



Agroforestry handbook for the montane zone of Uganda



Alex Lwakuba
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Foreword

One of RELMA's strengths is its capacity to produce good publications for extension workers, aimed at helping them to address effectively the issues that are relevant for small-scale land users. For me as a forester, it is indeed satisfying to assist in the publication of an agroforestry handbook.

More trees in the landscape means a lot for farmers' economy—through reduced costs of living and increased incomes—as well as for the environment. Often the highest valued trees are those suitable for sawn timber, especially the durable hardwood species. Viable approaches to the commercial conversion of a few scattered timber trees on small farms into valuable products do exist, including the use of light, mobile sawmills.

A prerequisite for profitable tree growing is a good start for the trees. The cost of preparing the site, planting the seedling and taking good care of the young tree is often much higher than the cost of the seedling itself from the nursery. Efforts to ensure a high survival rate and healthy growth of tree seedlings are essential to ensure that the money paid for the seedling turns out to be a good investment.

In comparison with crops, tree growing is a long-term business. The final result is not known at the time of establishment. Therefore, it is important for the farmer who is planting trees that long-term benefit is secured. Secure land tenure is crucial.

When reforesting bare lands, we have a unique opportunity to influence the future composition of tree species. Not necessarily the original native species are the most suitable in perspective of future multipurpose use. Open minds towards both indigenous and exotic trees are likely to result in the greatest benefits in the long run.

Some handbooks on agroforestry are already available, but so far none has been specifically adapted for the montane zone of Uganda. I am pleased to note that quite a number of persons have contributed in different capacities and with different professional experience. It is our hope that the blend of technical know-how from different subject areas with the practical experience of farmers and field workers that has been synthesized in the manual will be found useful in a range of different situations—for extension workers and group leaders as well as for individual farmers. The practical examples given by innovative farmers verifies that agroforestry is a viable and profitable land-use system.

Åke Barklund
Director, RELMA

Preface

The current rate of environmental degradation in Africa threatens people's basic survival. In Uganda, environmentally insensitive farming practices have over the years given rise to land degradation in many parts of the country, particularly in the highland areas. As a result, Uganda's agriculture continues to register one of the lowest yields in the world.

Consequently, the government of Uganda has adopted its Plan for Modernization of Agriculture (PMA), with an aim of transforming subsistence agriculture into an agriculture sector that is commercial and market oriented. Effective links between researchers, farmers and extension agents, and the conservation of natural resources and the environment are some of the priorities that this plan emphasizes.

Agroforestry, the growing of trees or shrubs in association with crops, pastures and livestock, has been invariably identified as an ideal, ecologically and economically suitable land-use system, which aims to increase total production per unit area while maintaining or enhancing soil fertility. Farmers in some parts of Uganda have been practising agroforestry for many years and have enough experience to share with other farmers. Additionally, the Forest Resources Research Institute has developed agroforestry technologies suitable for the montane zone of Uganda.

It is my sincere hope that this manual, which is intended for farmers as well as extension workers, will go a long way in promoting the understanding and practice of agroforestry in Uganda, particularly in the montane zone.

I wish to thank all those who contributed in one way or another towards producing this manual. Furthermore, I convey special thanks from the National Agricultural Research Organization, FORRI, and the Ministry of Agriculture, Animal Industry and Fisheries to the Regional Land Management Unit for financially supporting the production of the manual. There is no doubt that the manual will greatly contribute to the process of modernizing agriculture in Uganda.

J.F.O. Esegu

Director

Forest Resources Research Institute

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Many individual farmers as well as organizations and institutions contributed to the production of this handbook. The authors wish to express their gratitude to all.

The Regional Land Management Unit (RELMA) provided both financial assistance and necessary guidance. We particularly thank Christine Holding Anyonge, agroforestry extension advisor, for streamlining and coordinating the exercise. Thanks are also due to Alex Oduor, the information officer, for facilitating the early stages of production and for technical input. Mary Ouma, secretary, facilitated the organization of finances and the consultative and review workshops. We are grateful to her. Anthony B. Katende, a botanist with taxonomic and ecological knowledge accumulated over decades of dedicated scientific work, provided input on the list of tree species that are suitable for the montane zone. Raymond Wamukoya, a Nairobi-based artist, prepared all the drawings. These are frequently based on drawings from other RELMA and ICRAF publications, for example, *Agroforestry in dryland Africa* and *Agroforestry extension manual for Kenya*. Other drawings are based on sketches that were prepared in Uganda. Bo Tengnäs reviewed the draft, gave useful comments and assisted in the final production stages.

The authors acknowledge with great appreciation the direct and indirect contribution made by several institutions and organizations: the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), the Forestry Department, the Forest Resources Research Institute (FORRI), the International Union for Conservation of Nature (IUCN), the Mount Elgon Conservation and Development Project (MECDP), Africa 2000 Network/Uganda, CARE-Kabale, AFRICARE and ICRAF.

We extend our sincere gratitude to the staff of the institutions and organizations that committed their time and resources to preparing the handbook: to mention a few, Charles Rusoke, Soil and Water Conservation Section of MAAIF; Simon Nyangas of MECDP in Kapchorwa; Jamaali Waniaye, field extension worker in Mbale; Pascal Bizimana, field extension worker in Kabale; and the district agricultural officers and district forestry officers of Kabale, Kapchorwa and Mbale. Thanks are extended to Christine Saru and Susan Ogwang, FORRI secretaries, for typing the initial drafts of the handbook.

Above all, the authors are extremely grateful to the farmers who volunteered information that enriched this handbook. A list of these farmers and other contributors is given in appendix 2.

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Acronyms and abbreviations

AFRENA	Agroforestry Research Network for Africa
FORRI	Forest Resources Research Institute
ICRAF	International Centre for Research in Agroforestry (World Agroforestry Centre)
IUCN	International Union for Conservation of Nature
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MECDP	Mount Elgon Conservation and Development Project
NARO	National Agricultural Research Organization
RELMA	Regional Land Management Unit
RSCU	Regional Soil Conservation Unit
Sida	Swedish International Development Cooperation Agency
UGS	Uganda shilling, valued at about 1,900 to 1 US dollar in 2002
ULAMP	Uganda Land Management Programme
UNDP	United Nations Development Programme

1 Introduction

Agriculture supports the livelihoods of most people in Uganda, particularly farmers, who constitute over 80% of the country's population. The government has formulated policies to improve agricultural production. Consequently, a Plan for Modernization of Agriculture (PMA) has been adopted, which includes the following strategies:

- promote specialization in production
- promote improved agricultural technologies
- promote profit-driven investment (commercialization)
- diversify land use, including promoting agroforestry
- control land fragmentation
- promote production of high-value crops

In Uganda, agroforestry research started in 1988. Through rigorous promotion, farmers have adopted some technologies generated from research. The promotion of agroforestry in Uganda has, however, been constrained by limited access to suitable tree seeds and seedlings, inadequate numbers of extension staff and limited support in terms of information and facilities.

Development agencies concerned with promoting agroforestry and related farming practices have recognized the lack of suitable extension materials, and some effort has been made to produce them. For example, Africa 2000 Network in collaboration with the Regional Soil Conservation Unit (RSCU) of the Swedish International Development Cooperation Agency (Sida) published *Sustainable agriculture practices and technologies: guidelines for farmers*. Farmers have used the version translated into the local language. However, that guideline does not cover agroforestry very well. The VI Agroforestry Project has produced other subject-specific materials. A handbook on agroforestry practices suited for the banana–coffee zone of Uganda has been published by Sida's Regional Land Management Unit, RELMA. Nevertheless, a comprehensive handbook on agroforestry in the mountainous areas of Uganda has so far been lacking.

This handbook is published specifically to address the scarcity of agroforestry extension materials for farmers and extension services in the montane zone of Uganda. It is largely based on farmers' experiences. During its preparation, field studies were undertaken in the three districts of Kabale, Kapchorwa and Mbale. Informal interviews were conducted and discussions were held with farmers to gather information on their agroforestry practices. Interviewed farmers and other respondents are listed in appendix 2. Some farmers were selected for in-depth interviews. They were selected based on guidance by key informants on the best practitioners of a given agroforestry practice. Additional information was obtained through observation and review of published research work.

The manuscript was distributed to collaborators for evaluation of appropriateness of the content and relevance to farmers. Adjustments were made based on the comments received, and the case studies were further reviewed during a workshop in which farmers and potential users of the handbook took part. Participants in that workshop are listed in appendix 3. Attempts were made during the workshop to list local names of tree species discussed in this handbook. Farmers at the workshop were from Kabale, Kapchorwa and Mbale. Consequently, local names for the trees were listed in Kupsabin and Lugishu when farmers from Kapchorwa and Mbale reported or in Rukiga when farmers from Kabale provided the names. Additional names have been extracted from Katende et al. (1995).

2 The montane zone

The montane zone comprises the mid- and high-altitude farming systems of Uganda; it stretches between 1,500 and 2,300 metres above sea level. This manual focuses on the densely populated part of the montane zone that receives more than 1,000 mm of rain annually. Other areas that fall within the altitude range, for example the mountains in Kotido and Moroto Districts and higher parts of the hills near Mbarara, are not discussed. The result of this approach is that the manual geographically covers four different areas of Uganda, as shown in figure 1:

- the south-west corner of the country, covering the Mufumbiro Mountains, Kabale and Kisoro Districts, and minor parts of Kanungu, Ntungamo and Rukungiri Districts
- in the east, in the Mount Elgon area, with portions of Kapchorwa, Mbale and Sironko Districts falling within the zone
- in the west, covering portions of Bundibugyo, Kabarole and Kasese Districts
- in the north-west, a highland part of Nebbi District

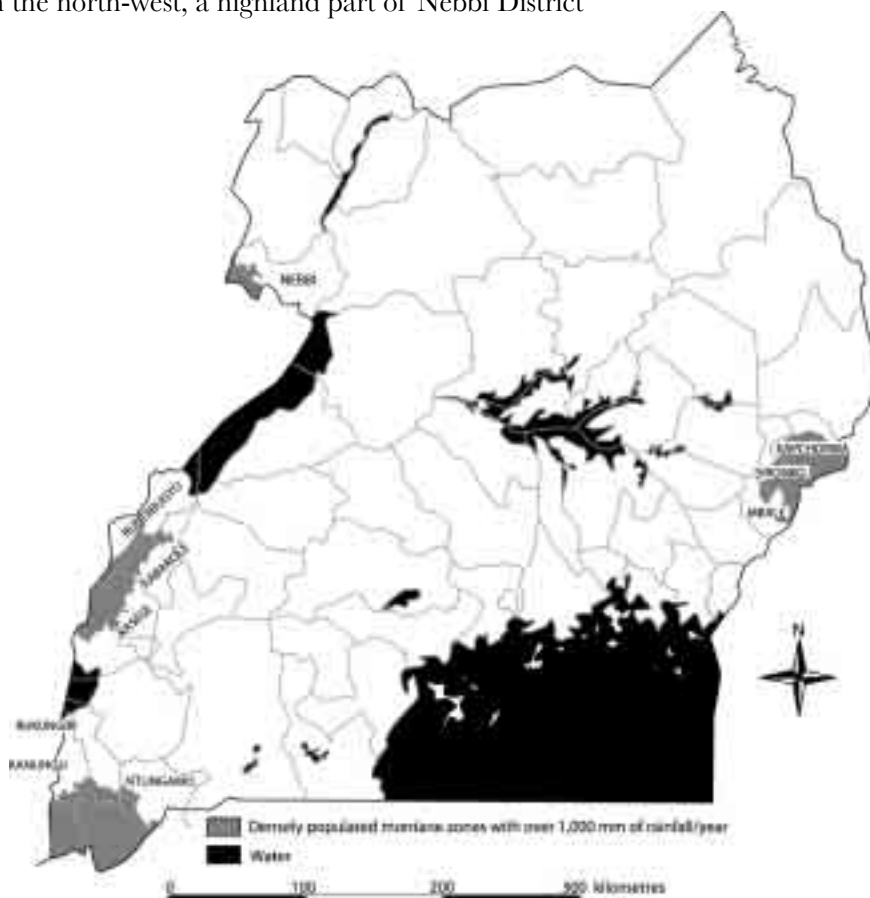


Figure 1 The montane zones of Uganda covered in this manual. Source: National Biomass Study, Kampala.

The land use in these areas is quite diversified. In some areas, such as in Kapchorwa and Mbale Districts, extensive grazing and mixed subsistence farming are the main land use. Subsistence crop production is also common in the mountainous Kabale. The main crops in the areas covered by the manual include banana, bean, cassava, coffee, finger millet, irish potato, maize, sweet potato, vegetables and wheat. Sorghum is grown on the middle and lower parts of hill slopes, especially in Kabale District.

2.1 Relief and soils

The montane zone is characterized by hilly terrain and steep slopes. The zone experiences relatively low to high temperatures, closely related to altitude. The annual rainfall is mostly between 1,200 and 1,500 mm and is well distributed throughout the year. Marked rainfall peaks occur during April to May and October to November. Two dry spells of comparatively short duration occur in June to July and December to January.

The soils are often of volcanic origin and of medium to high productivity. They are well drained, deep and relatively fertile. Agricultural potential is high.

The average cultivated area per household is small, ranging from as little as 0.1 ha in some areas in the south-west up to 0.4 ha in parts of the Mount Elgon area in the east. Land is highly fragmented, largely because of population pressure.

2.2 Farming systems in the montane zone

The montane zone has three distinct farming systems, listed here and described in the sections following:

- medium-altitude intensive banana–coffee system
- Sebei annual food crops system
- Kigezi annual food crops system

Medium-altitude intensive banana–coffee system

The banana–coffee farming system covers parts of Kabale (Rukiga County), Kabarole, Kapchorwa, Kasese (Bukonjo and Bwamba Counties) and Nebbi Districts. These areas are hilly, with altitude ranging between 1,500 and 2,000 m above sea level. The mean annual rainfall varies from 1,250 to 2,000 mm. The rain falls in two seasons, from March to May and from August to November. The rainy seasons are interspersed with dry seasons. The predominant soil type varies from one area to another. Sandy loams are common in Nebbi and other drier areas. Well-drained volcanic soils dominate in Kabale.

The population density is high and the land is extremely fragmented. Farm sizes are small, averaging about 0.2 hectares per household. The main cash crop is coffee, while banana is the main food crop. Other crops grown are bean, cassava, irish potato, maize

and vegetables. Farmers also keep livestock, typically one to three cattle, and in addition some goats and sheep. Trees are grown together with banana, coffee and annual crops. Eucalyptus woodlots are common.

Sebei annual food crops system

The Sebei land-use system covers Kwen and Kongasis Counties in Kapchorwa District in the Mount Elgon area. The zone lies at around 1,800 m above sea level. The climate is mild, with mean annual maximum and minimum temperatures of 25°C and 10°C, respectively. The mean annual rainfall is about 1,500 mm, with non-severe dry seasons. Peak rainfall comes in the months of May and October. The soils are typically shallow red sandy-clay loam.

The region is not as heavily populated as other montane areas. Cultivation of annual food crops is the main land use. Maize is the major food and cash crop. Other crops include bean, irish potato, sweet potato, wheat and yam. Cattle, goats, sheep and donkeys are commonly kept. Woodlots are not common and wood is in short supply in many areas.

Kigezi annual food crops system

The Kigezi land-use system occurs in Kabale and Kisoro Districts on the northern slopes of the Mufumbiro Mountains and on other hilly areas. Temperatures are moderate and usually range between a minimum of 10°C and a maximum of 23°C. The annual rainfall is between 1,000 mm and 1,500 mm. The soils are typically deep, volcanic and relatively fertile.

The population density is high, ranging between 450 and 600 persons per square kilometre. Land is scarce and the farms are small. The average size of farms ranges between 0.1 and 0.2 ha per household. The major crops are bean, field pea, indigenous vegetables, irish potato, sweet potato, maize, sorghum and wheat. Sorghum is the main cash crop. Mixed cropping is a major land-use practice. Terraces for soil erosion control are common.

Most households keep goats. Only a few have cattle because land is scarce. The animals are herded and grazed on marginal hillsides, valley bottoms, roadsides and on fields during seasons when there are no crops. Trees are grown around homesteads and in small household woodlots. Eucalyptus is the main tree species planted in woodlots. Although most of the natural vegetation has been cleared for settlement and agriculture, important remaining forests in the area are the Echuya Bamboo Forest, the Impenetrable (Bwindi) Forest and the Mgahinga Bamboo Forest.

3 Agroforestry as a sustainable form of land use

3.1 What is agroforestry?

In its simplest definition, agroforestry means the growing of trees on farms. Trees are grown together with food crops on the same plot. Agroforestry can also involve using agricultural land for temporarily growing trees during a fallow period and for intermittent grazing. Those practices are known as rotational agroforestry.

Agroforestry can be practised on a single garden or field, or throughout extensive areas like a watershed or on extensive communal land. Agroforestry refers to a land-use system but not to a fixed arrangement of plants.

3.2 Agroforestry in Uganda

Farmers in Uganda have long practised agroforestry. Growing coffee together with bananas and fruit trees is one example. Agroforestry practices address poor soil conditions, production of firewood and other tree-related needs of farmers. Some new agroforestry practices were introduced to Uganda in the early 1990s.

Most farmers in Uganda practise subsistence agriculture. However, as the population in the country has grown, the land has been further subdivided and family holdings have thus decreased in size. Consequently, pressure on land has increased and the old sustainable systems of agriculture, which operated efficiently when land was plentiful, can no longer be practised. Overcropping and overgrazing have therefore degraded the land. This is the direct result of current farming methods, in which fallow periods are short or non-existent. Soil fertility has declined and soils have become more prone to erosion.

Agroforestry technologies can increase and sustain land productivity. Even from a small farm, farmers practising these technologies can grow different types of food crops and harvest tree and livestock products. Chapter 5 provides more details on relevant agroforestry practices as well as reports on farmers' experiences.

3.3 Land tenure

A main factor that influences the type of agroforestry farmers practise is land tenure—the ownership and other forms of rights to land and land use. Uganda has three common types of land tenure.

The *mailo* type is common in central and western Uganda. In the mailo land-tenure system, the absentee landlord who owns the land allows small-scale tenant farmers to occupy and use it. Most farmers living on and cultivating mailo land have no legal land

titles. Farmers who cultivate mailo land are known as *kibanja* owners. Another common type of land tenure is *leasehold*, in which occupants have land titles that cover a specific lease period, of either 49 or 99 years. The third type is *customary*, which is ownership based on inheritance. An individual owning inherited land can pass it on to descendants.

Without assured future security of tenure, households tend not to plant trees. Generally, farmers on mailo land feel secure of tenure and grow trees—even those that take a long time to mature, because one can claim compensation if evicted. Individual households grow trees on customary land too, once the land has been properly allocated. Where farmers are not assured security of land tenure, they tend to grow short-duration shrubs. Some agroforestry shrubs grow fast and can be harvested within a year after planting.

4 Interaction between trees and crops

4.1 Why trees and crops together?

African traditional agricultural systems that were based on shifting cultivation used the capability of trees and other plants to restore soil fertility. Even now farmers grow or leave trees on their land, often noting that doing so has beneficial effects for the soil and crop yields. It is well known that the topsoil in forests is usually rich in nutrients and has good structure. In a natural forest there is little leakage of nutrients out of the system. Agroforestry systems are more similar to natural ecosystems than are monocropping systems since both trees and herbaceous plants are present, and a well-functioning agroforestry system potentially can decrease the leakage of nutrients.

Soil status is one of the factors that determine how a crop will perform on a certain site but it is not the only factor of importance. Moisture content, shade and occurrence of pests and diseases are others.

Trees provide litter and mulch, some trees fix atmospheric nitrogen, and most trees and shrubs have roots that penetrate deeper into the soil than the roots of most agricultural crops. The presence of trees planted in a suitable arrangement will also reduce soil erosion. In addition, trees provide direct benefits like timber, firewood, fruits, fibres and raw material for local medicine. Trees can improve the microclimate by, for example, acting as a windbreak, and trees and shrubs can be used as live fences, which help regulate land use.

Different crops have different requirements with regard to light, moisture, risk of bird damage, risk of build-up of high levels of nematodes in the soil, and risk of wind damage.

All these factors need to be considered, together with socio-economic factors like labour demand, when agroforestry systems are promoted.

Various management interventions can be applied to fine tune the interaction between trees and shrubs. Shading, for example, can be reduced by pollarding and pruning, and some trees can be cut and allowed to resprout (coppiced). When considering the effectiveness of an agroforestry system, it is important to remember that it is not the output of one single component that should be maximized but rather the combined outputs of the different components. Another aspect is how sustainable the farming system is. A system that gives high production for a few years but that leaves the soil exhausted is of little value. High, sustainable and profitable output from a given piece of land should be the key objective in promoting agroforestry through extension.

4.2 Management of trees in agroforestry systems

Some of the management techniques applied to trees and shrubs in agroforestry systems are similar to those used in managing trees in forestry plantations, but others are different.

The most important management techniques with regard to the part of the tree above ground are

- pruning
- lopping
- pollarding
- coppicing
- thinning

In addition, root competition can be reduced by applying management techniques to tree roots.

Pruning

Some trees form extensive branches. Where such trees are grown together with crops, they shade the companion crops and reduce crop yield. It is therefore necessary to remove the side branches to maintain good crop yield. This is pruning. Trees are also pruned to encourage growth of a straight stem, to produce good timber. The cut is made close to the stem but it avoids destroying the stem bark around the branch. Figure 2 illustrates pruning.

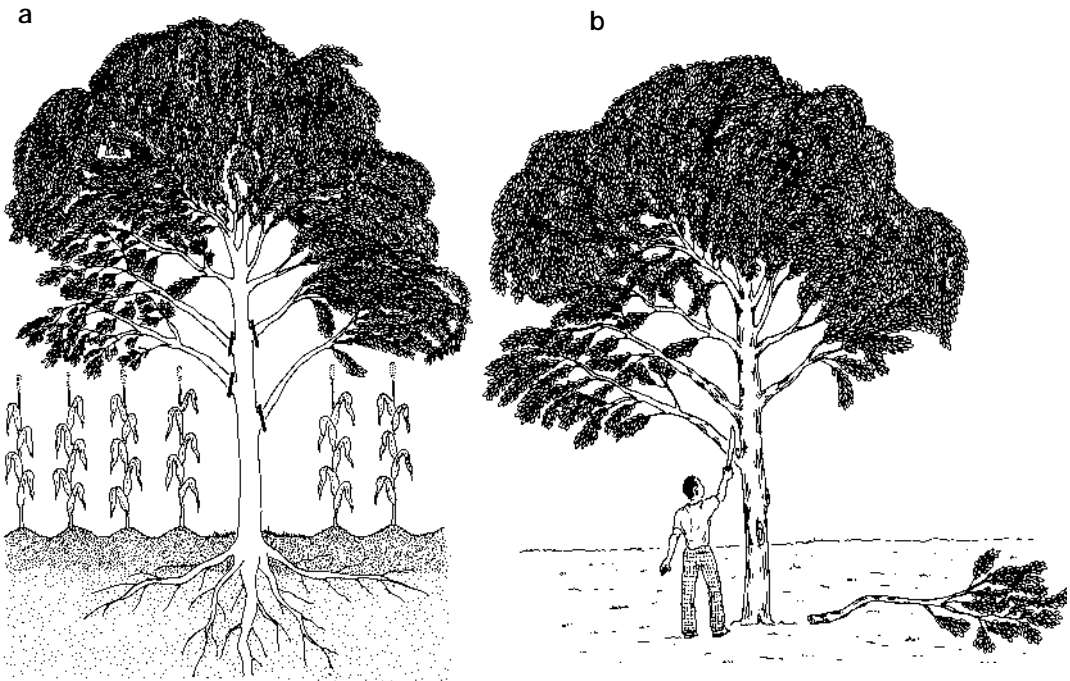


Figure 2 Trees may be pruned to reduce shade: a) the lower branches of this tree may be removed where marked; b) pruning is best carried out in the dry season.

Too much pruning may reduce the growth of certain species. Young trees can usually be pruned up to about two-thirds of the tree height, while older trees of certain species can tolerate more severe pruning (see 'Pollarding').

Branches should be pruned at least up to the height of the adjacent crops if trees are growing in fields. Such pruning facilitates farming operations and reduces competition. The best time for pruning is towards the end of the dry season when the work will not interfere with growing crops and when the workload in other agricultural tasks is not so heavy.

Lopping

Lopping is distinguished from pruning in that branches are not cut from the base. Also lopping is not always done starting from the lower part of the tree but can be random. The main criterion in selecting branches to cut often is good green leafy biomass since lopping is usually done to obtain branches for fodder.

A main advantage of this technique is that it allows harvest without killing the tree. All tree species can be lopped, but the growth rate of certain species may be retarded if they are heavily lopped.

Tree species that can be lopped are those that regrow easily when cut, such as *Acacia* spp., *Calliandra calothyrsus*, *Cordia abyssinica* and *Grevillea robusta*. Lopping is illustrated in figure 3.

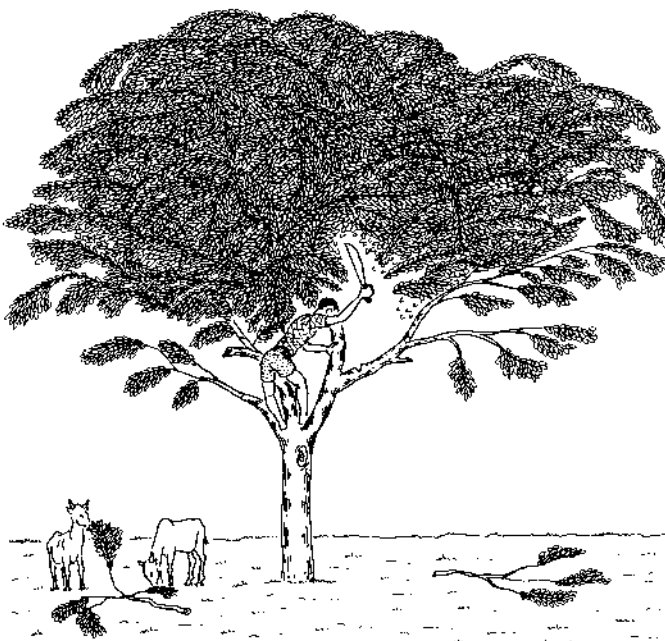


Figure 3 Lopping branches for fodder.

Pollarding

Cutting off all the branches and the top part of a tree is known as pollarding (fig. 4). Pollarding may be done with several objectives in mind:

- early harvest of wood, fodder or other biomass
- production of wood or fodder that is out of the reach of livestock, hence there is no need for protection from browsing
- reduction of shading of nearby crops
- regeneration of the tree crown to promote growth of the trunk for timber or poles

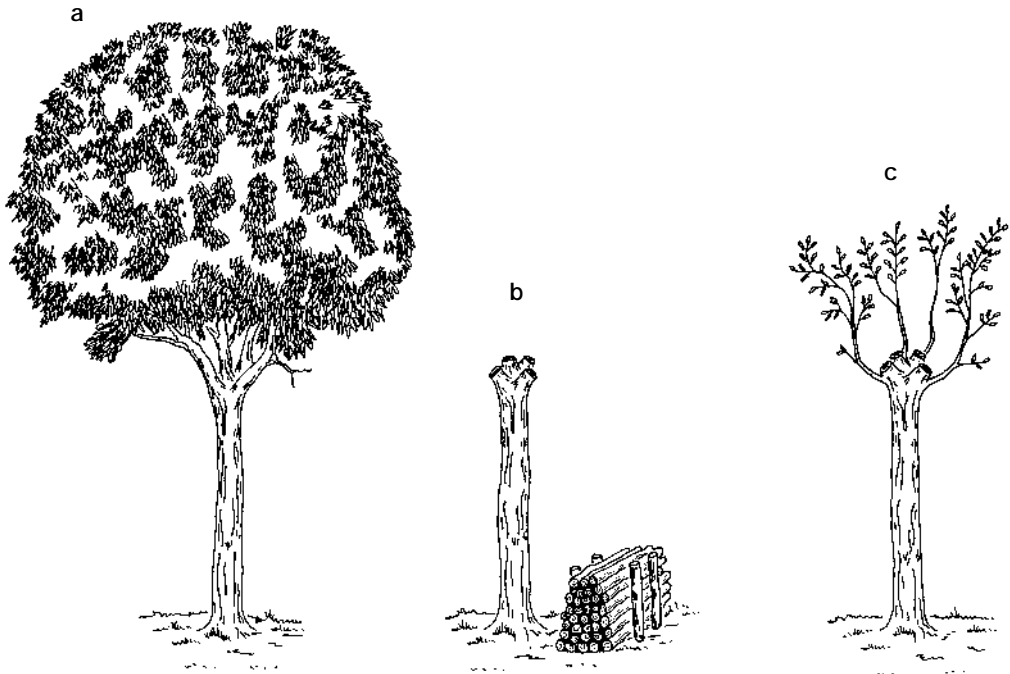


Figure 4 Pollarding: a) tree before pollarding; b) after pollarding; c) resprouting.

The choice of pollarding height and frequency depends on the desired products. If the main aim is to produce timber or poles, the top of the tree should be cut as high up as possible, and the pollarding interval should be such that the crown is kept as green and vigorous as possible for the maximum production of trunk wood. An interval of 2 to 5 years is appropriate in such cases.

If the main aim is to produce firewood or fodder, it is better to pollard lower down the tree to facilitate access. Pollarding can then be done more frequently, such as once a year. It is advantageous to try to form a wide 'stool' (the part of the tree remaining at the base after it has been cut) to achieve a substantial production of biomass.

Sometimes the main aim is to produce staking material, poles or withies for construction. In such situations a wide stool will allow many stems to grow. Initially, too dense a stand may sprout after pollarding, and thinning is then recommended, leaving a suitable number of branches in relation to the size of the stems eventually desired.

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

- *Bridelia micrantha*
- *Casuarina* spp.
- *Cordia abyssinica*
- *Croton* spp.
- *Erythrina abyssinica*
- *Grevillea robusta*

- *Manihot glaziovii*
- *Markhamia lutea*

Coppicing

Many species of trees and shrubs can resprout after the whole tree has been cut. When this ability is used to regenerate the tree the practice is known as coppicing. Coppicing can almost be regarded as a method of tree propagation since it can substitute for the task of planting a new tree after a mature one is felled.

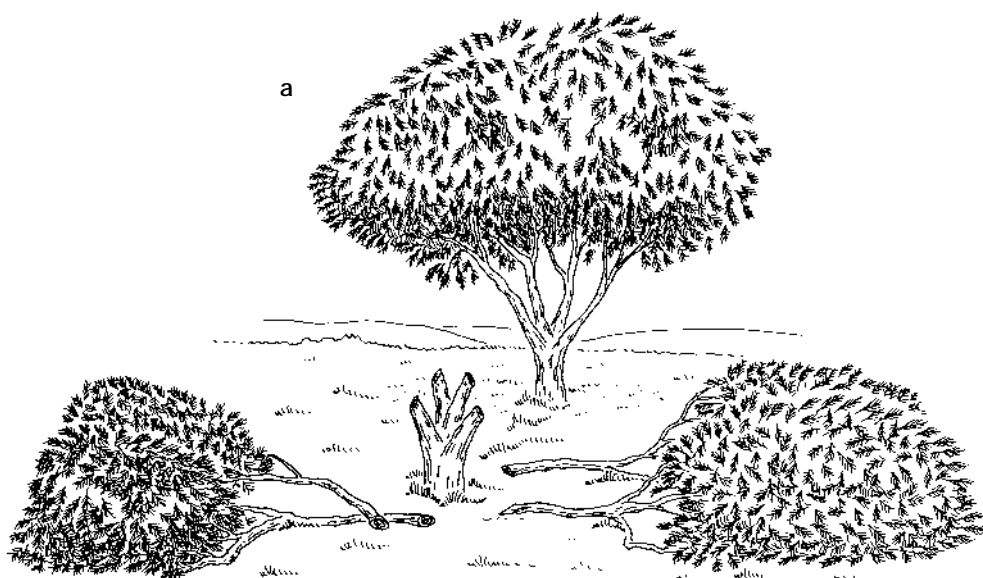
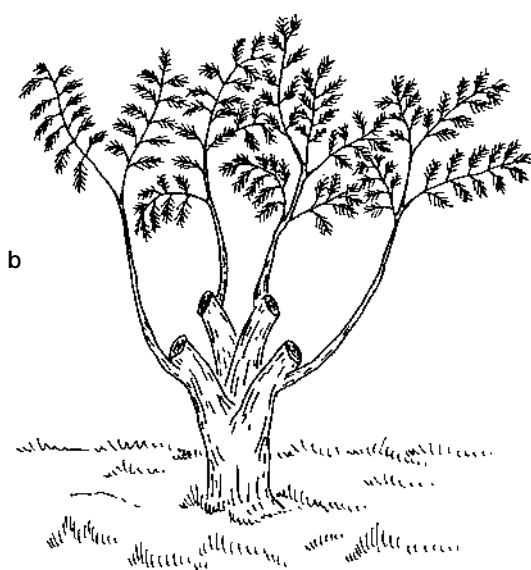


Figure 5 Coppicing: a) coppicing cut made at a slanting angle; b) resprouting coppice shoots.

The height at which trees are cut for coppicing can vary from near the ground to about knee height. Coppicing should be done towards the end of a dry season or just at the beginning of a rainy season to allow the coppiced plants to regrow. Figure 5 illustrates the coppicing technique.

Systematic coppicing can be applied as the management technique for trees on soil-conservation structures. In such a situation coppicing may be done an-



nually, but in other situations, such as regenerating *Eucalyptus* for pole production, it may be much less frequent, and an interval of 6 to 8 years may be more suitable.

Not all tree species will coppice after being cut. Some commonly coppiced species are:

- *Calliandra calothyrsus*
- *Eucalyptus* spp.
- *Leucaena* spp.
- *Markhamia lutea*

Certain species coppice well when young but may not do so if cut at maturity. Examples are *Casuarina* spp., *Grevillea robusta*, *Sesbania sesban* and some *Albizia* spp.

Thinning

Trees established by direct seeding or that have been planted with little space between them will soon start to compete with each other. A dense stand initially promotes straight growth and small branches, but later the trees must be thinned; otherwise, they will grow too slender and eventually not reach the desired size. Thinning is particularly important for trees grown in woodlots, but it applies also to other situations where trees are growing close to each other. A woodlot can be established with trees spaced 1 by 1 m. Thereafter, the spacing is increased to 2 by 2 m by cutting some of the trees.



Figure 6 Thinning: a) thinning is necessary when trees become too crowded; b) a thinned stand.

Thinning can, for example, be done by removing every second tree or two out of every three trees. Thinning is also a way of obtaining some early harvest. Figure 6 shows a woodlot before and after thinning. The materials removed from the woodlot during thinning may be used as firewood or in construction.

Management of roots

Just as the tree crown can be managed to reduce competition, so can the roots be managed, and for the same purpose. Trees growing in cropland can have their shallow roots cut 0.3 to 0.6 m from the trunk when they reach a height of 2 to 3 m. This is applicable to species that would otherwise compete with crops. The roots are best managed by digging a relatively deep trench (0.3–0.6 m) along the edges of woodlots of, for example, *Acacia mearnsii*, where the woodlots border cultivated land (fig. 7). The trench serves to minimize competition.

An obvious disadvantage of all techniques for root management is that they require a lot of work.

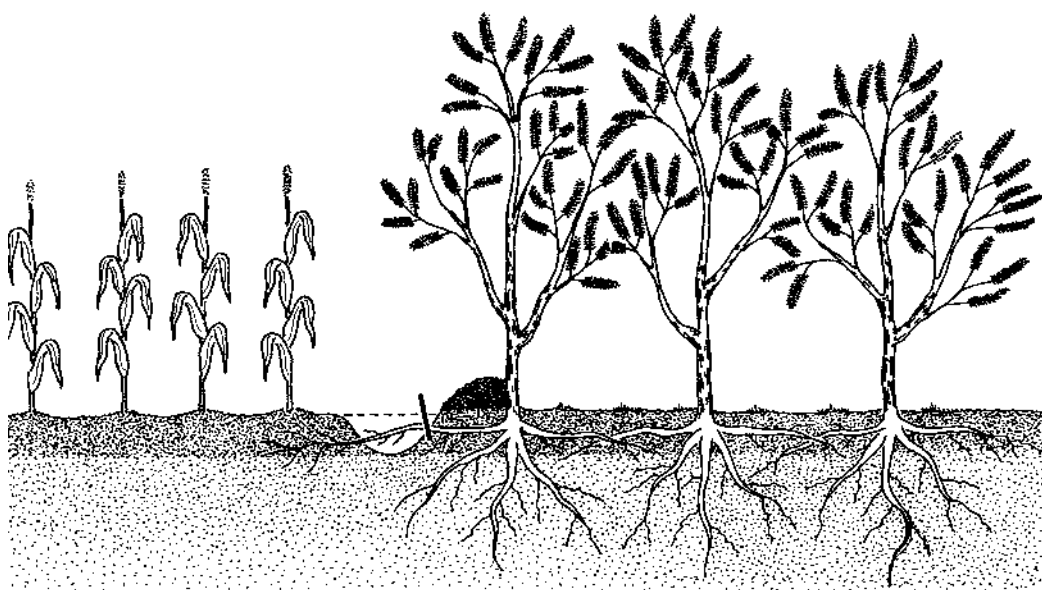


Figure 7 Root pruning to reduce competition with the adjacent crop.

5 Agroforestry practices in the montane zone

In the sloping land of montane areas, good topsoil is easily lost if not managed properly. It may be washed away during heavy rains or blown away by strong winds. When this happens, the productivity of the land declines. The following sections describe agroforestry practices that can sustain high productivity from land in montane zones.

5.1 Scattered trees on farmlands

The practice of growing trees together with crops is as old as the history of farming. This practice is gaining more attention among farming communities, who have now recognized the role of trees on land, especially cropped land.

Trees can be planted on a farm and managed to provide various products. This section describes how to grow trees on farmland for various purposes including improving soil fertility.

Expected benefits

- fruit and nuts
- fodder
- medicine for people and livestock
- firewood and charcoal
- timber
- poles for construction and electric power lines
- honey production and increased flower, crop, plant pollination
- support for climbing crops such as yam, bean and passion fruit
- improved soil fertility through nutrient recycling
- increased total production from the land
- conservation of soil and moisture
- windbreak
- land demarcation

Description and design

Various types of tree are commonly found scattered on farmland in the montane zone. The trees are managed for various tree products such as stakes, poles, firewood or timber. Trees improve soil fertility and conserve soil moisture. A good mix of trees and crops leads to increased production and income from a single farm. The practice involves protection and management of selected mature trees already on the farm, planting new trees, or managing selected seedlings established on site through natural regeneration.

Trees retained on farmland should ideally have the following qualities:

- light, open crown
- nitrogen fixing
- quick resprouting after pruning
- deep rooting
- resistance to drought
- able to provide fodder and forage
- easy to propagate

Tree species suitable for retaining on farmland and their uses are listed in table

Table 1 Some suitable tree species for retaining on farmland and their uses

Scientific name	Local name (language)	English name	Uses	Approximate spacing (m)
<i>Albizia coriaria</i>	guluku (Lugishu)	—	shade, firewood, manure, nitrogen fixing, timber	10 by 10 m
<i>Calliandra calothyrsus</i>	—	calliandra	nitrogen fixing, fodder, stakes, firewood, building poles	0.5 by 8 m
<i>Cordia africana</i>	gukiyili (Lugishu); mukengeret (Kupsabin)	—	timber, shade, manure	15 by 15 m
<i>Croton macrostachyus</i>	guyiyi (Lugishu); toboswet (Kupsabin)	—	firewood, shade, timber	10 by 10 m
<i>Ficus natalensis</i>	gudodo (Lugishu)	—	fodder, firewood, timber, manure	10 by 10 m
<i>Grevillea robusta</i>	—	grevillea	shade, firewood, timber, manure	10 by 10 m
<i>Leucaena leucocephala</i>	—	leucaena	nitrogen-fixing, building poles, stakes, fodder	0.5 by 8 m
<i>Maesopsis eminii</i>	musizi (Lugishu)	—	timber, shade, firewood	10 by 10 m
<i>Mangifera indica</i>	gumuyembe (Lugishu)	mango	food, shade, firewood, fodder	15 by 15 m
<i>Markhamia lutea</i>	lusoola (Lugishu); swayet (Kupsabin); misaavu (Rukiga)	—	firewood, stakes, building poles, shade, manure	10 by 10 m
<i>Persea americana</i>	—	avocado	food, fodder, firewood, shade	15 by 15 m
<i>Sesbania sesban</i>	—	sesbania	nitrogen fixing, stakes, fodder, firewood	0.5 by 8 m

Source: Information gathered during a workshop reviewing this manuscript, held in Mbale, Uganda, in 2000 (see appendix 3)

Establishment

How to space trees on farmland depends on the ultimate size of the trees and desired types of products. Space the trees wide enough to encourage good performance of the associated crops. On farmland, the number of large trees can be 40 to 200 per hectare, while shrubs can be many more if planted in rows. Rows of shrubs are a better option than square spacing since rows allow for movement of tractors or animals for ploughing. Suggested spacing for various trees is listed in table 1.

Management

Trees on cropland need proper management to avoid affecting crop yields negatively. They should be weeded along with food crops. During the first years of growth, protect the trees from livestock. Protect each tree by placing thorny branches or a cage around it, or fence off the whole area where the trees are planted. Management may include all practices that are described in chapter 4.

Limitations

- Farm trees attract birds that can damage crops.
- Some trees can be a source of diseases that later damage crops. For example, *Ficus* spp. and *Grevillea robusta* can be sources of wilt that damage coffee and cocoa.
- Trees can seriously compete with crops if not well managed.

5.2 Trees and shrubs for soil conservation

Several techniques can be used to stop soil erosion and increase agricultural production. These include farming on the contour, growing trees on earth bunds, strip cropping and constructing mechanical structures to prevent runoff.

The first step in soil conservation on sloping land is to mark contour lines at desired intervals. Two tools that can be used to locate the contour, the A-frame and the Mount Elgon level, are presented here, with details on how to use them.

A-frame

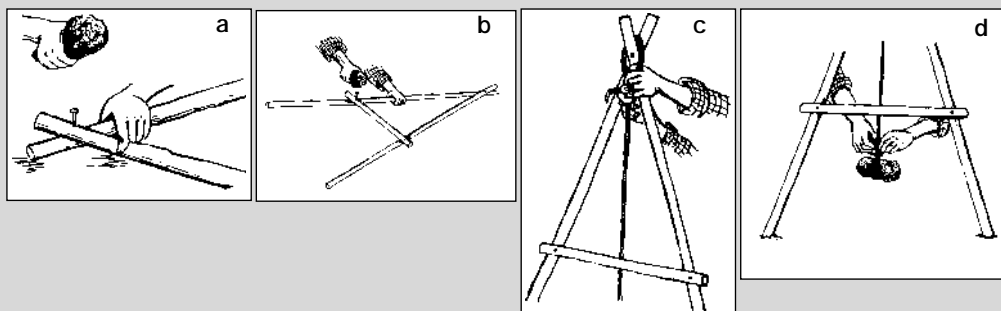
An A-frame consists of three pieces of wood fastened together in the shape of a capital letter A. The A-frame is held upright, and a weight hangs on a string from the top of the A to act as a plumb line. If the A-frame is on perfectly level ground, the string crosses the horizontal bar of the A at its mid-point, which is marked during calibration.

The A-frame is 'walked' across a slope, making sure that the two legs are level each time by checking if the string crosses the horizontal bar at the calibrated point. If not, the forward leg is moved until the string shows the frame is level. The position of the legs on the ground is marked with pegs, and then the frame is pivoted around to mark a new point on the slope.

MATERIALS REQUIRED TO MAKE AND USE AN A-FRAME

- two strong sticks, each 1.5 to 2 m long
- one stick, 1 to 1.5 m long
- three 50-mm nails
- about 1.5 m strong string
- a fist-sized stone
- two pegs, roughly 40 cm each

MAKING THE A-FRAME



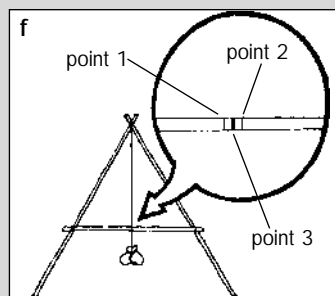
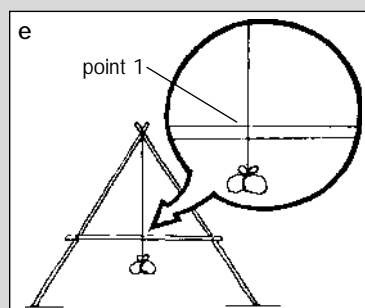
- Step 1** Cross the two 2-m sticks at the top and nail them together securely. [a]
- Step 2** Nail the 1.5-m stick across the other two to form letter A. [b]
- Step 3** Tie a string to the top of the A-frame and let it hang below the crossbar. [c]
- Step 4** Tie a stone to the end of the string, below the crossbar. [d]

CALIBRATING THE A-FRAME

Before the A-frame can be used to mark contours, a point must be found on the crossbar to indicate when the two legs are in a level position. [e] This is done in the following way:

- Step 5** Stand the A-frame upright and drive a peg into the ground next to each leg of the A-frame.
- Step 6** With a pencil, piece of chalk or charcoal, mark the point (point 1) where the string settles without touching the crossbar of the A-frame.
- Step 7** Turn the A-frame so that the placement of the legs is reversed and the left leg is now put where the right leg had been. Leg 1 touches the second peg and leg 2 touches the first peg.
- Step 8** If the ground is level, the string will settle in the same position as in step 6.
- Step 9** If the string does not settle in the same position as in step 6, mark the new point (point 2) where the string settles without touching the crossbar.
- Step 10** Put a third mark (point 3) halfway between points 1 and 2. This is the point on the crossbar that will indicate when the two legs are in a level position. [f]
- Step 11** Using a panga or knife, make a permanent mark by cutting a notch at the level position.

When the weighted string hangs directly in front of the cut notch, the two legs are in a level position. The A-frame is ready to be



used to mark contours on sloping land. The A-frame should be used only in the dry season when the ground is firm and the legs of the A-frame do not enter the soil.

USING THE A-FRAME TO MARK THE CONTOUR

- Step 12** Study the area of your field where you want to mark contours. Start at the highest point (upper boundary) of your field.
- Step 13** Cut a supply of pegs to be used to mark the contours.
- Step 14** Drive in the first peg (peg 1) at the level chosen for the uppermost contour. You will begin marking the contour line at this point.
- Step 15** Place one leg (leg 1) of the A-frame just above peg 1. Adjust the other leg (leg 2) until the string settles at the position of the notch without touching the crossbar.
- Step 16** When the string settles at the position of the notch, drive another peg (peg 2) into the ground just below but touching leg 2 of the A-frame.
- Step 17** Now lift the A-frame and move it along, placing it so that leg 1 of the A-frame is put at peg 2.
- Step 18** Adjust leg 2 until the string settles at the position of the notch without touching the crossbar. Drive another peg (peg 3) just below but touching leg 2 of the A-frame. [g]
- Step 19** Continue with the exercise across the slope up to the end of the field. Now you have a line—a contour—of pegs across the field.
- Step 20** Adjust the pegs that are not in line with the others to make a smooth curve (fig. 8).

Source: Adapted from *Sustainable agriculture practices and technologies: guidelines for farmers* (Africa 2000 Network/UNDP and RSCU/Sida, 1997).

Construction and use of the Mount Elgon level

The Mount Elgon level is a tool that farmers around the Mount Elgon areas of Mbale and Kapchorwa Districts in eastern Uganda use to locate contour lines. It consists of two sticks, a string, a weight and a paper. For reasonable accuracy it is essential to have a paper that is stiff and large enough.

MATERIALS REQUIRED TO MAKE AND USE A MOUNT ELGON LEVEL

- manila paper, A1 size (59.4 by 84 cm) or approximately that size

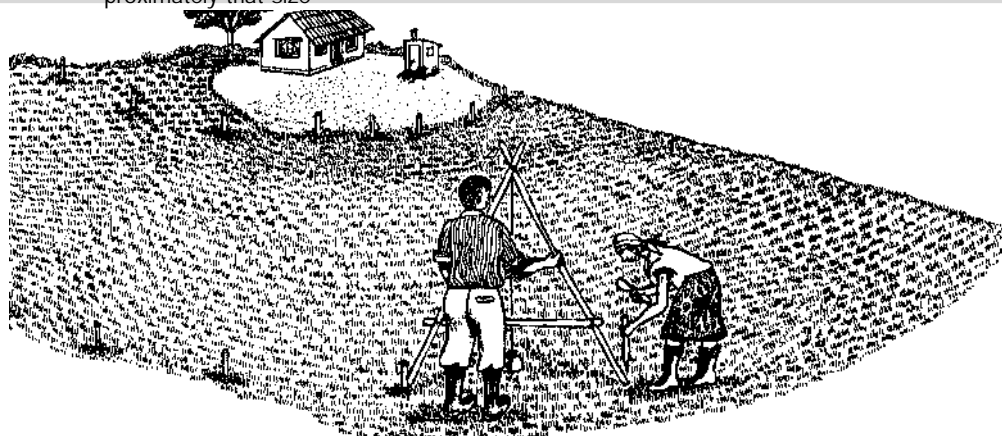
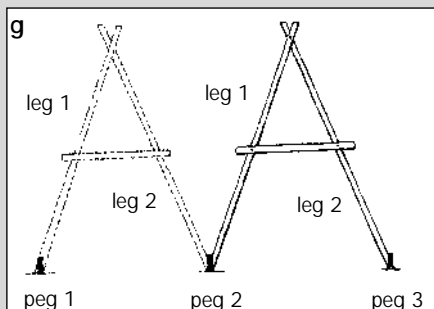
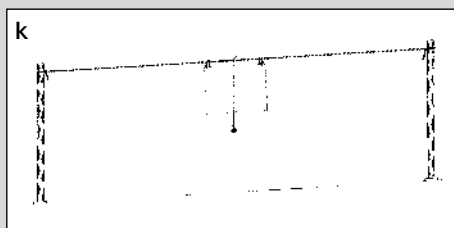
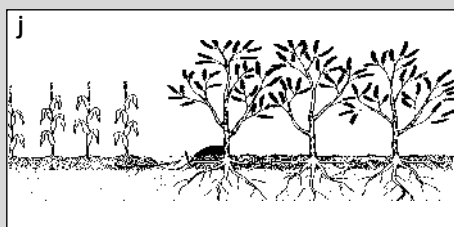
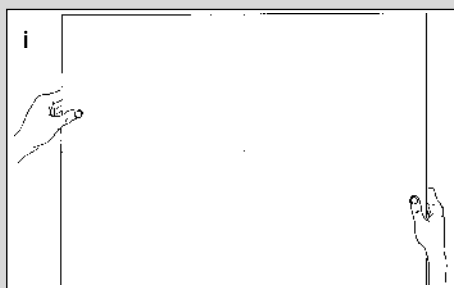
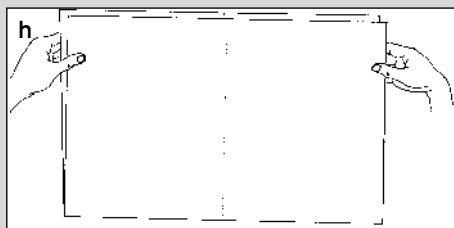


Figure 8 Using the A-frame to establish contour lines across a field.

- two strings; one about 80 cm, another 5 m long
- two sturdy sticks 1.6 to 2 m long with flat ends (the flat ends stop the sticks from sinking into the ground)
- a knife
- a weight
- paper clips or tape
- pegs to mark the contour lines (1 peg for every 5 m along the contour)

MAKING THE MOUNT ELGON LEVEL

- Step 1** Fold the manila paper into four equal parts and open it up again. Folding must be done carefully at exactly right angles. [h]
- Step 2** Draw a line exactly along the folding mark across the paper (the vertical folding mark when the paper is held in landscape position). [i]
- Step 3** Attach the 5-m string to the sticks at exactly the same height from the ground on both sticks.
- Step 4** Measure and mark the mid-point of the 5-m string, that is, the point from where the distance is equal to both sticks. [j]
- Step 5** Hang the paper in landscape orientation with the vertical line at the mid-point that was marked on the string. The upper edge of the paper must be exactly parallel to the string when it is stretched. The paper can be attached to the string with strong paper clips, threaded through holes in the paper or strong tape.
- Step 6** Tie the 80-cm string firmly at the mid-point of the 5-m string and attach the weight at the other end of the 80-cm string. If the two posts are not level, the weighted string will not hang along the line on the paper. [k]



USING THE MOUNT ELGON LEVEL TO MARK THE CONTOUR

To use the Mount Elgon level, three people are needed. Two hold the sticks at either side while the third reads the line (fig. 9). The two sticks will be at the same elevation when the 80-cm string with the weight is hanging exactly along the line drawn on the paper. Then the long string is also level when it is stretched. The person holding the first stick puts a peg on that point and stays there, while the other one moves up or down until the reader finds that the two sticks are at the same elevation. Then proceed with the following steps:

- Step 7** Study the area of your field where you want to mark contours. Start at the highest point (upper boundary) of your field.

- Step 8** Cut a supply of pegs to be used for marking the contours.
- Step 9** Drive the first peg (peg 1) at the starting point chosen for the uppermost contour. Begin marking the contour line at this point.
- Step 10** One person places a stick (stick 1) at peg 1. The other person moves up or down with stick 2 until the reader gives an indication that the next level point has been reached, that is, when the string with the weight settles exactly along the line on the paper.
- Step 11** The person holding stick 2 drives another peg (peg 2) into the ground just at that stick.
- Step 12** Now the person with stick 1 walks further, passing the other person who stays at point 2. Stick 1 is moved up or down until the reader gives an indication that the next level point has been reached.
- Step 13** Continue with the exercise across the slope up to the end of the field. Now you have a line—a contour—of pegs across the field.
- Step 14** Adjust the pegs that are not in line with the others to make a smooth curve.

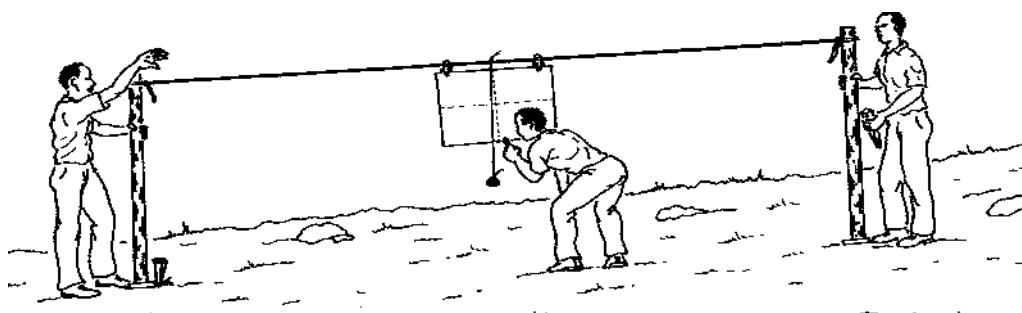


Figure 9 A survey team searching for two level points to lay a contour.

Contour hedges

In contour farming, barriers are created along contours across a slope. Live vegetation, dead vegetation (trash) and stones may be used to create the barriers, which slow the speed of runoff water down a slope. This encourages water to sink into the soil. Subsequent farming operations are carried out along the contours, that is, across the slope. A contour hedge consists of live vegetation growing along a contour. The hedge can be made more effective by adding mulch or trash along it to form a strong barrier. The hedge itself can be used as a source of such material. The contour lines are easily marked using tools such as the A-frame, the Mount Elgon level or similar equipment.

Expected benefits

- control of soil erosion
- enriched soil

- better infiltration of water into the soil
- improved crop yields
- provision of an additional range of products from the field, for example, firewood, stakes, fodder and mulch
- sustainable crop production on sloping land

Description and design

After contour lines are located, trees or shrubs or both are planted along them. Once the hedge is established it will help to trap runoff water and soil particles, and soil bunds will gradually be formed. Water runoff and soil erosion will then be reduced. Figure 10 shows contour hedges on sloping land.

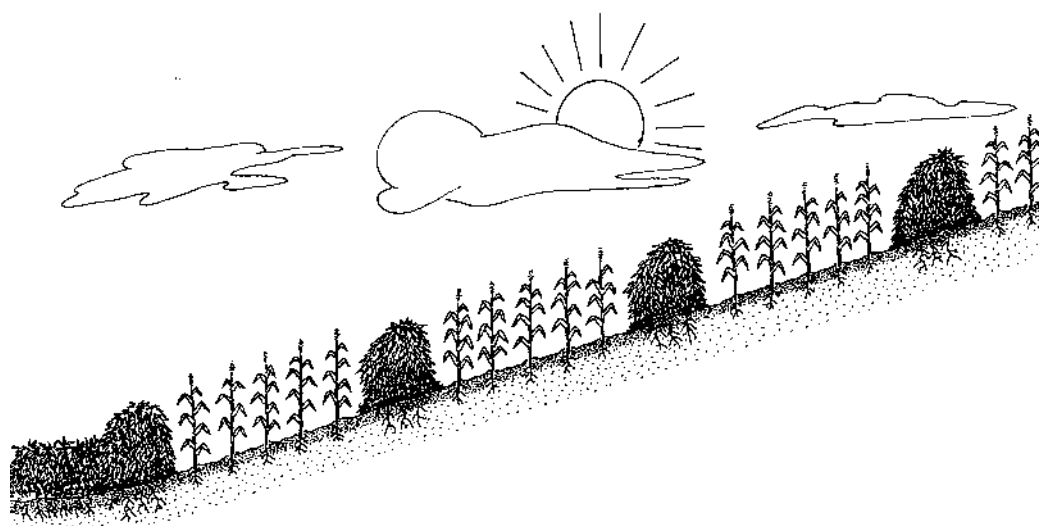


Figure 10 Contour hedges on sloping land.

On steep slopes (20 to 30%), the distance between the hedges should be small (6 to 10 m) while on gentler slopes the distance between the hedges should be wider (10 to 20 m). Contour hedges may not be sufficient in areas with steep slopes and high rainfall, and they are not recommended on slopes steeper than 30%. The recommended distance between the hedges depends on the slope of land (table 2).

Table 2 Recommended spacing between hedges according to slope of the land

Slope (%)	Distance between hedges (m)
5	20
10	14
15	12
20	9
25	7
30	6

In Kabale, bunds, or strips with vegetation, usually mark boundaries between fields belonging to different households, irrespective of the recommended spacing.

Trees and shrubs grown on contour hedges should

- compete minimally with the crops for nutrients and water
- provide valuable products such as fodder and firewood and gradually improve soil fertility
- improve water conservation and reduce erosion

Some suitable shrubs for use as hedges are *Calliandra calothyrsus*, *Dodonaea angustifolia*, *Leucaena diversifolia* and *Tithonia diversifolia*. Larger trees like *Alnus acuminata*, *Grevillea robusta*, *Maesopsis eminii* and *Markhamia lutea* may be planted at a wide spacing in the hedge to mark the contour permanently even when the shrubs need to be replaced from time to time.

Establishment

Plant the contour hedges or let natural vegetation grow along the contour. Establish the hedges using seed, seedlings or stem cuttings, depending on the species. Grow the hedge-rows alone in single or double lines, or in combination with larger trees and with grasses like Napier grass (*Pennisetum purpureum*), Guatemala grass (*Tripsacum laxum*) or vetiver grass (*Vetiveria zizanioides*). Follow these points to establish a contour hedge:

- Locate the contour lines on the land on which the hedges are to be established, using the A-frame or the Mount Elgon level.
- Dig holes along the contours 50 cm deep and 30 cm wide if seedlings of large trees like *Maesopsis eminii* are to be planted and 30 cm deep and 20 cm wide for seedlings of shrubs like *Calliandra calothyrsus*. Leave a spacing of no more than 30 cm between shrubs if the hedgerow is to be established by shrubs only. However, if shrubs and grasses are to be grown together, the distance between the shrubs can be greater. Plant after heavy rains, following the recommendations given in chapter 9. Alternatively, if seeds of shrubs are to be sown directly, make shallow holes, sow with 2 or 3 seeds in each hole and cover lightly with soil. Thin later if more than one seed germinates.

Management

Once established, hedges should be weeded at least twice during the first growing season. They need to be protected from animals. Hedges can be managed to obtain various products. If fodder and mulch are desired, the hedge can be cut frequently to maintain a height of 50 cm above ground; if stakes or firewood are desired, more selective harvesting is feasible, to obtain either stakes of the desired length or firewood pieces of larger dimension. Root pruning is recommended if there are signs of competition with the crops.

Manage trees that are to be grown to pole size as follows:

- Prune the trees two years after planting.
- Repeat the pruning every season before planting crops.

- During the third year, thin by removing every alternate tree in a row to allow better growth of companion crops and trees. Firewood, poles, stakes and other minor construction materials can be obtained from the thinned trees.
- Pollard the remaining trees if the species is suitable, such as *Grevillea robusta* or *Markhamia lutea*.

Limitations

- The contour hedges may harbour weeds and pests.
- If poorly managed, hedge species can become weeds.
- The trees and shrubs may compete with food crops when mismanaged.
- Contour hedges are expensive and time consuming to establish and maintain. Direct seed sowing is far cheaper than planting seedlings but the method requires good management in the early stages.

Trees and shrubs for terrace stabilization

Hedgerows as described above will, if well managed, trap runoff water and soil particles and soil bunds will gradually form. On steep land, however, a better option may be to construct physical structures first and plant trees and shrubs on the terraces or bunds to stabilize them. Terracing is a soil erosion control measure, commonly practised in hilly areas. The process starts by marking contours using the A-frame, the Mount Elgon level or more advanced equipment. Earth bunds are then constructed along the contours. Two different methods are commonly used: 'fanya juu' is constructed by digging and throwing soil upslope; 'fanya chini' is made by digging and throwing soil downslope (fig. 11).

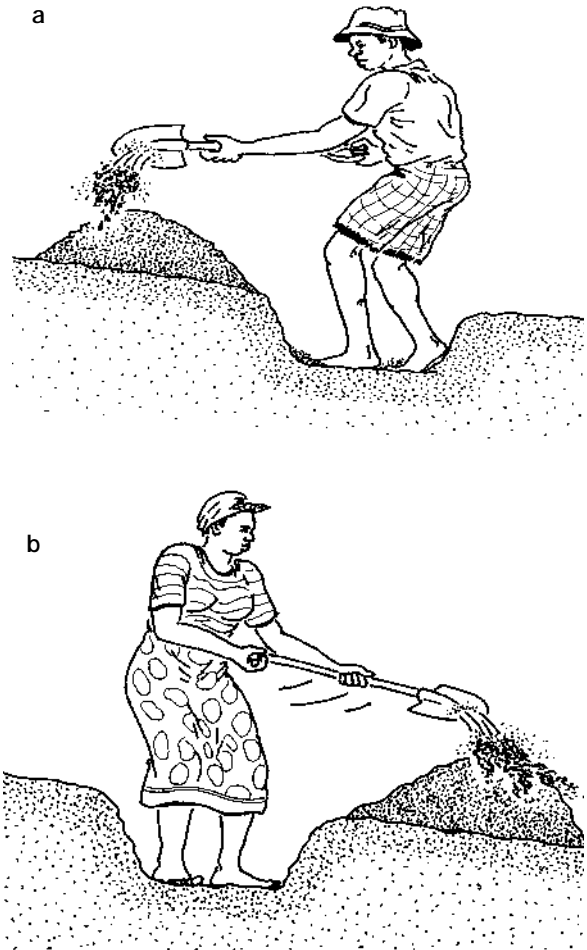


Figure 11 Fanya juu and fanya chini terrace construction: a) fanya juu, b) fanya chini.

Expected benefits

- Stabilized earth bunds control soil erosion.
- They improve soil fertility.
- They produce fodder and mulch.
- They provide firewood and stakes.
- They increase and sustain total production.

Description and design

The bunds should be stabilized by planting trees and shrubs in combination with grasses. Usually grass is planted first because it establishes quickly and easily. Trees and shrubs are then introduced to give the structure additional stability. Weeding and control of grass are essential for good growth of the trees and shrubs. Napier grass, for example, grows vigorously and may easily out-compete newly planted seedlings if not controlled. The benefits of stabilizing terrace bunds may not be evident immediately. However, well-maintained terrace bunds produce long-term benefits, as illustrated in the case of Mr and Mrs Kegere, farmers in Mbale District (box below).

The same species that are used for contour hedges can also be used to stabilize bunds. Spacing should be 10 m if tall trees such as *Alnus acuminata*, *Grevillea robusta*, *Maesopsis eminii* or *Markhamia lutea* are planted.

Mr and Mrs Kegere use earthworks to conserve soil and water in Mbale District

Soil erosion is a common land-use problem affecting Mbale farmers. However, farmers who practise soil and water conservation improve their land productivity. Mr and Mrs Kegere, who live in Bukidiye Village, Bwalasi Sub-county in Mbale District, practise soil conservation.

The family owns 4 acres of land, all on a slope, on which they have been growing crops for 30 years. Kegere inherited the land from his late father. Before 1990, the land looked barren, and most of the fertile soil had been eroded. Crop yields were poor.

In 1990, the Kegeres joined a farmers' group known as the Bugusege Women's Livestock Project, which was funded by Heifer Project International. From this group, the Kegeres learned about earthworks and constructed 'fanya juu' and 'fanya chini' bunds on the land. Fanya juu trenches are 60 cm wide and 45 cm deep; fanya chini trenches are 120 cm wide and 45 cm deep.

On the bunds, they planted fodder shrubs: 300 *Sesbania sesban*, 150 *Calliandra* and 100 *Leucaena diversifolia*. They grow two rows of shrubs spaced at 30 by 30 cm on the bunds. They maintain the trenches by removing weeds and scooping out soil after every rainy season.

They cut the fodder trees grown on the bunds at about 90 cm above ground and feed the leaves to their cows or use them for mulching. Mr Kegere says their soil productivity has improved. Their increased income from the sale of their crops is a clear benefit gained from soil conservation.

Establishment

To establish trees on grass bunds:

- Dig holes 30 cm wide and 50 cm deep if seedlings of large trees like *Maesopsis eminii* are to be planted and 20 cm wide and 30 cm deep for shrubs at the edge of the grass bund. The spacing will vary according to species. Between 5 and 10 m is recommended for larger trees; shrubs can be planted more densely.
- Plant after heavy rains, following the recommendations given in chapter 9. If sowing seeds of shrubs directly, make shallow holes, sow with 2 or 3 seeds in each hole and cover lightly with soil. Thin later if more than one seed germinates. Weed twice during the season and protect the seedlings from animals.

Management

Management of trees on grass bunds or terraces is the same as for contour hedges.

Limitations

- The vegetation on the bunds may harbour pests such as mole rats.
- If the bunds are poorly managed, they can reduce crop yields.
- Trees and shrubs that produce a lot of seed can become weeds if poorly managed.
- Land available for crop production is reduced.

5.3 Trees and shrubs for soil fertility management

Green manure

Green manure can be produced by cultivating fast-growing leguminous plants such as *Crotalaria juncea* (sun hemp), *Dolichos lablab*, *Mucuna pruriens* (velvet bean) and *Tephrosia vogelii*. The planted green manure crop also protects soil from erosion. Green manure crops are usually short spreading plants that grow fast and cover the soil surface rapidly. During or after the growing season, the green manure plants are slashed and incorporated into the soil, where they decompose to release nitrogen. Green manure therefore improves the quality of soil in several ways. First, it adds nitrogen to the soil. Second, as organic matter is added, the structure of soil and its moisture-holding capacity are improved. Green manure crops also bind the soil and prevent it from being washed away; they also protect the soil from the direct heat of the sun, conserving soil moisture and soil structure.

Green manure crops are appropriate both as a pure stand and in a mixture with other crops. If phosphorus in the soil is sufficient, they are especially effective during dry periods for fixing nitrogen, when inorganic fertilizers cannot be used effectively because of limited soil moisture. Sandy and heavy clay soils especially benefit significantly from green manure, because it adds organic matter.

One of the reasons for research on *Tithonia diversifolia* is that its foliage is rich in phospho-

rus. Using it as green manure may be a key to improving the ability of nitrogen-fixing plants to fix good amounts of nitrogen.

Expected benefits

- Crops for green manure are cheap to establish and easy to manage.
- Green manure plants suppress weeds.
- Green manure conserves the soil.
- Green manure improves soil fertility.

Establishment

Seeds, inoculants (for some types of legumes) and a hoe are needed to grow a green manure crop. Establish a green manure crop as a pure stand by sowing directly in the field in the following way:

Step 1 Prepare the field by digging the soil and removing the weeds.

Step 2 Sow seeds of the green manure crop at a time when moisture in the soil is adequate. Space the seeds closely so the crop covers the ground rapidly.

Step 3 Weed the plot regularly to reduce not only weeds but also pests.

Step 4 Cut leaves and stems for fodder if the species is suitable and if fodder is needed. Do not remove the entire plant or expose the soil surface.

Step 5 Slash the remaining stalks and leaves and turn them into the soil. Fodder legumes such as *Mucuna pruriens* (velvet bean) and *Dolichos lablab* bean can be left to grow for 2 years before slashing. Steps 4 and 5 should be done just after the plants have flowered.

Step 6 Plant the next crop in the soil, for example, a cereal.

A green manure legume can also be planted as an intercrop between the rows of the main crop. Choose the type of green manure crop that grows well in the specific area. Broadcast small-seeded legumes, such as *Cajanus cajan* (red gram or pigeon pea), *Crotalaria juncea* (sunn hemp), *Macroptilium atropurpureum* (siratro) or *Stylosanthes* spp. Plant larger seeds in rows between the rows of the main crop. Plant *Mucuna pruriens* (velvet bean) and *Dolichos lablab* bean 2 weeks after the main crop, because they grow fast and would shade out the main crop if planted earlier. Follow steps 3 to 6 above.

Limitations

- Incorporating green manure into a standing crop may be difficult and laborious.
- Some green manure crops may attract new pests and diseases that attack the main

crop.

- Some green manure crops grow poorly during the dry season.
- A soil in which a green manure legume has not been grown before may not contain the bacteria ('obukooko') needed for fixing nitrogen effectively.
- Some green manure crops may become weeds when they seed and grow in the crop field during the following season.

Rotational woodlots

On sloping land, unsuitable tilling methods such as digging up and down the slope can increase the amount of runoff and soil erosion during heavy rains. Soil fertility may decline rapidly but can be restored by growing crops and trees together and alternating their dominance in a given period of time. This technology is known as a rotational woodlot.

Expected benefits

- Soil fertility is improved.
- Over 20 t of dry firewood can be obtained per hectare.
- Over 40 t of green manure can be obtained per hectare.
- Soil erosion is controlled.
- Woodlots produce a continuous supply of mulch, fodder and stakes for climbing crops.

Description, establishment and management of rotational woodlots

Space trees that grow to large size such as *Alnus acuminata* 2 m apart. Shrubs like *Calliandra* can be spaced 1 m apart.

During the first two seasons, grow a crop such as bean. During the second year, when crop yield starts to decline, leave the trees and shrubs to grow into a woodlot. When they have grown big enough to yield the desired products, cut them about 30 cm above the ground. After this, resume crop planting. Use products from the woodlot such as green leaves and twigs as mulch or incorporate them into the soil to improve fertility.

Alternate growth of food crops and woodlots for several years until crop growth proves difficult. This occurs when stumps grow big and the crop area is reduced. At this stage, either leave the trees to grow into a long-term woodlot or cut and uproot them and replace with new trees or shrubs.

Limitations

- Continuous pruning of tree regrowth is tedious.
- The growing trees may harbour pests and birds that damage crops.
- Large stumps may make land preparation difficult.
- Cropland must be given over to the woodlot.

Improved fallows

An improved fallow is an agroforestry practice used to regain the fertility of poor or exhausted soil. Through continuous cultivation, plant nutrients are lost when crops are harvested and the waste material is not returned to the field. Soil is eroded during heavy rain. These factors lead to crop yield gradually being reduced. Trees or shrubs can be planted, letting the land rest from cropping it and the soil regain its lost fertility.

Expected benefits

- Trees break the hard, compacted soil, improving its structure and capacity to retain water.
- If nitrogen-fixing species are grown, nutrients such as nitrogen are fixed into the soil.
- Stakes, firewood and poles are useful by-products.
- Crop yield is increased in the following season or seasons.

Description and design

Trees are planted or sown in a natural fallow and left to grow. Some species that have been tried for improved fallows are *Alnus acuminata*, *Calliandra calothyrsus*, *Sesbania sesban* and *Tephrosia vogelii*. On good sites, *Alnus acuminata* and *Calliandra calothyrsus* can produce over 24 t/ha of good-quality firewood in 2 years. *Calliandra*, *Sesbania* and *Tephrosia* may induce more than a 100% increase in crop yield.

It is usually difficult for farmers in densely populated areas to sacrifice production temporarily while fallowing land. However, farmers in Kabale do set aside the upper parts of the outward sloping terrace benches for improved fallow. But they often make the distance between soil conservation structures more than is recommended, resulting in considerable erosion on the plots between the structures. The upper part especially becomes degraded since soil loss there is continuous as opposed to the lower parts where soil is deposited.

Sesbania is the most popular species for improved fallows in Kabale. The production of significant amounts of firewood is an appreciated additional benefit.

Establishment

Raise the seedlings of desired tree or shrub species in a nursery (recommended for *Alnus*, which has very small seeds, and for *Calliandra*, where seed is often in short supply) or sow the seeds directly in the field (easily done for *Sesbania* and *Tephrosia*). If seedlings are raised, plant out in natural fallow at a spacing of 2 by 2 m. Spot weed around the seedlings. In direct seeding, the germinating seedlings require intensive weeding and protection, especially in the early stages. Leave the trees or shrubs for 1 to 3 years, depending on the species. Improved fallow planted with trees or shrubs are particularly useful in areas where soils are subject to erosion, such as upper parts of terraces.

Management

Protect trees and the area from grazing animals and fire.

Limitations

- Establishing improved fallows is labour intensive.
- Birds perching on the grown trees may damage crops.
- To change land use from improved fallow to food crop production can be difficult if the fallow is overgrown.
- Land scarcity may not allow fallowing.

5.4 Beekeeping

Beekeeping for honey production is an agroforestry practice through which a farmer can generate income while still using the land for food crops or tree production. It is a practice that can conveniently be integrated into home gardens and scattered trees on farmlands. Traditional beehives are shown in figure 12. The Uganda topbar hive and two methods of placing it are shown in figure 13.

Apart from beehives, proper clothing and tools for harvesting the honey are necessary, like the bee smoker, buckets, veil and boots.



Figure 12 Hives used in traditional beekeeping.

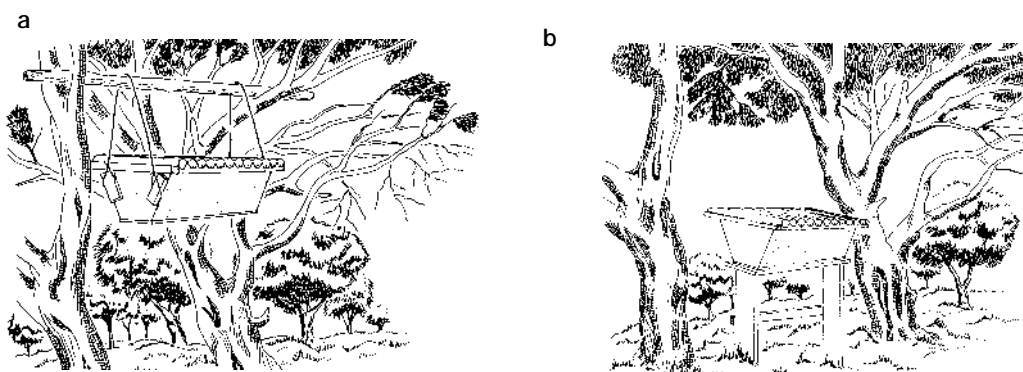


Figure 13 Two methods of placing a Uganda topbar hive: a) hanging the hive at some height makes it more difficult for wild animals to get at the honey; b) placing it on a wooden stand makes it easier to manage but puts it at greater risk of damage by animals.

Beekeeping can be profitable (see box), but for good honey production it is essential to grow a selection of tree species that will flower and produce a continuous flow of nectar throughout the year. Trees suited for a beekeeping enterprise include *Calliandra calothyrsus*, *Cordia africana*, *Croton macrostachyus*, *Dombeya torrida*, *Eriobotrya japonica*, *Eucalyptus camaldulensis*, *Grevillea robusta* and *Hagenia abyssinica*.

The bee farming of Mr and Mrs Perezi Steven Wamboga, Mbale District

Mr and Mrs Perezi Steven Wamboga live in Lukuku Village in Bubulo County, Mbale District. Steven is 35 years old and his wife, Irene, is 26. They have four children and live with six additional dependants in their home. Steven obtained a diploma in sustainable agriculture in the United Kingdom.

The couple has a farm comprising 2 acres of land. On it they rear cattle (they have four grade cows) in a zero-grazing unit and have pigs. They have a fishpond and a tree nursery. They grow bananas and plant trees all over the farm. Their soil is good, and they have built water conservation structures. They are constructing a biogas plant and have a kitchen garden. They keep bees.

The couple has progressed so much that several development programmes use the Wamboga farm as a training and demonstration centre. Steven emphasizes that this progress has been through hard work, commitment and patience.

Lukuku Village is located at the foothills of Mount Elgon, in a parish bordering the Mount Elgon Conservation Park. The people in Lukuku largely depended on the forest for their livelihood before it was converted into a conservation park in 1992.

When the Mount Elgon Conservation and Development Programme (MECDP) was initiated in the area (to reduce the amount that the local community was encroaching on the forest), several income-generating activities were introduced. Beekeeping was one that farmers rapidly took up.

Beehives were made from local materials such as banana fibre, bamboo and logs of big trees like *Acacia* and *Cordia*. These hives were placed in the forest. However, as Steven recalls, the beekeepers realized they were getting very little honey from their hives and their honey was of poor quality because they lacked processing skills. In 1992, MECDP introduced improved hives including the Uganda topbar.

Beekeepers were taught how to confine the queen in the hive using a queen excluder inserted in the topbar hive. They learned how to use a bee smoker to harvest the honey and how to place the beehives. They bought improved hives—which other farmers later stole. The hives were expensive and unaffordable, with a Kenya topbar costing UGS 30,000.

Later, MECDP trained the beekeepers in how to make hives. They then started making their own hives. Now, local community members provide their own materials and hives are constructed at a cost of UGS 4,000. This makes the hive affordable for local people.

These pioneer beekeepers sited the hives in forest areas and mountains. However, their hives were often disturbed by forest guards and by monkeys, prompting the beekeepers (under the chairmanship of Steven) to form an association.

In 1993, a group of 39 youth members, 13 of whom were women, formed the Lukuku Youth Development Association to champion the fight against rural poverty. Members seriously embarked upon beekeeping as a key method through which they could fight poverty. The youth now comprise the major proportion of the Buwabwala Sustainable Agriculture Farmers' Association.

Materials and tools

- **Beehive:** In the market, a Uganda topbar beehive usually costs between UGS 25,000 and 30,000. The Lukuku Youth makes and sells the same type of hives at UGS 15,000. According to Steven, with improved hives, 8 to 15 litres of honey can be harvested from the Kenya topbar or Uganda topbar as compared with 5 litres or less from a traditional hive.
- **Bee smoker:** costs UGS 6,000. Only one is necessary for any number of hives and it lasts long when handled well. A bee-smoker enables friendly harvesting of honey because bees are less likely to harm the person harvesting.
- **Protective clothing:** costs UGS 100,000. Without protective clothing harvesting has to be done at night. One disadvantage of harvesting at night is that it is difficult to identify the queen.
- **Square veil:** UGS 36,000
- **Gloves:** UGS 8,000
- **Gum boots:** UGS 10,000
- **Plastic buckets:** UGS 2,000 each. The number of buckets needed depends on the number of hives.

Placing the hives

An important step in beekeeping is siting the hives. According to Steven, many hives may be placed in one area but a distance of at least 1 m should be maintained between them. Hives should be placed under shade. Hives should be placed where a variety of crops are grown, preferably near beans, tomato gardens, under big trees like *Cordia*, or near a river or stream with wild trees. Honey of high quality is produced if *Calliandra* or coffee are growing in the vicinity.

Harvesting

After the hives are placed, they should be monitored for honey production. Steven says that when honey is ready for harvesting, the bees crawl around outside and inside the hive and the cells in the honeycomb are sealed with beeswax. If the cells are not sealed, the honey is not yet ready for harvesting. After the first harvest, Steven waits for 5 to 6 months to harvest again. The harvesting period can be synchronized to follow the season when trees are flowering.

Benefits

Beekeeping is profitable. According to Steven, the only costs incurred in the activity are those of the initial investment. Sales from the first harvest are enough to pay back all the investment cost for each hive.

Steven said in 1998 his harvest from 7 hives averaged 15 litres of honey each, giving him a total of 105 litres in a season. He harvested twice that year and got 210 litres, which he sold raw from the farm at UGS 1,200 per litre. He also sold beeswax.

By the time Steven was visited in 2000, he had hung 4 more hives, 2 of which were already colonized. Steven has become interested in expanding the beekeeping enterprise further. Currently, a litre of honey sold on the farm brings in UGS 2,000 on average.

Limitations

The few limitations that Steven mentions are the following:

- Beekeeping involves a modest initial investment cost.
- Bees may attack neighbours, especially if one has a small farm.
- Hives are sometimes stolen.

The Wambogas are generous in sharing their knowledge. Steven is currently a farmer trainer, training other farmers on a wide range of farming activities. At the time of the visit to the Wamboga farm, he was constructing a training room.

5.5 Stake production for climbing crops

The practice of providing climbing crops with support is known as staking. Some crops need support in order to grow faster, healthier and produce higher yields. Traditionally, crops like tomato, passion fruit and yam are grown using support. In the montane zone, cultivation of climbing bean (a climbing variety of *Phaseolus vulgaris*) is important, and growing beans on stakes is becoming popular in south-western Uganda. Staked beans yield more and suffer less from pest and disease attack than the bush bean. They also yield continuously for a much longer time. A major constraint to the technology is the scarcity of staking material. This section describes the practice of producing and using stakes.

Expected benefits

- Staking increases the yield per unit area.
- Staking tends to produce a healthy crop.
- Leaves from freshly harvested stakes can be used as fodder.
- After being used for one or two seasons, the stakes that are no longer good for staking can be used as firewood.
- The sale of stakes provides income.

Description

Staking is usually done on crops planted in rows with the stakes placed between the crop rows. One stake can support one to three different plants, depending on the crop and on the type, length and strength of the stake.

However, even crops that are scattered in the field can be staked, although the process requires more labour and resources. Tree species from which stakes are produced are *Acacia mearnsii* (black wattle), *Alnus acuminata*, *Calliandra calothyrsus*, *Eucalyptus grandis*, *Markhamia lutea*, *Senna didymobotrya* ('omugabagaba' in Rukiga) and *Sesbania sesban*.

Stakes can be made from dry or fresh wood. They can also be cut from reeds. Some farmers use live coppice shoots of tree species like *Alnus* and *Calliandra* as staking material. Others use reeds or maize stalks, especially when other staking materials are scarce. Different farmers have different preferences for staking materials.

Establishment

The most common place for growing trees for stakes is on the terrace bunds close to the homestead. There, the growth can be easily protected against animals and thieves, and

access to it is convenient. Stake materials can also be obtained from woodlots, pruned hedgerows or trees grown on cropland and along field boundaries. Propagation methods vary for the different species. Some, like *Sesbania sesban*, may best be sown directly while others are best raised in nurseries for later planting out in the field.

Management

Trees planted for stakes must be pruned to allow stakes to grow to the preferred length, which is usually not more than 1.8 m. The stakes must be properly stored away from rain for reuse in subsequent seasons. The pointed ends should face upwards during storage.

Mrs Mary Kanyoma profits from bean stakes

Growing climbing bean on stakes has become a popular technique with farmers in south-western Uganda, particularly Kabale and Kisoro Districts. The demand for stakes has therefore increased in the area.

Mrs Mary Kanyoma is a farmer about 55 years old who lives with her husband and six children (three boys and three girls) in Nyamyerambiko Village of Ndoorwa County in Kabale District. She grows climbing beans—a practice she learned from a 2-day training session organized by the agroforestry research station near Kabale and the National Bean Programme in Namulonge. During the training session participants visited the District Farm Institute at Kachwekano in Kabale District. They also visited farmers in neighbouring Kisoro District.

By staking and growing climbing beans, Mary reports obtaining yields up to three times higher than she got from bush beans.

In addition to benefiting from better production of her own beans, Mary has taken advantage of the increasing demand for stakes and started producing them for sale. In this way, she generates extra income for her family.

Her customers prefer the tree and shrub species that can be used as stakes for 2 or 3 seasons. They prefer stakes from black wattle (*Acacia mearnsii*; 'burikooti' in Rukiga), *Cyphomandra betacea* ('obutunda bw'abariisa' or 'omunywamiizi' in Rukiga) and *Croton sylvaticus* ('omwatanshare' in Rukiga) because they are durable and can be used for 3 seasons. *Calliandra calothyrsus* is next in preference, because it is smooth, making it easier to remove the beans during harvesting. Other species used as staking material are *Senna didymobotrya* ('omugabagaba' in Rukiga), 'ebikondogorom ekisindokwa', *Eucalyptus* spp. and *Acanthus pubescens* ('ekitojo' in Rukiga). *Acanthus pubescens* can be used only when mature.

Profit from selling stakes

Mary grows her stakes to a length of about 3 m. She sells a bundle of 15 stakes of black wattle, *Cyphomandra betacea* or *Croton sylvaticus*, for UGS 1,000. She sells bundles of 30 stakes of other species for UGS 500 per bundle. Staking one acre of climbing beans requires 21,250 stakes, equivalent to 1,417 bundles of 15 sticks, or 708 bundles of 30 sticks. If a customer buys 1,417

bundles of the expensive type from Mary, her gross income will be about UGS 1,417,000. From 708 bundles of stakes of the cheaper species her gross income will be UGS 354,000.

Limitations

- The enterprise suits only those with large pieces of land.
- Much labour is needed to collect and prepare the stakes.
- Space is needed to store the stakes properly, with the pointed part of the stake facing up.
- Staked crops require careful handling during harvesting, especially if the stakes are of black wattle.

5.6 Trees on boundaries

In the montane zone trees are commonly grown on farm or field boundaries. Both upperstorey trees and live fencing of shrubs are common on boundaries.

Boundary planting of upperstorey trees

Trees that do not compete with food crops are most suited for boundaries. They should have an open canopy. Both these features are especially important if the land borders another farmer's land, to ensure that the trees or shrubs do not negatively affect the crops on the neighbouring farm.

Expected benefits

- Total yield is increased.
- The trees help prevent soil erosion.
- The trees mark farm or field boundaries.

Description and design

Lines of trees such as *Alnus acuminata*, *Casuarina* spp., *Grevillea robusta*, *Maesopsis eminii* and *Markhamia lutea* are planted along field or farm boundaries.

Establishment

It is best to raise most species that are well suited for boundaries in nurseries, but *Maesopsis eminii* may also be sown directly in the field. A suitable spacing for larger trees along boundaries is 10 m. Protect young trees on field and farm boundaries from animals and fire, which usually requires making proper arrangements with neighbours, especially if the farmland is used communally for grazing during the dry season.

Management

Weed the young trees regularly. Once they are 2 years old, prune the lower branches every season before planting crops. Prune the roots once the trees are 3 years old. After 4 years, thin by removing alternate trees. The thinned trees provide poles.

Limitations

- Trees might harbour crop pests and diseases.
- Trees might attract birds that can damage crops.
- Trees can compete with crops if not properly managed.
- Trees may create disputes among neighbours.

Live fencing

Live fences are permanent or semi-permanent rows of trees or shrubs grown around farmlands and homesteads, managed to form a barrier. Live fence barriers keep out stray animals. They can also be managed to provide products like fodder, stakes, firewood and medicine, and they add beauty to the homestead.

Expected benefits

- Live fences keep animals away from crops.
- They reduce wind damage and when managed properly generally create a good environment for growth of crops.
- They beautify the environment.
- They protect the homestead.
- Leaf litter from the live fence increases soil fertility.
- Live fences may provide fodder.

Description and design

Lines of trees are planted or sown close together in one or two rows. The trees or shrubs are periodically trimmed on the sides and at the top. For some species, such as *Dovyalis caffra*, the branches are woven around the stems to form a thick, dense barrier. Species often used for live fencing include *Agave sisalana*, *Cupressus lusitanica*, *Dovyalis caffra*, *Euphorbia tirucalli*, *Lantana camara* and *Thevetia peruviana*.

Establishment

The basic design of a live fence is simple. Plant trees or shrubs at 30- to 90-cm intervals in one or two lines. A zigzag pattern is best to establish a fence that is difficult to pass through. The spacing between the trees depends on the type of tree and the intended purpose. Since live fences are relatively permanent, do not plant too close to a garden or in areas where they may interfere with other existing uses. Depending on species and circum-

stances, establish a live fence, by direct sowing, cuttings or planting seedlings according to procedures described in chapter 9.

Management

During the first 2 to 5 years, a living fence requires careful maintenance. While the plants are small, protect them from damage. Place a barrier of dead branches along the fence. Water regularly, weed and protect from fire, and continue the protection until the fence is well established.

Trim the fence regularly to attain the desired shape, trimming both the sides and the top. Although the interval between the trimmings depends on the species grown, trimming twice a year during the rainy season is the usual recommendation. Another management practice is to weave stems and branches. The weaving reinforces the fence, especially if the branches are thorny. Trim new growth on the fence.

Limitations

- If poorly managed, live fences can adversely affect neighbouring land use, for example by blocking paths.
- The fence may attract birds and insects that damage crops.
- Thorny fences planted near the homestead can be a problem for children.
- Sap from *Euphorbia tirucalli* may cause skin problems and severe eye irritation.

5.7 Home gardens

A home garden is an agroforestry practice in which different types of trees, crops, grasses and herbs are grown together as a garden. Growing one is common practice throughout Uganda. Home gardens, usually located near the homestead, are sustainable with little external input (fig. 14). Usually high-value, short-rotation crops like amaranth ('eshwiga', 'eshogyia', 'ekituru-nguma', 'ekicuringanyi', 'omu-riri' or 'munete' in Rukiga), cabbage, carrot, cucumber, irish potato, onion, pumpkin and tomato are

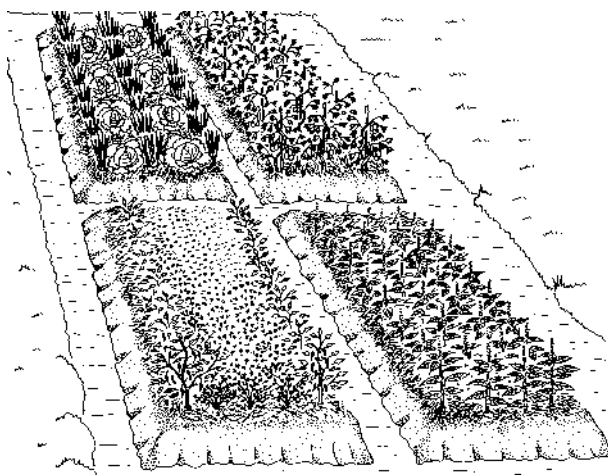


Figure 14 The location of a home garden near the house makes it an ideal place for high-value production of fruits.

grown.

Expected benefits

- Decomposed litter from trees improves soil fertility.
- The home garden helps control soil erosion and conserves soil moisture.
- It produces a sustained output of different products.
- Crop yield is high.
- It is easy and convenient to manage because of its proximity to the homestead.
- Its many products (fruits, vegetables, herbs, firewood, fodder, timber and poles) provide a regular cash income.
- The kitchen garden supplies vegetables and other food throughout the year.
- The home garden uses locally available resources.

Description and design

Home gardens consist of a diverse mixture of vegetables, fruits and medicinal plants as well as fodder grasses and shrubs all grown around the house. Most useful tree species can be grown, but species that grow very big should be avoided as well as those that easily blow over or have brittle branches. Eucalyptus, black wattle and pines are examples of relatively competitive species that suppress undergrowth and that are, therefore, not well suited for a home garden. *Prunus africana* (for timber, shade and medicine), *Cyphomandra betacea* (tree tomato) and many other fruit trees are suitable.

A kitchen garden may consist of small plots, 1 to 2 m wide and 5 to 10 m long that are located within or near a homestead. The size of the plot often depends on the size of the land. However, relatively narrow plots, about 1 m wide, are more convenient to work on. The plots are well prepared like seedbeds. Organic manure is applied before a desired crop is sown.

A very small kitchen garden can also be established in a tin whose bottom and sides are perforated or in a gunny bag perforated on the sides (fig. 15).

Fill the tin or gunny bag with well-prepared soil

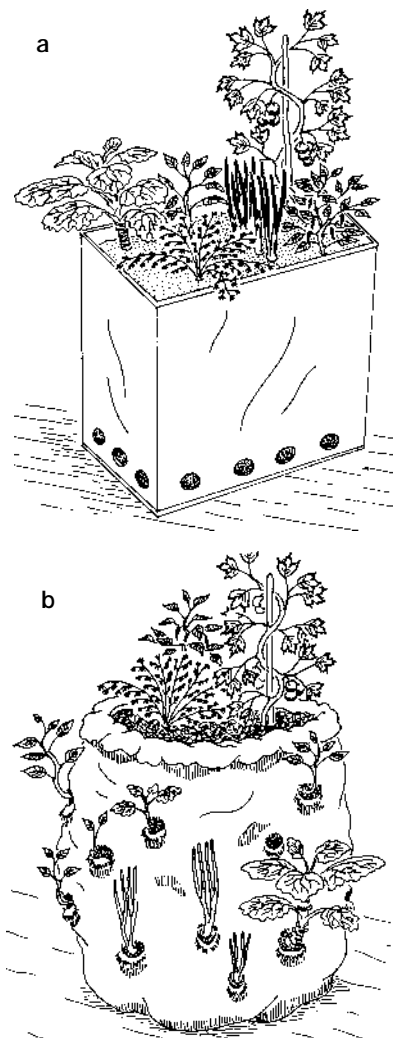


Figure 15 A kitchen garden may be established a) in a tin or b) in a gunny bag.

mixed with manure. Sow the desired crop at the top or on the sides of the container. Place the tin or bag in a convenient place within the homestead. The kitchen garden can be placed on the veranda like a potted flower, under a tree, or in any convenient place in the compound.

Management

A home garden needs to be looked after continuously. A kitchen garden needs intensive management. Maintain soil fertility by continuously applying manure. Water and weed regularly.

Limitations

- Establishing and maintaining a home garden is labour intensive.
- The kitchen garden is often very small and cannot sustain large families for long.

The home garden of Mr and Mrs Nasimolo

Mr and Mrs Nasimolo live in Mango Village in Bungokho County, Mbale District. They live on a 3.5-acre piece of land, which they inherited. They have six children. On acquiring ownership of the land, they found a few trees already established: avocado, 'fene', 'mituba' and 'nekasi'.

Gradually they have improved the land by growing other types of fruit such as pawpaw and mango. They also grow arabica coffee, *Calliandra calothyrsus* for fodder, banana and sweet potato.

The home garden is about half an acre with 30 arabica coffee, 15 avocado, 15 fene, 10 *Grevillea robusta*, 10 mango, 6 pawpaw and 1 jeabuba tree. There are also 50 banana stumps and 100 *Markhamia lutea* along the border of the farm.

The Nasimolo family says that home gardens are easy to manage but that regular pruning of the trees and fodder shrubs is essential. They use manure, which they compost on the farm, on the bananas and coffee. Their weeding is limited, as few weeds grow in the garden.

Mrs Nasimolo is proud of her home garden. That is where she gets the firewood she uses for cooking. Trees that are cut and sold provide cash with which she buys household items. Using resources from the home garden, the Nasimolos have constructed a cowshed and a zero-grazing unit. The materials used for these would have cost the family UGS 150,000 if they had had to buy them from the market.

They sell the mangoes and avocados they harvest from the home garden at UGS 30,000 and UGS 40,000, respectively, per 90-kg bag. Each year they harvest a bag of mangoes and a bag of avocado, and they expect production to rise when most of the trees start to bear fruit. This will be an additional source of income.

The family feel that they benefit from their home garden in a number of ways:

- They have a constant supply of poles for home use and sale.

- They have a supply of firewood for home use.
- They have a continuous supply of vegetables and other food.
- Support poles for banana, tomato, climbing bean and yam are always available.
- Leaves pruned from fodder trees provide feed for livestock.

They are aware, however, that shade from trees can lead to a build-up of pests and diseases.

The kitchen garden of Mr and Mrs Nasimolo

Within the homestead of the Nasimolo family, a small area of about 10 by 10 m has been set aside for a kitchen garden. It has 9 beds, each measuring about 1 by 9 m, in which the Nasimolos grow a variety of vegetables. They add fertility by using compost baskets (see chapter 11). The Nasimolo family adopted the kitchen garden technology because soil in their home garden had become poor and they could no longer harvest enough vegetables to feed the family.

Now they have better production with healthier vegetables. Production from the kitchen garden is continuous and they sell vegetables to their neighbours during the dry season. The first harvest from their garden illustrates what income can be obtained from kitchen gardens:

Type of crop	Number of plots	Size of plot (m)	Income from plot in one season (UGS)
Cabbage	2 plots	1 by 15	20,000
Tomato	2 plots	1 by 15	60,000
Eggplant	1 plot	1 by 9	30,000
'Sukuma wiki'	1 plot	–	10,000
Amaranth	1 plot	–	8,000
'Gobe'	1 plot	1 by 9	4,000
'Jyoby'e'	1 plot	–	3,000

To establish their kitchen garden they took the following steps:

- cleared and cultivated the area
- separated and demarcated the plots and applied compost
- constructed compost baskets
- dug the soil twice to loosen it
- mulched and planted

They planted the seeds in rows, according to the recommendation of the agricultural extension service. To hire labour to construct the kitchen garden would have cost the family UGS 3,500. Thus, by working on the garden themselves, the family saved money.

They found that regular weeding is essential. They change the compost basket regularly to ensure that the growing plants have a continuous supply of nutrients. They periodically spray the vegetables with a liquid mixture made of urine, crushed pepper and neem leaves as well as ash from burnt weeds to protect the plants from insects.

They gain a number of benefits from their kitchen garden:

- a continuous supply of vegetables for the family
- a good source of income
- help in control of soil erosion, as the 1 by 9-m plots are laid across a slope

- improved soil fertility

The family says that establishing and managing a kitchen garden takes a lot of work, but the garden amply rewards their efforts by yielding a lot of produce from a small piece of land.

5.8 Commercial wood production

Farmers in the montane zone establish woodlots to produce firewood, timber and stakes. Commercial woodlots can be of a single species or a mixture of several different species. Woodlots of *Eucalyptus grandis* or *Cupressus lusitanica* or a mixture of species including remnants of natural forests are common. In areas where rearing cattle is a major land-use activity, woodlots are interspersed in paddocks and banana–coffee fields. This practice is common in Kapchorwa and Mbale Districts.

Expected benefits

Benefits from planted woodlots cannot be quantified simply in terms of income. A typical Kabale farmer can benefit in a number of ways:

- Woodlots provide firewood. Firewood is the main source of energy for cooking and other subsistence needs of farmers in the montane zone. Firewood is particularly important in this zone because the climate necessitates warming houses.
- Cash income can be earned from selling poles, timber and firewood.
- The financial gain is ultimately sustainable since trees can be coppiced and repeated harvests can thus be secured without investing in tree planting between each harvest.
- Woodlots help secure the tenure of both land and trees.
- They provide tree products for home consumption.
- They provide windbreaks.
- They help control soil erosion.
- They provide shade, and the flowers provide bee forage.
- When suitable species of trees are grown temporarily as a fallow, the land regains its fertility.

Trees in woodlots are either grown with food crops or planted on their own. Growing vegetable crops in woodlots during the establishment phase of trees is usually possible and recommended. Later, if competitive tree species like eucalypts are grown, intercropping will not be possible.

Description

Commercial woodlots can be single species or mixed stands that resemble dense natural growth. Woodlots of single tree species or mixtures are established to produce firewood,

poles and timber. The most appropriate species for this agroforestry practice are *Acacia mearnsii*, *Cupressus lusitanica*, *Eucalyptus grandis*, *Eucalyptus saligna*, *Markhamia lutea* and *Pinus patula*. Eucalypts and *Markhamia* are good trees for woodlots because their products such as poles, timber and firewood are easy to market. In addition, some species of eucalypts grow well in swampy areas where other crops cannot be grown. Other trees that can be grown in woodlots are *Albizia* spp., *Alnus* spp., *Melia azedarach*, *Podocarpus* spp. and *Terminalia* spp.

Woodlots can vary in size from very small to 10 ha or more depending on the availability of land. Generally, a spacing of 2 by 2 m during establishment is recommended. At this spacing, 2,500 seedlings are planted on 1 ha of land.

Establishment

Establish woodlots in areas that are rocky, steep, have valleys or are swampy and thus are not well suited for producing food crops. Once the area for a woodlot is identified:

- Clear the area.
- Mark the area in a grid of 2 by 2 m using pegs.
- Dig holes (30 cm deep and 20 cm wide) at the marked points.
- Carefully remove the seedlings from the containers and plant as per recommendations in chapter 9.

Management

The important management activities on a woodlot are weeding, pruning and thinning. table 3 lists the period when the three management operations should be implemented during the growing cycles of *Eucalyptus* and *Markhamia*.

Different trees grow at different rates. Therefore, the period from planting to complete harvesting (rotation cycle) also differs. The rotation cycle also depends on which product is desired. Table 4 shows how different types of products can be harvested from the same type of tree depending on how many years it is left to grow.

Table 3 Management of a *Eucalyptus grandis* and a *Markhamia lutea* woodlot

Activity	How to do it	When to manage <i>E. grandis</i>	When to manage <i>M. lutea</i>
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Clear weeding	Weed the whole field	Alternate years after planting	Grow vegetables to nurse trees up to 1 year after planting
Spot weeding	Slash and weed around tree roots	2 to 3 years after planting and as it becomes necessary during rainy seasons	Every alternate year after planting
Thinning, singling	On coppice growth of trees, remove diseased parts of stems and cut all regrowth except 3–4 stems per stump; for thinning, see chap. 4	2 to 3 years after coppicing	About 3 years after coppicing, depending on initial spacing and intended end use of products to be harvested from the woodlot. If seedlings were planted at 2 by 2 m, then remove every second tree, 2 to 4 years after woodlot is established. Repeat as trees become crowded
Pruning	<i>E. grandis</i> tends to be self-pruning if grown at the right density. Remove lower branches of <i>M. lutea</i> to about 1/4 of height of trees	Not needed if the density is right (self-pruning)	2 years after planting
Harvesting		Depends on type of product needed	Depends on type of product needed

Table 4 Types of products from woodlot trees with time

Type of tree	Years after planting	Type of products
<i>Eucalyptus grandis</i>	4	withies
	7	poles
	15	posts firewood, charcoal
<i>Markhamia lutea</i>	2.5	withies
	5	poles (7 cm diameter)
	7	posts (10–12 cm dia)
	15	timber
	15	charcoal

Limitations

- *Eucalyptus* and *Markhamia* stumps are difficult to remove when land is required for other activities.

- Soils planted with *Eucalyptus* become poor for crops after trees are harvested.
- In remote areas, marketing products, particularly poles, is difficult because of poor roads and lack of transport.

Tree products for domestic use are becoming scarce in most parts of Uganda and most households deliberately grow trees in woodlots. While the long-term benefits of woodlots are well known, the benefits are not significant in the very short term because trees take much longer than agricultural crops to mature. Most farmers are discouraged at the prospect of establishing large areas of woodlot. Yet woodlots are beneficial and farmers realize direct benefits when they sell tree products from the woodlot. Indirect benefits include saved cash, which would otherwise be spent to buy needed tree products from the market.

Mr Kameneso Gaitana's commercial woodlots

Mr Kameneso lives in Nyakatare Village in Ndurwa County, Kabale District. He was the chairman of the Nyakatare Mixed Farmers Group, which comprises 50 households. As the chairman, one of his main objectives was to demonstrate to other farmers land-use technologies that can improve both their crop yields and the environment.

A brief observation of his farm confirms that he is a good demonstrator of beneficial agricultural and forestry practices. His cabbages, for example, give high yields. He received training from the Africa 2000 Network and relies heavily on *Sustainable agriculture practices and technologies: guidelines for farmers*, a book published by Africa 2000 in collaboration with UNDP and RSCU (1997).

Kameneso was inspired to grow trees after attending a 2-week course for farmers organized by Africa 2000 Network. Subsequently, his contacts with ICRAF in Kabale made it possible for him to acquire the skills and knowledge he needed to start a tree nursery and manage different types of trees.

He owns 50 acres of land under long-term leasehold tenure. He has planted trees on 30 of the acres. His farm is well planned. On slopes where soil is poor, he established 'fanya juu' terraces. On the terraced land, he used sorghum stalks and other crop waste to make trash lines to control soil erosion. The fields on sloping and poor parts of his farm he planted with *Grevillea robusta* and other trees that improve soil fertility.

In 1992, after attending a course by Africa 2000 Network, he collected seeds of eucalypts from neighbours and raised seedlings in his own nursery. He planted eucalypts on 10 acres and *Pinus patula* on 11 acres. The remaining land, about 30 acres, he planted to other types of trees and food crops. He planted the eucalypt woodlots at a spacing of 2 by 2 m and the *Pinus patula* at 3 by 3 m.

Establishment

Kameneso depends entirely on his farm for his income and livelihood. At 48 years of age, he is able to support his family of eight with its income.

Most farmers observe that establishing and managing woodlots takes a lot of labour. Kameneso says that although this may be true, it should not deter farmers from establishing woodlots. He raised his own seedlings and planned farm work so that the family contributed the labour. Occasionally he hired labour, paying UGS 5,000 per person per day. Although he does not recall his past expenditure on hired labour for establishing the woodlots, his opinion is that it is not exorbitant if done gradually. The strategy is to hire labour for short periods only, to accomplish the demanding tasks.

Benefits

Kameneso started his woodlots for several reasons, mainly to earn cash income. Although he started the woodlots in 1992, as early as 1994 he cut a 1-acre portion of the eucalypt woodlot and sold the products for UGS 60,000. At the same time, he obtained wood for construction and fuel for the household. He thus saved money that would have been spent to buy those products from the market. The benefits Kameneso and his family have enjoyed from the woodlots are a result of his commitment and work.

Limitations

Kameneso cited the following limitations:

- Labour needed to establish and maintain woodlots, especially in hilly areas where terraces need to be constructed, can be limiting.
- Weeding woodlots is laborious.
- Capital is required to purchase farm tools and other resources.
- Farmers may lack knowledge about planting techniques and tree management.
- Neighbours may start fires that get out of control.

5.9 Fodder production for smallholder dairy farming

Fodder trees can be grown in single plots or planted along contours. Trees grown for this purpose, known as fodder banks, are an appropriate practice where human population is high, land sizes are small, and farmers keep one or a few cows.

Expected benefits

- Good-quality fodder is produced.
- Biogas can be produced from the cow dung.
- Milk yield and household nutrition are improved.
- The manure and urine produced are available for farm use.
- Household income is increased through the sale of milk and occasionally the sale of animals.
- Soil erosion is controlled as movement of animals in the fields is restricted.
- Excess fodder can be used for mulching.

Description

Large quantities of fodder can be produced from small pieces of land using high-yielding grasses such as Napier grass, Guatemala grass, or giant setaria (*Setaria splendida*), or shrubs such as calliandra, gliricidia, leucaena, pigeon pea and sesbania. A fodder bank is an area used for such intensive fodder production. A fodder bank may consist only of shrubs or it can be a mixture of both shrubs and grasses.

Establishment of a Napier grass fodder bank

- Slash and clear the area to be planted.
- Napier grass is best propagated by use of cuttings. The cuttings should have three nodes—two are buried and one is exposed above the ground as shown in figure 16.

The cuttings should be cut from the lower and more mature part of the stems.

- The planting arrangement as illustrated in figure 16 ensures that competition is low and that the grass gets good access to nutrients in the soil. Suitable spacing for a fodder bank where only Napier grass is planted is 0.5 by 1 m. Plant cuttings with use of a hoe.

Establishment of a mixed fodder bank

- For a mixed fodder bank, plant the shrubs first in rows with 1 m between seedlings and 4 m between the rows.



Figure 16 How to plant Napier grass.

- Plant three rows of grass between every row of the fodder shrub with a spacing of 0.5 m between the Napier grass cuttings within the rows and 1 m between the rows.
- Weed the seedlings and Napier grass 2 weeks after planting and periodically afterwards to keep the plot free of weeds.

Management

A fodder bank needs proper management to produce quality fodder in adequate quantities. Some trees and shrubs grown for fodder such as *Calliandra calothyrsus* and *Leucaena diversifolia* must be cut periodically to encourage regrowth of new leafy material. After Napier grass is established, cut it repeatedly about 25 cm above ground to harvest the fodder. Protect the fodder banks from animals. Weed every season. Apply manure if available, especially at the beginning of the rainy season. One metre of a row of well-managed *Calliandra calothyrsus* produces 6 kg of fresh fodder per harvest every 3 months.

6 Management of weeds, pests and diseases in agroforestry systems

Mixtures of trees and crops make a more diverse environment than monocropping. A

diverse environment means that a greater variety of species of all kinds of organisms—both desirable and less desirable—can thrive. Usually, a greater diversity of species also allows for better regulatory mechanisms, which may reduce the seriousness of pests and diseases and help control weeds.

Pests and diseases can be attributed to the agroforestry technology in use only if one component in the system promotes an organism that is harmful to other components. The most obvious situation would be if trees planted in or near a farmer's field introduced a pest that wiped out or reduced crop yields. Birds being attracted to nest or roost in certain trees is another realistic example.

Besides these situations in which both trees and crops are involved, there are a number of pests and diseases that affect only one component in the system. The occurrence of such problems has strictly little to do with the agroforestry technology concerned but may still make using that technology undesirable, as one of the components may not perform well enough to meet the overall objectives of the technology.

Another situation of interest when discussing problems associated with agroforestry is when an agroforestry species turns into a weed itself.

6.1 Positive interactions for reducing weeds, pests and diseases

Striga

Diverse farming systems such as agroforestry systems help regulate weeds, pests and diseases. Striga is a good example of how agroforestry can reduce seriousness of a serious weed.

Striga is a parasitic weed that is widespread in most parts of eastern and southern Africa. Traditional African farming systems have included prolonged fallow, rotation, and intercropping, which kept striga infestations at tolerable levels. But as land use has intensified, there is now more cereal monocropping and little or no fallow. As a result, the frequency and the intensity of striga infestations have increased. Cereal loss caused by striga can reach 100%.

Research at ICRAF on improved fallows has shown the potential of certain species to reduce striga infestation of maize (Rao et al. 1998). Among those species are the legumes *Calliandra calothyrsus*, *Desmodium* spp. and *Sesbania sesban*. The decrease of striga could partly be because of increased soil fertility, which affects striga negatively, and partly because the legumes, acting as false hosts, stimulate striga seeds to germinate (Oswald et al. 1996).

Other weeds

Agroforestry, if correctly applied, can reduce weeds in other ways as well. Fallowing is generally effective and so is mulching. Hence increased access to mulch in agroforestry systems also helps to reduce weed problems.

Birds

Because trees are a source of feed (fruit, nectar, insects), shade, shelter and nesting sites, they attract various kinds of birds. Birds can be beneficial in many ways. In an agroforestry system insect-eating birds may help control insect populations, and birds of prey help control rodent populations. For the latter reason, owls have become welcome residents in or near oil palm plantations in South-East Asia.

6.2 Negative interactions with regard to weeds, pests and diseases

Nematodes

Nematodes cause irregular swellings called root galls that are quite distinct from the nitrogen-fixing root nodules that arise from the root surface (Evans and Macklin 1990). Each of the different species of nematode is selective with regard to its host plant. Particularly the root-knot nematode infests sesbania and *Tephrosia vogelii*, reducing their growth. The root-knot nematode that infests sesbania and tephrosia also infests *Phaseolus* bean but not maize or groundnut. Another agroforestry species that has been used for improved fallows is *Crotalaria grahamiana*. This species harbours root-lesion nematodes that may infest maize. Various types of banana and irish potato are also among the crops that are known to be negatively affected by different nematodes. The fact that the nematodes are associated with certain plant species explains why crop rotation is essential for controlling nematode populations.

Birds

The birds attracted by trees may not always be beneficial but can instead be a cause of concern. Some birds that feed on grain have long been a problem when certain crops are cultivated. Traditionally both children and adults would spend much time guarding crops, but nowadays such labour is often unavailable. A well-known destructive bird is the red-billed quelea, *Quelea quelea*, which sometimes invades cultivated areas in East Africa in huge numbers. Little is known about the effect of trees on the severity of quelea damage. Sorghum, millet and many fruits are at high risk of bird damage, while rice and sunflower are at some risk.

6.3 Pests affecting one component of an agroforestry system

A number of pests affect either trees or crops in agroforestry systems. If serious, such pests can make a technology impracticable. A few such pests that have received attention in recent years are mentioned here.

Sesbania beetle

With the widespread planting of sesbania, insect pests have become serious in some areas, especially the sesbania beetle, *Mesoplatys ochroptera*. The beetle causes defoliation, with heavy loss of biomass, thus diminishing the benefits of improved fallows.

Nursery seedlings may bring the beetles with them, which then spread widely in the surroundings. If infestation is severe, it might be better to try direct sowing of sesbania in the field. Clean weeding of the fallows during establishment can minimize competition. The soil should then be cultivated at least once during the first season since this will destroy larvae and pupae of the beetle. Other ways to control the population are to rotate with fallows of other species and to avoid having continuous sesbania fallows on adjoining plots. Avoid using chemicals in the field because they are likely to kill beneficial insects as well as the pest being targeted.

Cypress aphid

The cypress aphid is an exotic aphid that first appeared in southern Africa around 1986. It has gradually spread northwards and appeared in eastern Africa in 1990, where it has become a serious pest on cypress (*Cupressus lusitanica*). Damage has also been reported on other conifers, such as *Widdringtonia nodiflora* in Malawi and cedar (*Juniperus procera*) in eastern Africa. This pest is of significant economic importance in forestry, and since cypress is widely used for live fences it also affects many small-scale farmers.

Leucaena psyllid

Leucaena leucocephala, which is widely grown throughout the tropics, was suddenly attacked in Hawaii in 1984 by a sap-sucking insect, *Heteropsylla cubana*. The insect, which seems to have originated from the same area as leucaena, has spread from the Pacific to South-East Asia, Australia and India and appeared on the Kenya coast in 1992. Later it was found that *Leucaena diversifolia* is somewhat resistant to psyllid attack. Therefore, this species is now recommended rather than *Leucaena leucocephala*. Irrespective of the psyllid, *L. leucocephala* is not well suited to the montane area of Uganda.

Fruit flies

Fruit flies (*Ceratitis* spp. and others) are found throughout Africa. They use 300 or so cultivated and wild fruits as hosts for their larvae. Fruit flies are among the most destructive of pests, reducing the output of mango cultivation, for example, by 20 to 40%, occasionally even by 80%. Various controls have been attempted—using chemicals, bagging fruits, raking the ground, and indirectly by controlling aphids and wax scales, whose honeydew attracts fruit flies. Composting or other destruction of fallen infested fruits is also important. Alternative biological control methods are now being developed as a substitute for harmful chemical pesticides, such as baiting the flies with a lure, which could be a

food bait containing an insecticide, or trapping them with pheromones, the scent that attracts fruit flies even at very low concentrations. As pheromones are expensive, however, they are not commonly used in eastern Africa. These baits or traps can be placed at a density of 20 to 50 per hectare to attract the flies to where they can be easily collected or killed by a control agent without risk of contaminating the fruit.

Stem borers

Stem borers or stalk borers are the wormlike larval forms of certain species of moths. They attack not only cereal crops (maize, sorghum, rice) but also other plants in the grass family such as sugarcane and wild grasses. Frequent problems with stem borers are among the reasons why farmers sometimes choose to burn crop residues rather than use them for build-up of organic matter in the soil. Recent research at the International Centre for Research in Agroforestry (ICRPE) has shown that both domestic and wild grasses can help protect the maize by attracting stem borers. The moth larvae are destroyed when the grass is harvested and fed to cows. When grasses are planted as a border strip around the maize field, invading adult moths become attracted to chemicals the grasses emit. Instead of landing on the maize plants, the insects head for what appears to be a tastier meal. Good trap crops include Napier grass (*Pennisetum purpureum*) and Sudan grass (a type of wild sorghum), which can effectively limit pest damage. Using plants to attract the pest is called the 'pull' approach. ICRPE has also developed a 'push' approach, which involves intercropping maize with plants that emit chemicals (kairomones) that repel the borers and drive them away from the main crop. The best candidates discovered so far for their borer-repelling properties are members of the leguminous genus *Desmodium* spp. In addition, *Desmodium* is very good fodder.

Controlling stem borers in this way may promote better land management, including agroforestry, since it reduces the reasons for burning crop residues.

6.4 Agroforestry trees turning into weeds

Several exotic tree and shrub species in East Africa have now spread on their own. Such species may be regarded as weeds, but as they may also be useful in some circumstances their spread is not always a nuisance. Uncontrolled spread of a tree or shrub species is, nevertheless, a warning sign that the species has the potential to become a nuisance. It is always difficult to predict the possible end result in the early stages of such a process.

Acacia mearnsii and guava (*Psidium guajava*) have shown such potential in highland areas in eastern Africa. *A. mearnsii* is known as a weed in many parts of Africa, including some parts of the montane zones of Uganda. Its seeds remain viable for a decade or even longer, and after fire they may germinate over large areas. The tree is useful, but it competes aggressively with other plants and therefore its natural spread may not always be desirable. It is poor for soil conservation on steep slopes since in dense stands it discour-

ages undergrowth. This undesirable characteristic can be further aggravated if *A. mearnsii* is the only tree species in the area, thus attracting livestock seeking shade.

Another potentially troublesome species is *Psidium cattleianum*, the strawberry guava, which has also been introduced into some parts of eastern Africa. That species, classified as highly invasive, has already become so in other parts of the world.

6.5 Prevention is better than cure

In agroforestry systems, problems can be prevented by using methods similar to those used in agriculture. Hints on preventive measures, as applicable to general agriculture as to agroforestry, follow.

Observation and learning

Nature has much to teach us. Observing and learning are the first steps towards minimizing problems with weeds, pests and diseases. If, for instance, a plant is infested with insects, it is essential to try to understand what causes the infestation. Perhaps the balance between prey and predator has been upset, or perhaps the plant itself is not as healthy as it should be. If the plant is less healthy, soil fertility, water, plant diseases, plant suitability and timeliness of planting all need to be scrutinized. By studying the insects that birds and animals eat, prey and predator relations can be understood, and understanding those relations is fundamental for preventing pest damage.

Soil fertility

Maintaining a good and healthy crop by ensuring that nutrient status in the soil is reasonable is also essential for low incidence of pests and diseases. Proper weeding reduces competition and improves crop performance. Applying agroforestry methods to replenish soil fertility may thus indirectly result in reducing problems with crop pests and diseases.

Crop rotation

If the same crop is planted on the same piece of land every year, the pests and diseases that attack that crop tend to multiply. Rotating crops is therefore an important method for controlling pests and diseases.

Diversity rather than uniformity

Biological diversity is often better than uniformity. When only one type of crop or one variety is grown, pest attack may wipe it out. If different types of crops, or several varieties of the same crop, are grown, some may be resistant and survive. A diverse farm environment is also more likely to provide a suitable environment for natural predators of the pests.

Hygiene

Cleanliness is extremely important in preventing the spread of insects and diseases, especially diseases. Should an outbreak occur, remove all infected plant materials. Compost infested fruits or use them as livestock feed, so that they do not further spread the pest.

Timely planting

Planting may be timed to minimize attack by pests and disease. To do this effectively the grower needs to know the life cycles of the pests and the conditions favouring the spread of diseases.

Plant spacing

Plant spacing can be varied to some extent to hinder the spread of disease. In some cases control can be achieved by increasing the humidity of the air through growing plants closer together. The activity of certain pests, the red spider mite, for example, is reduced by dense planting. On the other hand, most fungi thrive better if plants are grown densely, and plants should be spaced farther apart where fungus is problematic.

Frequent inspection of the crop

Regular and frequent inspection is essential to prevent and control disease. If a disease is detected early when only a few plants are infected, those plants can be destroyed and a major outbreak may be prevented. This applies to many fungal diseases, for example, powdery mildew.

Insect barriers

Locally available plants that are toxic or insect repellent can sometimes be interplanted with the crop being grown. *Tithonia diversifolia* grown at the edge of plots repels insects and provides green manure. Another example of an insect barrier approach is using grasses to reduce problems with stem borers (see section 6.3).

6.6 In case of an outbreak . . .

Sometimes an outbreak of disease or pest cannot be avoided. At such times, a farmer must intervene to prevent crops from being destroyed. This can be done in various ways.

Hand picking

Large insects can be collected by hand. This is possible only if the number of pests is not great, and if the pests are not too widespread on the crop. Again, it is important to inspect the crop frequently and act as early as possible. Banana farmers have perfected the method of collecting banana weevils from harvested banana stems.

Natural remedies that substitute for agrochemicals

Neem, tobacco and marigold (*Tagetes* spp.) are plants well known for controlling insect pests. Numerous other plants and methods have also been developed. Such use of plants for control is a major subject in itself and cannot be covered here.

Some losses have to be accepted

At other times, if for example shrubs in an agroforestry system are attacked, it may be necessary to accept that productivity is reduced or even that the shrubs die. Many pest populations fluctuate naturally, and a technology may still be viable even if once in every 5 or 10 years damage to short-lived shrubs like sesbania is fatal. The shrubs can easily be propagated again another year.

Use of agrochemicals

The use of agrochemicals to control weeds, pests and diseases that affect agricultural crops is adequately covered in other books on agriculture and is not covered here in detail. Pests and diseases affecting one component, like the crop, may occasionally have to be managed by use of pesticides according to accepted recommendations. If possible, consult a local agricultural or forestry extension officer any time before using synthetic agrochemicals. By applying the principles of integrated pest management and emphasizing preventive measures, farmers can minimize the use of harmful and costly chemicals.

Need to adjust or alter the agroforestry practice

If pest and disease problems that are directly related to an agroforestry practice become too serious, a better long-term solution than using chemicals is to look for alternative species or alternative agroforestry practices. *Combinations of trees, shrubs and crops that require a continuous input of pesticides to perform well should not be promoted.*

7 Propagation of agroforestry trees

The three main methods of raising planting stock of trees are from wildlings or seed or vegetatively by using parts of plants. To raise good-quality stock for planting trees, it is important to identify appropriate seed sources and individual trees from which seeds and other propagation materials can be collected. Vegetative propagation is the production of trees from cuttings or other non-seed material such as roots, bulbs or suckers. This method

has the advantage that the new tree will be genetically identical to the mother tree. Sometimes the term ‘clonal propagation’ is used for vegetative propagation, and genetically identical organisms that are descended from a common ancestor are said to be of the same clone.

This chapter describes how to raise trees both from seed and from vegetative material. Seed collection and handling is discussed in chapter 8. Figure 17 shows schematically the three methods of tree propagation.

Some methods require a significant amount of work and expenditure, whereas others are simple and involve no cost. Simple and cheap methods are always preferable, but for certain species such methods may not work well and then the more complicated methods are called for.

Examples of simple and cheap methods are

- use of wildings
- use of cuttings planted directly at the desired site
- direct seed sowing at the desired site

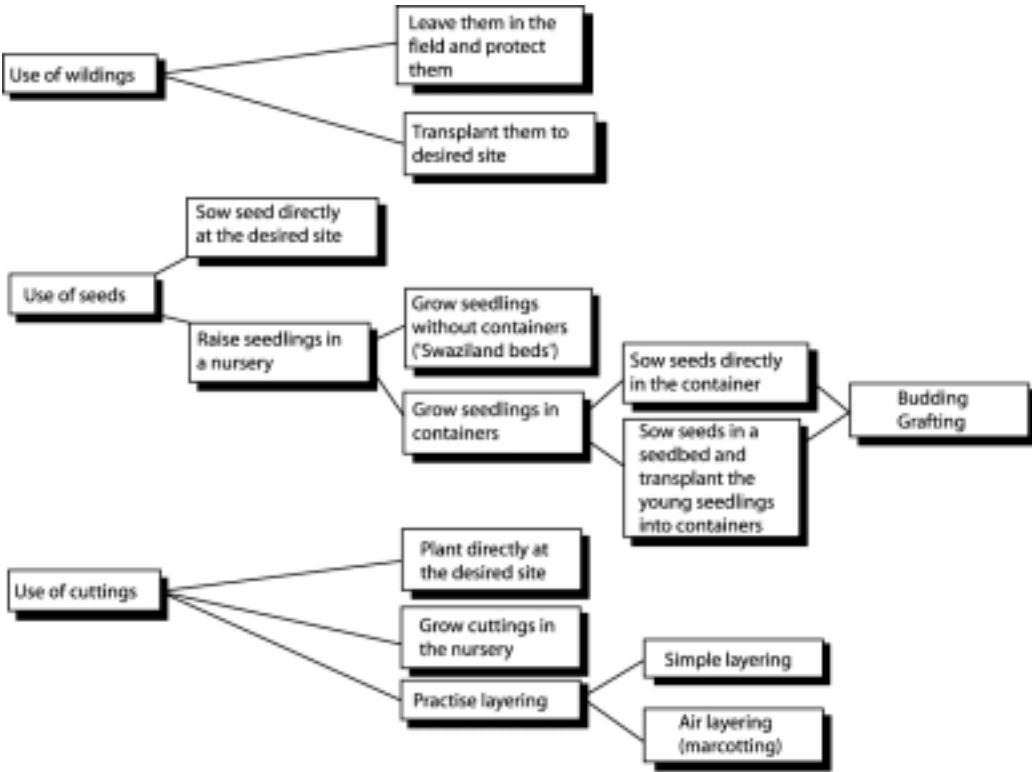


Figure 17 Methods of tree propagation (adapted from Simute et al. 1998).

- seedlings raised in on-farm nurseries

These methods, which enable farmers to have full control over the production, are preferable. When the farm family controls all the steps in the process of tree propagation, the family makes all the decisions and so the choice of species, planting time, and so on is likely to be according to the family's wishes.

Although farmer-managed methods are preferred for propagating many species, more advanced nurseries are still needed. Propagation of some tree species requires certain skills, such as budding and grafting of fruit trees and special seed treatment for some indigenous species. Such trees may be best propagated in nurseries from where seedlings may be bought.

7.1 Use of wildings

Wildings are seedlings that have grown naturally from dispersed seeds. Such seedlings are often found under mature trees, but they may also be found far from the mother tree if, for example, the seeds were dispersed by birds or wind. A simple way of promoting the growth of more trees is simply to protect young seedlings that come up naturally.

If wildings are available in the surroundings but not growing exactly where they are wanted, they can be dug out and transplanted to the desired site. If wildings of a certain species are wanted, the area under a seeding tree can be cleared of weeds and the soil loosened to help the seeds to germinate. When the rains start, the seeds will germinate and the wildings can be collected soon thereafter. Wildings can be collected when they are very small, even with only two to four leaves. However, such a small wilding requires good care, including weeding after transplanting, and therefore it is more common to transplant bigger wildings of up to 25 cm.

If bigger wildings are transplanted, they must be carefully uprooted, leaving soil around the roots, and planted on the farm in the same way as seedlings from a nursery.

Farmers already use wildings of many species, both exotic and indigenous. *Grevillea robusta* and *Cordia abyssinica* are examples of species commonly propagated in this way.

7.2 Direct seed sowing at the desired site

Another way of getting more trees on a farm is to sow the seed directly at the desired site. This is an important method for some species and for technologies that require very many trees or shrubs, such as live fences or dense woodlots.

A good seed supply is a must for this method since normally a certain amount of seed will be wasted. Normally, directly sown seedlings cannot be as well cared for as seedlings in a nursery, and one must also expect accidents, such as seeds being washed away by rain or eaten by birds, or young seedlings being mistaken for weeds and destroyed. Occasion-

ally there may be a dry spell soon after germination and if watering cannot be easily arranged the dry spell may result in almost total failure. It is thus necessary to have access to plenty of seed so that the sowing can be repeated.

Criteria for species and technologies where direct-seed sowing is recommended are as follows:

- Many seedlings are required, hence transporting the seedlings would be demanding.
- A good seed supply is necessary, allowing for waste of some seed.
- Initial growth of the seedlings should be rapid.
- Large seeds are better than small seeds since they are not so easily washed away by rain.

These are some of the species and technologies that meet most of the criteria:

- *Acacia mearnsii* for woodlots
- *Caesalpinia decapetala* for fencing
- *Croton megalocarpus* for fencing
- *Sesbania* spp. and *Leucaena* spp. generally
- *Thevetia peruviana* for fencing

It is rarely justifiable to raise any of these species in a nursery as they grow easily if sown directly at the desired site.

In addition to climatic factors, sowing depth is a factor that frequently causes problems when trees or shrubs are sown directly. If seeds are sown too deep, the seedlings may not reach the soil surface after they germinate, and if they are sown too shallow the risk of the seeds being washed away by rain increases as does the risk of their drying out during germination. As a general rule, sowing depth should be about twice the seed diameter.

It is also important that sowing be done as soon as the rains are well established to give the seedlings time to grow as big as possible before the dry season. If there is a dry spell, a little supplementary watering may make a big difference to survival. Weeding is more essential after direct-seed sowing than with any other tree-planting method since the seedlings are tiny initially.

7.3 Use of stem cuttings

A simple and cheap method of propagating trees that can easily be managed by the farm family is to propagate with stem cuttings. A stem cutting is a section of stem that will send out roots when it is placed in the soil. Only certain species, however, will propagate from cuttings unless rooting hormones are applied. Rooting hormones are synthetic growth-stimulating chemicals called auxins. Bought as powder or solution, they stimulate rooting when applied sparingly to the base of cuttings or to the injured area of branches used

for propagation through layering (see section 7.5). By applying rooting hormones a wider range of species can be propagated vegetatively.

Use of cuttings can be recommended even without rooting hormones but only for a limited number of tree species. Tree species such as *Ficus natalensis* and *Gliricidia sepium* and many ornamental plants like rose and hibiscus are among those that can easily be grown from stem cuttings. Do not take cuttings in the dry season or from old trees. The ideal length of the cuttings varies with the species. Some species grow well from cuttings about 30 cm long, while for other species cuttings up to 2 m long, called truncheons, are better. Such large cuttings are quite resistant to damage by livestock. Truncheons should be planted directly in the field where the tree is wanted.

Most species, however, grow best from woody cuttings that are 30 to 50 cm long and 1 to 2 cm in diameter. Best results are achieved if approximately 2/3 of the length of the cutting is in the ground (fig. 18) and at least two buds are under the soil surface. Plant the cutting at a slanting angle to speed up growth, and face the buds upwards. Cuttings planted upside down will not grow. If possible, plant cuttings immediately after they are cut from the parent tree. If this is not possible, because of distance, for example, protect the cuttings from drying out by wrapping them in a wet sack and keep them in a cool place. The planting site must be well prepared, weeded and protected from livestock to get good results.

Alternatively, cuttings may be raised in a nursery and later planted out in the field. Such cuttings are better able to withstand transportation and delays in planting than fresh cuttings. If a species can be propagated from either seeds or cuttings, cuttings normally grow faster.

These are other important species from which cuttings can be taken:

- *Erythrina* spp.
- *Euphorbia tirucalli*
- *Ficus* spp.
- *Gliricidia sepium*
- *Manihot glaziovii*
- *Morus* spp.

If a new species is to be introduced to an area it may be a good idea to grow its cuttings initially in pots.

Raise cuttings managed in nurseries in a well-aerated, warm area, free from pests and diseases. The soil should be of good quality, with adequate fertility and good

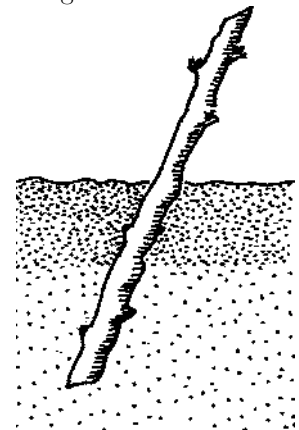


Figure 18 Stem cuttings.

drainage. The following procedure is recommended for raising stem cuttings in pots:

- Fill 2/3 of the pot with a mixture of topsoil and compost, and press it down to make it firm.
- Mix equal amounts of sawdust or coffee husks and washed sand or eroded soil and fill up the pot with this mixture.
- Water well.
- Dip the base of the prepared cutting in a dilute soap solution.
- Insert the cutting into the filled pot.
- Place the potted cutting under shade and cover one side.
- Water twice a day, morning and evening.

The cutting is ready for planting out when it has developed three new leaves.

Raising plants from cuttings successfully depends on successful root development. Three main factors influence the growth of plants from stem cuttings—quality of cutting, treatment of stock material, and environmental conditions while the cutting is rooting. Good soil moisture is a must for rooting cuttings of most species. Applying growth promoters such as rooting powder increases chance of growth.

7.4 Use of root cuttings and suckers

Many species, for example *Psidium guajava*, can produce shoots from roots that are exposed. Such shoots can be separated from the mother plant and planted elsewhere. Another option is to take care of root suckers, which many species produce vigorously after a tree has been cut or damaged. Use of root cuttings or suckers will yield an offspring similar to the presumed parent tree only if the parent tree was not grafted. A root cutting from a grafted tree will be genetically identical to the seedling on which grafting was done (the rootstock).

7.5 Layering

Layering is a method of propagating trees and shrubs by which a stem or branch is encouraged to develop roots before being removed from the parent plant. Rooting hormones (see section 7.3) stimulate the layers to root, but the layers of some species will produce roots even without rooting hormones. Of the several methods of layering, simple layering and air layering (or marcotting) are among the most common.

Simple layering

Simple layering is well suited for shrubs with branches near the ground that can be bent and partly buried in the soil. The following sequence of steps is recommended:

- Some months before layering is to take place, prune one or several young, pliable, low branches on the parent plant to encourage vigorous shoots, which will have a greater capacity to root.
- At the time of layering, loosen the soil below the branch and add compost if the

soil is heavy.

- Keep leaves at the tip of the selected shoot but strip off others and the side shoots.
- Bring the stem down to the ground and mark the ground about 22 to 30 cm behind its tip. This corresponds with the section that was stripped of leaves and side shoots.
- Dig a shallow hole or trench below the stripped section of the shoot. Cut the stem at the point where it will be pegged into the hole, at about 30 cm from its tip, either with an angled cut or by removing a portion of bark lengthwise on the underside of the shoot.
- Fix the stem in the hole by pushing it down with a wire bent into the shape of an upside-down U. The cut surface of the stem must be held in contact with the soil.
- Bend up the stem tip vertically and tie it to a thin stake.
- Fill the trench with soil, leaving the tip above ground. Firm the soil lightly and water.
- Keep the area around the layer moist for some months until the layer has rooted.
- Once the layered stem is rooted, lift it and cut it from the parent plant, severing it close to the new, young roots. Plant the layer at the desired site or in a container for further care in a nursery before planting it out in the field.

Only some species, for example guava, will root if this method is used without applying rooting hormones. A number of species can be layered if rooting hormones are applied.

Air layering or marcotting

The technique of air layering is particularly suitable for shrubs or trees with branches that are difficult to lower to the ground. The following procedure is recommended:

- Collect sand or coarse, well-aerated mineral soil low in organic matter or moss. Place it on a plastic sheet in the sun, cover with another plastic sheet and leave it for a week for heat treatment to reduce risk of disease. This will be the rooting medium.
- Choose a strong, healthy, woody stem of pencil size in thickness.
- Trim the side shoots or leaves to leave a clear length of stem well behind the tip.
- Cut the stem with an angled cut or ringbark the stem (fig. 19a). For many species it is necessary to dust the cut area with a rooting hormone for air layering to be successful.
- Cut off the sealed end of a plastic bag (preferably black as roots shun light) that is about 20 cm long and 18 cm wide when lying flat. Slip it over the stem like a sleeve (fig. 19b) and secure the end (fig. 19c) farthest from the growing tip by tying the bag tightly around the stem using tape, string or bark fibre.
- Moisten the treated rooting medium and fill the plastic sleeve (fig. 19d) until the medium is about 5 cm from the open end. Pack it firmly.

- Close the end and secure it firmly in place with adhesive tape or string (fig. 19e).
- Leave the sealed sleeve in place for 2 to 3 weeks to allow new roots to develop. If a transparent plastic is used, roots will become visible through the plastic.
- Once the layer has rooted, remove the sleeve (fig. 19f) and cut off the layer below the roots (fig. 19g).
- Plant out at the desired site or plant in a container for further care in a nursery before planting out in the field.

Several species require use of rooting hormones for this method to work well.

7.6 Budding and grafting

Budding and grafting are widely used methods of propagating fruit trees. Because budded or grafted trees show the true characteristics of the mother tree, the parent material should be good, giving advantages of earlier production, higher yields and greater resistance to disease.

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. Figure 20 shows how a rootstock and a scion are grafted.

Budding

In budding, a lateral bud is used to produce a new plant by inserting the bud from a desired variety into the rootstock of another plant.

Seedlings of many species are ready for budding after 8 to 12 months when the shoots are pencil size in diameter. Budwood 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 to 30 cm long and have 8 to 10 buds. Use the buds from the bottom and middle part of the bud stick. Do not use the bud nearest the top end of the bud stick. Remove all leaves and thorns before the actual budding work starts.

The two basic methods of budding are the T or shield budding method and the inverted T method.

T or shield budding

T or shield budding is illustrated in figure 21. The procedure is as follows:

- Trim off all leaves of the rootstock plant 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. Cut only through the bark, being careful not to penetrate the wood.
- Make a horizontal cut about 1 cm long at the upper end of the vertical cut to form

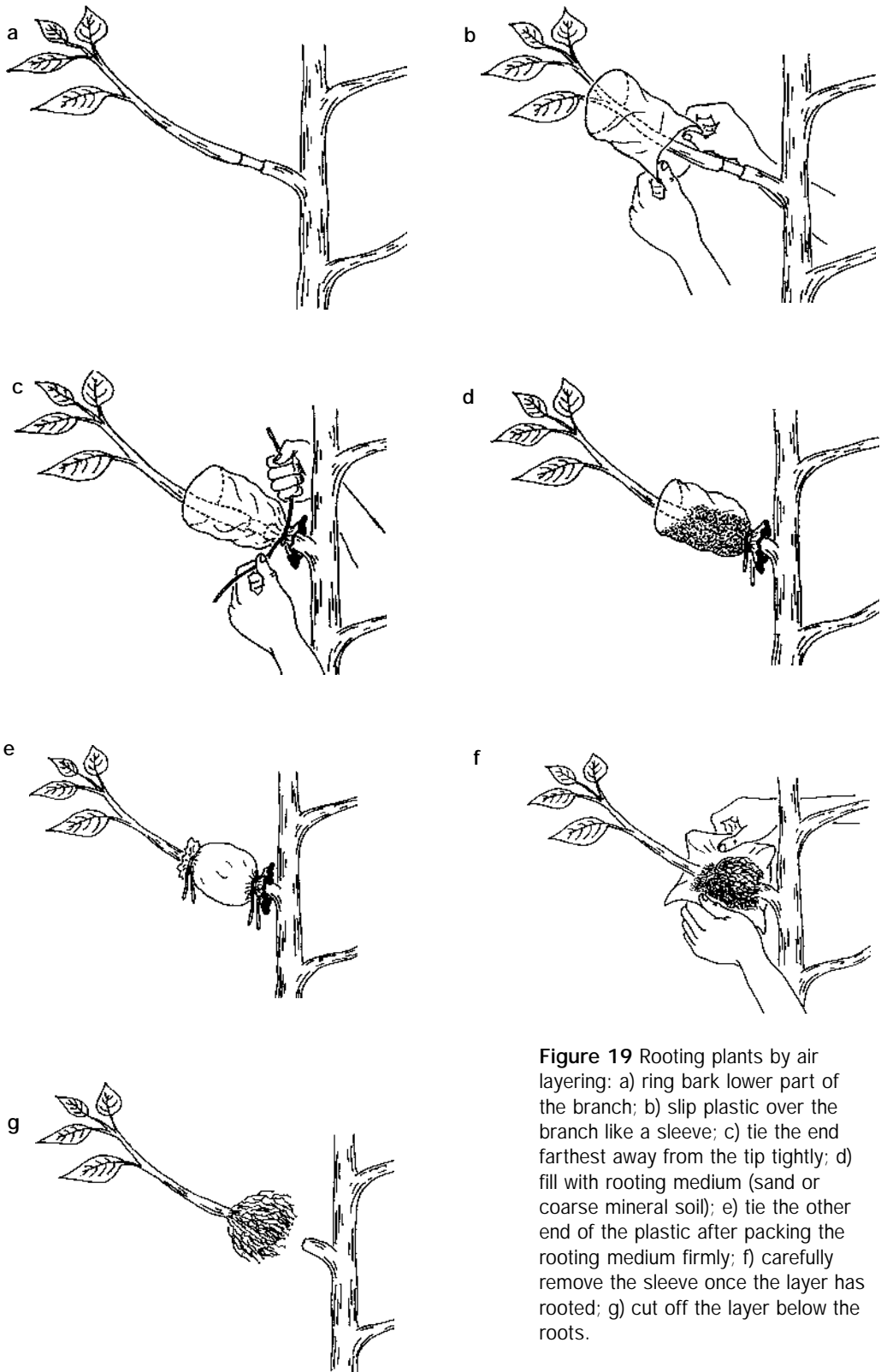


Figure 19 Rooting plants by air layering: a) ring bark lower part of the branch; b) slip plastic over the branch like a sleeve; c) tie the end farthest away from the tip tightly; d) fill with rooting medium (sand or coarse mineral soil); e) tie the other end of the plastic after packing the rooting medium firmly; f) carefully remove the sleeve once the layer has rooted; g) cut off the layer below the roots.

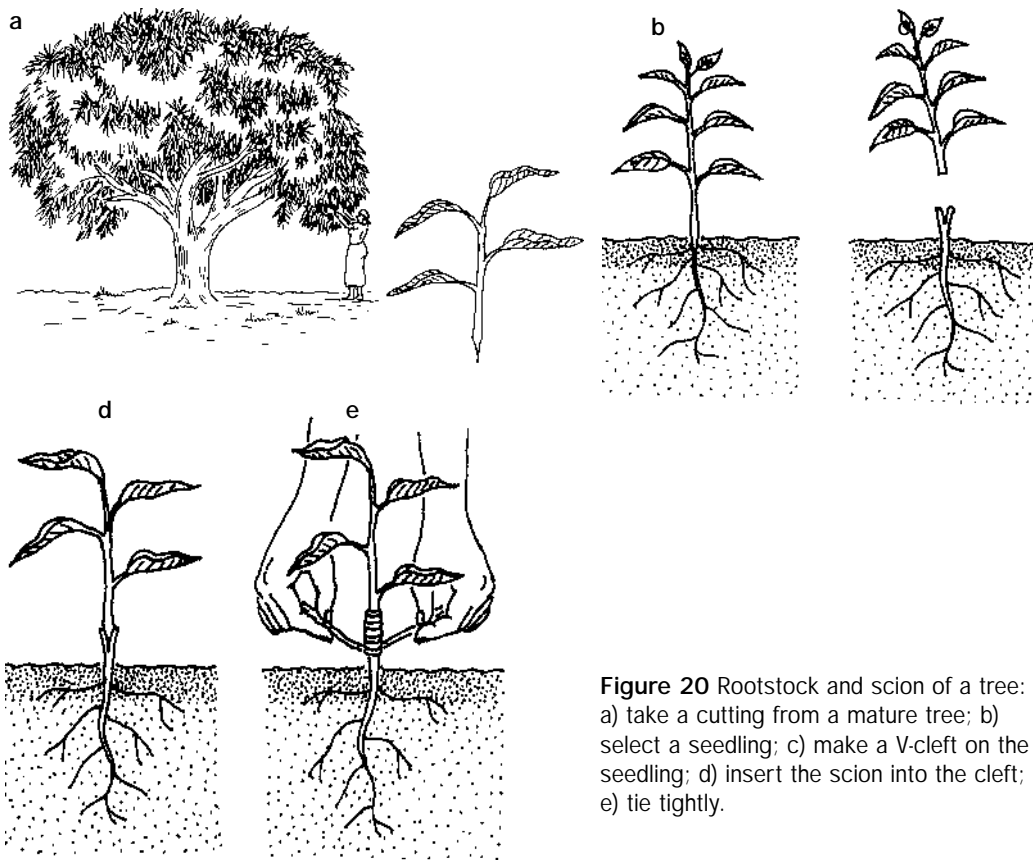


Figure 20 Rootstock and scion of a tree: a) take a cutting from a mature tree; b) select a seedling; c) make a V-cleft on the seedling; d) insert the scion into the cleft; e) tie tightly.

a T.

- Using the blunt part of the budding knife, open out the cuts.
- Remove a shield-shaped piece of bark including the bud from the bud stock. 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. Cut off any portion of the bark that extends above the cut.
- Wrap polythene sheeting or tape around the insertion firmly, working from the bottom upwards, but avoid covering the bud completely.
- Unwrap the bud after 15 to 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 to 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 to 30 cm long.

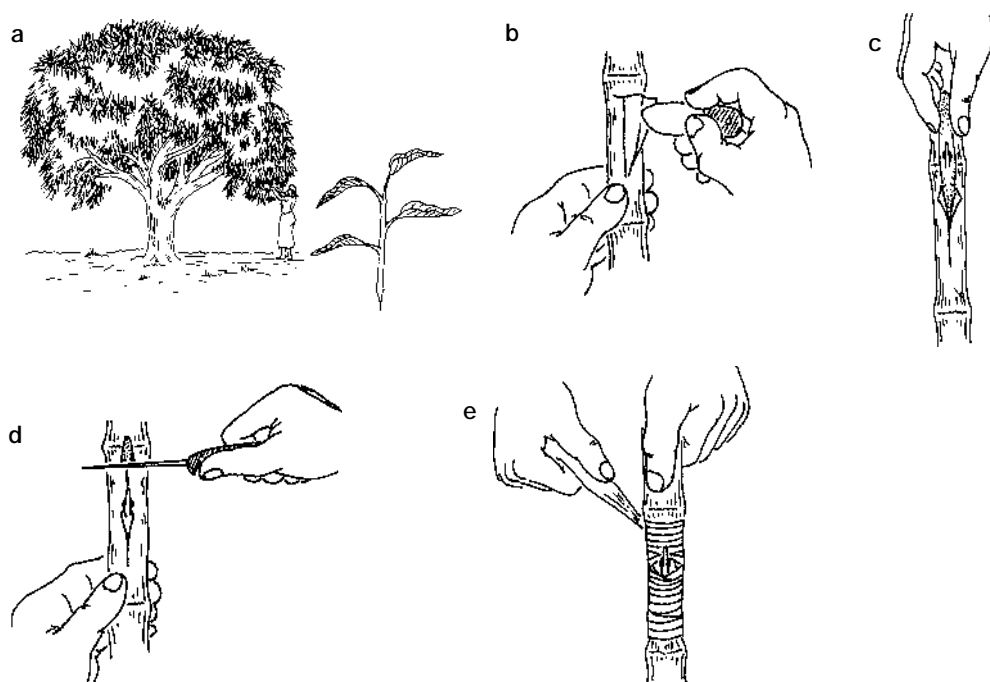


Figure 21 'T' or shield budding: a) make a vertical cut about 3 cm long, a horizontal cut at the upper end, and open the cuts carefully; b) remove a shield-shaped piece of bark including a bud; c) insert the shield-shaped piece in the cut; d) cut off the portion that extends above the cut; e) wrap around the insertion firmly.

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.

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

Grafting

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

Splice or whip grafting

A simple and common grafting method is splice or whip grafting, as illustrated in figure 22. The steps to follow are these:

- 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.

Wedge or cleft graft

The other common grafting method is wedge grafting (fig. 23). 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 in the growing stage. A recommended procedure is as follows:

- Prepare the scion by making two sloping cuts 4 or 5 cm long, 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. Ensure that the growth zones (cambium layers) of the scion and rootstock have good contact on at least one side.
- Tie the union securely with a polythene strip or tape.
- Protect the seedling against sunlight and water it regularly until the scion and the rootstock have united.

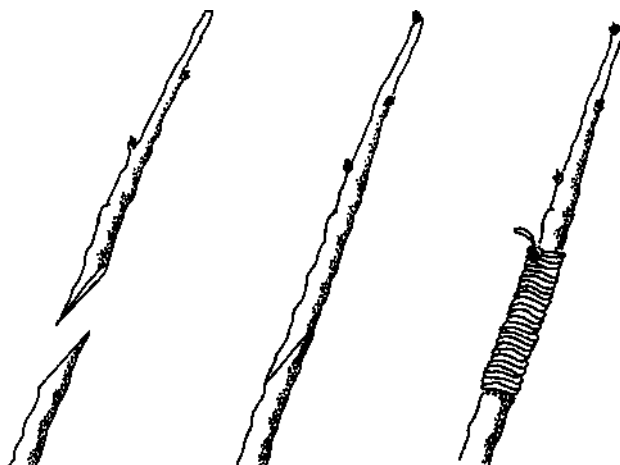


Figure 22 Splice or whip grafting.

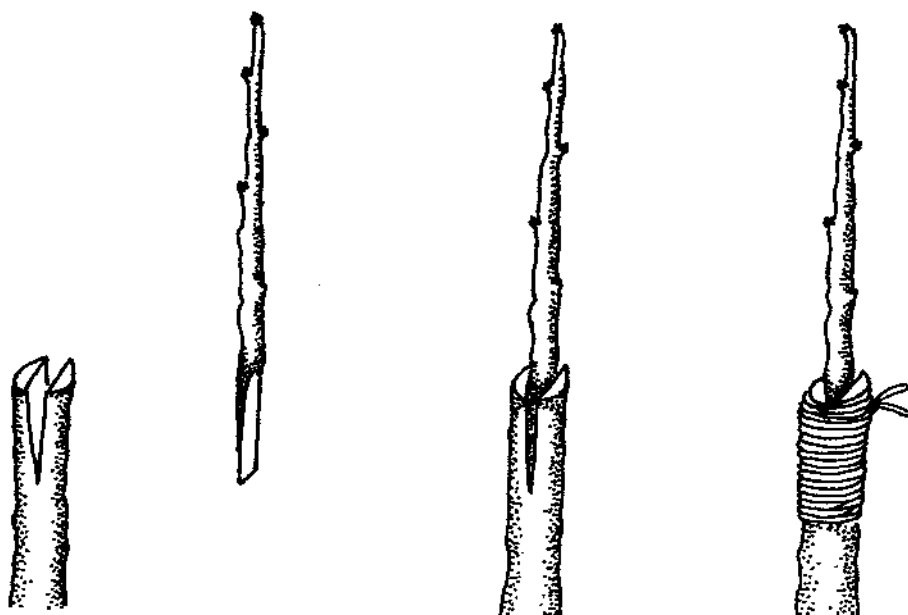


Figure 23 Wedge or cleft grafting. Ensure that the growth zones (cambium layers) of the scion and rootstock have good contact on at least one side.

7.7 On-farm nurseries

One of the factors limiting growing trees is that planting stock may not be available. Farmers in remote areas are often unable to obtain seedlings from nurseries. To obtain the seedlings needed at the right time for planting, they must be produced on or near the farm. A number of benefits are gained by raising seedlings in nurseries near the farm:

- The quality and quantity of seedlings required is guaranteed.
- Seedlings can be raised cheaply using locally available materials.
- Transport costs are reduced.
- Local skills in managing tree seedlings are improved.
- Seedlings provide an additional source of income.
- The nursery may also be used to raise seedlings of fruits and vegetables.
- Timely planting of seedlings to improve successful establishment is possible.
- Farmers raise seedlings of their choice.

Suitable species

Some popular tree species are best propagated in on-farm nurseries. Species with small seeds such as eucalyptus, grevillea and cypress are difficult to sow directly with good results and thus are best raised in small on-farm nurseries. The seeds of other species may be scarce and therefore optimum use must be made of the little seed that is available. This also calls for raising seedlings in nurseries.

Timing and availability of water

Sow seeds in time to obtain seedlings of a suitable size for planting out at the beginning of the rains. Fast-growing species need less than 3 months from sowing to attaining a suitable size for planting; the slower-growing ones will require 4 to 6 months. Thus the nursery needs to be in operation during the dry season, and all nurseries of any size should be located near a good water source.

If there is no water source on farm, then it is advisable to have only a very small nursery with 30 to 40 seedlings, which can be watered using household wastewater. Always avoid carrying water long distances for tree nurseries. It is easier to carry seedlings once to the desired planting site than to transport water for the seedlings throughout the dry season.

Setting up a nursery

The farmer and the farm family can easily establish and manage a small nursery. The number of seedlings raised can vary from very few to as many as may be needed on the farm or can be sold in the area.

Seedlings can be raised either in containers or without containers. Those grown in containers normally have a better chance of establishing quickly and surviving than seedlings raised without containers. If polythene tubes are not available, old tins, milk packets or containers made from banana fibre can do as well. If a farmer prefers to raise seedlings without containers, a small nursery bed, approximately 60 by 100 cm and 20 to 30 cm deep can be made in a well-protected area of the farm. Banana stems, poles, boards or bricks can be used for a frame for the bed, which can be secured by pegs, stones or soil.

Fill the frame with good fertile topsoil, neither too clayey nor too sandy. Firm the soil lightly. Sow seeds in furrows 10 cm apart and at a depth that is twice the seed diameter (fig. 24). Cover seed with soil and firm lightly after sowing. Cover the seedbed with leaves or grass to conserve moisture, and water carefully. Remove the cover when the seedling shoots appear.

A typical nursery for production of seedlings raised in containers is illustrated in figure 25 and a nursery for seedlings without containers in figure 26.

Materials needed to set up a nursery are

- tools such as hoe, panga (machete), tin with holes, polythene tube, banana fibres and watering can
- soil, stones and wooden pegs
- A good nursery bed is constructed in the following way:
- Position the bed in a well-secured place close to the homestead. It should be situated in a well-drained area on a relatively flat piece of land and aligned in the path of the sun.
- Prepare the site by removing all vegetation and digging the soil.
- Mark out a small plot of approximately 60 by 100 cm.

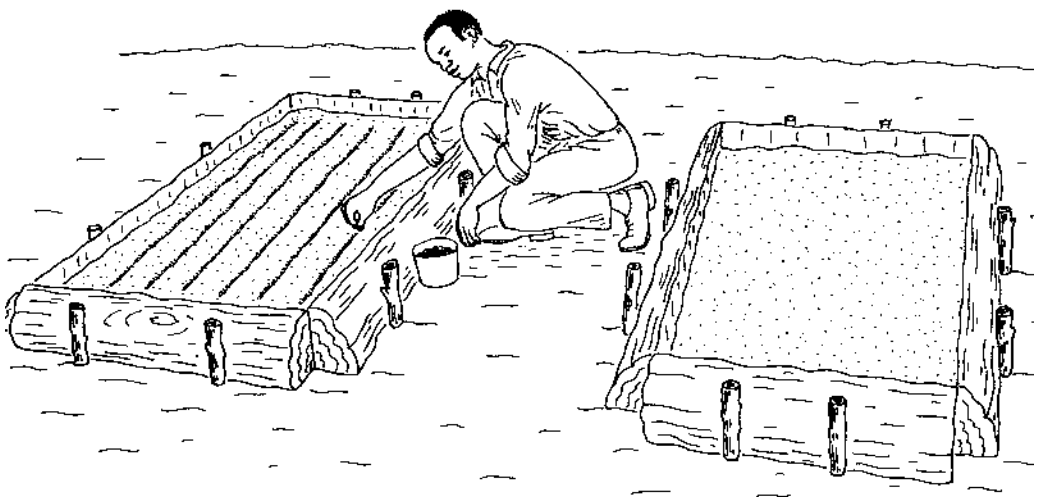


Figure 24 A farmer sowing small seeds in lines.

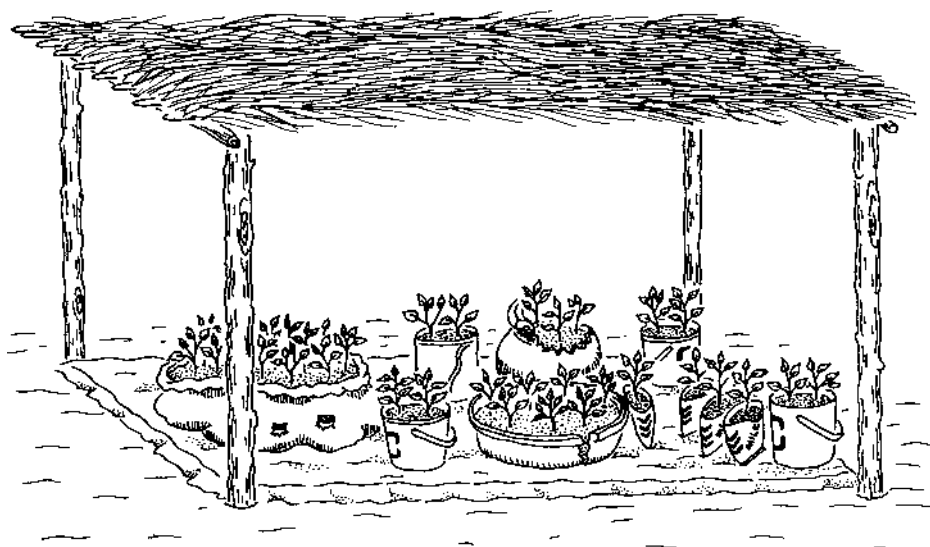


Figure 25 A home nursery with seedlings raised in containers.

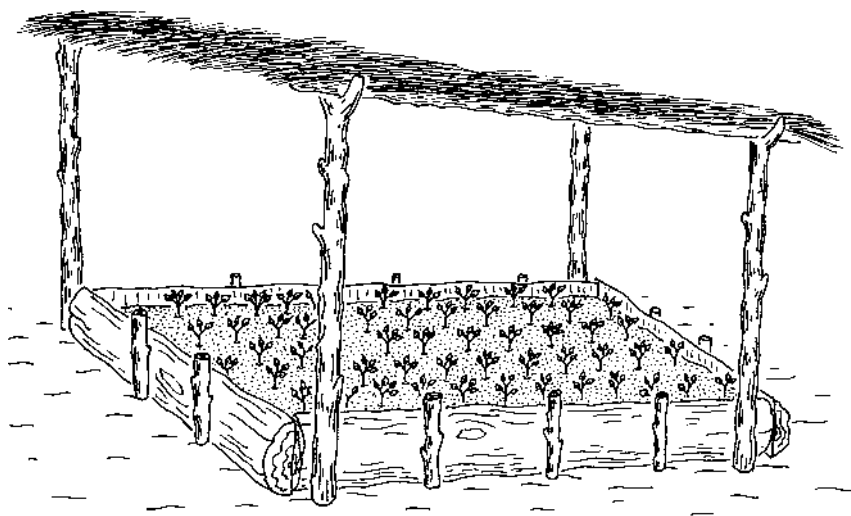


Figure 26 A home nursery for seedlings without containers.

- Use banana stems, poles or bricks to make a frame for the seedbed (fig. 26) and secure it with wooden pegs, stones or soil.
- Fill the bed with good, fertile topsoil that does not contain too much clay or sand. Mix compost and sand in a ratio of 2:1 (see chapter 11 for methods for preparing compost).
- Rake the soil lightly.
- Sow seed in furrows that are 10 cm apart, at a depth corresponding to the seed diameter. Mix small seeds with sand before sowing for even distribution.

- Cover seeds with soil and firm lightly.
- Cover the seedbed with leaves or grass to conserve moisture.
- Water carefully.
- Remove the leafy cover when seedlings appear.

Management of nurseries for seedlings raised without containers

When the seedlings emerge, they require regular watering, weeding, root pruning and protection from sun, animals, pests and diseases. Carry out the following activities to maintain a good nursery:

- Construct a light shelter about 60 cm high to shade the seedlings. Use sticks to form the side support and a roof of grass, straw or leaves for shade.
- Reinforce the sides by using a rough fence of sticks to protect the nursery from browsing and trampling animals.
- Label the bed to indicate the species grown and dates sowed.
- Water the beds twice daily during the dry season.
- Remove weeds when they appear.
- Pluck weak seedlings to allow adequate growing space for strong seedlings, which will be planted when mature.
- Progressively reduce shade as seedlings germinate and establish themselves.
- When ready to plant out, reduce watering to condition the seedlings to the field situation.
- On the day of planting out, water seedlings well to soften the soil and provide a reserve of water in the seedling.

Management of seedlings raised in containers

A farmer preferring to raise seedlings in containers has several management options. First, the containers are filled with a suitable soil mixture containing both humus and sand. Then seed can be sown either directly in the container or in a seedbed like the one described above. The first option, sowing directly in the containers, is preferred for species with large seed and a good germination rate. Species with small seeds are best sown in a seedbed and transplanted into containers (pricked out) when the seedlings sprout the first two or three leaves. Transplanting larger seedlings results in higher mortality.

The following procedure is recommended for pricking out:

- 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 exposing 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 some soil using a trowel or a flat piece of wood to

avoid damaging the roots or exposing them to the sun.

- Lift only a small number of seedlings at a time so that they can be transplanted quickly to avoid drying out. Keep the roots covered at all times or put the small seedlings in a container with cool water.
- Make a hole in the soil of the container or pot. It should be deep and wide enough to accommodate the roots of the seedling.
- Pick up one seedling at a time, holding it by its leaves, 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 the soil down around the seedling to close the hole. Make sure the hole is well filled and the soil is pressed down around the seedling 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.

Root pruning

Pruning the roots helps the seedlings grow stronger and build up a balanced root system. The first pruning is done when the seedlings are 5 cm high. Newly pruned seedlings are sensitive for the first few days and need careful watering and shade. Root pruning should be done at least once a month, and more often for fast-growing species.

Roots should always be pruned in the morning or evening or during cloudy days to reduce water stress on the seedlings. Lift the potted seedlings one by one and prune them, then put them back in the nursery bed. The following routine is recommended for seedlings raised without containers:

- Remove pegs or stones around the frame of the bed and water the bed thoroughly.
- Use a sharp panga and run it underneath the nursery bed to prune taproots and lateral roots, as shown in figures 27 and 28.
- Replace supports around frame.

Hardening off

During the last month of nursery growth, harden the seedlings by

- watering only once a day
- removing shade gradually until seedlings are exposed to full sunlight



Figure 27 Pruning the taproots of the seedlings in a nursery bed.

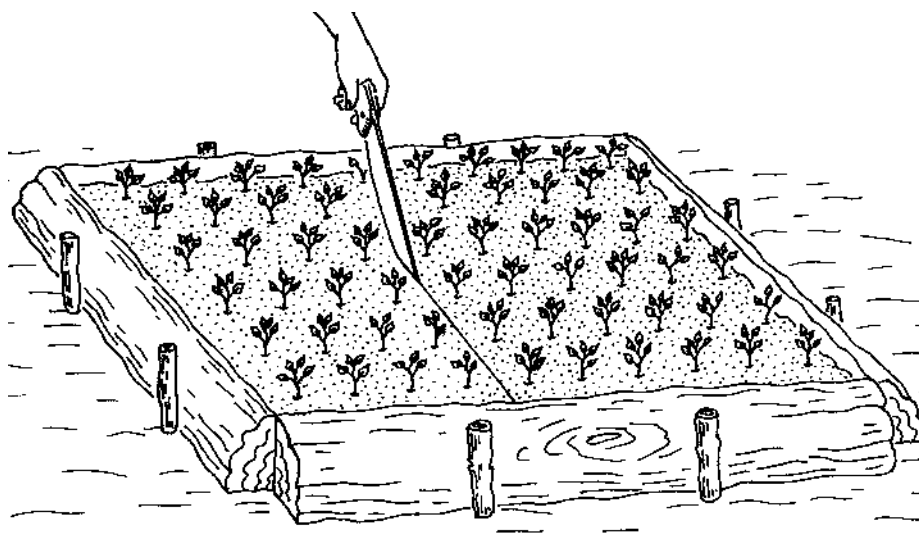


Figure 28 Pruning the lateral roots.

7.8 Where are on-farm nurseries feasible?

Small on-farm nurseries using household wastewater can be established and managed anywhere. Larger on-farm nurseries depend on a permanent water source and have to be located near a permanent spring or stream. It is also desirable to establish the nursery near the compound or on the farm where the trees are to be planted. Since the nursery is located on the farm, the seedlings are secure and easily available during the best planting time. Because the farmer and the farm family make their own decisions, they are likely to raise the seedlings they want. The nursery can also be developed into a commercial activity yielding income for the family.

7.9 Group, school and other specialized nurseries

So far we have discussed farmer-managed tree propagation techniques. Propagation of certain species does, however, require skills that not all farmers have, and such seedlings are best raised by specialists for sale to other farmers. These specialists can be either entrepreneurs or groups running commercial nurseries. The production should primarily be geared towards species that people cannot easily raise themselves. Fruit trees that require budding and grafting, and species where aspects of seedling health and good propagation material are important can profitably be raised in specialized nurseries. Schools may also run tree nurseries with a dual purpose: both to act as a training ground for pupils and to produce seedlings for the school.

A good and permanent water source nearby is a must for all nurseries of any size. Management of larger nurseries requires good organization to handle the necessary continuous attention and care. A short period of negligence—for instance, if one member of a group fails to meet obligations, or a school fails to organize people to water the nursery when the pupils are on holiday—may ruin months of work.

A group nursery may serve a whole village, parish, or sub-county.

Advantages with group nurseries

- Members can obtain free seedlings.
- Members learn from each other.
- Members with no other income can purchase household items.
- Working together improves social well-being and lives.
- Farmers with common interests can pool resources and solicit additional support from outside.
- Income from the sale of seedlings can be shared among members.

Limitations with group nurseries

- Seedlings may be stolen from the nursery.
- Seedlings may be maliciously uprooted from members' fields.
- Free range animals damage seedlings.
- Conflict and grudges between individuals may cause division in the group.

Since information on nursery techniques is available from many other sources no further elaboration is made here.

Rwene Two Wings Agroforestry Group Nursery

The Rwene Two Wings Agroforestry Group Nursery is located in Kagina Village, Rwene Parish, Buhara Sub-county, Ndorwa County, in Kabale District of Uganda.

The group started in 1995 with the aim of assisting members after a death in the family ('ekibiina

ky'engozi'). With a membership of 17, the group has a revolving fund into which each member pays UGS 500 per month. Members service loans with 10% interest per month. Non-members may borrow money at 20% interest per month. The group rents land for growing crops such as maize, sorghum and potatoes. Income from the sale of crops is banked for later use or used to purchase domestic items as decided upon by members.

The group has a nursery where they raise seedlings of fruit trees and other trees and vegetables. The land on which the nursery is established belongs to one of the members, who does not charge rent.

In the nursery, seedlings of alnus, cabbage, calliandra, eggplant, eucalyptus, grevillea, passion fruit and tree tomato (*Cyphomandra betacea*; 'ekitunda kyarushagama' in Rukiga) are raised. Rootstocks of avocado are also raised and grafted.

Members learned grafting techniques from experts at an agroforestry research station. Demand for grafted avocado is high. Priority is given to members but non-members also obtain grafted avocados after all members have planted at least one avocado tree each in their home. Tree seedlings that are sold include *Alnus acuminata*, *Calliandra calothyrsus* and *Grevillea robusta*. Each member is responsible for monitoring nursery activities such as watering.

The group meets every Wednesday at 10 a.m. to weed, prune roots, fill pots or sow seed. Members who are absent without apology or good reason are fined UGS 300. Failure to pay the fine leads to a deduction when profit is shared.

In one season, 2,000 seedlings worth about UGS 100,000 are sold. The group has also trained other groups in nursery establishment and management.

8 Tree seed collection and handling

8.1 Sources of seed

Seeds can be either purchased from central suppliers or collected locally. Local collection has several advantages:

- Seeds collected from indigenous trees in the area are well adapted to local conditions.
- Fresh seed can be collected and used in a timely manner.
- There is detailed knowledge of the seed source.
- No cash expenditure is involved.

The following points should be considered for collection of good-quality seed:

- Collect seed from vigorous, healthy mature trees with desired characteristics.
- Do not collect seed from isolated trees.
- Collect seed from a minimum of 10 trees spaced at least 100 m apart.

The characteristics of a tree depend principally on the species. But trees of the same species also vary. To the extent that such characteristics of trees depend on genetic factors, specific features are inherited. For example, seeds from trees with a good straight bole are likely to produce straight-boled trees while twisted or stunted trees are likely to produce trees with the same poor characteristics. Generally, the type of product desired from a tree determines the characteristics to be looked for in a mother tree. Table 5 lists some desired characteristics of mother trees for specific tree products.

Table 5 Desired characteristics of mother tree (seed source) for different end products

Desired tree products/services	Characteristics of mother tree (source of seed)
Timber	straight stem few branches on the lower part of the stem hard wood
Firewood	many branches fast growing
Shade	many leafy branches evergreen strong stem
Ornamental	nice looking continuous flowering
Fodder	many leafy branches nutritious and palatable fodder
Fruits	branching at lower level of the stem resistance to diseases and pests good-quality fruit fast maturing

8.2 Seed collection methods

Three methods of collecting seed are common:

- Collecting from crowns of felled trees is a simple method because the seeds or fruits are easily accessible from the ground. The trees are cut when they bear mature seeds.
- Collecting from fallen fruits or seeds is also a simple method but it requires careful selection of the fruits or seeds. Those attacked by disease or pests should not be collected. During the period of heavy fruiting or seeding, place a plastic sheet, canvas or mat under the trees to facilitate collection and to prevent falling seeds from direct ground contact.
- Collecting from standing trees is a relatively difficult method that requires climbing to the crown of the tree to pick fruits or seeds. This method can be used if the tree

has strong branches that can provide support during climbing. Ladders, ropes and hooked poles can also be used to collect seeds from the crown.

8.3 Seed handling

Seed handling covers the cleaning, sorting and storage of seed for future use.

Precleaning

Unwanted material such as bark, twigs, or leaf pieces should be removed from the fruit and seed after collection.

Seed extraction

The seed must be separated from the fruit. The method used depends on the nature of the fruit. Common methods are

- drying
- threshing
- depulping by soaking in water
- extraction by hand or by using simple tools like a knife

Some fruits, such as nuts, do not require extraction but are stored or sown as fruits. Sometimes several methods are combined, for example, some pods are first dried to split them open and then threshed.

Drying

Seeds of most agroforestry trees should be dried if they are to be stored. Seeds from most fruits that have pulp such as *Carica* spp., *Dovyalis caffra* and *Maesopsis eminii* should first be depulped and then dried under shade until the surface dries. Seeds contained in hard pods or capsules such as those of *Acacia* spp., *Albizia* spp., *Calliandra* spp., *Casuarina* spp., *Cupressus lusitanica*, *Eucalyptus* spp., *Grevillea robusta*, *Leucaena* spp. and *Sesbania sesban* should be dried in the sun. After drying, for some species such as *Grevillea robusta* it is enough to stir around the dry pods or capsules and the seed will fall out. For other species, threshing is required.

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 split open.
- Put the pods or cones in a sack.
- Beat the sack to extract the seed.
- Remove the seed from the sack and clean it by winnowing or another suitable method, depending on the species.

- Further drying may be best for some species if seed is to be stored.

Examples of seed that can be extracted in this way are

- *Acacia* spp.
- *Albizia* spp.
- *Markhamia lutea*
- *Sesbania sesban*

Depulping by soaking in water

Depulping is removing the fleshy part of the fruit—the pulp—from the seed. Depulping improves germination since the pulp often contains inhibiting chemicals that induce dormancy. Depulping also makes it easier to dry, sort and clean, store, distribute and sow the seed. A recommended procedure is as follows:

- Soak pulpy fruits in a container of water in a proportion of about 1 part of fruit to 3 parts of water. If water remains after the fruit has absorbed it, the amount has been adequate.
- 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.
- Separate the pulp from the seeds by hand.
- Throw out any floating seeds, as usually they are empty and non-viable.
- Dry the remaining seeds—but note that seed of some species should not be dried.

Examples of seed that can be extracted in this way:

- *Cordia africana*
- *Dovyalis caffra*
- *Melia azedarach*
- *Prunus africana*
- *Syzygium guineense*

Some pulpy seeds should not be stored, for example *Bridelia micrantha* and *Syzygium* spp., because they rapidly lose viability.

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 method is an alternative to threshing and can be applied to the same species. It is time consuming, however, if large amounts of seeds are to be handled.

Grading the seed

After extraction, empty and non-viable seed should be separated from the healthy seed. Then grade the seeds by size. Grading is recommended but may not be necessary if a small amount is being processed for direct use.

8.4 Seed storage

When it is not possible to use seeds immediately, store them in containers such as tins, bottles, plastic packets or boxes that are rodent proof. Seeds stored in air-tight containers must be thoroughly dry. The best place to store seed is in a refrigerator. If that is not possible, hang the seed containers from the ceiling or roof so that rodents cannot reach them. The lower the temperature at which the seed is stored the better. Label the container with the species name, date and site of collection. The period for which seed remains viable without losing germination capacity varies significantly with the tree species. For example, seeds of leguminous trees can be stored for one or several years under room conditions, but seeds of *Syzygium* spp. should not be stored at all. Seeds that are still somewhat moist and that should be stored for only a few days should be kept well aerated, preferably spread out on a floor. But there, rodents may easily cause problems. To obtain many good seedlings, it is generally advisable to sow seeds as soon as possible after they are harvested.

8.5 Preparing seed for germination

Seeds of many species do not germinate well unless they are exposed to certain conditions. This state of not germinating unless the required conditions are met is called dormancy. In the natural environment the conditions may be exposure to fire or being eaten by animals. When seeds are eaten they are exposed to the hydrochloric acid in the stomach of the animal, and this breaks the dormancy without damaging the seed.

People must use similar methods to germinate such seeds to break their dormancy. There are several methods of pretreating tree seeds, but knowledge of a few simple techniques is sufficient to get reasonable germination of almost all species.

By pretreatment method, seeds can be divided into five groups.

Group 1: Seeds requiring hot-water treatment or nicking

This group includes most leguminous trees with pods and more-or-less flat seeds with a hard seed coat. Normally, such seeds germinate faster and better if treated with hot water. The procedure is as follows (fig. 29). Place seeds in a pot, pour boiling water over the seeds, and let them soak for about 24 hours. Do not boil the seed. The seed will absorb water, swell and sink to the bottom of the pot. All swollen seeds should be removed and

sown immediately. Those that are not swollen should be left in the pot for a further 24 hours. After they have swelled up, they too should be sown.

Another efficient but time-consuming pretreatment technique for hard-coated seed is to make a small nick in the seed coat with a knife or fingernail clipper. Because of the amount of labour required, nicking can be recommended only for small quantities of seed.

Examples of species in this group are *Acacia* spp., *Calliandra calothyrsus* and *Leucaena leucocephala*. Seeds in this group can usually be stored for some time. The hot-water treatment is normally more important if the seed has been stored than if it is fresh.

Group 2: Small, light seeds with no need for pretreatment

Many common tree species have small, dry seeds, some of which can be stored for at least a few months without losing viability. Examples are *Casuarina* spp., *Cupressus lusitanica*, *Eucalyptus* spp., *Jacaranda mimosifolia*, *Juniperus procera*, *Pinus* spp., and *Psidium guajava*.

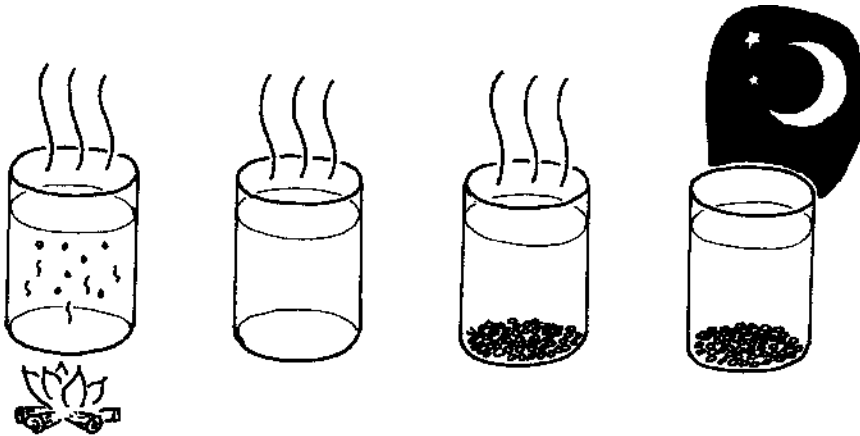


Figure 29 Hot-water treatment of seeds.

Other species also have small, dry seeds that do not require treatment but they cannot be stored for long. For these species the best germination is obtained from fresh seed. Examples are *Grevillea robusta* and *Markhamia lutea*.

Group 3: Large seeds with wings, which should be removed before sowing

Seeds with wings should be dewinged before sowing. Dewinging makes the seed easier to handle and increases the ability of the seed to absorb water. Such winged seeds are, for example, *Terminalia* spp. and *Tipuana tipu*. *Combretum* spp. also have winged seeds, but the procedure with those seeds is different. When the winged *Combretum* fruits are mature but not dry they can easily be opened, the seed extracted and sown immediately. Seeds of

many *Terminalia* species and of *Tipuana tipu* can be stored for some time, but *Combretum* seeds should be sown fresh.

Group 4: Medium-sized or large seeds with no need for pretreatment

This group includes many seeds with high oil content, such as *Croton* spp. and *Vitex* spp. Some of these seeds are surrounded by fruit pulp, and such fruits should be depulped (see above) before drying or sowing the seed. Seeds of *Bauhinia* spp., *Bridelia micrantha*, *Croton* spp., *Dovyalis caffra*, *Eriobotrya japonica*, *Erythrina abyssinica*, *Prunus africana*, *Syzygium* spp., and *Vitex* spp., for example, should be sown as fresh as possible for best results, whereas seeds of *Afzelia quanzensis*, *Cordia* spp., *Melia azedarach* and *Sesbania* spp. can be stored for some time. *Albizia* seeds can also be stored for some time, but only if they can be kept free of insects. Seeds of *Calodendrum capense* should be put in water before sowing to separate the floating non-viable seed from the sinking good seeds.

Group 5: Large seeds with hard seed coats require cracking

Some seeds that have a very hard seed coat can be treated mechanically to break the seed coat and allow water to penetrate the seed. Cracking the seed coat must, however, be done with great care not to damage the seed. This type of seed can normally be stored. An example is *Podocarpus* spp.

What to do if the recommended seed treatment is not known?

If the recommended method for a desired species is not known, it is necessary to try various options and monitor the result. One option is to sow the seed without any treatment. Compare the seed's appearance and structure with the groups described above as similarities with other better-known seed may indicate what treatment might be suitable.

Seed inoculation

To grow well, leguminous tree seeds need to be inoculated, which means coating the seeds with a bacterium named rhizobium. This ensures proper establishment of the roots and good growth. Each leguminous tree species needs a specific type of rhizobium. Some trees that do not belong to the legume family also live in symbiosis (they depend on one another and benefit from the interaction) with micro-organisms. An example is *Casuarina* spp.

Consult with extension officers in the area about where to get the rhizobium inoculant. If it is not available, introduce soil from an area where a leguminous tree of the same

species is growing into the planting holes or mix it in the nursery soil. That soil will contain the rhizobium bacteria and act the same as an inoculant. This method can be used also for non-legumes that live in symbiosis with micro-organisms.

The inoculant provided by extension officers consists of live bacteria mixed in material such as charcoal. The inoculant should be stored in a cool, dark place.

How to inoculate:

- Mix 2 parts of sugar in 1 part of warm water, to form a sticky liquid.
- Mix this sticky solution with the required amount of inoculant until an even slurry is formed.
- Mix the slurry with the required amount of seed until every seed has a fine, sticky coating of the slurry.
- Spread the seed to dry in a cool, shady area.
- Plant the inoculated seed the same day. If that is not possible, store for a day or two in a cool, dark place.

Further reading

The information provided here is a rough guideline. More detailed information may be found in other publications. *Useful trees and shrubs for Uganda* by A. B. Katende et al. (1995) and published by RSCU/RELMA is particularly recommended.

9 Tree planting

The main activities undertaken to ensure proper growth of young trees include land preparation, planting out and weeding.

9.1 Land preparation

Preparation of the land in which seedlings will be planted involves slashing and marking the land according to each tree species' spacing requirements. Tools such as mattocks, machetes, pegs, tapes, ropes, slashers and hoes are needed. Figure 30 shows a layout of a field for planting tree seedlings.

9.2 Planting seedlings

Seedlings raised in containers

Seedlings should be transported to the field for planting after sufficient rainfall, preferably during the peak of a rainy season. Care must be taken not to damage the seedlings during transportation. They should be well watered in the nursery the evening before they are to be planted out.

During planting, cut or peel off the pot or polythene tubing before placing the seedling in the hole. Pack the soil around the pot to ensure that the seedling is upright and to make sure that there are no pockets of air in the soil. If there is no rain, water the seedling.

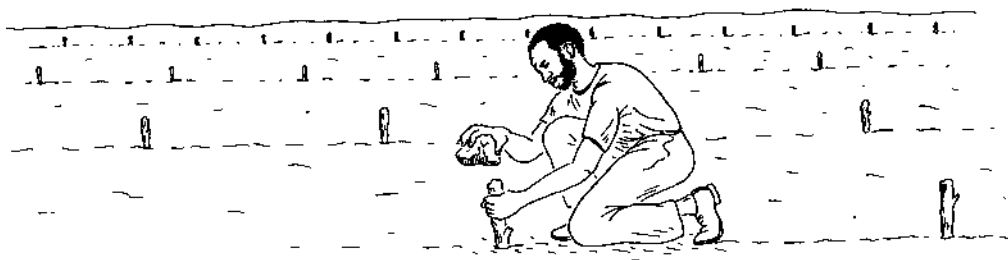


Figure 30 Layout of a field for planting tree seedlings. An initial spacing of 2 by 2 m is suitable for larger trees like eucalyptus. Thinning is later carried out as the trees grow.

Figure 31 shows the procedure for planting seedlings.

Seedlings raised without containers

Water the nursery bed and remove the frame. Use a sharp panga to cut the nursery bed into one soil block for each seedling. Carry the seedlings carefully to the planting site where holes have been prepared in advance. Place the soil block in the hole and firm the soil around it. Water the seedling immediately after planting if it is not raining. Weed and protect a seedling just like any other planted tree.

Plant seedlings when they reach a height of 20 to 30 cm. Plant either early in the morning or in the evening when it is cool, as the seedlings are likely to wilt if planted in the heat of the midday sun. Mulch the soil near the seedling to reduce evaporation and suppress weeds.

9.3 Weeding

Like any crop, trees suffer from competition with weeds. Weed periodically for good tree growth. Where it is uneconomical to weed the whole area, do spot weeding by clearing the area around the plant. Weeds may also be cleared by slashing around the trees.

10 Woodfuel conservation

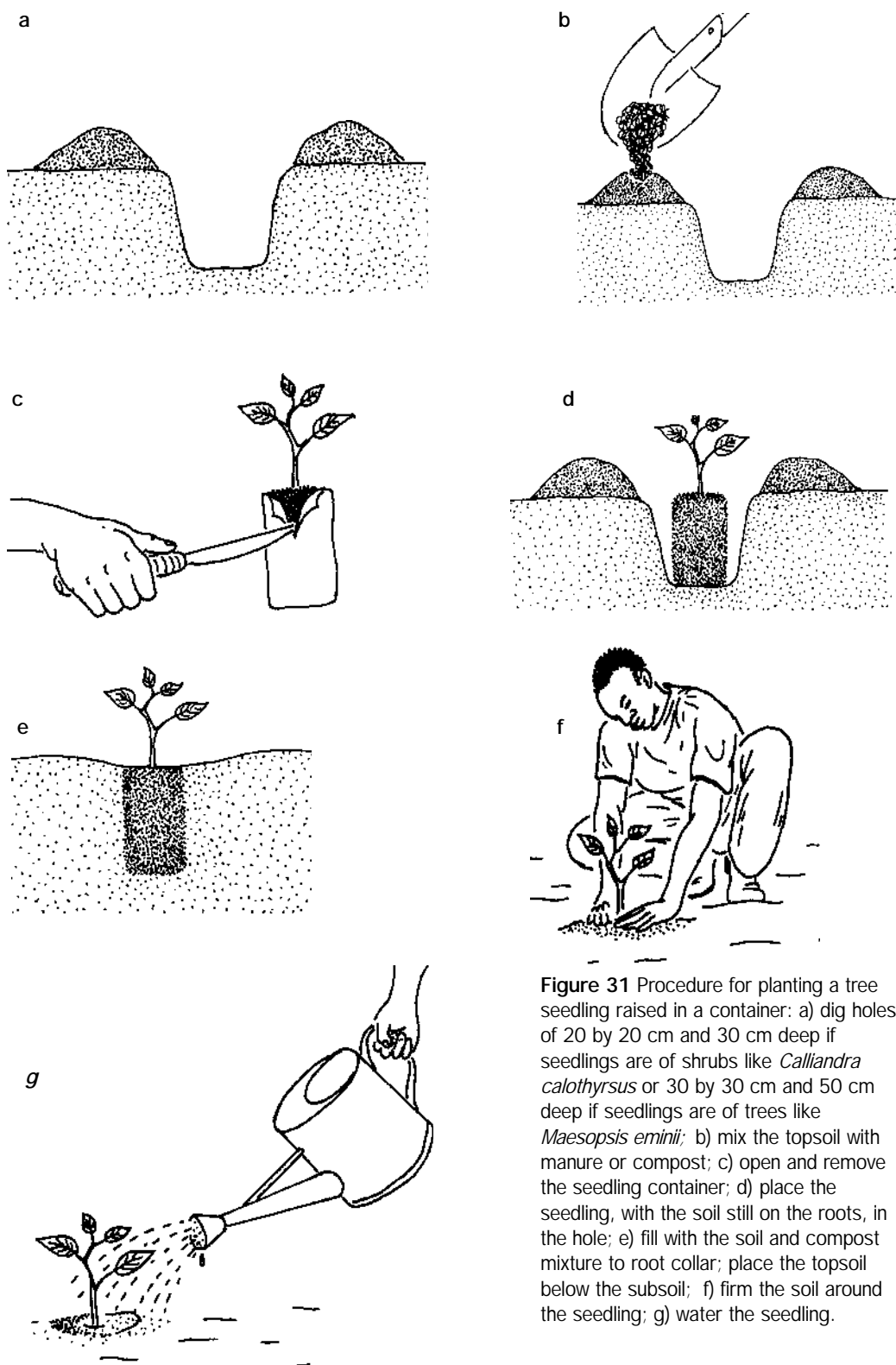


Figure 31 Procedure for planting a tree seedling raised in a container: a) dig holes of 20 by 20 cm and 30 cm deep if seedlings are of shrubs like *Calliandra calothyrsus* or 30 by 30 cm and 50 cm deep if seedlings are of trees like *Maesopsis eminii*; b) mix the topsoil with manure or compost; c) open and remove the seedling container; d) place the seedling, with the soil still on the roots, in the hole; e) fill with the soil and compost mixture to root collar; place the topsoil below the subsoil; f) firm the soil around the seedling; g) water the seedling.

Woodfuel is either firewood burnt directly or wood converted into charcoal. The vast majority of people in Uganda depend on trees as a major source of household energy.

Burning woodfuel, especially charcoal, is associated with environmental degradation. Efforts have been made, however, to reduce the rate of cutting trees for producing both charcoal and firewood. Some of the efforts have included designing and promoting efficient woodfuel stoves.

In the early 1980s the importance of wood, charcoal and crop residues for supplying energy in rural areas worldwide became fully recognized. Agroforestry practices have considerable potential for alleviating the fuel shortage. One important advantage of

agroforestry in this respect is that wood is produced where people live. There is, however, also a need to encourage people to use improved stoves to reduce wood consumption. Considerable work has been done in recent times and in many parts of the world both on supporting increased production of biomass for fuel and on reducing consumption of firewood.

This chapter highlights the importance of a good energy supply. It also describes different ways of reducing the consumption, including a description of common woodfuel stoves used in Uganda.

10.1 The importance of a good supply of fuel

Collecting firewood is traditionally women's work in rural Uganda. Most rural women are already overworked, and the farther away they are from the source of fuel the greater their workload becomes (fig. 32). As a result, women have less time and energy to spend on other activities such as caring for children or engaging in income-generating activities. This has a direct impact on the family's nutrition as food supply in the household is often strongly linked with the woman's income. The dwindling supply of food from wild trees also has a negative effect on family nutrition, particularly on that of children.

Firewood scarcity may influence both the type and the amount of food cooked. Women may be forced to choose foods that do not require a long time to cook although they may not be the best from the nutritional point of view.

Although for all these reasons a good supply of firewood is extremely important for the rural household, farmers are rarely interested in planting trees if the only objective is to produce firewood, which is often regarded as a by-product. If extension is to be successful, any intervention suggested must be based on the needs and priorities of the farm family. If the household head is a man, the needs of women and children may not always be addressed.



Figure 32. A rural woman must carry heavy loads of firewood to cook for the family.

Most tree species can be used for fuel, but the quality may vary greatly. Some species burn rapidly and their calorific value is low. Other species may produce a lot of irritating smoke or be difficult to dry well. Most appreciated for cooking are species with heavy wood that burns slowly with much heat and little smoke. Wood that lights easily is preferred for lighting the fire. The best charcoal is made from species that have heavy wood of large dimensions. Some species burn even if they are not dried first, and although the convenience of this may be appreciated, using wet or moist firewood is always inefficient and should be discouraged.

10.2 Efforts to reduce consumption of wood for fuel

Metal charcoal-burning stoves have featured in urban kitchens ever since they were introduced by the Indian railway builders at the turn of the century. In rural areas, the traditional open three-stone fire pit is still common (fig. 33). In recent times, effort has been devoted to developing and disseminating improved types of fuel-saving stove and to practices that reduce consumption of woodfuel.

Conservation practices include soaking food, cutting it into small pieces, covering cooking utensils with tight-fitting lids, using dry firewood, simmering food instead of boiling it strongly, and using a good type of stove, possibly complemented by one or more 'fireless cookers'.

Using a lid prevents energy loss to the air, and cooking time is shortened if utensils are closely covered. The efficiency of the lid is greatest if it is tight fitting and a stone is put on top of it. Dry wood always burns better, and less is required than if wet wood is used. With dry wood the kitchen is also less smoky and more comfortable. A small fire to simmer food is better than if the water is kept boiling strongly. Soaking food and cutting it into small pieces cuts down the cooking time and thus reduces the amount of firewood needed (fig. 34).

The Ugandan ceramic 'sigiri' has been widely accepted in Uganda, even in urban areas. It has been estimated that this stove reduces charcoal consumption by 30 to 50%. No wonder that this model of stove has become popular. In Nairobi, Kenya, it has been estimated that more than 10,000 units of the similar Kenyan ceramic 'jiko' are produced every month.

Improved stoves have also been designed for households using firewood. They are mostly based on the same principles as the improved charcoal stoves but have a larger firebox designed



Figure 33 The traditional three-stone fire, here built with wet wood.

to facilitate the combustion of wood.

‘Fireless cooking’ is a technique in which food is brought to the boil or allowed to boil for a short while and then removed from the stove and put in a basket filled with insulating material (fig. 35). The heat is preserved in the basket and the food continues to cook until it is ready without using any additional energy.

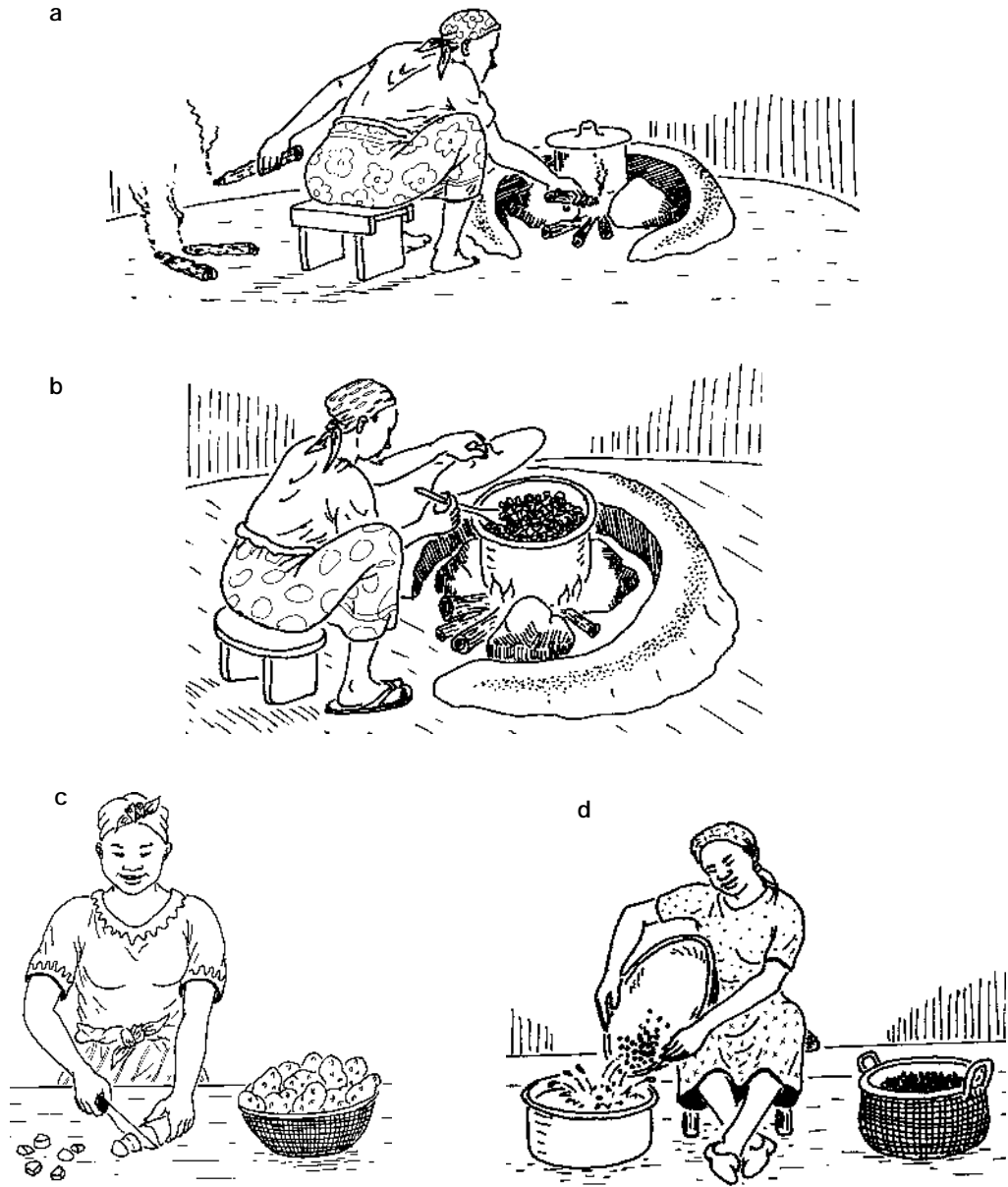


Figure 34 The three-stone fire can be made much more efficient by using dry wood and good cooking methods: a) simmering; b) using a lid; c) cutting food into small pieces; d) presoaking food.

10.3 Improved stoves available in Uganda

Firewood-saving stoves

Three-stone hearth (fig. 36)

Fuel: Firewood and other biomass.

Distribution and use: Widely used in households, institutions, and local breweries.

Advantages: Versatile, portable, free, easy to light.

Limitations: Can cook only one dish at a time; considered inefficient, especially when used outdoors; is a fire hazard, produces smoke pollution.

UNICEF or dembe stove (fig. 37)

Fuel: Firewood and other biomass, charcoal if a metal grate is included.

Distribution and use: Mainly in the central region, for household cooking.

Advantages: Portable, uses a variety of fuels, saves firewood, removes smoke from kitchen if a chimney is installed, built by owner or a group, using mud and a mould.

Limitations: Difficult to light, cracks in stove require regular repair, can use only certain pot sizes and cook only one dish at a time, chimney must be cleaned.

UNICEF wood-saving stove (fig. 38)

Fuel: Firewood and other biomass.

Distribution and use: Common in areas where UNICEF and affiliated projects have carried out training.

Advantages: Saves time, more than one dish can be cooked at a time.

Limitations: Fixed stove.

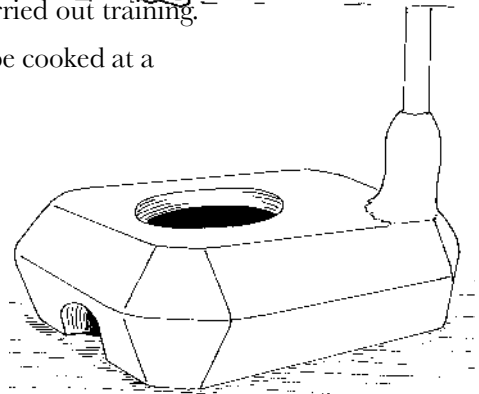
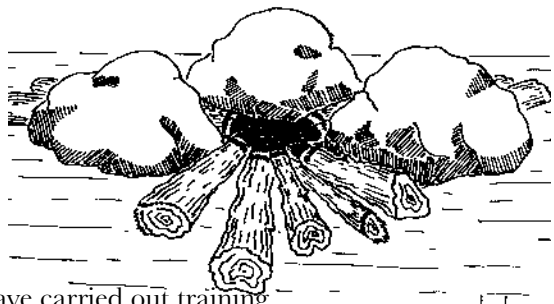
'Y' or Lorena stove (fig. 39)

Fuel: Firewood and other biomass.

Distribution and use: Mainly in central region and areas where YWCA groups are active,



Figure 35 The fireless cooker



used for household cooking.

Advantages: Can cook two dishes at the same time, removes smoke if chimney is included, saves on firewood, built by owner or group using mud mix or bricks.

Limitations: Fixed stove, difficult to light, can use only certain pot sizes, stove cracks require regular repair, chimney needs cleaning.

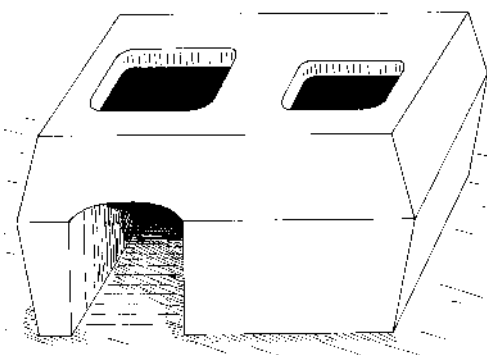
Institutional stove (fig. 40)

Fuel: Firewood and other biomass.

Distribution and use: In institutions throughout the country, used for cooking for 20 or more people.

Advantages: Energy efficient, saves firewood and removes smoke from kitchen, creates employment as stove is commercially built.

Limitations: Fixed stove, cooks only one dish at a time with one pot size for a given stove, costly to operate.



Hearth wood-saving stove (fig. 41)

Fuel: Firewood and other biomass.

Distribution and use: Mainly in rural areas where artisans have been trained to build it, common in Mount Elgon area, construction requires bricks.

Advantages: Saves energy and time, can cook three dishes at the same time.

Limitations: Fixed stove.



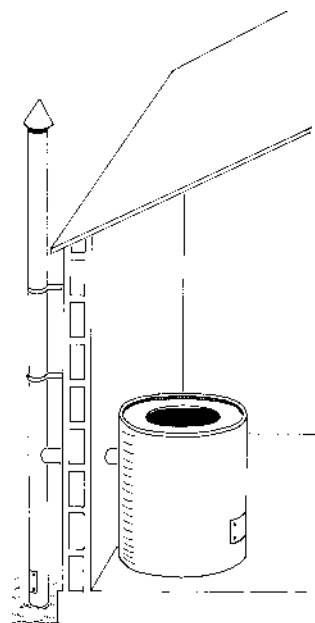
Local wood-saving stove (fig. 42)

Fuel: Firewood and other biomass.

Distribution and use: Mainly in rural areas around Mount Elgon.

Advantages: Saves energy and time, two dishes can be cooked at the same time.

Limitations: Fixed stove.



Charcoal-saving stoves

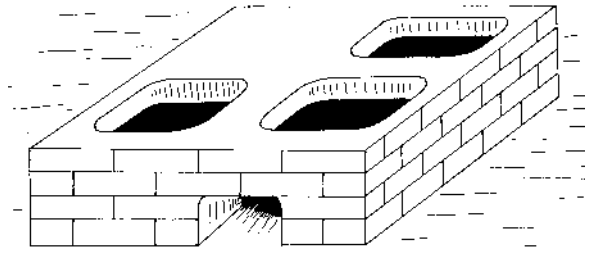
Kabale stove (fig. 43)

Fuel: Charcoal.

Distribution and use: Mainly central and eastern region, used for household and commercial cooking.

Advantages: Saves charcoal, easy to light, portable, cheap, made in different sizes, creates employment for potters.

Limitations: Breaks easily, no door to control air inlet.



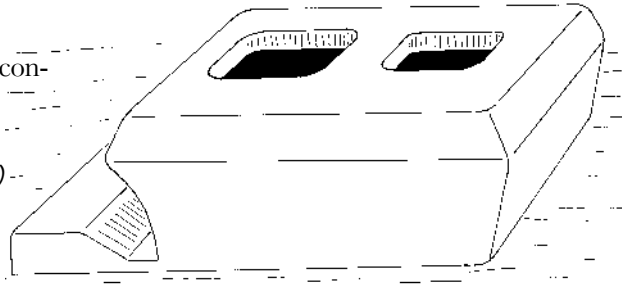
Traditional metal stove (sigiri) (fig. 44)

Fuel: Charcoal, firewood if gate is removed.

Distribution and use: Found in most urban areas, for household and commercial cooking.

Advantages: Cheap, portable, easy to light, various stove sizes made, creates employment for artisans.

Limitations: User risks burns and scalding, inefficient, stove does not last long.



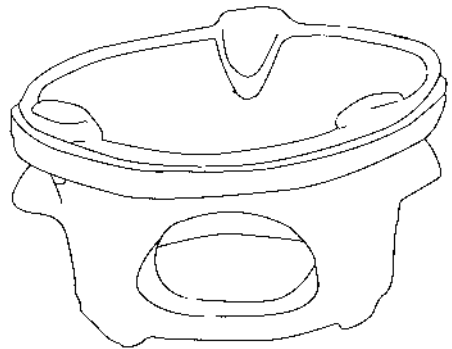
Ugandan ceramic sigiri (fig. 45)

Fuel: Charcoal.

Distribution and use: Mainly central and eastern region, used for household and commercial cooking.

Advantages: Energy efficient, portable, can last a long time, made in different sizes, creates employment for artisans and potters.

Limitations: Fired clay lining breaks easily if poorly handled, difficult to light, good-quality stoves are expensive.

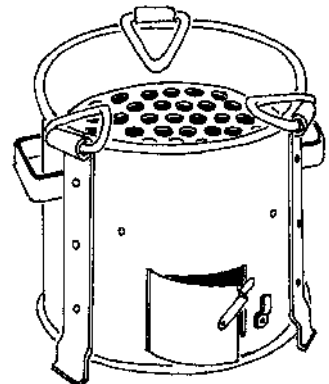


Black-power charcoal stove (fig. 46)

Fuel: Charcoal.

Distribution and use: Mainly central and eastern region, used for household and commercial cooking.

Advantages: Saves charcoal, portable, can last a long time,



different sizes made, creates employment for artisans and potters.

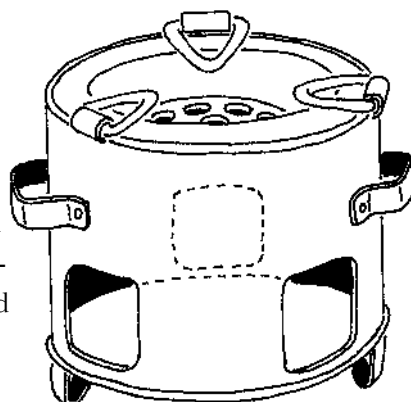
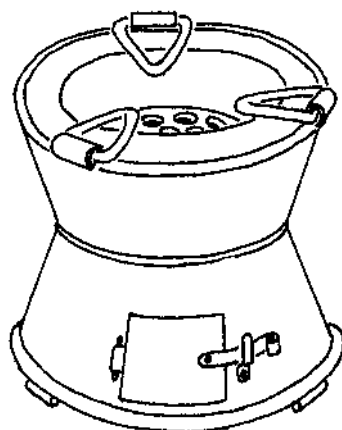
Limitations: Expensive, difficult to light, lining can break if poorly handled, no air control because stove lacks door and has three large air inlets.

11 Use of organic fertilizers

The productivity of agricultural land in the montane areas of Uganda is declining rapidly because the land is cultivated continuously, without rest, to support the large population. This practice depletes soil nutrients unless corrective measures are applied.

To sustain crop yields, farmers need to replace the lost nutrients by growing nitrogen-fixing plants and applying organic or inorganic fertilizers or both, while at the same time minimizing the loss of nutrients.

Some farmers in the highlands of Uganda, such as those in Kapchorwa District, use inorganic fertilizers. This type of fertilizer is expensive, however, and most farmers cannot afford it. For best results their use also requires knowledge and skill. Organic fertilizers (manure) are cheaper and easier to use.



However, when only manures are applied, they may not supply all required nutrients. Phosphorus in particular may have to be added in the form of rock phosphate or by using commercial inorganic fertilizers to achieve high production.

Organic fertilizers include animal dung, compost, liquid and green manures. The organic matter that manure adds to the soil is very important for the soil structure, because it forms soil aggregates, and for the soil's ability to withstand erosive forces. Inorganic fertilizers can never completely substitute for organic fertilizers as they do not contain organic matter. A soil rich in organic matter (humus) is crumbly and therefore easy to cultivate. A soil with crumbly structure is well aerated. Air in the soil is needed for proper growth of crops. A soil rich in humus also retains more water and nutrients than soil depleted of organic matter.

This chapter describes the use and importance of organic manure and gives a few highlights on how trees and shrubs can be used to boost the available amount.

11.1 Animal dung

The use of animal dung for boosting soil fertility is well known and requires little explanation. In zero-grazing systems the bedding material, which includes the dung, must be removed from time to time. This material makes good manure. In the central highlands in Kenya farmers often use litter from grevillea trees to keep the bedding dry. The resulting mix of cow dung and grevillea leaves has been found to be excellent for improving the soil, and this use of the litter from grevillea is recommended. The bedding material may need to decompose further before it is suitable for use on the field. Often it may be allowed to mature in the cattle kraal. See also section 11.3 for details on how animal dung can be used to produce liquid manure.

11.2 Compost

Compost can be made either entirely from vegetative material or as compost manure, which is a mixture of animal refuse and vegetative material such as crop residues that are allowed to rot together. Making compost is beneficial in several ways:

- If properly made, nutrients rapidly become available to plants.
- Good crop yields can be obtained without extra chemical inputs or with only a small amount added.

One of the good features of composting is that it is easy and requires no major investment. Most farmers who have livestock can make and use compost manure. Compost can be used in all soils and is particularly useful in areas where the soils are low in organic matter, such as sandy soils.

Methods for making compost

Making compost is a process of converting vegetative materials such as crop residues, kitchen waste, other organic household waste and hedge cuttings into nutrient-rich, partly decomposed organic material. Composts can be made in piles above ground or in pits below ground. The procedure for preparing the compost is slightly different for each, but the process of decomposition and use of the compost are the same.

The following materials are needed for composting:

- dry plant material
- green vegetative material; the green vegetation should include nitrogen-rich leaves of legumes such as *Calliandra*
- waste from animals and if available from birds
- ordinary topsoil from the garden
- ordinary wood ash
- water and materials for covering
- tools such as hand hoe, panga or machete, and a stick

The recommended mixture for composting is 10 parts dry plant material, 5 parts green plant material and 1 part each of ordinary topsoil and animal waste. The ash that becomes available from a normal family kitchen can be added but it should not exceed a small percentage of the total volume. Other matter that will decompose may also be added but materials that do not decompose, such as plastic, metal and glass, should not be in the compost.

The pit method

The pit method should not be used in wet areas or during wet seasons, as the compost may become waterlogged. However, in a dry area or season, the pit method is preferred because it conserves moisture.

Follow this sequence of activities to build a good compost:

- Select a sheltered, shaded place, such as under a tree. If natural shade is not available, make shade artificially using locally available materials such as grass or banana leaves. The place should be sheltered from wind, rain, sun and runoff.
- A suitable pit may be 1.5 m wide and 0.5 m deep. The pit can be as long as necessary, depending on the amount of available material. Put soil to one side of the trench for later use.
- Loosen the soil on the bottom of the pit to a depth of 30 cm and water it. The compost material needs close contact with the loose soil at the bottom for good results.
- Pile the ingredients into the pit. Make the bottom layer of rough, dry vegetative material such as maize stalks, dry grass, leaves or sunflower heads. Chop or cut

these materials into small pieces and pile them to form a 30-cm layer.

- Make the second layer of green leaves from high-protein leguminous trees or shrubs like *Albizia* spp., *Calliandra calothyrsus*, *Leucaena* spp. or *Sesbania sesban*. Make this layer about 15 cm thick. Where no such leaves are available, use any green leaves.
- Make the third layer of animal or bird waste or old compost material. Make this layer 10 cm thick. It is an important layer, as it contains organisms necessary for decomposition. Sprinkle topsoil to a thickness of 5 cm to cover it.
- Add wood ash and topsoil. The ash contains valuable minerals and neutralizes acidity.
- Water the compost thoroughly at this stage before adding more layers. Then repeat layers in the same sequence.
- Take a long, sharp-pointed stick and drive it into the compost in a slanting position. This stick is a ‘thermometer’ for checking the condition of the compost, as explained below.
- Water the pit slightly. The compost should never be too dry or too wet. Cover it with a layer of topsoil 5 to 10 cm thick. Cover the pit also with dry vegetation to reduce water loss through evaporation.

It is not critical to follow this sequence in precise detail.

The pile method

A compost pile is built up in layers similar to the process used for the pit method. The pile method is recommended during rainy seasons and in wet areas. First remove a layer of about 30 cm of soil on the site where the pile is to be placed, and then build the compost pile layer by layer as in the pit method. Build the compost up to waist level. Sprinkle water on the pile about every 3 days, depending on the weather. If it has been raining watering may not be necessary. Cover the pile with topsoil and leaves to conserve moisture. Drive a stick into the compost at a slanting angle just as in the pit method (fig. 47).

Managing the composting process in a pit or pile

Water the compost occasionally to keep it moist. After 3 or 4 days, pull the stick from the compost pit or pile to check if the material is decomposing. The stick should be warm and smell slightly (fig. 48). Use the stick from time to time to check the condition of the compost. It will indicate if the pit or pile is too dry or too moist. When the stick becomes cool, decomposition has stopped and it is time to turn the compost. If the stick turns white, it is caused by the fungus, fang, which also indicates that decomposition has stopped. Then add water and turn the compost.

After 2 to 3 weeks, turn the compost over. Do not add anything except water. Turning the compost is important because it makes decomposition faster and more complete.

Turn so that the bottom part of the compost becomes the new upper layer. The compost should be ready after 4 to 5 weeks depending on the weather conditions. During dry weather, composting is faster. During rainy seasons with low temperatures, composting takes longer. Ready compost should have a fresh, earthy smell and contain no visible grass, leaves or animal manure. Cover the ready compost with a layer of banana leaves or dry grass to store if it is not needed immediately.

A household should have several compost heaps or pits since household waste should not be added continuously to one heap or pit.

Using compost from the pile or pit

Compost should be placed as close to plant roots as possible. The bigger the amount of compost applied, the better the soil and crops. For perennial crops, apply compost at planting time and during the rains. In tree crops, make a trench at the end of the canopy line and apply the compost. Cover with topsoil. The earlier the compost is applied, the better the crop grows. In general, well-decomposed compost should be applied at the rate of 20 t/ha (8 t/acre). This amount will cover the ground thinly with a 1-cm layer.

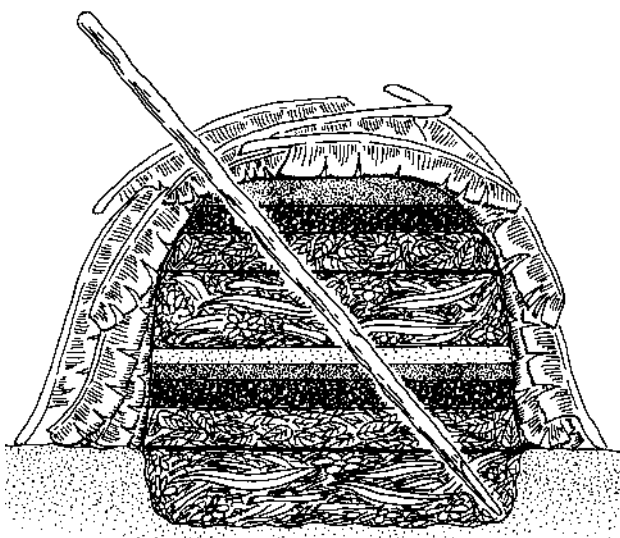


Figure 47 Cross-section of a compost pile, with a stick pushed through to check on the process of decomposition.



Figure 48 Checking the decomposition process in a pit compost. If the stick is warm, the composting process is ongoing.

Limitations

Some pests, such as weevils ('eshinya' in Rukiga) are usually prevalent where manure is applied, and they may damage crops. Other drawbacks in using compost is that it is bulky and heavy to carry to fields far way, and during the dry season, enough material may not be available for composting.

Mrs Beatrice Ngabirano makes and uses compost manure

Mrs Ngabirano lives in Kashaki Village, Nyamiyaga Parish in Kabale District. Her household comprises her husband, Ambrose Ngabirano, three daughters and two male dependants. The couple makes joint decisions about activities on their farm. The family homestead is on 1 acre of land. They own scattered pieces of land totalling 3.5 acres within Kashaki Village. They grow bean, cabbage, cauliflower, eggplant ('entonga', 'biringanya'), green pepper, irish potato, maize, onion, spinach, 'sukuma wiki', sweet potato, tomato and other vegetables,. They also rear 2 dairy animals, 7 pigs and several rabbits.

Beatrice Ngabirano, who is the chairperson of the Bukombe Women's Group, learned about composting from the Uganda Food Security Initiatives Project implemented in Kabale by Africare. The project organized a 2-day seminar on sustainable agriculture and food security in 1998 for members of the group.

Beatrice digs four pits for the different stages of composting. She makes them 1.8 m deep and 1.2 m wide. They are dug in an area near the vegetable garden so that she does not have to carry the manure far. In the first pit, she throws all domestic and kitchen waste, animal dung, rabbit and pig droppings, crop residue from bean, maize and sorghum, ash from the kitchen, remains of fodder and bedding from the dairy unit. When the first pit is full, the contents are transferred to a second pit, which is later covered with dry or green grass to retain nutrients. During the dry season, this pit is watered two or more times a week.

The materials decompose for 2 weeks in pit 2 with continued watering if necessary. The duration depends on the contents in the pit. She finds that finely chopped materials decompose most easily.

If the compost is ready at a time when it is not needed Beatrice stores it in pits 3 and 4. These pits are covered with dry or green grass to keep the compost intact.

The application rate depends on the type of crops grown. She applies two wheelbarrow loads of compost on a plot 5 by 10 m planted with cabbage and three on bean in the same size plot.

When planting cabbage, she digs a hole and mixes the topsoil with the compost before planting. She plants beans in shallow furrows in a row, applying the compost along the furrows and then mixing it into the topsoil before sowing. She also uses the compost when growing eggplant, maize, potato, onion, sorghum, spinach, tomato and tree tomato ('ekitunda kya rushagama').

Beatrice's costs for growing cabbage on a 5 by 10 m plot:

Cultivation, preparation and planting	UGS 2,000
Weeding twice @ UGS 500 per time	UGS 1,000
Ambush insect spray	UGS 2,000

On average, Beatrice harvests 162 cabbages, which she sells at UGS 150 to 200 each. Thus, she

makes a total of around UGS 28,000 a season. Overall, with the cost of labour and other inputs deducted, she earns more than UGS 20,000 a season from selling her cabbages.

Digging the four pits takes a full day, with four adults working. This labour costs her UGS 6,000. The cost for digging the compost pits is, however, a one-time investment since the pits can be used continuously. The compost produced from the pits is enough for other plots too, so the cost of the compost is small in relation to the cultivation of vegetables.

Basket compost

Where the piece of land to be planted to a crop is small, such as a kitchen garden or in situations where organic manure is not available in large quantities, the basket method can be used to make compost (fig. 49). The following materials are needed:

- banana fibres, long strips 15 cm wide
- 5 to 9 sticks at least 60 cm long
- kitchen garbage, farm and garden waste, and plant material of leguminous crops

Follow these steps for good results:

- Prepare the garden. Keep leaves and vegetative materials of leguminous plants for use during composting. These materials are important as they contain high levels of useful nitrogen.
- Dig holes along the centre of the planting beds. The holes should be at least 12 cm deep with a diameter of 0.5 m, spaced 1 m apart.
- Drive 5 to 9 sticks into the ground at the periphery of each hole. An uneven number of sticks is good for weaving the basket.



Figure 49 A basket compost for high-intensity vegetable production.

- Use the long strips of banana fibre to weave around the sticks to make a basket. If banana fibres are not available, use a larger number of sticks at closer spacing without weaving.
- Place rotten garbage and animal manure in the basket first.
- Add fresh material like bean pods or other vegetative material, preferably of leguminous plants.
- Fill to the brim with other organic waste, include some ash, and water the material.
- Plant seedlings around the basket, but at a distance of 15 to 20 cm from it to prevent the organic matter concentrated in the basket from scorching the seedlings.
- Water the basket and the seedlings while the seedlings are young. As they grow older, water only the basket. The plant roots will grow towards the source of moisture, and the basket will then serve as a reservoir of moisture and nutrients for the plants.
- After harvesting and when the compost is exhausted, remove the decomposed material and incorporate it into the soil during cultivation.
- Repair the basket if needed, and fill it with new composting material to start the process again.

11.3 Liquid manure

Liquid manure is an organic fertilizer applied to plants in their early growing stages. It is made from animal dung or fresh leaves of leguminous trees and shrubs. The process described here is adapted from *Sustainable agriculture practices and technologies: guidelines for farmers*, by Africa 2000 Network, UNDP and RSCU/Sida (1997).

Liquid manure is a cheap source of nutrients for plants that is easy to prepare and use. It is used to topdress crops already established and increases yields, especially of cabbage, eggplant and tomato. It should be applied near the plants but not on them.

Liquid manure from animal dung

Liquid manure can be produced easily on a farm from animal dung using a drum (fig. 50). Required materials and equipment are

- chicken, rabbit, goat, pig or cow dung free of sawdust and stones
- a drum or any similar size of container
- a strong pole and rope
- a strong gunny bag ('gunia')

The following procedure will give good results:

- Fill the gunny bag half full with animal dung.
- Tie the open end of the bag with a strong rope.
- Suspend the bag of dung in a drum full of water. Immerse the bag fully in the water but do not let it touch the bottom of the drum.

- Cover the drum to prevent water loss.
- Leave the material suspended in water for 2 weeks, but every 3 days stir by lifting the bag several times using the cross pole.
- In 2 weeks, the water will have turned dark, and most of the nutrients contained in the dung will have been dissolved in the water. Remove the bag and squeeze as much liquid from it as possible into the drum.
- Dilute the contents of the drum in a 1:2 ratio—to 1 part liquid manure, add 2 parts clean water.
- Apply around the growing plants.

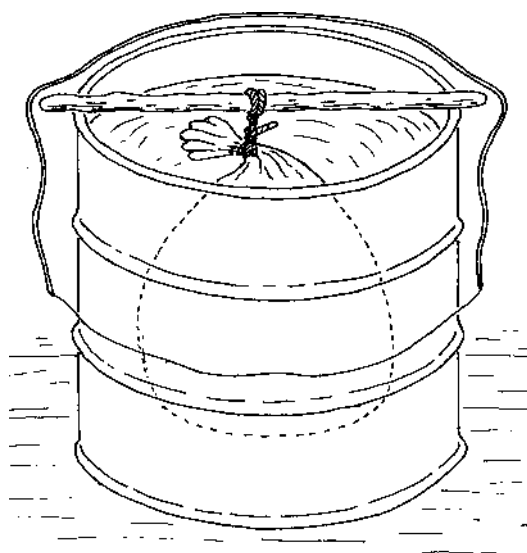


Figure 50 A drum used for producing liquid.

Liquid manure from plant material

The steps for producing liquid manure from fresh plant material are similar to those for producing liquid manure from animal dung. Liquid manure can be prepared from the leaves of leguminous trees or shrubs such as *Albizia* spp., *Leucaena diversifolia* and *Sesbania sesban*, and also from the leaves of leguminous forage crops.

Liquid manure from urine

Liquid manure from urine can be produced if there is a zero-grazing unit on the farm. Collect the urine in a pit as illustrated in figure 51. Urine may also be collected in a container—a method often preferred since it minimizes loss. This is especially important if the soil in the pit is permeable. After collecting the urine from the pit or container, mix 1 part of urine with 2 parts of water before applying the mix to crops.

Once a week, use a watering can to sprinkle the liquid manure around the stem. Do not apply on the leaves of crops.

11.4 Green manure

Deep-rooted green manure crops break the hard, compacted soil, improve the soil structure and increase water retention capacity. If nitrogen-fixing species are grown, nitrogen

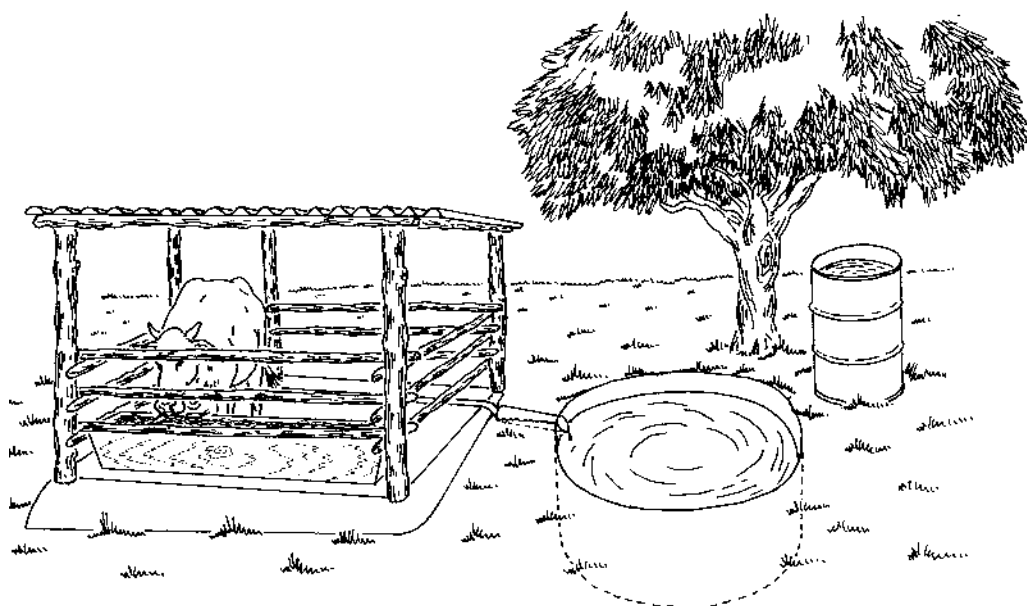


Figure 51 A zero-grazing unit designed to collect urine for producing liquid manure.

is fixed into the soil. The crop yields would be expected to increase in the following season or seasons. See section 5.3 for more information on green manure.

Bibliography

Africa 2000 Network, UNDP and RSCU/Sida. 1997. *Sustainable agriculture practices and technologies: guidelines for farmers*. Nairobi: Regional Soil Conservation Unit (RSCU) and UNDP.

Elwell, H., and Maas, A. 1995. *Natural pest and disease control*. Harare, Zimbabwe: Natural

Farming Network.

- Evans, D.O., and Macklin, B., eds. 1990. *Perennial sesbania production and use: a manual of practical information for extension agents and development workers*. Paia, Hawaii, USA: Nitrogen Fixing Tree Association.
- Fahlström, K. 1991. *Trees in cropland*. Nairobi: Conservation Branch, Kenya Ministry of Agriculture, Soil and Water.
- Gachanja, S.P., and Ilg, P. 1990. *Fruit tree nurseries*. Nairobi: Conservation Branch, Kenya Ministry of Agriculture, Soil and Water.
- Holding, C., and Omondi, W., eds. *Evolution of provision of tree seed in extension programmes: case studies from Kenya and Uganda*. Nairobi: RELMA.
- International Centre for Research in Agroforestry. 1992. *A selection of useful trees and shrubs for Kenya: notes on their identification, propagation, management and use by agricultural and pastoral communities*. Nairobi: ICRAF.
- International Centre for Research in Agroforestry. 1996. *Annual report 1995*. Nairobi: ICRAF.
- International Institute of Rural Reconstruction. 1998. *Sustainable agriculture extension manual for eastern and southern Africa*. Nairobi: IIRR Africa Regional Office.
- International Labour Office. 1989. *Tree nurseries: an illustrated technical guide and training manual*. Booklet No. 6, Geneva: UNDP/ILO Special Public Works Programmes.
- Katende, A.B., Birnie, A., and Tengnäs, B. 1995. *Useful trees and shrubs for Uganda*. RSCU Technical Handbook No. 10. Nairobi: RSCU.
- Kenya Forestry Research Institute, 1990. *Guide to tree planting in Kenya*. Nairobi: KEFRI.
- Kenya. Ministry of Agriculture. 1991. *Home nurseries*. Nairobi: Soil and Water Conservation Branch.
- Kimwe, S.K. 1994. *Utilisation of agroforestry trees: experiences of the Kenya Woodfuel Development Programme*. Nairobi: Kenya Woodfuel and Agroforestry Programme and ETC Kenya Consultants B.V.
- Kimwe, S.K., and Noordin, Q. 1994. *Management and use of agroforestry trees: agroforestry field manual*. Nairobi: Kenya Woodfuel and Agroforestry Programme and ETC Kenya Consultants B.V.
- Mwangi, M., Ekise, I., Eanjohi, H., Noordin, Q., and Wacira, A. 1994. *Seed procurement and distribution*. Nairobi: Kenya Woodfuel and Agroforestry Programme and ETC Kenya Consultants B.V.
- Nair, R.P.K. 1993. *Introduction to agroforestry*. Doordrecht, The Netherlands: Kluwer Academic Publishers in cooperation with the International Centre for Research in Agroforestry.
- Nielsen, F. 1998. Issues in the utilisation of indigenous knowledge in agroforestry research. M.Sc. thesis. Faculty of Natural Resources, University of Copenhagen.
- Nielsen, F., Guinand, Y., and Okorio, J. 1995. *Farmers' participatory diagnostic research: lakeshore*

- banana-coffee land-use system of Uganda*. Nairobi: International Centre for Research in Agroforestry.
- Oduol, P.A., and Aluma, J.R.V. 1990. The banana (*Musa* spp.)-coffee robusta traditional agroforestry system of Uganda. *Agroforestry Systems* 11(3):213–226.
- Oluka-Akileng, I., Esegu, J.F., Kaudia, A., and Lwakuba, A. 2000. *Agroforestry handbook for the banana-coffee zone of Uganda: farmers' practices and experiences*. Technical Handbook No. 21. Nairobi: RELMA.
- Oswald, A., Frost, H., Ransom, J.K., Sheperd, K., and Sauerborn, J. 1996. Studies on the potential for improved fallow using trees and shrubs to reduce striga infestation in Kenya. In: *Proceedings of the Sixth Parasitic Weed Symposium, Cordoba, Spain*.
- Pawlick, T. 1989 Markhamia: a very practical ornamental. *Agroforestry Today* 1(3:10–11).
- Rao, M.R., Nair, P.K.R., and Ong, C.K. 1998. Biophysical interactions in tropical agroforestry systems. *Agroforestry Systems* 38:3–50.
- Rocheleau, D., Weber, F., and Field-Juma, A. 1988. *Agroforestry in dryland Africa*. ICRAF, Nairobi.
- Simute, S., Phiri, C.L., and Tengnäs, B. 1998. *Agroforestry extension manual for eastern Zambia*. RELMA Technical Handbook No. 17. Nairobi: RELMA.
- Tengnäs, B. 1994. *Agroforestry extension manual for Kenya*. Nairobi: ICRAF.

Appendix 2: Contributors

Farmers

Mr Henry Bukose, Kapchemuro Village, Tegeres Parish, Kaptanya, Kapchorwa
 Mr Augustine Chemonges, Kapchorwa

Appendix 1: Important tree species in the montane zone and their local names

Botanical name	English	Kupsabin (Sebei)	Luo	Lugishu	Rukiga	Rukonjo	Rutoro
Acacia abyssinica	flat-top acacia, umbrella thorn				munyinya		
Acacia mearnsii	black wattle	bulikoti					
Acacia sieberiana			lachari				muninya, munyinya
Acacia tortilis	umbrella thorn						
Acanthus pubescens					ekitojo		
Acokanthera schimperi	poison-arrow tree	kelyo					
Acrocarpus fraxinifolius	Indian ash, shingle tree						
Albizia adianthifolia				komosovi, chiruku, kirongo, kisubi	mushebera,	muschero	
Albizia grandibracteata	large-leaved albizia		awok		mushebebe		mulongo, nongo
Albizia gummifera	peacock flower	swessut		chiruku, kirongo, kisubi	mushebebe		mulongo
Allophylus abyssinicus		bionwa		gulindi, kirindi			
Alnus acuminata	alder						
Artocarpus heterophyllus	jackfruit						
Bersama abyssinica		sigirwo			mukaka		muhungura
Bridelia micrantha		margalgalyet		kumuholong, shigakara	muyimbo, mubabantomi		mubalagaza
Caesalpinia decapetala	Mauritius thorn						
Calliandra calothyrsus	calliandra						

Botanical name	English	Kupsabin (Sebei)	Luo	Lugishu	Rukiga	Rukonjo	Rutoro
<i>Carapa procera</i>	crab nut, Uganda crabwood				muruguya		muhungulia, mujogo
<i>Carica candamarcensis</i>	mountain papaya	papari					
<i>Carissa edulis</i>			achuga		muyonza,	munombi	
<i>Casuarina cunninghamiana</i>	casuarina						
<i>Catha edulis</i>	khat	tume-yondet		kitandwe, lutandwe	munyaga, ngongo		muhambulya
<i>Chrysophyllum gorungosanum</i>							
<i>Combretum collinum</i>		uskinwo	okechu, odugu				
<i>Combretum molle</i>	velvet-leaved combretum	kembe	okechu, oduk	shikimira murama	murama		
<i>Cordia africana</i>	large-leaved cordia	mugengere		chichikiri, chikichikiri	mjugangoma	mutumba	mutumba
<i>Croton macrostachyus</i>	broad-leaved croton	toboswa	ekwanga, ekwango	guyi, gwihihi, lwihihi	murangari		muhoti
<i>Croton megalocarpus</i>	croton				mutakura, muyuni		munyabakuru, mwenya-bakikuru
<i>Croton sylvaticus</i>	forest croton		chetwingo		mwatansale, omwatanshare		
<i>Cupressus lusitanica</i>	cypress						
<i>Cyphomandra betacea</i>	tree tomato				ekitunda kyarushagama, obutunda bw'abariisa, omunywamiizi		nyanya-ezomuti
<i>Diospyros abyssinica</i>	giant diospyros	cheptua			muhoko, nsenene		muhoko

Botanical name	English	Kupsabin (Sebei)	Luo	Lugishu	Rukiga	Rukonjo	Rutoro
<i>Dodonaea angustifolia</i>	sand olive	tombolokwa			musambya		
<i>Dovyalis caffra</i>	kei apple	yekinek					
<i>Ekebergia capensis</i>	Cape ash, dog plum	bumet		musalamumali	mufumba		
<i>Entandophragma excelsum</i>					mushalya, muyove	kikula	muyovu, muhungura
<i>Erythrina abyssinica</i>	red-hot-poker tree, Uganda coral	kaborte	lochoro, kisoro, oding, loting	cheroguru, muragolo	bwiko	muko, kiko	
<i>Eucalyptus grandis</i>	flooded gum, rose gum	eritusi, kalitunsi					
<i>Euphorbia tirucalli</i>	finger euphorbia		kilajok		nkoni		nkoni
<i>Ficathoa laurifolia</i>					mumaga, muvumaga		

Botanical name	English	Kupsabin (Sebei)	Luo	Lugishu	Rukiga	Rukonjo	Rutoro
<i>Ficus natalensis</i>	bark-cloth fig						
<i>Flacourtia indica</i>	Indian plum	tungururu		singulurwe			
<i>Gliricidia sepium</i>	mother of cocoa, Mexican lilac, quick stick						
<i>Grevillea robusta</i>	grevillea, silky oak						
<i>Hagenia abyssinica</i>	hagenia	sigurwa	leo	kisitchetwa, museregego, nafuru	omujesi		
<i>Halea rubrostipulosa</i>					muziko		muzingu, mutoro, mutororo
<i>Harungana madagascariensis</i>					mungolero, munlianga, muliamanga		murinda, musoga
<i>Ilex mitis</i>	African holly	segar, sigara		mwandanda	munyambasi	bwiso	
<i>Jacaranda mimosifolia</i>	jacaranda						
<i>Juniperus procera</i>	African pencil cedar	torokio		ntorokya			
<i>Kigelia africana</i>	sausage tree		yago	lukulungu, chifungu			mwikya
<i>Leucaena diversifolia</i>	leucaena						
<i>Macaranga kilimandscharica</i>		kaptebema		mudwess, kiaranwe, luwessu	murara, muburashasha, mushasha	muhunga	muhoti
<i>Maesa lanceolata</i>		gogorwo		naporo, nabutusa, kisangulia, kisiangulu	muhanga		muhanga-bagenzi
<i>Maesopsis eminii</i>	maesopsis, musizi				muguruka		
<i>Markhamia lutea</i>	markhamia	swayet		lusola	musavu		

Botanical name	English	Kupsabin (Sebei)	Luo	Lugishu	Rukiga	Rukonjo	Rutoro
<i>Melia azedarach</i>	Persian lilac						
<i>Morus</i> spp.	mulberry						
<i>Myrianthus holstii</i>	giant yellow mulberry				echuvu, mufe		mwebende
<i>Myrica salicifolia</i>		segatetit		maruss, kiberassia	mujeje, ekijeje	mukikembo, mundrindi	
<i>Neoboutonia macrocalyx</i>		chebakwa		dowa, kidowadowa, mudowa	chanya, muranga, mwanya	kiona	
<i>Newtonia buchananii</i>	newtonia				mukungu		muchenche
<i>Nuxia congesta</i>		chorowa			mumuli		
<i>Ocotea usambarensis</i>	East African camphorwood				mwiha		
<i>Olea capensis</i> subsp. <i>welwitschii</i>	Elgon olive	masgat, pekeriaondet		gibengeyi	mugando		musoko, musodo
<i>Olea europaea</i> subsp. <i>africana</i>	brown olive, wild olive	yemit					
<i>Olinia rochetiana</i>		narekio			mubaba		
<i>Peddiea fischeri</i>					mushinya		
<i>Persea americana</i>	avocado pear	bizuma					
<i>Phoenix reclinata</i>	wild date palm		otit				mukindu
<i>Piliostigma thonningii</i>	camel's-foot-leaf tree	chumutwet, sakiandet	ogali				
<i>Pinus patula</i>	Mexican weeping pine						
<i>Pittosporum spathulacalyx</i>					mushekera, musimbura		

Botanical name	English	Kupsabin (Sebei)	Luo	Lugishu	Rukiga	Rukonjo	Rutoro
<i>Podocarpus latifolius</i>	podo, East African yellow-wood	sitetet	akikache	musagali, gumuhalamwa	omuhulire	obwipe	
<i>Polyscias fulva</i>	parasol tree	lamadi		gafuti, gufuti, gufuri	mungu, murungi, webina	kyango, kyongo, mukungu	mujuganlara
<i>Pouteria adolfi-friedericii</i>		lulyo		mwiruni		sosi	
<i>Prunus africana</i>	red stinkwood			chiramati, charamandi	musuba		
<i>Psidium guajava</i>	guava						
<i>Punica granatum</i>	pomegranate						
<i>Rapanea melanophloeos</i>		sitoto				muongo-nyonye	musonga-nyonye
<i>Ricinus communis</i>	castor oil plant						
<i>Sambucus</i> sp.	red-berried elder						
<i>Sapium ellipticum</i>		mujustet		musasia	mushasha		musasa,
<i>Schefflera volkensii</i>		kwelet, kwalet		mubondwe, chichipeno			musanvuma
<i>Schinus molle</i>	pepper tree						
<i>Schrebera alata</i>		gagawa					
<i>Senna didymobotrya</i>	candle bush, peanut-butter cassia	senetwa		mubenobeno, kebenobeno	omugabagaba		
<i>Senna siamea</i>	blackwood cassia, ironwood						
<i>Senna spectabilis</i>	cassia						
<i>Sesbania bispinosa</i>	sesbania						
<i>Sesbania sesban</i>	river bean, sesbania				munyuganyege		
<i>Spathodea campanulata</i>	Nandi flame	chemungwa	lepengwata		ekifurafura		murogorogoro

Botanical name	English	Kupsabin (Sebei)	Luo	Lugishu	Rukiga	Rukonjo	Rutoro
<i>Symphonia globulifera</i>					musisi	mumimba	munyawankwai, munyenye, nkwasii, mukarangeye
<i>Syzygium cordatum</i>	waterberry tree	lemalyua, reberwo	kano	chiemo, sizanzass, wandiviri	mufumba, mugote, mukondo		
<i>Syzygium guineense</i>	waterberry	lemalyua, reberwo	kano	chiemo, sizanzass, wandiviri	mufumba, mugote		
<i>Tabernaemontana pachysiphon</i>					ekinyamagosi		mwongogwenkende
<i>Teclea nobilis</i>	teclea	gurio	achacha, opodeko, atachogat	lutati	muzo		muzo
<i>Thevetia peruviana</i>	lucky nut, yellow oleander						
<i>Tipuana tipu</i>	pride of Bolivia, tipu tree						
<i>Toona ciliata</i>	toon tree						
<i>Trema orientalis</i>			opobobunga		mubengabakwe, mugwampira	muhera	mutete, kasisa, mwitha
<i>Vangueria apiculata</i>			adengoye			kasogo	
<i>Vangueria madagascariensis</i>				shikomosi			
<i>Vernonia amygdalina</i>			labori	muuluza, chichilusa, luluza			
<i>Vitex doniana</i>	black plum	bulgelwa	oyelo				
<i>Warburgia ugandensis</i>	East African greenwood						muhamami
<i>Zanthoxylum gillettii</i>	East African satinwood	sagawat		shukuma	omushaga	nyakabonde	mutatembwa

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Agroforestry technologies



Markhamia lutea is a popular tree that is grown scattered in farmland in valleys of the montane zone.



Recently introduced in the montane area, *Alnus acuminata*, here intercropped with maize, does well.



Grevillea here is pollarded high enough to allow for production of valuable timber.



Pruned and straight-boled *Grevillea* trees planted along the contour help make the terrace permanent while also producing valuable timber.



Newly pollarded young grevillea trees grown on the contour.



The cultivation of climbing beans has gained considerable popularity in south-western Uganda. Calliandra makes a good live stake.



Passion fruit supported by sesbania live stakes. The purple varieties do well up to about 2,000 m.



Calliandra is not only beautiful. More importantly, it produces good firewood and the leaves are fodder for livestock.



A small kitchen garden for onion established in a gunny bag.

Soil management



Fertility gradient on a outward sloping terrace with finger millet. The crop is poor on the upper part due to nutrient loss.



Severe rill erosion.



Serious erosion on steep slopes.



Conservation measures are insufficient as there is sedimentation at the valley bottom.



Too much sediment accumulation has completely spoilt this vegetable cultivation.



Severe runoff with heavy sediment load.



A combination of calliandra and grevillea planted on the contour provides an effective barrier. Note the accumulation of soil that leads to terrace formation.



Guatemala grass planted as a barrier along the contour.

Tree propagation



A calliandra seed bed of an on-farm nursery.



A small on-farm nursery.



Kifu nursery.



The grafting shed at Kifu nursery.



Raising rootstock on a large scale in a nursery at Kabale.



Sprouting scions and shooting rootstock.



Flowering peach grafts.

(below) Air layering guava results in new plants with fruits that are true to type.





Sprouting fig cutting.



Sprouting grape cutting.



A young avocado suffering from being planted too deep.

Facilitators' manual for communication skills workshops

Pamela Baxter. 1996. TH No. 13. ISBN 9966-896-25-2

Useful trees and shrubs in Eritrea: identification, propagation and management for agricultural and pastoral communities

Estifanos Bein, B. Habte, A. Jaber, Ann Birnie and Bo Tengnäs. 1996. TH No. 12. ISBN 9966-896-24-4

Agroforestry extension manual for northern Zambia

Henry Chilufya and Bo Tengnäs. 1996. TH No. 11. ISBN 9966-896-23-6

Useful trees and shrubs for Uganda: identification, propagation and management for agricultural and pastoral communities

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Agroforestry manual for extension workers in Southern Province, Zambia

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Useful trees and shrubs for Ethiopia: identification, propagation and management for agricultural and pastoral communities

Azene Bekele-Tessema, Ann Birnie and Bo Tengnäs. 1993. TH No. 5. ISBN 9966-896-15-5

Guidelines on agroforestry extension planning in Kenya

Bo Tengnäs. 1993. TH No. 3. ISBN 9966-896-11-2

Agroforestry manual for extension workers with emphasis on small-scale farmers in Eastern Province, Zambia

Samuel Simute. 1992. TH No. 2. ISBN 9966-896-07-4

Curriculum for in-service training in agroforestry and related subjects in Kenya

Stachys N. Muturi (ed.). 1992. TH No. 1. ISBN 9966-896-03-1

The Swedish International Development Cooperation Agency (Sida) has supported rural development programmes in eastern Africa since the 1960s. Through its Regional Land Management Unit (RELMA), Sida promotes initiatives to increase agricultural production in order to enhance food security and reduce poverty.

RELMA, the successor of the Regional Soil Conservation Unit (RSCU), is based in Nairobi and operates mainly in six eastern and southern African countries: Eritrea, Ethiopia, Kenya, Tanzania, Uganda and Zambia. RELMA's goal in the region is to improve livelihoods of small-scale land users and enhance food security for all households. In pursuit of this goal, RELMA promotes environmentally sustainable, socially and economically viable farming and marketing systems, and supports policies that favour small-scale land users.

RELMA organizes, on a regional level, training courses, workshops and study tours. It also gives technical advice, facilitates exchange of expertise and produces information materials for the dissemination of new knowledge, techniques and approaches. A variety of reports, handbooks, posters and other information materials are published and distributed in the region on a non-profit basis.

About this book

Trees and shrubs provide direct products such as poles, woodfuel and fruit as well as services in farming systems, for example augmentation of soil fertility and reduction of soil erosion. Agroforestry, the combination of trees and crops in farming or pastoral areas, is a land-use system that has the potential to increase the total output from a given piece of land. But to realize that potential, trees and crops have to be combined in a wise way and the trees may have to be managed to reduce shade and other competition with the crops.

The woodfuel consumption in Africa amounts already to around 500 million tonnes annually, and it is the only continent where the use is rising sharply. Soil fertility is on the decline in many areas, and low productivity of farmland is one of the main forces driving deforestation in Africa. With low productivity large areas have to be cultivated and the additional areas are often secured by the clearing of forests or woodlands.

No doubt is there need for more trees in many parts of Africa, and Uganda is no exception. This book provides ideas on how best trees can be incorporated in the farming systems of montane zones of Uganda. It also offers ideas on measures aimed at enhanced soil fertility and reduced consumption of woodfuel.

Although the book is primarily targeting the montane areas of Uganda, practices and technologies described are also applicable to other areas with similar farming systems, for example in parts of the Kenyan highlands, the highlands with bimodal rainfall in northern Tanzania and humid areas in western Ethiopia.

ISBN 9966-896-55-4



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