. The fence should be about 0.5-1 metre high. The sand will pile up behind the fence. On the little hill formed a second fence can be built, and so on until it is impossible for the sand to blow over it.
- Cover the dune surface with a layer of branches, palm leaves or the like.
- Sow grass or plant bushes or trees to cover the ground and keep the sand in place. Local, fast-growing species with creeping roots should be used.

Since sand dunes are often found in areas with scarce or very unreliable rainfall, it is particularly important and difficult to pick the right moment to plant. On some sites irrigation from a local well or using a cistern truck or trailer may have to be provided for if the plantation is to succeed at all. The high cost of irrigation is only justified where the plantation protects such valuable assets as villages, roads or an oasis, and where other measures like protection from grazing and direct sowing are not effective.

#### **Common mistakes in planting on difficult sites**

- Local experience not adequately considered. Contact local forest officers if available.
- Starting on too large a scale, and not allowing time to learn by experience.

# Chapter 6



## Maintaining Plantations

Planting trees is one thing, protecting them during the critical first three to six years, however, is something else. Far too many plants that have been raised and planted with care, effort and knowledge, die due to lack of maintenance of the plantations.

The maintenance operations and protection that might be needed are:

- Weed control
- Protection from grazing
- Fire prevention
- Protection from insects, diseases and rodents
- Fertilizers
- Replacement planting

### 6.1 Weed Control

Grasses, herbs and other vegetation on the planting site compete with the seedlings for light, water and nutrients. Cutting or removing the vegetation from around the seedlings reduces the competition. If weeding is neglected, the seedlings will die. How often and in which way the weeding is carried out depends on the climate, the soil, the species planted and the size and quality of the seedlings used.

The more hot and humid the climate, the more weeding operations are needed. Depending on weed competition in some places it will be enough to weed once during the first year. In other places three or more weeding per year might be needed. If small and poor quality seedlings are used, the number of weeding operations needed will increase. As a general rule of thumb there should be:

- 2-3 weeding during the first year after planting;
- 1-2 weeding during the second year after planting;
- 0-1 weeding during the third year after planting.

Weeding must be carried out early, before the seedlings suffer from being smothered by

## Maintaining Plantations

Planting trees is one thing, protecting them during the critical first three to six years, however, is something else. Far too many plants that have been raised and planted with care, effort and knowledge, die due to lack of maintenance of the plantations.

The maintenance operations and protection that might be needed are:

- Weed control
- Protection from grazing
- Fire prevention
- Protection from insects, diseases and rodents
- Fertilizers
- Replacement planting

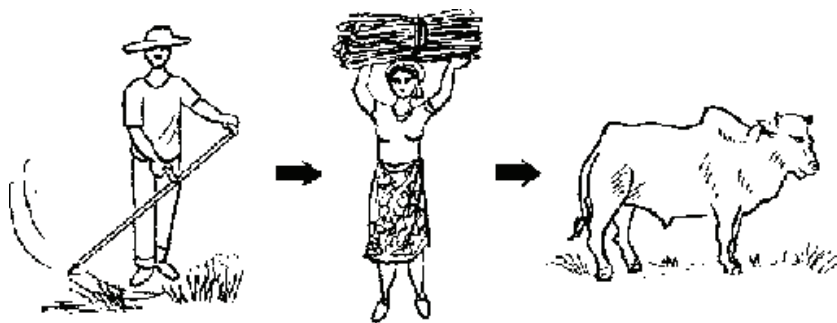
### 6.1 Weed Control

Grasses, herbs and other vegetation on the planting site compete with the seedlings for light, water and nutrients. Cutting or removing the vegetation from around the seedlings reduces the competition. If weeding is neglected, the seedlings will die. How often and in which way the weeding is carried out depends on the climate, the soil, the species planted and the size and quality of the seedlings used.

The more hot and humid the climate, the more weeding operations are needed. Depending on weed competition in some places it will be enough to weed once during the first year. In other places three or more weeding per year might be needed. If small and poor quality seedlings are used, the number of weeding operations needed will increase. As a general rule of thumb there should be:

2-3 weeding during the first year after planting;

1-2 weeding during the second year after planting;



*Grass-cutting decreases competition and provides fodder*



*Mulching*

- *Suppresses weed growth*
- *Reduces water loss*
- *Provides nutrition*

## 6.2 Protection from Grazing

Tree seedlings may also be harmed by animals. Cattle, sheep, goats and sometimes wild animals must be kept out of the plantation until the trees are big enough to withstand grazing. This problem is most acute in dry areas with sparse vegetation where animals turn to planted trees for food. Without the cooperation of the livestock owners protection will be difficult. It is therefore essential to discuss the problem very early during planning and to meet regularly after planting to sort out problems.

When bigger areas representing a large portion of the accessible grazing lands are being planted and where grazing is scarce, it might be necessary to divide the planting area into compartments and to plant them one at a time. The livestock is then allowed into the first compartment when the second one is being planted some years later, and so on. In this way the area where grazing has to be avoided is minimized. It may also be necessary to use species that are not readily grazed by the animals (for example prosopis, ailanthus and some eucalyptus). If these measures are not sufficient, fences should be built before or during planting.

For smaller plantations fences can be built with branches cut from thorny trees or other suitable material to protect the plants for the first couple of years. However, these lands of fences require a large quantity of branches and may put an additional pressure on an already stressed forest or bushland.

Hedges of closely planted bushes and trees (live fences) can also be created. Thorny plants such as Cactus, Euphorbia, Aloe, Sisal, Acacia or Juniperus can be used. Species that can be grown from large cuttings are preferable. Live fences must, however, be planted some years before the trees are planted and be given time to reach a sufficient size to keep out the animals.

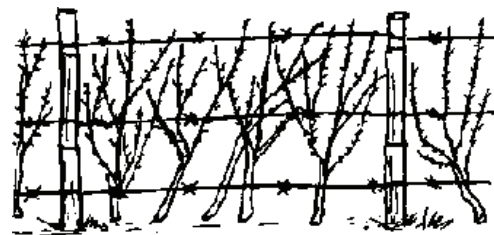
All types of fences have to be maintained. Where fences alone do not protect the plantation, a watchman can also be used to look after the plantation.

### *Protection from grazing*

Hedges



*Thorny Branches*



*Bamboo fence combined with thorny branches*

## 6.3 Fire Prevention

Bush fires in planted areas are almost always man-made. Fire is used to clear land, to improve grazing and to chase away wild animals. Fires may also be caused by carelessness during charcoal burning and honey collection.

Prevention of fire depends to a great extent on information and extension work. An understanding of the value and benefits of the forest for all members of the community must be reached. Where the plantation to be protected does not belong to individual private owners or to the local community, the interest of the local population can be increased by sharing the

produce of the plantation. This can be done in several ways. Local people can be given the right to collect non-wood products like grass, mushrooms, honey, etc. They can also be offered a share of the wood or other products from the plantation. To protect large areas of state forest plantations, local people can be given private wood-lots to form a protective belt around the state forest.

Firebreaks combined with a well-designed road system may keep the fire from spreading. Firebreaks consist of corridors about 20 m wide that are kept without vegetation cover. Maintenance of firebreaks is simple but labour intensive. They must be cleared at least once a year at the beginning of the dry season. Controlled grazing or cutting grass for stall-feeding can be used to minimize the amount of flammable dry grasses in the forest. Controlled grazing can also be used for clearing firebreaks.

Plantation staff and peasant association members may be trained in fire control. Small fires might be extinguished with water or plantation tools such as hoes or spades. If a fire has spread over a bigger area, the only practical way to control the fire is to remove flammable fuel from the path of the fire by opening up corridors without vegetation (fire lines). Already existing fire lines such as firebreaks and roads can be enlarged. Large forest fires can be fought with the help of backfire. A backfire is started on a strong fire line and directed towards the main fire. A wide corridor will be burned and when the two fires meet they will die for lack of fuel. Backfiring techniques need a lot of labour and should only be used under the supervision of an experienced fire fighting crew since there is always a danger that the fire can spread away from the back of the fire, starting new main fires.

#### **6.4 Protection from Insects, Diseases and Rodents**

Tree seedlings may also be harmed by insects, diseases and rodents.

Species liable to insects and diseases should be avoided. The best form of protection is to diversify the plantation, using various tree species. Treatment with pesticides or dipping of plants (i.e. planting seedlings treated with pesticides) may also be used. Some safety guidelines for the use of pesticides are given in section 9.5.

Rodents may cause damage to saplings, especially at high altitudes. The best form of protection from rodents is to keep the soil around the seedlings bare, i.e. well weeded. Rodents avoid bare soil where they are visible to birds of prey. Therefore, weeding limits the damage that can be done by rodents above the soil surface. Mechanical protection of the lower stem of young trees also works quite well. A suitable protection would be a split bamboo tube. The two halves of the tube are placed around the stem and tied together with a string. Protecting seedlings from rodents that damage the roots underground is more difficult. Traps, repellants or poisoning may be used.

#### **6.5 Fertilizers**

On poor sites a dose of manure or chemical fertilizer may be valuable. It should be applied during a rather dry period towards the end of the rainy season, preferably in combination with weeding in order to avoid run-off or absorption by weeds. The simplest method is to apply about one tablespoon of chemical fertilizer in two small patches on each side of the tree, 15-30 cm from the stem, and hoe it in.

## 6.6 Replacement Planting

Even if the seedlings are of good quality, carefully planted and suitable to the site conditions, there will always be a number of seedlings which do not survive. Replacement or “beating up” is always expensive. Therefore it is necessary to decide carefully, whether replacement is required or not. This depends on the percentage of seedlings that died and on their distribution on the site.

Replacement will be necessary only if more than two in ten plants have died and only where at least two neighboring seedlings have died. If the rate of failure is below 20 per cent, replacement will only have to be done if the failures are concentrated in particular areas of the site. A method of establishing survival rates is described in Technical sheet 3. The survival count should be carried out at the end of the dry season following planting. Replanting is then done at the beginning of the rainy season that follows.

For replacement, big seedlings of the best quality should be planted at the beginning of the rainy season. If one person completes the whole replanting operation - carrying of the seedlings, digging the holes, planting the seedling - a minimum of time will be spent for walking and locating where planting is needed.

There might be a need for more than one replacement planting. But where after two replanting operations the area is still not adequately stocked, a thorough check is necessary as regards suitability of planting techniques, plant quality, weeding practices, choice of species and the quality of the work.

In the long run it is better to invest more in site preparation, planting and weeding than in replacement.

### Common mistakes in maintaining plantations

- Weeding too late.
- Not continuing weeding long enough.
- No, or insufficient, protection from grazing.
- Protection from grazing and fire relies too much on technical means such as fences and firebreaks rather than on reaching agreement with the local population.

# Chapter 7

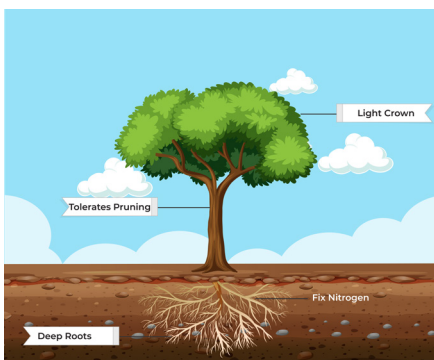
## Planting Trees Outside Woodlots and Forests

In many areas land is scarce and it is not possible to set aside a plot only for planting trees. In such cases trees can often be planted in ways that do not require a separate plot. Trees may be combined with agricultural crops or grazing, they may form a shelterbelt, or be planted along roads and rivers or around homesteads. The selection of species, spacing and protection are different in these cases from those described for woodlots.

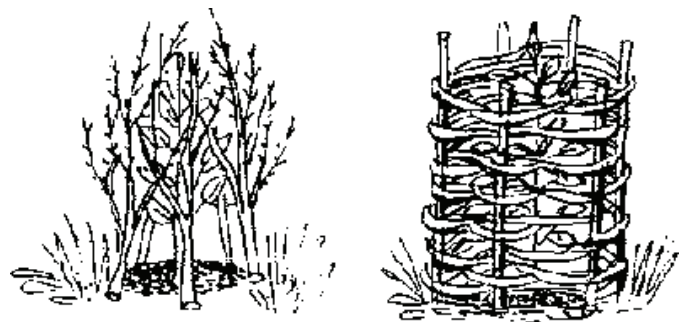
### 7.1 Trees in Crop and Grazing land

The most common form of agroforestry is simply to have trees scattered in grazing land or in fields. The trees can supply such useful products as food, fuel, fodder or gum. The trees can also provide shade, improve soil fertility and conserve soil moisture.

Agroforestry trees should have a light crown so that the shade provided is not too great for the



*Good characteristics for trees for agroforestry*



*Protecting natural generated sprouts from grazing*

### 7.2 Alley Cropping

When field crops are planted in alleys between hedgerows of trees and shrubs it is called alley cropping. The hedgerows provide fodder, green manure and mulch material. This is rather labour intensive since they have to be kept pruned throughout the cropping season to control shading and competition. Trees for alley cropping should fix nitrogen, coppice very easily after trimming and have leaves that are preferred by livestock or that decompose easily when applied as mulch. On dry sites competition for water may be so strong that alley cropping damages the crop. It should therefore not be practiced on such sites.

### 7.3 Intercropping in Rotation

When intercropping trees and crops, follow in sequence and combine restoration of the soil by trees with agriculture. The land is usually devoted to food growing for some years before trees are planted. Thereafter the agricultural crop is grown together with tree seedlings for some years until the shade from the trees interferes with the growth of the crop or the agricultural crop with the growth of the trees.

### 7.4 Intercropping for Tree Planting

It is also possible to intercrop only for a few years while a woodlot or tree plantation is being established. This is known as the Taungya system. The trees benefit from the soil preparation and weeding for the agricultural crop. The farmer will protect both his food crops and the seedlings. As a result, the trees survive much better and grow much faster. This form of intercropping can be practised by individual farmers or by landless cultivators that lease the land for two or three years.

After ground preparation food crops are planted. Normally annual crops are cultivated such as beans, maize or sweet potatoes. A particularly good combination are sweet potatoes cultivated on ridges, as shown in the figure opposite. Sweet potatoes can grow on relatively poor sites, they are quite shade-tolerant and the ridges provide excellent soil and water conservation. Perennial crops like bananas, papaya and cocoa can also be grown. Tree seedlings are planted at the same time, or one or two years after the food crop. Large tree seedlings should be used because they are sturdy and easily seen. Spacing between the rows of trees should be wider than for a normal plantation to delay the time when the canopy of leaves closes over and shades the food crop.

The raising of food crops continues until the shade from the trees prevents satisfactory growth.

This may last up to four to five years depending on tree growth, initial spacing and the kind of food crops grown. The area is abandoned by the farmer when it is no longer suitable for growing food. Normally, he will already be working in a new area nearby. The farmer may also work several small areas at the same time, clearing a new one each year.

### 7.5 Shelterbelts

Shelterbelts or windbreaks are strips of trees and other vegetation that reduce the force of the wind. They are very important in areas with frequent high winds and windblown sand. Often they consist of several rows of shrubs and trees of different heights.

Shelterbelts are most effective if they do not block the wind completely, like a wall, but force it to slow down. If the wind cannot pass through the shelterbelt at all, it will try to pass underneath it or over the obstacle. If it flows over the shelterbelt, it produces turbulence which is harmful for the crops behind the belt. If it goes underneath, the belt acts like a funnel and the wind becomes very strong. Therefore choose large trees for the centre row. On each side of this row plant one or two rows of smaller species. Outside these rows shrubs or other vegetation can be planted to make sure that the wind cannot pass underneath the belt. Plant the trees with close spacing, e.g. 1-2 m apart.

The trees need to be able to stand up to the wind and to have flexible branches and medium dense crowns. The crowns should be long and narrow rather than spreading

(the Casuarina species, for example, forms ideal windbreaks). The species should preferably be able to provide by-products. A well chosen mix will not only provide shelter from the wind but will also yield fruits, firewood, etc. If Shelterbelts are planted across grass and cropland where animals are grazing, it will be advantageous to plant thorny shrubs along the edges so that the shelterbelts can provide protection from livestock, like a live fence.

The shelterbelts should be planted perpendicular (at a right angle) to the direction in which the wind usually blows. The length of the zone protected is about 10 times the height of the shelterbelts. If large areas are to be protected, parallel shelterbelts should be planted. The spacing between the shelterbelts should then be 10-20 times the height of the tree.

### 7.7 Homesteads and Public Places

The household compound and public places (school yards etc.) are important areas for tree planting. Trees often add to the comfort, beauty and utility of the place.

It is practical to have trees around the house where they can be protected and tended with ease. Most people are more likely to benefit from a few trees planted in their home garden than from central woodlots or forest plantations. In many countries it is the women who are responsible for homesteads. Trees planted around the homestead might therefore directly benefit the women, a group which is often difficult to reach through tree planting projects.

The choice of species for homesteads and public places must be made by the people who will live in and use the areas. However, fruit trees and multipurpose trees are often preferred. Trees with noxious odours or irritating pollen (for example, the Croton species) should be avoided.

Homesteads and public places

#### Common mistakes in planting trees outside forests

- Ownership, duties and rights not clearly defined.
- Advantages and harvest are expected too fast. Farmers get disappointed and stop caring for the trees. Expectations must be set realistically.
- Suitable species, such as fruit trees and agroforestry trees, are not available from nurseries.
- As regards leasing of land:
- Contracts are too complicated.
- The legal framework is not clear.

## 8.7 Supervision and Control

Supervisors and foremen are the key persons. They should ensure that the work runs smoothly in the field.

The bigger the workforce, the greater the need for supervision. One foreman is usually needed for ten to fifteen workers and one supervisor, usually a technician, has to be appointed for each worksite. The supervisor is responsible for organizing the workers, for giving clear instructions on the work to be done, for motivating and encouraging workers to perform well, and for controlling and correcting the work. The supervisor must know the methods and techniques used and be able to demonstrate them.

The supervisor and/or the foremen should be responsible for controlling the quality of the work, the presence of the workers, instruction and training, the work achieved and the stock and maintenance of tools. The supervisor should also be responsible for checking that safety rules are kept, that working conditions are appropriate and that first aid equipment is available at the worksite. To effectively supervise the work, inspections have to be carried out on a regular basis at least once or twice a day. The work should be regularly checked and corrected. The better the control, the easier it is to correct problems when they are still minor.

To improve planning and coordination of the work, there must be regular feedback from the supervisors on the sites to the planners.

## 8.8 Records to Keep

Information about performance and about the cost of the different operations is essential for future planning. This information will help to improve work organization and forestry activities. A number of records has to be kept.

These include:

- Daily worker attendance sheets and payrolls;
- Records on silvicultural operations completed and costs (number of workdays/ha and other costs);
- Records on inventories of plant performance (for different species and provenance).

A form summarizing performance and costs is given on the opposite page as an example. On this sheet it can be seen that the total cost forecast agreed rather well with the actual cost. It can also be seen that pegging was carried out on only two-thirds of the area planned and that micro-catchments were constructed on a bigger area than planned. This might be taken into account for planning the next plantation.

The first part of the plantation plan is filled out at the planning stage (page 21). All operations and vital information should be added to this form and the associated map. A form containing the information for a two year old plantation is shown on the next page.

A copy of the plantation record, or for larger plantations a specification for each task, should always be available to the supervisor at the site. This should contain information on the type of activity, the scale and timing, the number of workdays planned, work norms and the tools needed.

**SUMMARY OF PERFORMANCE AND COSTS (suggested contents)**

TOTAL AREA:

YEARS: SITE:

SITE:

Operations	Unit of Measurement	Quantity				Work days		Cost (15/Rp/workday)		Cost	
		Forecast		Actual		Forecast	Actual	Forecast	Actual	Rp/ha	unit
		ha	no.	ha	no.						
Brash clearing	(ha)	35		35		350	350	5250	5250	150	
Pegging out	(ha)	30		20		120	93	1800	1395	70	
Micro catchments	(ha & no.)	10	6250	15	9400	200	330	3000	4950	330	0.5
Planting	(ha & no.)	35	21875	30	19000	875	800	13125	12000	400	0.6
Weeding 1	(ha)	35		30		700	712	10500	10680	356	
Weeding 2	(ha)	35		26		725	509	7875	7635	294	
Weeding 3	(ha)	35		20		160	124	2400	3600	180	
Replanting	(ha)	10		10		160	172	2400	3600	360	
Overheads								6000	6000	170	
Wet pay, Sick pay						100	123	1500	1845	53	
Total						3390	3213	53850	56955	<b>COST/HA 1627</b>	

**Survival Count**

Replacement planting is an expensive measure. The cost per seedling is double or triple compared with the first planting. Therefore it is necessary to decide carefully if replacement is needed or not. This is done by calculating the survival rate.

**Common mistakes in organizing the work**

- Arrival of funds delayed.
- Insufficient planning leading to delays in the work due to, for example, lack of transport or lack of manpower.
- Appropriate tools not available; use of poorly maintained agricultural tools results in low productivity.
- Workers not motivated (by fair wages, training and information on the objective of the plantation).
- Information from records, monitoring and work-studies not continuously used to improve work organization.

Survival is difficult to estimate by simply looking at a plantation site. As looking at each and every seedling planted would be extremely time-consuming, the survival of a portion of the plants is checked. The check should include all sections of the plantation (not only the one closest to the road). The best procedure is to check a number of rows equally distributed across the planting area. In areas of less than 2 hectares, you should sample every 5th row and in areas of

above 2 hectares you should sample every 10th row.

For every spot in the row where a tree was planted, mark on a piece of paper whether it is dead/missing or alive. An example of a survival count form is given on the following page. Recording plant survival separately for each line will help you to see in which part of the plantation replacement planting might be needed.

If the plantation consists of more than one species, survival should be checked species-wise. This together with information on how many seedlings were planted of each species (noted on the plantation history form), will make it possible to get a good idea of the survival of the different species. Together with estimates of the average height of the species, it can also provide useful information for planning future plantations.

The survival rate is calculated by dividing the number of surviving plants by the total number of plants and multiplying by 100.

$$\frac{\text{No of Surviving Plants}}{\text{Total No * of Plants}} * 100 = \text{Survival Rate}$$

Replacement is needed only if more than two out of ten plants are dead and only where at least two successive seedlings have failed. If the overall rate of failure is less than 20 per cent, replanting is carried out only in places where failures are heavily concentrated.

To make replacement planting easier, bring sticks or ribbons along when counting. Mark any part of the plantation with a high failure rate.

The difference in size between the plants used for replacement and the plants at the site should be kept as small as possible to minimize competition. The survival rate should be checked in time to carry out the replacement planting one year after planting, at the latest, in fast-growing plantations. In slower-growing plantations it should be checked in time to carry out replacement planting during the second year after planting.

During the survival count, the height growth should be estimated and noted.

### Survival Count Form

*Plantation:* \_\_\_\_\_ *Date Inspected:* \_\_\_\_\_

*Area:* \_\_\_\_\_ *Inspected by:* \_\_\_\_\_

*Planting Date:* \_\_\_\_\_

Line no	Surviving			Total surviving	Dead or missing	Concentrated or scattered
	Velvel	Vagai	Usilam			
2				63	9	5
7				69	7	2
12				55	17	5
17				64	8	6
22				60	18	5
27				62	9	5
<b>Total</b>	<b>194</b>	<b>69</b>	<b>110</b>	<b>373</b>	<b>68</b>	<b>mostly scattered</b>

Grand total 373 - 68 = 441

**SURVIVAL RATE**

$$\frac{\text{No of Surviving Plants}}{\text{Total No of Plants}} * 100 = \frac{373}{441} * 100 = 55\%$$

**ROUGH SURVIVAL RATE SPECIES WISE**

$$\frac{\text{Surviving No of Plant Species}}{\text{Total No of Plants Planted} * \text{Total No of Plants Checked}} * 100 = X$$

Velvel:  $\frac{194}{0.55 * 441} * 100 = 80\%$

Vagai:  $\frac{69}{0.18 * 441} * 100 = 87\%$

Usilam:  $\frac{110}{0.27 * 441} * 100 = 92\%$

<b>Estimated Height</b>	
Velvel	0.6 m
Vagai	0.4 m
Usilam	0.2 m





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