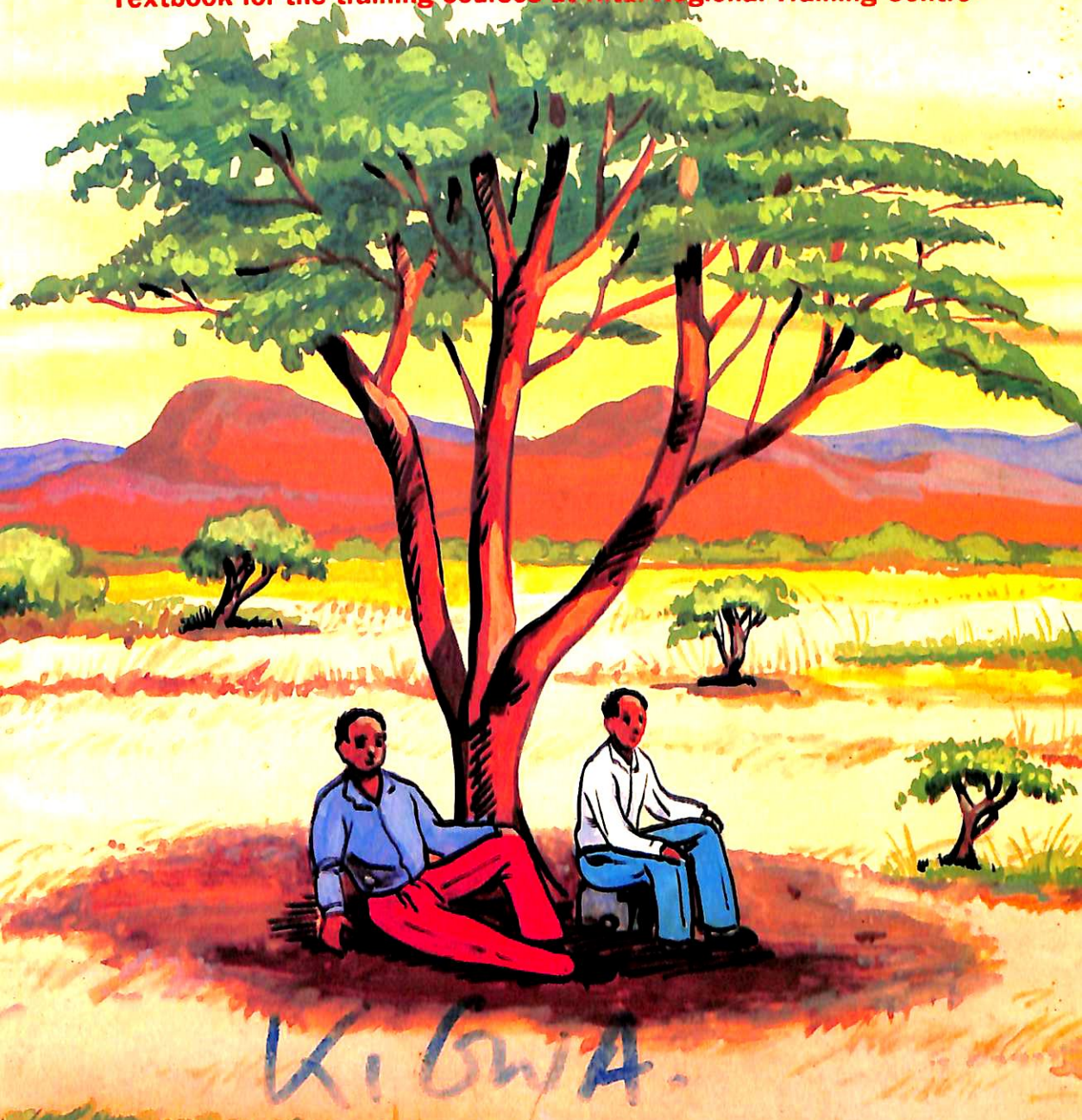
SOCIAL FORESTRY TECHNIQUES

PART ONE

Textbook for the training courses at Kitui Regional Training Centre



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Kenya/Japan Social Forestry Training Project

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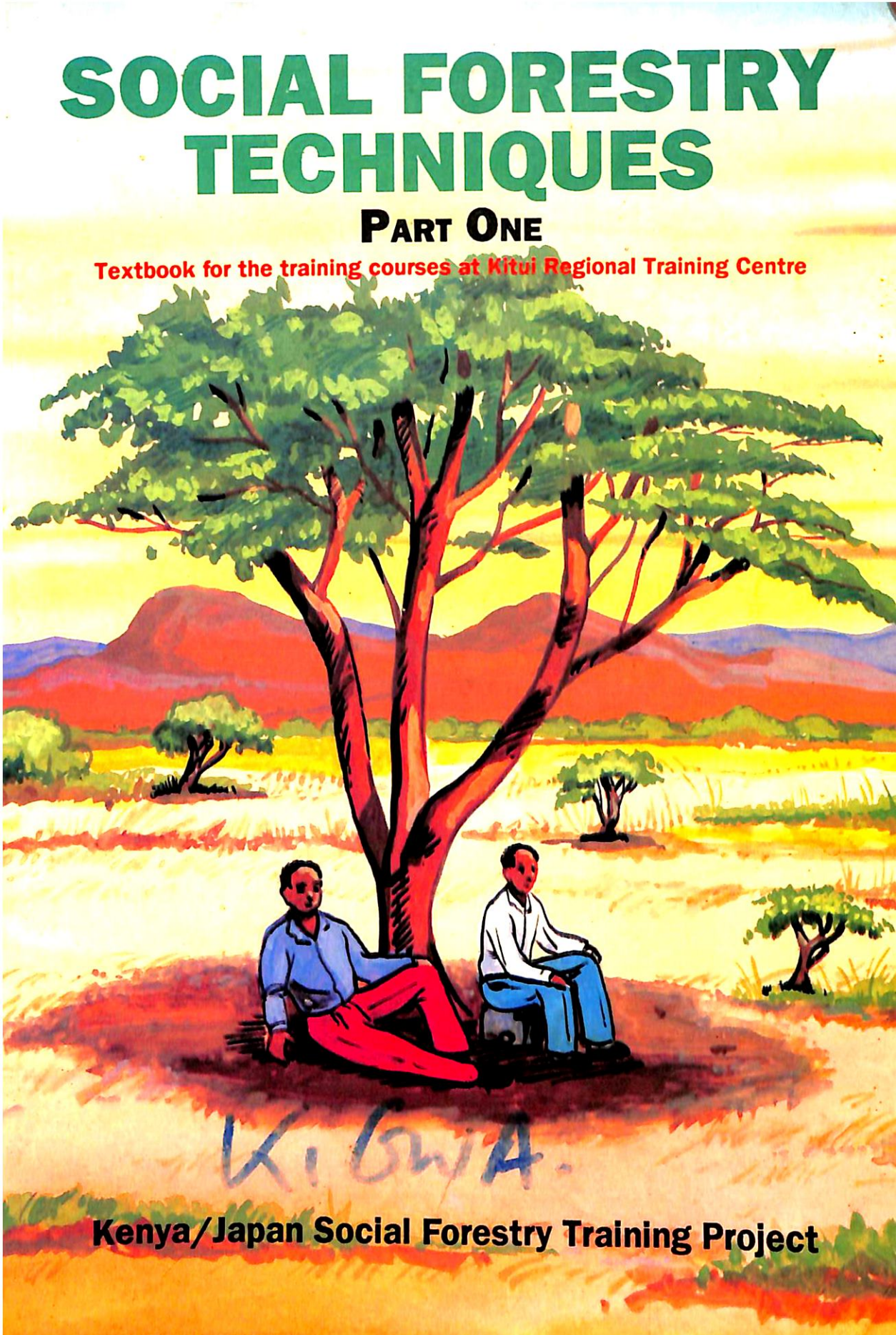

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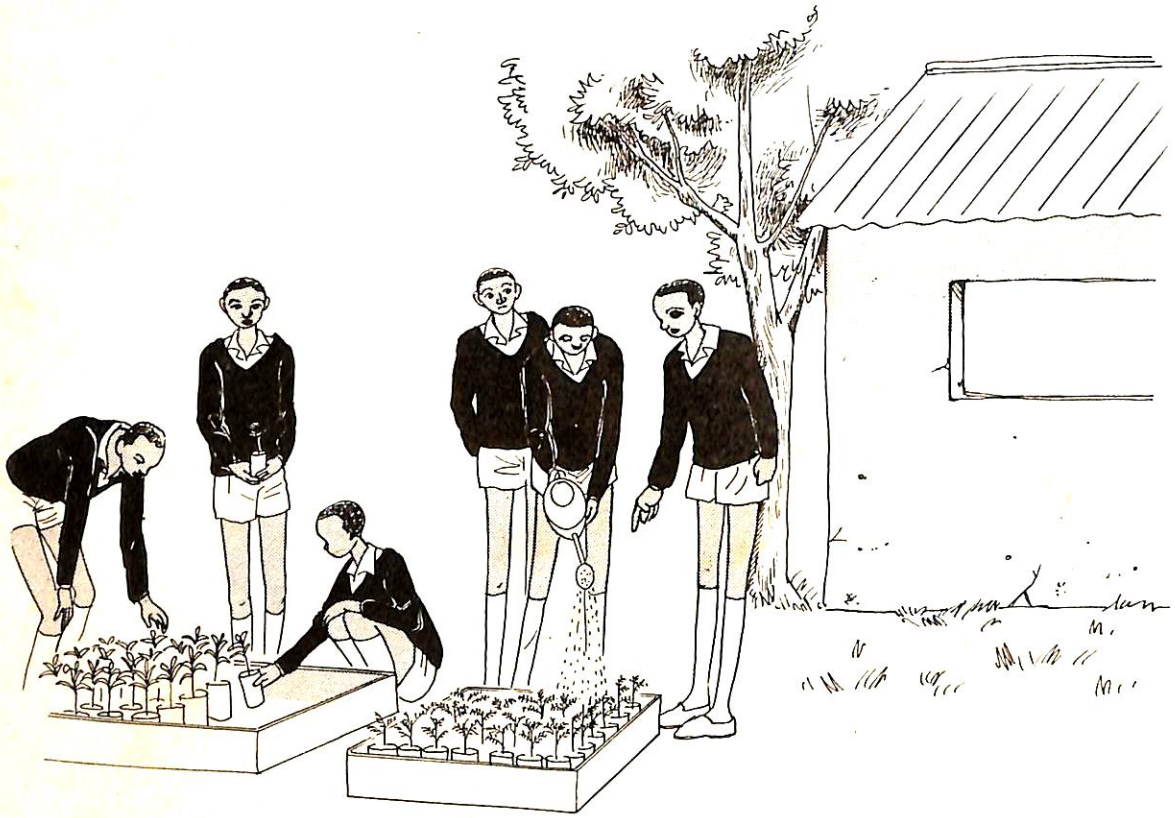

This textbook was prepared for training courses held at Kitui Regional Training Centre of Kenya/Japan Social Forestry Training Project which serves the rural people, especially in semi-arid areas in Eastern Province of Kenya.
Training activity at this Centre started in December 1988. However, there was no uniform textbook and so handouts prepared by lecturers were used for the initial courses. Most of the chapters in this textbook are based on such notes and more information has been collected from reference books listed at the end of this book.

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Chapters without the editor's name and the entire text of this textbook was edited by Mr. N. Noda. Most of the illustrations were drawn by two Japanese ladies, Mrs. Yoko Kato and Shima Ozawa.
This textbook contains only the most important subjects which were covered in the initial training courses. Books on other related subjects, especially for extension staff, are under preparation.

CHAPTER 1

ROLE OF TREES IN THE HUMAN ENVIRONMENT

1. INTRODUCTION

Trees play a very important and vital role in the human environment. They provide us with many of our necessities, and are an indispensable part of our environment.

Trees have associated with human beings ever since our first ancestors appeared on the earth, deriving their livelihood from trees in terms of food, shelter, firewood, etc. Before sedentary agriculture started, wild plants including trees had given people a large percentage of their diet such as fruits and nuts. Even after cultivation started, some trees have been domesticated and they continued to play an important role in human life. There are many benefits from trees, some of which are tangible while others are intangible. In this chapter, we shall look at the role of trees, and see how indispensable trees are to the human beings.

2. TREES IN DAILY LIFE

(1) Timber: Trees are a source of timber which is used for many purposes, e.g. building houses, bridges and other architectural structures.

In many places of Kenya, houses are built with stone or bricks, but even in this case, doors, windows and roof supports (trusses) are built with timber. Furniture made from timber is quite popular because of its durability, price and appealing qualities.

(2) Poles and Posts: In many places, electricity and telephone transmission lines are supported by poles of wood. These are usually treated with oil, so that they are not affected by insects or rain water and last longer. Metal or concrete transmission poles are much more expensive and require an engineering skill to manufacture and to install. Posts are used in many rural areas to fence compounds and farms; moreover, most houses built of wood or mud are supported by posts.

As demand for houses and fences rises, the demand for posts also goes up. Government forests are hard pressed to provide the posts and poles needed, and it would be cheaper and more convenient if they were produced on the farms or near the users.

(3) Traditional Furniture and Tools: In most of areas in Kenya, traditional furniture like stools used to be made from trees which were locally available. Also local tools such as mortars and ploughs have been made from wood. Tool handles are also made from locally available hard and durable wood.

(4) Fuel: One of the major role of trees in the rural areas is to provide fuel for cooking and heating. Many women spend a large part of their time on collecting firewood. Charcoal is playing an important role in people's lives especially in urban areas. And as it becomes scarce, it is becoming more and more expensive. In the foreseeable future, before people turn to alternative forms of energy, a majority of the population in most of the developing nations will continue to depend on firewood and charcoal for their domestic and industrial uses.

For example pottery and brick making require firewood. More trees need to be planted in order to provide firewood and charcoal to the people.

(5) Fruits and Nuts: Many trees produce edible fruits or nuts. Apart from the cultivated trees like mangoes, oranges, pawpaws, avocados, loquats, coconuts, etc., people have also collected fruits from wild trees.

(6) Medicine: Many medicines for persons as well as for livestock are made from plants including trees. Their medicinal contents are extracted and packaged into tablets, liquids and other forms of medicine. Trees like *Azadirachta indica* (Neem) and a large number of other trees are used to treat diseases worldwide.

The leaves, roots, bark, flowers and other parts of their stems are boiled, crushed and chewed, to extract the medicinal contents.

Before modern medicines were introduced, people relied on medicinal wild plants to cure their sickness. Then after the introduction of modern medicines, traditional medicines were almost neglected, but they are still being used and nowadays there is a renewed interest in them.

(7) Ornamental Use: It is a well accepted fact that areas with trees are more beautiful and appealing to the eye than those without trees. In many places like towns, along the roads and highways, in home compounds and in schools, trees are planted for beauty. *Cassia spectabilis* (Mwenu), *Ficus benjamina* and other *Ficus* spp. (fig trees), *Jacaranda mimosifolia*, etc. are quite popular for this purpose.

3. TREES ON THE FARM

(1) Fodder: Many trees such as *Leucaena leucocephala* (Ipil-ipil), Acacia spp., *Terminalia brownii* (Muuku), etc. produce leaves, branches or pods that can be eaten by livestock as supplementary feed especially during the dry season. Of pasture lands or as hedge rows, these trees are beneficial.

(2) Living Stakes: Climbing crops like yams and passion fruits need to be supported by poles or stakes. Alternatively, living stakes have being used. *Commiphora* spp. (Mutunguka, kitungati, mururi) is commonly used for this purpose.

(3) Bee-Keeping: Bee-keeping is an important farm activity to supplement farmers' cash income. Traditional beehives have been made from tree stems and modern ones are made from timber. Beehives are usually hanged on the branches of big Acacia trees whose flowers are also the most important and valuable source of high quality honey.

(4) Shade: It is important that trees absorb radiation from the sun, and maintain cool temperature below them. People and animals take this advantage during the hot hours of the day. Some plants like coffee also require shade in order to grow.

(5) Soil Erosion Control: The trees control erosion caused by water and wind. Tree roots firmly bind the soil particles together and they cannot be detached easily. Their branches and leaves absorb and reduce the force of the rain drops which strike the ground. Their stems let the water trickle slowly downwards and seep into the ground. A large part of the rain in a wooded area seeps into the ground, while in a bare area, most of the rain water flows away with soil. Windbreaks of tree rows reduce the wind erosion by forcing the wind to climb over them. In the bare areas, the wind travels near the ground, picks up and transports particles of soil in the form of dust, and also accelerates the evaporation from the soil surface.

(6) Improvement of Soil: Most trees contribute a lot towards the formation of humus on the soil surface by leaf fall. Twigs, branches and roots that are on the ground decay and form the humus, so that the fertility of the soil increases considerably. Some trees fix nitrogen into the soil, and this has an overall effect of increasing the fertility of the soil and the yields of the crops. Trees that fix nitrogen are *Acacia* spp., *Sesbania sesban* (Mwethia, Munyongo), *Leucaena leucocephala* (Ipil-ipil), *Casuarina equisetifolia* (Mvinje), etc.
Tree roots make a soil lighter and less compact, air and water can, therefore, infiltrate quite easily. This leads plants to produce better growth and yields since the improved soil structure can hold more water and air usable by plants.

4. TREES IN THE ECONOMY

4.1 Trees in Household Economy: As already pointed out, trees and their by-products are essential for rural life and have great economic value to rural households both directly and indirectly. Use of trees and their by-products in daily life saves a lot of money since most of them are collected freely or with only a little investment. Firewood, charcoal, poles, timber, fruits, nuts, medicines, furniture, tools, fodder, green manure, honey, etc. are consumed in the households and these products can also be sold in the market to earn cash income. Thus it is very important to invest some part of your income from tree products to replace trees once cut to sustain the yield permanently. Growing some valuable and marketable trees on your farm may help you like savings in a bank. They do not require the intensive care like livestock do, and increase their value naturally, slowly but steadily.

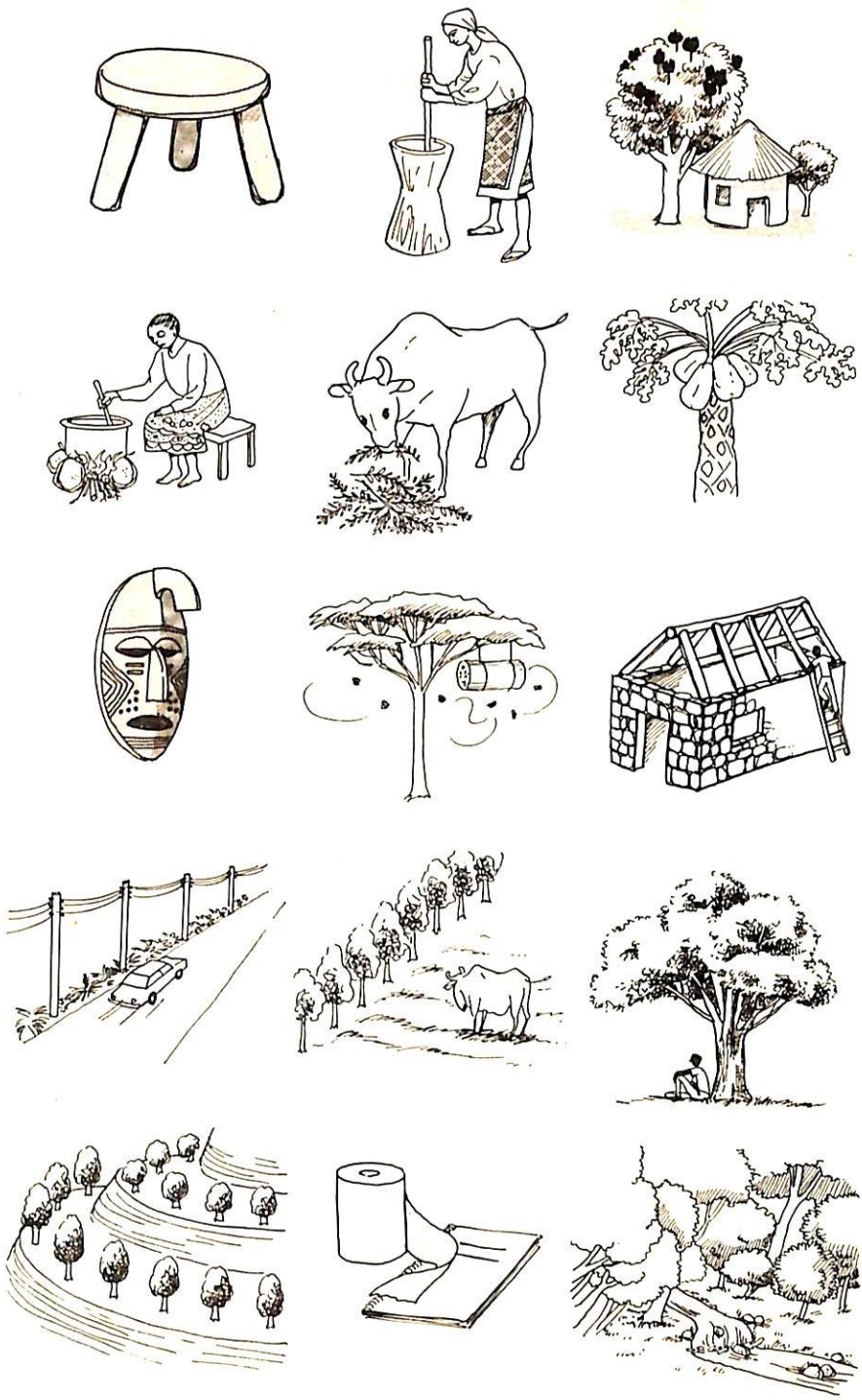


Figure 1-1: Characteristics of trees

4.2 Trees in National Economy: Trees also play an important role in large scale economy at the national level.

(1) Employment: The Ministry of Environment and Natural Resources employs over 30,000 workers, most of them dealing directly with tree growing, protection and management of the tree resources. Non-government organizations, e.g. Green Belt Movement, Care Kenya, etc. are other employers in their endeavour to grow trees.
In addition, many sawmillers and factories dealing with tree products, employ a large number of people. Furniture and construction companies, distributors and transporters of wood and wood products are other large scale employers of people. Carpenters, pit sawyers, charcoal producers and its dealers are also dependent on trees.
All in all, many Kenyans are employed or are dependents of people who care for, plant, manage or exploit the trees, or convert them into saleable or useable products.

(2) Industrial Products: Paper, plywood, fibreboard, blockboard, tiles, roofing shingles, matches, tool handles, etc. are all made from wood. Some are made in large scale industries, while others are produced in small scale industries.

(3) Carvings: Many Kenyans depend on the wood carving industry, and they produce good quality carvings which are sold to the public, tourists or outside the country to earn some income.

(4) Other Products: Oil, gum arabic, tannin, dyes, etc. are extracted from many species of trees on commercial basis as well as rural use.

5. TREES IN ENVIRONMENT

(1) Amelioration of Air: Trees purify the air by removing carbon dioxide and producing oxygen which is then breathed in by human beings and animals. Trees and other plants are, therefore, important in maintaining carbon dioxide at the proper level in the atmosphere.

(2) Watershed Protection: A wooded watercatchment area produces clean water at a stable quantity. If trees are planted along a river or a stream, the water is kept clean and cool.
However, most of Kenyan rivers are not properly protected, therefore, water levels are unstable and the water is always muddy.

(3) Reclamation of Eroded Areas: Bare hillsides, eroded land and places with gullies, once trees are planted there, will be reclaimed slowly.
The trees once established, stop any further erosion, and through leaf fall and breaking the rocks on the ground, the soil is gradually build up. Trees also encourage other plants to grow under them.

(4) Wildlife Protection: An important part of our national heritage is the abundance of wildlife in our country.
Many animals and birds depend on trees as shelter and food. The predators eat the meat of tree-dependant ones, and therefore, most of the wildlife would die, if it were not for trees.

6. CONCLUSION

As described above, trees are indispensable in human environment and it is clear that the survival, well-being and future of human beings is closely related to trees.
However, the situation nowadays is very alarming, more and more trees are being cut to sustain the rapidly growing population, and fewer trees are being planted. The human environment is being degraded at a rapid pace, desertification advances, and the human being, the major cause of these becomes the loser.
It would be ideal for everybody to be self sufficient in whatever tree products that they need. All farmers should plant as many trees as possible on their land. This reduces the pressure on forests.

CHAPTER 2

RURAL TREE PLANTING AND USEFUL SPECIES

1. INTRODUCTION

In Chapter 1, we saw the over all role of trees. In this Chapter, we focus on trees in rural life and introduce some important species. In rural areas, trees are indispensable for the people's daily life. Most people depend for their cooking fuel on firewood or charcoal and livestock feed on tree leaves as well as grasses. Trees also give comfortable shade to the people, animals and even to other plants, and they also protect soils from erosion and degradation. However, increasing population has been encroaching the forest areas and this wood resource is decreasing quickly. If the current rate of the population growth continues and the trees once cut are not replaced with new ones, the forests will disappear and the wood resource will be depleted sooner or later. If you plant and take care of trees replacing the ones you cut, the crisis never comes and, you and your children can enjoy the benefits offered by the trees.

2. WHERE TO PLANT

The place where trees are to be planted highly depends on their purpose. Big trees for timber cannot grow in the farm with maize, and it is meaningless to plant flowering trees in grazing land, far from the homestead.

2.1 Home Compound: It is recommended to start tree planting from your home compound. Ornamental trees, shade trees, fruit trees and some medicinal trees can be planted around the house.

2.2 Hedge Rows: This is to demarcate your own land and protect your house, livestock and shambas from thieves, animals and sometimes wind. Thorny and bushy trees or shrubs are usually used. To mix other types of trees, i.e. mulch-purpose trees, fruit trees, firewood trees or trees for poles, is also a good idea.

2.3 In Shambas: Planting trees in farmlands should be carried out carefully. Inconvenient tree species and bad management may affect main farm crops. However, suitable nitrogen fixing or multi-purpose trees with good care can help crops a lot. Another purpose of planting trees in shambas is soil conservation. Trees planted along the contour lines or on the hedge of terraces stabilize the soil. See Chapter 12 for details.

2.4 In Grazing Land: In grazing land, the first priority should be given to the fodder trees. If the land is large enough, firewood trees, fruit trees and larger trees for poles and timber are also planted. Trees must be protected from livestock when they are young and small. Trees within the grazing lands also provide livestock with the shade to rest and shelter to protect them from bad weather.

2.5 Fallow Land: The purpose to be fallow is to recover the productivity or fertility of the soil, therefore the nitrogen-fixing trees should be planted. Some fast growing multi-purpose trees or firewood trees also can be combined.

2.6 Woodlot: If you have enough land to devote only for trees, you can establish a woodlot. Any type of trees you need can be planted if the trees are adaptable to the climate and other conditions.

2.7 Public and/or Communal Land: This may not be a private activity. Usually these activities are carried out as a public work or a type of group work. Before starting the planting, property and distribution of the products, labour inputs, necessary costs, etc. should be discussed and agreed.

3. USEFUL SPECIES FOR RURAL TREE PLANTING

Every tree species has its own characteristics and suitable use. A tree which produces smoke when it is burnt should not be selected as a firewood species and a tree which has bitter leaves is not fed on by livestock. Climate and soil condition are also critical matters to select species. Many fast growing tall trees can be seen in highlands in Kenya, however, most of them cannot perform well or even cannot survive in much drier areas. Adaptability of the species or provenance to the particular condition of your area should be examined before planting.

3.1 Recommended Species for most of semi-arid areas:

(1) Acacia albida (Apple-ring Acacia, Olasiti): This is a well known agroforestry species especially for dry areas in Africa. Its root is deep and does not compete with crops for moisture. This species is nitrogen fixing like other legumes and nutrient-rich leaves can be used as fertilizers. This species loses its leaves in the rainy season so that the crops under the trees are never disturbed by shading. The pods are excellent fodder for goats especially in dry season alternating grasses and other types of fodder sources which are hardly available in this season. *(Figure 2-1)*

Figure 2-1: Acacia albida

(2) Acacia tortilis (Mulaa): This is probably the most common tree for charcoal making in dry areas in Kenya. Leaves and pods are good fodder for sheep and goats. This tree is also nitrogen fixing, so it may use as living fence of farms or a shade tree. Acacia nilotica (Musemei, Mugungu) has similar characteristics and uses. Other Acacia species are also good for firewood and charcoal, and some of them produce good quality of gum. *(Figure 2-2)*

Figure 2-2: Acacia tortilis

(3) Azadirachta indica (Neem): This is one of the most widespread trees in Africa but originally came from Asia. This is a real multi-purpose tree. Fast growing, giving high yields of firewood and timber is also high quality for poles and construction timber. Leaves, twigs and seeds are good fertilizer containing nitrogen and other important materials. Leaves are eaten by goats. Some medicine and insects repellant are extracted from leaves and seeds. Insecticide extracted from seeds are used to control pests on other crops and fruit trees. Oil is also extracted from seeds on commercial basis. This tree can grow in poor soil and is good for soil conservation and erosion control as well. *(Figure 2-3)*

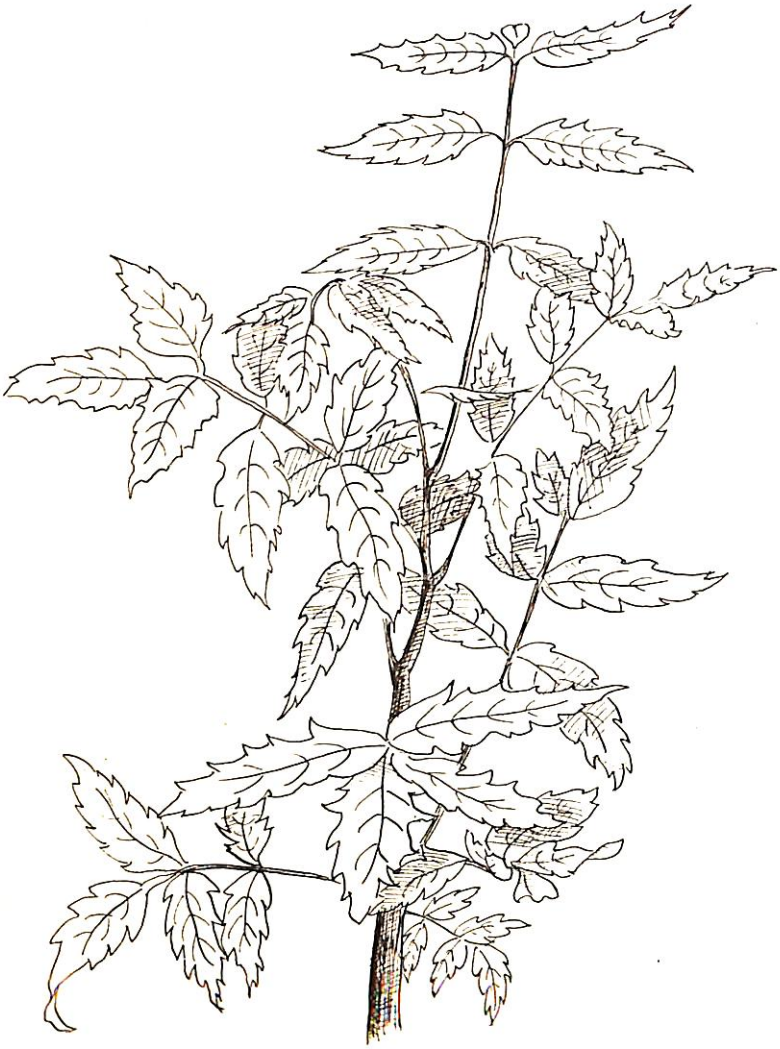


Figure 2-3: *Azadirachta indica*

(4) Cassia siamea (Ikengeka): This tree also came from Asia. The wood is hard and heavy. Firewood is also good but a little smoky. This tree coppices well and grows quickly in suitable conditions. Leaves contain nutrients and are used as green manure. As fodder, leaves are said to be toxic to pigs, and other animals do not prefer them. *(Figure 2-4)*

Figure 2-4: Cassia siamea

(5) Cassia spectabilis (Mwenu): This tree is indigenous to tropical America. General characteristics are similar to C. siamea. This tree is commonly found in home conpounds and along the streets planted for ornamental purpose because of its shape and beautiful yellow flowers. *(Figure 2-5)*

Figure 2-5 Cassia *spectabilis*

(6) Croton megalocarpus (Mukinduri, Muthulu): In natural distribution, this tree is very common rather in highland and midland than semi-arid areas. This is a good firewood tree but not very good for charcoal. Leaves provide a good mulch. The bark contains medicinal properties to cure stomachache.
(Figure 2-6)

Figure 2-6: Croton megalocarpus

(7) Dalbergia melanoxylon (Mpingo): This tree is known as African ebony or blackwood, possibly one of the most valuable timber in East Africa. The wood is used for wood carvings in Kenya and Tanzania, and musical instruments in Europe. However, the number has been greatly reduced by overcutting because of the high economic return and slow growing. It is recommended to keep some trees on farms for future investment. *(Figure 2-7)*

Figure 2-7: Dalbergia melanoxylon

(8) Leucaena leucocephala (Ipil-ipil): This is also a tree from Central America but nowadays widely introduced into the tropics all over the world. There are many varieties, some of them grow big and good for timber while others are comparatively small and good for fodder and green manure. This is known as a fast growing tree but only under suitable conditions and it does not grow well in areas with droughts of four months or more, on shallow and/or acid soil. Planting in farms is most recommended and generally it grows well. However, it may compete with other crops for water. *(Figure 2-8)*

Figure 2-8: Leucaena leucocephala

(9) Prosopis juliflora: This tree is native to Southwestern U.S.A. and Mexico. This tree is the best for firewood and charcoal, and can also be used for durable posts. Leaves are not palatable but make good fodder. Pods are edible even for humans. This thorny tree has potential as livefence. This is fast growing, drought tolerant and easy to coppice, but not very much recommended to be grown in cultivated areas because of its weediness. The relative Prosopis chilensis is from South America and also has almost same characteristics. *(Figure 2-9)*

Figure 2-9: Prosopis juliflora

(10) Tamarindus indica (Tamarind, Mkwaju, Muthumula): The wood of this tree is of high quality used for furniture, mortars, boat building, etc. The fruit is delicious, contains high Vitamin C and its market value is also very high.

This tree also provides good shade, mulch, medicine and charcoal. However, this is said to be a very slow growing species especially when it is very young. *(Figure 2-10)*

Figure 2-10: Tamarindus indica

3.2 Other Trees: In 3.1 The most recommended trees are introduced. There are many other useful trees, however, it is impossible to introduce them here in detail. Therefore, only the names (scientific, common and local) are listed below according to their use:

(1) Species for Firewood and Charcoal: Trees which have high calorific value, low water content in their tissues and should be smokeless. Fast growing species are recommended as they reproduce themselves quickly, however, slow growing hard wood species usually give the better quality.

Acacia albida, (Apple-ring Acacia, Olasiti)
A. gerrardii, (Muthii)
A. mellifera, (Muthia)
A. nilotica, (Musemei, Mugungu)
A. polyacantha, (Musewa)

A. senegal, (Gum arabic, Mung'ole, Kikwata)
A. seyal, (Musewa)
A. tortilis, (Mulaa, Mgunga)
Albizia lebbek, (Mkungu)
Azadirachta indica, (Neem)

Cassia siamea, (Ikengeka)
C. Spectabilis, (Mwenu)
Casuarina equisetifolia, (Mvinje)
Conocarpus lancifolius
Croton megalocarpus, (Mukinduri, Muthulu)

Eucalyptus camaldurensis, (Red river gum)
E. microtheca, (Coolabah)
Faurea saligna, (Beechwood, -
Muto, Mutoroswa, Makwa)
Gliricidia sepium

Grevillea robusta, (Silky oak, Mkima)
Leucaena leucocephala, (Ipil-ipil)
Melia volkensii, (Mukau)
M. azaderach, (Persian lilac, Mukau)
Parkinsonia aculeata, (Jerusalem thorn)

Piliostigma thonningii, (Camels foot, -
Mulema, Msaponi)
Prosopis chilensis
P. juliflora
Schinus molle, (Peruvian pepper tree)

Tamarindus indica, (Tamarind, - Mkwaju, Muthumula)
Terminalia brownii, (Muuku)
Zizyphus mauritiana, (Mkunazi)

(2) Species for Use of Wood (Poles, Timber, Tools, etc.): Larger trees with straight trunk and durable wood are used for pole and timber. For tools, very hard and durable wood is required but the size and straightness are not so important.

Acacia polyacantha, (Musewa)
A. nilotica, (Musemei, Mugungu)
A. senegal, (Gum arabic, Mung'ole, Kikwata)
Acrocarpus fraxinifolia, (Indian ash)
Albizia gummifera, (Mukurwe, Mwethia)

Azadirachta indica, (Neem)
Balanites aegyptiaca, (Desert date, -Mulului, Mjunju)
Brachyleana hutchinsii, (Muhugu, -Mbunbu, Muhuhu)
Cassia siamea, (Ikengeka)
Casuarina equisetifolia, (Mvinje)

Combretum zeyheri, (Muthithi)
Conocarpus lancifolius
Croton megalocarpus, (Mukinduri, Muthulu)
Dalbergia melanoxylon, (Mpingo)
Eucalyptus camaldurensis, (Red river gum)

Faurea saligna, (Beechwood, Muto, - Mutoroswa, Makwa)
Gliricidia sepium
Grevillea robusta, (Silky oak, Mkima)
Melia volkensii, (Mukau)

Piliostigma thonningii, (Camels foot,-
Mulema, Msaponi)
Tamarindus indica, (Tamarind, -Mkwaju, Muthumula)
Terminalia brownii, (Muuku)
T. prunioides, (Mutoo, Mwangati)

T. spinosa, (Mwangati, Mutula)
Zizyphus mauritiana, (Mkunazi)

(3) Species for Shade and Ornamental Purpose: Suitable species for shade trees have widespread crown but the density of the leaves depends on the purpose and place. Ornamental species should have beautiful shape, beautiful flowers or beautiful leaves.

Acacia xanthophloea, (Naivasha thorn)
Albizia gummifera, (Mukurwe, Mwethia)
Azadirachta indica, (Neem)
Callistemon citrinus, (Bottlebrush)
Calodendrum capense, (Cape chestnut, - Mukobo, Yangu)

Casuarina equisetifolia, (Mvinje)
Cassia siamea, (Ikengeka)
C. Spectabilis, (Mwenu)
Croton megalocarpus, (Mukinduri, Muthulu)
Delonix regia (Flamboyant, Mjohoro)

Erythrina abyssinica, (Muhuti, Mvuti)
Ficus benjamina
Grevillea robusta, (Silky oak, Mkima)
Jacaranda mimosifolia
Kigeria africana, (Sausage tree, Muratina)

Melia azedarach, (Persian lilac, Mukau)
Parkinsonia aculeata, (Jerusalem thorn)
Schinus molle, (Peruvian pepper tree)
Spathodea nilotica, (Nandi flame, Kibobakasi)
Tamarindus indica, (Tamarind, Mkwaju, Muthumula)

Terminalia brownii, (Muuku)
T. mentalis
Thevetia thevetioides, (Yellow Oleander)
Tipuana tipu, (Tipu tree, Pride of Bolivia)

(4) Species for Fodder: Species for fodder trees should contain high nutrients and should be ever green to feed livestock in dry season.

Acacia albida, (Apple-ring Acacia, Olasiti)
A. brevispica, (Mugusi)
A. gerrardii, (Muthii)
A. nilotica, (Musemei, Mugungu)
A. polyacantha, (Musewa)

A. senegal, (Gum arabic, Mung'ole, Kikwata)
A. seyal, (Musewa, Mgunga, Mugaa)
A. tortilis, (Mulaa, Mgunga)
Azadirachta indica, (Neem)
Balanites aegyptiaca, (Desert date, - Mulului, Mjunju)
Euphorbia tirucalli, (Mtupa Mwitu)
Gliricidia sepium (but toxic to pig)
Grevillea robusta, (Silky oak, Mkima)
Leucaena leucocephala, (Ipil-ipil)

Parkinsonia aculeata, (Jerusalem thorn)
Prosopis chilensis
P. juliflora
Salvadora persica, (Toothbrush tree, Mswaki, Mukayau)

Terminalia brownii, (Muuku)

(5) Species for Inter-cropping and Land Reclamation: Nitrogen fixing trees are planted on farm together with agricultural crops, and they are also useful to reclaim fallow and other degraded lands.

Acacia albida, (Apple-ring Acacia, Olasiti)
A. gerrardii, (Muthii)
A. senegal, (Gum arabic, Mung'ole, Kikwata)
A. tortilis, (Mulaa, Mgunga)
Albizia gummifera, (Mukurwe, Mwethia)

Azadirachta indica, (Neem)
Casuarina equisetifolia, (Mvinje)
Conocarpus lancifolius
Croton megalocarpus, (Mukinduri, Muthulu)
Gliricidia sepium

Grevillea robusta, (Silky oak, Mkima)
Leucaena leucocephala, (Ipil-ipil)
Parkinsonia aculeata, (Jerusalem thorn)
Piliostigma thonningii, (Camels foot, Mulema, Msaponi)

Sesbania sesban, (Mwethia, Munyongo)
Terminalia brownii, (Muuku)

(6) Species for Bee Foliage offering good quality of honey;
Acacia spp.
A. mellifera, (Muthia)
A. tortilis, (Mulaa, Mgunga)
Cordia abyssinica, (Muringa)
Croton megalocarpus, (Mukinduri, Muthulu)

Dombeya spp., (Mukeo)
Eucalyptus camaldurensis, (Red river gum)
Faurea saligna, (Beechwood, Muto, - Mutoroswa, Makwa)
Gliricidia sepium

Grevillea robusta, (Silky oak, Mkima)
Leucaena leucocephala, (Ipil-ipil)
Prosopis juliflora
Melia azaderach, (Persian lilac, Mukau)
M. volkensii, (Mukau)

Sesbania sesban, (Mwethia, Munyongo)

(7) Species for Fencing: For living fence, thorny and shruby trees are used. The crown should be dense not to allow people or animals to pass through.

Aberia caffra, (Kei apple, Kayava)
Acacia brevispica, (Mugusi)
A. mellifera, (Muthia)
A. tortilis, (Mulaa, Mgunga)
Euphorbia tirucalli, (Mtupa Mwitu)

Gliricidia sepium
Opuntia opuntia, (Paddle cactus)
Parkinsonia aculeata. (Jerusalem thorn)
Prosopis juliflora
Thevetia thevetioides, (Yellow Oleander)

Terminalia spinosa, (Mwangati, Mutula)
Zizyphus mauritiana, (Mkunazi)

(8) Species for Medicinal Use:
Many plants are known and used as medicinal plants. Some of them are used very locally while some others are commonly used. Some species were scientifically proved, and rejected.
Some of the comparatively common -medicinal plants are:

Acacia spp.
Albizia anthelmintica, (Muoa)
Azadirachta indica, (Neem)
Balanites aegyptiaca, (Desert date, -Mulului, Mjunju)
Commiphora spp., (Iguu, Mbambara)

Cordia ovalis, (Msasa, Muthia)
Croton megalocarpus, (Mukinduri, Muthulu)
Dalbergia melanoxylon, (Mpingo)
Euphorbia spp.
Ficus spp.

Kigeria africana, (Sausage tree, Muratina)
Piliostigma thonningii, (Camels foot, - Mulema, Msaponi)
Salvadora persica, (Toothbrush tree, - Mswaki, Mukayau)
Tamarindus indica, (Tamarind, - Mkwaju, Muthumula)
Warburgia ugandensis, (Kenya - greenheart, Muthiga)

CHAPTER 3

SEED COLLECTION, HANDLING AND PRE-TREATMENT

1. INTRODUCTION

Like many other farm crops in most cases trees are grown from seeds. Seed collection and handling techniques are the most fundamental subjects in tree growing. Seeds must be collected from the right source and be of good quality. However, people tend to collect seeds which are easy to collect and less attention has been paid for quality of the seeds. Since seeds are very delicate, it is also necessary to handle them properly otherwise they will not germinate vigorously. It is very important, therefore, to gain the right knowledge on these procedures which include selecting the right seed source, right collection timing, collecting methods and proper handling and treatment techniques to ensure the sufficient germination.

2. SEED COLLECTION

2.1 Mother Tree: Usually some trees which have good quality of seeds are used continuously as the seed source until they lose the fruiting vigor. These trees are called "mother trees", and to select good mother trees is the first step of seed collection.

2.1.1 Selection: First of all, mother trees, must be healthy, vigorous, well formed and sustain good quality and quantity of seeds. (Figure 3-1)

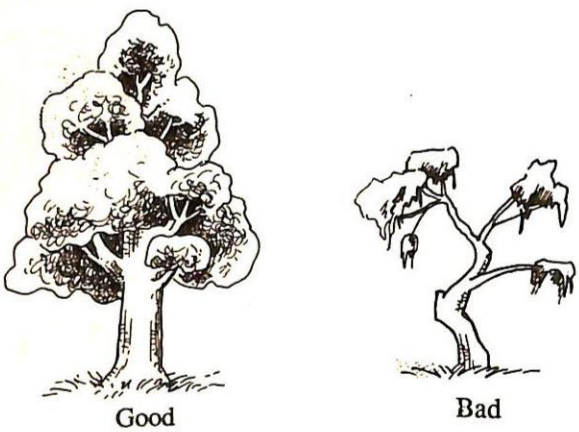


Figure 3-1: Mother Tree

Very young trees and old trees should not be selected because they may not produce viable seeds. A tree which stands far away from its relatives, even if it is well performed should be avoided, since it might be due to rather geographic advantage than genetic superiority; The best trees grow in the midst of a healthy stand of the same species. However, an isolated small stand should not be selected, since there may occur inter-breeding which can result in undesirable fruiting. The distance between the mother trees should be at least 50 m to avoid inter-breeding. And 20 to 50 trees should be selected. Areas, where mother trees grow, are also to be selected.

The areas should be similar, on various aspects, e.g. altitude, temperature, rainfall and soil types, to the areas where seedlings from the seeds will be planted. Well-formed trees on sandy soils may produce poor offsprings on loamy, rocky or other type of soils. Several number of trees should be selected as the candidates of the mother trees to avoid the risk at the initial stage, then the germination and growing performance traced will show which is the best for mother tree.

2.1.2 Conditions Required: Characteristics of the trees to be planted depend on the purposes of tree planting as in the table, and the mother trees must be superior in all the points.

2.2 Seed Collection Timing

2.2.1 Optimum Timing: Seed surveying is very important prior to organizing seed collection trips. Since different trees flower at different times or periods, it is important to note flowering periods of trees to monitor seed maturity closely. If the above condition is observed properly chances of collecting immature seeds will be eliminated. Therefore, seed collectors should have the knowledge or the ability to judge the optimum timing for seed collection *The best time for seed collection is as soon as the seed is mature and ready for harvest. Some types of seeds will not germinate if they stay on the tree for too long. Good seeds which are neither rotten, pest infested nor raw (green) should be collected when trees are at the peak of seed production when seeds are abundant and of best quality.*

1. Timber trees
a. Trunk is straight
b. Branches are few
c. Fast growing

2. Fodder trees
a. Fast growing
b. Profuse in branches
c. Multi-stemmed
d. Easy to coppice
e. High productivity of leaves and pods

3. Fruit trees
a. Produces good quantities of sweet and healthy fruits of marketable size
b. Easy to pick fruits from low branches
c. Resistant to disease and pests

4. Firewood trees
a. Have high calorific value
b. Fast growing
c. Easy to coppice

2.2.2 *Judgement of Seed Maturity:* Maturity of seeds is a major factor in seed collection. In general, when they appear cracked and attain a dark brown colour (e.g. *Acacia* spp.). However, for some types of seeds, it would be difficult to judge whether they are ripen and/or when they should be collected.

(a) The seeds of Combretum spp. and Terminalia spp. appear brown even when unmatured. Careful observation must be made to ensure that the seeds are mature before harvesting.

(b) Seeds of dehiscent (opening) fruits, such as Grevillea robusta (Silky oak, Mkima), have to be carefully observed since their seeds are light and easily blown away by wind

2.3 Collection Methods: There are several methods of collecting seeds. Some are easy while others require some skill. Some common methods are mentioned below:

2.3.1 *Collection of Fallen Seeds:* This is the method to collect fallen seeds by shaking trees *naturally or compulsorily.*

(a) Method: Large plastic sheets or canvas are spread under the mother trees for seeds to fall on. Seeds on sheets should be collected daily to avoid chances of insect attack and fungal infection. If plastic sheets are not available, leaves, branches and the undergrowth on the ground under the mother trees should be removed so that the fallen seeds can be found easily. This method is adaptable especially for large fruits e.g. *Croton megalocarpus* (Mukinduri, Muthulu), *Delonix regia* (Flamboyant, Mjohoro), etc. (*Figure 3-2*)

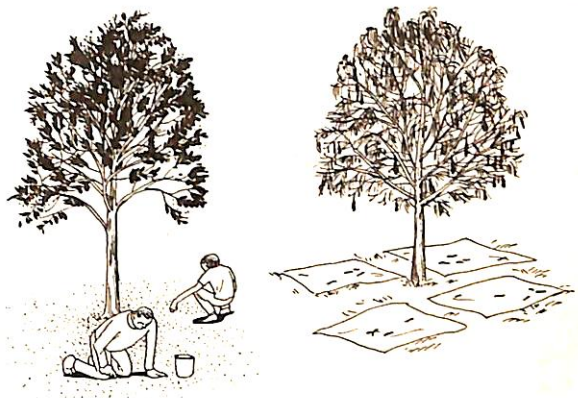


Figure: 3-2 Collection of fallen seeds

(b) Advantages and Disadvantages: This is the simplest method and does not need skilled labour. Equipment required are only a sieve, rake, seed containers and plastic sheets if available. However, seeds might have fallen from the tree immaturely, and there is also a high risk of fungal infection and insect attack while seeds are on the ground.

2.3.2 *Collection of on-Tree Seeds:* There are several collecting methods of on-tree seeds, some of them are manual and others need some tools. These are usually adopted for standing trees in dry zones since they are of open form and relatively small.

(1) Collection in the Crown

(a) Method: There is a limit of the height to which long-handled tools can be used for collecting seeds and then the climbing into the crown of the mother trees is only the practical method. The collectors

remove branches with seeds using a saw, a panga or similar implements. *(Figure 3-3)*

Figure 3-3: Collection in the crown

(b) Advantages and Disadvantages: Portable ladder, if available, makes this method easy and safe, the collector can quickly reach the crown of trees. A small ladder is, of course, appropriate for small trees. If a ladder is not available, it is risky and needs skill to climb and work on the branch. In some cases, collectors climb trees bare-footed or with the help of a rope which ties both feet togather to press them against the trunk of the tree. The disadvantage is that the collectors prefer easily climable trees which may not be desirable.

(2) Collection from the Ground

(a) Method: In the case of shrubs or trees with low branches, the collector would stand on the ground and pick seeds from branches which he can reach. While pods are closed, branches would be bent over and drop them to the plastic sacks or polythene sheets spread on the ground.

(b) Advantages and Disadvantages: This is the easiest and cheapest method when trees are small and branches droop low enough for collectors to reach them easily from the ground.

(3) Use of Pole Implements

(a) Method: This is also a collecting method from the ground but with the use of the pruning shears, the hooked poles (poles should be made of light but rigid material, e.g. bamboo, aluminium or plastic) or long-handled rakes. The latter two implements are used to bend down chosen branches sometimes in combination with a saw to cut them, or to shake the branches to have seeds fallen. Fallen seeds are collected on the sheets properly spreaded under the branches so that seeds, especially in case of pods seeds, are not lost by falling impact.

(b) Advantages and Disadvantages: Using these implements, the collector can reach the branches which are out of reach without some implements.

(4) Use of Ropes

(a) Method: The collectors throw a rope with a weight on one end and get a chosen branch twisted, then pulling the other end of rope, to collect seeds. As weight, ordinary stones, a small bag of sand etc. are used. *(Figure 3-4)*

Figure 3-4: Use of rope

(b) Advantages and Disadvantages: Skill is required in throwing the rope over the aimed branch and in the correct position.
However, once the collectors acquire the skill, this method is recommended, since ropes are cheaper than ladders and pole implements, and are easy to carry.

2.3.3. Collection from the Felled Trees: This method is cheap and easy while the collectors can get large quantities of seeds in a short time.
However, it is not advisable to fell trees only for seed collection, especially in dry areas where regeneration ability is very low. This can be, therefore, undertaken when the harvesting of trees is occasionally going on during seed picking period.

3. HANDLING AND STORAGE

After seeds are collected, some of them are to be stored whether it will be fora long or a short time, while others must be sown immediately.
As the periods of harvesting and sowing do not always coincide, and sometimes for future use, some species, especially legumes would be stored in order to ensure the availability during poor seed years.
While stored seeds will gradually lose their germination vigor. The speed mainly depends on the species, but the handling and storing conditions are an important factor. The procedures between harvesting and sowing are mentioned below:

3.1 Extraction: In most cases seeds are collected while they are either in fresh fruits, dried fruits, pods or in cones, and proper extraction must be done before other treatment.
Fresh fruits are treated by depulping process which normally conbines soaking in water with pressure or gentle abrasion.
Most seed extraction process of the cones and woody or leathery fruits requires pre-drying of the fruits to extract the seeds easily. *(Figure 3-5)*
Those which require soaking are generally in pulpy fruits or pods that have been dried and cannot be opened easily. A pestle and mortar can be useful to

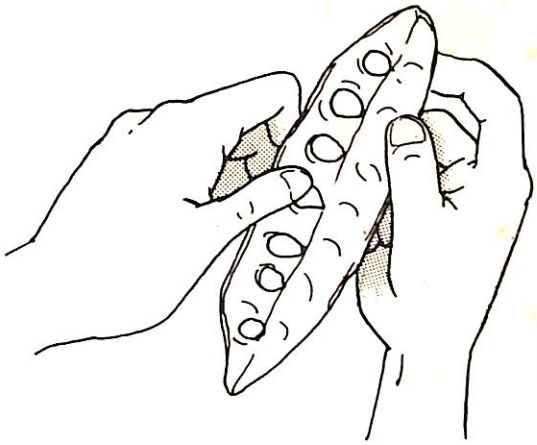


Figure 3-5: Seed extraction

thresh them. The seeds in pods that split on maturity can be put in a sack and beaten with a stick (like people do with beans) when pods are dry.

3.2 Cleaning and Sorting: Cleaning and sorting are also necessary for good germination and protection against diseases. What should be removed are dirt, immature light seeds and seeds that are rotten, broken, damaged by insects or infected by diseases. They should be removed by hand sorting and, if available, a fan sorting machine.*(Figure 3-6)*

Figure 3-6: Cleaning seeds

3.3 Drying: Although there are several methods of seed drying, sun drying is the most common. Seeds should not be directly exposed to naked flames.

4. SEED TESTING

Seed tests are very important to verify the seed quality and vigour, also monitor seed condition from collection through handling to storage. All incoming seeds to the station must be tested before storage or despatch for purity percent, seed weight, moisture content and germination capacity prior to storage. It is necessary to know about seed viability of a seedlot before embarking on seed sowing.

4.1 Seed Purity Analysis: This is mainly carried on seeds that have been cleaned and sorted. These are necessary for good germination and protection against diseases.

Generally, tree-seed samples often contain impurities, for example detached seed structure, leaf particles and other objects. Therefore, the above analysis is conducted to determine the composition by weight of the sample being tested.

4.2 Seed Germination: This is the resumption of active growth in an embryo which results in its emergence from the seed and development of those structures essential to plant development.

There is a belief that the potential germination of seeds is the most important factor in the seeds in the measure of seed quality. The germination test is used as an estimate of the number of seeds which can germinate at a given time. In Kitui station, the germination tests are carried out in the nursery and glasshouse.

The seeds are sown in four replicates of 100 seeds each as stipulated in ISIA rules (International Seed Testing Association).

Note: Seed germination tests should be made on only the pure seed fraction obtained in the purity analysis.

5. SEED STORAGE

This involves maintaining the viability of a seedlot from collection time until when the lot is required for tests or sowing. The storage longevity of seeds is affected by their storage condition, even if stored under ideal conditions most of the seeds are defective from the start. The two most important factors in good seed storage are keeping the seeds dry and keeping them cool. Wet seeds spoil and rot in storage, so they must be dried in air first. They are then stored in dry containers such as jars, boxes or bags. The seed storage containers should be kept off floors and away from walls. This practice helps keep insects and dampness away from the seed containers. *(Figure 3-7)*

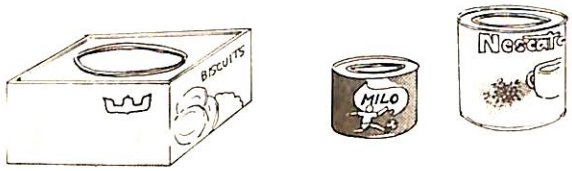


Figure 3-7: Containers

The collection of seeds showing a high incidence of fungal or insect attack should be avoided. All operations for collection, transport, processing etc. have to be carried out as quickly as possible to ensure seed is not damaged before it foes into storage.

The seeds are normally stored at room temperatures of about 20 °C. Some species are sown fresh due to rapid loss in viability e.g. *Warburgia ugandensis* (Muthiga), *Azadirachta indica* (Neem), Olea spp. and others.

On the other hand, there are some species like the *Acacia* spp. which can be stored even for 3 - 15 years.

Lastly the most important factors to be considered for seed storage are moisture content and temperature. There are seeds that are killed by excessive drying e.g. *Grevillea robusta* (Silky oak, Mkima), *Dovyalis caffra, Azadirachta indica* (Neem) and many others.

Points to remember when using sealed containers are;

a. Moist (wet) seeds must not be sealed.

b. Air-tight containers should be used for storage.

c. The container should be clean and dry.

d. The container should not be opened except when necessary.

e. It is advisable to keep the container full of seeds.

f. A label on which the name of seed species, collection date and place or mother trees are written should be attached to the container. *(Figure 3-8)*

Species : _____
Weight : _____
Date : _____
Collected : _____
Date : _____
Stored : _____
Origin : _____
Collector : _____

Figure 3-8 : An example of seed label

6.PRE-TREATMENT OF SEEDS

In natural condition, seeds of many tree species need a long period to germinate or have very low germination percentage.

Pre-treatment of seeds is then practised to hasten the germination time and to get good germination percentage. To use properly collected and properly kept seeds is more essential. There are many pre-treatment methods and the most effective treatment differs with tree species.

This Chapter shows the most commonly used and practical method for the farmers for some common species.

6.1 Nipping: Nipping is the treatment by cutting the seed coat to enable moisture to enter the inside of the seeds. This treatment can be done with nail clippers, fine pliers, knives or a needle. A small scar at the end of the seed indicates the point to nip. This is the end of the seed furthest from the point where the seed was attached to the pod or fruit and where the radicle (young root) is found. The radicle must not be damaged. *(Figure 3-9)*

The same effect can be achieved with a broad file or sandpaper. Seeds can be mixed with an equal amount of sand and are then put in a tin lined with sandpaper. The tin has to be shaken thoroughly until the seeds are dull.

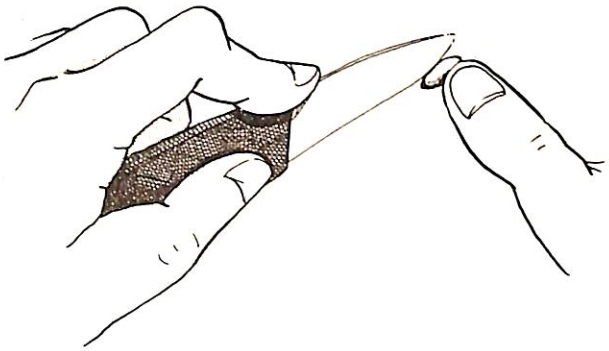


Figure 3-9: Nipping

6.2 Soaking in Boiling Water: This is a frequently used technique whereby the seeds are immersed in boiling water 4 - 10 times their volume, then the heat source is immediately removed, and the soaked seeds are left in water to cool gradually for 12 - 24 hours. This method is widely applied but can give erratic results.

The optimum soaking time may vary between species. This method appears to give better results for *Acacia* spp. since it removes the cuticle and sometimes part of the palisade layers of the seed coat and finally breaks seed dormancy effectively. *(Figure 3-10)*

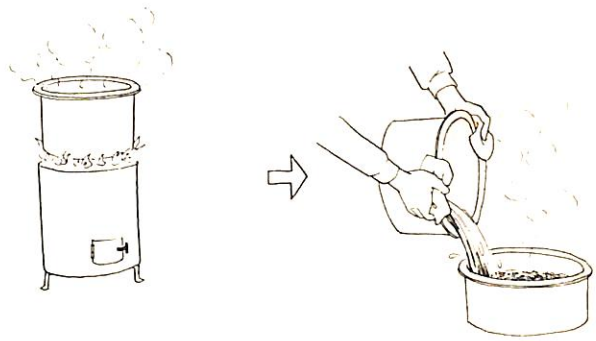


Figure 3-10: Soaking in boiling water

6.3 Soaking in Hot Water: The soaking of seeds in water within a range of 60 - 90°C is often as effective as soaking at 100 °C (boiling water) but there is less chance of damage at the lower temperatures. This method is normally applied for the seeds with hard

coats or testa e.g. *Delonix regia* (Flamboyant, Mjohoro), etc.

6.4 Soaking in Cold or Warm Water: The soaking of seeds in water below about 40 °C is effective in promoting germination only in those seeds which already have a permeable seed coat (soft seeds). In some instances most seeds tend to develop impermeability as they mature on the tree or in subsequent storage e.g. *Acacia senegal* (Gum arabic, Mung'ole, Kikwata). Seeds are immersed in about four times their volume of cold water and then left for the required time.

6.5 Fresh Seeds Only: As it was mentioned before, some species will not germinate after being stored for some time. These species should be sown soonest after collection.

6.6 Species to be Pre-treated

(1) Nipping:

Acacia albida, (Apple-ring Acacia, Olasiti)
Acacia brevispica, (Mugusi)
Acacia mellifera, (Muthia)
Acacia nilotica, (Musemei, Mugungu)

Acacia polyacantha, (Musewa)
Acacia senegal, (Gum arabic, Mung'ole, Kikwata)
Acacia tortilis, (Mulaa, Mgunga)
Acacia xanthophloea, (Fever tree, Naivasha thorn)
Acrocarpus fraxinifolia

Albizia anthelmintica, (Muoa)
Albizia gummifera, (Mukurwe, Mwethia)
Albizia procera
Cassia siamea, (Ikengeka)
Cassia spectabilis, (Mwenu)

Leucaena leucocephala, (Ipil-ipil)
Melia volkensii, (Mukau)

(2) Soaked in Boiling Water

Acacia senegal, (Gum arabic, Mung'ole, Kikwata)
Acacia polyacantha, (Musewa)
Leucaena leucocephala, (Ipil-ipil)
Acacia mearnsii
Delonix regia, (Flamboyant, Mjohoro)

(3) Soaked in Hot Water

Acacia gerrardii, (Muthii)
Acacia mearnsii
Acacia mellifera, (Muthia)
Acacia xanthophloea, (Fever tree, Naivasha thorn)
Cassia siamea, (Ikengeka)

Cassia spectabilis, (Mwenu)
Cordia abyssinica, (Muringa)
Delonix regia, (Flamboyant, Mjohoro)
Leucaena leucocephala, (Ipil-ipil)
Piliostigma thorningii, (Camel's foot, Mulema, Msaponi)

Tamarindus indica, (Tamarind, Mkwaju, Muthumula)
Prosopis juliflora

(4) Soaking in Cold/Warm Water

Tipuana tipu, (Tipu tree, Pride of Bolivia)
Newtonia hildebrandtii
Ziziphus mauritiana, (Kunazi)

(5) Fresh Seeds Only

Azadirachta indica (Neem)
Kigelia africana, (Sausage tree, Muratina)
Salvadora persica, (Toothbrush tree, Mswaki, Mukayau)
Warburgia ugandensis, (Kenya greenheart, Muthiga)

(6) No Treatment Required

Casuarina equisetifolia, (Mvinje)
Croton megalocarpus, (Mukinduri, Muthulu)
Dalbergia melanoxylon, (Mpingo)
Eucalyptus spp.
Grevillea robusta, (Silky oak, Mkima)

Jacaranda mimosifolia
Melia azederach, (Persian lilac, Mukau)
Prosopis juliflora

CHAPTER 4

NURSERY TECHNIQUES

1. INTRODUCTION

As we learnt in Chapter 1, trees are indispensable for our daily life, and to grow them, much more tree seedlings are required. To produce vigorous seedlings, all the people involved in the nursery operation have to master the necessary techniques on nursery operations. Nursery techniques are the most basic forestry technology.

2. ESTABLISHMENT OF SMALL SCALE TREE NURSERY

The main obstacle to tree planting activity in rural area has been inavailability of tree seedlings due to lack of near-by nurseries. To raise tree seedlings is not a difficult job for farmers, it only needs a small patch of land, tools and materials, and the care farmers always give to their farm crops. Nurseries can be owned and managed by individual farmers, cooperatives, women's groups, schools, churches and other institutions. The benefits from own nurseries are:

(1) Possibility to produce suitable number and species
(2) Income expected from the selling of seedlings (especially fruit tree seedlings)
(3) Flexibility of planting time since the seedlings are always with you
(4) Use as a teaching material for of schools

2.1 Location: The first step to start a nursery is to designate a site. Several important factors are to be considered, out of these a few fundamental factors for semi-arid areas are:

(1) Water availability throughout the year (near the river, near your kitchen to utilize wasted water)
(2) Accessibility for transporting equipment, soil, and seedlings if the nursery scale is comparatively large
(3) Availability of good soil (preferably forest soil)
(4) Protected from a strong dry wind
(5) Sunny condition
(6) Gentle slope for water drainage
(7) Near the supervisor's house for daily management, in case of nurseries managed by groups

However, it is usually hard to find a place which fulfills all these requirements. The most important things is to start, and if some problems are encountered, then some alternative way or necessary measures can be explored.

2.2 Scale: The size of a nursery depends on the number of seedlings to be raised. Some examples are:

(1) If a farmer wants to raise 500 seedlings, he needs a space of 3 m by 3 m.
(2) If a group wants to raise 2,000 seedlings, they need a space of 6 m by 6 m or a circular plot of 8 m in diameter. In addition to the above, for collected soil, sand and manure, and some space for mixing them are also needed.

2.3 Facilities required are:

(1) Storage for keeping the nursery tools safely and in good condition, but not necessarily in the nursery.

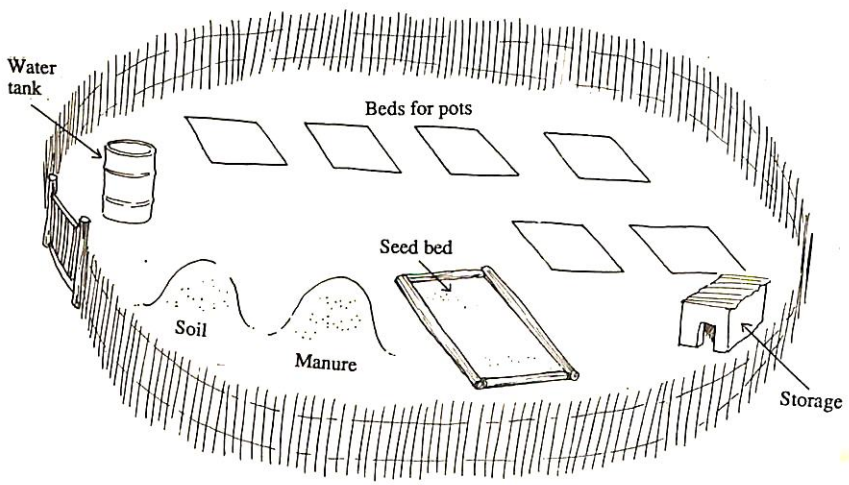


Figure 4-1: An example of nursery layout

(2) Fencing around the nursery for keeping livestock out. A boma of local materials is enough for starting a new nursery. For permanent use, a live fence is recommended.
(3) If there is no near-by water source like rivers or ponds, a water tank or a drum to keep water is necessary. *(Figure 4-1)*

2.4 Tools: The number and kind of essential tools depends on the scale of the nursery and number of workers. The basic nursery tools, especially * marked ones are essential and others are recommended: Rakes*, Jembes*, Slashers, Watering cans, Wheel barrows, Pruning knives, Sharpening files, Soil sieves, Shovels*, Pangas*, Jerry cans, etc.
Individual farmers can start their nurseries with only their farming tools in daily use. Tools like watering cans and pruning knives are substituted with other locally available materials like empty tins with small holes on their bottom and kitchen knives respectively. In larger nurseries (i.e. women's group nurseries and school nurseries), considering the working efficiency, the use of watering cans, wheel barrows, etc. should also be considered.

2.5 Time to Start Nursery: The time to start establishing a nursery firstly depends on the time to plant seedlings. There must be enough time for seedlings to grow up to plantable size.
Secondly, availability of labour should be considered since initial labour input for bed construction, soil collection, fencing, procurement of tools and materials, etc. is a lot much higher than daily operation.
Hence, the busy farming season (i.e. cultivating, sowing and harvesting seasons) should not be selected. In case of regions where tree seedlings are usually planted in November, December or January is the best time to start nursery establishment.
If seeds are sown by February, pricking out can be done in March, and, then, short rain in April/May helps the young seedlings to be ready for the long dry spell.

3. SOIL MIXING AND PREPARATION OF SOWING

3.1 Soil Mixing: Forest soil, manure and sand are usually mixed and used for the sowing. A soil collection site should be identified under the forest.
Soil must be rich in nutrient. The soil is dug up to about 10 cm deep using jembes after scraping off the vegetation. *(Figure 4-2)*

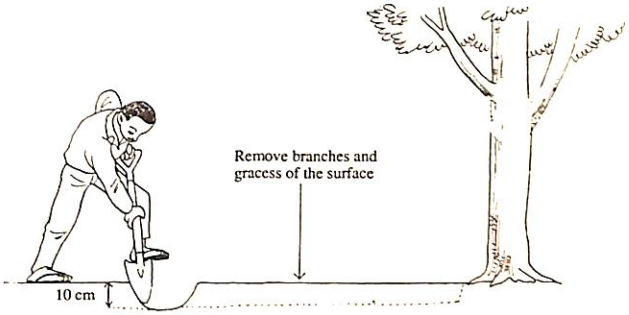


Figure 4-2: Collection of forest soil

It is recommended to collect soil three months prior to the potting so that the organic matters can decay, and the seeds of weeds germinate and can be removed easily. Soil must be sieved before mixing to remove stones, branches, roots and other unnecessary matters. The soil is mixed with fermented cow manure in the ratio of four to one. If the soil is clayey, sand should be added to allow the air and the water to infiltrate. *(Figure 4-3)*

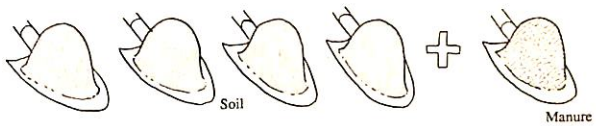


Figure 4-3: Soil mixing ratio

3.2 Potting: The polythene tube (normally 4" x 7") is used as planting pots. Also locally available materials like small or big tins, tetra-packs, milk packets, boxes, etc. can be used. When potting, ensure three quarter of the lower part of the pot should be made firm with fingers while the upper one quarter should not be. The soil used for the filling should contain some moisture but never wet. *(Figure 4-4)*

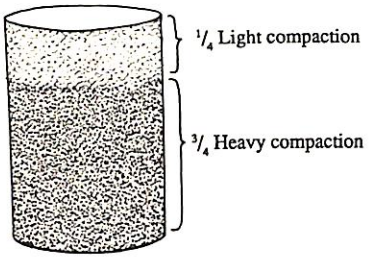


Figure 4-4: Compaction of soil in the pot

3.3 Bed Arrangement for Pots: There are two ways of making a simple bed as shown below:

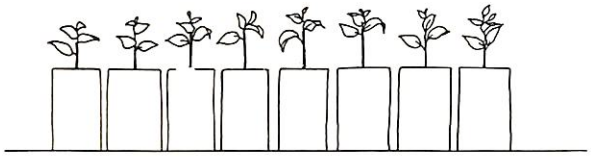


Figure 4-5: Bed on flat ground

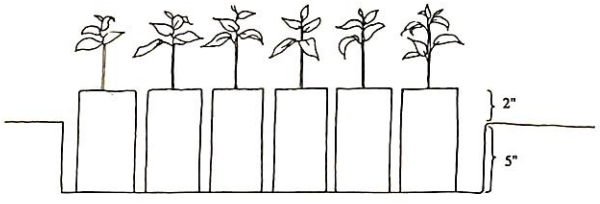


Figure 4-6: Sunken bed

This bed is used in very dry area to retain moisture. The depth is usually five inches.
It is recommended to make 100 pots (10 x 10) a unit to ease the work and counting. *(Figure 4-7)*

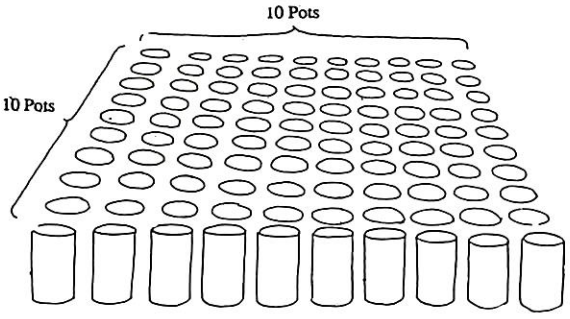


Figure 4-7: Arrangement of pots

3.4 Seed Bed Construction: Necessary materials are sieved sand, sieved forest soil, big and small stones. Sieve the sand and forest soil separately, and mix them in 1:1 proportion. They are layered as the *Figure 4-8* shows. If the seed bed had been in use, remove the soil/ sand mixture and refill the bed with new soil/sand mixture. The recommended width of the bed is one meter.

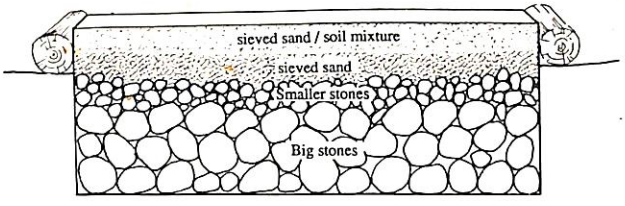


Figure 4-8: Structure of a seed bed

4. SOWING

4.1 Direct Sowing in Pots: For big seeds like those of *Tamarindus indica, Croton megalocarpus* and *Cassia* spp., it is more economic to sow them directly into the pots.
(1) Water the pots properly one day prior to the sowing.

(2) Use a stick or dibble to make two holes in each pot. *(Figure 4-9)*

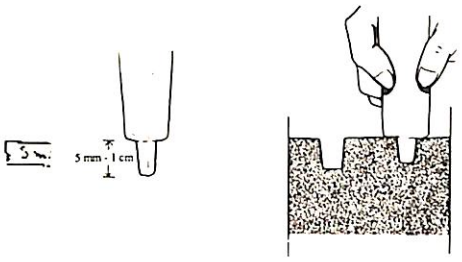


Figure 4-9: Sowing dibble and its use

If the germination rate is comparatively low, make three holes. The depth of holes should depend on the size of the seeds (usually 5 mm or 1 cm). Sowing too deep will render the seeds to decay.
(3) Put a seed in each hole and gently cover with soil.
(4) Water the pots.
(5) Make the shade covers the pots with small poles and grasses. *(Figure 4-10)*

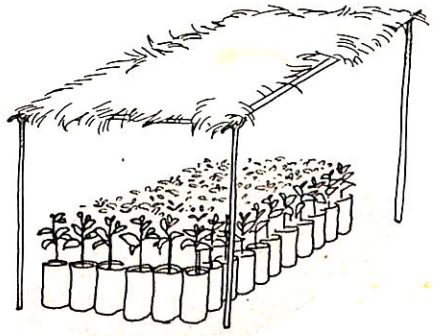


Figure 4-10: Sading

(6) Water twice a day, early in the morning before 9:00 a.m. and in the evening after 4:00 p.m. Watering in hot daytime must be avoided.
(7) If two or more seeds germinate in one pot, wait until the sprouts reach to about two inches, then remove the small ones remaining the most healthy one.

4.2 Sowing in the Seed Bed: Fine seeds and also large seeds with low germination rates are sown in the seed bed.
(1) Use the flat piece of timber to make the soil/sand mixture surface evenly flat.
(2) Broadcast the seeds evenly on the bed. The seeds should not be overcrowded lest fungal attack will be encouraged after germination. For very fine seeds like Eucalyptus spp. mix the seeds with sand before sowing. This method helps to broadcast the seeds evenly.
(3) Cover the seeds lightly with the soil/sand mixture.
(4) Cover the bed with dry grasses lightly to protect from the water drops and to keep the moisture.
(5) Water the bed gently. Use of the watering can with fine holes is recommended.
(6) Make light shade using small poles and dry grasses.
(7) Water twice a day.

5. PRICKING OUT

When the seedlings in the seed beds attain between one to two inches in height, the pricking out process can be carried out. Pricking out is to transplant the seedlings from the seed beds into the pots. This is usually about two weeks after sowing but depends on the species.
The pricking process:
(1) Prepare an empty can (Kimbo, Cowboy, etc.) and fill 3/4 with water.
(2) Water the bed.
(3) Hold the leaves of seedlings and insert a dibble underneath the root system of the seedlings to loosen the soil.
(4) Pull out the seedlings gently and immediately put them in the can which contains water. If the roots of the seedlings are kept under sunshine they lose the viability quickly.
(5) Water the pots.
(6) Make a hole with a dibble at the center of the pots.
(7) Hold the leaves of the seedling and insert the whole of but only its root system in the hole.
(8) Hold the dibble in a tilting position, insert it in the soil about half inch away from the seedling to the same depth as the hole.
(9) Push the soil towards the seedling to hold it tightly. This ensure that all air pockets around the

roots are closed.
(10) Cover the hole you made. *(Figure 4-11)*

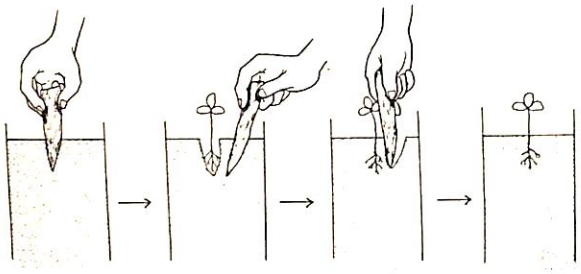


Figure 4-11: Pricking out

(11) The seedlings pricked out from the same batch of the seed bed should be arranged in the same place.
(12) Water the pots properly.
(13) Make the shade.

6. WATERING

Watering can or an empty can with holes at the bottom (if watering can is not available) should be used for watering. *(Figure 4-12)*

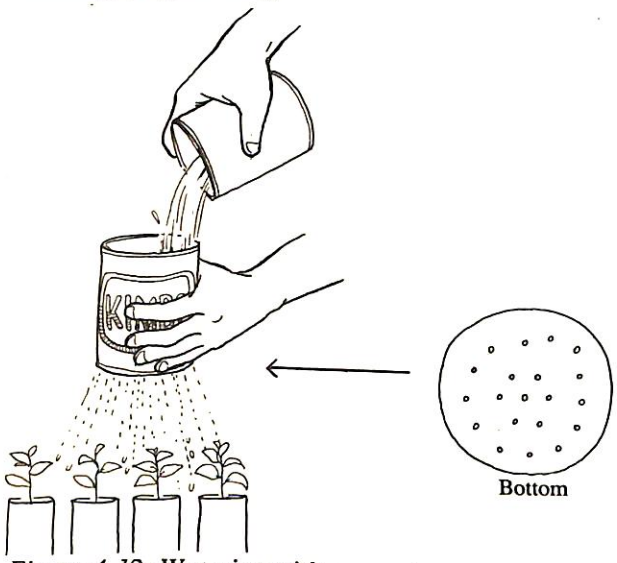


Figure 4-12: Watering with an empty can

This is to reduce the power of water drops which cause soil erosion and to distribute water evenly. As already mentioned, watering in principle should be done twice a day, once in the morning and once in the evening .

The soil in the pots should be kept moist, however, watering too much causes some fungal disease. If it is raining, watering might not be necessary.
Dirty water e.g. soapy water or chemical wastes should not be used for watering. The temperature of the water should be cool. If the surface of the soil becomes too hard for water to penetrate, use the dibble to brake.

7. WEEDING

Removing weeds from the pots reduces the competition for nutrients. Don't wait until the weeds become too big with deep roots lest they damage the roots of seedlings. In case the weeds overgrow, use a dibble to root them out.

8. CLEANING AROUND THE BEDS

Weeds come up not only in the pots but also around the beds. These weeds attract crickets, caterpillars and other insects which feed on the seedlings, and also give them a place to hide. Remove all the weeds around the beds with jembes and don't leave any rubbish around.

9. APPLICATION OF ADDITIONAL FERTILIZERS

If seedlings show sign of weakness, some agricultural fertilizers can be applied. The most common ones are NPK and DAP, and also manure from livestock can be used. However, the weakness of the seedlings can be caused not only by insufficiency of the nutrient but also by pests and disease. Some common pests and disease are introduced in Chapter 5 but it is recommended to consult the foresters or extension staff.

10. ROOT PRUNING

When seedlings have reached to a certain size, their roots become longer than the depth of the pots. If the roots are left without pruning, they penetrate into the ground and develop the root system there.
Once the root system develops under the ground, it is hard to move the pots, and if the roots are cut, the seedlings will be weakened. Hence, periodical root

pruning is required before the root system reaches into the ground. The period and interval of pruning depends on different species and other conditions. Water the seedlings properly in the evening before the day of pruning. Cut the roots using a knife, a razor blade or scissors at the bottom of the pot. Water the seedlings again after pruning. *(Figure 4-13)*

Figure 4-13: Root pruning

11. HARDENING UP

Hardening up is to expose the seedlings to harsh conditions to make them strong so that they will be able to survive under harsh climate in the field after planted out.

The methods for hardening up are:

(1) When the seedlings grow and reach the certain size, the shade should be removed to inure them to the heat of the sunshine.

(2) Before planting out, root pruning should be carried out frequently.

Once the roots penetrate into the ground, the plants get extra nutrient and water from there and develop delicate and soft tissues, so these seedlings cannot survive in the field.

(3) Reduce the quantity or frequency of watering to insure the plant against the drought.

(4) Arrange the seedlings pots in one or two lines to harden their roots. *(Figure 4-14)*

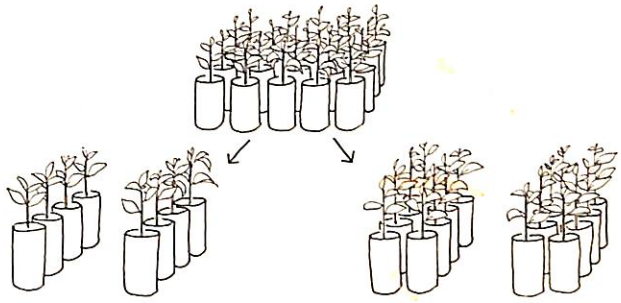


Figure 4-14: Re-arrangement of pots

12. DAMAGE

There are many factors which cause damage to the seedlings in the nursery. Among them, biotic factors like pests are mentioned in Chapter 5.

Damages by people are not technical matters and concern to management matters. Therefore, in this Chapter only meteorological factors are mentioned.

(1) Drought: Drought is a climatic disaster which cannot be anticipated. The only measure is to keep a permanent water source near the nursery or construct the nursery near a water source.

(2) Wind: Strong wind encourages evaporation from the surface and the seedlings can also be damaged physically by the sand carried by the winds.

To establish windbreaks is recommended and the details of this technique are presented in Chapter 12.

(3) Sunburn: The heat of the sunshine near the equator damages the leaves directly and also damages the shallow roots by heating the soil surface.

These damages may occur when the tissues of the seedlings are soft or weakened by some reasons.

Use of the shade is strongly recommended especially when the seedlings are young.

CHAPTER 5

NURSERY PROTECTION FROM PESTS AND DISEASES

1. INTRODUCTION

Seedlings are delicate and susceptible to attacks by various pests and diseases as well as some meteorological conditions. Damages by such pests and diseases seriously weaken or sometimes even kill the seedlings unless they are properly protected before the attacks or treated after the attacks without any delay. It is, therefore, very important for a nursery worker to have knowledge on anticipated pests/diseases and protecting/control methods against them.

2. DAMAGE AND DISASTERS IN NURSERY

There are many factors affecting tree seedlings in nurseries, and they are generally categorized into three factors as follows:

(1) Meteorological factors

These are drought, high temperature, strong wind, etc. Most of disasters caused by meteorological factors can be prevented by physical countermeasures, e.g. frequent watering, shading and windbreaks. Details of these techniques are shown in Chapter 4, Nursery Techniques, and windbreaks are mentioned in Chapter 12.

(2) Human factors

Disasters caused by men are such as trespass in a nursery and robbery of seedlings. Since they are more social than technical matters, control measures can not be specified. It can be said that the livestock damage is also a human factor. Physical measures can also be taken, however, to make the people's awareness is more important and effective.

(3) Biotic factors

Some mammals, birds, insects and fungi also damage or attack tree seedlings. Only these factors are mentioned in detail below in this Chapter.

3. BIOTIC DAMAGES (PESTS) AND CONTROL METHODS

There are several types of damages caused by biotic factors. According to types of feeding habits, control measures must be decided.

3.1 Insects: Most of the insect pests breed and hide under rubbish and weeds. The nursery should at all times be kept clean by sweeping all rubbish away with brooms; this includes leaves and twigs from the trees in the nursery. All weeds should be regularly uprooted and swept away. This cleanliness will reduce the breeding grounds and numbers of the insect pests. However, even in cases where cleanliness is maintained, an attack by the insects could occur. Protection measures such as chemical application or manual removal should be carried out as soon as the insects are observed.

(1) Defoliators (Leaf Eaters): Various groups of insects such as caterpillars (larvae of butterflies or moths), grubs (larvae of beetles), crickets, grasshoppers, locusts *(Figure 5-1)*, etc., are defoliators. They eat a part of or the whole leaves, and retard the photosynthetic ability of the seedlings. Hence the seedlings will not be able to have a good performance or, in case of serious defoliation, they will die.

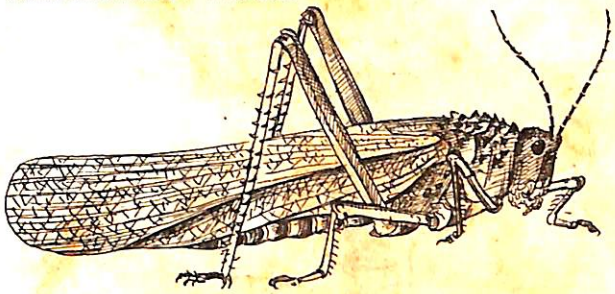


Figure 5-1: Locust

Control: To control such defoliators, chemical spraying of Agrocide or Parathion are effective, especially for larvae in their early stages.

(2) Stem cutters: Cutworms are the caterpillar type larvae of various nocturnal moths *(Figure 5-2)*.

They cut the stem of seedlings usually at night, and lead the seedlings to immediate death. Even when population is low, cutworms can cause a great deal of damage.

Control: It is not easy to deal with cutworms once they have started to attack. However, some measures, such as spraying chemicals e.g. Aldrin and Diazinon, could

be effective. Poisoned bait or sprinkling of Gammexane into the soil could also be used when pots are being filled, which will reduce the incidence of loss by these pests.

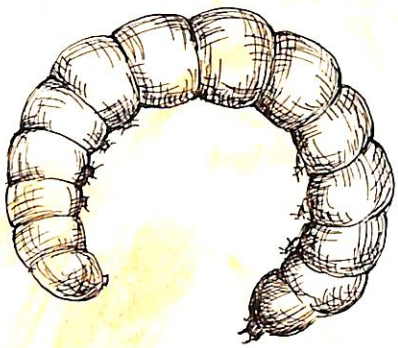


Figure 5-2: Caterpillar

(3) Sap Suckers: Small insects such as wooly aphids and bugs suck sap from the seedlings *(Figure 5-3).* These insects sometimes transmit diseases to the leaves of the seedlings through their saliva. Leaves or, in case the attack is serious, the whole plant of seedlings are damaged and die. Sometimes unusual structures, called galls, are formed on the leaves or stems, which are also caused by these insects.

Figure 5-3: Aphids

Control: The most efective measure is use of chemicals.
(4) Termites: More than 2,000 species of termites are distributed mainly in the tropics. *(Figure 5-4)*
Common termites seen in semi-arid areas nest in the ground or dead wood and infest seedlings through the tunnels in the surface soil. They eat roots and stems of seedlings of many tree species. Eucalyptus species are particularly susceptible to termite.

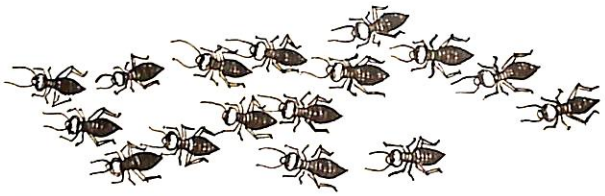


Figure 5-4: Termites

Control: Termites can be controlled by several methods;
(a) Using ash together with soil mixture in potting. *(Figure 5-5)*

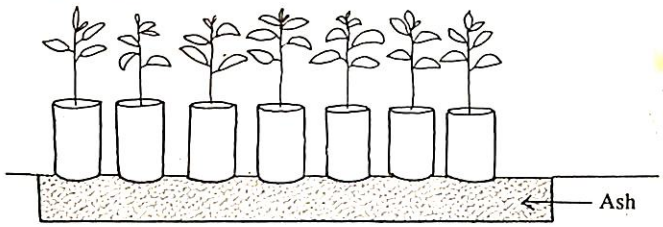


Figure 5-5: Layer of ash

(b) Putting a thin layer of ash (2 - 3 cm thickness) on the bed, where the pots or tubes of seedlings will be placed. However, the effectiveness of the ash cannot last long. Periodical application is recommended.
(c) Using chemicals such as Dieldrin and Aldrin.
(d) Digging out queens of nearby colonies (termite hills). Extermination of all the termites in the colonies by chemicals is much effective.
(e) If milk packs are used as pots, wash the packs with soapy water or solution of insecticide before use, otherwise termites may be attracted. Information about termites is also abailable in Chapter 8.

3.2 Wild Animals

(1) Rodents: Field mice/rats frequently cause serious damage to seedlings in the nursery as well as in the field by eating them.
Control: Cleaning the nursery helps to reduce their population. A well maintained boundary around the nursery will keep off the rats. Poisoned baits and traps can be quite effective against them.

(2) Birds: Birds are sometimes troublesome especially in seed beds. They feed on the seeds and sprouts of some species.
Control: The best protection is surrounding and covering the beds with fine-mesh wire netting.

3.3 Livestock: Where free grazing is being practised, the livestock, especially goats invade the nursery and eat young seedlings.
Control: The only protection method is fencing around the nursery. A thick live fence is recommended. *(Figure 5-6)*

Figure 5-6: Fencing

3.4 Fungal Diseases: Although there are various diseases which attack seedlings in the nursery, only Damping off and Botrytis wilt are described here since they are the most common fungal disease in the country.
(1) Damping off: This is a fungal disease caused by *Pythium* spp., *Rhizoctonia salani* and other various fungus. *Pythium* spp. causes damping off at temperature below 25°C and severity increases as the soil moisture increases up to saturation. Rhizoctonia causes it at temperature above 25 °C and soil humidity of 65% saturation. Severity is highest at that level and decreases below and above that level. Damping off can occur before germination, after germination and immediately after pricking out when the seedlings are still tender. The fungi attacks the seedlings at soil level and causes the rotting of the part attacked, consequently killing the seedlings. The most susceptible species are Pines and Eucalyptus.

Conditions favourable to spreading of the disease are;
(a) High sowing density
(b) Overwatering
(c) Using soil with under-composed material
(d) Using soil affected by damping off
(e) Damping the bark of the tender seedlings

Control: Control measures of the disease are as follows;
(a) To use optimum sowing density in the seed bed.
(b) To dig soil three months in advance to allow decomposition of humus and other organic matters.
(c) Not to overwater the seedlings.
(d) To replace soil used when sowing a different batch of seeds.
(e) Not to damage the bark of young seedlings.
(f) Not to use alkaline soil.
(g) To apply chemical to disinfect soil in seed bed.
(h) To use the shade when the seedlings are very young.
(i) To sterilize used soil by burning with a bank torch.
(2) Botrytis wilt
This is dying back of the main shoot of seedlings which are overgrown or overcrowded. Pathogenic fungus of this disease is called Botrytis cinerea.
Control: It can be controlled by either separating the seedlings or planting them out when rains come.
(3) Powdery mildew: A number of fungi belonging to Erysiphaceae cause the disease called as powdery mildew. At first small white powdery patches are formed on the leaf surface. Finally the whole surface of the leaf is covered with white powdery mycelial colonies. Damaged leaves gradually defoliate. This is not a fatal disease, however, it affects the growth of young seedlings. This disease mainly appears in the dry season and disappears in the rainy season in natural condition.
Control: Fallen diseased leaves should be buried in soil or burned. On the young seedlings, spraying Benlate is effective.

4. OTHER REMARKS ON NURSERY PROTECTION

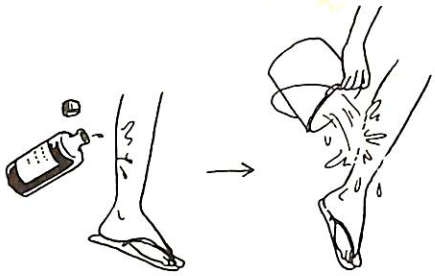
Even though the direct factor to the disease is a biotic pest, meteorological or other factors could be indirect ones and vice versa.
It is, therefore, indispensable to tend properly seedlings/ nurseries in order to prevent damage by biotic pests. In case of using chemicals, special knowledge of and fully care are required, since some of them are toxic or harmful even for a human body.

(a) Don't touch chemicals directly.

(b) Wear a mask not to breathe chemicals sprayed.

(c) Wash your hands clean after using chemicals.

(d) If chemicals happen to touch any part of your body, you must completely wash that part immediately.



(e) Change and wash your clothes well after using chemicals.

(f) If you feel bad during or after using chemical, you must go to consult a doctor as soon as possible.

The following are usually to be noted;
(a) Don't touch chemicals directly.
(b) Wear a mask not to breathe chemicals sprayed.
(c) Wash your hands clean after using chemicals.
(d) If chemicals happen to touch any part of your body, you must completely wash the part immediately.
(e) Change and wash your clothes well after using chemicals.
(f) If you feel bad during or after using chemical, you must go to consult a doctor as soon as possible.
Foresters are ready to advise on all aspects of nursery protection.

CHAPTER 6

NURSERY MANAGEMENT AND ROLE OF NURSERY FOREMAN

1. INTRODUCTION

In Chapters 4 and 5, practical nursery techniques have been introduced. However, a nursery can not be operational by these techniques only. Of course, some nursery tools and materials are indispensable, but the most important thing is proper management. Management includes a wide range of crucial matters, i.e. planning of the operation, procurement of tools and materials, labour arrangement, supervising the work, recording the activities, etc. In every nursery (except individual ones), there should be a person who is responsible for all the nursery management. We can call him or her "nursery foreman". In case of schools, a teacher, possibly of science or agriculture, should be assigned. This Chapter is especially for the nursery foreman, teachers-in-charge of nurseries (hereinafter included in foremen) and individuals who operate their own nurseries.

2. NURSERY MANAGEMENT

2.1 Planning of Nursery Operations – These procedures are:

(1) Selection of the Species: Select the species to be raised in the nursery, considering the use (See Chapter 2-3.). In case of the groups' nurseries, the selection and priority of the species should be discussed and agreed among the members. In case of a school nursery, local demand should be surveyed.

(2) Operation Scale: Since the scale of operation is highly depending on the availability of materials, tools and labour, decide the number of the seedlings to be raised, considering them.

(3) Availability of Materials, etc.: List the necessary materials and tools (See Chapter 4-2.4), and think about the procurement whether your budget allows to buy or not. It is recommended to use local materials (farming tools, empty cans, milk packs, etc.) since they are cheaper and easily available.

(4) Annual Operation Plan: Make an annual working schedule (sometimes called as "a nursery calendar") considering the fruiting seasons of candidate trees (necessary for seed collection), the duration to grow up (it differs depending on species, provenance and environment) and other conditions. For example, if a species needs six months in the nursery to be of plantable size, the seeds must be sown probably seven months before planting. Consult near-by foresters and/or extension staff if available. *(Figure 6-1)*

2.2 Before Starting the Operation: There are some important matters to be done or clarified before the nursery operation starts. The indispensable ones are:

(1) Assignment of Staff: Nursery foreman, store keeper and other necessary staff should be assigned.

(2) Condition to Work: In case of a group's nursery, the mode and condition of work, and assignment of labour force should be agreed by all the members of the group.

(3) Technical Guidance: All people supposed to work in the nursery should be given the necessary technical guidance, possibly by the foreman.

2.3 Daily Operation in the nursery is supervised by the foreman. The important matters in the daily operation are:

(1) *Assignment of the Day's Jobs*: The foreman assigns the works of the day to the workers (or

ANNUAL WORKING PLAN 1991, TIVA NURSERY

Month	Activities
January	Soil collection, mixing, potting. Collection of Cassia spp. seeds. Sawing acacia seeds. Seed bed construction.
February	Pricking out of Eucalyptus seedlings. Sawing Terminalia seeds. Collection of shading materials.

(Figure 6-1)

students in the school nurseries). Details and the target of the jobs should be explained and understood. *(Figure 6-2)*

(2) *Supervising the Jobs:* The foreman supervises the jobs and gives the necessary instructions to all the workers.

(3) *Technical Consultation:* If any technical or other problems are encountered, consultation is available from the near-by foresters and/or extension staff. *(Figure 6-3)*

(4) Record and Record Keeping: Make necessary record of the nursery activities and all these records should be kept with the foreman. See Chapter 7 for the details of records and record keeping. In schools, it is a good idea to involve the daily operation in classes or in a club activity (4K Club, etc.). *(Figure 6-4)*

Figure 6-2: Assignment of day's jobs

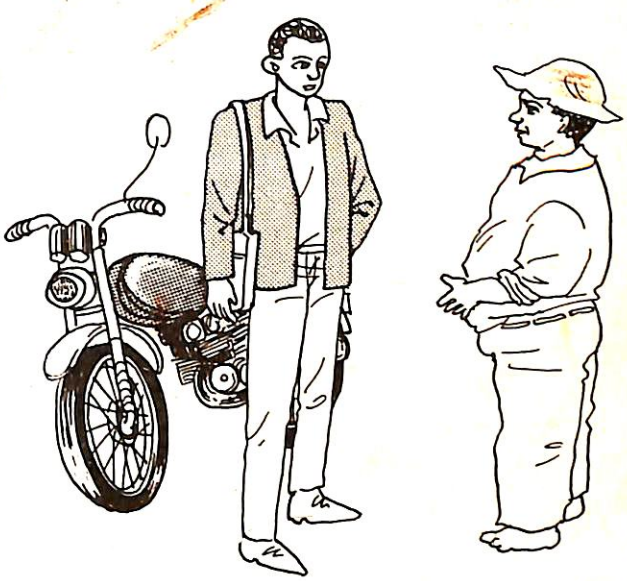


Figure 6-3: Technical Consultation

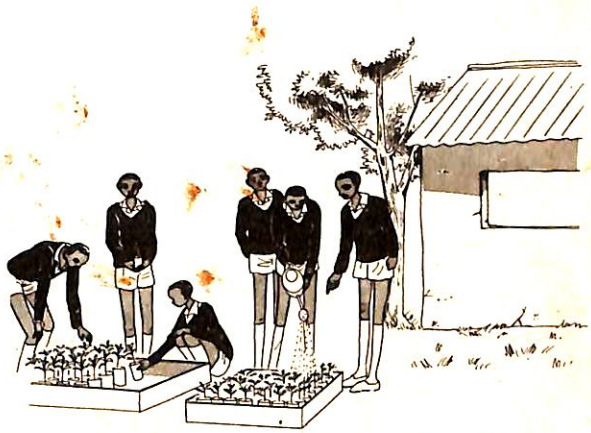


Figure 6-4: Nursery operation in club activity

3. NURSERY FOREMAN

Nursery foremen should be appointed from among the people who have most of the following characteristics;

(1) Writing: As record keeping is one of the most important jobs in the nursery, he/she should be able to write.

(2) Training: He/she should be trained properly on nursery techniques and management before starting to work.

(3) Personality: He/she should be able to keep good relations with other people and be able to lead them.

(4) Honesty: He/she should be a very honest and strict person because there are many valuable things in the nurseries, and sometimes even money, for operation.

(5) Availability of Working Time: He/she does not need to be a full-time nursery worker, but should have enough time to be in the nursery.

CHAPTER 7

NURSERY RECORDS AND RECORD KEEPING

1. INTRODUCTION

Recording all the work and progress in the nursery is essential for nursery management, i.e. management of daily operation, labour, cost, etc. Well-maintained nursery records also help to improve techniques and to rationalize the works, and it can also be used as basis for the next year's operation. To keep and accumulate the records is also important. Accumulated data may reveal some new findings and knowledge. Foresters and extension workers can trace the nursery operation carried out and can advise you properly.

2. NURSERY RECORDS

Several types of records are used and they mainly depend on the scale of the nursery. A large nursery needs an intimate record and many record books while a small nursery being operated by an individual farmer may need only a book. The necessary records for small nurseries operated by a group or a school are given below:

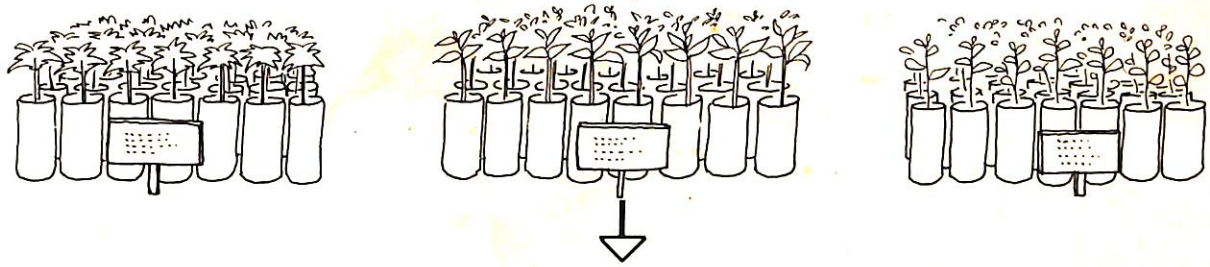
2.1 Nursery Diary: This is the most important record book. All the operations and observations of the day should be mentioned in this book as minutely as possible. The diary should be filled out in the morning after allocation of duties and in the evening before leaving for home. *(Figure 7-1)*

2.2 Nursery Register

This is the record on individual nursery bed basis. All the main nursery operations should be recorded on a board. *(Figure 7-2)*

Date	Work Done	Remarks
23/5/89	4 people pricking out from seed bed	4000 Eucalyptus seedlings transplanted to bed No.5
	1 person attending training at JICA	Termite damage was observed in bed No.3 but not serious.

Figure 7-1: Nursery diary



Bed No.1	
Species	Eucalyptus camaldurensis
Sowing	8/4/89
Germination	22/4/ - 6/5/89
Pricking out	15/5/89
Root pruning	3/8, 10-9, 11/10
Remarks	

Figure 7-2: Nursery register

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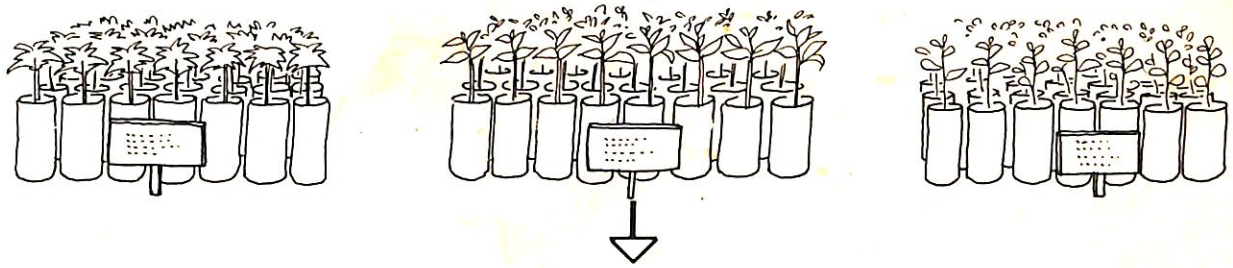

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Germination	22/4/ - 6/5/89
Pricking out	15/5/89
Root pruning	3/8, 10-9, 11/10
Remarks	

Figure 7-2: Nursery register

2.3 Nursery Delivery Record: This is to keep the record to show how the seedlings were distributed. Names of the people who received the seedlings from nursery and their addresses should also be recorded in sufficient details to enable a follow up. If the stocks were used for some plantation programmes, details should be recorded.

Date	Species	Number	Bed No.	Name and address
19/11/89	E. camaldurensis	30	2	Musyoka M., Kwavonza
	Melia volkensii	15	4	Mutemi K., Tiva

2.4 Muster Roll: Daily attendance of all workers is recorded in this book. *(Figure 7-4)*

Date / Name	1 We	2 Th	3 Fr	4 Sa	5 Su	6 Mo	7 Tu	8 We	9 Th	10 Fr	11 Sa	12 Su	13 Mo	14 Tu	15 We	16 Th	17 Fr
Mutemi K.	P	P	P	P	H	O	P	L	L	L	L	L	O	P	P	P	P
Kamene G.	P	P	O	P	P	P	S	S	P	O	P	P	P	P	P	P	O
Musyoka M.	A	A	A	L	H	L	L	P	P	P	P	P	O	P	P	P	P

NB: P : Present, H : Holiday, O : Off duty, L : Leave, S : Sick, A : Absent
Figure 7-4: Muster roll

2.5 Visitors Book
This is not an essential record of the nursery operation. However, whenever there are some visitors, not only to ask them to sign on the book, but also to comment about your nursery and to record their suggestion which may be useful. *(Figure 7-5)*

Date	Name and Occupation	Comment	Signature
25/10/89	N. Noda, Expert of JICA	Nursery is well operated generally. Root pruning of Acacia senegal should be done soon.	

Figure 7-5 : Visitors Book

CHAPTER 8

PLANTING AND TENDING TECHNIQUES

1. INTRODUCTION

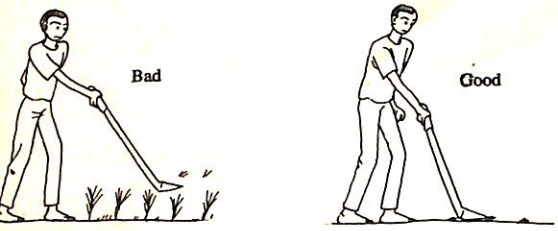
An uncountable number of trees have been planted by rural people since the extension service started, however, it seems that only a few trees have survived. Although the harsh environment such as drought, poor soil, wildlife, grazing animals and so forth account for the low survival, poor knowledge and techniques to control them or to protect trees from them are the main reasons.

Healthy seedlings are probably available from your own nursery or near by nurseries, however, if the seedlings are not planted properly, the trees never grow well. If your trees are attacked by termites and no countermeasure is taken, a high survival rate must be forgotten. Natural trees grow without any care, however, their survival rate is generally very low and unstable. If you expect high survival rate of the trees you planted and faster growing, tending is very important especially when the trees are still young and small.

2. PLANTING TECHNIQUES

2.1 Site Preparation: The site where the trees are to be planted should be prepared before planting. Planting holes must be ready in time waiting for the rain and then the seedlings.

2.1.1. Clearing: If there are bushes or grasses around your planting site, clear them before in order not to disturb the digging process and also prevent the competition between seedlings to be planted on moisture and sunshine *(Figure 8-1).*



igure 8-1: Clearing of planting site

Bushes and grasses should be cut at the base. Remove and pile the branches and grasses in an orderly manner. Branches can be used to make temporary fence.

2.1.2 Digging: Planting holes should be dug before rainy season commences. The popular size of a hole is 60 cm (2 feet) diameter by 60 cm (2 feet) depth in dry area, but a larger hole seems more effective.

The purpose of planting hole is to soften the soil so that the roots of the tree can easily penetrate into deep, and the soil can catch and contain more moisture. *(Figure 8-2)*

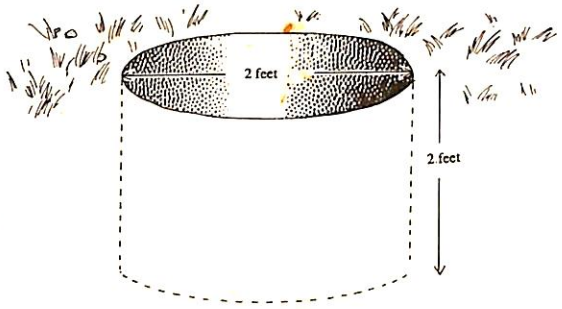


Figure 8-2: Minimum size of a hole

2.1.3. Re-filling of the Holes: After some rain, dig the soil surface and check whether the soil is wet. If water penetration has reached a certain depth (about one foot from the surface) then it is time to re-fill the planting holes.*(Figure 8-3)*

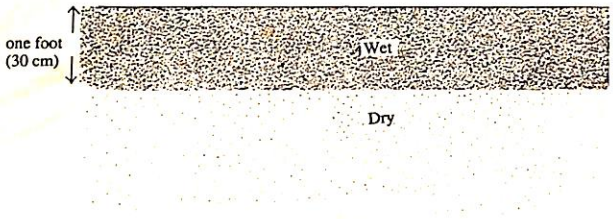


Figure 8-3: Depth of wet soil

Throwing the waste water into planting holes is also a good idea.

For re-filling, use only wet top soil around the holes,

and don't mix dry branches and grasses which attract termites. *(Figure 8-4)*

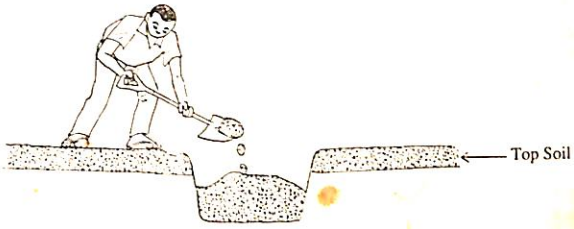


Figure 8-4: Re-filling

2.2 Seedlings Preparation for Planting

(1) *Watering before Transport*

Water the seedlings just before transporting them from the nurseries to the planting sites. This water is to protect seedlings from drying up during the transportation.

(2) *Transportation of the Seedlings*

Seedlings are living things and very fragile so they must be handled carefully. Don't pile them up each other when transporting. Using boxes or bags are recommendable especially when the planting site is far.*(Figure 8-5)*

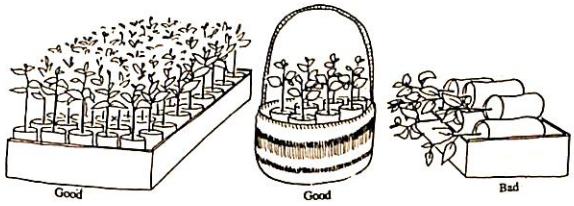


Figure 8-5: Transportation of the seedlings

(3) *Provisional Allocation Site*

The seedlings should be planted on the spot shortly after arriving at the site. In case it needs some time until planting, the seedlings must be kept in a shade and protected from wind. Water them if necessary to keep them moist and vigorous. *(Figure 8-6)*

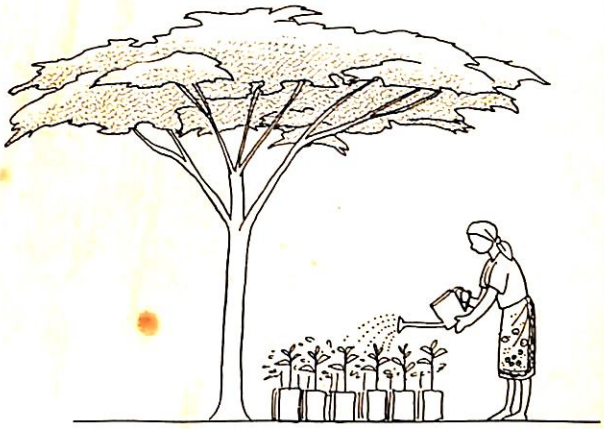


Figure 8-6: Provisional allocation

2.3 Planting: Planting should be carried out when it rains or just after the rain under the cloud. Never under the sunshine not to damage the vulnerable roots.

The common planting process is:

(1) Make a hole of the size of the pot by panga or stick. *(Figure 8-7)*

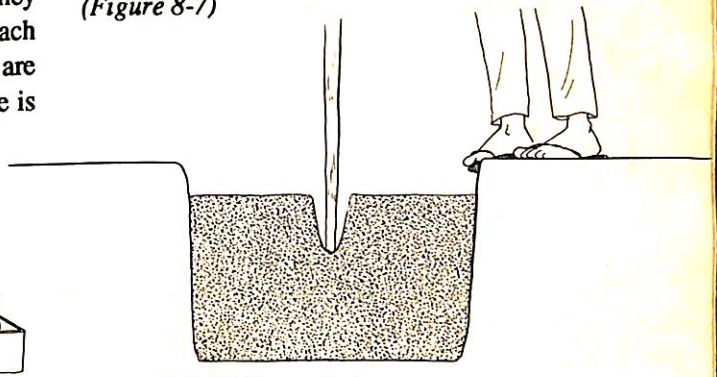


Figure 8-7: Making a hole

(2) Hold the pot and harden the soil by two hands. *(Figure 8-8)*

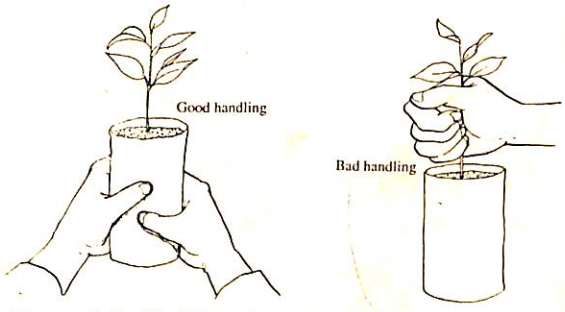


Figure 8-8: Holding the pot

(3) Remove the pot with razor (if available) carefully. (*Figure 8-9*)

Figure 8-9: Remove the pot

(4) Plant the seedlings without removing the pot soil and cover it well with wet soil. Don't mix dry soil and grasses. (*Figure 8-10*)

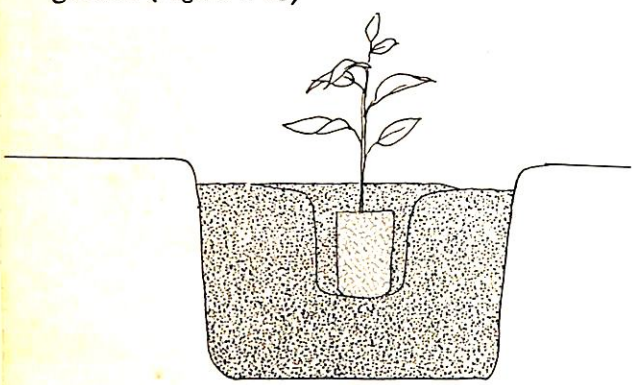


Figure 8-10: Planting

(5) Push the soil around the seedlings firmly by hands to avoid leaving any space between soil and roots. (*Figure 8-11*)

Figure 8-11: Pushing the soil

(6) Add some more wet soil and step on the soil around the seedlings. (*Figure 8-12*)

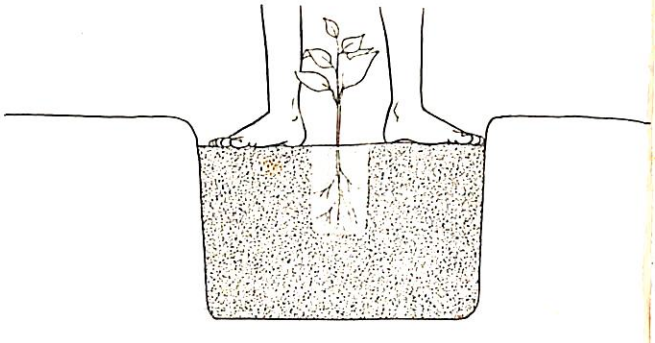


Figure 8-12: Step on the soil

(7) If the water is available, give it to the seedlings.

3. TENDING

3.1 Slashing or Weeding: If grasses or bushes grow around the seedlings, clear them to avoid the water and light conflict between seedlings. Take precaution to avoid damaging the seedlings.

3.2 Shading: When the trees are very young, especially in the first dry season, it is advisable to shade the trees to protect them from strong sunshine which damages young shoots and shallow roots and encourages the evaporation from the soil surface. (*Figure 8-13*)

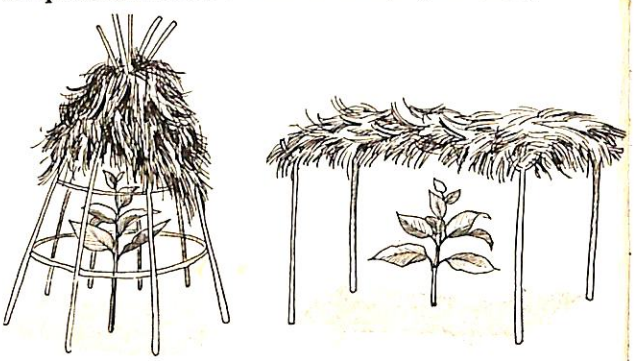


Figure 8-13: Shading

3.3 Watering: Watering will be necessary sometime after planting especially in dry seasons. To water directly to the ground around the tree is the easiest method but it seems not very effective and wastes the

water. Some methods to utilize limited quantity of water effectively are:

(1) *Bottle Watering:* The bottle should be buried into the soil so that only a quarter of it remains above the surface. 0.75 or one litter bottle is recommended. Give at least two bottles of water per week. *(Figure 8-14)*

Figure 8-14: Bottle watering

(2) *Can Watering:* Prepare two empty cans of the same diameter. Make several holes in the base of a can (upper can) and make three small holes on the edge of the bottom of another can (lower can). The top of both cans are removed. Bury the two cans into the soil near the seedling with the three holes of the bottom nearest to the seedlings. The upper can should be about five centimeters above ground level to prevent soil falling into. Fill the cans with water and cover the can with a stone to reduce the loss by evaporation. *(Figure 8-15)*

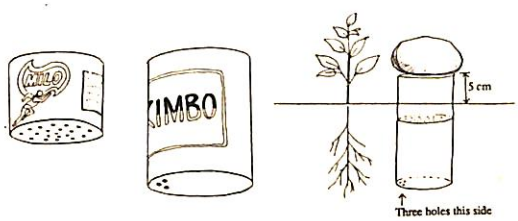


Figure 8-15: Can watering

3.4 Water Harvesting: To utilize the rain water, several types of micro-catchment are used to harvest the water effectively and conduct it to the seedlings. For example:

(1) *Shallow Trenches:* V shaped trenches are dug to conduct the rain water to the planting holes. *(Figure 8-16)*

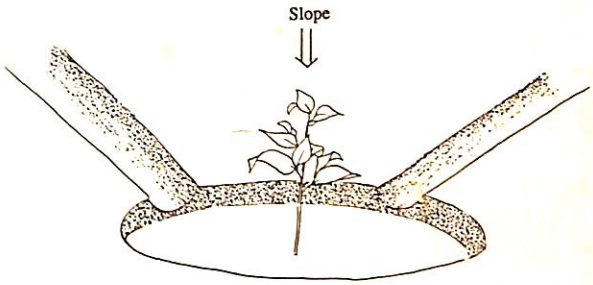


Figure 8-16: Micro-catchment with trenches

(2) *Divisions of the Ground:* This method is used where the rainfall is very scarce. Ground is divided by ridges and all the rain water is conducted to the plants. *(Figure 8-17)*

Figure 8-17: Micro-catchment with ground divisions

3.5 Mulching: The soil surface of the planting holes is covered with some materials to avoid evaporation. This technique is called mulching. Small stones are recommended as covering materials. Dry branches and grasses are easily available but may attract termites. *(Figure 8-18)*

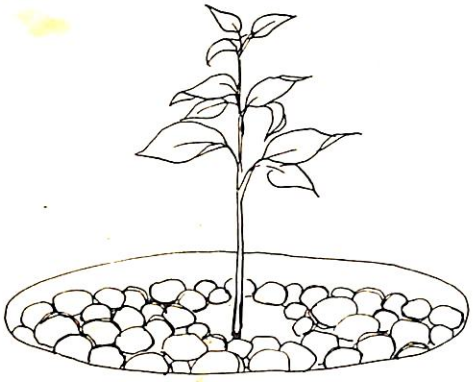


Figure 8-18: Mulching with stones

3.6 Supporting a tree: For some species and where there is strong wind, it is recommended to support young trees with sticks or small poles. The tree is loosely tied against the pole with soft string or rubber tube. *(Figure 8-19)*

Figure 8-19: Supporting a tree

3.7 Pruning the Branches: In Kenya, people tend to cut off the branches of small trees probably to let them grow in height. However, this is a misunderstanding. When trees are very young, cutting off their branches is rather harmful. Insects and disease may be able to invade into trees through the injury made by pruning.

It is also easily observed in the field that young trees were malformed and the growth was slowed down because they lost many leaves where necessary materials and energy for their growth are being made. Therefore, it is recommended not to prune the young trees until they reach a certain height (three metres or more), even the shape of tree does not look so good. Also, people tend to cut too many branches. When trees are young, at least a half or possibly two thirds of branches should not be cut. *(Figure 8-20)*

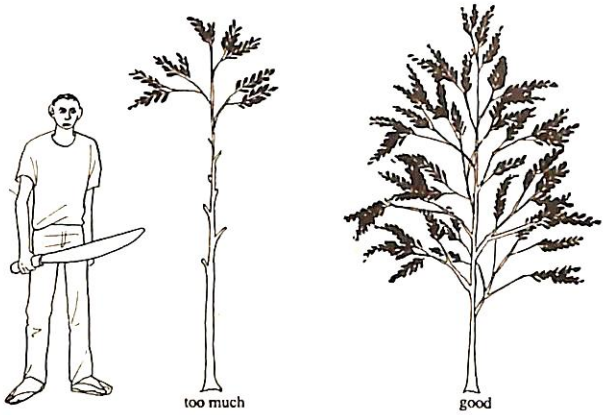


Figure 8-20: Pruning branches

4. PROTECTION

Many animals, insects and diseases attack the young seedlings and cause certain damage. Among them, wild animals, livestock and termites pose the most serious problems according to the experience and information obtained through various field surveys.

4.1 Livestock and Wild Browsers: To protect seedlings from livestock and wild browsing animals like antelopes, fencing is the most effective. If the number of trees is small, fencing individual trees is easier and economical. *(Figure 8-21)*

For larger scale plantations, fencing all around the area to keep animals out is recommended. Branches of thorny trees e.g. Acacia, etc. can be used as fencing materials which are readily available in rural areas. *(Figure 8-22)*

Smaller antelopes like dik-diks can easily pass through the holes of the fence and, therefore, it is very difficult to control them. A game moat of 6 feet width by 6 feet depth surrounding the planting area may scare them off, however, it is not very realistic to construct it

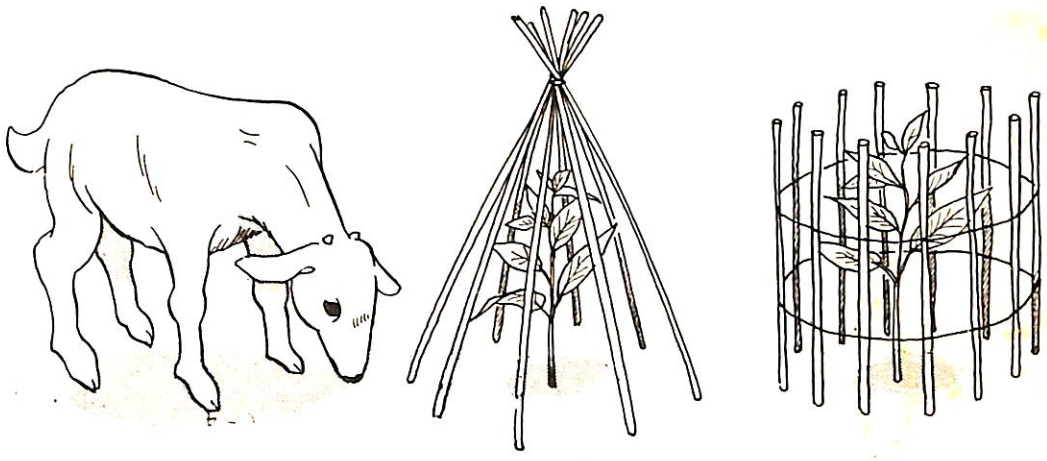


Figure 8-21: Fencing around individual trees

Figure 8-22: Fencing around the trees

because the workload is too much for individual farmers or their groups.

4.2 Rodents: Field mice/rats attack the seedlings in the nursery but rarely in the field. Spot weeding and cleaning of the plantation site are important to keep them away and poisoned bait is to be used with care – strictly only when the damage is serious since it is harmful to other animals and humans. To kill their enemies like snakes and mongooses should be avoided because they feed on mice/rats as well as dik-diks.

4.3 Termites: Digging out queens of nearby colonies (termites hills) is said to be easy and effective. However, it is necessary to observe a colony after picking out the queens since there are some species that substitute the lost queens with their daughters and recover their activeness. *(Figure 8-23)*

Figure 8-23: Termite queen

Use of chemical insecticides to exterminate all the termites in a colony is, of course, much effective but costly and dangerous. Instructions to use chemicals are given in Chapter 5. However, these are repeated here since they are very important and must be observed strictly:

(a) Don't touch chemicals directly.
(b) Wear a mask not to breathe chemicals sprayed.
(c) Wash your hands clean after using chemicals.
(d) If any part of your body happens to touch chemicals, you must completely wash that part immediately.
(e) Change and wash your clothes well after using chemicals.
(f) If you feel bad during or after using chemical, you must go to consult a doctor as soon as possible.

Drowning termites by pouring water into colonies is suspicious. Application of used oil instead of water has shown some positive effects. Ash and chicken droplets spread around the seedlings do not last long but are worth trying.

CHAPTER 9

RECOMMENDED FRUIT TREES AND THEIR PRODUCTION TECHNIQUES

1. INTRODUCTION

Fruits are very important farm products for earning cash as well as an important source of nutrients in rural areas. Depending on climatic and other conditions, many different types of fruit trees have been planted, e.g. citrus, mangoes, pawpaws, guavas, bananas, etc.

Merits of fruit trees are:

(1) Can be started from small scale (even only a tree!) while other crops require certain size of lands.

(2) Market is already established.

(3) Comparatively more drought tolerant than other farm crops.

(4) Once established, intensive labour force will be not necessary.

(5) Can be combined with other crops like agroforestry system.

(6) Can be used as ornamental and/or shade trees in the house/school compounds.

(7) Seedlings are easily available from various nurseries.

2. IMPORTANT FRUIT TREES AND TECHNIQUES

2.1 Mango (*Mangifera indica*)

(1) *Varieties*

(a) Ngowe: Good quality, most popular for export, large long fruit, deep yellow.

(b) Boribo: High yielder, good quality for export, large and long orange-red. Suitable for canning.

(c) Batawi: Good quality, very large round fruit, olive-green to purple in colour.

(d) Apple: Good quality, suitable for export, round fruit, yellow-orange red.

(e) Dodo: Fibrous fruit.

(2) *Ecology*

(a) Rainfall 650 - 1,000 mm. Dose well in high rainfall but dry period is essential at flowering and fruiting. Flowering depends on photoperiodism, temperature and dry period.

(b) Limited to lower altitude areas under 1,500 m.

(c) Soils should be rich and well drained with a pH of 5.5 - 7.5.

(d) Optimum temperature is 24 - 27 °C.

(3) *Propagation*

(a) From the seeds is the most common practice but it can also be propagated vegetatively.

(b) Seeds must be obtained from fruits just before sawing. Husk should be removed immediately to reveal any weevil larvae and seeds should be sown as soon as possible.

(c) As soon as the shoots reached 10 cm high the seedlings should be transplanted into pots.

(d) Seedlings should be shaded and kept well watered.

(e) Transplanting is carried out after the seedlings have taken four months in the nursery.

(4) *Field establishment*

(a) Spacing is 10.5 x 10.5 m or 12 x 12 m.

(b) Dig holes 60 x 60 x 60 cm or 1 x 1 x 1 m and supply two debes of organic manure.

(c) Young plants should be mulched and shaded and weed-free circle maintained around each.

(d) Capping the seedlings at height of 0.9 m helps to produce a spreading framework.

(5) *Field maintenance*

(a) Prevent excessive growth of vegetation beneath the trees.

(b) Apply fertilizers (CAN) when the trees are bearing a heavy crop of fruit in order to stimulate the vegetative growth necessary for the next crop;

year 1 050 g CAN
year 2 100 g CAN
year 3 150 g CAN

(c) Pruning to remove dead wood and low hanging branches and to 'open up' the tree is vital. In the second year leave 4 -5 well spaced branches which will be the future main ones.

(6) *Pests*

(a) Mango weevil (*Sternochetus mangiferae*)

Small larvae enter the fruits and attack the seeds. There may be a hard white area in the flash. Fruits may fall early or rot in storage.

Control: Field sanitation, regular removal of fallen

fruits.

(b) Mango scale: Small, flat, whitish, circular scales, which excrete honey dew and sooty mould.

Control: Spray Diazinon and white oil or Malathion and white oil.

(c) Fruitfly: Causes premature colouring of some of the fruits. The flesh in the affected area become liquid. Shiny white maggots up to 1 cm may be seen in the fruit.

Control: Collect fallen fruits regularly and bury. Spray Fenthion (Levayad, Baytex).

(d) Red banded thripes: Leaves become dark strained and rusty in appearance, with small shiny black excreta present.

Control: Spray Fenitrothion (Folithion, Sumithion, Agrothion, Novathion).

(7) *Diseases*

(a) Anthracnose (*Colletrotrichum gloeosporiodes*) Black spots on fruits.

Control: Captan or copper fungicide to be a routine spray.

(b) Powdery mildew (*Odidium mangiferae*) White mildew mainly on the flowers.

Control: Spray Dinocap. Routine spray fortnightly from flower buds to fruit sets.

2.2 Pawpaw (*Carica papaya*)

(1) *Varieties*

(a) Honeydew: An Indian cultivar of medium height with sweet juicy oval fruits of medium size.

(b) Kiru: Tanzanian selection which bears large fruits and is high papain yielder.

(c) Mountain Pawpaw: Grows at high altitudes and bears small fruits for jams and preserves only.

(d) Solo: Hawaiian cultivar which bears small round fruits, considered to be about the best for table use and can also be used for papain production.

(e) Sunrise Bears: Bears medium fruits which are sweet.

(2) *Ecology*

(a) Mean temperature of about 25 °C and annual rainfall of over 1,000 mm being distributed evenly.

(b) Deep well drained soil capable of retaining moisture

(3) *Propagation*

From seeds - which may be sown directly in the field or in the nursery beds, seed boxes or any other containers e.g. polethyne bags. In direct sowing, about six seeds are sown per planting hole.

(4) *Field establishment*

(a) Spacing is 3 x 3 metres.

(b) Planting holes are dug 60 cm wide and 60 cm deep.

(c) A debe of manure mixed with three table spoonfuls of DSP or DAP per hole and the holes filled with the mixture.

(5) *Field maintenance*

(a) When well established after transplanting, the seedlings should be topdressed with about two tablespoonfuls of CAN per planting hole.

(b) Once a year at the beginning of the rains apply 200 (g) of CAN or DAP or NPK compound fertilizer.

(6) *Pests*

(a) Systates weevil (*Systates pollinosus*)

A black weevil that feeds on leaves especially when the plants are young. The weevils feed at night and rest by the base of the plants during the day.

Control: Pick by hand and kill the weevil.

(b) Red spider mites (*Tetranycus* spp.)

Leaves turn yellow and fruits become roughened with brownish colour.

Control: Spray Malathion 40 ml per debe of water when symptoms are observed.

(7) *Diseases*

(a) Stem-rot (*Pythium* and *Phytophthora* spp.)

This is a soil borne fungus disease common in poorly drained soils. The truck of the tree rots and the base and leaves wilt.

Control: Spray water-soluble sulphur 40 g/debe of water or spray Benlate or Karathane at 16 g/debe of water.

(b) Black spot (*Ascochyta caricae*)

Circular, brown spots on leaves, stems and pods.

Control: Destroy crop residues.

2.3 Citrus Spp.

The common citrus species are:

(a) Orange - Citrus sinensis
(b) Lemon - Citrus limon
(c) Mandarins / Tangerines - Citrus reticulata
(d) Lime - Citrus aurantifolia
(e) Grape Fruit - Citrus paradisi
(f) Pumelo - Citrus grandis

2.3.1 Orange:

(1) *Varieties*

(a) Washington Navel: Most commonly grown high quality orange variety in Kenya. It performs best between 1,000 and 1,800 m, and produces large seedless fruits. The fruits take between seven and nine months from flowering to maturity.

(b) Valencia: This variety performs better at a lower altitude between 0 and 1,500 m. Fruit is smaller than Washington navel, but the number of fruits per tree is more. The fruit is mainly seedless and has a thin skin.

(c) Hamlin: Grows between 0 and 1,500 m. A seedless variety.

(d) Pineapple: Grows also between 0 and 1,500 m. Seeded variety.

(2) *Ecology*

(a) Require readily available soil moisture at all times.

(b) Require at least 900 mm of annual rainfall well distributed over the growing season.

(c) Water requirement reaches a peak at the time between flowering and ripening. Lack of water during this period will cause excessive flower and fruit drop.

(d) Require deep, light, loamy well drained soil with pH of 5.0 - 7.0.

(3) *Propagation*

(a) It is mainly grown from vegetatively propagated plants. The seeds of this plant can be used for orchard establishment.

(b) The most widely used method of propagation is budding. (See Chapter 10 for detail)

(4) *Field establishment*

(a) Planting holes should be 60 cm wide and 60 cm deep.

(b) Top soil mixed with two debes of well decomposed manure and 250 g of DSP.

(c) Young trees should be set slightly higher than in the nursery to allow for setting, so that the union is well above the ground.

(d) Subsoil should be used to make a basin around the trees, after planting to retain water.

(e) Spacing is 6.0 x 6.0 m.

(5) *Field maintenance*

(a) Pruning: All side shoots growing from the tree trunk below the main branches and on the root-stocks should be rubbed off. Remove dead and broken branches.

(b) Manuring and Fertilizer Application

Manure should be applied at the rate of one or two debes per tree per year.

The following rate of nitrogen fertilizers per tree is recommended:

1st year 100 g CAN
2nd year 250 g CAN
3rd year 400 g CAN
4th year 550 g CAN
5th year 700 g CAN

A subsequent yearly application of 1.0 - 2.5 kg in mature orchard will maintain a high level of production. Phosphorus should be applied as SSP beginning in the third year.

3rd year 250 g SSP

4th year and 5th year 500 g SSP and 1.0 - 2.5 kg per tree in subsequent years.

(c) Potash: Application of up to 750 g of sulphate of potash per year for mature tree, in split application.

(d) Trace elements: Deficiencies of one or more minor elements may occur in citrus orchards. This is mainly seen in different degree,and patterns of leaf discolouration. Magnesium and zinc may be deficient and routine annual spray using 20 g of each zinc and magnesium sulphate in a debe (20 litres) of water, preferably applied after the new flush, will control the deficiency. Commercial liquid fertilizers (foliar feed)

which contain most the trace elements may also be used to control the deficiency.

(e) Windbreaks: Suitable windbreaks greatly reduce damage to trees and fruits in areas subject to occasional high winds and to strong prevailing winds.

(6) Pests

(a) Citrus aphid (*Toxoptera citricidus* and *T. aurantii*) *(Figure 9-1)*

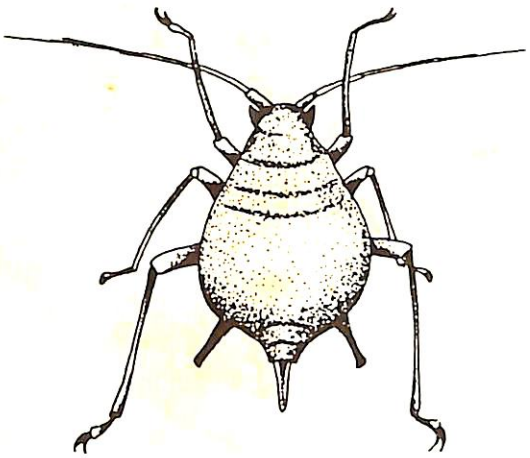


Figure 9-1: Citrus aphid (Source 5)

Masses of small black or brown, soft bodied insects that concentrate on tender young shoots causing growth distortion.

Control: Spray Diazinon, Malathion, Fenitrothion or Dimethioate.

(b) Citrus psyllid (*Trioza erytreae*)

The small brown scale like nymphs causing mumps on the leave.

Control: As for aphids.

(c) Scales: Red scale (*Aonidiella aurantii*) is circular and reddish brown in colour. Soft green scale (*Coccus viridis* or *Coccus alpinus*) is yellowish to greenish in colour. Mussel (*Lepidosaphes beckii*) is long, brown pointed at one end and rounded at the other. These scales attack leaves, branches and fruits. Soft brown scale (*Coccus hesperidium*) is oval and red-brown to yellowish in colour, and attacks young shoot. Scales are immobile insect pests and usually appear in dusters. They may be spread by wind, attendant ants and feet of birds or other insects. Scales suck sap from plants and lead to premature leaf fall, die back and stunting of the trees.

Control: Spray Malathion, Diazinon or Dimethoate. During spraying all parts of the branches and leaves should be thoroughly covered with the insecticide. Heavily affected branches should be pruned and burnt. Attendant ants should be controlled by banding the tree with Dieldrin.

(d) False codling moth (*Cryptophlebia leuotreta*)

Larvae of this moth penetrates into the fruit pulp causing premature yellowing of the area around the point of entry. The fruit changes into orange colour prematurely and drops off. This is a serious pest problem in Kenya.

Control: Collect all the fallen fruits. Pick infested fruits of the trees. Dip the fruits in the insecticide. Mix water or burn the fruits (insecticides - Diazinon, Endosnlphan, Carbarly).

(e) Mediterranean fruitfly *(Ceratis capitata)*

Eggs are laid into cavities made under the surface of the fruit skin. A small dark spot occurs on the fruit surrounded by bright zones. The fruit affected by the larvae will rot and fall off from the tree.

Control: Infected and fallen fruits must be removed from orchard. Spray with Fenlthion or Malathion weekly starting when fruits are 4 cm diameter.

(f) Orange dog (*Papilio demodocus*)

The caterpillars (larvae of the butterfly) are defoliators. The young ones are brownish to blackish in colour with white patches and spiny outgrowth. Old ones are large and greenish with some light marking.

Control: The caterpillar may be picked by hand and destroyed where the infestation is not serious. Application of insecticide is as for mediterranean fruitfly.

(g) Mites: Citrus bud mite (*Aceria sheldoni*) feeds in well protected parts of the shoots and cause mal-formation of the twigs, leaves, flower buds and sometimes the fruits. Citrus rust mite (*Phyllocoptruta oleivora*) attacks fruits, and the affected fruits show cracking and silvering of the skin which later turns black. Spider mites (*Tetranychus* spp.) include various species which feed on citrus leaves causing mottling

and browning. Severe infestation may cause premature leaf fall.
Control: Spray Dicofol, Dimethoate or Thiovit as soon as attack found.

(7) *Diseases*
(a) Tristeza (Stem-pitting) The virus is found on young or old citrus grown on susceptible rootstocks of sour orange and grapefruit. It causes partial suppression of new growth and yellowing of the leaves followed by leaf fall and die back.
Control: Use resistant rootstock like rough lemon, sweet orange and cleopatra mandarin. The budding materials should be collected from healthy mother trees. The control of aphids and scales may prevent the spread of the disease.
(b) Citrus scab (*Elsinoe fawcetti*)
Yellow to orange, corky spots occurring singly or grouped on the underside of leaves especially on rough lemon. Infected leaves may become crinkled and rolled. Similar pattern of spotting is observed on fruits and twigs.
Control: Fortnightly spray copper fungicide e.g. Perecot, Cupravit and shell copper.
(c) Foot rot (*Phyphthora citriphora* and *P. parasitica*)
Attacks trees grown in poorly drained soils on susceptible stocks.
The first sign is the appearance of gum on the bark near the bud union and later spreads to roots. In severe infection, girdling and uneven drying are observed.
Control: Avoid planting trees in water-logged areas. Rough lemon, sweet orange and cleopatra mandarin are all susceptible.
(d) Sooty mould (*Capnodium citri*) Fungus Capnodium lives and thrives on the excretion from scales and whiteflies.
Control: Use Dimethoate, Diazinon or Carbaryl.
(e) Green mould (*Penicillium digitatum*) Common in stored fruits although it may be observed in the orchard.
Control: Care should be observed when harvesting to avoid abrasion and wounding of the fruit. For long storage fruits protective fungicides dips e.g. Benlate and store sanitation will reduce the risk of damage.
(f) Alternaria leaf spot (*Alternaria citrii*)
This is a leaf spot disease which also causes firm black rot on navel oranges and water brown rot on lemons. On leaves, this is observed as large blotches with yellow halo. Is more common in high altitude areas.
Control: As for scab.

2.3.2 Other Citrus: The propagation and protection method mentioned above are also *applicable to other citrus species.*
(1) Tangerines: Emperor is the most widely grown variety and does well in lower altitude areas under 1,500 m. Satsuma is well adapted in higher altitude between 1,000 and 1,800 m. Kara is also for low altitude under 1,500 m. Dancy and Clementine are other varieties.
(2) Lemons: Lemons are grown in a much wider range than other citrus species. Some varieties such as Eureka, Lisbon and Villafranca perform best between 1,000 and 1,500 m. The rough lemons which are commonly used as the root stock for budding, grow best between 0 and 1,800 m.
(3) Limes: The common varieties are Tahiti, Mexican and Bearss. Limes grow between 0 and 1,500 m.
(4) Grape Fruit: Marsh is the most common, seedless variety. Other varieties are Red Blush, Thomson and Duncan. They grow best between 0 and 1,500 m.

2.4 Bananas (*Musa* spp.):
Musa sapientiunm - Dessert banana - fresh
Musa paradisiaca - Cooking banana (plantain)
Musa cavendishii - Dwarf banana

(1) *Varieties*

(a) Mraru (Mulalu):	Tall variety.
(b) Kinguruwe:	Short variety.
(c) Mbiili (Ndiri):	Small fruit.
(d) Katithi:	Small medium fruits.

(2) *Ecology*
(a) Requires high temperatures (20 - 25 °C) high humidities and light intensities.
(b) Can grow from 0 - 2,100 m above sea level.
(c) Well distributed in the areas with annual rainfall of 2,000 - 2,500 mm.

(d) In semi-arid areas bananas are often planted at riverside, water spring lines, drains, bottom of deep pits or under irrigation.
(e) Weak against strong winds hence windbreaks are necessary.
(f) Requires deep well drained loamy soil with a high humus content with a pH value of 5.0 - 8.0.
N/B: Bananas has a pseudostem i.e. fleshy leaf sheaths which encircle one another.

(3) *Propagation:* Propagated vegetatively except for breeding since banana is Parthenocarpic (Ovary develops without fertilization and bears no seeds). *(Figure 9-2*

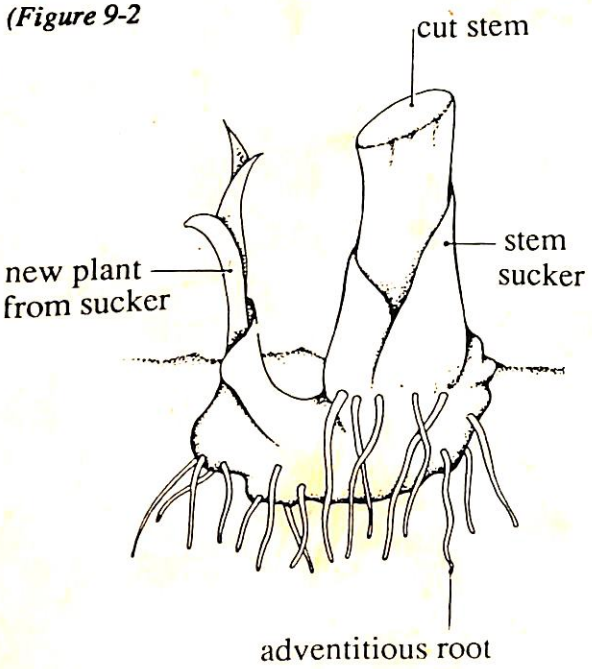


Figure 9-2: Sucker of banana (Source 5)

The following planting materials are used:
(a) Sword suckers: suckers that are formed from bud low on the corn and bear narrow sword leaves, plucked from the plant when they are 0.6 - 1.2 m in height and about 15 cm in diameter.
(b) Broad leaf maiden suckers: well developed suckers which have broad leaves but have not yet shot of a bunch and are 6 - 8 months old.
(c) Bull heads: obtained from the corn of a plant which has borne a bunch.

(4) *Field establishment*
(a) Planting holes should be dug 0.6 m wide and 0.6 m deep.
(b) 2 debes of well rotten manure and 110 g of DSP to be mixed with the soil in planting hole.
(c) Suckers should be planted 30 cm deep in the soil. Spacing depends on varieties, soil fertility, and management; Tall varieties 3.6 x 3.6 m. Dwarf varieties 2.7 x 2.7 m.

(5) *Field maintenance*
(a) Mulching to keep soil moist, enrich the soil and to suppress weeds.
(b) Two debes of manure applied around the stool after every year.
(c) Chemical fertilizers (CAN or DSP) are also applied to supplement the organic matters. (100 g/ stool per year).
(d) Pruning to reduce pseudostems into three per stool at equally spaced stages of development.

(6) *Pests*
(a) Banana weevil (*Cosmopolites sordidus*) *(Figure 9-3)*

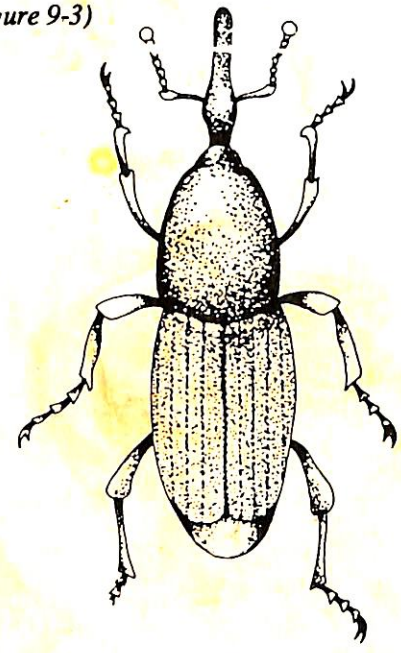


Figure 9-3: Banana borer (Source 5)

Banana borer or beetle. Eggs are laid at the base of the pseudostem and larvae burrow into stems making tunnels which are seen if the plant is cut up.
Control: Apply Dieldrin dust around the base of the stock. Repeat it every two months. Dip suspected planting in Dieldrin in solution before planting. Restrict the movement of materials from infested areas. Mulch should be kept away from the stool.
(b) Banana thrips (*Hercinothrips bicinctus*) Silvery patches on fruit skin with small black spots are scattered over the bunches.
Control: Spray Dieldrin ML (Miscible Liquid).

(7) Diseases
(a) Panama disease (*Fudstium oxydporum, F. cubense*) Caused by fungus. The disease is alternatively known as banana or vascular wilt. Attacks roots first and slowly spreads to the corn. Vascular bundle in the corn turns into purple and is followed by yellowing of the leaves and wilting.
Control: Plant resistant varieties e.g. cavendish group. Dig and discard the infected plants and remains. Select disease free suckers for planting or move to new land.
(b) Cigar end rot (Fungus - *Verticillium theobromae*) Tips of the fingers look like ash on the end of cigars.
Control: Remove the ends of the inflorences (flowers) on developing fruits.

2.5 Avocadoes (*Persea americana*)
(1) *Varieties*
(a) Fuerte: Hybrid of Guatemalan and Mexican races with thin-skinned, green pebbled fruit of very good flavour.
(b) Hass: Vigorous grower and bearer of black fruits. Propagates well.
(c) Nabal: Bears fruit in alternate years. Its green fruits have a good flavour.
(d) Puebla: Spreading, dark green tree bearing deep purple round fruit. Used as a rootstock.
(e) Others: include Pinkerton and Bacon.

(2) *Ecology*
(a) Grows well at altitudes of 1,500 - 2,100 m in areas with a well distributed rainfall of more than 1,000mm per annum.
(b) Soil should be deep and free draining.

(3) *Propagation*
(a) Select healthy, egg-sized seeds and plant them in boxes or seed beds. Immediately after germination, transplant the seedlings into tins, pots or polythene bags.
(b) Grafting should be carried out when the seedling reaches pencil thickness.
The wedge grafting method is the most successful. Grafting should be done at the point where the rootstock is soft. The scion should be dormant at the time of grafting and should match the size of the stock. Wrap the grafting point thoroughly to exclude water from the union.

(4) *Field establishment*
(a) Planting holes should be 60 x 60 cm, keeping the top soil and sub soil separate.
(b) Mix the top soil with 20 kg of well decomposed manure and 120 g of double superphosphate (DSP).
(c) Remove the plant from its pot, keeping the root and soil structure to fill up the hole.
(d) The sub soil may be used to make a basin around the tree.
(e) Water immediately after planting. Shade the plants with banana leaves or similar material is they are putting up a new flush.

(5) *Field maintenance*
(a) Pruning: Initial pruning may be done to give the tree a good shape. Otherwise, pruning is limited to the removal of deadwood.
(b) Windbreak: A windbreak may be appropriate under certain conditions, to protect the plants from leaning to one side and to help prevent shedding and fruit drop and bruising.

(c) Manuring and fertilizer application: An application of manure and fertilizer is desireable at the onset of each long and short rain. To determine the precise amount, the soil should be tested annually, otherwise the following table will be a guide:

Age (years)	CAN	DSP	Muriate of potash	Manure
1 - 3	120g	220g	--	15kg
4 - 5	220g	450g	--	15kg
6 - 7	450g	650g	220g	30kg
8 - 9	650g	650g	450g	30kg
10 - 14	900g	1kg	650g	--
15+	1.3kg	1.2kg	650g	--

(d) Trace element: Deficiencies in one or more minor elements may occur in avocado orchards, seen usually as a varying degree of leaf discolouration. Accurate analysis can be made by the National Agricultural Laboratories to which leaf samples should be sent.

(e) Nutrient element symptoms and control

Zinc: Mottled leaves with yellow areas between the veins and abnormal development of the growing shoots. Control by applying of 250 g zinc sulphate for each year of age to a maximum of 4.5 kg.

The application done in a 60 cm strip around the drip circle.

Manganese: Spray young leaves with a foliar spray of manganese sulphate.

Iron: Causes loss of green colour in the leaves. Apply 360 g iron chelate for each year of age.

Chlorine: High concentrations of chlorine in the soil may cause tip burn and also damage the root system. Apply calcium, magnesium or ammonium phosphate and avoid fertilizers containing chlorine.

(6) *Pests:* There are no major pests of avocadoes. Purple scale (*Chrysomphalus aonidum*) may be controlled with a spray of any one of the following: Diazionon, Fenitrothion + white oil or Malathion + white oil.

(7) *Diseases*

(a) Root rot (*Phytpphthora cinnamoni*): The fungus attacks and kills feeder roots of the avocado tree, preventing the uptake of moisture from the soil. Due to the moisture stress, leaves of the infected tree turn yellow, wilt and shed off giving the tree a sparse appearance.

As the disease progresses branches die back and the diseased tree dies prematurely.

Root rot is favored by excess moisture in the soil. It can easily be spread from one area to another by use of infected seed, infested soil and irrigated with fungal spore.

Seed for planting should be taken from fruit picked from avocado trees.

Control: Where possible heat the seed in a hot water bath at 48 to 50 °C for 30 minutes. Grow seedlings in containers using clean nursery soil. Carefully irrigate to avoid excessive soil moisture.

Newly infected trees should be drenched with Ridonil at the rate of 15 - 20 g/m^2 every three weeks. Uproot

(rogue) all severely infected trees and take precautions to prevent movement of soil and irrigation water from the diseased to non-infected areas.

(b) Scab (*Sphaceloma perseae*): The disease is most prominent and easily recognized on the fruit. It initially starts at oval, slightly-raised spots, brown to purplish brown in colour.

As the fruit matures spots coalesce and their centres become sunken.

The spots roughen and crack. Lesions on the leaves often occur in the upper part of the tree canopy. Scab starts as discreet small spots less than 3.5 mm in diameter. The spots are mostly found on veins on the underside of leaves. As they develop, they often take on a star-like pattern with the centre eventually dropping out to give a shot hole effect.

Cool moist conditions are conducive to scab infection. *S. perseae* attacks only young tissues. Leaves become resistant after one month. The fruit becomes resistant once it reaches about half size.

Control: Copper based fungicides give adequate control of this disease. The first spray should be applied when the flower buds appear followed with sprays when the fruit sets in and then a month later.

(c) Cercospora spot (*Cercospora purpurea*) Spots on leaves are small, less than 2.5 mm in diameter and brown to purple in colour. The angular appearance on the leaf spots is highly diagnostic. Many of these leaf spots are surrounded by yellow holes. On the fruit, lesions begin smaller irregular brown spots that enlarge and coalesce. Cracks often appear in these spots and every often seen as entry points for the anthracnose fungus.

The disease is spread by wind, rain and insects. It is normally serious during the rainy season.

Control: Use copper based fungicides or Benomyl (Benlate).

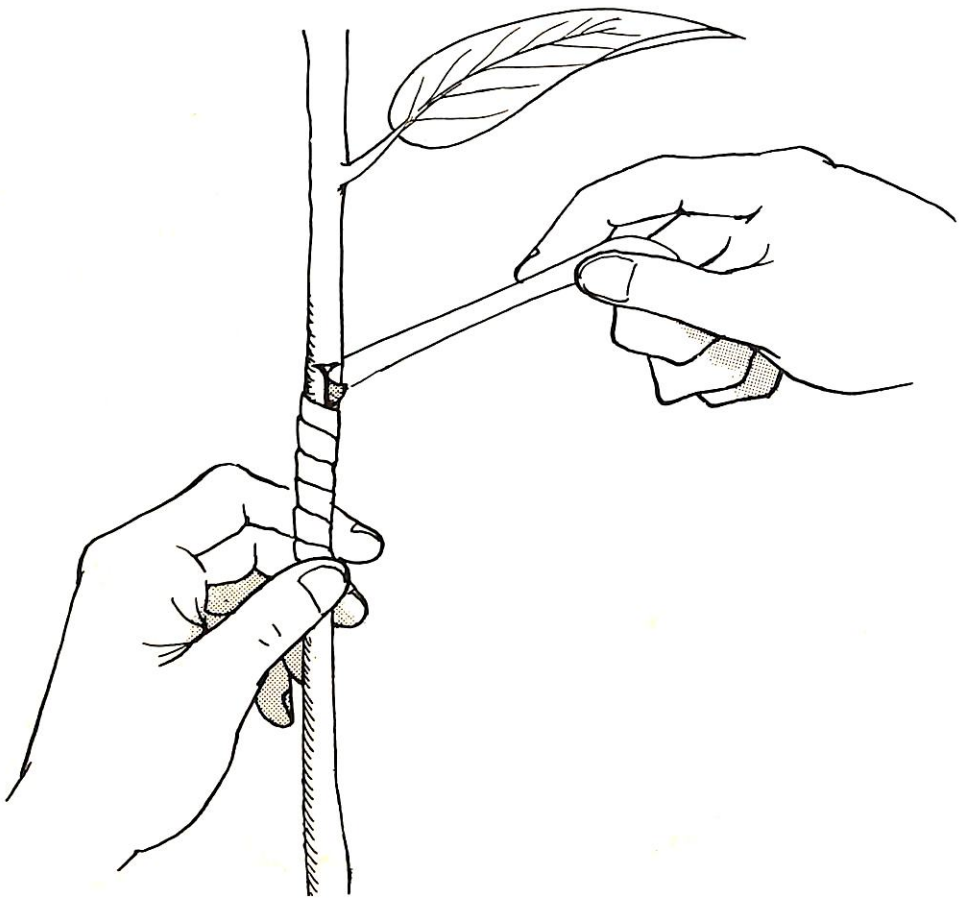
(d) Anthracnose *(Colletotrichum gleosporioides)*: Fruit lesions start as circular, slightly sunken brown to black spots.

These spots enlarge rapidly under wet conditions developing cracks radiating from the lesion centre and eventually may cover a large portion of the fruit. The fungus requires some type of wound created by some other means in order to penetrate the fruit and cause the rot. Mechanical damage, scab and especially cercospora spot lesions are known entry sites for the anthracnose fungus. Insect may also provide wound infection sites.

Control: Good anthracnose control depends on effective control of scab and especially cercospora spot.

Cuts and bruises to the fruit in handling should be avoided. Fruits showing any symptoms of anthracnose should not be packed with healthy ones. If scab and Cercospora spot control is inadequate, spray Dithiocarbamate fungicides e.g. Zines, Manes, Mancozes, Metiriam etc.

GRAFTING AND BUDDING PRACTICE



1. INTRODUCTION

Grafting is the uniting of two separates structures, for example the union of a stem to a root or the union of two stems. The upper portion is called scion, and the lower portion or root is called stock or rootstock. *(Figure 10-1)*

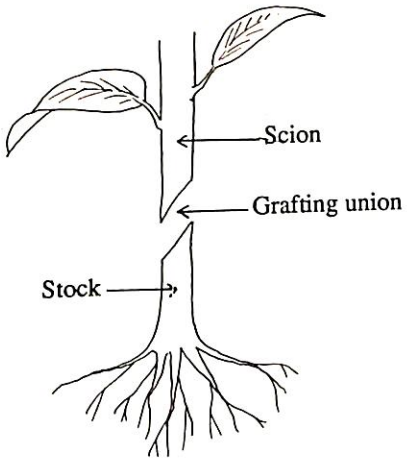


Figure 10-1: Scion and stock

The scion has usually one or more buds which give rise to the future fruiting plant. All methods of joining plants are called grafting, but when the scion part has only a single bud, the operation is called budding.

2. REASONS FOR GRAFTING AND BUDDING

(1) Help propagate clones that can not be conveniently reproduced by other means e.g. cuttings, layers, division, or other sexual methods.
(2) Obtaining special plant forms.
(3) Getting the benefits of certain rootstocks e.g. stocks which can tolerate unfavorable conditions, such as heavy, wet soils, or resistant soil borne pests or disease organisms.
(4) Hasten the growth of a variety selected.
(5) Make it possible to change variety.

3. HEALING OF THE BUD UNION

The ability of the scion and stock to form a union successfully is termed compatibility. The opposite is incompatibility which is the inability of the scion and the stock to form a union. Only structures from botanically closely related plants are compatible.

3.1 Influential Factors: The healing of the graft union depends on:
(1) The type of plants.
(2) Temperature, moisture and oxygen condition during and after grafting/budding.
(3) Growth activity of the stock plant.
(4) Age of the stock.
(5) Virus contamination, insect pests and diseases.
(6) Propagation technique.

3.2 Symptoms of Incompatibility : Symptoms of incompatibility or failure are:
(1) Yellowing foliage in later part of the growing season, followed by early defoliation. Decline in vegetative growth, appearance shoot dieback and general ill health of tree.
(2) Premature death of trees which may live a year or two in the nursery.
(3) Marked differences in growth rate or vigour of scion and stock.
(4) Differences between scion and stock in the time which vegetative growth for season begins or ends.
(5) Overgrowth at, above or below the graft union.

4. GRAFTING

Several methods of grafting are practised, and, tongue (whip) grafting and splice grafting may be the commonest among them.
These methods are used for materials in which the stock and scion are of similar diametre of 1/4 - 1/2 inch (0.6 - 1.5 cm).
Many fruit tree species, e.g. avocadoes and mangoes, are propagated by these methods.

4.1 Tools and Accessories for Grafting
(a) Grafting knife (sharp knife) b. Coarse sharpening stone c. Tying materials (polythene tapes) d. wrapping materials (polythene bags)

The bud stick must be taken from a high yielding, good quality tree.

(4) Use the knife to open the budding slit.

(5) Insert the bud into the slit. If the upper part of the bud remains above the slit, chop it so that the bud enters the slit entirely. *(Figure 10-9)*

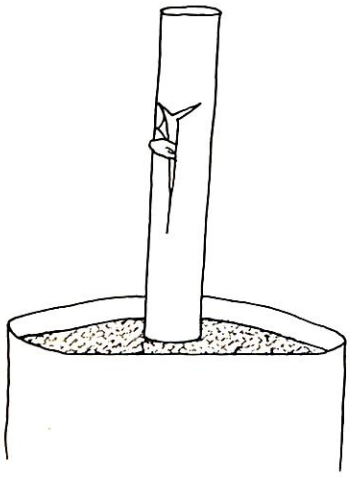


Figure 10-9: Inserting the bud

(6) Tie with polythene tape. *(Figure 10-10)*

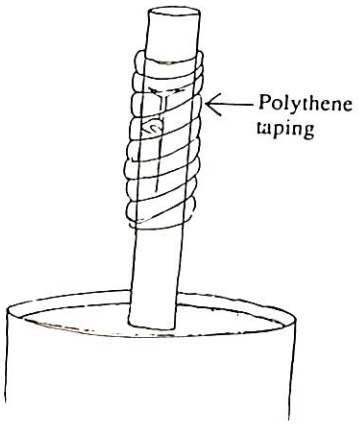


Figure 10-10: Tying the bud

(7) Wax over the tape (if grafting wax is available) to prevent drying.

(8) Water the plant properly.

CHAPTER 11

AGROFORESTRY

1. INTRODUCTION

Agroforestry, as the name implies, simply means the integration of the two concepts, agriculture (agronomy) and forestry.

This is a land-use system that combines trees and crops and/or livestock on the same land unit simultaneously or in time sequence.

Trees and crops/livestock coexist symbiotically or sometimes rather independently.

More economical returns and better ecological benefits on a sustained yield basis are obtainable than from mono-culture on the same unit of land.

This food crop/tree relationship has existed before in form of shifting cultivation as a land-use system where bush or forested land was cleared to give way to cultivation of food crops.

On exhaustion, this land was let to lie idle and for natural re-generation to occur for a number of years while land users use other parcels of land and later to return to this same land.

However, high pressure on the land due to the increasing population in recent years has disabled and outdated this system. Land users are forced to come back to the same piece of land year after year, and this does not allow the land to be in fallow and for natural regeneration to occur, resulting in the land being overused.

This high population pressure has resulted in excision of forests and pushing them further away from the farmers and population centres.

Most energy needs and other benefits have been satisfied from trees, so with receeding forests, tree planting on the farm by using an agroforestry system has become a necessity.

2. THE ROLE OF TREES IN AGROFORESTRY SYSTEM

Many functional roles and products of trees can be expected in an agroforestry system. These are the important factors to choose a suitable system to be adopted. The selection of tree species depends on the purpose, intended end-use and the services that the trees offer to the farmers as well as crops to be cultivated, and also land availability. Important tree species are introduced in Chapter 2.

2.1 Nutrient Recycling: Because of their deep roots, trees are able to take up nutrients which are out-of-reach of the shallow roots of the most of food crops. Through the leaf-fall and consequent decay on the soil surface, the nutrients become available to food crops. Browsing animals also eat the tree leaves and their manure has much faster effect in making these nutrients available to the crops.

2.2 Rehabilitation of Saline Soil: In most of the very dry areas, soil becomes saline due to capillarity action. Some tree species, e.g. *Kochia* and *Atriplex* spp., can take some of these salts rendering the soil to be less alkaline and then the soil becomes more productive.

2.3 Control of Soil Erosion: Trees can also be planted to control soil erosion. In this case the tree roots hold the soil together on the surface to avoid the soil being washed away by water run-off. See Chapter 12 for more details.

2.4 Soil Reclamation: By the functions mentioned above, some of tree species e.g. *Conocarpus* and *Casuarina* spp. (Mvinje, etc.) grow on denuded/poor productivity lands and make the soils fertile hence make the lands available for crop production or grazing.

2.5 Shade: Trees provide shade to men, animals and plants as well. Some crops only can grow under the shade. Livestock take rest under the trees in grazing lands as human beings do on the farm.

2.6 Use of Trees as End Products: Trees can be planted on the farm expecting end products for immediate use or for economic gain, or utilizing the services enumerated above.

(1) Firewood: Most households in rural areas depend for their daily cooking and heating fuel on firewood usually collected from nearby forests or

bushes. However, as mentioned in the introduction, forests have been pushed away by cultivating lands and over cutting of trees. Thus tree planting for firewood supply has become a necessity.

(2) Timber and Poles: Trees to provide timber and/or poles are comparatively large and need a longer rotation to reach to the required quality and size.
Therefore, when this type of trees is combined with other crops, shade tolerance of crops should be considered.

(3) Fodder: On-farm tree planting provides fodder for the animals in settled farm areas.
This is also in pastoral areas. In view of the pressure on land due to high population densities and a need to provide fodder for the many zero grazing units.
Some tree species e.g. *Leucaena leucocephala* (Ipil-ipil) contain high nutrition (protein) and are better than most of fodder grasses.
In pastoral areas, trees like *Acacia albida* (Olasiti) provide fodder especially during the dry seasons.

(4) Fruits: Fruit trees also can be incorporated in an agroforestry system.
However, large trees, e.g. mango, are not suitable for inter-cropping because of the dense canopy which shades the light from other crops.

(5) Green Manure: As already mentioned , trees can improve the soil through decaying of their leaves and twigs. They are also used as green manure to be ploughed into the farm soil or to be used as materials for the compost making.

(6) Mulch: Leaves and litter fall from the trees provide mulch for food crops and consequently manure as listed above.

3. AGROFORESTRY SYSTEMS

The agroforestry systems or the modes of planting are several and the choice of system depends on individuals' needs on benefits to be derived, end products required, crops to be intercropped, size of the farms and the mode of farming being practised.
Some popular systems of tree planting on farms are cited below:

3.1 Dispersed Trees: This is a traditional agroforestry arrangement where trees dispersed in farm lands form an integral part of a cropping system.
In traditional systems these trees regenerate naturally, and so they are more or less homogeneously distributed across the farms in random patterns.
When they are planted by men, regular spacing is normally 10 x 10 metres. Regular spacing is particularly important if mechanized cultivation or animal traction is practised.
The trees planted provides shade, organic matter, firewood, fruits and fodder to livestock, especially in dry season.

3.2 Intercropping: Trees can be intercropped with other crops emphasizing either food crops or trees.

3.2.1 Taungya System (Shamba System): The objective of taungya system is the establishment of woodlots or tree plantation.
Food crops are cultivated between tree rows when trees are young until the shade of trees starts interrupting the growth of crops.
The performance of trees in this system is usually much higher than others due to the continuous weeding and cultivating for food crops.

3.2.2 Line Planting: Combination of comparatively larger trees and/or shrubs for timber/poles, firewood, such as *Grevillea robusta* (Silky oak, Mkima), or fruits like citrus and avocado, and other crops. Both crops and trees or their products will be harvested. Nitrogen fixing trees also can be mixed.
The optimum spacing between rows is around eight metres but also depends on the crops and their shade tolerance and the tree species with its consequent shading effect.

The end-use of trees and the rotation also determine the spacing between rows. For example, for trees with an end-use to provide firewood with the rotation of about five years, the spacing is at a lower spacing than trees to provide timber with a rotation of 20 years. Spacing between trees are 1-2 metres. *(Figure 11-1)*

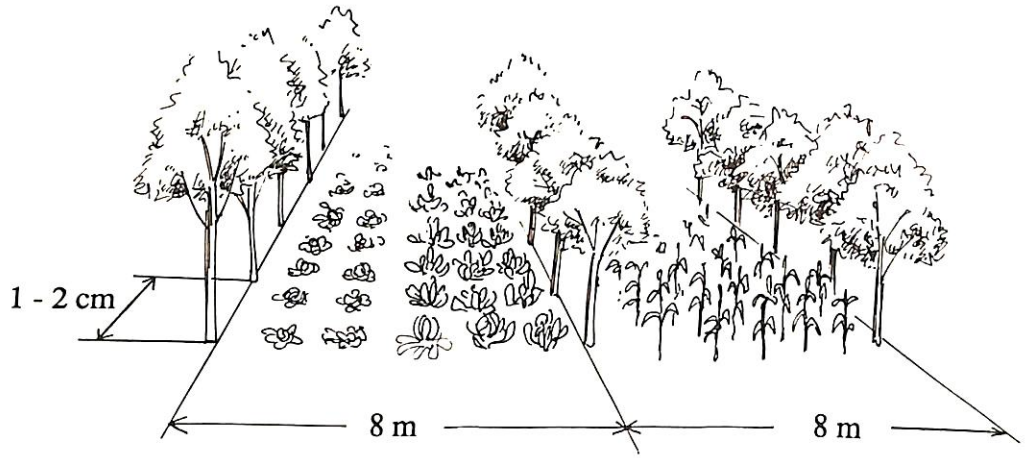


Figure 11-1: Tree lines on farm

Trees are thinned expecting better height growth and form, but not as intensively pruned as in alley cropping, although branches may be pruned off to let more light through to the crops below and harvesting firewood is also done by lopping-off the branches until the whole trees are to be felled. *(Figure 11-2)*

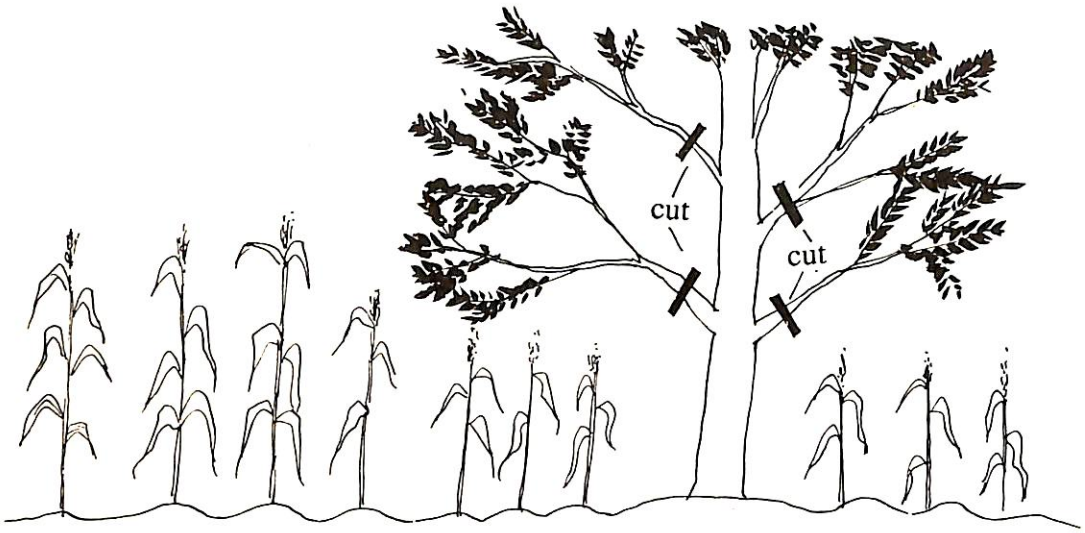


Figure 11-2: Pruning branches

Roots are also sometimes cut by ploughing if they encroach too far into crops fields.
(Figure 11-3)

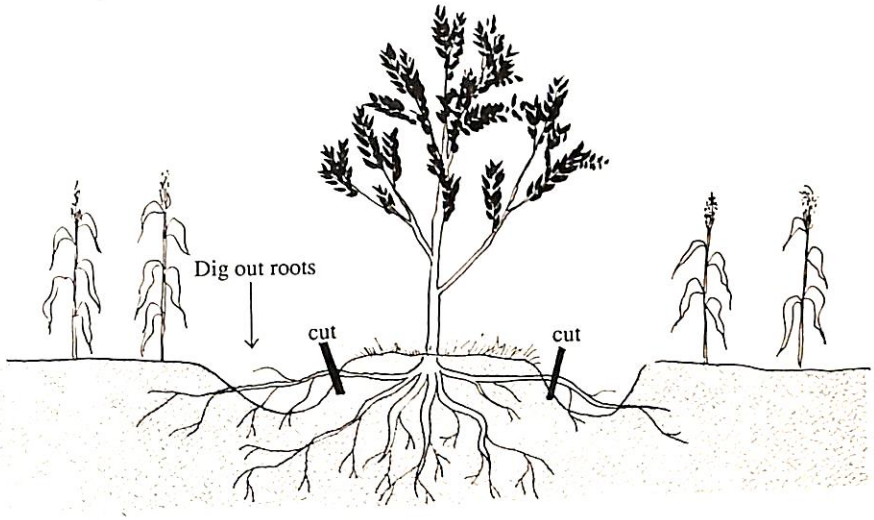


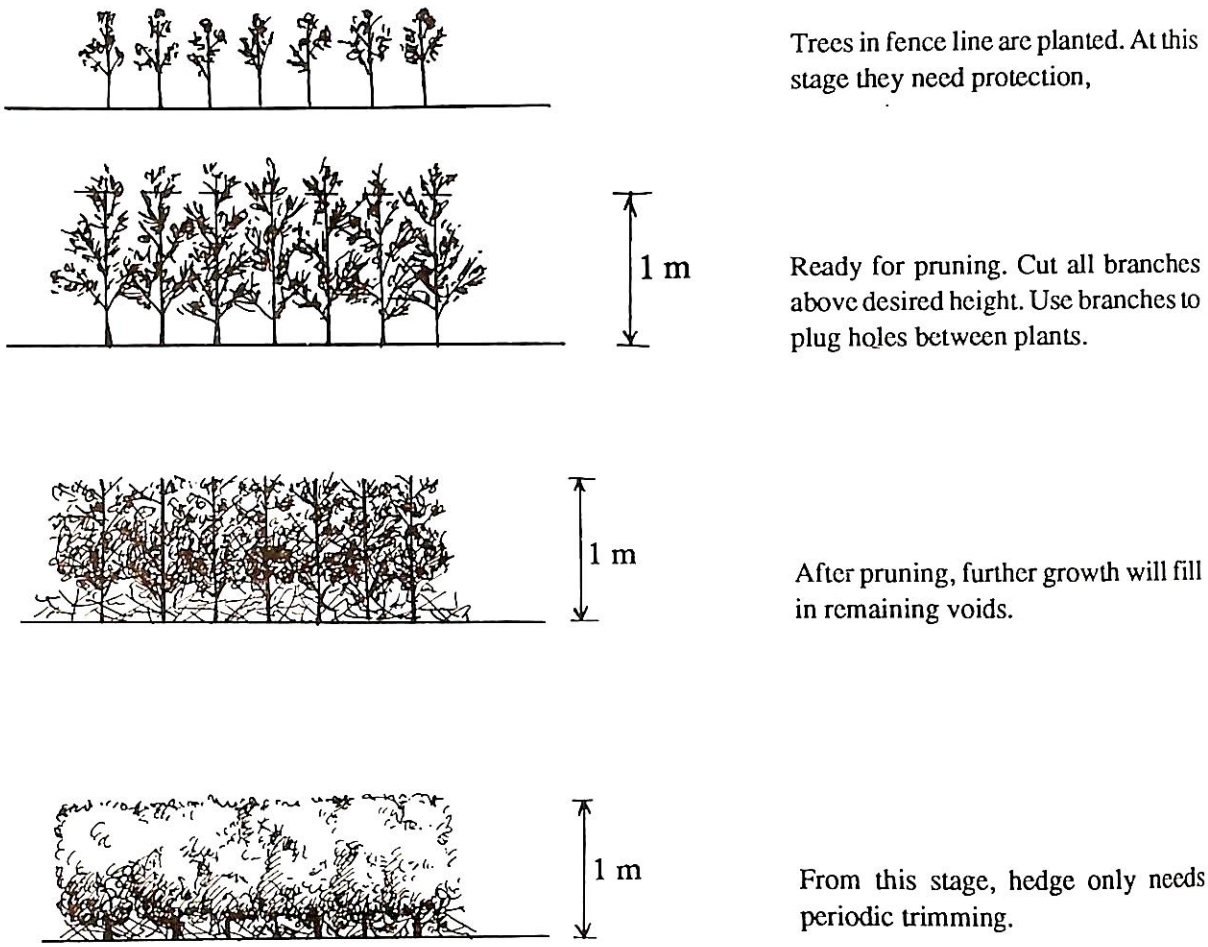
Figure 11-3: Cutting the encroaching roots

3.2.3 Alley Cropping: While the line planting aims at the harvesting of trees and crops, objective of alley cropping is mainly harvesting crops, not trees.
Trees are used as green manure to increase crop yields and/or may be as contour strips to prevent soil erosion.
Fast growing legumes, such as *Leucaena leucocephala* (Ipil-ipil), *Cassia siamea* (Ikengeka), *Sesbania sesban* (Mwethia, Munyongo) and *Acacia albida* (Olasiti), are suitable for alley cropping because of their high productivity and potential to fix nitrogen.
Spacing between tree rows is 2-4 metres and trees planted are pruned frequently to prevent them from producing too much shade.
Clippings are laid down as a mulch around crops or ploughed into soil, to decompose gradually and become incorporated into the soil as organic matter.
Clippings and pruned branches also can be used for fodder, poles and firewood, however, in this case alley cropping may not have the effect of increasing crop yields.
In drier areas, sometimes the water competition between crops and trees (especially shallow root species) is observed. To prevent this competition, it is recommended to cut the side-roots of trees growing towards the crops.
Alley cropping requires fairly close placement of tree rows, which can substantially reduce the amount of land left for the crop rows. Where land scarcity is a problem, alley cropping is probably not the best method to use.

3.3 Live Fencing: Live fence consists of dense hedges or thickets usually planted around a garden or farm to protect it from free ranging livestock.
They are also planted around family compounds and other buildings. Shrubbier species are used, and the shrubs or trees are tightly spaced (0.5 - 1 metre), and they are intensively pruned to maintain a compact, dense barrier.
Live fences can also be established to protect fallow lands and/or denuded areas due to overgrazing and to allow the area to be rehabilitated by the natural regeneration or planting certain tree species. The workload wasted for fencing with thorny branches and repairing every year may also be reduced. Thorny, easily coppicing, unpalatable and fast growing species should be selected.

However, no one species will meet all these requirements. Species recommended for live fence are *Euphorbia* spp. (Mtupa mwitu), *Acacia machrostachya, A. nilotica* (Musemei, Mugungu), *A. senegal* (Mung'ole), *A. mellifera* (Muthia), *A. seyal* (Musewa), *Aberia caffra* (Kayava), *Balanites aegyptiaca* (Mulului, Mjunju), *Comiphora* spp. (Iguu, Mbambara), *Leucaena leucocephala* (Ipil-ipil), *Parkinsonia acculeata, Prosopis juliflora,* and *Zyziphus* spp.

A mixture of species may provide the most protection. If protection from animals is not a primary concern, the spacing between trees can be wider, and also species for other purposes such as fodder, green manure and fruits, can be planted. *(Figure 11-4)*



Trees in fence line are planted. At this stage they need protection,

Ready for pruning. Cut all branches above desired height. Use branches to plug holes between plants.

After pruning, further growth will fill in remaining voids.

From this stage, hedge only needs periodic trimming.

Figure 11-4: Proper fence pruning

3.4 Borderline Trees: Trees and shrubs are planted as property markers to delineate individual farm fields. They do not occupy too much space, nor do they shade large areas.
As in line plantations, wood and other products can be harvested from these trees.
Tree rows are not actually in the fields, so they don't interfere with farming operations.
Protection of young trees are necessary unless the livestock dislike the species being used. Issues of land and tree tenure should be carefully discussed before this techniques is tried if the trees are to be planted on a borderline between two farmers' properties

3.5 Woodlot: This is not exactly an agroforestry practice. A certain portion of land is kept for tree planting aimed at production of fodder, firewood, green manure and fruits as well as timber and poles. However, this also means that the farm size must be large enough to allow some land to be set aside.
A fallow is also a good place to plant fast growing species which can improve the soil fertility such as legumes.

3.6 Silvi-Pastoralism: This is the growing of trees on pasture lands especially for the livestock to provide fodder. The branches of the trees planted in grazing areas are lopped off or pollarded and the animals are allowed to eat leaves and the pods.
However, trees are difficult to protect from livestock when they are young. Fencing around individual trees is effective but expensive. *(Figure 11-5)*

Certain trees, e.g. *Acacia albida* (Olasiti), leaves and pods provide a welcome source of food for livestock during the dry season when there is no grass.
Other trees have a very high protein content in their pods and leaves e.g. *Leucaena leucocephala* (Ipil-ipil) and can be mixed with other grasses which usually have lower protein content as animal feed.
Fodder trees can also be intercropped with grasses along the edges of terraces to stabilize the benches and also provide fodder.

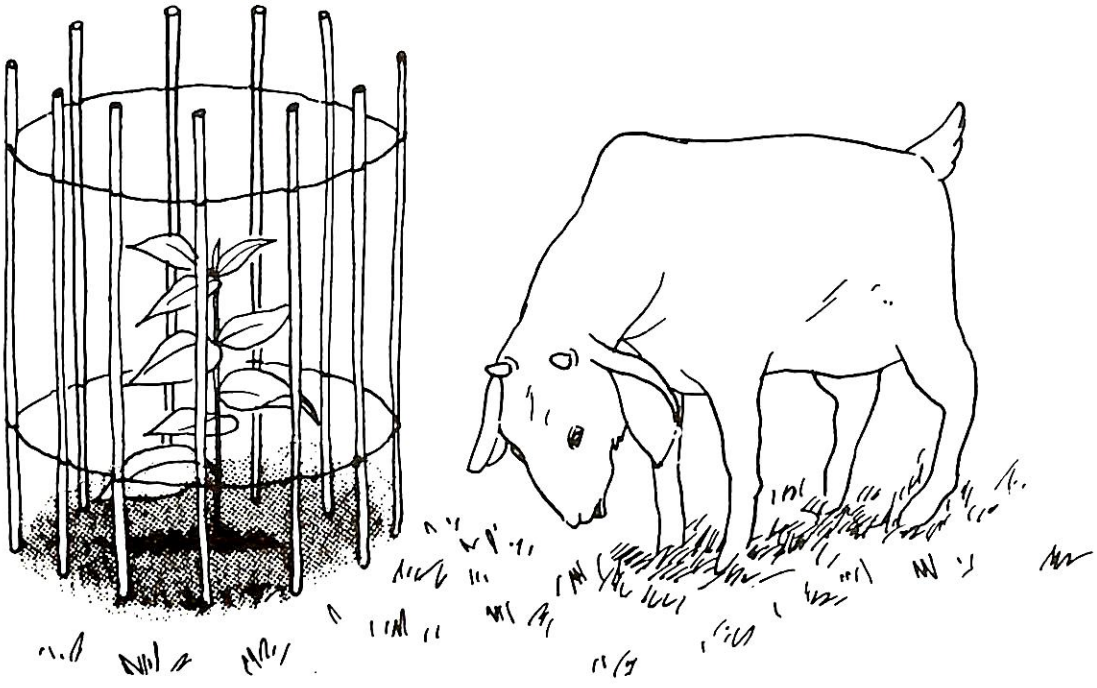


Figure 11-5: Individual tree protection

3.7 Windbreaks: In addition to the main aim of this planting to reduce the speed of the wind, tree species which provide above mentioned profits also can be planted in rows.
Details are given in Chapter 12.

4. HARVESTING METHOD

Many of the tree and shrub species used in agroforestry system have the capacity to regenerate new growth from stumps, roots, or branches after being cut.
In dry areas where it is difficult to re-establish trees once they have been cleared, this adaptation is a particularly valuable characteristic.
Wood products can be repeatedly harvested from such trees and shrubs without destroying the plants.
Several harvesting methods allow the plant to regenerate through sprouting.

4.1 Coppicing: This is a particularly suitable methods for production of firewood and one of the most widely practised harvesting method for dry land species.
When the main stem has reached the desired dimensions, it is cut at the base of the trunk.
New shoots develop from the stump or roots.
Only three to four of the most vigorous shoots should be allowed to grow to full size.
The others should be cut back to prevent competition for growing space.
Several rotations of coppicing are usually possible with most species.
The length of the rotation depends on the size of the specific wood products.
After several harvests, sprouting vigor will diminish, and this period of viability varies for different species.
Eucalyptus spp. and many of the legumes can be harvested by coppicing. *(Figure 11-6)*

4.2 Pollarding: With this harvesting system, all the branches are removed, but the main trunk is left standing.
After the branches are cut off, new shoots are allowed to sprout from the main stem and form a new crown.
When the tree loses its sprouting vigor, the main stem

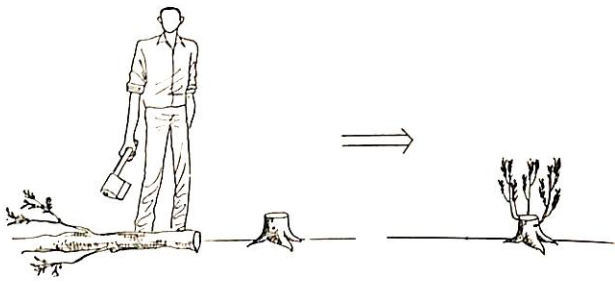


Figure 11-6: Coppicing

can also be cut for use as large diametre poles. An advantage of this method is that the new shoots are high enough off the ground that they are out of reach of most grazing animals.
Azadirachta indica (neem) is usually harvested in this manner, and branches are used for poles, firewood and toothbrushes. It is important to allow the tree to become well established before the first cut.
Eucalyptus spp. and *Grevillea robusta* (Mkima) are also good for pollarding practice. *(Figure 11-7)*

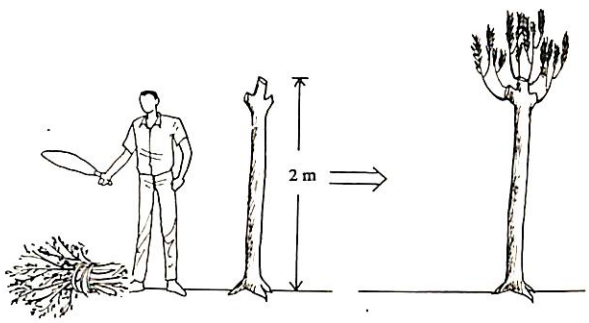


Figure 11-7: Pollarding

4.3 Lopping: Lopping is a form of harvesting in which only lower branches are cut and new branches re-sprout along lower portion of the stem.
This harvesting method can be used to reduce shading when trees are intercropped with other crops. *(Figure 11-8)*

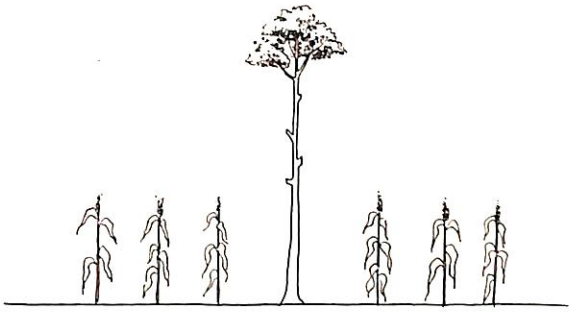


Figure 11-8: Lopping

4.4 Pruning: Pruning is usually the removal of smaller branches and stems and these clippings can be a major source of firewood and other purposes. Branches are also used as mulch between tree rows in alley cropping system. Pruning is often required for the maintenance of fruit and forage trees, alley cropping and live fences. *(Figure 11-9)*

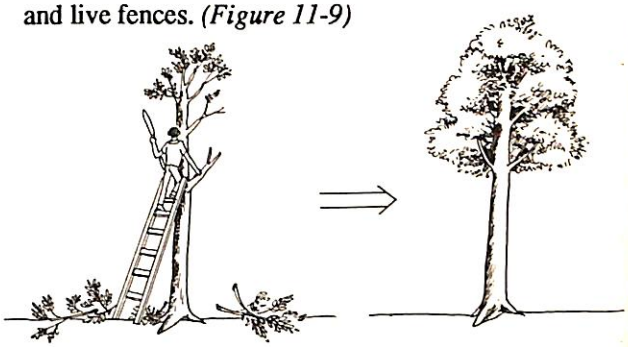


Figure 11-9: Pruning

CHAPTER 12

SOIL CONSERVATION

1. INTRODUCTION

Soil erosion can be defined as the detachment and transportation of soil particles by water and wind. The present topography and distribution of soil are the results of erosion and sedimentation process over millions of years. In natural condition, while most of lands are covered with good vegetation protecting the soil, erosion is a slow process and thus needs less attention. However, through the process of developing human civilization, man's activities have messed around the natural vegetation and soil erosion has been accelerated.

2. CAUSES OF SOIL EROSION

(1) Removal of Vegetation - If the vegetation is removed or burnt prior to cultivation or some other purpose, the surface soil can be easily washed away by rain and taken by wind.

(2) Overcut of Trees - Overcutting trees and shrubs for firewood/charcoal or other purpose also causes the same disaster mentioned above.

(3) Bad farm management - Improper farm management like continuous cropping (cultivate a crop without fallow or crop rotation) and insufficient manuring causes degradation of soil fertility and structure. Once the soil structure has degraded, the soil can not hold the water and then easily eroded.

(4) Overgrazing - Overgrazing makes bare patches in the vegetation cover on the ground, compacts the soil through trampling by hooves and replaces the good grass species by poor ones.
Also gullies often develop along the livestock tracks.

(5) Cultivation and Overgrazing on Riverbanks - Once the vegetation is lost on riverbanks through the cultivation or grazing, there is nothing to prevent erosion or encroachment by rivers.

3. TREES IN SOIL CONSERVATION

Trees are important or rather indispensable in soil conservation and in the rehabilitation of eroded areas. They help to maintain a favourable micro-climate, prevent the erosion by wind and water and improve both structure and fertility of soil.

3.1 The function of Trees in Soil Conservation

(1) Canopies and litters catch the raindrops or reduce their force to strike the soil surface. Water once caught will be released slowly.

(2) Stems and litters on the ground interrupt water flows, slow down the speed and trap the soil particles taken by water.

(3) Litters once decayed, improve the soil fertility and structure and the infiltration rates into soil becomes higher.

(4) Roots of trees hold the soil particles firmly and particles are not easily detached. Roots can also improve the soil structure physically.

(5) Trees planted in rows can slow down the wind speed to prevent erosion and high evaporation.

3.2 Where Trees to be Planted

(1) On the parts of farms not suitable for crop production, for watershed and as a source of poles, firewood, etc

(2) In and around the eroded lands and gullies for rehabilitation.

(3) On riverbanks to prevent erosion.

(4) Along cut-off drains, ridges and terraces to stabilize the structure.

(5) Along the contour lines to slow the water flow on the slopes (contour strips).

(6) Windward of the farms, houses etc. to prevent the wind erosion (windbreaks).

4. SOIL CONSERVATION TECHNIQUES

The soil conservation approach can be taken in two ways. One is the biological/cultural measures including farm management techniques and another is physical measures like terraces, usually combined with biological measures.

4.1 Good Farm Management

Good farm management can improve the soil fertility and structure, and then, especially on gentle slopes, can prevent the soil erosion more effectively comparing with the physical measures which are much more costly. However, in heavily eroded areas or where there is danger, physical measures should be introduced.

1) Mulching: Use of the dead plant residues or the tree leaves as the cover over the farm soil surface. The mulch covering the ground decreases rain drop erosion, slows down the water flows and also encourages insects and worms to make holes into the ground thus permeability of the soil increases. Through the process of decaying, fertility and structure of the soil will also be improved.

(2) Crop Rotation and Fallow: A crop like maize should be rotated with green manure crop (legumes like peas, which can fix nitrogen), or farms should be rested for a few years as fallow and let the grasses grow to recover the fertility and good structure of the soil.

(3) Contour Farming: Plant the crop in lines along the contours (across the slope). On gentle slopes, this may be sufficient to slow down the surface run-off.

(4) Mixed Cropping: Planting of different crops e.g. maize and pigeon peas as traditionally practised. This farming method can reduce the erosion and degradation of the soil.

(5) Agroforestry: Producing system whereby crops are integrated with trees. Some soil conservation measures are often combined with this system (see Chapter 11).

(6) Pasture Land Management: As already mentioned overgrazing causes erosion. To prevent it, livestock should be limited within a certain number which does not destroy the vegetation, or, pasture should be rotated to let the vegetation recover.

4.2 Contour Strips and Grass Strips

Living shrubs or trees are planted in rows along the contour usually in combination with grasses.
Properly maintained strips can effectively control surface runoff, and reduce the soil losses.
(Figure 12-1)

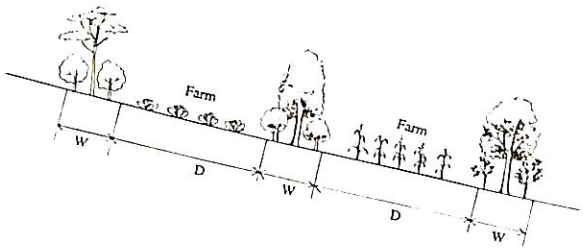


Figure 12-1 : Contour strips

Distance between contour strips (D) and width of the vegetation band in the strip (W) depend on the degree of slope and annual precipitation. In the areas with 600 - 1,000 mm annual precipitation and 5 - 10° slope, D is about 40 - 45 m and W is about 5 m.
Strips of grasses along the contour lines may be used only on gentle slopes. Trash line is a row of trash or farm waste laid along the contour. This is a technique also on gentle slopes and usually combined with grass planting.

4.3 Cut-off Drains (fanya chini)

To avoid surface run-off that carries the soil away and develops the gullies, cut-off drain (COD) has been commonly used. COD is a channel which traps the surface run-off and leads it away to watercourse to discharge. Watercourse is a way of water which takes water collected from CODs straight down the slope. Artificial waterway and natural stream are used as the watercourse, both of them must be well protected

with grass cover or check dams, if necessary, not to cause any erosion. *(Figure 12-2)*

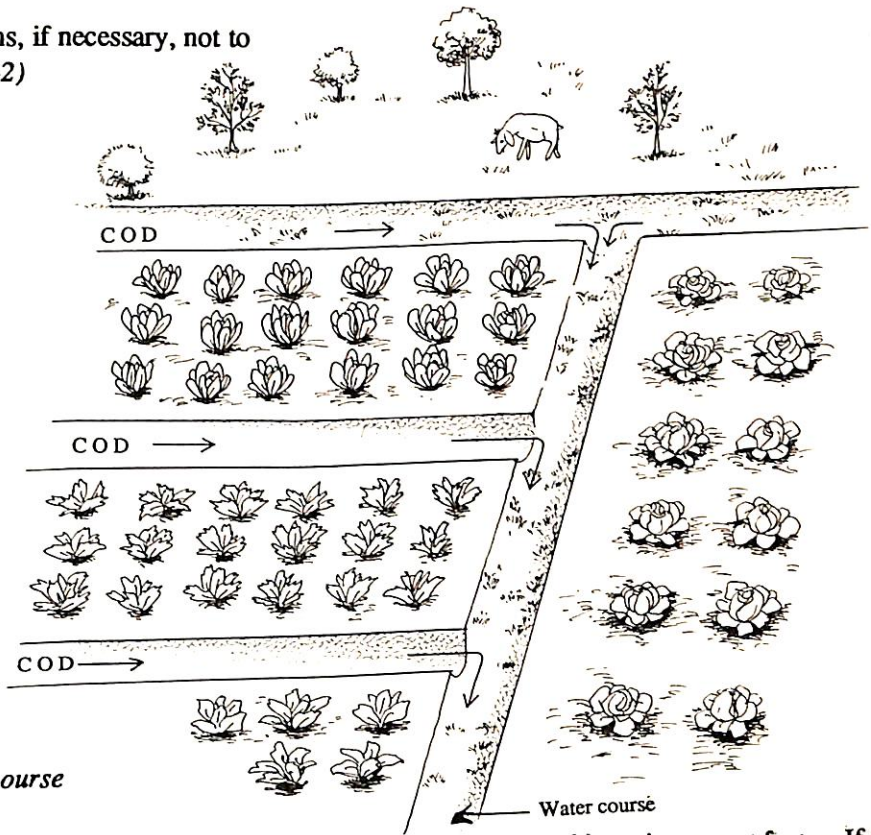


Figure 12-2 : COD and watercourse

CODs are constructed where there is surface run-off, e.g. below a road, below a homestead in slope, a farm below a hill or grazing land, and above a cultivated land. Where there is high precipitation, CODs are also built within the cultivated lands. In Kenya, COD is usually 3 - 4 feet width and 2 - 3 feet depth. Maximum length is 250 m on sandy soil and 400 m on clay soils respectively. *(Figure 12-3)*

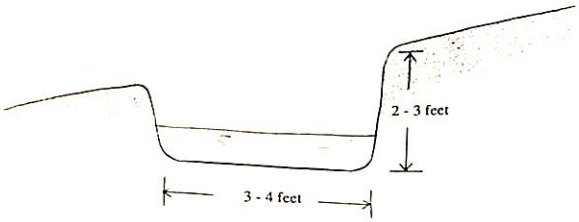


Figure 12-3 : Size of COD

The gradient of a channel is an important factor. If it is too steep it will scour the bed, if too flat it will flow and silt.

4.4 Retention Ditches: Retention ditches are also fanya chini but to hold the water while cut-off drains are to discharge the water. Retention ditches are dug along the contour lines and water caught is going to infiltrate into the soil. This technique is recommendable especially in dry area. *(Figure 12-4)*

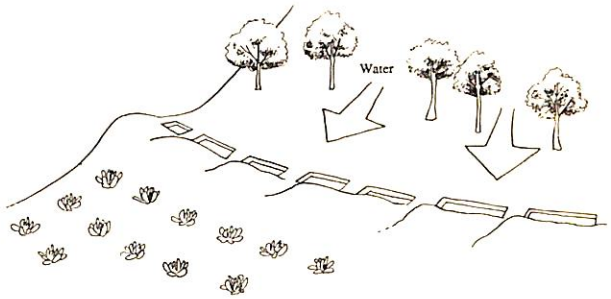


Figure 12-4 : Retention ditches

4.5 Terraces (fanya juu): Terraces are constructed along the contour lines to minimise the surface run-off. A bench terrace is a combination of horizontal or nearly horizontal ledges, vertical or almost vertical walls and often channels, to convert a steep slope into a series of steps .*(Figure 12-5)*

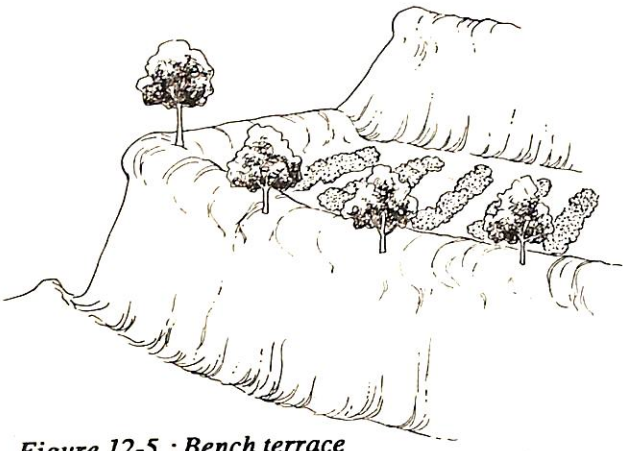


Figure 12-5 : Bench terrace

hold up the vertical face some structural wall, usually of stone, is necessary. In very stable soils the walls may be held only by grasses. Trees are also planted along the hedge of ledges and sometimes in channels. *(Figure 12-6) and (Figure 12-7)*

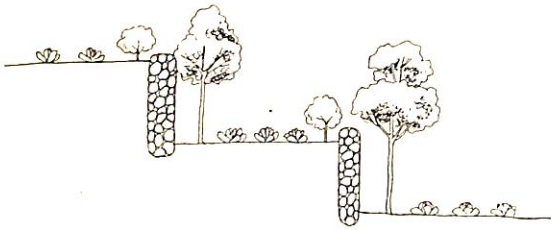


Figure 12-6 : Rock wall terrace

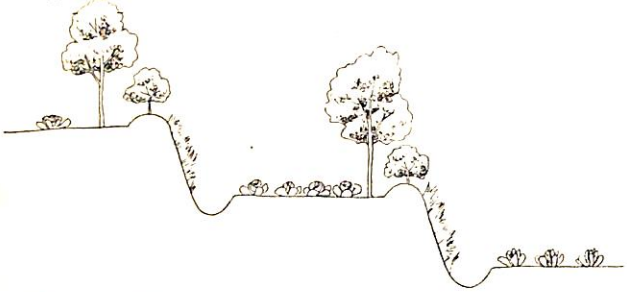


Figure 12-7 : Grass wall terrace

"Fanya juu" terraces are the ridges made by digging a channel (60 cm wide and 60 - 90 cm deep) and throwing the soil uphill. Grass should be planted on the ridge to protect it. The channel is filled up mainly through cultivation and by deposits, but part of it should be maintained as a drain for water passing through the grass strip during heavy storm. *(Figure 12-8)*

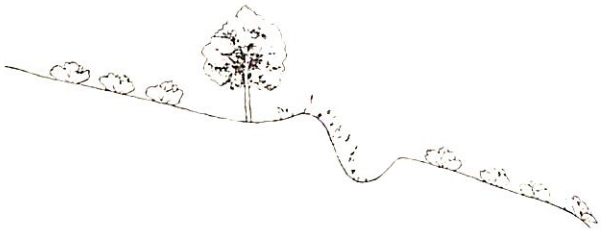


Figure 12-8 : Self-help terrace

Width of the terrace and height of the wall depend on the steepness of the slope (maximum is 25° when built by hand) and depth of the soil. A greater depth of soil and a gentle slope allow the wider terraces.
When bench terraces are used for cultivated crops it is desirable for each bench to be as wide as possible. When cultivation is not required, as for fruit trees, smaller terraces will need less earthmoving and be equally effective.

4.6 Contour Ridges: This method involves the construction of ridges, using rock or tamped earth walls along contour lines. The ridges prevent soil erosion as well as increase infiltration of moisture into soil. Trees, shrubs and grasses are usually planted on the ridges to stabilize the structure. After heavy rains, a channel of water breaks through the ridges occasionally. These breaks must be repaired promptly

to prevent gully formation. *(Figure 12-9)*

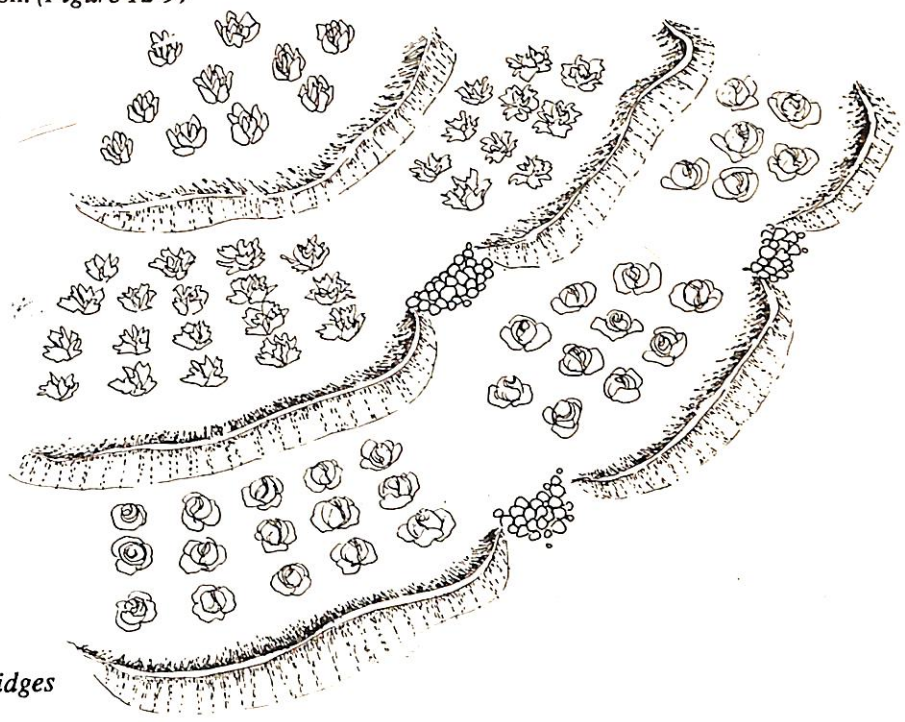


Figure 12-9 : Contour ridges

4.7 Tied Ridges: Tied ridges consist of closely spaced ridges in two directions at right angles so that the ground is formed into a series of rectangular depressions. All the rainwater is held until it infiltrates into soil so that there is no surface run-off and no erosion.

However, if an exceptional storm comes, the water overflows and the ridges will break. On the slope, this can cause worse erosion when the water overflowed concentrates into a flow. It is, therefore, recommended that a back-up system, e.g. cut-off drains, should be combined. Tied ridges are only recommendable on the place where the soil is deep and permeable, and the slope is gentle or rather flat. *(Figure 12-10)*

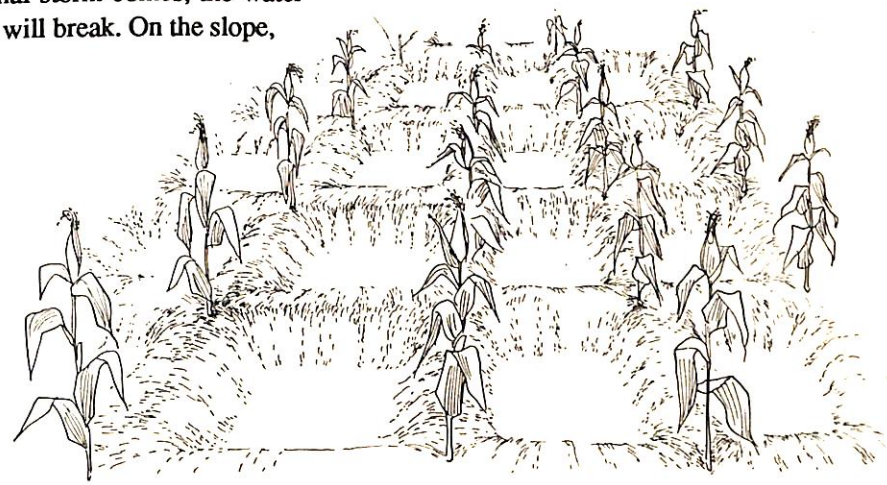


Figure 12-10 : Tied ridges on maize land

4.8 Gully Control: Gullies cause serious problems, because they occur on slopes. Gully erosion is difficult to reverse once it has started, and it can quickly destroy valuable agriculture lands. To prevent the formation of gullies along waterways, line the banks with trees and shrubs. Trees, shrubs and grasses established within the gullies can control further erosion and rebuild the soil layers once destroyed. To control already developed gullies or on steep slopes, structural gully control methods like check dams and gabions may be needed combining with vegetation rehabilitation. *Figure 12-11*

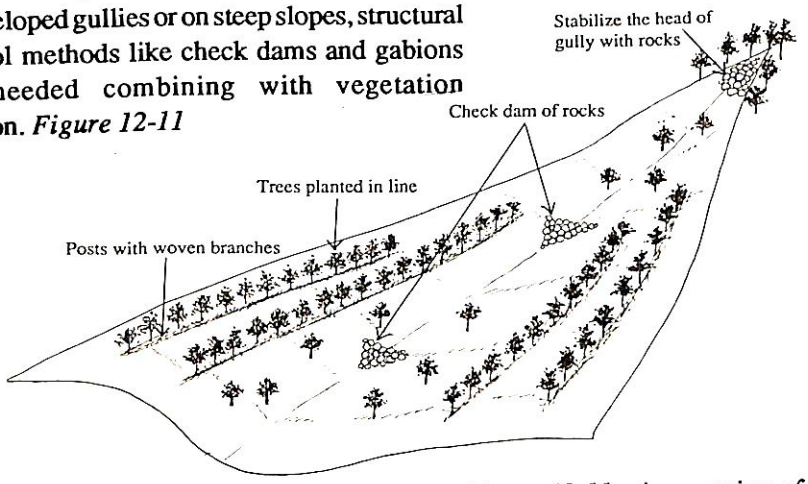


Figure 12-11 : An overview of gully control system

Some examples of structural gully control methods (check dams) which can be readily constructed are given below: (*Figure 12-12*)

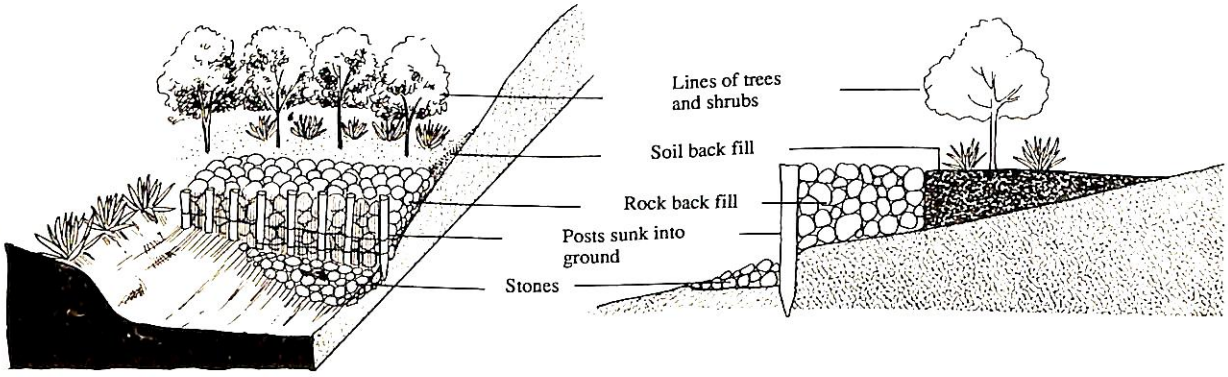


Figure 12-12 : Live check dam

Check dam made of wooden poles sunk into the gully bed in two lines 45-60cm apart the space is filled in with brush wood, and secured with galvanished wire. *(Figure 12-13)*

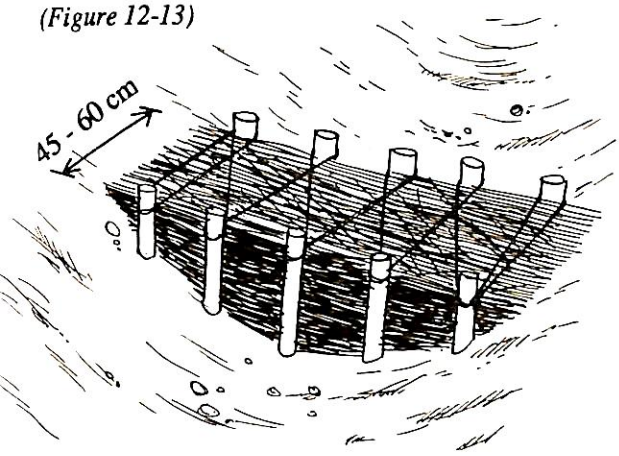


Figure 12-13: Wood check dam

Check dams made of stone must not reach to the top of the gully. Stones should be carefully laid, and in-filled with earth sods. Excavate base in gully floor, and fill with smaller stones. *(Figure 12-14)*

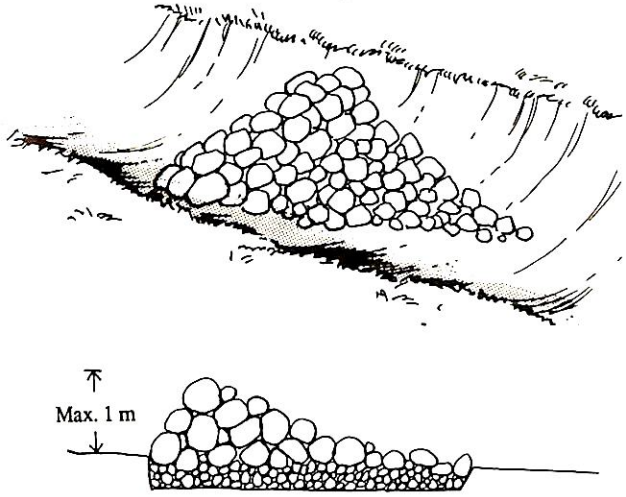


Figure 12-14: Stone check dam

4.9 Windbreaks: Windbreaks and shelter belts are strips of trees and other vegetation that slow the flow of the wind, reducing wind erosion, evaporation and wind damage to crops. Windbreaks have an especially high potential in farming areas where cereal crops are grown. The wind break trees, if properly harvested, can also provide significant quantities of firewood, poles and fodder without jeopardizing their primary function.

The effectiveness of a windbreak depends on how efficiently the wall of vegetation blocks the wind and confines the wind's turbulence to the areas close to the windbreak. A barrier dense enough to block wind passage completely will cause turbulence close to the ground loosening soil particles that can then be picked up by the wind. As well as removing needed top soil, wind that is carrying soil particles causes abrasive damage to crops. *(Figure 12-15)*

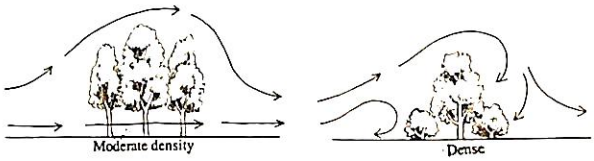


Figure 12-15 : Density of windbreak and wind turbulence

Gaps or opening in the windbreak should be avoided as much as possible. Wind is funneled through gaps in the tree rows, concentrating its force and speed so that the final effect can be very damaging. Any path through the windbreak should be at an oblique angle rather than perpendicular to the tree rows. *(Figure 12-16)*

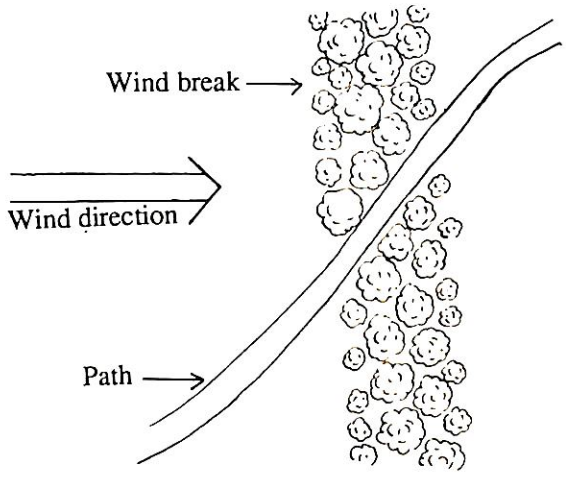


Figure 12-16 : A path through windbreak

Windbreaks can furnish protection for downwind areas up to 10 times the height of the trees. The most efficient windbreaks are those with one or two rows of low-growing shrubs or trees on the outside and two or three rows of taller trees on the inside. Large fast-growing trees (like *Eucalyptus* spp.) should be chosen for row A below. Row B should be composed of shorter species, chosen if possible for their by-products, e.g. *Azadirachta indica* (Neem), *Tamarindus indica* (Mkwaju, Muthmula), *Acacia senegal* (Mung'ole, Kikwata), etc., and rows C and D are auxiliary rows. These are planted with lower, bushier trees, shrubs (e.g. *Bauhinia* spp.), and grasses. The utility of the wider shelterbelts can be enhanced by the selection of multiple use species for the middle rows expecting the secondary products and use. *(Figure 12-17)*

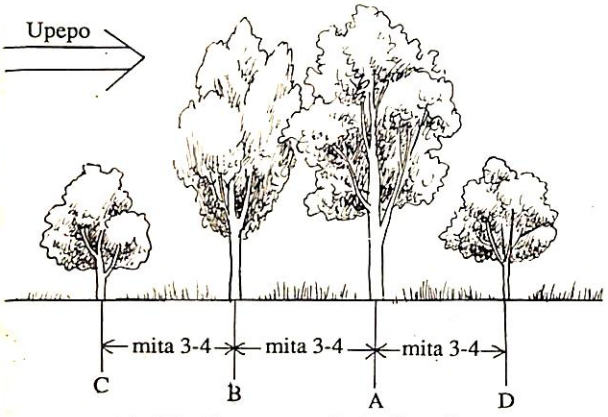


Figure 12-17 : Structure of windbreak

Where complex land ownership patterns exist, it may not be possible to establish continuous straight tree rows across individual fields and parcels. In this case windbreaks may be staggered so that they conform with established boundaries such as borders of fields, roads, trails, streams, and other natural or man-made features. Staggered windbreaks can also provide the most effective protection around towns and villages, where they are laid out in a pattern of overlapping blocks. *(Figure 12-18)*

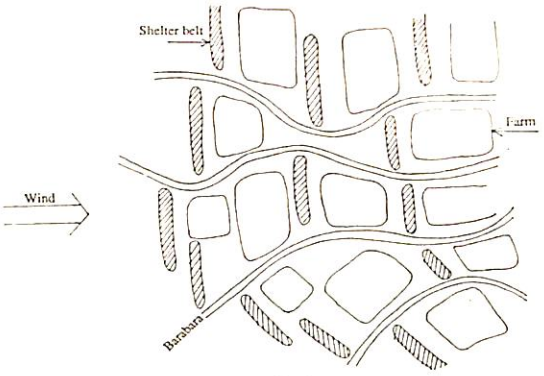


Figure 12-18 : Shelterbelts

4.10 River Banks and Water Ways Protection: Bushes and tall grasses reduce the velocity of water over flooded ground. Trees can hold the soil and rocks on river banks with their roots. However, along small water courses strips of grasses on both sides give better protection against erosion than the trunks and roots of the trees. *(Figure 12-19)*

Figure 12-19 : Vegetation establishment along waterways

Bush-wood dam is a temporary control structure. Small branches up to two or three centimetre in diametre are woven or tying down with wire to the vertical posts. Both branches and posts may be from species that can be propagated from cuttings (e.g. Commiphora spp.). This techniques can also be used

for gully control. *(Figure 12-20)*

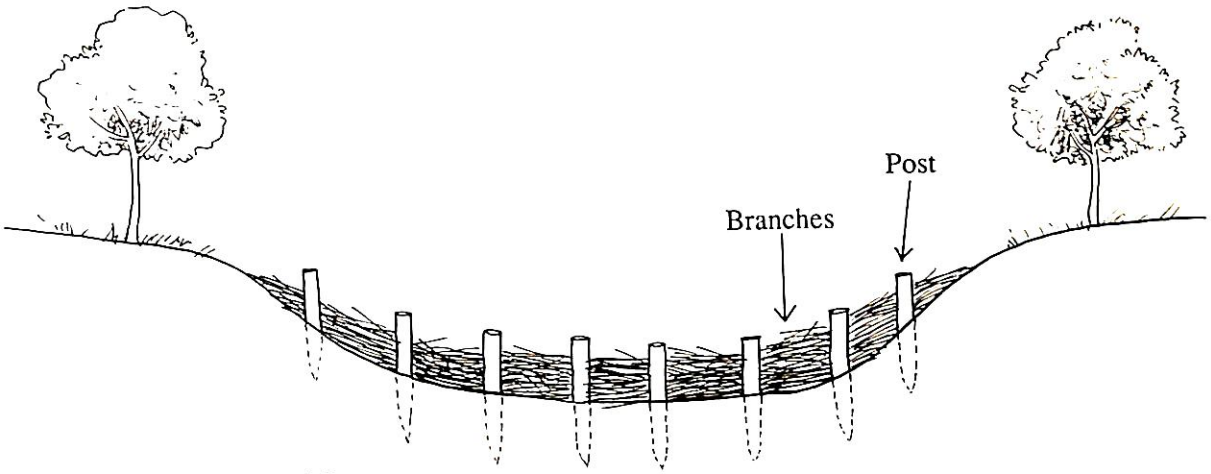


Figure 12-20 : Bush-wood dam

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Kenya/Japan Social Forestry Training Project

How the Project helps Kenyans to a better life

ORIGINS

Sowing the Social Forestry seed 1985 - 1987

Kenya Government and Japanese Government get together to start a Social Forestry Training Project to train more Kenyans to plant more trees and enjoy a higher standard of living. Two Social Forestry Centres are set up and training courses are worked out. A Pilot Forest Scheme is started.

AIMS

The Project aims to

1. Promote self-help tree planting activities at grass-roots' level.
2. Develop social forestry training at national and regional levels.

ACTIVITIES

The project offers...

1 Training in social forestry to plant more trees for the community, e.g. providing the latest information on social forestry, advanced extension techniques, practical skills and knowledge for tree planting.

2 Establishing and managing a Pilot Forest Scheme as a demonstration in the semi-arid area of Kenya.

ORGANISATION

Muguga National Centre offers

Four training courses at national level for participants from all over Kenya:

1 Refresher Course I for highest ranking forestry officers.

2 Refresher Course II for other forestry officers.

3 Workshop on extension techniques for extension officers

4 Seminars for foresters and non-foresters.

Pilot Forest Scheme involves

1 Trial planting for selecting and growing the right trees.

2 Helping voluntary group planting.

3 Providing seedlings and technical guidance for the surrounding area.

Kitui Regional Centre for semi - arid areas of the Eastern Province offers

Two training courses for:

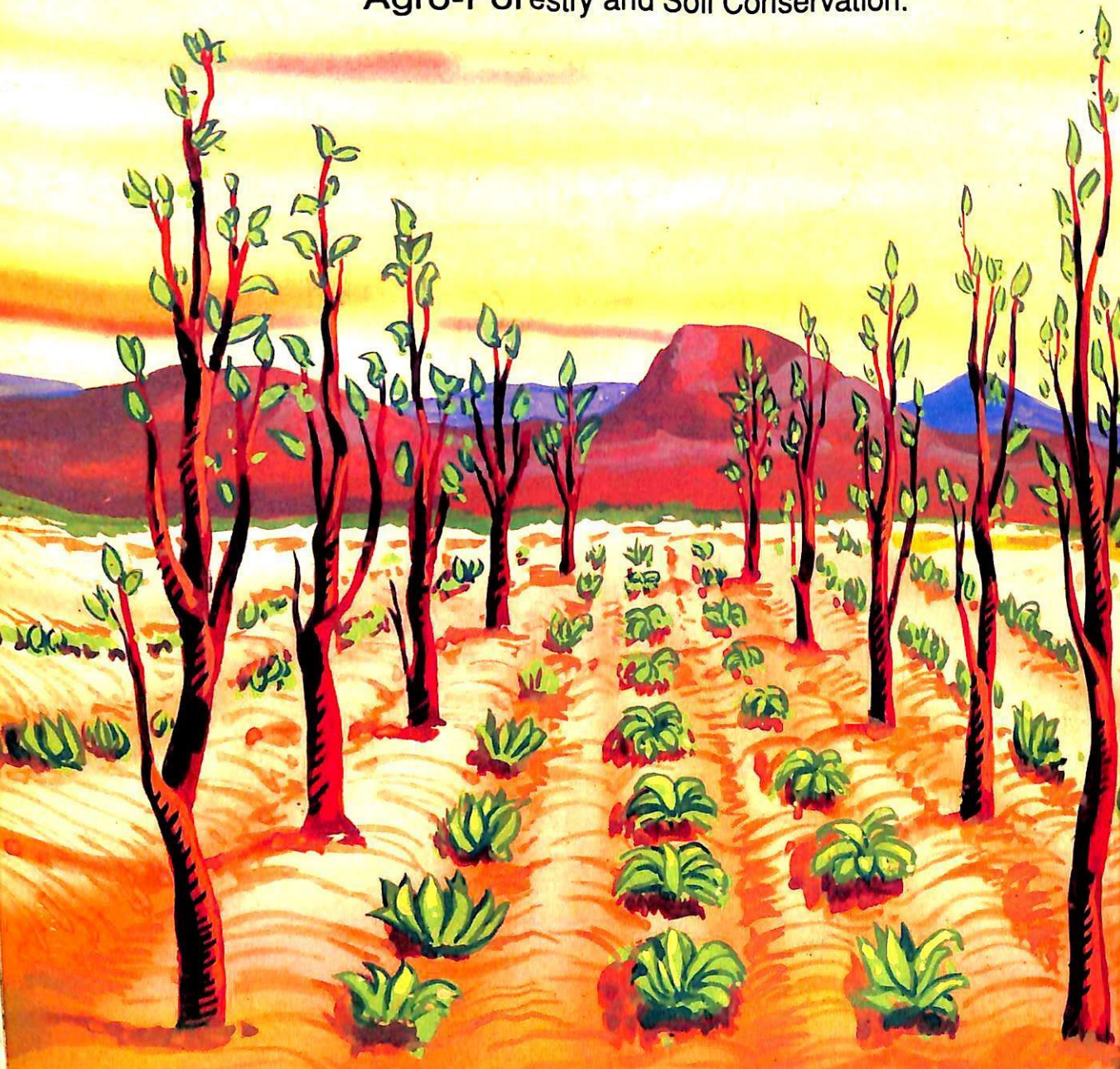
1 Extension Workers

2 Leaders of women's groups, farmers and other community leaders.

Project Headquarters and Muguga National Social Forestry Training Centre
c/o KEFRI, P.O. Box 20412, Nairobi, Kenya Tel: 0154-32891/2.
Kitui Regional Social Forestry Training Centre and Pilot Forest Liaison Office
P.O. Box 892, Kitui, Kenya Tel: 0141-22626.
Kenya Forestry Research Institute
P.O. Box 20412, Nairobi, Kenya Tel: 0154-32891/2.
Japan International Cooperation Agency, Kenya Office
P.O. Box 50572, Nairobi, Kenya Tel: 724121/2/3/4.

Raising a Forest

This practical textbook covers the basic aspects of Social Forestry from Seed Collection, Starting and Managing a Nursery, Planting and tending, Grafting and budding, Agro-Forestry and Soil Conservation.



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