Agroforestry Extension Manual for Eastern Zambia

RELMA Technical Handbook No. 17

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REPUBLIC  OF ZAMBIA

Department of Agriculture
Ministry of Agriculture, Food and Fisheries

Agroforestry Extension Manual for Eastern Zambia

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Nairobi

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This book is a revised and updated version of the *Agroforestry Manual for Extension Workers with Emphasis on Small-Scale Farmers in Eastern Province, Zambia* by Samuel Simute, first published by RELMA (then RSCU) in 1992.

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Contents

Foreword

The first edition of this manual was published in 1992 by the then Regional Soil Conservation Unit (RSCU), Nairobi.

However, many developments have taken place since then. In many cases these developments have brought new knowledge and experience in agroforestry technologies which must be taken into account for the benefit of the farmer, especially small-scale farmers in Eastern Province. The importance of this knowledge and experience cannot be over-emphasized. Agroforestry technologies are dynamic and constantly changing and it is therefore imperative that these experiences are shared in order to enhance our understanding and use of these technologies.

This is the main reason that a revised version of this manual has been produced. I believe that it will continue to benefit all concerned and that it will provide the keen researcher with a springboard for further research.

I wish to pay tribute to Bo Tengnäs for spearheading the production of the manual and to take this opportunity to thank RELMA and Sida for providing the necessary financial support. I would also like to thank all those who have contributed in other ways to the final product.

Lastly, I wish to sincerely thank Samuel Simute, the main author, for a job well done.

P. C. Manda
Acting Deputy Chief Conservator of Forests
Head of the Technical Committee

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First and foremost, we wish to express our gratitude to the farmers of Eastern Province for sharing their valuable knowledge on tree species and their farming practices with us. It would have been difficult to prepare this manual without their input.

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Mr Christopher Chimfwembe, the Provincial Agricultural Co-ordinator for Eastern Province, Zambia, contributed to Chapter 5 on Experiences in Agricultural and Forestry Extension.

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Mr Saiton Gondwe, retired Forest Officer, provided Senga names, while Mr George Zimba of National Parks and Wildlife Services helped with Kunda names of the tree and shrub species.

Many of the illustrations in Part I were taken from *Agroforestry Extension Training Source Book* by Louise E. Buck, and from *Agroforestry in Dryland Africa* by D. Rocheleau, F. Weber and A. Field-Juma. Most illustrations of the plants described in the species Fact Sheets in Part II are taken from the other manuals in RELMA's Technical Handbook series (where sources or artists are indicated), but Ann Birnie drew new ones for *Kirkia acuminata, Hyphaene petersiana* and *Uapaca nitida* for this volume.

We are very grateful to Mrs Yasmin Kalyan for typing services and to Mrs Caroline Agola for editing and typesetting the final book.

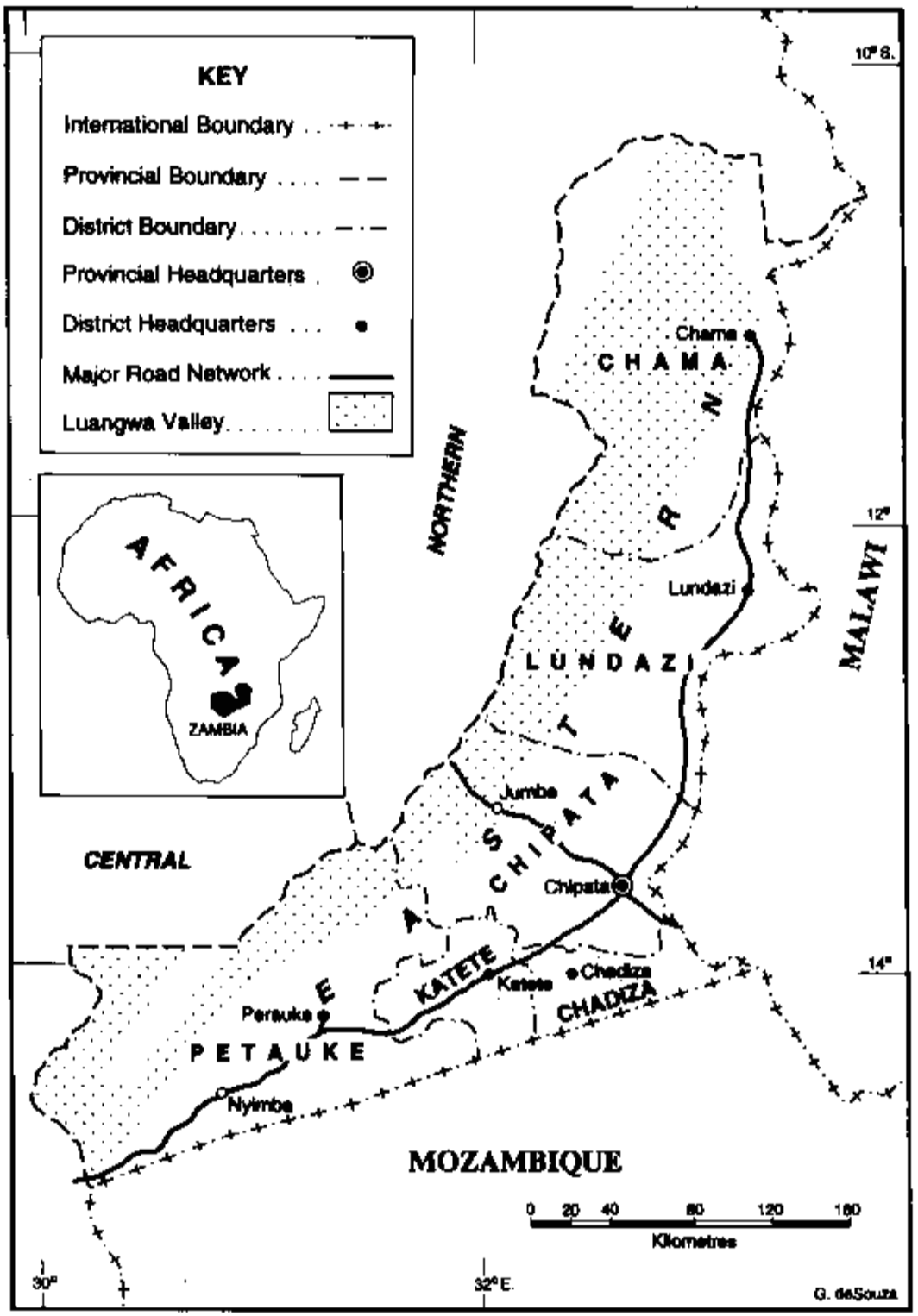
We thank the Chief Conservator of Forests and the Director of Agriculture for their support.

We are aware that no publication of this nature can be correct in every detail; therefore, we take responsibility for any errors or omissions.

S. Simute
C. L. Phiri
Bo Tengnäs

Part I

Agroforestry



Map 1. The Eastern Province of Zambia

1

INTRODUCTION

Agroforestry is a form of natural-resource management that plays a key role in a wide range of situations from providing important income-generating tree products and crops for land users in areas with developed markets to reclaiming degraded lands.

According to the definition currently used by ICRAF, agroforestry "refers to a dynamic, ecologically based, natural resources management system that, through the integration of trees in farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels" (ICRAF 1996).

Two missionaries, Danforth and Noren (1994), suggested another definition of agroforestry: "Agroforestry is an ancient farming system established by God when he created the Garden of Eden (Genesis 1 and 2). In Eden, God had every kind of plant and animal in association with trees for the benefit of people's survival and pleasure."

Figure 1.1 Agroforestry may sometimes have different meanings for different people

1.1 The need for agroforestry in Eastern Zambia

Much deforestation has occurred in the last 40 years. This has been due to the rapid population increase which has not been coupled with parallel economic and technological development. The following activities have contributed to deforestation:

- Clearing forests for agriculture and settlement
- Cutting of trees for charcoal production

- Collection of firewood for domestic as well as commercial purposes
- Late burning of forests
- Overgrazing by livestock in some areas, e.g. Kagoro, Chief Kawaza's area, Chief Saili's area.

Some of the consequences of these activities are:

- Shortage of construction poles and timber
- Fuelwood problems in some areas
- Shortage of fodder during the dry season
- Silting and flooding of rivers and streams
- Declining soil fertility leading to low crop yields
- Increased soil erosion.

1.2 Benefits of agroforestry

Some of the main benefits of agroforestry are:

- Provision of fruits and other food, e.g. honey
- Provision of poles and timber
- Improvement of soil fertility
- Provision of material for traditional medicine
- Provision of fodder
- Provision of fuelwood
- Control of soil erosion
- Stabilization of stream and river banks.

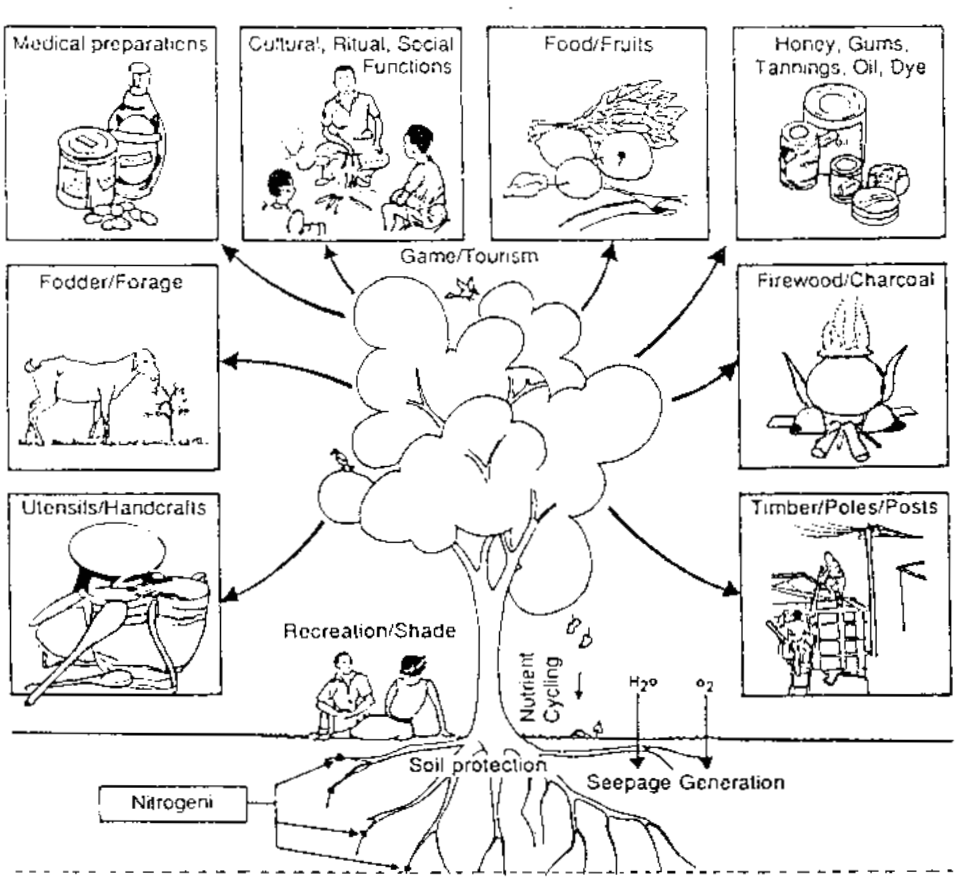


Figure 1.2 Benefits of agroforestry

Fruits and other food

Fruits are important in the diet even in small quantities since they are rich in vitamins and minerals. Fruits are a seasonal food supply and are often eaten as snack food or to provide tasty "additions" to the staple foods, increasing appetite and thus general food intake. Wild leaves, either fresh or dried, still frequently accompany staple grain dishes. Some leaves have a high protein content. Seeds and nuts are also used in side dishes and sauces. Roots and tubers provide energy, carbohydrates and minerals. They are especially valuable as dry-season and famine-period foods. Although some may be eaten raw as snacks, others require complicated processing and these are only used in times of food scarcity. All these types of food provide essential elements in the human diet.

Among the important food-producing trees in Eastern Province are *Hibiscus* (leaves), *Cordyla africana* (fruit, seeds are cooked), *Tamarindus indica* (fruit), *Moringa oleifera* (leaves and flowers) and cashew nut (fruit, nuts are roasted). Increased cultivation or protection of such species and use in agroforestry systems would ensure continued good access to food and many other producs.

Poles and timber

There are many pit-sawyers in the Province who mainly exploit *Pterocarpus angolensis* (Mlombe), *Pericopsis angolensis* (Muwanga), and *Afzelia quanzensis* (Mpapa, Mupapa). The pit-sawyers are mainly concentrated in Mambwe sub-boma and Petauke District. A number of carpentry workshops have been established in towns throughout the Province and construction is a major consumer of timber and poles. The Minga Timber Company is the major private company involved in the exploitation of forestry resources in the Province, mainly using indigenous trees.

Soil fertility

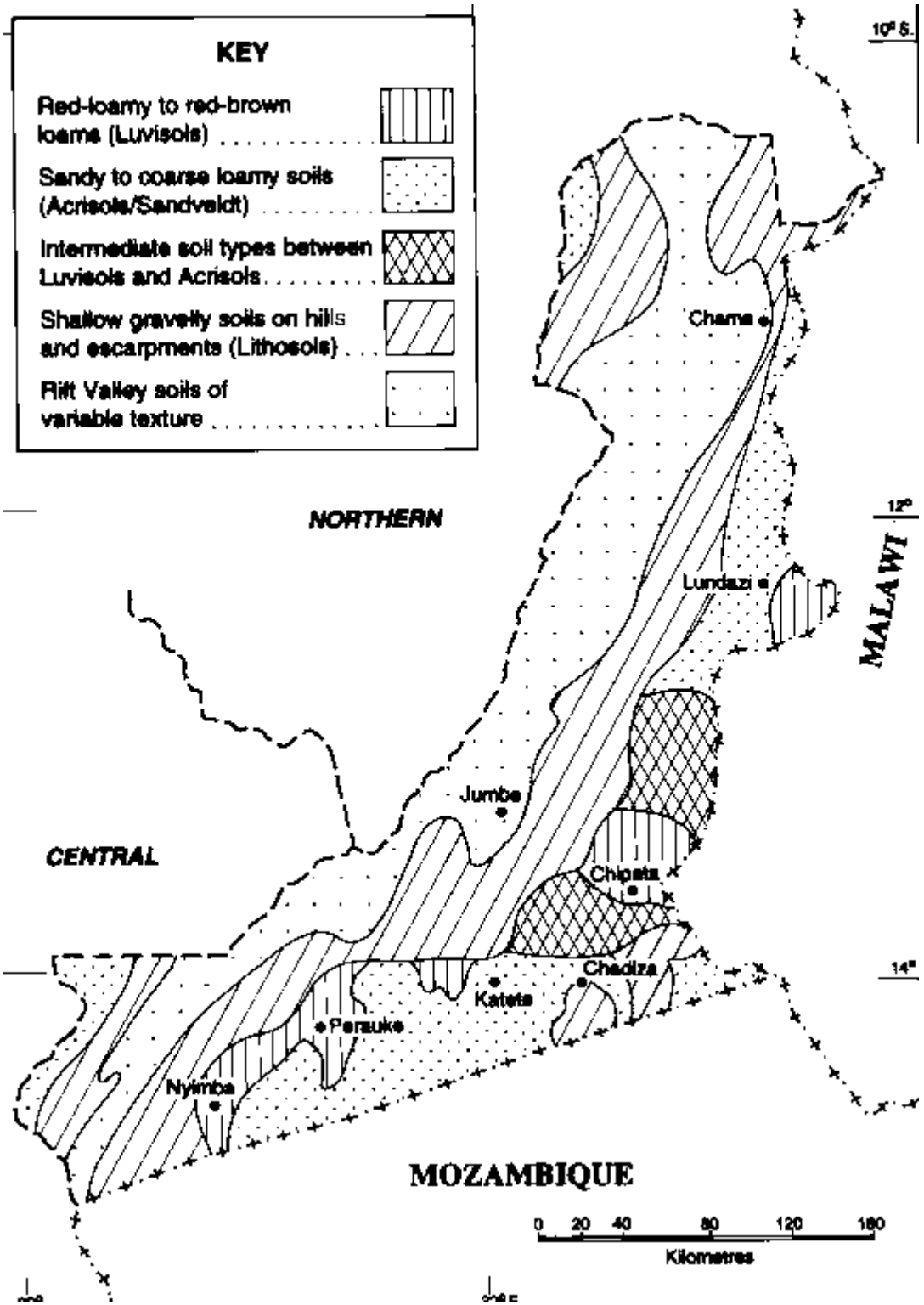
Apart from providing various products, trees also have service functions. Many species have the ability to fix nitrogen from the atmosphere and can play an important part in sustaining or improving soil fertility. This is becoming increasingly important as fallow periods become shorter, and larger and larger areas are devoted to agriculture.

Research results from Msekera in Eastern Province have confirmed that soil fertility can be improved by trees, an opinion that is also widespread among farmers. Researchers have systematically been working on development of agroforestry technologies for soil-fertility improvement, e.g. improved fallows with *Sesbania sesban*.

Fuelwood

The main source of domestic fuel is firewood, and demand increases as the population increases. Charcoal production is a commercial activity and demand is also rising rapidly. The National Breweries in Chipata is a major user of fuelwood, and so are education institutions and hotels and restaurants scattered throughout the Province.

Increased efforts at tree growing near settlements would, in the long run, reduce this pressure on woodlands and forests.



Map 2. The major soil types of Eastern Zambia

1.3 Profile of Eastern Province

Location

The Province lies between latitudes 10° and 15° S and longitudes 30° and 33° E and has a land area of approximately 69,000 km^2. It is bordered by Lusaka Province to the south-west and Central and Northern Provinces to the west, and has international boundaries with Malawi to the east and Mozambique to the south (see Map 1).

Topography

The landscape is generally one of gentle to moderate slopes. There are two distinct zones, namely:

- The plateau which lies at an altitude of 900–1,200 m above sea level. The lower parts of the plateau (dambos) have a reliable supply of water even during the dry season. They become flooded during the rainy season
- The Luangwa Valley is 300–600 m above sea level.

Climate

There are three distinct seasons: the warm rainy season from November to April, the cool dry season from May to August, and the hot dry season from September to October. Annual rainfall ranges from 800 to 1,000 mm. Approximately 85% of this rainfall falls during the four wettest months, i.e. December to March. In the valley areas, the rainy season tends to begin and end earlier than elsewhere.

The mean temperatures vary between 15° and 18°C during the coldest months (June and July) whilst the hottest months have a mean temperature of between 21° and 26°C (September and October).

Soils

The arable soils of the Eastern Province fall into three main categories (see Map 2):

- Yellowish sandy soils (Sandveldt or Acrisols), which are the most common in the Province. These soils are light and easy to till but are low in nutrients and water-holding capacity. They tend to form a hard pan at certain depths.
- Red clays or red brown loams (Luvisols) found near Chipata (within 50 km), between Petauke and Nyimba, and in smaller areas near Seya and Vulamukuko in Katete District. These soils are heavy, difficult to till by hand, but rich in nutrients and have a good water-holding capacity.
- Valley sedimentary soils, a complex of pale sands, grey-brown alluvual soils and dark grey clays, found in the Luangwa Valley. These soils have developed through deposition of soil by the rivers. They are often poorly drained and in the valley/escarpment zone only about 3% of the land area, mostly bordering tributary streams, is suitable for upland crops. A further 2% may be suitable for swamp rice production, taking the Lupande Game Management Area as an example.

Another type of soil that occurs in the Province is the shallow gravel (Lithosol) that is found on hills and in the escarpment zone between the Luangwa Valley and the plateau areas. These soils are not suitable for cultivation.

Nitrogen is deficient throughout the Province. On the poorer sandy soils good yields of maize cannot be obtained without nitrogenous fertilizers. With good management, a profitable response by hybrid maize can be expected with an application of 100–120 kg nitrogen per hectare on most soils.

Severe sulphur deficiency occurs in parts of the Eastern Province on the sands and the heavier soils, on the plateau and in the valleys (Jumbe, Chama). However, even the most severe deficiency can be corrected by application of about 20 kg sulphur per hectare. Current compound fertilizers contain about 10 kg sulphur in 100 kg. Application rates over 10 kg per ha give only marginal increases in yield and the use of sulphur should be limited as much as possible since it increases acidity and therefore leads to depletion of other nutrients in the soil.

Phosphate is generally not deficient, nor is potash, although when continuous cropping is practised application of maintenance rates of phosphate and potash is recommended. The Petauke red clays may be deficient in phosphate. In such areas, the use of R compound instead of X on cotton (and maize) may be preferable.

Eucalypts are sensitive to soils which are deficient in boron, nitrogen, phosphorus and potassium. They tend to show stunted growth, chlorosis and severe die-back. Application of NPK and borate fertilizers can improve the growth in such instances.

Soil acidity is measured as pH—the lower the pH the more acid the soil. Groundnuts, soy beans and sunflower all thrive better in soils of pH 4.8 or higher. In most of the Province soils are not very acidic (pH usually in the range of 5.0 to 5.5) but more acidic soils do occur, for example in some sandy areas in Chipata south, Chadiza and Katete Districts.

When pH falls below 4.6, groundnuts are likely to yield many "pops" or empty shells. In this case an economic response can be expected from the application of lime or "L" mixture. The benefits of lime are likely to last for at least three seasons. Some leguminous shrubs, e.g. *Leucaena leucocephala*, do not grow well in acidic soils.

Demography

According to the 1990 population census, there were 973,818 people in Eastern Province, or 12.5% of Zambia's total population. In the same year, it was estimated that 90% of the people of the Province lived in rural areas and depended on subsistence agriculture for their livelihood.

The average population density of 14.1 per km^2 is higher than the national average of 10.4 per km^2. Katete is the most densely populated District in the Province. The Province also has a higher population growth rate (4%) than the rest of the nation (3.2 %).

Table 1.1 Population density by District, 1969, 1980, 1990 (persons per km^2)

District	1969	1980	1990
Chadiza	12.5	17.4	24.7
Chama	1.8	1.8	3.0
Chipata	12.4	17.1	24.5
Katete	20.2	23.6	35.0
Lundazi	6.6	8.2	12.3
Petauke	6.6	9.3	13.4

Vegetation

Much of Eastern Province is covered by woodlands. Different types of woodlands are recognized depending on the species composition:

- Miombo (*Brachystegia*) woodland is the major vegetation type in the Province. This is a two-storeyed woodland with an open and semi-evergreen canopy 10–20 m high. The predominant tree genera are *Brachystegia, Julbernardia* and *Isoberlinia*. The predominant grass species are *Themeda triandra, Hyparrhenia* spp. and *Heteropogon contortus*.

- Munga (*Acacia* spp.) woodland is dominated by acacias, often *A. polyacantha*, which form a park-like woodland with trees scattered or in groups. *Combretum* spp. and *Terminalia* spp. are other trees found in this type of woodland. Munga woodland is usually found on rich clayey soils.
- Mopane *(Colophospermum mopane)* woodland is usually a one-storeyed woodland dominated by that species. *Colophospermum mopane* is, however, also found mixed with miombo and munga woodland at dambo edges.
- Riparian woodland occurs in narrow strips on stream banks and along rivers. The common species are *Syzygium* spp., *Khaya nyasica* and *Trichilia emetica*. Orchids and ferns are common.
- Termitaria (anthill) woodland. Anthills are common in miombo, mopane and munga woodlands, and due to the termite activities certain species thrive there. Such species are *Strychnos* spp., *Diospyros* spp. and *Sterculia* spp.

In addition to the vast woodlands, there are grasslands which occur mainly in dambos and on plains where the water-table is high and where trees are uncommon. Common grasses are *Panicum maximum* and *Echaocloas* spp.

The growing stock of wood in woodlands has been estimated at around 85 m^3 per hectare. Total forest cover in Eastern Province has been estimated at approximately 6 million ha, with a total standing volume of 344 million m^3 (Alajärvi 1996). This figure includes the growing tree stock in Forest Reserves, forests in open areas, in Game Management Areas, National Parks and trees outside forests. Since the woodland areas are extensive, the tree resources in Eastern Province are still substantial. As noted earlier, apart from wood, many other important products can also be obtained from the woodlands, e.g. food, honey, fodder and raw material for medicine. But in order to sustain supplies of tree products in the Province, good management of these woodlands is important.

The total area of forest reserves is approximately 847,297 ha, equivalent to 12.3% of the land area. There is also a substantial area of ungazetted forest in traditional (trust) lands. Some 600 ha of *Eucalyptus* plantation and a smaller area of pines have been established by the Forest Department.

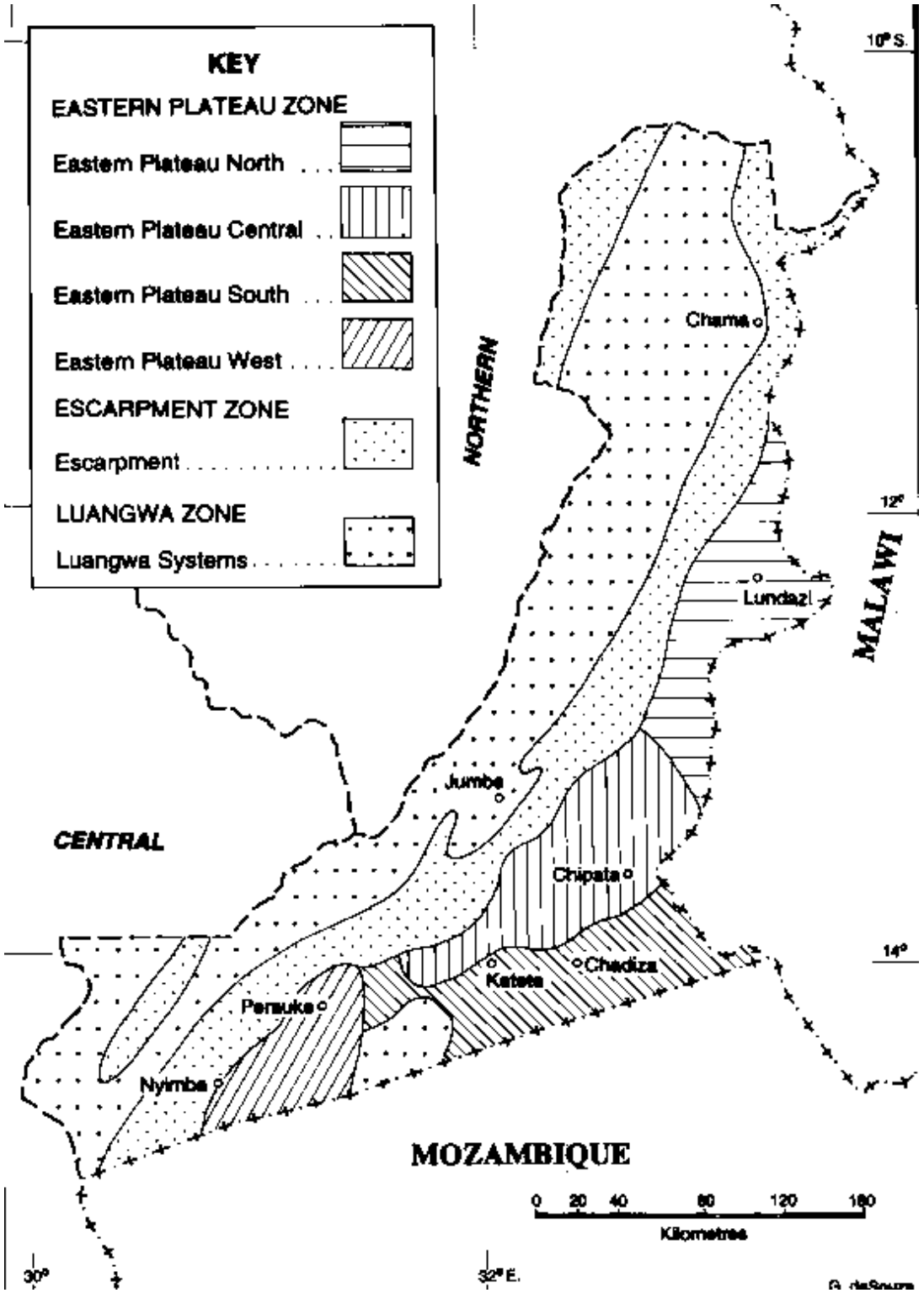
Land tenure

During the colonial era land was divided into two distinct tenure classes: Tribal Trust land and Crown land. What was designated Crown land then is now called State land and Tribal Trust land is now called Traditional land.

Out of the total available land in the Province, 96% is classified as Traditional land. This land may be used or occupied according to customary law without leasing it or having any formal right assigned and it is controlled by Chiefs with their Headmen in charge of villages. Utilization depends on both right and ownership of the community. An individual can, however, acquire a certificate of title depending on how the Chief perceives the request, though normally Chiefs do not accept such requests because they fear it might lead to a loss in popularity among their subjects.

Only 4% of the total land in the Province, about 280,000 hectares, is designated State land. This land is directly under the control of the President of the Republic of Zambia who makes grants and arranges leases of 14–99 years through the Commissioner of Lands. An individual or a group of people can be title holder.

The tenurial arrangements have a bearing on the farming systems in the Province. In many areas tree felling, grazing and overall management of natural resources are regarded as free for all, resulting in over-use and degradation.



Map 3. Agro-ecological zones

Traditional economic activities

Agriculture, hunting (mainly in the Valley), gathering/collecting wild fruits and vegetables and trading, mostly through the barter system, have been the main traditional economic activities of the people of Eastern Province.

Agriculture

The type of soils and vegetation influence the kind of agriculture practised in the Province. Most of the inhabitants practise mixed farming, combining both pastoral and arable activities. Pastoral farmers concentrate on cattle keeping and other smallstock, e.g. goats. Crop production involves growing of staple crops like millet (both bulrush and finger millet), sorghum and maize.

Hunting

Traditionally many societies in the Province were hunters, especially those in the Valley areas (Kunda). This was either to supply meat for their own consumption or for bartering. Hunting became important in the area and it created a society with well-respected specialist hunters. Even though fishing brought in some income and was a source of protein, the occupation was never accorded the same status as hunting. Nowadays hunting is confined to Game Management Areas due to excessive deforestation around villages and open areas, and the number of traditional hunters has declined because hunting in Game Management Areas requires a licence.

Gathering

Products from the miombo woodlands such as roots, tubers, fruits, mushrooms, honey and caterpillars were very important in the past and are still gathered on a small scale. In addition, certain species of trees such as *Albizia* spp., *Brachystegia* spp. and *Pseudolachynostylis maprouneifolia* provided medicines for traditional healing. Nowadays people walk long distances to collect some of these forest products.

Farming systems

Eastern Province is the third most important cattle-rearing area in the country after Southern and Western Provinces. Close to 30% of the farmers in the Province keep cattle but this is mainly on the plateau rather than in the Luangwa Valley because of the prevalence of tsetse fly in the Valley (see Map 3). The amount of cultivated land varies from one area to another: the majority of farm families cultivate 2 ha. Ox-cultivation is practised by some 50% and the other 50% use hoe.

There are three major farming systems found in Eastern Province:

- **Hand-hoe cultivation:** In this farming system the area under cultivation is usually small (i.e. 1–2 ha). Some hoe cultivators, however, are able to hire oxen for cultivation from their friends/relatives when resources permit. This kind of farming system is prevalent in the traditional land that is controlled by the Chiefs and their Headmen.
- **Valley hand-hoe cultivation**: This system is practised in the Luangwa Valley where there are no work oxen because of the presence of the tsetse flies. In this system, millet, sorghum and groundnuts are the main crops with cotton being grown as a cash crop. Rice is also important both as a food and cash crop. A very limited amount of land is cultivated by each family unless tractors are hired. The growing season ranges from 125 to 140 days and the average annual rainfall ranges from 700 to 900 mm. The conditions are such that weeds grow faster than the crops and a farmer has to weed his field many times before the crop reaches maturity. Soils are alluvial, medium to heavy textured and fairly fertile.

- **Ox-cultivation:** On the plateau many families have cleared fairly large tracts of land for crop production (5 ha or more per family). Oxen are used to cultivate the land and the crops generally grown under this system are maize, groundnuts, cotton, sunflower, tobacco and soya beans. The growing season ranges from 125 to 145 days with an annual rainfall of 800–1,000 mm. Soils are well to moderately drained sands and sandy loams of medium acidity. This system is found both on Traditional and State land.

Because of pressure on land from both livestock and people, and earlier policies on agricultural marketing, most people practise monocropping of maize and this crop takes up about 70% of the cultivated land. Poor marketing arrangements are recognized as being constraints in all the farming systems, especially in remote areas.

In the areas cultivated by hand-hoe, the main constraints are lack of labour early in the season, drought, limited cash to purchase inputs, seasonal food shortages in the period from January to March, and declining soil fertility. Where fallow periods are allowed, they are too short to allow restoration of soil fertility and in the long run people abandon such fields in search of fresh ones.

People start working in their fields as early as July and work continues through to October. This work is known as *galauza* in Nyanja. In this system, trash and stalks are buried by piling soil between two old ridges to make a new ridge. This ridging, if done systematically along the contours, results in controlling run-off, but if done along the slope, both soil and trash are swept away. The people involved in *galauza* are mainly women and children. Men normally attend to the large fields which are used for the production of cash crops and where oxen are used after the onset of the rains.

In all farming systems, harvesting is done between June and July. Many farmers, especially in Chipata, Katete, Chadiza and Petauke, leave their cattle free during the dry season without anybody to herd them so they often damage other people's fields. Bush fires in these four Districts are very common because people burn grass and maize stalks to clear the fields in search of mice which are a delicacy among the Ngoni, Chewa and Senga. Such fires clear the ground of any vegetation, leaving the soil unprotected and vulnerable to erosion. Vegetative soil cover is important in controlling erosion, and also acts as a mulch which maintains soil moisture thus providing a better environment for microbial activity.

People on the plateau are usually busy with the field crops up until about March when they start to utilize dambos to grow vegetables to generate extra income. The main crops in these dambos are vegetables, sugarcane and fruit trees. To keep livestock away from the gardens, people use live fences and also make wooden fences. When wooden fences are used, the poles have to be replaced every three years. The extension service discourages people from using poles for fencing and has put the emphasis on live fences using *Agave sisalana* (Sisal E) and shrubs like *Caesalpinia decapetala* (Chatata N).

In the valley hand-hoe cultivation system, there are some people who cultivate two distinct areas on their farms, one during the rainy season and another area during the dry season. During the planting season they plant their field crops such as maize in the silt-fertilized river valleys from May to August: this system is referred to as *nyata* and it allows people to have two crops a year which helps to overcome poverty and hunger.

2

TREE AND CROP INTERACTION

2.1 Introduction

The capacity of trees and other plants to restore soil fertility was utilized in African traditional agricultural systems that were based on shifting cultivation. Farmers still grow or leave trees on their land, often noting that this has beneficial effects for the soil and crop yields. It is well known that the topsoil in forests is usually rich in nutrients with a good structure, and scientists have concluded that nutrient cycling under natural vegetation is relatively efficient; that is, there is little leakage of nutrients out of the system. Agroforestry systems are more similar to natural ecosystems than monocropping systems since both trees and herbaceous plants are present, and a well-functioning agroforestry system has the potential for decreasing leakage of nutrients out of the system.

Soil status is one of the important factors that determine how a crop will perform on a certain site. It is, however, not the only one. Moisture content is another important factor, and trees growing with the crops will also have an impact on the moisture content of the soil. Roots from some tree species compete significantly with crops for moisture whereas, on the other hand, the presence of trees reduces wind and thus evaporation. Due to litter fall and decomposition, trees also contribute to the organic-matter content of the soil, which increases the capacity of the soil to retain moisture.

Above the ground a tree will provide shade, which will have some effect on crop performance. Occasionally trees may harbour organisms that are harmful to crops, e.g. a tree may attract grain-eating birds to nest in its crown.

These and other factors affect the nature of the tree's interaction with crops surrounding it. The area where this interaction takes place is sometimes called the tree/crop interface. Agroforestry is only beneficial to the farmer if the net effect of all the factors involved in this interaction is positive. The trees planted with crops certainly do not always contribute to a higher output or to more sustainable land use. The benefits will only be obtained through a combination of the right tree species with the right crops in the right spatial arrangements with the right management practices. It is important to understand these factors and their effects on the trees and crops before agroforestry interventions are discussed and planned with farmers.

2.2 How trees improve soils

The processes through which trees improve soils can be grouped into four different categories, as follows (adapted from Young 1989):

- Increasing inputs (organic matter, nitrogen fixation, nutrient uptake)
- Reducing losses (organic matter, nutrients) by promoting recycling and checking erosion
- Improving soil physical properties, including water-holding capacity
- Beneficial effects on soil biological processes.

The processes by which trees maintain or improve soils

Processes which augment additions to the soil

- Maintenance or increase of soil organic matter through carbon fixation in photosynthesis and its transfer via litter and root decay.
- Nitrogen fixation by some leguminous and a few non-leguminous trees.
- Nutrient uptake: the taking up of nutrients released by weathering of rocks in deeper layers of the soil.
- Atmospheric input: the provision by trees of favourable conditions for input of nutrients by rainfall and dust, including via throughfall and stemflow.
- Exudation of growth-promoting substances by the rhizosphere.
- Reduction of acidity through addition of bases in tree litter.

Processes which reduce losses from the soil

- Protection from erosion and thereby from loss of organic matter and nutrients.
- Nutrient retrieval: trapping and recycling nutrients which would otherwise be lost by leaching, including through the action of mycorrhizal systems associated with tree roots and through root exudation.
- Reduction in the rate of organic-matter decomposition by shading.

Processes which affect soil physical conditions

- Maintenance or improvement of soil physical properties (structure, porosity, moisture-retention capacity and permeability) through a combination of maintenance of organic matter and the effects of roots.
- Breaking up of compact or indurated layers by roots.
- Modification of extremes of soil temperature through a combination of shading by canopy and litter cover.

Soil biological processes and effects

- Production of a range of different qualities of plant litter through supply of a mixture of woody and herbaceous material, including root residues.
- Timing of nutrient release: the potential to control litter decay through selection of tree species and management of pruning and thereby to synchronize nutrient release from litter decay with the plants' requirements for nutrient uptake.
- Effects upon soil fauna.
- Transfer of assimilate between root systems.

Litter and mulch

During the lifetime of a tree, leaves, twigs and branches die and fall to the ground as litter. In agroforestry, trees are often managed and the biomass from the tree may be cut and used as mulch. The roles played by mulch and litter are similar.

Litter or mulch lying on the ground provides cover for the soil and this reduces erosion rates. In general, tree canopies only reduce the erosive effect of rainfall by about 10%, and in certain situations the canopy may make the rainfall even more erosive than if there were no tree. If the soil is covered with litter or mulch, on the other hand, erosion will often be reduced to low levels.

Another characteristic of litter is its contribution to the organic-matter content of the soil after it decomposes. A soil that is rich in organic matter has a better capacity to absorb and retain water, and thus is also more resistant to erosion. A good cover of litter or mulch can also be very effective in suppressing weeds.

In general, trees do not necessarily lead to control of erosion. What matters is their spatial arrangement and the way they are managed.

Nitrogen fixation

Many leguminous trees and a few non-leguminous ones have the ability to fix atmospheric nitrogen through symbiosis with bacteria or fungi in root nodules. The fixation of nitrogen has been proven and found to be a significant factor in soil fertility. Tree species that have the ability to fix nitrogen may not always be efficient in doing so, however. One of the preconditions for efficient fixation of nitrogen is a minimum level of phosphorus in the soil. In exhausted soils which are low in phosphorus, therefore, nitrogen fixation may be insignificant even if nitrogen-fixing species are planted.

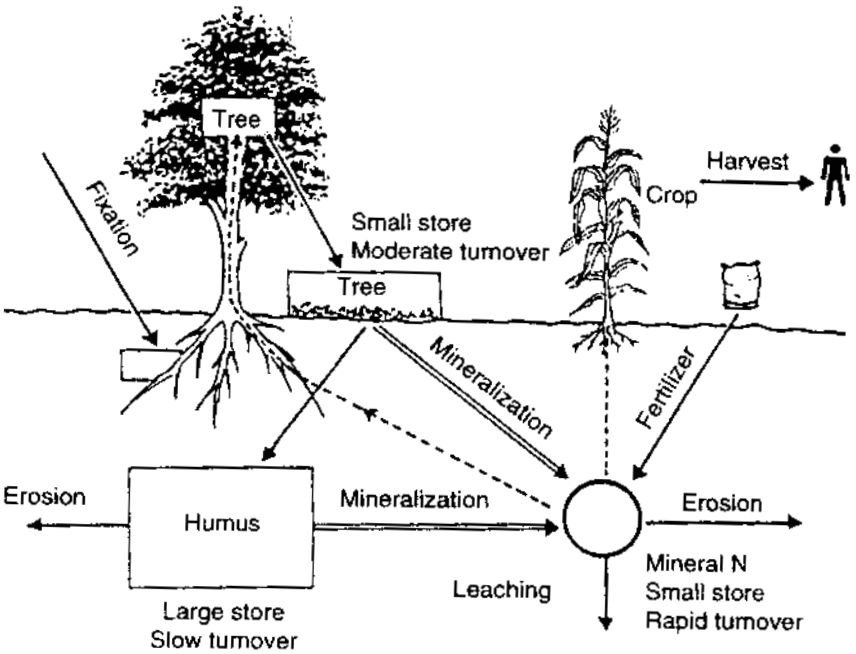


Figure 2.1 The nitrogen cycle under agroforestry simplified to show major stores and flows

The roots of a plant constitute 20–30% of its biomass. But the roots often contribute more to net primary production than the above-ground biomass. This is because the fine roots only have a short lifespan and therefore there is rapid turnover of them. Hence,

root decay is a significant process, and it is probable that cutting back the biomass above ground (coppicing, pollarding, etc.) results in a temporary increase in root die-back. When the roots die, nitrogen is released and can be used by other plants, e.g. crops. So far, these processes that release nitrogen from roots are not very well understood but they are being studied. Besides release of nitrogen, the death of the fine roots also contributes to organic-matter build-up.

A major part of the nitrogen which is fixed by the roots is used by the nitrogen-fixing plant for its own growth, so the litter from nitrogen-fixing plants is often rich in nitrogen and this is added to the soil when the litter or mulch decomposes.

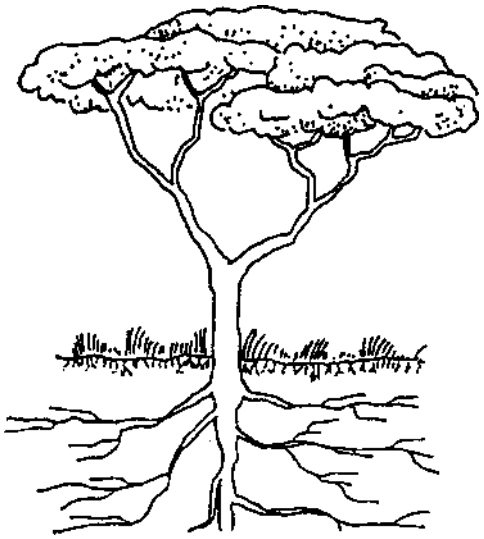


Figure 2.2 Spatial distribution of the roots of trees and crops in the soil

Nutrient uptake

Tree roots normally penetrate deeper into the soil than the roots of crops. It has, therefore, been assumed that trees are more efficient than crops in taking up nutrients released by weathering deep in the soil. Potassium, phosphorus and micronutrients are essential for plant growth and these elements are often released through such weathering. The nutrient uptake from deep layers of the soil, sometimes called nutrient pumping, has still not been experimentally verified.

Nutrients from the atmosphere

The presence of a tree reduces wind speed and creates good conditions for the deposition of dust. Nutrients in the atmosphere are conveyed to the soil when they are dissolved in rain or settle with dust. Rain water dripping from leaves and flowing along the branches carries the nutrients to the ground, together with those released from the tree itself and associated plants growing on it. It is known that the amounts of nutrients reaching the ground in this way are substantial.

Protection from erosion

Soil erosion can be controlled by checking the flow of water down a slope with runoff barriers—the barrier approach—or through maintaining a cover of living plants and litter

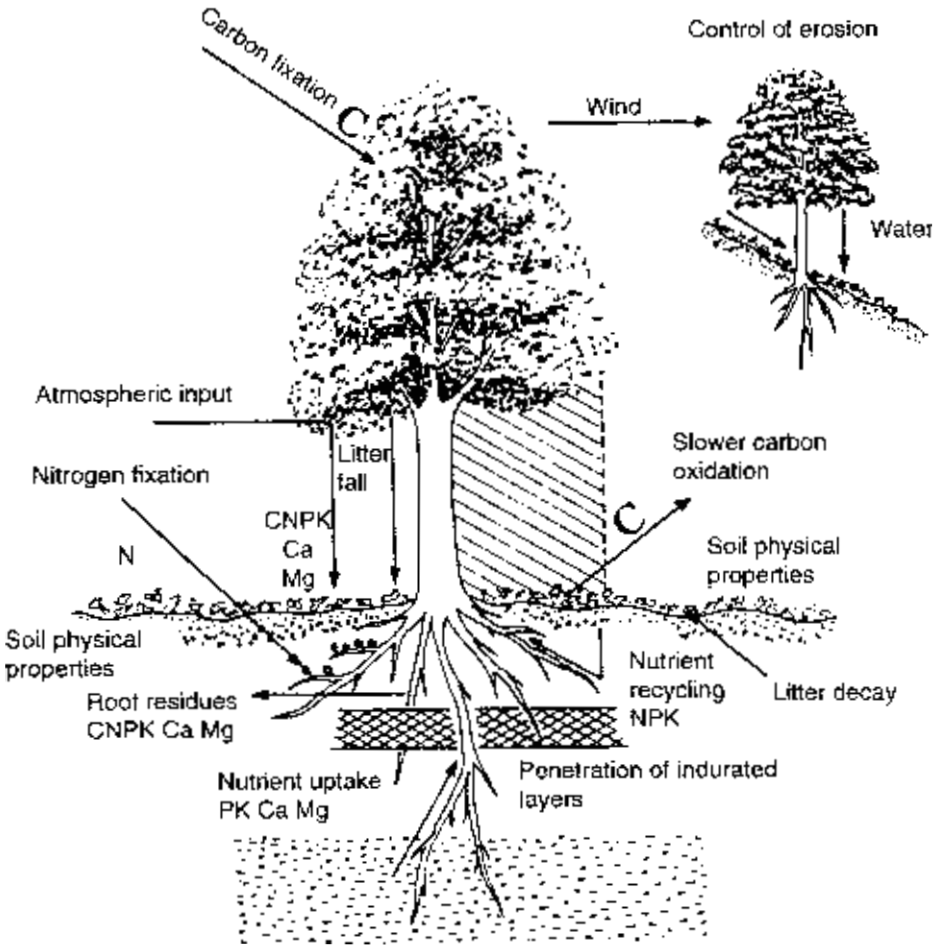


Figure 2.3 Processes by which trees maintain or improve soil

on the ground—the cover approach. A cover of mulch or litter on the soil reduces the impact of rain drops and provides dispersed micro-barriers to runoff (Young 1989). Soil erosion involves loss of topsoil, including loss of both organic matter and nutrients. Trees play an important role in erosion control, both through the barrier and cover effects. Formerly the barrier effect was thought to be the most important, but in recent years the cover effect has received increasing attention.

In the barrier approach, trees and shrubs play a direct role in reducing erosion if they are grown in rows on contours. Another effective control method is to combine trees and grass in strips along contours. Combining trees and grass is a means of making optimal use of the strips of land which are taken out of direct crop production. If productive use is made of the strips, the soil-conservation measures are more likely to be regarded as beneficial by the farmer and therefore to be adopted on a permanent basis.

If physical soil conservation structures are constructed, trees or shrubs that are planted on or near them can help to strengthen and stabilize the structures. Another example of the use of trees in the barrier approach is the growing of trees as a windbreak.

The benefits of trees in the cover approach have been discussed earlier in connection with litter and organic-matter maintenance.

Reduction of the rate of organic-matter decomposition by shading

Trees influence the microclimate. The shade resulting from tree canopies and litter reduces temperatures during the heat of the day and this cooling effect slows down the decomposition of organic matter.

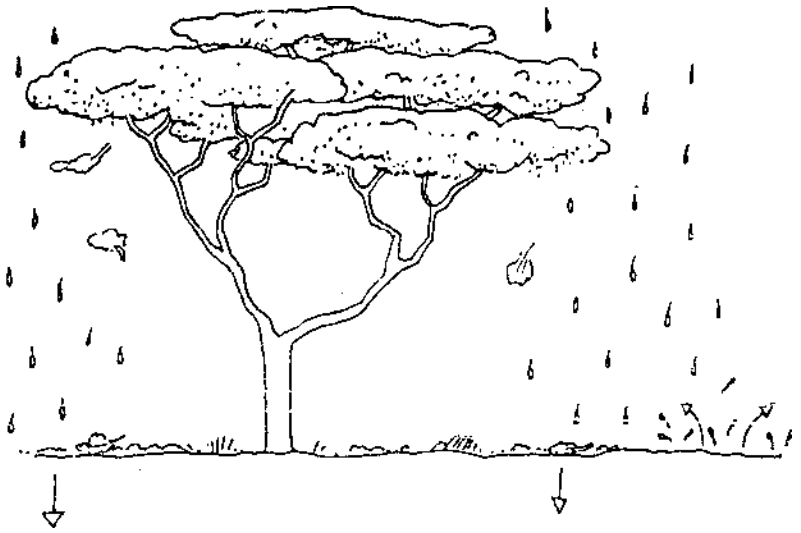


Figure 2.4 The effect of leaf mulch in reducing splash erosion and increasing infiltration

2.3 The crop component

Some of the more important crop-related factors that determine how the crop will perform with trees are:

- Light demand
- Demand for moisture and nutrients (or the "aggressiveness" of the crop)
- Potential for bird damage
- The distribution of roots in the soil profile
- The potential for wind damage.

Characteristics of some common crops grown in Eastern Province are summarized in Table 2.1.

Table 2.1 Characteristics of some important crops in relation to agroforestry

Crop	Demand for light	Demand for moisture	Risk of bird damage	Root distribution / nematode risk	Risk for wind damage
Maize (Chinangwa)	Moderately demanding	Demanding	No risk	Shallow	No risk
Sorghum (Mapila)	Demanding	Low demand	High risk	Shallow	Moderate risk
Finger millet (Mawele)	Demanding	Low demand	High risk	Shallow	No risk
Rice (Mupunga)	Demanding	Very demanding	Moderate risk	Shallow	No risk
Bananas (Nthochi)	Shade tolerant	Very demanding	No risk	Rather deep, nematode risk	High risk
Sweet potatoes (Kachamba)	Demanding	Low demand	No risk	Shallow	No risk
Irish potatoes (Mbwasi)	Shade tolerant	Demanding	No risk	Rather shallow, nematode risk	No risk
Tobacco (Fodya)	Demanding	Low demand	No risk	Shallow	No risk
Sugar cane (Nzimbe)	Very demanding	Very demanding	No risk	Shallow	No risk
Sunflower (Mchinga-zuwa)	Moderately demanding	Low demand	Some risk	Shallow	Some risk
Groundnuts (Nshawa)	Demanding	Moderately demanding	No risk	Deep	No risk

2.4 The tree component

A good agroforestry species should have at least some of the following characteristics:

- Fast growth, e.g. *Senna siamea* (Makechi N)
- A light, open crown, e.g. *Faidherbia albida* (Musangu N) to reduce shade if grown with crops
- Ability to coppice or respond to pollarding, e.g. *Piliostigma thonningi* (Msekese N)
- Provide products like poles, food, fodder and medicine, e.g. *Parinari curatellifolia* (Mpundu N)
- Nitrogen fixation, e.g. *Sesbania sesban* (Jelejele N)
- Deep rooted, e.g. *Pterocarpus angolensis* (Mulombe N) to reduce competition if grown with crops
- Should not harbour pests and diseases
- Be easy to propagate and manage, e.g. *Tephrosia vogelii* (Buwa N).

In short, the tree should be compatible with crops or livestock.

A farmer is likely to appreciate a tree that gives him or her higher yields. The farmer's perceived value of the direct benefits, e.g. poles and timber, and the indirect benefits, e.g. erosion control and nitrogen fixation, should be high. Which product or service is seen as being most important may vary from one area to another and from one farmer to another according to his needs. In fact, the values attached to various products or services may often vary even within the family, e.g. the wife's preferences may sometimes be quite different from those of her husband. Thus it is desirable to involve both wife and husband in discussions on tree species.

Where land holdings are small, very competitive trees (e.g. *Eucalyptus* spp., *Acacia mearnsii*) may not be accepted by the farmers even if they are fast growing and have valuable production. Trees with a deep root system are usually less competitive with crops than those with many shallow roots. A shallow root system may be desired if the trees are intended to stabilize soil and competition with crops is less important. Examples of trees with shallow roots are *Casuarina* spp., *Cupressus lusitanica* and *Sesbania sesban*, although the latter does not compete much with crops since this species fixes its own nitrogen.

3

SOCIO-ECONOMIC ISSUES IN AGROFORESTRY

3.1 Cultural background

The major ethnic groups in Eastern Province are Ngoni, Chewa, Senga, Nsenga, Tumbuka and Kunda.

The Ngoni are predominant in Chipata, while the Chewa are found in Chadiza and Katete Districts and the Nsenga in Nyimba and Petauke. The Tumbuka and Senga live in Lundazi and Chama, respectively. Apart from the Ngoni and Tumbuka who follow patrilinear lines, the other ethnic groups have a matrilinear line of inheritance.

Traditions and customs vary between different ethnic groups, and the work of an extension worker becomes easier if he or she familiarizes him or herself with such traditions and customs.

3.2 Traditional power structure and local governance

In Eastern Province, the local communities fall under the authority of the traditional leaders such as the Chiefs, Indunas, Headmen and household heads (in the case of married couples).

At household level, the man is the decision maker in a house and his views must be respected by his wife/wives.

The traditional leader's role in a society is to maintain law and order in the manner that is socially and culturally accepted by everyone in that society. Apart from the maintenance of law and order in their communities the Chiefs in Zambia are the custodians of traditional land and have the responsibility of land distribution in their areas of jurisdiction.

Thus local leaders play a major role in enhancing development in their areas. Chiefs and Headmen take initiatives in organizing their people and also mobilizing resources

for active participation of local communities in development. This is a positive aspect of the local leadership. Even if there may occasionally be negative aspects of local leadership, avoiding or ignoring the leaders altogether can prove to be detrimental to any extension or community development work. Chiefs and Headmen have extensive powers over their subjects and over land, and thus it is of vital importance to recognize their authority and work with them and through them to achieve results.

3.3 Tenure issues in relation to agroforestry

Land tenure refers to the possession or holding of the many rights associated with each parcel of land. Ownership or user rights are not static because such rights can be subdivided or transferred by the holder. Also the different kinds of right to a certain piece of land may not be held by the same person.

An example of such a situation is a field or a plot that is privately owned when a crop is growing on it but after the harvest animals from different villages, or those belonging to different people in the same village, may be allowed to graze through the same field. In such cases, communal grazing may be regarded as a right that the neighbours have to the land in spite of formal individual ownership. In such a situation, planting or protecting trees in a farmer's field would require a change of tenure, i.e. the practice of uncontrolled grazing after the harvest would have to be discontinued if trees are to survive and grow. Therefore, such an initiative would have to involve the whole village or community reaching an agreement on where and how animals should be herded, and such agreement may be difficult to achieve.

Communal tenure also often involves restrictions on land use, e.g. cutting of trees, which are recognized and observed by all members of the community.

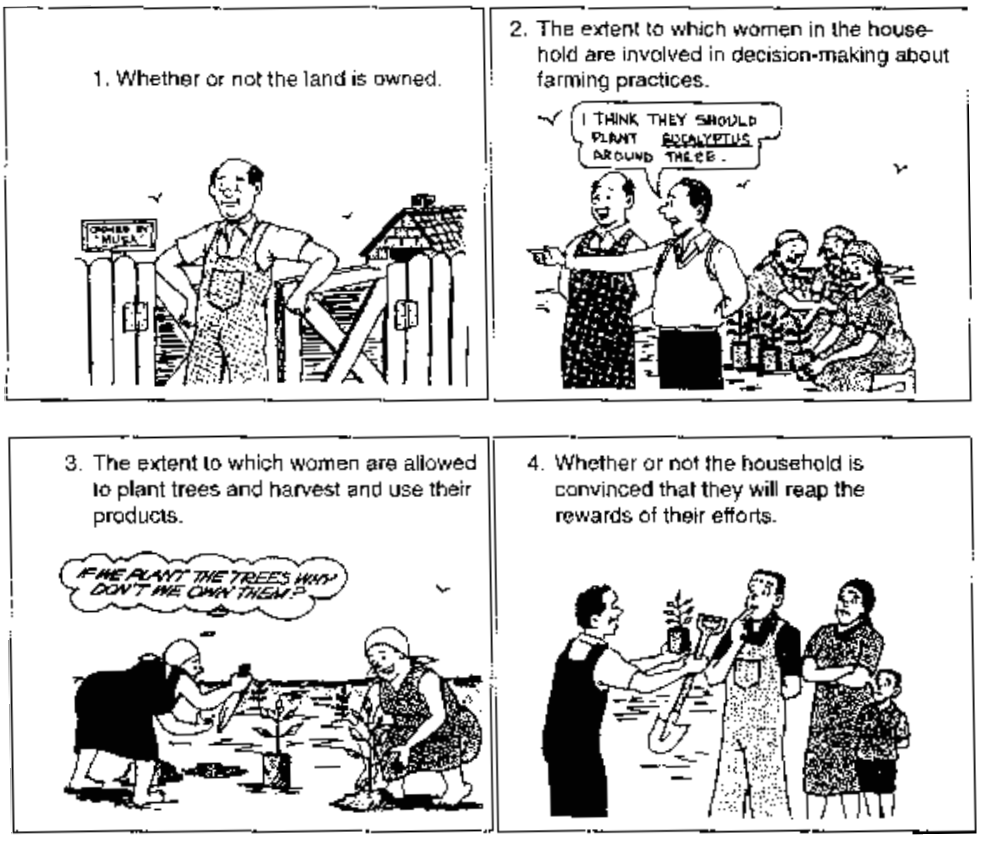


Figure 3.1 Land- and tree-tenure issues

3.4 Gender

In different societies there are differences between men and women with regard to their responsibilities, user rights, legal status, division of labour, decision-making powers, and so on.

Much research is being focused on the role of women in agriculture and resource management. Studies on the role of women have revealed that women in Eastern Province (and Zambia as a whole) do a large share of farm work in addition to all the other duties that are traditionally their responsibility. In fact, on a national average women spend more than three times as much time in the fields as do men. This division of labour implies any effective agroforestry intervention must be such that it reduces rather than increases the workload of women.

Some of the gender-related issues to be taken into account in agroforestry extension programmes are:

- The different roles played by men and women in agricultural production and how these are recognized, valued and rewarded
- The different needs of men and women and how they are catered for in the extension programme
- The extent to which men and women become involved at different levels in the extension programmes.

Gender analysis is an essential tool in planning and implementing agroforestry extension programmes for a number of reasons:

- The relationship between men and women is part of the social organization of the community and therefore dynamic rather than static
- Universally, women are less privileged than men in the same social group
- Focusing on one sex only, e.g. the women, ignores the fact that both men and women interact and are interdependent.

Figure 3.2 A woman carrying firewood home

Gender-related constraints that affect women in most communities are:

- Limited access to formal education
- Limitations caused by socio-cultural taboos

- Limited access to land
- Women seldom have control over the benefits derived from development programmes
- Unfavourable credit facilities
- Most work done by women is unrecognized, unappreciated and undervalued
- Absence of appropriate technology
- Women have a heavy workload.

As a general conclusion, it is important to get the whole family involved in discussion on agroforestry. All family members have ideas and knowledge to contribute and their individual needs and priorities should be taken into account. Planning and implementing agroforestry extension programmes can be treated as opportunities for involving both men and women and reducing any conflicts between them. The analysis should also consider the different roles, functions and workloads of women and men and how these affect the implementation of the extension programme. Particular attention should be paid to households headed by women.

4

AGROFORESTRY TECHNOLOGIES AND PRACTICES

The guidelines provided in this chapter should not be treated as inflexible rules, but rather as a basis for consultations with farmers. Farm conditions and farmers' priorities vary from place to place and therefore flexibility is a must. Thus, farmers need to be active partners in adapting and evaluating new technologies, and their technical knowledge should be valued. Still, much remains to be learnt about the interaction between trees, crops and livestock in existing and new agroforestry technologies under different conditions.

4.1 Trees in homesteads and around institutions

Trees can be planted around the homestead for shade, beauty, as a windbreak, and for medicine, fruits, timber, poles, fuelwood and fodder. Trees can also improve the microclimate of the area around homes.

There are advantages and disadvantages to planting trees in homesteads and around institutions. The major advantage is that it is easy to look after trees and the products (e.g. fruits) are easily accessible to the user.

There are, however, several disadvantages too. The trees need protection not only from livestock but also from children and sometimes even adults. Sometimes trees can damage buildings, e.g. by branches or a whole tree falling during rain storms, or roots of trees like *Ficus* spp. growing into and cracking walls and foundations. Trees can also cause too much shade and dampness and can attract insects and snakes.

Criteria for selection of species

Trees that would be suitable for planting in homesteads and around institutions should:

- Provide valuable products or services (shade, fruit, beauty, etc.)
- Not shed too much litter
- Be deep rooted
- Be resistant to wind damage.

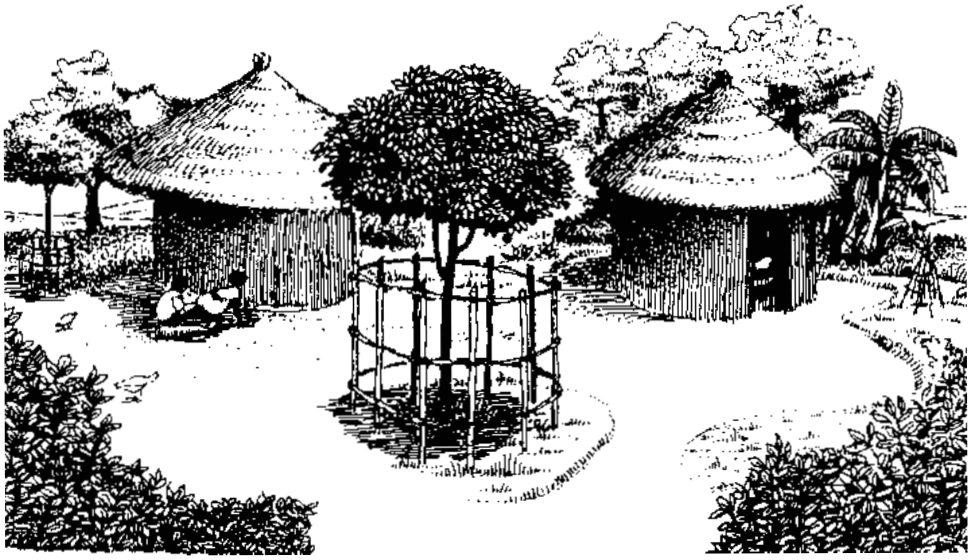


Figure 4.1 A fenced fruit tree in a homestead

Recommended species

Suitable trees for shade

- *Ficus brachylepis* (Kachele N)
- *Ficus sycomorus* (Mkuyu, Mukuyu N)
- *Khaya nyasica* (Mubawa, Mlulu N)
- *Mangifera indica* (Manga N)
- *Senna siamea* (Makeche N)
- *Senna spectabilis* (Golden cassia E)
- *Tamarindus indica* (Bwemba N)
- *Trichilia emetica* (Msikizi N)

Fruit trees

- *Mangifera indica* (Manga N)
- *Citrus* spp. (Lalanje, Ndimu N)
- *Morus nigra* (Malubeni N)
- *Prunus americana* (Avocado E)
- *Anacardium occidentale* (Kashunati N, Cashew nut E)

Ornamental trees

- *Delonix regia* (Flamboyant E)
- *Jacaranda mimosifolia* (Jacaranda E)
- *Senna siamea* (Makeche N)
- *Senna spectabilis* (Golden Cassia E).

Establishment

By cutting, direct seeding and seedlings. Fruit trees must be spaced according to the recommendations for that species (in the Fact Sheets in Part II of this book). Ensure that the trees are planted at least 5 m away from houses. (For further details, see Chapter 8 on planting, tending and management of trees in the field.)

Management

Trees around homesteads need to be protected against livestock. They can be pollarded, pruned, fertilized and watered to improve the performance and growth. Simple water-management techniques such as basins, bunds or half-moon-shaped depressions are useful during dry seasons. However, the best type of management to be used depends largely on the species and the purpose of planting.

4.2 Trees on boundaries and as windbreaks

Trees and shrubs can be planted along boundaries of fields and structures for demarcation purposes. Traditionally, field boundaries were planted with trees for permanent demarcation. Trees can also be planted along roadsides for beautification and to provide shade for pedestrians.

Windbreaks are lines of trees or shrubs planted for the purpose of protecting crop fields, institutions, houses, etc., from wind damage. In Eastern Province planting around field boundaries and on soil-conservation structures should, in most cases, offer sufficient wind protection since the area does not experience strong winds.

Benefits of boundary planting

- Production of fuelwood, poles, fruits, fodder and timber.
- Marking of field or farm boundaries.
- Protection of crops and soil against wind (yields are known to increase when windbreaks are established in areas with strong winds).

Criteria for selection of species

Trees that would be suitable for windbreaks should be:

- Easy to establish
- Easy to manage
- Not harbour pests and diseases
- Deep rooted
- Resistant to wind
- Provide minimum competition for light, water and nutrients to adjacent crops
- Not spread on their own.

Recommended species

Suitable species for boundary planting:

- *Azadirachta indica* (Neem E)
- *Casuarina* spp. (Whistling pine E)
- *Eucalyptus camaldulensis* (Bulugamu N; Red river gum E)
- *Eucalyptus tereticornis* (Bulugamu N; Forest red gum E)
- *Senna siamea* (Makeche E)
- *Senna spectabilis* (Golden cassia E)
- *Tamarindus indica* (Bwemba N; Tamarind E).

Establishment

Trees on boundaries

The main method of establishment is by seedlings. Seedlings of the desired species are first raised in the nursery and planted out at the beginning of the rainy season when they are 25–30 cm high. However, direct seeding and cuttings may also be used depending on species. (See species Fact Sheets for further details.)

The spacing for smaller and medium sized fruit trees is normally 3 m. Other multi-purpose tree species can be spaced between 2 and 4 m depending on species.

Windbreaks

The main method of establishing windbreaks is by seedlings. Planting a single line of trees is sufficient to mark a boundary and to serve as a windbreak. A windbreak should be established at a right angle to the prevailing wind direction. The spacing between trees is normally 2 m, but this may vary with species.

The efficacy of a windbreak can be improved by planting tall trees in the first line and shorter trees in a parallel line. If the boundary separates two fields, the first line of trees should be placed one or two metres inside the boundary. If both farmers are interested, each can plant a line of trees inside their boundary.

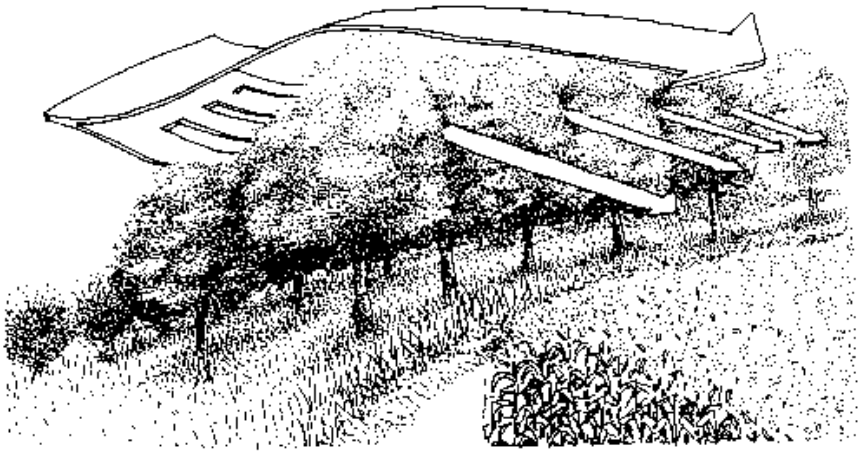
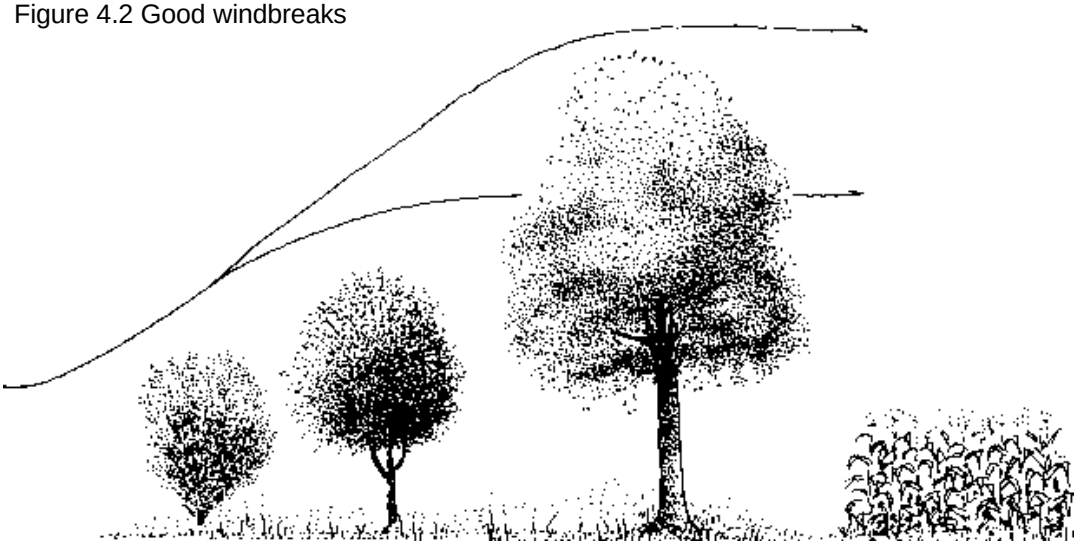


Figure 4.2 Good windbreaks



Management

Trees on boundaries

Protect young trees against livestock and fires. Tend the trees by pruning and pollarding to reduce shade on the adjacent crops. The prunings and pollarded branches can be used as construction materials or firewood.

Windbreaks

Protect young trees against livestock and fires. Termite control is necessary for trees such as eucalyptus which are susceptible to termite attack. Mature trees can be selectively pruned or pollarded to reduce the shading effect on the adjacent agricultural crops.

4.3 Natural shelterbelts

Natural shelterbelts are strips of trees which are left when establishing new fields. The main functions of natural shelterbelts are to protect fields from runoff and wind damage. They also provide tree products like fuelwood, timber, fruits and medicine. In Eastern Province natural shelterbelts are mainly found in settlement schemes.

Establishment

Natural shelterbelts should be aligned across the slope for them to be effective in soil conservation. The width of a shelterbelt can range from 30 to 50 m and the length will depend on the area of the piece of land under cultivation. Spacing between shelterbelts can be 50 m or more depending on conditions.

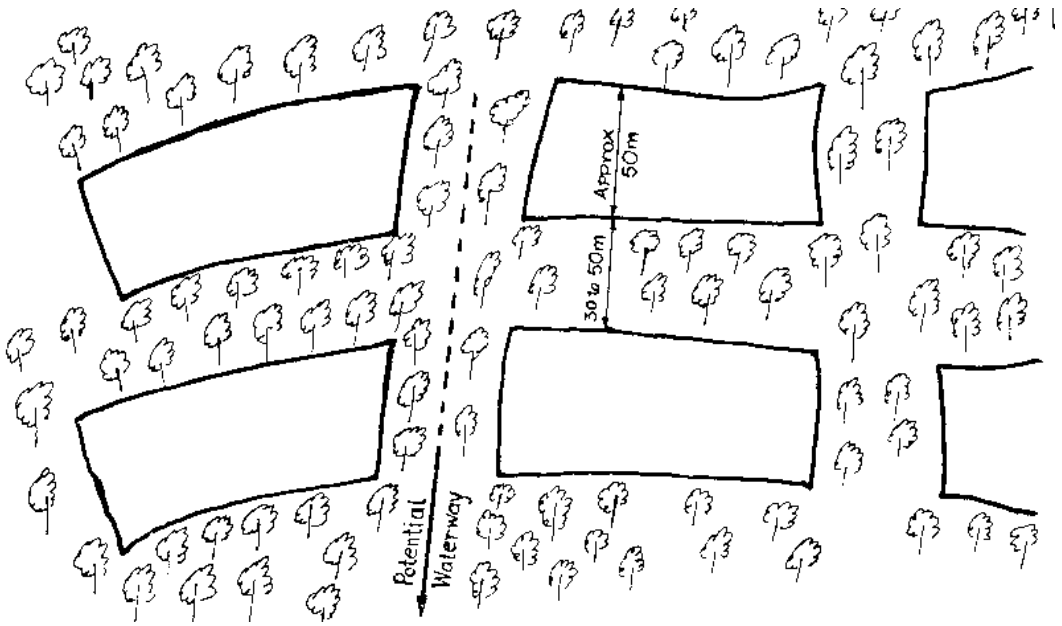


Figure 4.3 Natural shelterbelts

Management

Natural shelterbelts require sound silvicultural management practices to sustain their productivity. Fires have generally been one of the biggest problems in management of forests in Eastern Province. Early burning of shelterbelts from May to June is recommended. Controlled grazing should be practised in order to avoid overgrazing.

Trees can be pollarded or coppiced. This will ensure sustainable use of forest products. Natural regeneration should be well protected.

The following species tolerate pollarding: *Albizia* spp., *Balanites aegyptiaca*, *Bauhinia* spp., *Bridelia micrantha*, *Commiphora* spp., *Cordia* spp., *Ficus* spp., *Piliostigma thonningii, Syzygium* spp. and *Terminalia* spp.

4.4 Woodlots

Woodlots are plots of planted or naturally growing trees. They provide multiple products and services such as timber, poles, fuelwood, medicine, soil-erosion control and shelter. Poles, fuelwood and timber may be used by the farmer or sold to supplement cash income for the household or community.

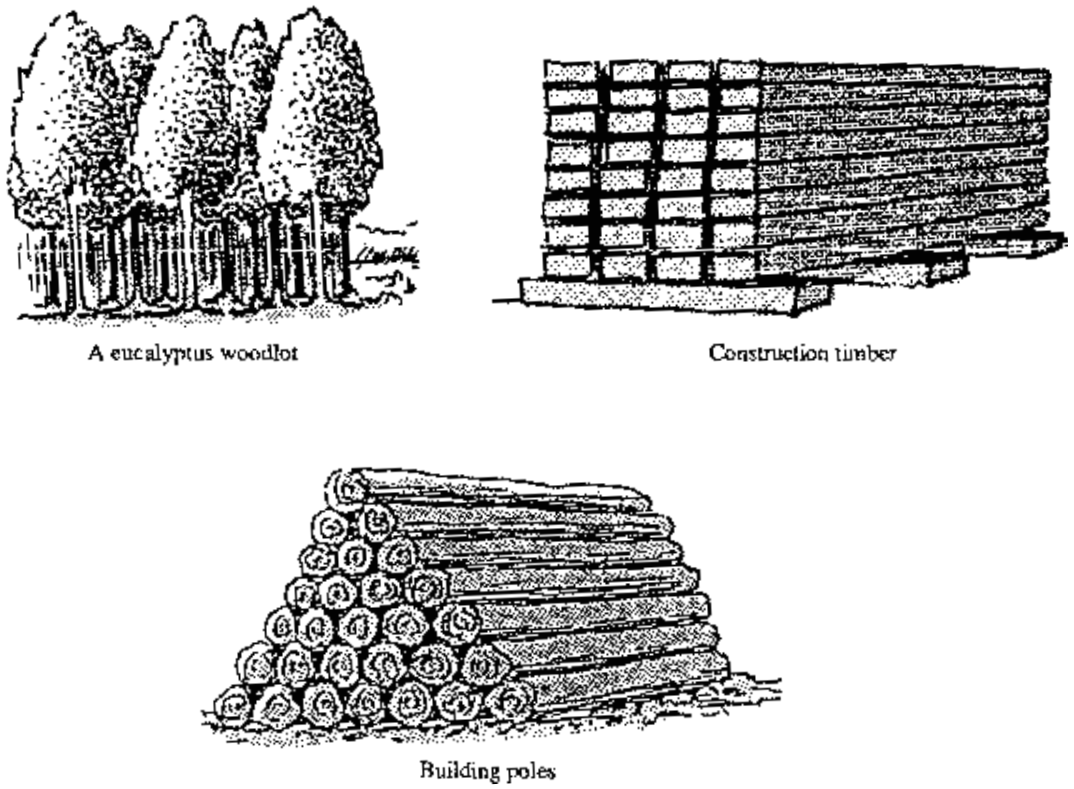


Figure 4.4 A woodlot and some of its products

Siting of woodlots

A woodlot should be sited where it can be easily protected from livestock and fires and this is easier if it is sited close to a village. It may also serve as a demonstration plot.

Like crops, most trees grow better on fertile, deep soils. Most farmers will give priority to the crops and choose to plant trees on poorer soils. Thus, if the farmer expects the trees to grow fast on such soils, fertilizer or manure may have to be used. Shallow soils where termites are common should be avoided.

Recommended species

- *Eucalyptus camaldulensis* (Bulugamu N; Red river gum E)
- *Eucalyptus tereticornis* (Bulugamu N; Forest red gum E)
- *Gmelina arborea* (Malaina N)
- *Khaya nyasica* (Mubawa, Mlulu N)
- *Melia azedarach* (Bead tree E)
- *Pinus kesiya* (Pine E)
- *Pinus oocarpa* (Pine E)
- *Senna siamea* (Makeche N)
- *Tamarindus indica* (Bwemba N).

Establishment

The spacing of trees in woodlots varies depending on the management objective and the tree species. The common spacing for most woodlots is 2 m x 2 m which is later thinned to allow bigger diameter trees for production of timber. Other spacings such as 3 m x 3 m, or even 4 m x 4 m, may also be used and the trees may be intercropped with low crops, e.g. beans or groundnuts, in the first few years. Where land is scarce and small-diameter wood is needed, planting at a dense spacing, e.g. 1 m x 1 m, is also feasible.

Woodlots can also easily be established if indigenous trees are simply allowed to regenerate.

Management

- Weed around young trees and shrubs to reduce competition for moisture, light and nutrients.
- Protect the young seedlings against livestock, termites and fires.
- Apply manure or fertilizer to trees and shrubs which show signs of nutrient deficiency, e.g. die-back on eucalyptus, yellowing of leaves and poor growth.
- Mature trees could be pruned, thinned and later coppiced depending on the species.

Management options for woodlots of indigenous trees are similar to management of woodlands (see section 4.11).

4.5 Fodder banks

Fodder banks are plots of fast-growing and high-yielding trees, grasses and shrubs managed for fodder production. The animals are given supplements of protein-rich feedstuffs during the dry season when other good-quality fodder is scarce. The fodder may be cut, carried and fed to livestock in their enclosure (kraal). The kraal manure can be applied to crops, and the amount of manure increases with good feeding of the animals. Alternatively, livestock can be allowed to graze on the fodder bank, although not all fodder species tolerate this well.

Criteria for selection of fodder species

Trees that would be suitable for fodder should be:

- Palatable to livestock and rich in protein
- Easy to manage
- Drought tolerant

- Tolerant of trampling if to be grazed
- Able to resprout easily.

Recommended species

Leaves

- *Leucaena leucocephala* (in recent years, attack by the leucaena psyllid has reduced production in some areas)
- *Cajanus cajan*
- *Pennisetum purpureum* (Napier grass E)
- *Panicum maximum* (Kanjala, Ntende N)
- Siratro, *Desmodium* and other fodder legumes
- *Leucaena diversifolia* (research still being carried out).

Pods

- *Acacia tortilis* (Mzunga, Nyoswa N)
- *Faidherbia albida* (Msangu N)
- *Dicrostachys cinerea* (Kalumphangala N)

Pods and young leaves

- *Piliostigma thonningii* (Msekese N)
- *Acacia polyacantha* (Ngowe N).

Establishment

Direct seeding, cuttings or seedlings depending on species. Shrubs may be planted in pure stands or intercropped with grasses.

In pure stands, plant shrubs at 1 m x 1 m. When shrubs are mixed with grasses, space the shrubs 1 m apart in 4-m-wide alleys with three rows of Napier grass in between the shrub rows. A spacing of 45 cm between the Napier cuttings is suitable. Fencing is usually required for good establishment.

Management

- Weed around the plants.
- Protect the plants against livestock and fires during establishment.
- Cut back when the plants (hedges) attain a height of more than 1 m.
- Cut back *Leucaena* and *Gliricidia* to 30 cm with a slanting cut.
- Cut back at least three times a year for optimum quantity and quality, e.g. December, February and early June.

4.6 Improved fallows

An improved fallow is a piece of land planted with, preferably fast-growing, nitrogen-fixing species of trees/shrubs for the purpose of enhancing soil fertility.

Benefits

- Protect the soil from erosion.
- Reduction of nuisance weeds (e.g. *Striga asiatica*).
- Increase the nutrient and organic-matter content of the soil thereby improving its fertility and structure, including aeration, water-holding capacity and tilth.
- Production of fuelwood.

In Eastern Province, interest in this technology is very high because of the high cost of fertilizers and the promising results that have been obtained in on-station and on-farm trials. Maize yields have been reported to have increased from about 0.15 tonnes per ha to 4.0 t per ha after only two years of *Sesbania sesban* improved fallows on farms with depleted soils (Kwesiga *et al*. 1995). After three years of *Sesbania sesban* fallow, there is a potential to produce maize yields of up to 6 tonnes per ha, but such long fallow periods have been found to be less profitable than shorter ones.

The technology may, however, not be applicable to farmers with very small landholdings since it requires land to be taken out of crop production for fallowing.

Recommended species

Fast-growing nitrogen-fixing species recommended for improved fallows are:

- *Sesbania sesban* (Msalasese, chigoma, jelejele N)
- *Sesbania macrantha* (Chizonga N)
- *Tephrosia vogelii* (Ububa N)
- *Cajanus cajan* (Pigeon pea E, Nyamundolo N)
- *Crotalaria* spp. (Sunhemp E, Kalongonda, Sanyembe N).

Establishment

Plant short-lived shrubs such as *Sesbania sesban* at 1 m x 1 m or 90 cm x 90 cm. Use of seedlings is expensive, however, since many are required, and direct sowing of *Sesbania* can also be tried. *Sesbania macrantha* normally nodulates well even without inoculation and is thus more suitable for direct sowing than *S. sesban*. Improved fallows can be sown with a mix of species to obtain more benefits, e.g. *S. sesban* with *Cajanus cajan*.

Management

Weed during establishment to improve growth of the shrubs and protect the shrubs against livestock and fires. Cut short-lived shrubs after 2–3 years and thereafter let the crops grow. A limiting factor for use of *Sesbania sesban* in improved fallows is its susceptibility to pests, e.g. root-knot nematodes, beetles (*Mesoplatys ochroptera*) and termites.

4.7 Live fences and hedges

These are barriers of closely spaced trees or shrubs to protect crops or structures against livestock and human interference. Live fences may be semi-permanent or permanent. Land-use patterns throughout the year should be considered before introducing a live fence. Live fences can be combined with other trees for production of wood and fruits.

Benefits

Fencing of fields, dimba (gardens), fodder banks, woodlots, paddocks and around homesteads makes improved management practices possible. With a fenced field, the farmer can improve his management of crop residues, pastures, trees, fallows, etc., by regulating access of livestock and people. Fencing and controlled grazing are the only ways that he and his cattle can benefit from such improved farming practices.

The use of live fences is a cheap method of fencing large areas because once the live fences become established they are permanent. Their establishment requires no expensive materials to be purchased and they are easy to maintain. Living fences may also give produce, e.g. fruits.

Criteria for selection of species

The species which are to be used for live fencing should be:
- Able to keep off livestock (thorny and/or densely branched)
- Easy to establish and maintain
- Able to withstand temporary waterlogging when planted in dimba
- Resistant to fire
- Able to provide useful by-products.

Recommended species

The following species are suitable for live fencing. Some of them are already being used by farmers for fencing their gardens and homesteads:
- *Agave sisalana* (Khonje, Gavi N)
- *Bougainvillea* sp.
- *Caesalpinia decapetala* (Chatata N)
- *Commiphora africana* (Chitonto, Mchovwe N)
- *Commiphora mollis* (Chololo, Chitonto N)
- *Cupressus lusitanica* (Cypress E)
- *Dovyalis caffra* (Kei apple E)
- *Euphorbia tirucalli* (Nkhadzi N)
- *Opuntia* spp. (Dorofiya N; Prickly pear E)
- *Ricinus communis* (Nsatsi, Tsatsi, Mono N)
- *Thevetia peruviana* (Yellow oleander E)
- *Ziziphus abyssinica* (Kankande, Mlashawantu N)
- *Ziziphus mauritiana* (Masau, Msau N)
- *Acacia polyacantha* (Ngowe N)
- *Lannea discolor* (Shaumbu N)
- *Solanum aculeastrum* (Katuntula, Ntuntula N).

There are other potential live fencing species which can be tested, for example:
- *Balanites aegyptiaca* (Nkuyu N)
- *Jatropha curcas* (Nyamukumanga, Chivumulu N)
- *Ricinodendron rautanenii* (Mkusu N)
- *Thyracantha* spp.

Establishment

The establishment method for live fencing must be simple and cheap. Direct seed sowing or use of cuttings (depending on the species) is primarily recommended, e.g. direct sowing of *Caesalpinia decapetala* (Chatata N) and use of cuttings for *Euphorbia tirucalli* (Nkhadze N). When direct seeding, sow more than one seed per station, the number depending on seed viability. The sowing depth should not be more than twice the diameter of the seed.

It is better to raise seedlings in nurseries for *Dovyalis caffra* and cypress since they have small seeds and are relatively slow in growth in the initial stage.

In dimba and other waterlogged areas seedlings or cuttings should be planted on ridges.

It is better to sow seeds and plant seedlings or cuttings in two staggered rows to make the fence or hedge impenetrable. The distance between the rows should be 15–30 cm. Spacing within the row varies between 15 and 50 cm depending on the species.

Management

- Protect the young seedlings against livestock and fires.
- Weed young seedlings.
- Replant (gap) the dead seedlings as quickly as possible to minimize gaps in the fence.
- Trim or prune to make a dense fence. Most species, e.g. Kei apple, make a better fence if trimmed to a pyramidal shape so that even the lowest branches can get some light.
- Apply manure/fertilizer if seedlings do not grow well or show other signs of nutrient deficiency.

4.8 Trees, shrubs and grasses on conservation structures

Trees, shrubs and grasses can be planted as biological soil conservation measures. Since trees alone can only be effective on slopes less than about 6%, it is important to combine trees with grasses for effective soil-erosion control, especially on steeper slopes. These trees, shrubs and grasses can be planted along or on marker ridges, level bunds, graded bunds, storm drains and buffer strips.

Benefits of trees on conservation structures

The main benefits are:

- Stabilization and preservation of soil-conservation structures
- Marking of the contour lines
- In the case of shrubs, acting as barriers to water run-off
- Provision of ground cover and fertility improvement through litter fall
- Provision of poles, fuelwood, timber, fruit and/or fodder.

Recommended species

- *Cajanus cajan* (Nyamundolo N; Pigeon peas E)
- *Carica papaya* (Papayi N; Pawpaw E)
- *Faidherbia albida* (Msangu N)
- *Leucaena leucocephala* (Lusina, Lukina N)
- *Psidium guajava* (Gwawa N; Guava E)
- *Senna siamea* (Makeche N)
- *Senna spectabilis* (Golden Cassia E).

Establishment

A single line of trees/shrubs should be planted along the pegged (marked) contour line or on existing physical structure.

Tees/shrubs may be established by direct seeding, cuttings or seedlings. The latter method is the commonest in Eastern Province.

Some of the recommended species and spacings for planting on soil conservation structures are listed in Table 4.1.

Table 4.1 Species and recommended spacing for planting on soil-conservation structures

Botanical name	Local name	Spacing	Comments
Faidherbia albida	Msangu	10–12 m	Can be combined with grasses, e.g. Vetiver grass at 15 cm apart between the trees
Cajanus cajan	Nyamundolo	50–90 cm	For barrier hedges. For food production, space widely
Carica papaya	Papayi	3 m 2 m	Combined with grass Without grasses
Senna siamea	Makeche	50 cm 2 m	For barrier hedges For production of poles/firewood
Senna spectabilis	Makeche	50 cm 2 m	For barrier hedges For production of poles/firewood
Leucaena leucocephala	Lukina	30–50 cm	For hedges
Pennisetum purpureum	Senjele (Napier grass)	20–25 cm	Can be cut and fed to livestock
Psidium guajava	Gwawa	4 m	For fruit production. Wider spacing when combined with grasses (6–8 m)
Vetiveria zizanioides	Kaluvela, Vuluvela	15 cm	Forms a good hedge for control of soil erosion
Mangifera indica	Manga	4–6 m	Dwarf variety can be closely spaced. Giant variety 10–12 m
Anacardium occidentale	Kashunati	4 m	Dwarf variety can be closely spaced. Giant variety 10–12 m

Management

The main management practices are side pruning, pollarding and coppicing. These practices aim at reducing the shading effect on crops as well as harvesting of tree products. The prunings from nitrogen-fixing trees may be incorporated into the soil for soil improvement or used as fodder. Others may be used as fuelwood or poles and timber. Shrubs can be pruned as hedges when they are more than 1 m high.

4.9 Trees in cropland

Some farmers in Eastern Province retain and sometimes plant trees in their cultivated fields for a variety of reasons, e.g. production of fruits, fuelwood or medicine, or other functions such as soil improvement, shade and various cultural uses. *Faidherbia albida is* suitable for intercropping with food crops and can grow to a large size.

Unlike other trees, it has leaves in the dry season and drops them gradually in the rainy season. Thus, there is limited shading of the crops during the rainy season, and it provides both fodder and shade for livestock in the dry season.

The leaves which fall at the start of the rainy season are a rich source of nutrients that improve soils and crops. Cattle also benefit from the pods which ripen and drop in October (up to 150 kg per tree). Cattle eat the fruit, enjoy the shade and drop their manure under the tree, which helps to add nutrients and humus to the soil. Because of the nutrients supplied by the leaves and the cattle manure, it has been reported that crops grown adjacent to these trees can give up to 60% increase in yields as compared with crops grown further away from the tree.

Benefits of trees in cropland

The benefits that may be obtained by having trees in the fields are:

- Improved soil fertility by converting atmospheric nitrogen to a form usable by plants and the decomposition of leaves and other residues to organic matter
- Reduction of soil erosion because leaf litter acts as mulch, conserves soil moisture, improves water infiltration and suppresses weeds
- Provision of fodder for livestock
- Provision of poles and timber
- Provision of fuelwood and medicine
- Improvement of the microclimate on cropped land.

Recommended species

Some of the common species found on cropped lands are:

Plateau area

- *Afzelia quanzensis* (Mpapa N) Timber
- *Pericopsis angolensis* (Muwanga N) Improves soil fertility, timber
- *Dicrostachys cinerea* (Kalumpangala N) Fodder
- *Diospyros mespiliformis* (Mchenja N) Timber, fruit
- *Mangifera indica* (Manga N) Fruit, shade
- *Piliostigma thonningii* (Msekese N) Improves soil fertility, fodder
- *Flacourtia indica* (Ntudza N) Fruit
- *Parinari curatellifolia* (Mpundu N) Fruit
- *Parkia filicoidea* (Mpeza, msenya N) Fruit
- *Pterocarpus angolensis* (Mlombe, mlombwa N) Soil fertility, timber
- *Strychnos cocculoides*(Mzai N) Fruit
- *Uapaca kirkiana* (Msuku N) Fruit
- *Ximenia americana* (Ntengele, matundulukwa N) Fruit.

Valley area

- *Acacia polyacantha* (Ngowe N) Improves soil fertility, fodder
- *Adansonia digitata* (Mlambe, mkulukumba N) Fruit, traditional value
- *Borassum aethiopum* (Chipamba, kakoma N) Fruit, fibre products
- *Faidherbia albida* (Msangu N) Improves soil fertility, fodder
- *Mangifera indica* (Manga N) Fruit, shade, shelter at night
- *Ziziphus mauritiana* (Masau N) Fruit, beer making
- *Sclerocarya birrea* (Mgamu, msewe N) Fruit, medicine.

Establishment

Trees can be established in cropland by direct seeding, wildings, seedlings and cutting, depending on the species. However, the most convenient method is to leave desirable trees when clearing land for agriculture, or if they are too few, to protect naturally growing seedlings, suckers or coppice shoots.

Spacing is determined by the size of the trees when they are mature in order to fit them into cropland with minimum negative interference with crop cultivation and production. Preferably, trees growing in cropland should be beneficial to crop growth.

Spacing

The trees may be scattered or spaced systematically. In the maize–sorghum-based crop-

ping system in the Valley, the tree density ranges from 2 to 40 trees per hectare for *Faidherbia albida.* For *Borassus aethiopum* some 10 palms per hectare are common.

Young seedlings should be established at the following spacings:

- 10 x 10 m or 12 x 12 m for *Faidherbia albida* and other species with a large tree canopy.
- 6 x 10 m or 6 x 12 m for other species with small canopies like *Parkia filicoidea* and *Uapaca kirkiana*.

On sloping ground, the tree lines should follow the contour so that crop ridges are aligned along the tree lines and thus on the contour.

Tall crops like maize should be planted at least 1 m away from the seedlings to reduce competition while the trees are young and to reduce damage during harvesting. When trees with dense shade, like mango for example, mature they will compete with light-demanding crops, and it is better not to plant crops under these tree canopies.

Management

Tree management will depend on the tree and crop species cultivated, but generally there is need to protect the young seedlings from livestock and fires, especially during dry seasons.

Trees intercropped with light-demanding crops like maize should be pollarded or pruned. Trees for timber and poles should be coppiced, e.g. *Pterocarpus angolensis*.

4.10 Beekeeping (apiculture)

Beekeeping is the art of keeping bees for production of honey and beeswax. Bees feed on nectar in flowers and since they carry pollen on their hairy legs when collecting nectar they pollinate crops like sunflower, mangoes, legumes, pawpaws and avocados. Good pollination increases crop yields of many crops. It has been reported that four well-managed beehives per hectare in a field of sunflower increase the yield of sunflower seeds by 15–20% (Paulick 1989).

The obvious advantage of beekeeping is that it does not require a big piece of valuable land and the labour requirement is low as bees do not need daily attention in order to produce well. Honey produced by bees is good food, good medicine and can also be sold.

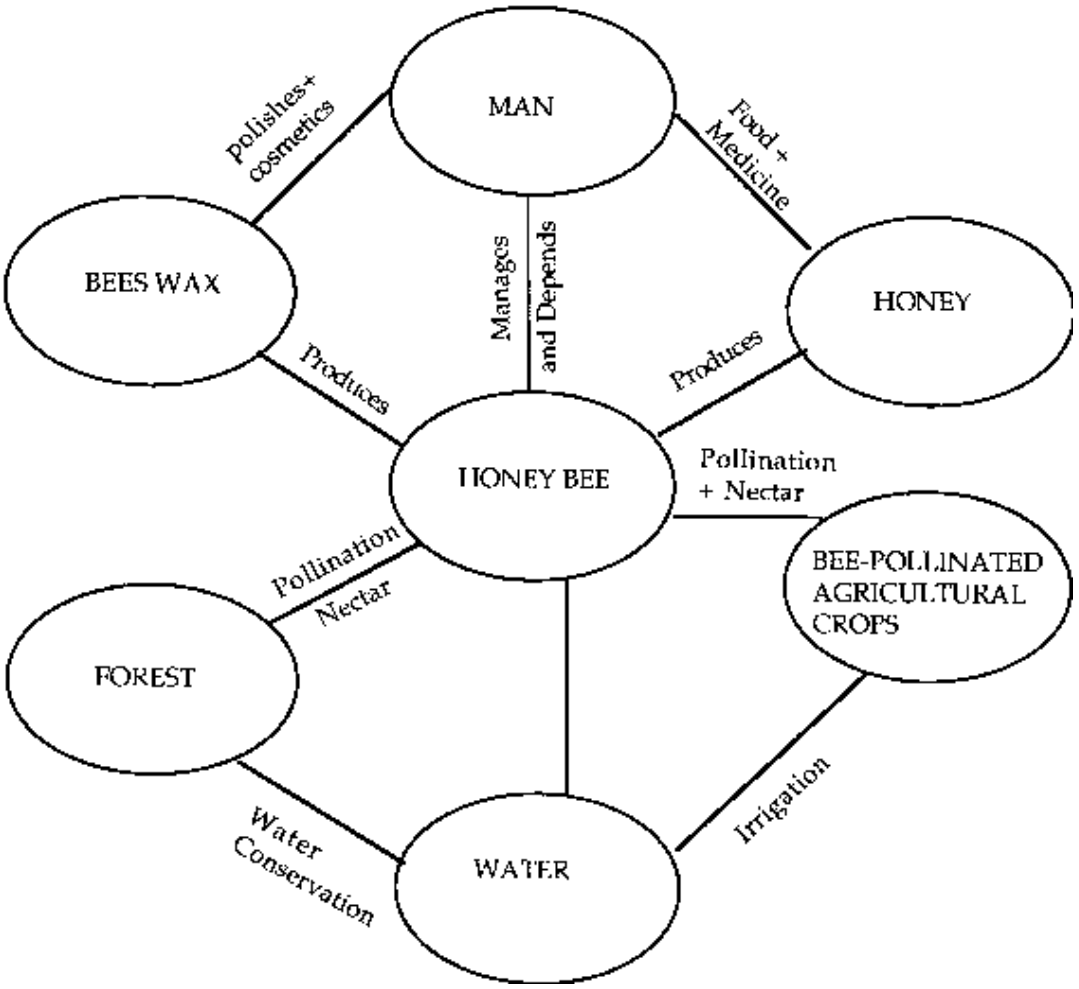
Bees play an important role in the ecosystem as illustrated in the diagram on the next page.

Benefits of beekeeping

- Provision of valuable food.
- Provision of income to the farmer.
- Improvement of crop yields through pollination and subsequently better development of seeds and fruits.
- Provision of incentives for protection of nectar-producing trees.

Uses of beeswax

- Cosmetics (perfumes, hair creams).
- Polishes.
- Candles.



The role of bees in the ecosystem

Uses of honey

- Food, sweetener, beverages.
- Cookery.
- Preservative.
- Medicinal uses:
  - For colds and sore throats, honey in lemon juice is soothing
  - Insomnia—drink honey with hot milk.
  - Fatigue—take a dessertspoon of honey when you are tired.
  - Germicidal—for dressing burns, cuts, abscesses, boils, etc.
  - Hangovers—honey combined with lemon juice is a good cure for hangover; 2 tablespoons in as much lemon juice as you like. It also acts as a preventive measure if taken before drinking alcohol.
- Cosmetics.
- Shampoo—2 tablespoons in a litre of warm water for the final rinse is said to preserve the colour of the hair.
- Skin cleanser—honey and warm water can be used to wash the face and neck. Rinse off with warm water.

Management of bees

Modern beekeeping is based on sound management techniques which can result in higher yields than the traditional methods.

Traditional beekeeping is based on bark hives, but trees are ring-barked when making bark hives and this leads to destruction of species such as *Julbernardia paniculata* (Mtondo N) and *Brachystegia* spp. (Muombo, mputi N) which are good nectar producers. The following are some of the hive types which are not destructive to the trees: calabashes, oil drums, baskets and frame hives. Frame hives produce more honey than bark hives. The average yield of comb honey per bark hive is only 8 kg, whereas frame hives can yield up to 20 kg per season. Modern methods of beekeeping should be encouraged.

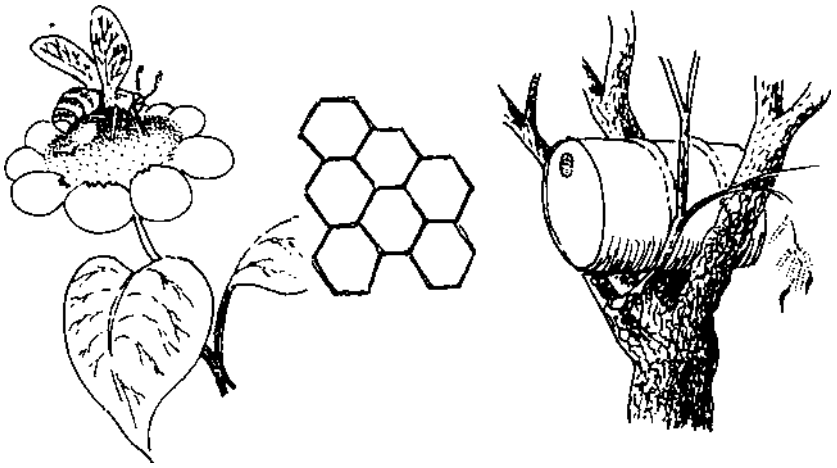


Figure 4.5 A foraging bee and a beehive made from an old oil drum

The apiary

For effective management hives should be located at a clearly designated area, with one or more hives, called an apiary. The number of hives in the apiary will depend on the capacity of the individual to handle the task.

Siting an apiary

- Should be sited within 2 km of nectar-producing plants.
- For safety reasons, the distance between the apiary and public places like markets, villages and schools should be at least 100 m and at least 50 m from homesteads.
- The site should be protected from adverse weather conditions such as excessive humidity, cold, strong winds and heat.
- Water should be available within a 500 m radius.
- Hive stands (bushes or trees) should be available for hanging the bee hives.

Baiting hives

New hives must be baited in order to attract bee swarms to occupy them. Beeswax is the most suitable baiting material. Smoke or heat the hive and hold a block of beeswax close to the flames and rub the molten surface of the block all over the inside of the hive. Heat the hive further to ensure that the wax penetrates into the hive walls.

"Bee glue" (propolis) can also be used for baiting.

Hanging the hives and occupation by swarms

Hives should be hung shortly before the swarming season. The swarming season in Zambia is between August and October and February and April. The hives should be hung above 4 metres in the forest or woodlands where you get good occupation.

Important species for honey production are listed in Table 4.2. If hives are located where these trees occur the chances of a good harvest are high.

Table 4.2 Important tree species for honey production

Botanical name	Local names
Acacia spp.	Ngowe, mtubetube, nyafungu
Albizia antunesiana	Msase, chisale
Brachystegia spp.	Mufundanzizi, muombo, msamba, muputi
Burkea africana	Kawidzi, mkoso
Citrus spp.	Lalanje, ndimu
Eucalyptus spp.	Bulungamu
Julbernardia globiflora	Kamponi
Julbernardia paniculata	Mtondo
Kigelia africana	Chizutu, mvungala, mvunguti
Parinari curatellifolia	Mpundu
Syzygium cordatum	Mchisu, msombo
Tamarindus indica	Bwemba
Ziziphus mauritiana	Masau

In low and sparse woodland, cultivated and fallow areas the occupancy rate will be good at any time. Cylindrical hives may be placed in the fork of a branch, or on top of large branches, and tied with bark fibre or suspended from a bark rope or wire attached to a strong forked stick which is hooked over a branch.

Table 4.3 Beekeeping calendar

Month	Floral activity	Bee activity	Beekeeper's activity
June	Few flowers	Little activity	Feed bees with sugar syrup under extreme conditions
July	*Parinari curatellifolia* *Syzygium cordatum* and *Uapaca kirkiana* start flowering	Breeding starts and builds up during the month	Start preparing new hives; supply water near occupied hives
August	*Brachystegia* spp. start flowering together with other species	Breeding continues rapidly and swarming occurs	Hang and bait new hives for occupation
September–mid-October	*Brachystegia* in full flower	Breeding slows and surplus honey stored	Protect hives against termites and honey badgers
Mid-October –November	Few trees in flower	Breeding stops and then starts again at low level	Cropping of honey and processing of beeswax
December–February	Few trees but rather more herbs in flower	Breeding still slow	Cropping continues on small scale
February–March	*Julbernardia* starts flowering	Rapid build up and swarming	Maintenance of old hives. Hang and bait new hives and re-bate old hives
March–April	*Julbernardia* in full flower	Breeding slows and honey surplus stored	Cropping can be done depending on the availability of honey in the hive
May–June	Little flowering	Little hive activity	Clean the apiary early. Inspect hive for diseases and pests. Repair and maintain beekeeping equipment

Note: For more information on beekeeping, contact the nearest Forest Officer.

Cropping

The honey should be cropped at the end of the flowering season, which varies from one area to another depending on the tree species. Generally, however, cropping takes place in October and November in *Brachystegia*-dominant forest areas and in May and June in *Julbernardia*-dominated woodlands.

Cropping should be done early in the morning or in the late afternoon when it is cool and the bees are confined to their hives. The beekeeper should prepare the following equipment for cropping traditional hives:

- A container in which to put the honey
- A piece of rope for lowering and mounting the hive
- A smoker to subdue the bees (the traditional type made of a core of dry twigs wrapped around with a layer of fresh leafy branches is sufficient)
- A cropping knife
- A brush for removing bees from the honeycomb
- Protective clothing (veils, overalls, gloves, safety boots)
- At least one helper.

After the equipment has been organized, prepare the smoke and blow a moderate amount through the flight entrance of the hive. The bees will be driven to one side of the hive. Remove the grass door and start removing honeycomb while continuing to blow in small puffs of smoke. Continue cropping until you reach the brood area. Leave enough honey for the bees themselves to feed on, otherwise they will abscond to a new home. After cropping, replace the hive door and mount the hive in its usual position.

Honey processing

Honey processing starts with grading. During this process, all impurities such as pollen, dead bees and other debris should be removed so that only sealed combs (also known as ripe honey) remain. After grading, the honey is extracted as follows:

- Break up or crush the combs and put the pieces into a container
- Put the crushed combs into a honey press with a clean cloth or mesh wire inside
- Apply pressure on the combs to extract the liquid (home-made sieves and strainers can also be used)
- Heat the pressed honey to liquify, strain, settle and then bottle it. (Do not place the honey directly on the heat, place it in another container filled with water.) The honey is ready for sale.

Ungraded honey can be consumed at home or made into honey beer (*imbote* B) for sale. How much processing is carried out on the honey depends on the type of market and demand.

Processing of beeswax

After extracting the honey, the combs are processed into beeswax, another valuable bee product. The process involves heating and filtering. The following are the basic equipment and materials required:

- Two containers to heat the combs and half-cleaned wax
- Two straining containers
- Two pieces of sacking or calico material for straining
- A piece of rope for squeezing out the wax
- A piece of soap or detergent.

The process is as follows:
- Put the combs into a container
- Fill the container with an amount of cold water equivalent to the amount of comb
- Heat the mixture to just below boiling point and stir continuously until the mixture is like soup
- When all the wax is melted, pour it onto the straining material held over a container by two helpers
- The third person ties rope around the lump of beeswax, twists and squeezes out the molten wax
- Leave the mixture to cool and a solid layer of wax will float to the top of the water
- Break the cake of wax into a clean container and add a few drops of water. Repeat the heating process until you get a clean cake of beeswax.

Marketing of honey and beeswax

Honey and beeswax are valuable commodities with ready local and export markets. In addition to honey, eaten as a food and for making beer, brood (the bee larvae) is also eaten by some people and said to be very nutritious. The value of honey and beeswax can be increased through processing. Beeswax can be used to make polishes and candles, which can be sold locally.

4.11 Sustainable management of miombo woodlands

Miombo woodlands cover most parts of the plateau of Eastern Province. Currently they are being extensively exploited for agricultural production, fuelwood, food and timber without any proper management system.

In this chapter sustainable management means wise utilization of the woodlands for the benefit of present and future generations. The woodlands have to be managed in such a way that the needs of different people in the community are met.

Traditional leaders have an important role to play in mobilizing the local people. The forests can only be effectively managed if the local people are fully involved in the planning and management process. In Chipata, Paramount Chief Mpezeni has made rules to protect the hill catchment areas at Indaba and Luangeni villages, while in Lundazi, Senior Chief Mwasa has protected the forest at Nthakalavu. These examples demonstrate how effective traditional leaders can be in conservation of natural resources.

The following guidelines are meant to assist extension officers in encouraging farmers and the local community in managing the woodlands sustainably.

Harvesting techniques

The trees can be cut selectively or clear felled.

Selective felling

This is the common form of harvesting selected tree species for a specific use, e.g. poles, timber and firewood. However, selective cutting creates uneven gaps in the tree canopy and natural regeneration is irregular. Selective felling may also endanger certain valuable species, e.g. *Pterocarpus angolensis* (Mlombe N), since such species tend to be cut more often than other species.

Adjacent trees should be cut to create gaps with little shade on the stumps and young seedlings. This will ensure good regeneration either from stumps (coppices), roots or seeds.

Clear felling

This harvesting technique involves the removal (felling) of all the trees in a given area. This is the best method of encouraging coppicing of stumps and sprouting of seedlings.

Clear felling should be designed in such a way that huge areas are not cut at once. Instead, strips alternating with shelterbelts should be cut. The strips and shelterbelts should be at least 30 m wide. The shelterbelts will serve as seed sources for regeneration in the cleared areas.

Cutting/felling height for stumps

In order to encourage good shoots from the stumps, trees should be cut 30 cm above ground. The stump should be trimmed at an angle to prevent water collection and rotting.

The best time for coppicing miombo species in Zambia is between September and October (Chidumayo 1996).

Rotation

Table 4.4 shows the rotation periods (time between clear felling) in miombo woodlands based on Chidumayo's recommendation. Cutting of small poles may have the same effect as thinning. The dense stands of trees should be thinned to promote good growth of the remaining trees.

Table 4.4 Types of forest product/size

	gbh (cm)	Rotation period (years)
Small poles	12–25	10–20
Medium-sized poles	26–38	21–30
Large poles	39–63	31–50
Sawn timber	> 62	> 50
Firewood (pole size)	12–63	10–50
Charcoal (large pole)	39–63	31–50

Note: gbh (girth at breast height) is girth 1.3 m above the ground

Harvesting roots

This is mainly done to obtain material for medicinal purposes or dyes. Lateral roots should only be harvested from one side of the tree or shrub to ensure that the plant does not die. The remaining roots should be buried and not left exposed to the sun. The taproot should not be removed.

Harvesting bark

Bark should be harvested in long vertical strips; ring-barking should always be avoided as ring-barked trees usually die.

Grazing and browsing by livestock

Grazing areas should be well managed to ensure that they are not overgrazed. Rotational grazing should be encouraged in order to prevent mortality of preferred browse species.

The following trees could occasionally be coppiced at about 1 m height so that the animals can browse the fodder easily:

- *Baphia bequaerti* (Mbuwu N)
- *Brachystegia floribunda* (Mvukwe, Msamba N)
- *Brachystegia spiciformis* (Mputi N)
- *Diplorhynchus condylocarpon* (Mtowa N)
- *Isoberlinia angolensis* (Kapane, Msanganza N)
- *Julbernardia globiflora* (Kamponi N)
- *Julbernardia paniculata* (Mtongo N)
- *Parinari curatellifolia* (Mpundu N).

Conservation of catchment areas, streams banks, hill slopes

Trees need to be well protected for water- and soil-erosion control in these areas. No cultivation should be allowed near stream or river banks. Where cultivation is done near streams, only perennial crops should be cultivated.

The conserved woodlands can be utilized economically by exploiting non-woody products like honey, mushrooms and fruits. All these products are in high demand in Eastern Province.

Management of fires

Fire is the most important management issue in the miombo woodlands of Eastern Province. The major cause of the late fires is mice hunting. Young seedlings and shoots are killed by late fires.

In order to encourage natural regeneration of trees, controlled burning should be encouraged in villages. The forests should be burnt during May and June when the vegetation is partially dry. The slash from the felled trees should be collected and stacked at least 2 m away from live stumps before burning the forests.

5

EXPERIENCES IN AGRICULTURAL AND FORESTRY EXTENSION IN EASTERN PROVINCE

5.1 Historical background

In 1925, the colonial Government in Zambia set up the Department of Agriculture in order to address growing problems related to land use. Investigation of erosion, both in the Native Reserves and on Crown Lands, was high on the agenda. The methods used at the time to combat erosion were taken from the United States and the emphasis was on physical measures and very little on agronomic measures. The strategy was applied in a harsh manner and, as a result, was not successful because it was seen as an imposition on the people. Failure to adopt the measures ordered resulted in punishment, and very few people understood the benefits of soil conservation.

The Forestry Department was established in 1947. The major function of the Department was to protect and manage the forests for supply of timber to the mines and the local industries. After Independence, very limited changes were made to the Forest Act in order to involve the local community in the management of the forests. The community looked upon the forest estates as belonging to the Government and foresters as policemen who prevented them from collecting forest produce.

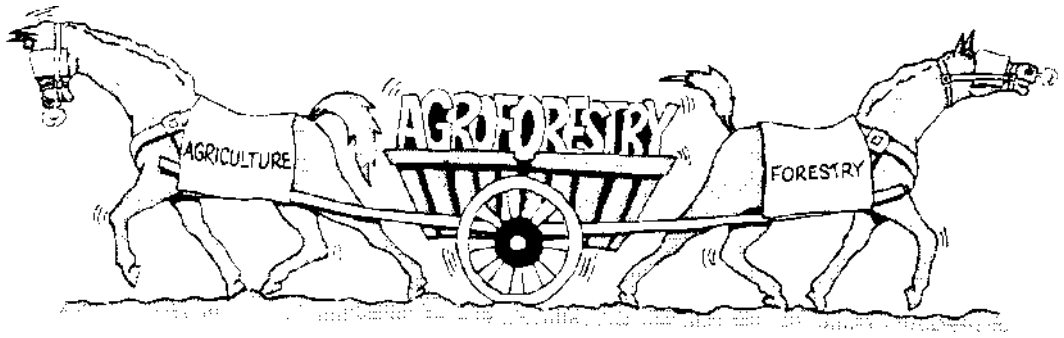


Figure 5.1 Agroforestry does not have to be a tug of war

5.2 The extension challenge

Extension is a term that has long been used to describe a non-formal education system aimed at improving the livelihood of farmers and their communities. Although various incentives, e.g. free tree seedlings or subsidized inputs, may be part of an extension system, the core activities in extension are education and training.

Sim and Hilmi (1987) used the term "forestry extension" to cover any situation in which local people are directly and willingly involved in forestry activities and from which they will derive some recognizable benefit within a reasonable period of time. These authors felt that too often in the past extension has been regarded as a means of passing down to farmers techniques which, it was believed, would be beneficial to them without taking into account sufficiently the particular social or environmental conditions of the area concerned. In particular, too often, the indigenous skills, social structure and detailed local knowledge of the people have been ignored in trying to transfer new skills or techniques to them.

Fortunately, extension is now being regarded as a much wider task of integrating indigenous with new skills and techniques through discussion and co-operation between the people and the extension organization.

The challenge for agricultural and forestry extension, therefore, is to address issues related to land management so that people can realize higher yields and higher income in both the short and long run. Farmers should not be regarded as targets for dissemination of technologies, but rather as partners to be involved in identifying their own problems and developing appropriate technologies for addressing those problems.

Figure 5.2 Farmers can be reliable sources of information provided you have gained their trust and understanding

5.3 Actors in extension

Farmers

The beneficiaries of an extension system should be the farmers in a given area. Indigenous technical knowledge is very important for both extension workers and researchers. Ideally, farmers should interact with researchers in on-farm research; thus farmers are a resource for extension and research, and vice versa.

Chiefs

Chiefs are hereditary tribal leaders in charge of specific tribes and they are very influential in their communities. Under the Chiefs are the Village Headmen who look after certain sections of their communities and advise the Chiefs in matters relating to land allocation and settling of disputes. Thus the Village Headmen also command respect and all such local leaders must be taken into account in the provision of extension services to their subjects. Before an extension worker goes to the people in a locality these leaders must be consulted and the proposed interventions explained and discussed. In this way, the extension worker will be treated as a friend and not a foreigner by the Chief, Headman and community.

A good example is in Chief Mwase's area in Lundazi where improved land-use technologies are being adopted because the Chief himself is actively taking part in the identification of problems and in technology development. Chief Mwase is convinced that extension efforts are important because he has travelled widely in Zambia and Malawi and has seen the effects of soil erosion and uncontrolled cutting of trees there.

Figure 5.3 An enlightened Chief asking his people for their views on local land-use problems

Extension officers

Agricultural extension has many roles to play in agricultural production and these roles may vary among the individuals performing such duties. Extension work is a dynamic process and, therefore, there is no single role for an extension worker. The list below gives some of the tasks that should be performed by extension officers:

Provision of information

Information is a vital resource which an extension worker provides to an individual or group of farmers. This information can either be appropriate or inappropriate depending on how the client perceives it.

Identifying and solving problems

Extension officers identify and solve problems with farmers. If an extension system does not make provision for farmer participation, then very little can be achieved by way of identifying problems and solving them.

Training of farmers

Improved technologies that have been developed must be passed on to farmers in ways that encourage them to adopt them. At the same time, extension officers must recognize that farmers also have their own prior knowledge and skills which must be taken into account in any training efforts.

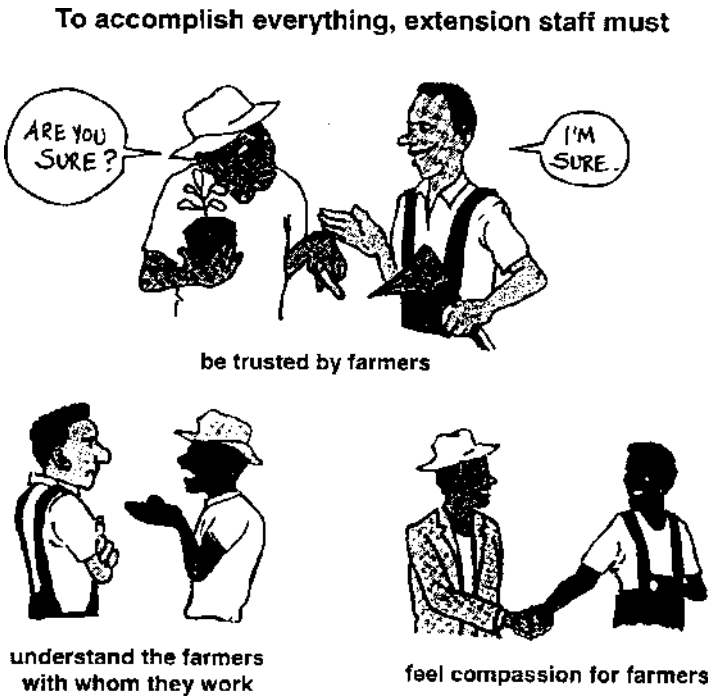


Figure 5.5 Extension workers should have a good relationship with farmers

Non-governmental organizations

Non-governmental organizations (NGOs) are important as their operations are often aimed at raising the standard of living of the rural poor. Several NGOs have personnel operating in remote and rural areas. In Eastern Province the NGOs do not operate in isolation but co-ordinate with research and with the Extension Branch of the Department of Field Services. NGOs that work with the farmers, sometimes in the absence of adequate Government extension personnel, play an important role in bridging gaps between farmers and researchers.

Figure 5.5 A village meeting with a woman extension worker

Researchers

Researchers develop technology for farmers to adopt. A farmer is a rational human being who is always searching for useful innovations and new knowledge. Research which is not farmer driven may not yield appropriate results. Research should, therefore, allow farmers to participate in identification of problems to be researched on. Farmers are also researchers on their own.

5.4 Recent extension strategies in Eastern Province

Extension planning

A basic fault in the conventional approach to development is that the rural poor are rarely consulted in development planning. Many technologies that are developed without the participation of the people turn out to be inappropriate, or fail to be adopted.

In any community, individuals and groups interact through dialogue and this also applies to outsiders. Each time a previously unknown person approaches a community, initially that individual is treated with suspicion. In order to remove this suspicion, extension workers should first carry out a participatory rural appraisal (PRA) in order to identify farmers' problems. Extension workers should allow the farmers to prepare maps, seasonal calendars, charts and trend lines.

Through PRAs, people's preferences can be identified. As far as tree growing is concerned, the community will indicate what tree species are useful for them both economically and socially. There has been growing interest in planting *Gmelina arborea, Senna* spp., *Melia azedarach,* indigenous species like *Khaya nyasica* and fruit trees like *Ziziphus mauritiana*.

A problem which may be identified as a result of PRA may be poor soil fertility. In this case, people should be guided as to how to increase fertility in soils. Here research would play a major role in screening tree species that can improve soil fertility.

In some parts of Eastern Province crop production is based on ox cultivation. It may be that the system is being limited by a lack of fodder during the dry season and, if so, extension and research should focus on tree species for fodder. Improved fallows using *Sesbania sesban* have become very popular because they have demonstrated the potential for improving soil fertility in degraded areas.

Communities have different beliefs about the trees that grow around them, and if they do not participate in problem identification and technology generation there may be conflicts with their customs. If that happens the technology will become a non-starter.

Gender sensitivity is of paramount importance. For example, only women go out looking for firewood for cooking. In an area where firewood is a constraint, a priority should be helping women to avoid having to walk long distances in search of fuelwood.

Figure 5.6 An extension worker acquainting himself with community needs

The approach that has been used in Eastern Province in the promotion of technologies is a liberal one where people are not forced to take up certain technologies but are given a choice. An adventurous farmer will always want to be updated on the latest information. When people are exposed to new ideas or techniques they become curious to know why there are differences between what they do and what others do.

Some hints for good communication

- Tell farmers why you are there.
- Do not write a lot while discussing.
- Do not act as an officer—you are now a learner.
- Accept local names of trees. Find out later which are the corresponding botanical names if needed.
- Stay longer with those people showing interest.
- Follow local customs and try to make people feel comfortable.
- Give positive feedback during the interview.
- Be flexible and allow the discussion to go beyond the questions that you had Intended to ask.
- Avoid challenging or too personal questions.
- Do not ask questions when the answer is obvious:
  'Do you have Napier grass?' when you are standing beside it. If you can see do not ask.
- Concentrate on the discussion. Do not look around admiring cows or whatever. Such behaviour gives an impression that you are not serious.
- Do not start lecturing. Remember, you are a learner.
- Observe whether the farmer has time or not. Minimize disturbance.
- Eye contact is important, but if you are too direct, thefarmer may feel uneasy.

Extension organization

Extension is not static but dynamic. This calls for the extension service to use more than one method to attract the interest of farming communities. The Training and Visit (T&V) system, in which an extension worker dealt with contact farmers and the contact farmer would pass on a technology to a non-contact farmer, was, on the whole, a failure. One factor which may have been overlooked in the T&V system was the rural structure of the community. Often Chiefs, Village Headmen and other leaders were not consulted or kept informed. This failure has led to a modification of the approach.

In the hope that this will make the extension service more effective, extension workers are now addressing farmer's groups instead of contact farmers. The individual farmers chosen to disseminate information are not selected by the extension workers themselves but are elected by the community and therefore they do not discriminate against individuals on grounds of gender or status. Groups or villages have come together because they have a common goal. These groups have proved to be more effective in the diffusion of agricultural and forestry information. This approach that has been developed because of the unsatisfactory results from T&V is called the Zambia Structured Extension and Training system (ZASET).

In ZASET, field extension workers have divided their areas into eight zones which they visit on a fortnightly basis. During the visits, farmers' problems are identified and those that can be solved by the field extension worker are attended to there and then, whereas those that are difficult are referred to the Block Extension Officer. Sometimes the Block Extension Officer may not have the answers. If so, the problem is referred to a District subject-matter specialist in that field. If such problems are common and persist, a course, which can be either mobile or residential, may be conducted.

By definition, communication is a two-way process requiring feedback. To achieve this two-way communication, monthly or quarterly training workshops are conducted at District level. In these workshops field staff report on their experiences in the field and the problems they face. These can be dealt with at length and answers are provided by the specialists. These meetings and workshops are held together with the Farming Systems Research Team, commodity research teams and extension officers. Researchable problems are identified and included in the research protocols.

During the planning process, and later in the implementation of various activities in the community, the stakeholders have roles to play. It is imperative that institutions related to extension co-ordinate effectively.

Linkages

With the introduction of District Agricultural Committees in every District, co-ordination has become a little easier than before. Each committee is composed of farmers, representatives of farmers' associations, the private sector, NGOs, researchers and extension workers.

Each Province hosts consultative workshops for promotion of agroforestry technologies twice a year, in March and September. In these workshops, the participants assess performance in promotion of agroforestry technologies in all areas of the Province. For example, improved fallows and any increase in the number of people establishing woodlots is assessed. In addition, other research extension meetings are held with farmers and NGOs also participating.

In Eastern Province a dissemination network has been set up which includes World Vision International (WVI), Lutheran World Federation (LWF), the Reformed Church in Zambia (RCZ), Farming Systems Research (FSRT), farmers' groups and Government departments, i.e. Field Services, Forestry and Natural Resources. These organizations are working together to set up demonstrations in the training centres and on farmers' fields. A multi-disciplinary approach involving the Departments of Forestry, Agriculture and Natural Resources has been used since 1986. This has reduced conflicts in information dissemination to the farmers and has harmonized planning.

Some constraints and remedies in extension

The extension services may not benefit many people in the community because at the moment the extension worker–farmer ratio is about 1:800. This simply means that there are too few extension staff compared to the number of farmers they serve. The presence of the NGOs in the field mitigates the shortfall to some extent.

To have a sound and reliable extension service, there must be strong links between research, extension, NGOs and farmers. Farmers must not be passive but active participants in finding solutions to the problems affecting them. Political and traditional leaders must participate in the dissemination of information to the community to which they belong. Participatory methods are effective in identification of problems people face. It is during these participatory meetings with farmers that they must be helped to realize the reasons for encouraging tree growing.

Many agricultural extension workers lack knowledge in forestry, and there is, therefore, a need for additional training. Training on topics such as nursery management, pest and disease control and general tree management is useful.

5.5 Extension methods in Eastern Province

Popularization campaigns

There is an assumption that the various communities are knowledgeable about the use of trees. This assumption can be true to a certain extent, but not many people have detailed knowledge about tree growing. It is, therefore, imperative that extension services, in liaison with other interested parties such as NGOs and other departments, take deliberate steps to carry out campaigns on tree growing. Campaigns are most important in areas which have been depleted of trees. Leaflets, video shows, drama performances, songs and

other methods can be used to popularize tree growing. Under the Soil Conservation and Agroforestry Extension Programme, such methods have been used extensively.

Training of farmers

After the community has been sensitized about tree growing, and enthusiasm and interest have been generated, training follows. Leaders such as Chiefs, Village Headmen and local politicians play an important role in this, and for extension to be effective these people need to be trained and sensitized.

The Extension Branch of the Department of Field Services has at least one Training Centre in each District and a Farm Institute in Chipata. These centres are used to train farmers by conducting one- or two-week specialized courses in various technologies. Farmers are selected for the courses on the basis of identified priorities or problems. For example, nursery management could be a subject to be tackled if farmers in an area wish to establish woodlots. Such recruitment ensures that people are trained to adopt technologies that are appropriate to their farming systems.

Farmers who may not benefit from the residential courses can instead attend three-day mobile courses that are conducted in the Districts. These mobile courses have proved popular and attract a lot of people.

The group approach

Since there are many farm families to be covered by one extension worker (e.g. in Chipata South the ratio is 1:1,020 per camp), substantial resources would be required to serve all farmers. Addressing a group rather than individual families reduces costs, increases coverage and encourages the formation of local groups, which in turn empower farmers to stand on their own feet.

Figure 5.7 A group meeting

The school approach

Schools have taken an active role in the establishment of school nurseries and woodlots. If young boys and girls are convinced of the benefits, they may be able to persuade their parents to adopt new technologies. In Eastern Province, agricultural extension workers, with assistance from the Department of Forestry, are providing agroforestry training in

schools. The Soil Conservation and Agroforestry Extension Programme is promoting the establishment of nurseries and woodlots in schools, and these can act as demonstration plots for the surrounding villages, thus creating awareness and interest in the community. A school tree-planting competition organized by the World Life Conservation Society, Chipata Branch, in conjunction with the Departments of Agriculture, Forestry, National Parks and Wildlife Services, has raised interest in tree planting in schools. The prizes range from a three-day game-viewing trip to South Luangwa National Park to ballpoint pens and exercise books. Survival rates of trees in schools have gone up as a result of this improved management.

Study tours

These provide opportunities for dissemination of information from farmer to farmer where individuals and groups learn from each other. Through study tours, farmers are exposed to new ideas in practice, e.g. through visits to research stations where they see on the ground what type of research is being undertaken.

Demonstrations, farm visits, field days

Schools, individuals and groups of people have set up woodlots, nurseries and improved fallows with the help of NGOs, extensionists and researchers. These can act as demonstrations.

Figure 5.8 An extension officer demonstrating how to plant trees

Drama

Drama is also used in extension to sensitize farmers to the latest agricultural technologies. Voluntary drama groups are encouraged where members participate in problem identification in a community. The identified problem is dramatized in the same community so that people can see for themselves. This is an approach which people like and it has become popular in many communities.

Posters, newsletters and bulletins

Posters, newsletters and bulletins are also used and distributed to the farming community. This, however, has only worked when funds are available for the production of

such materials and the language level and layout used make them suitable for the target groups concerned.

Radio programmes

Radio programmes may also play a role in technology dissemination, but of course are only relevant where people own radios or have access to them in public places.

6

SEED COLLECTION AND HANDLING

The following activities are involved in seed collection and handling:
- Selection of seed provenance
- Selection of mother trees
- Seed collection
- Seed extraction
- Seed storage
- Record keeping
- Pre-sowing treatment
- Inoculation.

6.1 Selection of seed provenance (seed origin)

Provenance means the place or site from which seed is collected. A good provenance is just as important as the choice of species. Seed should be collected from trees that are growing under similar agro-ecological conditions to those where the seeds will be eventually sown. This will ensure that the trees are adapted to the physical conditions of the new environment. It is therefore advisable to collect seeds from an area with similar altitude, temperature range, rainfall, humidity and soils. Often the best option is to collect seed in the locality where the seedlings are to be planted.

6.2 Selection of mother trees

A mother tree is a tree from which seeds and other planting material are collected. In a natural or man-made stand, some trees are of superior quality to others. Seed should be collected from the best individual trees which have good-quality disease-free seeds.

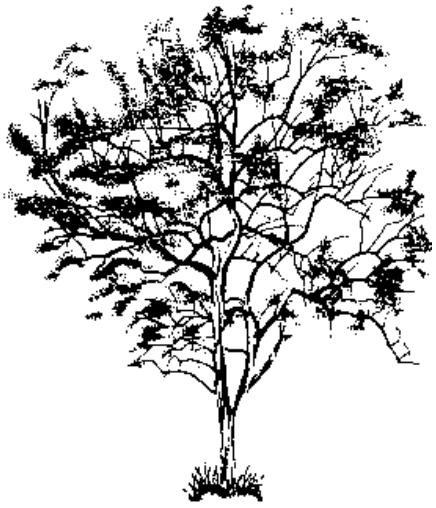
Seeds from straight and vigorous trees will most likely produce straight and vigorous trees, while twisted or stunted trees may produce trees with those same poor characteristics.

Selection of mother trees will depend on the end use:

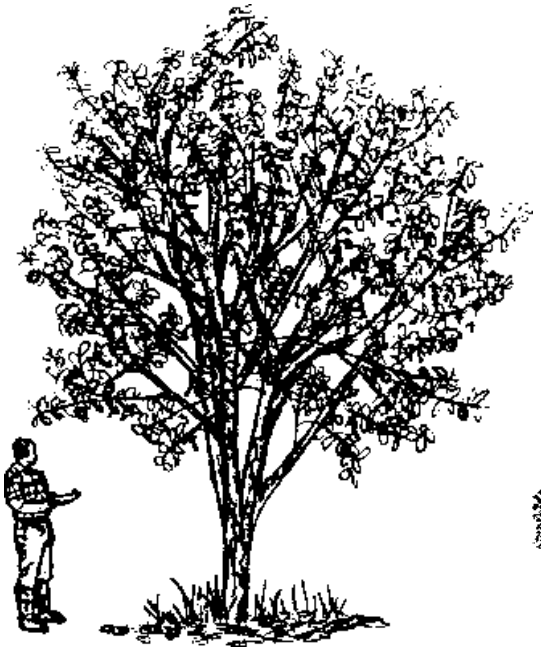
- For live fencing: shrubs or trees with dense or thorny branches.
- For timber: very straight trees with few branches
- For fodder: trees with palatable, dense foliage and/or pods
- For fruit: trees with good quantities of sweet, healthy fruits of marketable size.

Trees with early branching are preferable since it is easy to pick fruits from low branches. Fruit trees like oranges, should be budded or grafted in order to obtain better yields. In that case, buds or grafting material should be collected from good mother trees.

A good timber mother tree



A bad timber mother tree



A healthy fruit mother tree

A good fodder mother tree

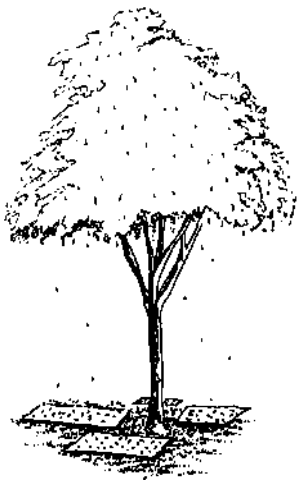
Figure 6.1 Selection of the right kind of mother tree

6.3 Seed collection

Seeds should be collected from ripe or mature fruits, cones or pods which are disease free. In order to provide genetic variation, a seed sample should consist of seeds collected from as many trees as possible. For commercial nurseries, for example, seed should be collected from at least 25 trees.

Different tree species require different seed-collection techniques depending on the nature of the seed. The best way of collecting most seeds is to harvest the pods or fruits when they are ripe but before they open and fall to the ground. Some large or hard-coated seeds and fruits can, however, be collected after they have fallen to the ground. Some ripe seeds remain on the tree for some time which allows for collection from the crown. Others are dispersed by wind so they can only be collected on the trees before they are blown away. Yet others fall to the ground while still fresh and sound, allowing collection from the ground. Each of these ways of collection has advantages and disadvantages.

Collection from the ground is cheap and easy but there is competition from seed eaters. Clear the ground below the tree of bushes and weeds. Newspapers or sacks can be spread around the base of the tree so that the seeds fall on them and can be collected easily. Seeds and fruits should be collected immediately they have fallen to reduce insect or animal damage. In some cases, pods, fruit or seeds may be dislodged by shaking or beating the branches, as with *Faidherbia albida* (Msangu).



Sacks spread around the tree to collect falling seed

A farmer shaking a tree to knock down the seed

Farmers beating branches to dislodge the seed

Collecting seed from the ground

Figure 6.2 Methods of collecting seeds from a tree

6.4 Seed extraction

Once the pods, cones or fruits have been collected, the seeds should be extracted. Various extraction methods can be employed depending on the species, amounts of seed required and the resources at hand:

- Threshing
- Depulping by soaking in water
- Hand extraction

Threshing

Threshing is an operation to extract seeds from pods or cones. A common procedure is as follows:

- Dry the pods or cones in the sun until they begin to open
- Put the pods and cones into a sack immediately they begin to open
- Beat the sack to extract the seed from the pods or cones
- Remove the seed from the sack and clean it by winnowing.

Examples of seed that can be extracted in this way are:

- *Sesbania sesban*
- *Acacia* spp.
- *Faidherbia albida*
- *Senna* spp.

Figure 6.3 Extracting seed by threshing

Depulping by soaking in water

Depulping is the removal of the fleshy part of the fruit (pulp) from the seed. Depulping enhances the germination capacity of seeds since the pulp contains inhibiting chemicals that induce dormancy. Depulping and extraction of seeds (both pulpy and non-pulpy) also makes it easier to dry, sort and clean, store, distribute and sow the seed. The recommended procedure is as follows:

- Soak the pulpy fruits in a container of water in a proportion of about 1 part of fruit to 3 parts of water to ensure that there is an adequate amount of water remaining after absorption has taken place
- Leave the pulpy fruits in water for a day or two. Change the water daily if the fruits are left in water longer than a day
- Remove the pulp by hand
- Remove and throw out any floating seeds (this means they are empty)
- Dry the remaining seed in the sun.

Figure 6.4 Removing the pulp

Examples of seed that can be extracted in this way are:

- *Azadirachta indica* (Neem E)
- *Dovyalis caffra* (Kei apple E)
- *Gmelina arborea* (Malaina N)
- *Syzygium guineense* (Katope N)
- *Melia azedarach* (Persian lilac E).

Some pulpy seeds should not be stored, e.g. *Azadirachta indica* (Neem E), *Bridelia micrantha* and *Syzygium* spp., because they lose viability very fast.

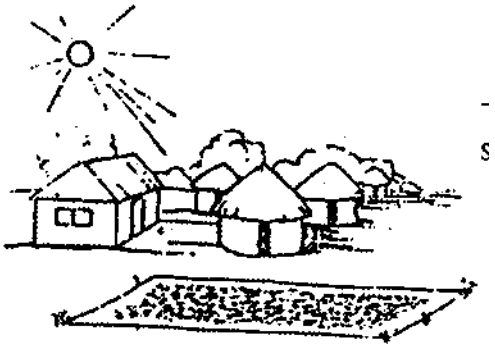


Figure 6.5 Drying seed in the sun

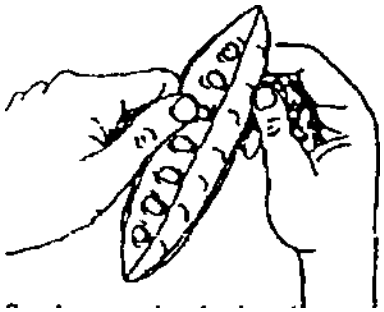
Hand extraction

Seeds can also be extracted manually:

- Dry the fruit in the sun
- Use your fingers to open the pod or fruit and remove the seed.

This is an alternative method to threshing, which can be applied to the same species but, of course, is time consuming if large amounts of seeds are to be dealt with.

Figure 6.6 Extracting seeds by hand



6.5 Seed storage

Whenever it is not possible to use the seeds immediately, store them in containers such as tins, bottles, plastic packets or boxes which are rodent proof. Stored seeds should be thoroughly dry. The best place to store the seeds is in a refrigerator. If no refrigerator is available, hang the seed containers from the ceiling or roof using a rope or string so they cannot be reached by rodents. The lower the temperature at which the seed is stored the better. Label the container with the species name, date and site of collection.

Figure 6.7 Containers for storing seed

6.6 Record keeping

Camp, Block and District Officers are advised to keep simple records indicating the species name, location of the species, name of collector and date when seed was collected.

6.7 Pre-sowing treatment

Seeds with hard seed coats, i.e. many leguminous as well as other kinds of trees, require treatment to break the resting stage (seed dormancy) and to speed up germination.

The following methods are often used to break this seed dormancy:

- Hot-water treatment
- Cold-water treatment
- Mechanical treatment.

Hot-water treatment

Hot-water treatment is suitable for hard-coated seeds such as *Faidherbia albida* (Msangu N) and *Leucaena leucocephala* (Lusina N). The recommended procedure is as follows:

- Boil some water in a pot. Use 3–4 parts of water to 1 part of seed
- Remove the pot from the fire and pour the hot water into the container with the seed
- Leave the seed to soak for a day or two
- Remove the swollen seed from the container and sow them immediately
- Leave unswollen seed in the container for one more day and then sow them.

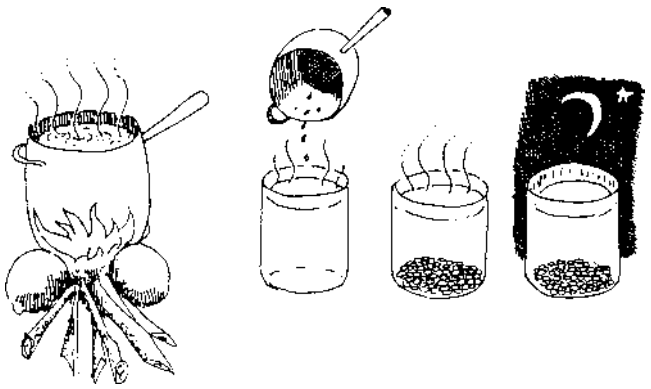


Figure 6.8 Hot-water treatment

Cold-water treatment

This treatment can be used on most types of seed, for example *Anacardium occidentale* (Cashew nut E) and *Senna siamea* (Makeche N), to accelerate germination. The recommended procedure is as follows:

- Pour 3–4 parts of cold water into the container with seed and leave to soak for a day
- Remove the swollen seed from the container and sow them immediately
- Leave unswollen seed in the container for one more day and then sow them.

Mechanical treatment

For large seeds with a very hard and thick shell, the best treatment is to break the shell and extract the kernel using a hammer or stone. Among the species needing this type of treatment are *Parinari curatellifolia* (Mpundu N), *Uapaca kirkiana* (Msuku N) and *Ricinodendron rautanenii* (Mkusu N).

Recommended procedure:

- Place the seed on a hard surface
- Use a hammer or stone to carefully break the seed coat and remove the seed
- Sow the seed immediately.

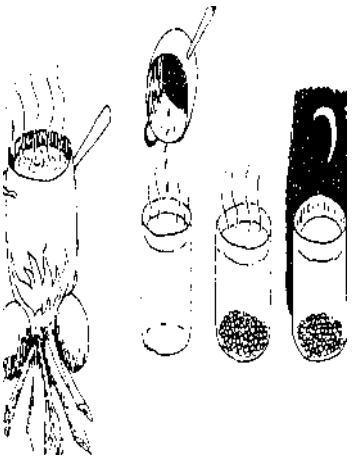


Figure 6.9 Breaking the seed coat with a hammer

6.8 Inoculation

Inoculation is the introduction of a beneficial micro-organism (usually a fungus or bacterium) into the soil. Such micro-organisms grow symbiotically with certain tree species and without the micro-organism the tree growth is hampered. Both trees and micro-organisms benefit from the presence of the other. Pines, *Casuarina* and most leguminous trees grow in such association with micro-organisms and for those species inoculation is required. Soil for inoculation can be collected from the ground under mature trees of the same species.

Recommended procedure:

- Mix 3 parts of ordinary soil and 1 part of inoculum soil
- Fill the soil mixture into the containers or spread onto the nursery beds
- Sow the seeds into the containers or nursery beds.

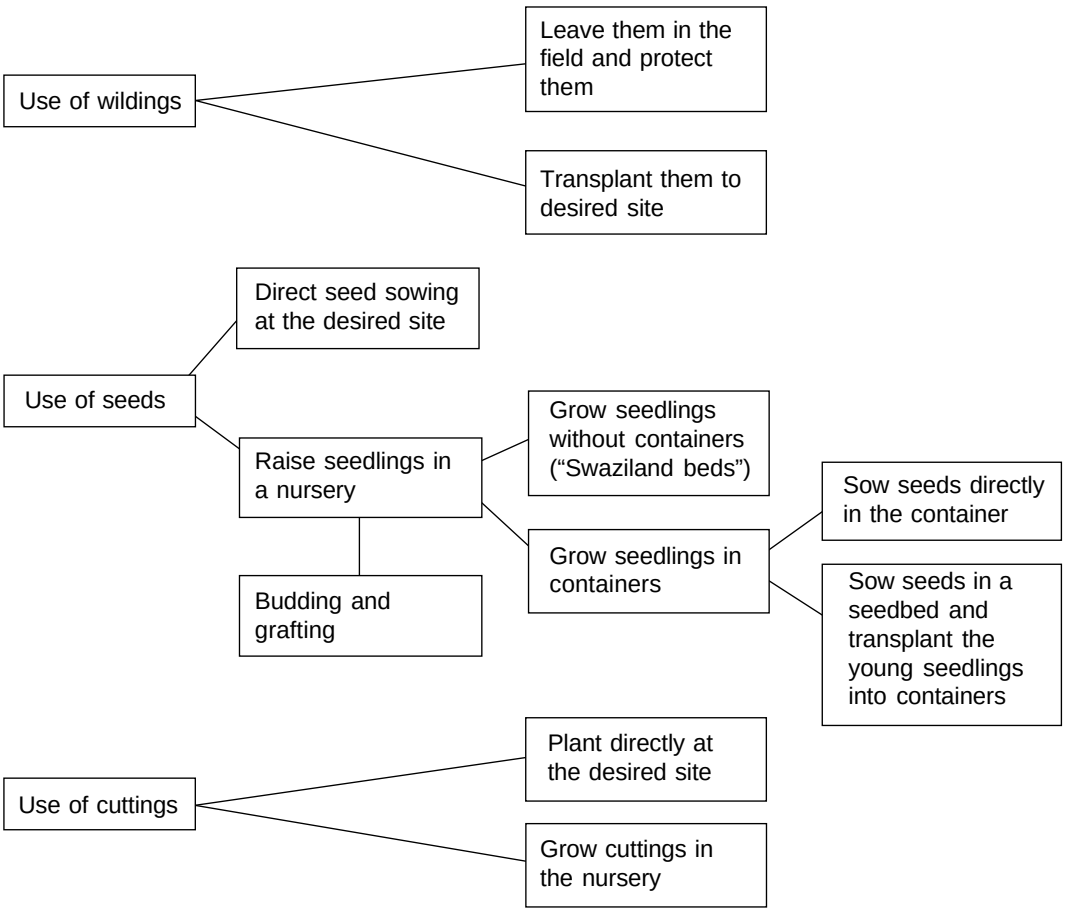
6.9 Further reading

For further details on seeds of different species of trees and shrubs and their treatment and storage, see the Facts Sheets at the end of this book and Table 9.2, Seed collection, handling and number of seeds per kg.

7

TREE PROPAGATION

Trees can be propagated in a number of ways, as shown in the figure below and described in the following sections.



Methods of tree propagation

7.1 Collection of wildings

A wilding is a seedling that regenerates naturally from dispersed seed. Wildings can easily be collected and replanted during the rainy season. The wildings of desired species can be collected while they are still young and transplanted to the farm where they can be protected. They should be carefully uprooted, leaving some soil around the roots, and planted in the same way as seedlings taken from a nursery. Young trees should be kept weed free.

For easy collection, the area under the seeding trees may be cleared of weeds and stones and the soil loosened to help the seedlings to grow. When the rains start, the seeds will germinate and the wildings can be collected soon after. The current year's wildings are recommended for transplanting because they survive better than older ones. Some examples of trees that can be propagated through collection of wildings are:

- *Delonix regia* (Flamboyant E)
- *Gmelina arborea* (Malaina N)
- *Khaya nyasica* (Mbawa N)
- *Mangifera indica* (Manga N)
- *Psidium guajava* (Gwawa N).

7.2 Direct seed sowing in the field

This is an easy and cheap way of establishing trees since the seeds are sown directly in the field. It eliminates the nursery stage and later planting out the seedlings. Many trees can be established much more quickly this way than if the seedlings are raised in a nursery. Direct seeding in the field is recommended for most indigenous tree species because they develop very deep taproots before there is any significant shoot growth.

Although this method has several advantages there are also some disadvantages:

- Large quantities of seed are needed
- The survival rate of the seed is lower than if they are sown in a nursery because both seed and seedlings may be exposed to sun, periods of drought or too much rain, pests, diseases and browsing animals
- Direct seeding can only be done at the onset of the rains, and therefore when the dry season approaches the seedlings will usually be smaller than those raised in a nursery with consequent effects on the seedlings
- More intense weeding is required.

Tree and shrub species suitable for direct seed sowing are:

- *Acacia polyacantha* (Ngowe N)
- *Cajanus cajan* (Ngolyolyo B, nyamundolo N)
- *Carica papaya* (Papayi N)
- *Faidherbia albida* (Msangu N)
- *Gmelina arborea* (Malaina N)
- *Khaya nyasica* (Mubawa N)
- *Leucaena leucocephala* (Lukina N)
- *Mangifera indica* (Manga N)
- *Melia azedarach*
- *Psidium guajava* (Gwawa N)
- *Senna siamea* (Makeche, msalasase, chigoma N)
- *Tamarindus indica* (Bwemba N).

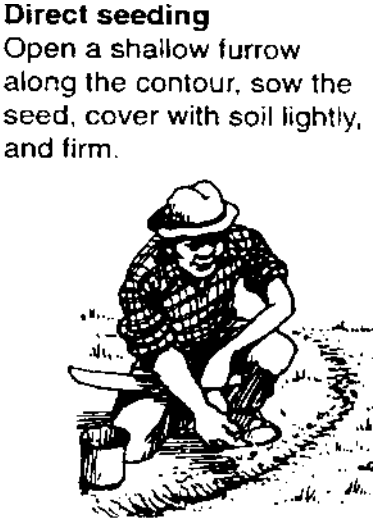


Figure 7.1 Direct seed sowing in a field

Establishment procedure:

- Till the site deep enough to facilitate quick and deep penetration of roots
- Mark planting holes
- When there has been sufficient rainfall, place at least three seeds in each hole and cover with soil. Ensure that the sowing depth is not more than twice the seed diameter. Remember to pre-treat seeds with a hard seed coat to enhance germination.
- Water daily if there is a dry spell during or after germination.
- Weed thoroughly around the seedlings, especially during the first year, to reduce competition for moisture and nutrients. This also reduces damage by fire.
- Protect the seedlings from livestock
- Thin out to one seedling per station where there are more than one. Leave the most healthy and vigorous seedlings.

7.3 Raising seedlings

Use of seedlings is the most common propagation method in Eastern Province. Tree seedlings can either be raised in containers or bare rooted. It is generally easiest to sow tree seeds directly in the field, but this is not always feasible. In that case, seedlings may have to be raised in a nursery where special care and protection can be given. This is especially recommended in the following situations:

- The species has very small seeds, e.g. eucalyptus
- The germination rate is low or uncertain
- The seeds are scarce
- Certain varieties are desired and seedlings require budding or grafting
- The seedlings are intended for an area where harsh conditions prevail (open land, poor soils, etc.)
- The seedlings are meant for very fertile sites where weed growth is vigorous (tall seedlings are recommended).

Seedlings in containers

Polythene pots and other containers are the most commonly used for raising seedlings. The main advantages of raising seedlings in containers are:

- The seedlings are easier to handle and transport
- Survival rate and growth are enhanced.

The main disadvantages are:

- The method is more expensive than direct seeding
- If the seedlings grow too big, root coiling occurs and the root-to-shoot ratio may be poor
- Good-quality soil must be used, which may mean collecting it from long distances
- They are heavy to carry if other means of transport are not available.

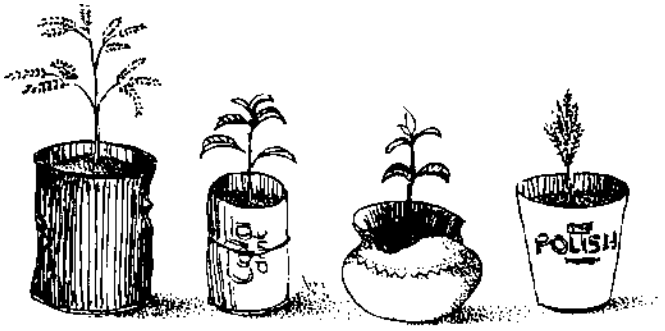


Figure 7.2 Containers for raising seedlings

Locally available materials are also used to raise seedlings. These include empty milk packets, used plastic containers, clay pots, old tins and large leaves such as those of banana. However, banana-leaf containers attract termites and are not very durable.

Soil collection

The ideal soil for raising seedlings in containers is light clay loam or sandy loam. These types of soils are somewhat sticky and therefore the soil does not fall out even if the containers are open ended. Besides this they allow aeration and are often rich in nutrients.

The sources of soil for the nursery can be:

- Forest or woodland
- Under individual trees such as acacia
- Dambo margins (black soil)
- Old livestock enclosures (with rotten manure).

Some miombo trees have a beneficial relationship (symbiosis) with bacteria or fungi (mycorrhiza). Root nodules are indicators of such partnerships. Therefore, if possible, miombo woodland soils should be used for raising seedlings of miombo species.

Preparation of a suitable soil mixture

If the soil contains too much clay and is too sticky, add sand from river or stream banks in a proportion of 2 parts of river sand to 2–3 parts of forest, woodland or garden soil.

The exact proportions of the different components depend very much on the quality of the soil available and no standard recommendation can be made. Nevertheless, the following mixture would be suitable in most situations:

- Three wheelbarrows of forest or garden soil
- One wheelbarrow of river sand
- One wheelbarrow of rotten manure or compost.

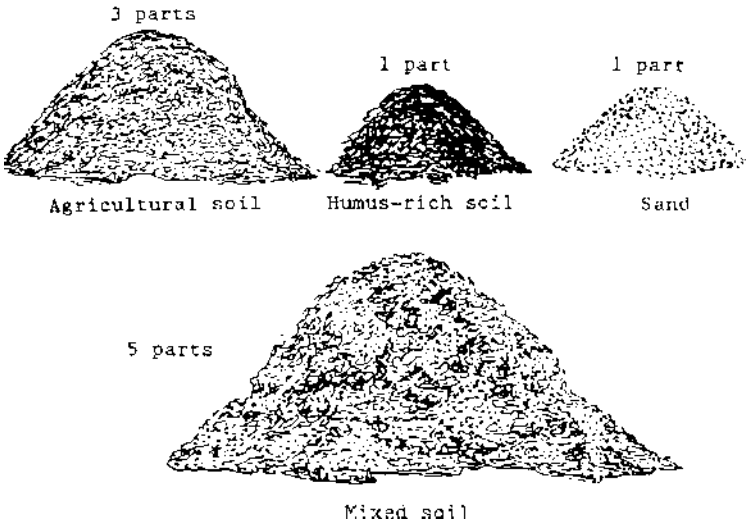


Figure 7.3 Prepare a suitable soil mixture

Good-quality soil, e.g. clay loam or sandy loam does not need to be mixed with any other soil. If the right type of soil cannot be obtained, then various types of soils must be mixed to obtain the right composition. Nursery soils should be sieved to remove unwanted debris (clumps, stones, small roots, etc.).

If seedlings which require an inoculant (addition of an essential micro-organism, e.g. mycorrhiza) for their development are being raised, e.g. pines and leguminous trees, the inoculant should be added to the soil. This may be obtained by collecting one part of soil

under the mature leguminous mother trees or pines and mixing it with five parts of other good soil (see Section 6.8).

Filling the containers

- Place the container on flat ground or on a piece of wood.
- Fill a bit more than a third of the container with soil.
- Compact the soil firmly so that it does not fall out easily.
- Fill the rest of the container evenly with soil. Do not compact the soil so much that it will not be aerated or leave it so loose that there will be air pockets as both of these things hamper root development. Press the soil down gently but firmly.
- After filling them, place the pots upright in rows on the beds. The width of the bed should not be more than 1 m with a space of 60 cm in between each for ease of movement.
- Use long containers for species which develop taproots, e.g. acacias, and for *Moringa* which is sensitive to root pruning.

Sowing

Sowing in containers

Species which have big seeds and a high germination rate may be sown directly into containers. Hard-coated seeds should be pre-treated before sowing. A dibble (small sharpened stick) should be used for making the hole in which the seed is to be sown. Two or three seeds may be sown per container, depending on the viability of the seed.

Seeds should be sown at the correct depth. As a general rule, this is a depth one or two times the diameter of the seed. Seeds sown too deeply will not germinate as the shoots will fail to push through the thick soil layer, while those sown too near the surface risk being dried out, destroyed by rodents and other pests, or being washed away during watering or by heavy rain.

The seeds should be covered with soil and gently pressed down to ensure contact with the soil. The containers should then be watered with a fine spray using watering cans or tins with small holes in the base and left in the shade until the seeds germinate. The soil surface on which the containers are placed should not be allowed to dry, and neither should it be too wet.

Sowing in seedbeds

Seeds of unknown viability, that are difficult or expensive to obtain, or too small to be counted (e.g. eucalyptus) should be sown in seedbeds. The seedbed soil should be well drained.

The two most common sowing methods are broadcasting and drilling. In the broadcast method, the seed are spread on the seedbed. The disadvantage of this method is that it is difficult to distribute the seed evenly over the seedbed. Very small seeds, such as those of eucalyptus, should be mixed with sand before sowing to make even distribution easier. In the drilling method, lines are made 5–8 cm apart. The seeds are then sown in the rows, covered with soil, watered thoroughly and shaded.

Time of seed sowing

Slow-growing seedlings, like pines, cypress and *Pterocarpus angolensis*, may be sown from June to August, and fast-growing species, like eucalyptus and leucaena, from September to October, i.e. 2 months before the tree-planting season. Other species which take only a few weeks to attain planting size, like *Sesbania* spp., can be sown in mid-October or later.

Most indigenous tree seeds are sown a year before the actual planting in the field since they are slow growing as seedlings. Exotic species like *Toona ciliata* whose seeds mature during the rains and have short viability periods can also be sown a year before the planned planting time.

Germination

Germination may take place in as little as three days or only several months after sowing, depending on species and treatment, but most species take between 12 and 24 days.

Shading/mulching

Shading is necessary to protect seedlings from direct sunlight. After sowing, the pots or seedbeds should be covered with mulch made of dry grass, reeds or other material. After germination, shading should be erected 50 cm above the pots or bed.

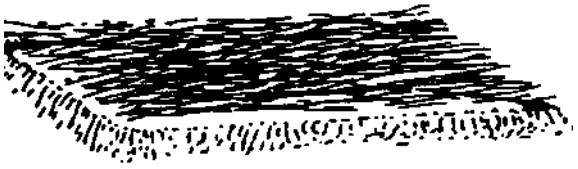


Figure 7.4 Grass mulch on a seedbed

Shading should be reduced gradually from being all day at the beginning to none at a later stage. For the last few months in the nursery, seedlings should be exposed to full sunlight. Shading mats can still be used at any stage to protect the seedlings against damage by heavy rain storms or when the sun is too strong.

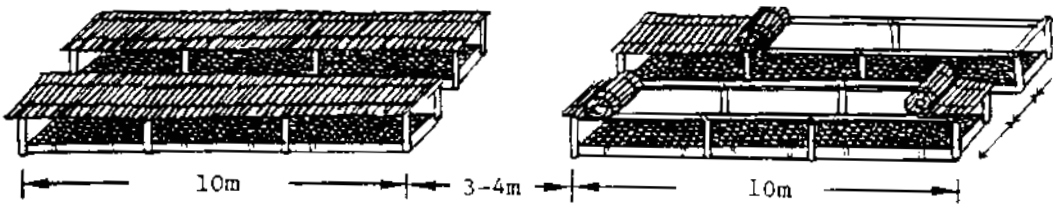


Figure 7.5 Raised shade over a seedbed

Watering

It is imperative that the seedbed should never dry out during the germination and early growth period. The watering regime described below will avoid moisture stress on seedlings.

- Remove the shading material/mulch before watering if it hinders the watering and replace it after watering. Mulch on newly sown seeds or on very young seedlings needs not to be removed.
- Before germination, and for the first few weeks thereafter, water twice a day, i.e. in the early morning and in the late afternoon.
- When the seedlings are established, reduce watering to only once a day, ensuring that the bottom of the container and the seedling bed are soaked.
- Occasionally check some seedlings in the bed by pushing a finger into the soil to see if it is still moist. If it is, do not water.
- Watering cans with fine nozzles, or tins with small holes, should be used so as not to wash the soil and seeds out of the pots or seedbeds.
- Ensure that the bed is watered evenly.

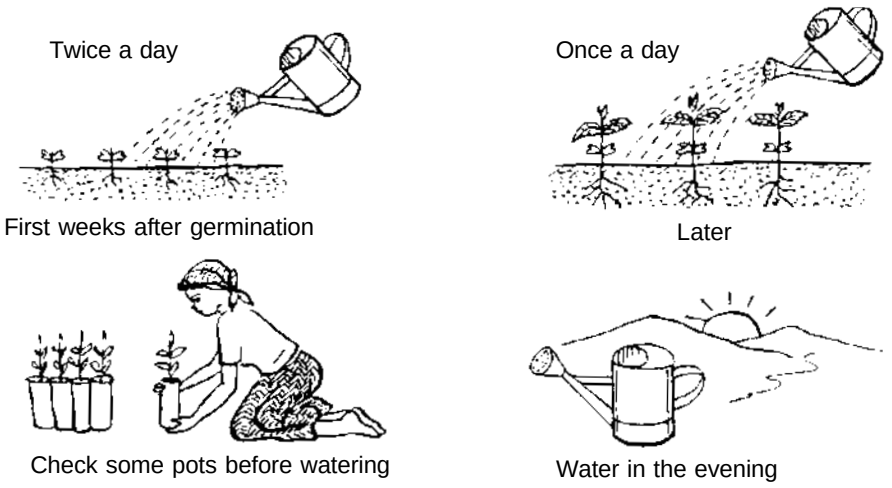


Figure 7.6 Watering seedlings

Avoid over-watering since it retards root growth, encourages fungal diseases and makes the shoot soft. Yellowing of leaves (despite application of fertilizers or organic manure) and a cover of moss on top of the container are signs of over-watering.

Pricking out (transplanting)

Seedlings in seedbeds need to be transferred to containers some time after germination. This is known as pricking out. Pricking out should be done when the seedlings have the first two or three leaves. Transplanting larger seedlings results in higher mortality.

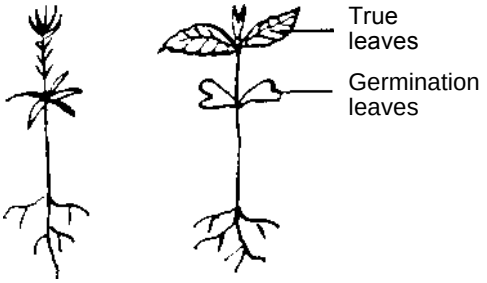


Figure 7.7 The right size for transplanting seedlings

The following procedure is recommended:

- Water the seedbeds and pots thoroughly the day before pricking out to avoid damaging the roots of the seedlings.
- Work in the shade in the early morning or late afternoon to avoid exposure of the roots to sunlight or wind. Pricking out may be done during the day if the weather is cloudy.
- Prick out only healthy well-developed seedlings.
- Lift the seedlings together with the soil using a trowel or a flat piece of wood to avoid damaging the roots or exposing them to the sun.

Figure 7.8 Handle seedlings gently

- Lift only a small number of seedlings at a time so that they can be transplanted within an hour to avoid drying out in the sun. Keep the roots covered at all times or put the small seedlings in a container with cool water.
- Make a hole in the container or pot—it should be deep and wide enough to accommodate the roots of the seedlings.

Figure 7.9 Transplanting a seedling

- Pick one seedling at a time; hold it by its leaves but not its stem to avoid damaging the soft tissues of the stem. Damaged stem tissues can attract damping-off fungi.
- If necessary, cut the long taproot with a sharp knife to about a third of its length to avoid the root coiling or bending into a U-shape when the seedling is transplanted into the pot.
- Place the seedling in the hole ensuring that the roots are not bent or pointing upwards. Bent or U-shaped roots result in deformed roots and high seedling mortality.
- Using your fingers and perhaps a piece of wood (dibble), gently press down the soil around the seedling to close the hole. Make sure that the hole is well closed and the soil pressed down around the seedling's roots to avoid air pockets which lead to high plant mortality. Be careful not to damage the root or stem.
- Water and shade the seedlings immediately after pricking out.

Containers in which direct sowing was done may contain more than one seedling. Such seedlings should be singled out when they are 2–5 cm high leaving only one strong seedling per pot. When singling out, the extra seedlings can be transferred to empty pots using the same procedure as for pricking out.

Weeding

Weeds compete with seedlings for light, nutrients and water and increase the risk of pests, diseases and fungal infection. Weeds should be uprooted by hand using a pointed stick or blunt knife. Never allow weeds to flower and fruit in a nursery or its surroundings. Do not damage the roots or shoots of the seedlings when weeding.

Fertilizer application

This may be necessary if the plants do not grow vigorously or if the leaves turn yellow. Do not use too much fertilizer otherwise the plants will become too tall before transplanting. Mix half a matchbox full of compound "D" fertilizer in 1 litre of water and apply the mixture to 100 plants. Subsequent applications, using the same concentration, may be made at fortnightly intervals. Approximately four such applications should be sufficient unless the soil in the pots is very poor. Be careful not to apply too much fertilizer.

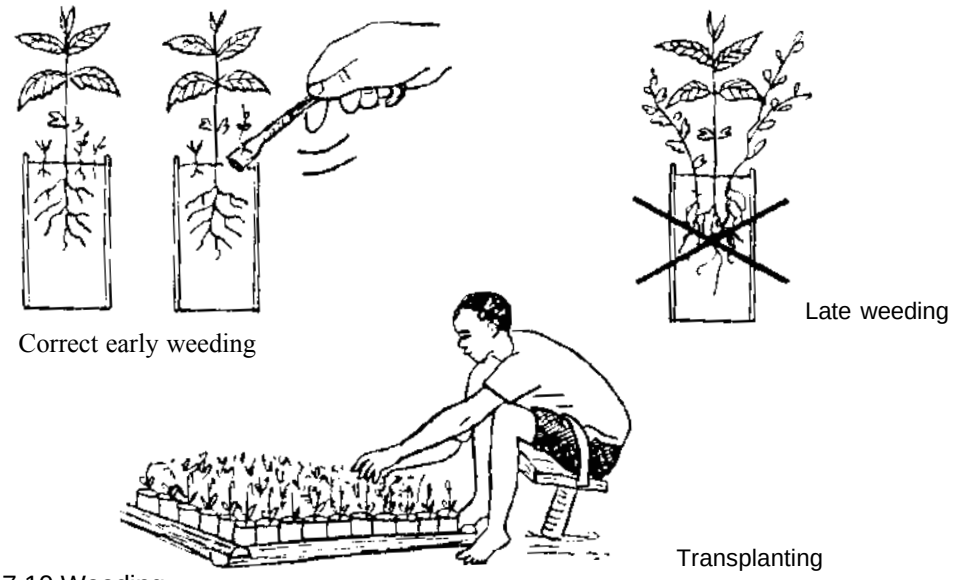


Figure 7.10 Weeding

Root pruning

Roots should be pruned to stop them growing through the open-ended containers into the ground underneath. The easiest method is to lift the container and prune the roots from underneath it. This must be done not later than when the seedlings have reached about 12 cm high and the roots start to penetrate the ground. As soon as the seedlings are more than 5 cm, the roots should be checked. If they have already grown too big, they should be cut with pruning shears or a sharp knife. Root pruning should be done repeatedly to prevent the roots growing too deep into the ground. Before root pruning, the seedlings should be well watered and then watered lightly again immediately afterwards.

Another method to control the root development is simply to shift the pots from one place in the bed to another (wrenching) as this detaches the roots from the ground.

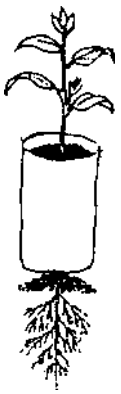


Figure 7.11 Overgrown roots

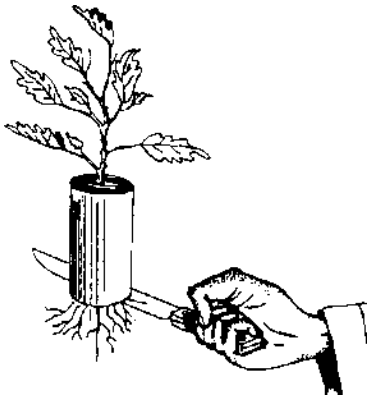


Figure 7.12 Pruning the roots with a sharp knife

Shoot pruning

When the shoot is more than twice the height of the pot or container, it may be necessary to trim it, but trimming the shoot is only possible for some broad-leaved species which sprout readily, e.g. eucalyptus, leucaena. It should not be done with conifers or species that become bushy rather than developing one leading shoot soon after pruning. Consult the nearest forester in case of any doubt.

Hardening off

Hardening off means conditioning or adapting seedlings to the harsher conditions that prevail in the field. This adaptation is achieved by gradual exposure to full sunlight through reduction of shade and a gradual reduction of watering frequency. The process of hardening should start one or two months prior to planting out.

The hardening process will make the stems hard and woody but vigorous, and the root system compact and well developed. Seedlings should be watched during the process. If signs of wilting appear, the plants must be watered and the hardening-off process slowed down.

Bare-rooted seedlings

Seedlings that are to be transplanted within the farm need not be raised in containers. In Eastern Zambia, experience of raising seedlings without polythene pots is limited, but some recommendations can be made:

- Clear the ground and remove the top 5 cm layer of the topsoil from the site where you want to establish your bed. Compact the soil thoroughly.
- Construct a frame, approximately 60 x 100 cm and 20–30 cm high, from bricks, planks or any other suitable material and secure it with wooden pegs, stones or soil. Fill this frame with good fertile topsoil, which should be not too clayey nor too sandy. Firm the soil lightly. Sow 2–3 seeds per planting station in rows, 10 cm between rows and 10 cm between stations. When the seedlings are about 5 cm high they should be thinned to one per station.
- You can also make a raised bed without a frame (similar to that for vegetables).

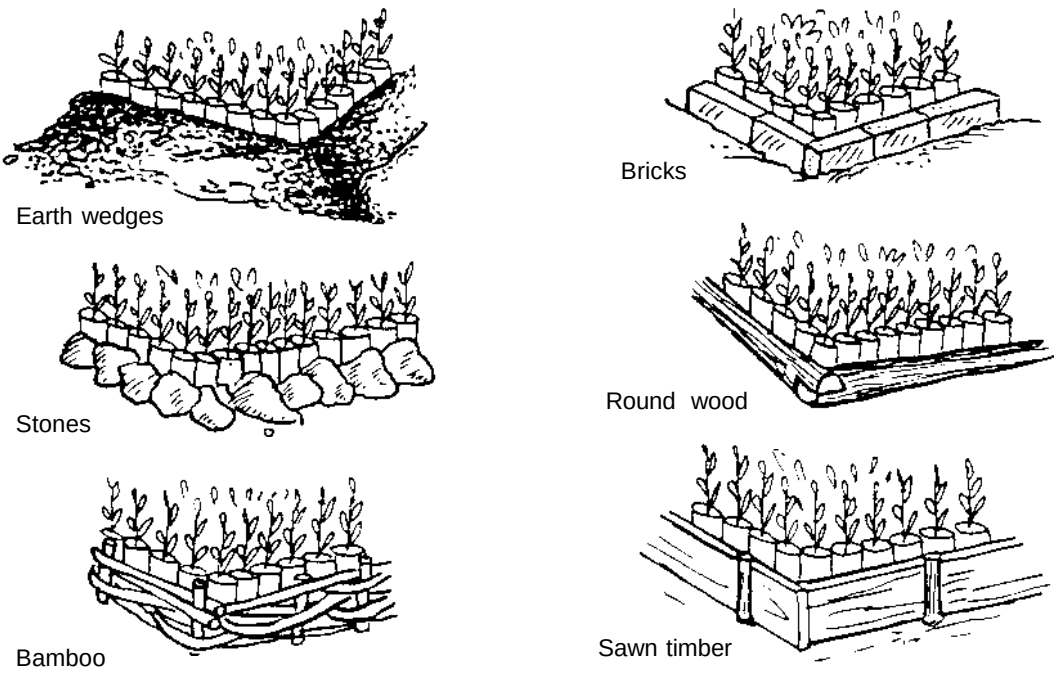


Figure 7.13 Different types of frames

Root pruning

Prune roots as soon as seedlings are about 10 cm high and the roots start to penetrate into the compacted soil layer.

Recommended procedure:

- Water the seedlings before pruning them
- Using a long sharp knife, panga, spade or a piece of wire, cut horizontally underneath the nursery bed to prune the taproots

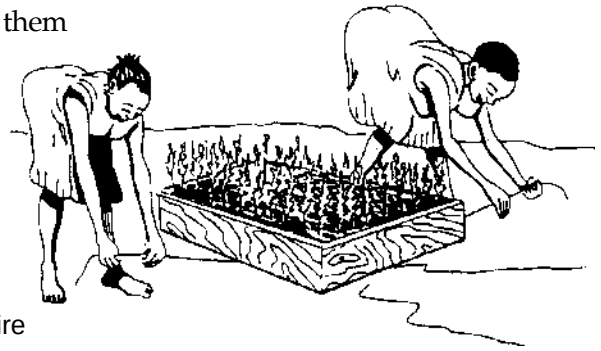


Figure 7.14 Root pruning using a thin wire

- Prune the side roots by cutting between the rows of seedlings using a sharp knife
- Water the seedlings again and shade them for at least a week to allow them to overcome the stress of root pruning
- Continue to root prune every four to five weeks.

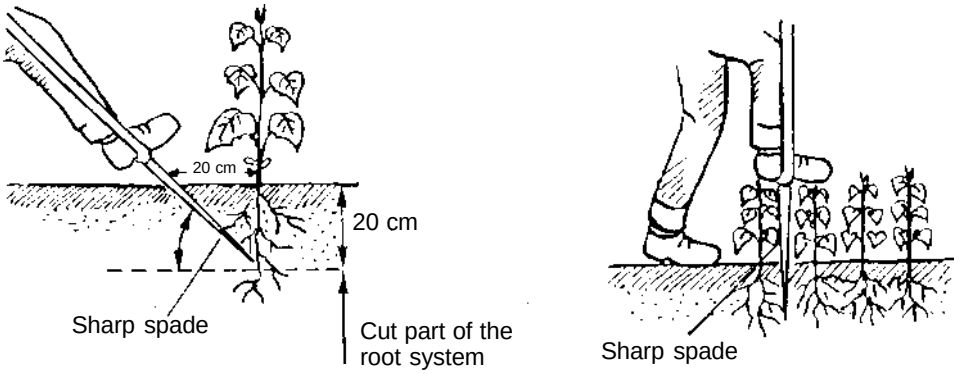


Figure 7.15 Root pruning

The other tending operations such as weeding, watering, shading and hardening off are the same as when seedlings are raised in containers.

Planting out

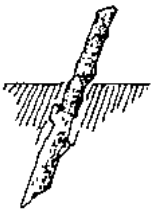
When planting out, seedlings should be dug up with a knife or spade, ensuring that all the soil around the roots is not removed. Avoid exposing the roots to direct sunlight when transporting seedlings and plant them as quickly as possible in holes that have been prepared in advance. The success rate will much depend on species and on how carefully the transport and planting was done.

7.4 Cuttings

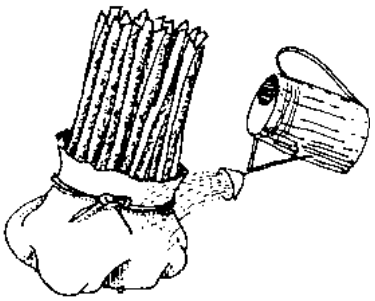
A cutting is a piece or section of a stem, branch, root or twig which is taken from the mother (parent) tree and which will develop into a new plant with similar characteristics as the parent tree. The mother tree from which the cuttings are obtained should be healthy and disease free. If the cuttings are not planted right away, they should be wrapped in a wet sack and stored in a cool, dark place. Alternatively, they may be buried in wet ground for a few days. There are many species that grow well from cuttings, e.g. *Morus alba*, *Euphorbia* spp. and *Lannea discolor*.

Cuttings between 1 and 2 cm in diameter and 30–50 cm in length are ideal for planting directly in the field. In certain species such as *Kirkia acuminata* (Mzumba N), *Pterocarpus angolensis* (Mlombe N) and *Lannea* spp., larger cuttings more than 50 cm long and 2 cm in diameter can also be planted directly. The planting site must be well protected. A cutting must be placed in the soil with the buds in the upright position (not upside down), with two-thirds of its length in the ground (at least two nodes being in the ground) and at a slanting angle to speed up the development of roots and shoots.

Cuttings can also be raised in the nursery before transplanting into the field. For this purpose cuttings can be cut from branches. The recommended size of cuttings for this purpose is 1–2 cm diameter and 20–30 cm long.



A cutting



Watering cuttings before transport

Figure 7.16 Management of cuttings before planting in the field

7.5 Budding and grafting

Budding and grafting are common methods of propagating fruit trees and have been widely used, especially for *Citrus* spp. The advantages of budding and grafting using good parent material are:

- Earlier production and higher yields
- Greater resistance to diseases
- Budded or grafted trees will show the true characteristics of the mother tree.

The part of the new plant that will grow to become the stem and branches is called the scion. The part that will grow to become the root is called the rootstock

Budding

Budding is the propagation method in which a lateral bud is used to produce a new plant by inserting the bud from a desired variety into another plant rootstock.

Seedlings, e.g. *Citrus*, are ready for budding after 8–12 months when the shoots are pencil-size. Bud-wood material should be obtained from high-yielding, disease-free mother trees and must be cut just before the budding is to be done. A good bud stick could be about 25–30 cm long and have 8–10 buds. Use the buds from the bottom and middle part of the bud stick. It is generally recommended not to use the bud nearest the top end of the bud stick. All leaves and thorns should be removed before the actual budding work starts

Budding methods

There are two basic methods of budding: the "T" or shield-budding method and the inverted "T" method.

"T" or shield budding

- Take the rootstock plant and trim off all the leaves below the point where you intend to bud the seedlings. This should be at least 25 cm above the ground.
- Using a sharp knife, make a vertical cut about 3 cm long (the cut should not penetrate the wood).
- Then make a horizontal cut about 1 cm long at the upper end of the vertical cut to form a "T".
- Using a blunt part of the budding knife, open out the cuts.
- Take the bud stock and remove a shield-shaped piece of bark including the bud—the piece should be approximately 2 cm long.
- Hold the shield-shaped piece you have removed and insert it into the "T"-shaped cut on the rootstock plant, pushing it downward.
- Using polythene sheeting or tape, wrap around the insertion firmly from the bottom moving upwards and avoid covering the bud completely.
- Unwrap the bud after 15–20 days.
- Two weeks later inspect the bud to check if it is still green. If so, the bud has taken and the seedling can be cut 15–20 cm above the bud to stimulate the bud to grow. If the bud is brown, then it is dead and the seedling must be budded again.
- Remove the old seedling stub close to the bud (2 cm above the bud) after the bud has grown 20–30 cm long.

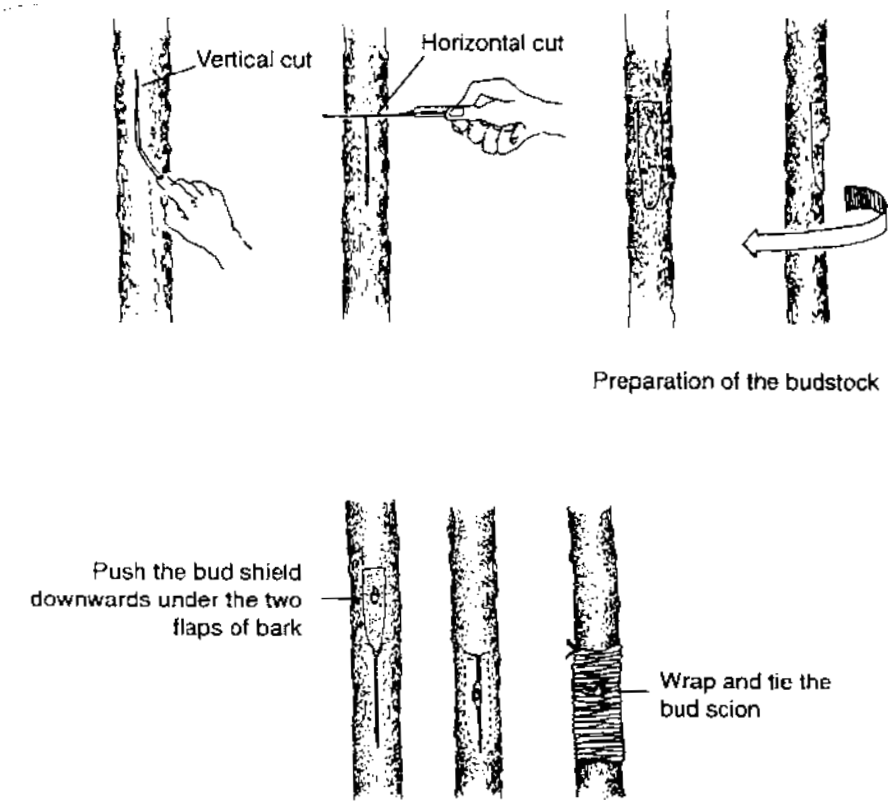


Figure 7.17 "T" or shield budding

Inverted "T" budding

The procedure is the same as in the "T" budding method except that the horizontal cut is made below the vertical cut. The "Inverted T" is good and it is the most common method in Zambia.

For more details on budding contact your nearest horticultural or forest officer.

Grafting

Grafting is joining together the scion and the rootstock so that they grow as one plant. There are several methods of grafting fruit trees. The two common ones are described below.

Splice (whip) grafting

- Using a sharp knife make a slanting cut at the basal end of the scion.
- Make a similar cut at the end of the rootstock.
- Place the cut surfaces together ensuring that the cambial regions are in contact.
- Tie the rootstock and scion together with a strip of polythene sheeting, tape or string.
- Protect the grafted plant against sunlight and water it regularly until the graft has united.

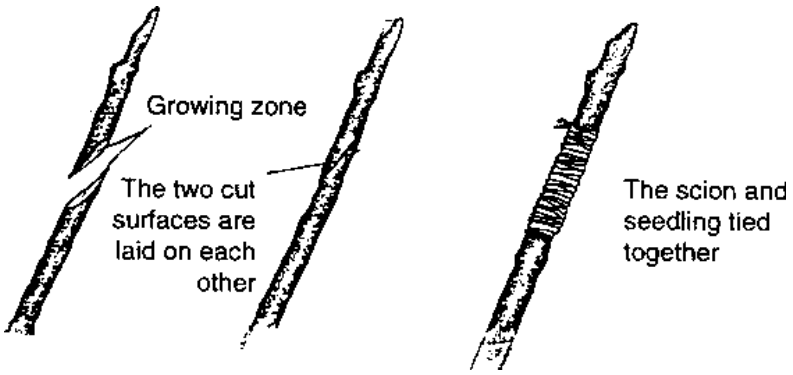


Figure 7.18 Splice grafting

Wedge or cleft graft

A wedge or cleft graft is made by inserting a scion into a split in the stock. This method is suitable for grafting young materials which are in the growing stage.

Grafting procedure

- Prepare the scion by making two sloping cuts (4–5 cm in length) slightly below the level of the leaves using a sharp knife almost parallel to the twig.
- Cut the rootstock across at a succulent (soft) point.
- Split the rootstock.
- Insert the scion into the split.
- Tie the union with a polythene strip or tape.
- Protect the seedling against sunlight and water it regularly until the scion and the rootstock have united.

Figure 7.19 Wedge grafting

8

MANAGEMENT OF TREES IN THE FIELD

The planting site must be well prepared in order for trees to become well established. All shrubs and bushes should be cut, piled up and burnt. Deep hoeing or ploughing must be done to get rid of weeds for a radius of at least 50 cm around the planting stations.

8.1 Planting

Planting should be done when the rains are well established, i.e. any time from mid-November to January. It is best to start planting after the top 30 cm of the soil are moist and the rains seem to be reliably established. The amount of moisture can be determined by simply digging a hole in the ground and feeling if the soil is moist. Seedlings must be well watered a day before planting.

At planting time, the seedlings should be between 15 and 30 cm tall. Overgrown seedlings should be avoided because they are more susceptible to mechanical damage and stress. Spacing will vary depending on the purpose and the desired products. Planting at high density is advantageous if small-sized poles or firewood are in high demand. For each seedling a big hole should be dug (30 cm x 30 cm x 30 cm) so that the roots can establish easily. Remove the polythene pots when planting, though this can be somewhat time-consuming. This ensures that the roots can grow sideways and quickly get access to water and nutrients from a larger volume of soil. The polythene pots can be reused.

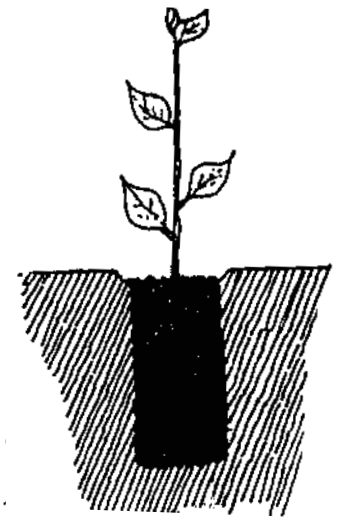


Figure 8.1 A seedling planted without a polythene pot

All dead or dying plants should be replaced 3–4 weeks after planting. This operation is known as beating up, making good or blanking.

8.2 Fertilizer application

This may be necessary when the trees show signs of nutrient deficiency such as stunted growth, yellowing of leaves and serious die-back. Organic manure and compost can be used instead of expensive inorganic fertilizers which farmers may not be able to afford. Some species can grow reasonably well without fertilizers, however, provided the soil is not too poor. Tree species which are susceptible to boron deficiency, e.g. eucalyptus and grevillea, do not do well or may even die without application of borate. The symptoms of boron deficiency are leaf deformity, serious die-back and high mortality rates.

8.3 Weeding

Weeding is an important tending operation for the following reasons:

- It reduces the competition for moisture and nutrients thereby boosting early growth of the tree seedlings
- It reduces the risk of fire to the seedlings
- Proper weeding combined with loosening of the soil surface facilitates percolation of water and reduces evaporation from the soil surface thus contributing to good plant development.

Young trees should begin the dry season completely weed-free. The number of times weeding will be required annually will depend on the amount of weeds in the locality and how vigorous they are.

Farmers should be encouraged to intercrop trees with crops, at least during the first two years. The labour invested in weeding is repaid by the value of the crops harvested in the short term. Further, farmers find it more natural to weed crops than trees, and therefore the trees will benefit indirectly from the crop management.

Weeding may be carried out by hand, hoe or oxen and should be continued until the seedlings are well established.

Weeding techniques

Spot weeding

This is a type of weeding in which an area of 50-cm radius around each plant is weeded with a hoe.

Clean weeding

This is when the entire plot of trees is completely weeded. It may be done by hand, hoe or with oxen. Oxen are ideal if the area to be weeded is very large.

Line or strip weeding

This is when the rows of trees are weeded. It is also known as line screening. Hand weeding or the use of oxen are both suitable for this type of weeding.

8.4 Protection of young trees

Newly planted seedlings and young trees are very sensitive and need to be protected against livestock, fire, termites, wind and people.

Livestock

Trees need protection from livestock until they are sufficiently high for at least part of the crown to be out of reach of browsing livestock, which normally takes at least 2–3 years. In Eastern Province livestock are left on free range during the dry season after the crops have been harvested. It is during this period, when there is a shortage of fodder in communal grazing areas, that newly planted tree seedlings are likely to be browsed or trampled if they are not protected.

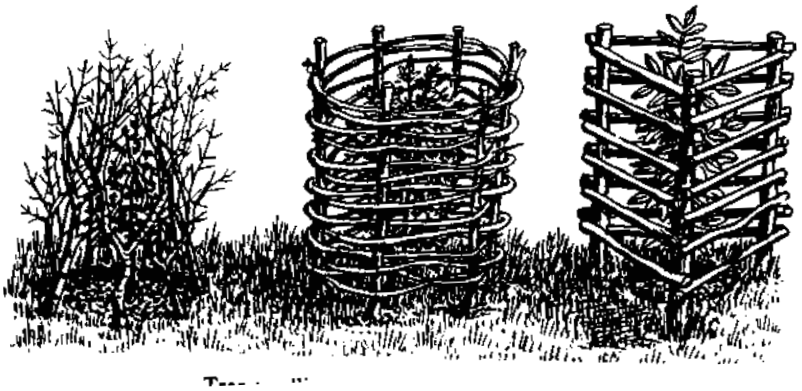


Figure 8.2 Tree seedlings protected against livestock

The most common way of protecting young trees from livestock is by fencing. Various materials can be used for fencing such as thorny branches, sticks and poles. Poles may be required for spot fencing (around individual young seedlings) or for fencing around a woodlot.

The other method of fencing is to use a living plant. Trees or shrubs, e.g. *Euphorbia tirucalli*, are planted around the young trees to form a live fence. To be effective, the live fence needs to be established 3–4 years earlier than the trees. If planted later it will need to be reinforced with dry thorny branches until it is sufficiently high and well established. This method is more permanent and requires little labour for repair. However, goats may find their way through a live fence of euphorbia, especially when the fence is still young. When the fence is older, it can be made quite impenetrable if well managed.

Yet another method of protecting trees against livestock is to use the animal's dung or urine. Fresh dung is mixed with water and soap to make a solution which is then allowed to stand for three days. The mixture is then painted or spread around the trees. An example is use of a solution of goat dung smeared on stems of *Gmelina arborea.*

Planting tree species which are not favoured for browsing by livestock, e.g. *Senna siamea*, is an alternative in areas with a lot of livestock.

General control of grazing animals after the harvest would reduce tree mortality due to trampling and browsing. However, post-harvest grazing is an accepted practice and a strong tradition and presently in many places there is no mechanism to control it. In Eastern Province controlled grazing is practised throughout the year in Paramount Chief Mpezeni's area, Chief Saili's area and Senior Chief Mwase's area. These Chiefs passed legislation on herding of livestock. Any animals which are not being herded are impounded and forfeited to the Chief. In the case of livestock grazing on or damaging somebody's crops, the livestock owner is required to compensate the victim. In addition, he/she has to pay a fine to the Chief. This kind of legislation has helped to reduce post-harvest grazing problems in these areas. Rotational grazing and introduction of fodder banks under a zero-grazing system (stall feeding) could also help alleviate these problems. Most of these techniques require fencing of relatively large areas if the technology is to work effectively. Sweet dambos are commonly used for grazing livestock during the dry season. With proper management they could sustain a certain number of animals throughout the dry season.

Fire

If young trees are weed free there is no grass to fuel a fire. Therefore, weeding is very important. Construction of a firebreak also helps to protect trees against fire. A firebreak should be 4–6 m wide and must be free of grass and dead wood. Firebreaks should be constructed between April and June before the beginning of the fire season.

Early burning of the surrounding bushes and forest should be carried out between April and June rather than later when it is very difficult to control a fire.

Control of pests and diseases in plants

There are several pests and diseases which affect plants, especially during the development stage.

Termites are among the most serious pests which damage growing trees. Termites eat practically any plant material containing cellulose. Growing of termite-resistant species is recommended in areas with a serious termite problem.

Tree mortality caused by termites represents a tremendous economic loss in terms of direct establishment costs and potential yields. Farmers incur equally heavy crop losses from other plant pests and diseases. A cheap method of controlling termites is to use natural pesticides. Some farmers use local plants to control pests and diseases in this way, though only on a small scale.

Application of wood ash in a planting hole and around the base of a tree has also been reported to be effective against termites. Dry tobacco leaves crushed and soaked in water and then applied around the plant have been tried in some parts of the Province. A more difficult method has been used in Kenya: the queen termite is located and killed and this leads to dispersal of the rest of the colony.

Some of the plants which can be used to control pests and diseases are listed in Table 8.1.

Wind

Young trees should also be protected against strong winds. A windbreak or hedge is effective against wind. Sticks can also be used to support the young trees against strong winds.

People

Trees should also be protected against people, particularly children, who may break, uproot or trample the seedlings. Thorny fences are effective against children.

8.5 Management of trees

The most important management techniques are coppicing, pollarding, pruning, lopping and thinning. These management practices are described below.

Coppice management

Coppicing is the cutting back of a tree to stimulate production of new shoots. When carrying out coppicing the following are the steps:

- The cut should be clean and slanting and at 10–30 cm above ground level.
- The bark of the stump should not be damaged.

Table 8.1 Natural pesticides

Botanical name	Local name	Part of plant used	Preparation	Pests/diseases controlled
Capsicaum frutescens (Chillies)	Sabola Mphilipili	Fruits, seeds	• Grind (crush) one handful (about 100 g) of dry chillies • Put the ground chillies in 1 litre of water in a bucket • Stir the mixture and allow to stand overnight • Add 5 litres of soapy water so that the mixture sticks to the crop leaves when applied • Apply on a small spot first to test the concentration (if it is too strong, leaves can easily be scorched). • Dilute with more water if the mixture is too concentrated • Spray (apply) on the crops in the evening.	Ants Aphids Beetles Cucumber mosaic virus Weevils Ring spot virus Tobacco mosaic virus
Allium spp.	Galiki	Garlic bulbs	• Grind 3–4 garlic bulbs • Soak the garlic powder in 500 ml of paraffin for 24 hours (one day) • Filter the mixture • Add 10 litres of water to the mixture • Dissolve a bar of soap in warm water and add to the mixture • Spray in the evening	Aphids Fungal diseases Cabbage worm
Swartzia madagascariensis	Mchelekete	Leaves, pods	• Pound fresh leaves and pods • Soak the mixture in hot water for 24 hours (there should be enough water to cover the pounded mash) • Dilute 1 part of the mixture to 1 part water • Sieve and spray the affected plants.	Termites
Carica papaya (Pawpaw)	Papayi	Leaves	• Chop and pound 1 kg of pawpaw leaves • Add 1 litre of water • Squeeze (sieve) the mixture through a cloth • Add half a litre of soapy water • Dilute 1 part of the mixture to 4 parts of water • Apply early in the morning or late evening.	Rust

Botanical name	Local name	Part of plant used	Preparation	Pests/diseases
Tephrosia vogelii	Ububa	Leaves	• Pound one bucket full (15 litres in volume) of fresh leaves • Soak in water for 2–3 hours • Sieve the mixture using a cloth or sieve • Dilute 1 part of the mixture to 4 parts of water • Apply (spray) once a week.	Aphids Cutworms Termites
Nicotiana tobacum	Fodya (Tobacco)	Leaves	• Boil a mixture 250 g tobacco leaves and 30 g soft soap in 4 litres of water for 30 minutes • Dilute 1 part of the mixture to 5 litres of water • Spray the tobacco tea on the affected plants	Aphids Termites Caterpillars Fungal, viral diseases.
		Cigarette butts	• Boil one cupfull of cigarette ends in one litre of water • Dilute the mixture with 5 parts of water • Add some soap to make the tobacco tea stick to the leaves	
Azadirachta indica (Neem)	Nimu	Seeds	• Prepare 500 g of crushed seed kernels • Mix the crushed seed with 10 litres of water • Stir the mixture • Leave to stand for at least 5 hours • Spray the neem water directly on the crop to be protected • The effect lasts for 3–6 days • It has been estimated that 20–30 kg of neem seed (an average yield from 2 trees) can normally treat one hectare.	Grain borers, beetles.
Tagetes erecta African/Aztec marigold		Plant	• It is advisable to intercrop marigold in gardens where there are nematodes and other pests. It is a good repellent.	Aphids Nematodes

- Preferably coppicing should not be done during the rainy season. This may increase fungal infection, and many timber trees, e.g. *Eucalyptus tereticornis* (Bulugamu N) sprout prolifically if cut during the hot dry season just before the onset of the rains.
- When the shoots are about a metre tall, all except the best one should be removed to reduce competition.
- Slash the grass to avoid uncontrolled fire in the area under coppice management.
- Carry out early burning (May–June) outside the area under coppice management.

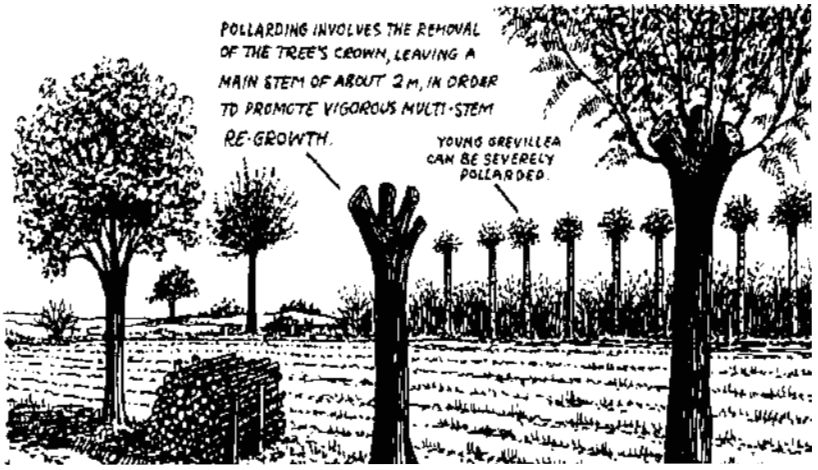


Figure 8.3 Coppiced trees

Not all trees coppice. For instance pine and cypress trees do not. Some trees that can be coppiced are:

- *Eucalyptus* spp. (Bulugamu N)
- *Gmelina arborea* (Malaina N)
- *Isoberlinia angolensis* (Kapane, Msanganza, Mtowo N)
- *Leucaena leucocephala* (Lukina, lusina N)
- *Pterocarpus angolensis* (Mlombe, Mlombwa N)
- *Senna siamea* (Macheche N)
- *Senna spectabilis*
- *Syzygium guineense* (Katope, Katubwi, Mfowo N).

Pollarding

Pollarding is the cutting back of the crown of the tree at a height of 2 m or more from the ground. The main purpose of pollarding is to harvest the branches or leaves and to stimulate the growth of a new, well-formed productive crown at a height where livestock cannot reach the new shoots.

The entire crown of the tree is cut. The branches and twigs can be laid on the ground and left for one week. They can then be shaken to remove the leaves and small twigs and used as fuelwood or poles.

Not all species can withstand pollarding. Some commonly pollarded species are:

- *Balanites aegyptiaca* (Nkuyu N)
- *Brachystegia* spp. (Muombo N)
- *Erythrina abyssinica* (Mlunguti N)
- *Faidherbia albida* (Msangu N)
- *Ficus sycomorus* (Mkuyu N)
- *Grevillea robusta*
- *Jacaranda mimosifolia*
- *Julbernardia paniculata* (Mtondo N)

- *Manihot glaziovii* (Chinangwa, katapa, mtambula N)
- *Morus alba* (Malubeni N)
- *Piliostigma thonningi* (Msekese N).

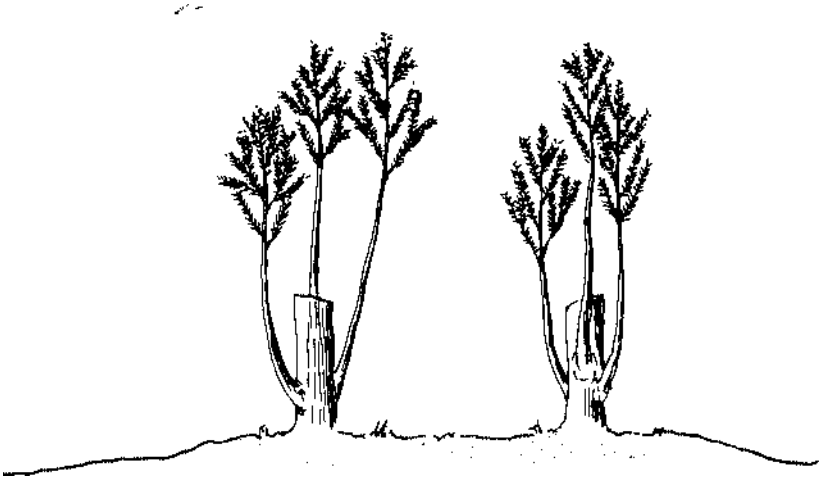


Figure 8.4 Pollarding

Pruning

Pruning is the removal of the lower branches of a tree. It is mainly done to:

- Reduce shade on the agricultural crop
- Harvest the branches for fodder, fuelwood, etc.
- Produce knot-free poles or sawn timber
- Allow passage through a woodlot.

Pruning should be done before planting the crop or during the cropping season when the trees have a shading effect on the crops. When pruning a branch, make the cut at an angle in order to allow rain water to drain away from the cut surface and therefore reduce the possibility of fungal attack. Trees for timber and pole production should be pruned close to the stem.

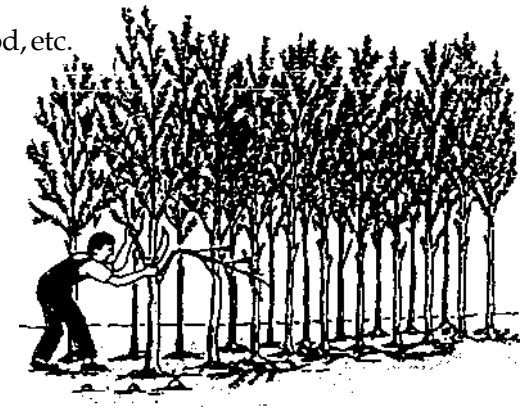


Figure 8.5 Pruning

Lopping

This technique involves cutting one or more branches from the trunk or stem of the tree, usually for fuel and/or fodder.

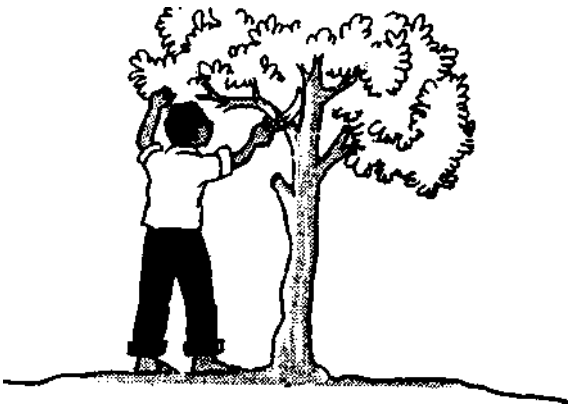


Figure 8.6 Lopping

Thinning

Thinning is a planned operation where closely planted trees are selectively cut. This requires the removal of about one-third of the trees leaving the best ones evenly spaced. In stands where trees are densely planted, thinning will occur naturally, but if active thinning is done the growth of the remaining trees will be promoted. The thinned stems can be used on the farm or sold, therefore thinning can be a profitable operation. Thinning can also be carried out for silvicultural reasons, for instance to salvage dying or diseased trees. Thinning out diseased trees reduces the risk of disease spreading to the rest of the stand.

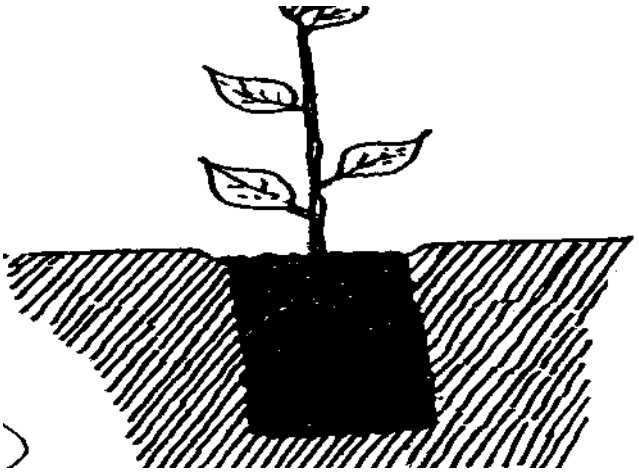


Figure 8.5 Thinning

9

MONTHLY PLANS FOR EXTENSION ACTIVITIES

9.1 Monthly plans

Table 9.1 gives details of extension activities to be carried out each month. The following subjects are covered:

- Practical topics in central nurseries (mainly Forest Department nurseries and, where applicable, horticultural nurseries in the Department of Agriculture). The areas covered under this topic range from propagation to sale of seedlings. The work in central nurseries should be co-ordinated by the District Forest Extension Officer.
- Topics for extension to individual farmers including nursery techniques, protection and management of trees and marketing of fruits.
  - This work should be done by Camp and Block Officers and co-ordinated by District Officers.
  - The District Forestry (Extension) Officer should make regular visits to supervise the programmes and help Block and Camp Officers with technical issues.
- Topics for extension based on group approach.
  - These include topics which need the active participation of the community, e.g. controlled burning, protection and management of indigenous forests and group nurseries. This work can best be done using a co-ordinated

Monthly plan for extension activities

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	No
ssues (what is to be done l nurseries)											
edlings for extension purposes	X										X
the nursery	X	X		X	X			X	X		X
ling distribution	X										
of nursery inputs	X	X	X								
nce of fire breaks			X	X	X						
ntenance			X	X							
on of nursery inputs				X	X	X	X				
ction				X	X	X					
maintenance of shade mats					X	X					
					X	X	X	X			
f slow-growing species						X	X	X			
of seedlings						X	X	X	X	X	X
out/singling of slow-growing species							X	X	X		
out/singling of fast-growing species									X	X	
of cuttings								X	X	X	X
of citrus								X	X	X	X
ning									X	X	X
g off										X	X
										X	X
of seedlings	X	X	X								X
ning			X	X				X	X	X	
ction (see Table 9.2)	X	X	X	X	X	X	X	X	X	X	X
f fast-growing species								X	X	X	X

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	No
extension work geared to families											
of wildlings	X	X									
f seedlings	X										
ding of live fences and woodlots	X										
f cuttings	X									X	X
ing of food crops, leguminous shrubs	X										
of seedlings from being s weeds when fields are weeded	X	X	X								
against insect damage and termites	X	X	X	X	X						
nd tending young seedlings		X	X	X	X						X
esting and marketing					X	X	X	X	X	X	X
against livestock damage					X	X	X	X	X	X	X
ent of on-farm nurseries						X	X	X	X	X	X
						X	X	X	X	X	
slow-growing species, including ment							X	X	X		
fast-growing species, including ment									X	X	X
against fire							X	X	X	X	X
g of woodlots									X	X	X
nd grafting							X	X	X	X	
learing of land/management t in fields								X	X	X	X

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	No
ration prior to planting or direct										X	X
nent and importance of wind breaks	X										X
out/singling of slow-growing species							X	X	X		
out/singling of fast-growing species									X	X	X

r extension based on the group

of seedlings from being removed when fields are weeded	X	X	X								
against insect damage (termites)	X	X	X	X	X						
against fire						X	X	X	X	X	X
and tending young seedlings		X	X	X	X						X
esting and marketing				X	X	X	X	X	X	X	X
ganization					X	X	X				
against livestock damage				X	X	X	X	X	X	X	X
nent of village/group nurseries					X	X	X	X	X	X	
d burning				X	X	X					
of indigenous bushland for establishment								X	X	X	X
ent of school nurseries when ose							X	X			X
e of indigenous trees							X	X	X		
clearing of land/management of n the field							X	X	X	X	X
nent and importance of windbreaks	X										X
ated to boundary planting										X	X

as there may be certain tree species which farmers need but that do not appear on the list. These may be added on your local collection programmes.

Seed collection should be spearheaded by the Forest Extension Officers if the demand for good-quality tree seeds and seedlings in the Province is to be met. Farmers with adequate knowledge and skills in collecting and handling seeds should be encouraged to collect for their own use.

Seed collection, handling and number of seeds per kilogram

n method

: collecting the fallen fruits and seeds from the ground.
ng: collection from the crown by climbing the tree with or without tools.
: collection from the crown with access from the ground with or without tools.

eriod

depends mainly on weather conditions. The period given in the tables applies under good drying weather conditions.

me	Local name	Time for seed collection (months)	Collection method	Extraction method	Drying		Separation (cleaning)	Seeds per kg	Storage	Pre-sowing treatment	T s
					Method	Period (days)					
cantha	Ngowe	June–Sept.	Picking Ground	Threshing	Sun	3–5	Winnowing	14,000–16,000	Airtight container	Soak in hot water	J
s	Mzunga Nsangu	May–Oct.	Climbing	Threshing	Sun	3–5	Winnowing	12,000–31,000	Airtight container	Soak in hot water	J
gitata	Mlambe	April–Oct.	Shaking Climbing Ground	Crushing Soaking	Sun	3–5	Washing	1,500–3,000	Airtight container	Soak in hot water	J
zensis	Mupapa	June–Oct.	Climbing Picking	Sun drying	Sun	3–5		450	Airtight container	Not necessary	J
a	Mkalanga Msengwa Mnyele	Dec.–April	Climbing	Drying	Sun	3–5	Hand	10,000–13,000	Airtight container	Soak in hot water	J
color	Mlilanzenze Mtanga Msasempanga	Aug.–Nov.	Climbing Ground	Threshing Drying	Sun	3–7	Hand	6,000–8,000	Airtight container	Soak in cold water	J

me	Local name	Time for seed collection (months)	Collection method	Extraction method	Drying		Separation (cleaning)	Seeds /kg	Storage treatment	Pre-sowing	T se
					Method	Period (days)					
	Chikuni Chashaba Buwa	March–June	Picking Ground	–	Sun	3–5	Hand	150–200	Container	Soak in	S
galensis	Mpovya	Dec.–April	Picking Ground	Crushing Squeezing	Sun	3–5	Washing	2,500–3,000	Airtight container	Not necessary Loses viability within 6 months	Ju
us	Jackfruit	Oct.–Feb.	Climbing Ground	Soaking	Sun	3–5	Hand washing	45–90	Not recommended	Not necessary	C
ndica	Nimu	Feb.–May	Picking	Soaking	Not recommended	–	Washing	5,000	Not recommended	Not necessary	A
eana	Mkole	Aug.–Sept.	Climbing Ground	Drying	Sun	3–5	Washing	±4,000	Looses viability within 6 months	Not necessary	F
yptiaca	Nkuyu	April–Sept.	Picking Ground	Mortar Pestle	Sun	3–7	Washing	350	Airtight container	Soak in cold water	Ju
rsiana	Mpondo Katondotodo	May–Sept.	Climbing Ground	Drying	Sun	3–7	Washing	±1,500	Airtight container	Soak in water	Ju
color	Mtacha Mziyi	Feb.–May	Picking	Squeezing	Sun	3–5	Washing	3,000–3,500	Airtight container	Not recommended	Ju
iopum	Mlaza Chipamba Kakoma	Aug.–Dec.	Climbing Ground	Soaking	Sun	4–7	Washing	2–3	Airtight container	Not necessary	M

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bussei	Mkongolo Mwanza Masaka	July–Aug.	Climbing Ground	Drying	Sun	3–7	Washing	1,500	Airtight container	Soak in water	
s	Mputi	June–Nov.	Climbing	Sun drying	Sun	5–7		1,500–2,600	Airtight container	Nicking	
antha	Mpasa Mlebezi Msongamino	Nov.–Jan. Ground	Climbing	Soaking Sieving	Sun 19,500	3–5 well	Winnowing necessary	19,000–	Does not store	Not	
na	Kawidzi Mkoso Ngalati Kapanga	April–Oct.	Climbing Ground	Threshing Drying	Sun	3–5	Hand	12,500–14,000	Airtight container	Soak in hot water	
decapetala	Chatata	June–Aug.	Picking Ground	Drying	Su	3–5	Winnowing Hand		Airtight container	Soak in hot water	
alothyrsus	Kalyandula	Aug.–Sept.	Picking	Threshing	Sun	3–5	Winnowing	19,000	Airtight container	Soak in hot water	
a	Papayi	Feb.–Nov.	Climbing Picking	Soaking	Sun	2–4	Washing	±20,000	Airtight container	Not necessary	
viata	Mkoswe Mtantany-elele Mnyoka	June–Aug.	Climbing Picking Ground	Drying	Sun	3–7	Winnowing Sieving	±15,000	Airtight container	Soak in cold water	
n	Nyamundolo	April–July	Picking	Drying	Sun	3–5	Washing		Airtight container	Soak in cold water	

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a	Kajwalina	July–Sept.	Climbing	Sun drying	Sun	2–5	Sieving	600,000–900,000	Airtight container	Not necessary	
	Ndimu	April–Aug.	Picking Ground	Soaking Squeezing	Sun	2–4	Washing		Airtight	Not necessary	
um	Kalamamba Tsanya Mpane'e Mkwela-mbulu	May–Oct.	Climbing Ground	Drying	Sun	3–7	Hand		Airtight container	Not necessary	
olle	Kalama Mkute Kailunguni	June–Sept.	Climbing Ground	Drying Threshing	Sun	3–5	Hand Floatation	10,000–15,000	Airtight container	Remove seed wings	
zonica	Saipuresi	May–July	Climbing Ground	Drying	Sun	3–5	Sieving	88,000–200,000	Airtight container	Not necessary	
itanica	Saipulasi	May–Aug.	Climbing	Sun drying	Sun	3–5	Sieving	160,000–290,000	Airtight container	Not necessary	
	Flamboyant	April–June	Climbing Ground	Drying Shaking	Sun	2–5	Winnowing	±2,000	Airtight container	Soak in hot water	
cinerea	Kalum-pangala	May–Oct.	Climbing Ground	Drying	Sun	3–7	Winnowing		Airtight container	Soak in hot water	
nis	Mchenja, Mchenja-musumu	April–Sept.	Picking	Trampling Mortar Pestle	Sun	2–4	Hand/ Washing	2,700–3,200	Airtight container	Not recom-mended	

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					Method	Period (days)				
us										
rpon	Mtowa, Mtombozi	June–Aug.	Climbing Ground	Drying	Sun	3–7	Floatation		Airtight container	Not necessary
undifolia	Matowo Mchiu	Oct.–Nov.	Climbing Ground	Drying Threshing	Sun	3–5	Hand Winnowing	35,000–40,000	Not recommended	Not necessary
yssinica	Mulunguti Mwale	Dec.–March	Climbing Ground	Drying Threshing	Sun	3–7	Hand Winnowing	6,800	Airtight container	Not necessary
itriodora	Bulugamu	May–Sept.	Climbing Shaking	Drying	Sun	1–3	Sieving	140,000–220,000	Airtight container	Not necessary
randis	Bulugamu	May–Sept.	Climbing Shaking	Drying	Sun	1–2	Sieving	900,000–3 million	Airtight container	Not necessary
s	Bulugamu	April–July	Climbing Shaking	Drying	Sun	1–2	Sieving	300,000–800,000	Airtight container	Not necessary
bida	Msangu	July–Oct.	Climbing	Mortar Pestle	Sun	3–4	Winnowing	±13,000	Airtight container	Soak in hot water
a	Chiyele Chinsense	Oct.–April	Climbing Ground	—	Sun	3–7	Winnowing	165,000	Not recommended	Not necessary
dica	Ntudza	May–Sept.	Climbing Picking	Drying Mortar Pestle	Sun	3–7	Winnowing	±200,000	Airtight container	Soak in hot water
hananii	Matatane Msamusa Msongwa	Jan.–April	Climbing Ground	Soaking	Sun	3–7	Winnowing	–	Not recommended	Soak in cold water

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lum	Quick stick	Aug.–Oct.	Ground Picking	Drying	Sun	3–5	Winnowing	6,500–8,000	Airtight container	Soak in hot water
rea	Malaina	Oct.–Dec.	Ground	Soaking Pounding	Sun	3–5	Floating	1,400–2,500	Airtight container	Not necessary
sta		May–July	Climbing	Threshing	Shade	3–5	Winnowing	±83,000	Airtight container	Not necessary
nosifolia		March –June	Climbing Picking	Drying	Sun	2–5	Hand	63,000–80,000	Airtight container	Not necessary
aniculata	Mtondo	Aug.–Dec.	Climbing	Drying Ground	Sun	3–7	Hand		Airtight container	Soak in cold water
lobiflora	Kamponi	July–Nov.	Climbing Ground	Drying	Sun	3–7	Hand	1,500–2,000	Airtight container	Soak in cold water
a	Mubawa Mlulu	June–Oct.	Climbing Ground	Drying	Sun	3–7	Hand	2,000–3,800	Airtight container	Not necessary
na	Mvunguti Mvungula Chizutu	Jan.–March	Climbing Ground	Soaking Mortar Pestle	Sun	3–7	Washing	3,400–6,000	Seed does not store well	Not necessary
ata	Mtumbwi Mzumba	April–Aug.ust	Ground Climbing	Drying Shaking	Sun	3–5	Floatation	3,000	Airtight container	Not necessary
nfurthii *hlmannii*	Chaumbu Kombwanyika Msambandola	Nov.–Feb.	Climbing Ground Picking	Soaking	Sun	3–5	Hand Floatation	40,000–45,000	Not recom-mended	Not necessary
ocephala	Lusina Lukina	June–Sept.	Picking	Threshing	Sun	3–4	Winnowing	13,000–34,000	Airtight container	Soak in hot water

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s capassa	Chimpakasa Mswaswa Chiwala-wala	May–Oct.	Climbing Ground	Drying	Sun	3–5	Winnowing Floatation	5,000	Airtight container	Soak in cold water
dica	Manga	Nov.–April	Climbing Ground	Drying	Sun	3–5	Washing	±50	Airtight container	Remove seed coat
	Kasanika Msusankwale	May–Sept.	Climbing Ground	Drying Threshing	Sun	3–5	Hand Floatation	±32,000	Airtight container	Not necessary
ach	Chinkondi	April–Aug.	Ground	Mortar Pestle	Sun	4–7	Washing	2,100–3,000	Airtight container	Not necessary
fera		July–Oct.	Picking	Threshing	Sun	2–5	Winnowing	4,000–5,000	Airtight container	Not necssary
atellifolia	Mupundu Mubula	May–Nov.	Climbing Ground Pestle	Soaking Mortar	Sun/ Shade	3–7	Washing	250–350	Airtight container	Not necessary
golensis	Muwanga	July–Oct.	Climbing Ground	Drying	Sun	3–7	Hand	3,000–3,500	Airtight container	Not Necessary
cana	Kotapela	Picking March–June	Climbing Ground	Soaking	Shade	3–5	Washing	±15	Seed does not store well	Not necessary
	Msekese	May–Sept.	Picking	Mortar Pestle	Sun	3–5	Winnowing	±7,200	Airtight container	Not necessary
	Paini	May–Aug. Tumbling	Climbing	Sun drying	Sun	1–4		143,000	Airtight container	Not necessary

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					Method	Period (days)				
	Paini	April–July	Climbing	Sun drying Tumbling	Sun	2–5	De-winging	55,000–62,000	Airtight container	Not necessary
a	Paini	May–Aug.	Climbing	Sun drying Tumbling	Sun	3–5	De-winging Hand	±36,000	Airtight container	Not necessary
stylis folia	Msolo	June–Oct.	Climbing	Soaking	Sun	3–7	Hand Washing		Airtight container 24 hours	Soak in hot water for
ava	Gwawa	April–July	Picking	Soaking	Sun Ground	2–5	Washing	±500,000	Airtight	
	Mlombe	April–July	Climbing	Sun drying Mortar Pestle	Sun	3–7	Hand	3,400–5,000	Airtight container	Remove seed coat, soak in cold water
a	Mkusu	April–Sept.	Climbing Ground	Drying	Sun	47	Hand Winnowing	–	Airtight container	Soak in hot water
aunis	Tsatsi Mono	Aug.–Oct.	Picking	Drying	Sun	37	Hand Winnowing	1,300	Airtight container	Not necessary
rrea	Mgamu Msewe	March–June	Climbing	Soaking Ground	Sun	2–5	Washing	400–450	Airtight container. Can store for months at room temperature	Soak in cold water
	Makeche	June–Sept.	Climbing Ground	Drying	Sun	3–7	Floating	30,000–45,000	Airtight container	Soak in cold water

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bilis		Aug.–Oct.	Climbing Ground Picking	Drying	Sun	3–7	Washing	31,000–45,000	Airtight container	Soak in hot water
rantha	Chizonga	July–Oct.	Picking	Threshing Winnowing	Sun	3–5	Hand	85,000–130,000	Airtight container	Soak in cold water
an	Chigoma Msalasese Jelejele	May–Oct.	Picking	Threshing	Sun	2–3	Floatation	±100,000	Airtight container	Soak in hot water
ata	Nandi flame	April–July	Climbing Ground	Drying Shaking	Sun	3–5	Floatation	±150,000	Not recom-mended	Not necessary
cana	Mgoza Mulele	April–July	Climbing Ground	Drying	Sun	3–7	Hand	15,000–17,000	Airtight container. Viable for 2 months only	Not necessary
nqueloba	Mgoza Mgozga Msambamfumu Mlelezombo	June–Oct.	Climbing Ground	Drying	Sun	3–7	Hand	24,000–28,000	Airtight container. Viable for 2 months at room temp.	Not necessary
cculoides	Mzimbili Mzai Mtemya	Oct.–Dec.	Climbing Ground	Crushing Soaking	Sun	3–7	Washing	1,800	Airtight container	Soak in cold water
nocua	Mteme Mtulutulu Kabulukulu	Nov.–Feb.	Climbing Picking Ground	Breaking Soaking	Sun	3–5	Floatation Hand	1,800	Not recom-mended	Soak in cold water

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nosa	Mzimbili Mzai Msongolo	Sept.–Dec.	Climbing Picking Ground	Breaking Soaking	Sun	3–7	Floatation Hand	1,800	Airtight container	Soak in cold water	
riensis	Mchelekete	May–Sept.	Climbing	Drying Mortar Pestle	Sun	3–7	Washing Floating	±2,500	Airtight container	Soak in hot water	
datum	Mchisu Msombo Msinyika	Nov.–March	Climbing Ground	Soaking	Sun	2–5	Washing	400–500	Seed does not store well	Not necessary	
neense	Katope Msombo	Oct.–Jan.	Ground			2–4	Winnowing	2,400–3,700	Storage in open moist container possible for a few days	Not necessary	
ndica	Bwemba	July–Nov.	Climbing Ground	Soaking Wire mesh	Sun	3–7	Winnowing	1,400–2,600	Airtight container for 24 hours	Soak in hot water	
is	Bamatiki	June–Aug.	Climbing Ground	Soaking	Sun	3–7	Floating	100	Airtight container	Not necessary	
elii	Wombo Mtetezya Buba	June–Oct.	Picking	Drying Threshing	Sun	3–5	Hand Winnowing	17,000–33,000	Airtight container	Soak in hot water	
ricea	Gonondo	May–Aug.	Ground		Sun	3–7	De-winging	1,200	Airtight container	Soak in cold water	

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					Method	Period (days)					
viana	Savesha	May–Aug.	Picking Ground	Soaking	Sun	3–7	Washing	±300	Airtight container	Not necessary	
	Sendelela	Nov.–Dec.	Climbing	Drying	Sun	2–5	Winnowing Sieving	300,000–380,000	Airtight container	Not necessary	
tica	Msikizi	Dec.–April	Climbing	Shade Drying Shaking	Shade	3–5	Winnowing	300	Moist storage possible in open containers for a few days	Not necessary	
ana	Msuku	Aug.–Dec.	Climbing Picking	Soaking Squeezing Ground	Sun	3–5	Washing	±2,500	Does not store well	Removal of seed coat	
a	Kasokolowe	Sept.–Nov.	Climbing Ground	Soaking	Drying	3–5	Winnowing	–	Not recommended	Not necessary	
barica	Kasokolowe Katoto	Sept.–Dec.	Climbing Ground	Soaking	Drying	3–5	Winnowing	–	Not recommended	Not necessary	
a	Mfimfya Mfifya Mfutu	April–Aug.	Climbing Ground	Soaking	Sun	3–5	Washing	900–1,300	Airtight container	Soak nut in cold water for 24 hours	
ricana	Ntengele Mtundulukwa	April–Aug.	Ground Picking	Soaking Squeezing	Sun	3–5	Washing	660–1,400	Airtight container	Not necessary Seed only viable for three months	

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sinica	Kankande Mlashawantu	April–Nov.	Picking Ground	Soaking Squeezing	Sun	3–5	Washing	430–2,000	Airtight container Remove fruit pulp	Soaking in water.	
ritiana	Msau Masau	May–Oct.	Ground Picking	Soaking Squeezing	Sun	3–5	Washing	650–3,500	Airtight container	Soaking seed in cold water for 24 hours	