TECHNICAL HANDBOOK No. 21

AGROFORESTRY HANDBOOK FOR THE BANANA-COFFEE ZONE OF UGANDA

Farmers' Practices and Experiences

I. Oluka-Akileng
J. Francis Esegu
with Alice A. Kaudia
and Alex Lwakuba

RELMA

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Middle: George Walusimbi in his Mukono farm consisting of coffee, bananas and vanilla interplanted together
Bottom: Trees in earthwork structures for soil and water conservation
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Table of Contents

Preface

This handbook arose out of a request from the forest department staff in Uganda to assist in the production of agroforestry extension materials. The first planning meeting was held on 5th June 1998, with representatives from the Forestry Department, Uganda; Forest Research Institute (FORI); CARE International; Ministry of Agriculture, Animal Industries and Fisheries (MAAIF), ICRAF and RELMA. At this first meeting the target group/recipients of the materials; languages; prioritization of agro-ecological zones of Uganda for which the materials would be developed; key agroforestry technologies in those zones; format of publication and projected contents was discussed.

The banana—coffee zone is a terminology describing one of Ugandas six agro-ecological zones. Though banana and coffee are the principle staple and cash crops in the zone, the zone is characterized by a diverse and complex farming system. This text focuses on the integrated role and nature of agroforestry in this complex system. This text does not address banana or coffee production which are extensively covered in other specialist publications.

The banana-coffee zone is situated in southern central Uganda, stretching from Bushenyi in the west, to Tororo in the east. The other agro-ecological zones of Uganda are the: montane system; cattle corridor; cereals based systems and pure pastoral system (map p. 3).

Two RELMA fellowships were allocated for the initial fieldwork to collect information on the technologies in the banana-coffee zone. These were completed by the end of 1998 and the first drafts circulated. Additional field work was commissioned thereafter to develop cases study materials of farmers' experiences and practices in implementing agroforestry in the banana-coffee zone. The final version of the handbook was thoroughly reviewed at a stakeholders workshop held in Masaka, Uganda in October 1999. Farmers, government and NGO extension workers, researchers, authors, and artists were present. The inputs from the workshop significantly improved the quality and scope of this final text and the inputs of all the participants of the Masaka workshop are appreciated. The authors of the handbook are:

I. Oluka-Akileng	Acting Deputy Commissioner, Forest Department, Uganda;
J. Esegu	Director of Forest Research Institute (FORI), Uganda;
Alice A. Kaudia	Assistant Director, Service Programme, Kenya Forestry Research Institute (KEFRI); and

Alex Lwakuba — Senior Agricultural Officer/Agroforestry & Soil Fertility Officer, Soil and Water Conservation Section, MAAIF, Entebbe, Uganda.

The principle beneficiaries of this text are designed to be frontline extension workers and farmers. In accordance with this objective, local names of tree species are the preferred entry point for technology descriptions. Scientific names are also provided in the text. For easy reference however, a glossary at the end of the book provides a full list of local scientific names. In a recent review of the utilization of RELMA sponsored extension materials in Uganda, it was demonstrated that farmers and extension workers preferred materials produced in local languages. Though extension workers would be satisfied with versions in English they still requested copies in vernacular to assist them in their training sessions with farmers. Copies of this text are therefore to be produced in English and Luganda, the predominant language in the banana-coffee zone.

RELMA and the authors sincerely hope that this handbook will facilitate the enhancement of the contribution of agroforestry to sustainable rural livelihoods in central Uganda. The authors and RELMA would welcome any feedback from persons or organisations who use this handbook, as such feedback contributes to the continual upgrading and improvement of extension publications produced by RELMA and its partners.

Ake Barklund
January 2000
Director, RELMA

Foreword

Introductory Remarks to the Workshop for Pre-Testing the Agroforestry Extension Manual for Farmers in the Banana-Coffee Zone of Uganda

In 1993 the Rio Conference brought public awareness about critical global environment issues. In 1994 the Cairo Conference brought the high population growth problem to public attention. Less publicised, but very critical to the future of humankind, is the need to greatly improve agricultural productivity. These three interlocked issues—environmental degradation, the high rate of population increase particularly in developing countries, and the need to enhance agricultural productivity—constitute the triple global challenge for the 21st Century. The core of this challenge is: How is the world going to feed the high population without inflicting damage on the environment that is already under great stress?

Agroforestry as a land-use system is known to contribute to both increased productivity and environmental sustainability particularly for the small-scale farmers in the banana-coffee farming system in Uganda. This workshop involving farmers to pre-test and evaluate the Agroforestry Extension manual for farmers in the banana-coffee zone, is timely, relevant, appropriate, and practical. It is timely because it relates to similar activities within the National Agricultural Research Organisation (NARO) and all the Institutes under NARO. It is relevant because it calls for mobilising the full range of both technology generation and technology transfer endeavours to address the needs of the households at the local levels. It is appropriate because it contributes to poverty eradication which is topmost priority for the government of Uganda. And it is practical because it is participatory and calls for the most effective collaboration among all stakeholders -technology users (farmers), technology generators (researchers) and technology transfers (extensionists) to produce a suitable manual on agroforestry for use by the farmers in the banana-coffee zone of Uganda.

J. F. O. Esegu,
Director, Forestry Research Institute (FORI)
Masaka, 12th October, 1999

1 Introduction

Agriculture supports livelihoods of most people in Uganda, especially the rural-based farmers. It is the policy of the government to improve production through modernisation of agriculture. To achieve this, the government has adopted a number of strategies which include:

- Promoting specialisation in production,
- Modernisation of rural economy,
- Promoting improved agricultural technologies,
- Promoting profit-driven investment activities (commercialisation),
- Promoting diversification of land use such as through adoption of agroforestry,
- Control of land fragmentation, and
- Promoting the growing of high value crops.

Agroforestry has been practised by farmers in Uganda for many generations. It has been part and parcel of their traditional production systems. However, agroforestry research started in the country around the mid 1980s. Since then, some of the technologies generated have been promoted and passed on to farmers for adoption. Effective promotion and dissemination of agroforestry has been limited by several factors notably inadequate number of extension staff, lack of suitable extension materials and limited support resources and facilities.

Development agencies concerned with promotion of agroforestry and related farming practices have recognised the gap in availability of suitable extension materials. Though various programmes have produced subject specific materials, a comprehensive manual on agroforestry to serve needs of farmers and agroforestry extension staff has been lacking. This handbook has been prepared as one of the strategies to address the lack of suitable agroforestry extension materials for farmers and within agroforestry extension services in Uganda.

Much of the contents of this handbook is drawn from farmers' experiences and practices. During preparations for writing the manual, discussions were held with farmers in several districts in the banana-coffee zone of Uganda including Mukono, Mpigi, Masaka, Mbarara, Iganga and Jinja. Through informal discussions with farmers, observation and photographic documentation, information was gathered. Additional information was obtained from interviews with researchers, published materials and other relevant documents. The final draft of the manual was reviewed at a workshop which brought together farmers,

research and development practitioners from government and non-govermental organizations.

The handbook is divided into six chapters. Chapter 1 is introduction. Chapter 2 presents a description of the banana-coffee region of Uganda. In Chapter 3, the definition of agroforestry, the benefits of agroforestry and related issues are described. In Chapter 4, sources of seeds and other tree propagation materials, raising of seedlings and management of grown trees are discussed.

Chapter 5 presents and discusses the agroforestry practices common in the banana-coffee zone. Pest and disease control in relation to trees is the subject of Chapter 6.

2 The Banana-Coffee Zone

Introduction

The banana-coffee zone covers around 13,000 sq. km of Uganda. This is mainly in areas that were originally covered by evergreen forests. The forests have been largely cleared and the land planted with bananas and coffee. The farming practices in this zone are based on bananas as the main food crop and Robusta coffee as the main cash crop. Bananas are grown both for sale and home consumption. Many other types of crops are grown by farmers together with the main crops. These include cassava, sweet potatoes, groundnuts, maize, beans and indigenous vegetables. The pattern of growing other crops together with banana and coffee varies from farm to farm.

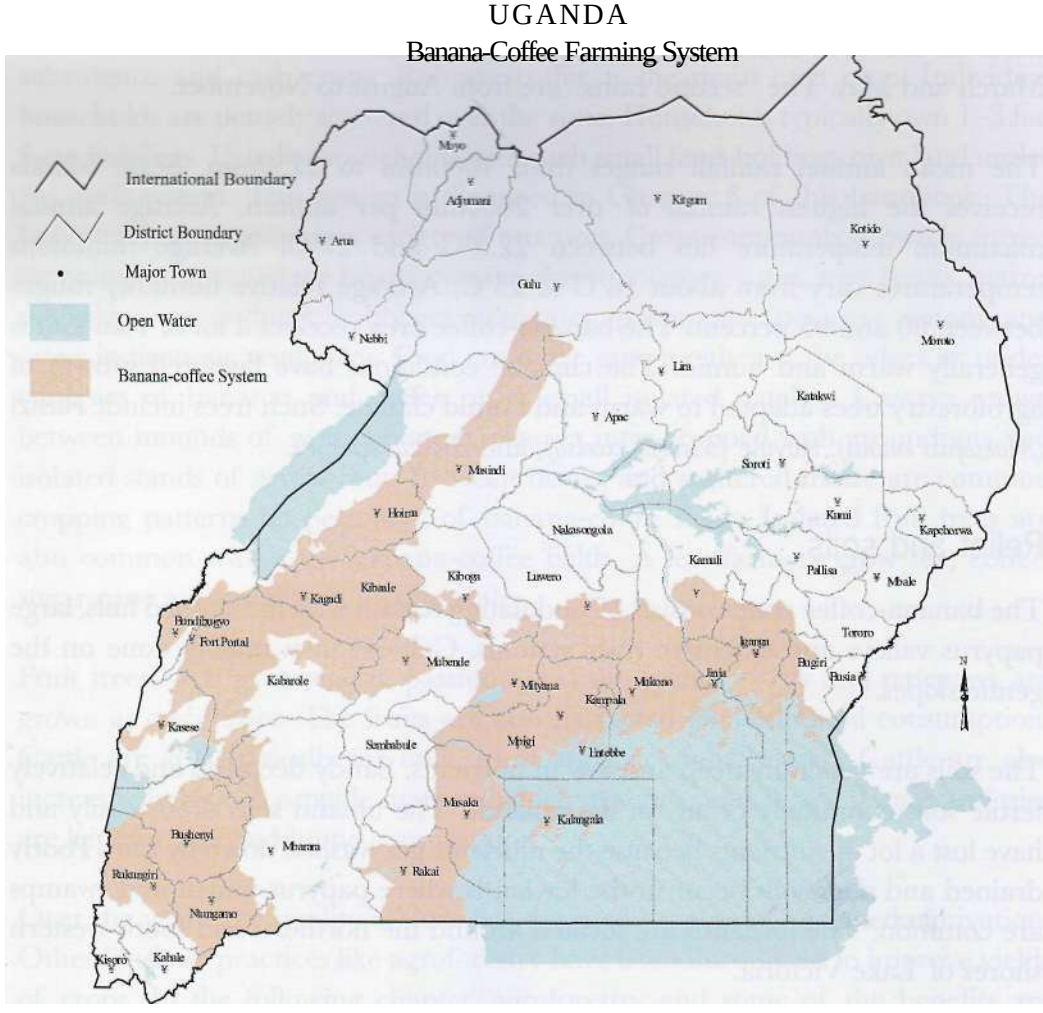


Figure 1 *Banana and Coffee growing areas*

Geographic location

The banana-coffee system is located in the southern region of the country, around the shores of Lake Victoria between longitudes 31°E to 34°E and latitudes 1°N and 1°S. Figure 1 shows the location of the zone.

The population is about 3 million people. The average density is 140 persons per square km. The annual population growth rate is 3%. The area has a good infrastructure. Good roads link most of the zone to market centres. The major towns of Kampala, Masaka, Jinja and Mbarara lie within this region. The average land holding per family varies between 1-3 ha.

Climate

Most of the area receives rain in two seasons. The "first rains" fall between March and May. The "second rains" are from August to November.

The mean annual rainfall ranges from 1000mm to 2250mm. Sesse Islands receives the highest rainfall of over 2000mm per annum. Average annual maximum temperature lies between 22.5°C and 27°C. Average minimum temperatures vary from about 18°C to 23°C. Average relative humidity ranges between 80 and 95 percent. The banana-coffee area receives a lot of rain and is generally warm and humid. The climatic conditions have favoured growth of agroforestry trees adapted to warm and humid climate. Such trees include Musizi *(Maesopsis eminii)*, Muvule *(Milicia excelsa)*, and *Albizia* species.

Relief and soils

The banana-coffee zone consists of undulating terrain with flat-topped hills, large papyrus valleys and extensive river systems. Cultivation is mainly done on the gentle slopes.

The soils are generally deep and low in nutrients. Sandy deep-red and relatively fertile soils commonly occur on the uplands. The upland soils drain easily and have lost a lot of nutrients because the nutrients get washed down by rain. Poorly drained and dark soils occur in the lowlands where papyrus marsh and swamps are common. The lowlands are located around the northern and south-western shores of Lake Victoria.

Vegetation

The vegetation of the area is comprised of tropical high forests, forest plantations, wood lots, bush-land, grassland, and wetlands. Medium altitude, moist evergreen forests occur in well watered areas of Mpigi, Mukono and Masaka districts. Medium altitude, moist, semi-deciduous and secondary forests occur in the northern lake shores including Mabira forest. Forest savannah mosaics occupy areas that were originally forested but have undergone repeated cultivation, cutting and burning. Elephant grass and other grasses are predominant. Wetlands, comprising seasonally and permanent swamps mainly of papyrus and palms occupy the low-lying areas.

Land-use practices

The banana-coffee zone is characterised by intensive smallholder production of subsistence and cash crops. Robusta coffee is the main cash crop. Individual households are densely scattered over the zone. Households typically own 1-3 ha. farm holdings. Usually, households with such small land-holdings own land under the *mailo* system. This system is discussed in Chapter 3 of this handbook. The households grow crops in a variety of mixtures. Crops commonly grown in mixed cropping pattern include beans, cassava, sweet potatoes, yams, soya beans, maize, pumpkins, groundnuts, cabbages, tomatoes, pineapples, pawpaw, onions and other indigenous vegetables. Food crops are grown either at the edges or under canopies of bananas and coffee or in small isolated patches. Cassava grown between mounds of sweet potatoes, cassava inter-cropped with groundnuts and isolated stands of arrow-roots between beans, and scattered maize are common cropping patterns on periphery of banana-coffee fields. Isolated fruit trees are also common within the banana-coffee fields. A few farmers grow tea, coffee, sugar cane and vanilla on a large scale.

Fruit trees such as avocados, passion, jackfruit, guava, citrus and pawpaws are grown as cash crops. The fruits are also harvested for household consumption. Cattle are kept basically for milk, meat and occasionally cash. Cattle are also increasingly kept to provide manure, which in some cases is sold. Goats and pigs are kept for sale and home consumption.

Over the years, the quality of soils has declined because of repeated cultivation. Other land use practices like agroforestry have been introduced to improve yields of crops. In the following chapter, agroforestry and some of the benefits are discussed.

3 Agroforestry as a Sustainable Form of Land Use

The definition of agroforestry

Definition of agroforestry in 1970s/1990s

The concept, definition and scope of agroforestry have changed over time as 'outsiders' have come to recognise the greater role of trees and tree products in farmers livelihoods.

Previous definition

Agroforestry is a collective term for land use sytems and practices where woody perennials are deliberately integrated with crops and/or animals on the same land management unit. The integration can be either in spatial mixture or in temporal sequence. There are normally both ecological and economic interactions between the woody and non-woody components in agroforestry. *(Manualfor ICRAF Board of Trustees—September, 1992.)*

Current Definition

"Agroforestry refers to a dynamic, ecologically based natural resources management system that, through integration of trees in farms and in the landscape, diversifies and sustains production for increased social, economic and environmental benefits for land use at all levels." *(Leakey, Agroforestry Today, September 1998).*

The benefits of agroforestry

Generated at stakeholders workshop, October, 1999, Masaka

1. *Increases revenue to farmer*
2. *Improvement of soil fertility*
3. *Stabilization of soil*
4. *Reduced crop failure*
5. *Provision offuelwood*
6. *Diversification of produce*
7. *Fodder production*
8. *Improved nutrition of the family*
9. *Provision of medicinal products*
10. *Reduced workload*
11. *Minimises labour cost*
12. *Increases construction materials*
13. *Involves most members of the family*
14. *Food security*
15. *Increases rain*
16. *Protects water catchments*
17. *Provides feed for fish*
18. *Continuous employment and continuous productivity on the fa year round*
19. *Reduces land fragmentation*
20. *Defines land ownership*
21. *Provides shade*
22. *Provides windbreaks*
23. *Provides beauty*
24. *Easier pest and disease control*

Agroforestry has been extensively practiced by farmers for many years. However, because land holdings have become small, it is necessary to introduce technologies for intensive land use. New agroforestry technologies can contribute to intensification and enhancement of agricultural production.

Farmers nowadays leave land to rest for shorter periods. Repeated cultivation and over-grazing of land without using methods that can maintain and improve quality of soil has led to degradation of land. Fertility of soils has declined. High yields can no longer be obtained.

Agroforestry in Uganda

The definition of agroforestry indicates that farmers in Uganda have been practising agroforestry for along time. The growing of bananas together with coffee and trees like *Albizia chinensis.* Mugavu *(Albizia coriaria),* Mututba *(Fiats naialmsis).* Nsambya *(Markhamia luted).* Musizi *(Maesopsis eminii)* and fruit trees is an agroforestry" practice.

There are additional agroforestry- practices, not yet commonly practised by farmers that address poor soil conditions, production of woodfuel and other tree-based needs. In the following chapter, a selection of the practices are described. One of the main factors that influence farmers' choice of agroforestry practices is land tenure. This is discussed in the following section.

Land tenure

Land tenure has implications for farmers' decision to grow long term crops like trees. There are different types of land tenure. The *mailo* type of land tenure is common in the Central and Western Uganda. In the *mailo* land tenure system, usually absentee landlords own land but allow small-scale farmers (tenants) to use the land. Most of these farmers living in and cultivating the *mailo* land have no legal titles to the land. They only have the right to use the land based on an agreement between them and the owners. Farmers who cultivate *mailo* land are known as *kibanja* owners. The 1995 constitution however states that land belongs to the people. The implication of this constitutional statement to ownership of land by small-scale farmers without legal title is not yet clear and is still to be fully implemented.

Leasehold is another common type of land tenure. In this case, the occupants have land titles over a specific lease period. The third type of land tenure is

customary. In this case, land is obtained through inheritance. An individual owns inherited land and it may be passed-on to descendants. Generally, there are no indications of insecurity of tenure of land and trees grown on *mailo* land. Some agroforestry shrubs grow fast and can be harvested even within one year after planting. Where security of land tenure is not assured, farmers should grow such shrubs. On the other hand, trees which take along time to mature can still be grown even under the *mailo* system because one can claim compensation in the event of eviction.

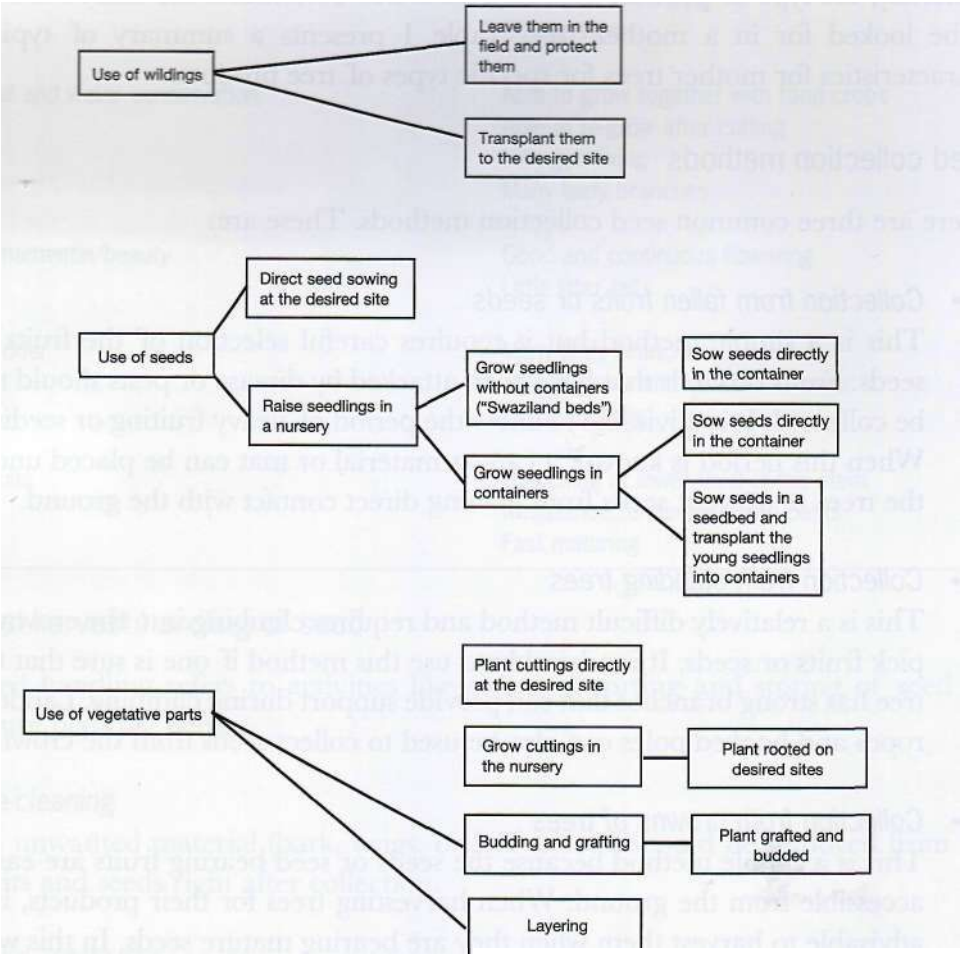
Ownership of land is therefore an important condition and affects patterns of land use for agroforestry. But before describing agroforestry practices in detail, we need to know something on how seeds for raising good tree planting materials can be obtained. This is the subject of the following chapter. The chapter also presents some general practices for managing trees.

4 Propagation and Management of Agroforestry Trees

Introduction

There are three methods of raising planting material of trees. These are from wildings, seed and from vegetative parts of plants. To raise good quality tree planting material, it is important to identify good seed sources and individual trees from which seeds and other propagation materials can be collected. In this chapter we discuss how to collect, handle and process seed and other propagation materials; and how to raise seedlings from seed.

Methods for growing tree seedlings



Adapted from: Agroforestry Extension Manual for Eastern Zambia by Samuel Simute; P.L. Phiri, Bo Tengnas. RELMA Technical Handbook No, 17 1998 pp.62

Seed collection and handling

Sources of seed

Seeds should be collected from trees growing over a large area and in a similar ecological zone. The place where the seed is collected should be as similar as possible to the place where the seedlings will be planted. To obtain good quality seed, the following factors should be carefully considered:

- Collect seed from vigorous, healthy, mature trees of good form;
- Do not collect seed from isolated trees; and
- Collect seed from a minimum of 10 trees spaced at least 100m apart. As a rule of thumb, the distance between the trees should be twice the tree height.

Generally, the type of product desired from a tree determines the characteristics to be looked for in a mother tree. Table 1 presents a summary of typical characteristics for mother trees for specific types of tree products.

Seed collection methods

There are three common seed collection methods. These are:

- *Collection from fallen fruits or seeds*
  This is a simple method but it requires careful selection of the fruits or seeds. Fruits or seeds that have been attacked by disease or pests should not be collected. It is advisable to know the period of heavy fruiting or seeding. When this period is known, a canvas material or mat can be placed under the trees to prevent seeds from gaining direct contact with the ground.

- *Collection from standing trees*
  This is a relatively difficult method and requires climbing into the crown to pick fruits or seeds. It is advisable to use this method if one is sure that 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.

- *Collection from crowns of trees*
  This is a simple method because the seeds or seed bearing fruits are easily accessible from the ground. When harvesting trees for their products, it is advisable to harvest them when they are bearing mature seeds. In this way, the seeds can be used for raising seedlings for planting.

Table 1 *Selection of a source of seed*

DESIRED TYPES OF TREE/PRODUCTS/SERVICES	CHARACTERISTICS OF MOTHER TREE (SOURCE OF SEED)
Timber	Straight stem Few branches Hard wood
Fuelwood	Many branches Fast growing Wood producing little smoke Wood that burns for a long time Able to re-grow after cutting
Shade	Many leafy branches Little litter fall Continuous flowering Strong stem
Soil and water conservation	Able to grow together with food crops Able to re-grow after cutting Nitrogen fixing Many leafy branches
Ornamental/beauty	Good and continuous flowering Little litter fall
Fodder	Many leafy branches Able to grow with other food crops Nitrogen fixing
Fruits	Branching at lower level of the stem Resistance to diseases and pests Fast maturing

Post-harvest handling of seed

Seed handling refers to activities like cleaning, sorting and storing of seed for future planting needs.

Pre-cleaning

All unwanted material (bark, twigs, or leaf pieces) should be removed from the fruits and seeds right after collection.

Seed extraction

This is the separation of seeds from the fruits. The method used depends on the nature of the fruit. Some fruits need de-pulping; others need drying until seeds

become detached from the fruit. Others need the use of a knife. Some fruits, mainly nuts do not require extraction but are stored or sown as fruits. The extracted seed should be cleaned by separating healthy sound seeds from empty and non-viable seeds, de-winging seeds and grading seed by size and appearance. Grading seed is recommended but may not be necessary if only a small amount is processed for direct use. In Table 2 the seed processing and treatment methods for common agroforestry trees is presented.

Generally, seeds from pulpy fruits, for example, Kiryowa *(Jatropha curcus),* Kei apple *(Dovyalis caffra),* Musizi *(Maesopsis eminii)* and Paapali *(Caricapapaya)* should be dried under shade until the surface has no moisture. Seeds contained in hard pods such as those of Nongo *(Albizia zygia),* Lusina *(Leucaena leucocephala), Calliandra calothyrsus,* Kasaana *(Acacia species)* and Muzimbandeya *(Sesbania sesban)* should be dried in the sun.

Seed storage

This is preservation of viable seeds from the time of collection until when they are required for sowing. The period for which seed can remain viable without losing germination capacity is greatly affected by quality at the time of collection, treatment between collection and storage and conditions in which seed is stored. Mature seeds free of pests and diseases and without physical damage can be stored for a time under room conditions. But, it is advisable to sow seeds soon after harvesting so that many of them can produce seedlings. Seeds of most agroforestry trees should be dried before storing.

Preparing seed for germination

Seed of most tree species, particularly those of leguminous agroforestry shrubs like *Calliandra* germinate easily Seeds of some types of trees need treatment. There are many methods of treating seeds to improve germination. These include cutting, soaking in water, drilling or cracking the coat of seed before sowing. Rubbing with sandpaper may also reduce the seed coat. Seeds can be soaked for one day in warm water at room temperature. Table 2 shows the simple seeds treatment methods for some agroforestry species.

Table 2 *Simple seed treatment methods for some agroforestry trees and shrubs*

LUGANDA NAME	SPECIES NAME	SEED PROCESSING METHOD AND PRE-TREATMENT FOR GERMINATION	VIABILITY (ONCE CLEANED AND STORED)
Avocado	Persea americana	Not necessary	Does not store well; use fresh seed
Calliandra	Calliandra calothyrsus	Immerse in hot water, allow to cool and soak for 12-24 hrs; soak in cold water for 24 hrs	
Fene/Kifenensi	Artocarpus heterophyllus	Using knife and hand	Viable only one month
Grevillea	Grevillea robusta	Drying and shaking, scarify mechanically	Seed can be stored for up to 3 months
Kabalira	Ficus mucosa	Not necessary	Can be stored up to 2 months
Kasaana	Acacia spp.	Drying and soaking	
Kei apple	Dovyalis caffra	Not necessary	Seeds do not store; use fresh seed
Kiryowa/Kinowa	Jatropha curcas	Cracking the seed slightly improves germination	Seeds do not store, use fresh seed for best germination
Kitafeli, Mulberry	Morus spp.	Remove pulp	
Leucaena	Leucaena spp.	Drying and shaking; soak in hot water for 24 hrs Pour boiling water over seed; allow to soak for 1-3 minutes; scarify mechanically	Can be stored for long periods if dry and insect free
Lira	Melia azederach	Remove pulp	
Lusambya	Markhamia lutea	Drying and shaking	Seed does not store well; sow fresh seed
Mapeera	Psidium guajava	Not necessary	Store in sealed containers in a cool place

LUGANDA NAME	SPECIES NAME	SEED PROCESSING METHOD AND PRE-TREATMENT FOR GERMINATION	VIABILITY (ONCE CLEANED AND STORED)
Mayembe	Mangifera indica	Using knife and hands, remove seed from fruit	Seed can only be stored for one month at room temperature. For best results, use fresh seed
Mpinnamiti	Cajanus cajan	Drying and shaking	
Mugavu	Albizia coriaria	Soak in cold water for 48 hours	Seed can be stored for up to one year
Mukebu	Cordia spp.	Remove pulp	
Mukoge	Tamarindus indica	Remove pulp, soak in cold water for 48 hrs Soak in hot water for 48 hrs	
Mukunyu	Ficus sycomorus	Not necessary	Can be stored up to 2 months
Mukyula	Senna spp.	Drying and shaking; scarify mechanically, soak in cold water for 48 hours	
Musaali	Garcinia buchananii	Soaking overnight	Store in a cool, dry place; spread out. If stored at room temperature, sow within 2 months
Musizi	Maesopsis eminii	Remove pulp (chewing), soak in cold water for 48 hours	
Musongole	Balanites eagyptica	Scarify mechanically, biological (seed excreted by animals like goats)	Store dry and insect free; seed removed from the fruit can be stored for up to a year. Add ash to reduce insect damage
Mutuba	Ficus natalensis	Remove pulp	Whole twigs can be stored. Add ash to reduce insect damage
Mutugundo/Mululuza	Vangueria apiculata	Soaking in cold water may hasten germination	Sow immediately after collection
Muvule	Milicia excelsa	Remove pulp	

LUGANDA NAME	SPECIES NAME	SEED PROCESSING METHOD AND PRE-TREATMENT FOR GERMINATION	VIABILITY (ONCE CLEANED AND STORED)
Muwafu	Canarium schweinfurthii	Immerse in hot water, allow to cool and soak for 24 hours	
Muyirikiti	Erythrina spp.	Drying and shaking	None
Muzimbandeya/ Mubimba	Sesbania sesban	Drying and shaking, scarify mechanically	Can be stored for long periods
Muziru	Pseudospondias microcarpa	Soak in cold water for 12 hours	Can be stored up to 5 months after drying whole fruit
Neem	Azadirachta indica	Remove pulp	
Nongo	Albizia zygia	Drying and shaking	
Paapali	Carica papaya	Not necessary	Store in cool, dry conditions. Viability up to 3 yrs
Kinazi/Pine	Pinus patula	Not necessary	Seed can be stored
Falawo	Alnus spp.	Drying and shaking	
	Casuarina spp.	Drying and shaking	
	Cedrela spp.	Drying and shaking	
	Cupressus spp.	Drying and shaking	
	Gliricidia sepium	Drying and shaking; scarify mechanically	
	Mimosa scabrella	Drying and shaking, soak in hot water	
	Tephrosis vogelii	Drying and shaking	
	Terminalia spp.	Drying and shaking, soak in cold water for 48 hrs Acid treatment; soak in cold water for 24 hours	

Vegetative "seed" material

Vegetative propagation is the growing of trees from cuttings or other non-seed material such as roots bulbs and suckers. The cuttings can be obtained from stems, leaves and branches.

Stem/root cuttings

Tree species such as Mutuba *(Ficus natalensis)* and *Gliricidia sepium* are grown from stem cuttings. Cuttings should not be taken from over-mature trees and in the dry season. The length of the cuttings can vary from 0.5 to 1.5 meters.

The success of raising plants from cuttings depends on successful development of roots and the stem cuttings. Three main factors influence the growth of plants from stem cuttings. These include quality of cutting, treatment of stock material and environmental conditions during rooting of the cuttings. The season of the year will also affect the process of rooting of cuttings. Application of growth promoters such as rooting powder will increase chances of growth.

Cuttings should be raised in well aerated, warm areas free from pests and diseases. The soil should be of good quality and well-drained.

Grafting and budding

Grafting

Grafting is the method of joining parts of plants together in such a way that they will combine and continue to grow as one plant. Grafting requires root stocks and scions. The scion is the part of the plant whose qualities are desired. A root stock is a plant on which the scion is placed to produce a union between the two and hence a plant with the desired qualities. Figure 2 shows a root stock and a scion of a Mango (Muyembe, *Mangifera indica)* tree. Other fruit trees commonly grafted to improve yield, quality of products and early fruiting are: Avocado *(Persea americana),* Oranges *(Citrus species)* and Passion.

It is important that the diameter of the scion matches the diameter of the root stock.

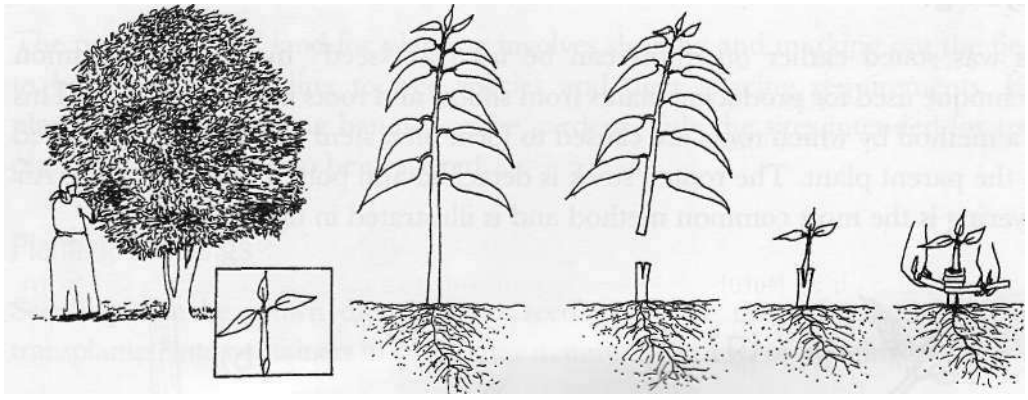


Figure 2 Roof *stock and scion of a Mango tree*

Budding

This is similar to grafting. However, in this case, the scion material is small and is known as a bud. Budding can be done in various patterns but the "T" and "inverted T" patterns are the most common. These "T" budding techniques are illustrated in Figure 3.

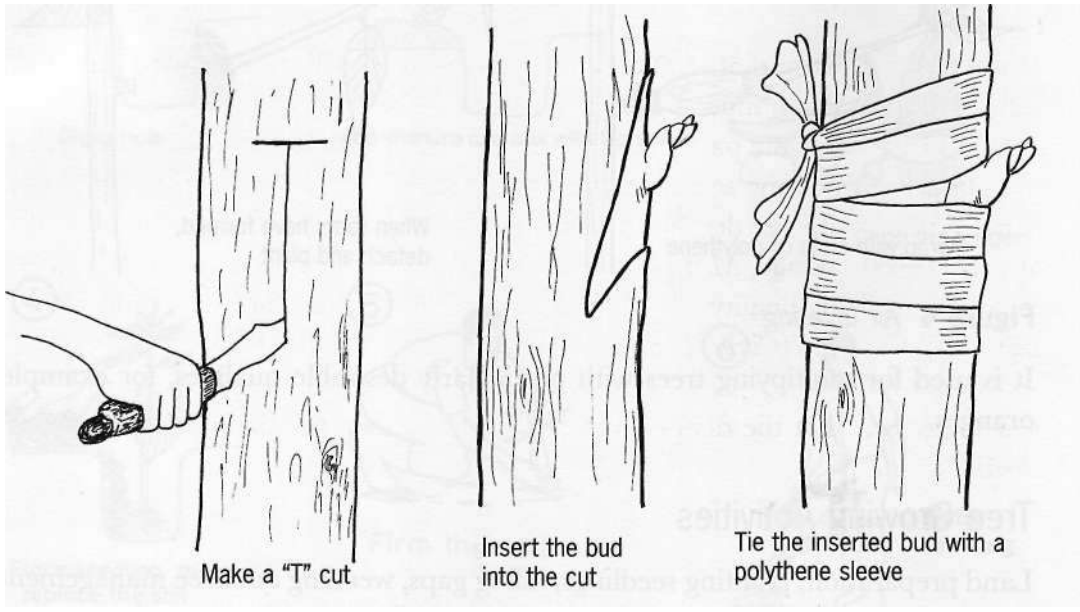


Figure 3 *Illustration of a budding method*

Layering

As was stated earlier on, roots can be used as "seed" material. A common technique used for producing plants from shoots and roots is called layering. This is a method by which roots are caused to form on a stem while it is still attached to the parent plant. The rooted stock is detached and potted as a new plant. Air layering is the most common method and is illustrated in figure 5.

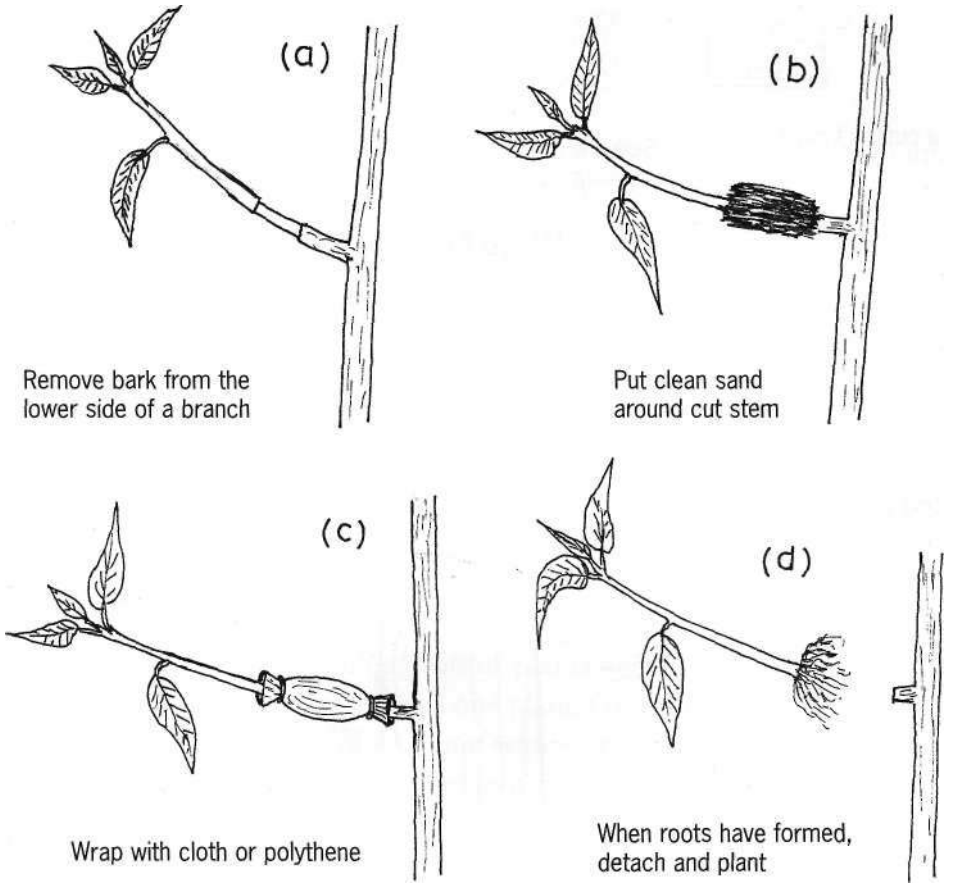


Figure 4 *Air layering*

It is used for multipying trees with particularly desirable qualities, for example oranges.

Tree Growing Activities

Land preparation, planting seedlings, filling gaps, weeding and tree management are the activities in the growing of trees.

Land preparation

The preparation of land for planting involves slashing and marking out the field to be planted according to tree species and their spacing requirements. For planting trees in existing banana-coffee gardens, only the sites intended for tree planting are required to be prepared.

Planting seedlings

Seedlings can be grown directly on a seedbed to the time of planting or are transplanted into containers in which they mature to the time of planting in the field.

Seedlings should be transported to the field for planting after sufficient rain has fallen and preferably during the peak of a rainy season. Care must be taken not to damage the seedlings during transportation. Seedlings should be well watered in the nursery the evening before they are transplanted into the field the following day.

During planting, the pot or polythene tubing is cut and peeled off before putting the seedling into the pit. The soil around the pot is firmed slightly making sure the seedling is upright. Figure 5 show the procedures for planting seedlings.

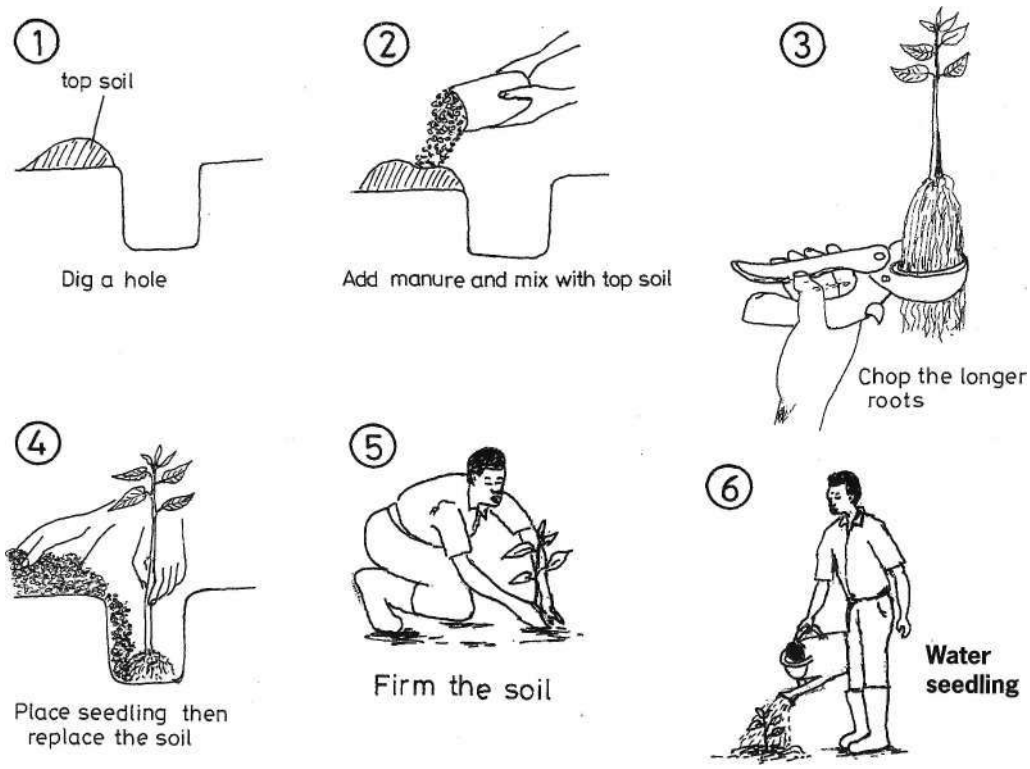


Figure 5a *Procedures for planting bare root seedlings*

Seedling should be planted when 15 to 20 cm tall. If the field is not very fertile, it is advisable to add some farm yard manure to the loosened soil to give the plants a good start. Seedlings should be planted either early in the morning or in the evening when it is cool. The seedlings are likely to wilt if they are planted out in the full heat of the mid-day sun.

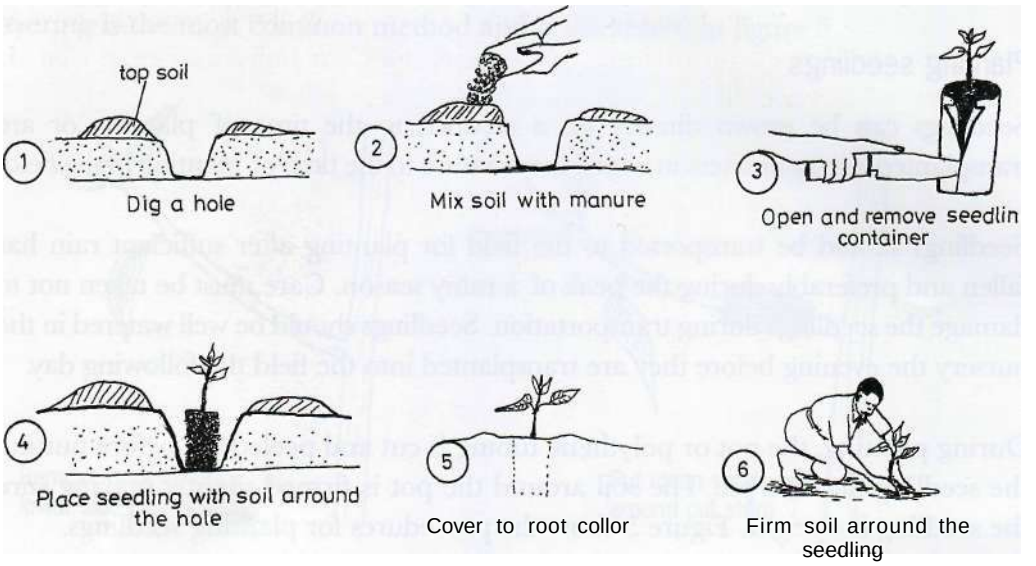


Figure 5b *Procedures for planting tree seedlings from containers*

Weeding

Like any crop, trees also suffer competition from weeds and damage by other organisms that take advantage of presence of weeds. To attain good tree growth, weeding should be done periodically. Where it is uneconomical to weed the whole area, spot weeding should be done. This involves clearing the area around the plant. The other method used is slashing along the line of trees.

Apart from weeding, planted trees should be managed so as to obtain the desired products and services. The different tree management practices are described in the following section.

Management of trees in agroforestry systems

To obtain desired products and services from an agroforestry practice, the management of the grown trees and shrubs is important. The common management activities are discussed in the following sections. The activities include coppicing, pruning, pollarding and thinning as well as weeding.

Coppicing

This is a management practice whereby trees are cut at about knee-height from the ground. Usually, only trees that can re-grow after cutting are coppiced. Such trees include Lusina *(Leucaena leucocephala), Calliandra calothyrsus,* Nsambya *(Markhamia lutea),* Kalitunsi *(Eucalyptus species)* and others. Figure 6 illustrates the coppicing angle and the re-grown tree after coppicing. Coppicing should be done towards the end of a dry season or just at the beginning of a rainy season so that the coppiced plants have the opportunity to re-grow well.

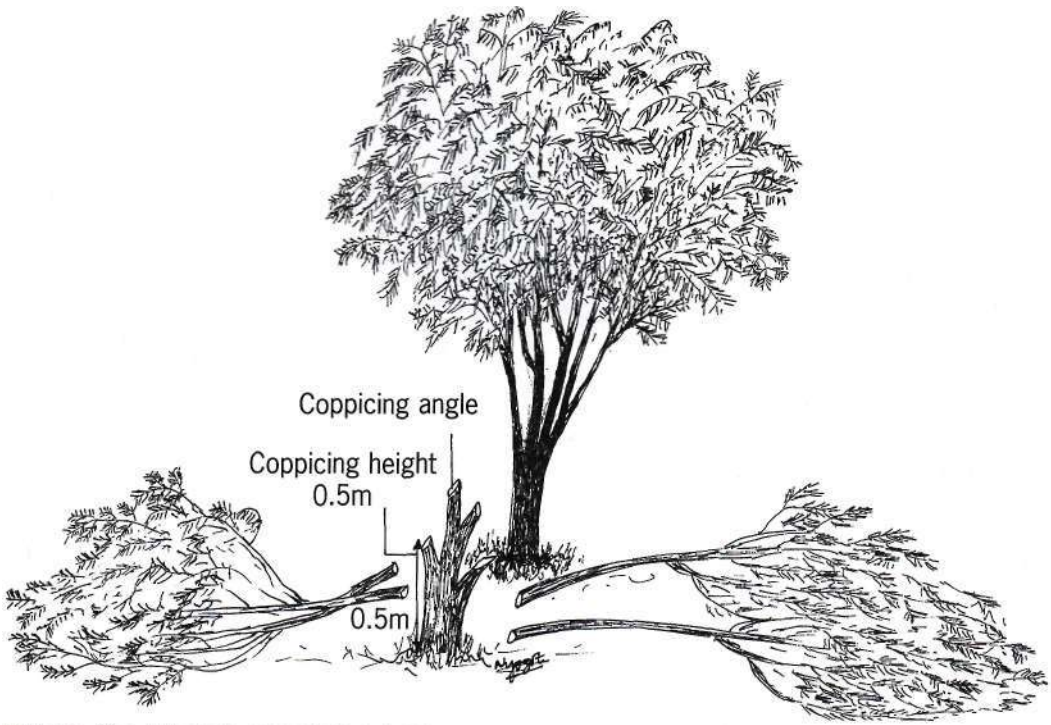


Figure 6a *How to coppice a tree*

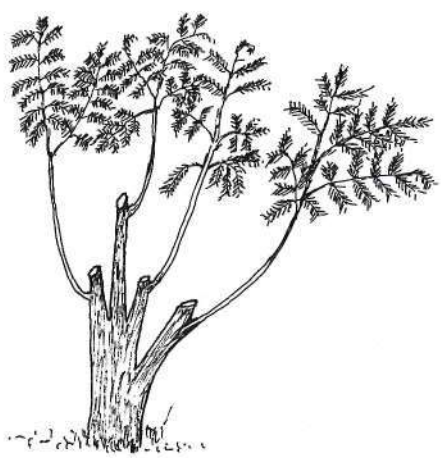


Figure 6b *Re-growth from a coppiced tree*

Pruning

Some trees form extensive branches. In situations where such trees are grown together with crops, they shade the companion crops and reduce crop yields. Removing the side branches is then necessary to maintain good crop yields. This is known as pruning. The branches are cut from the base of the trees to about % of the height of the trees. Trees are normally pruned to reduce their shading effects and also to encourage growth of a straight stem. Such trees produce good timber. Figure 7 illustrates pruning and the results of pruning.

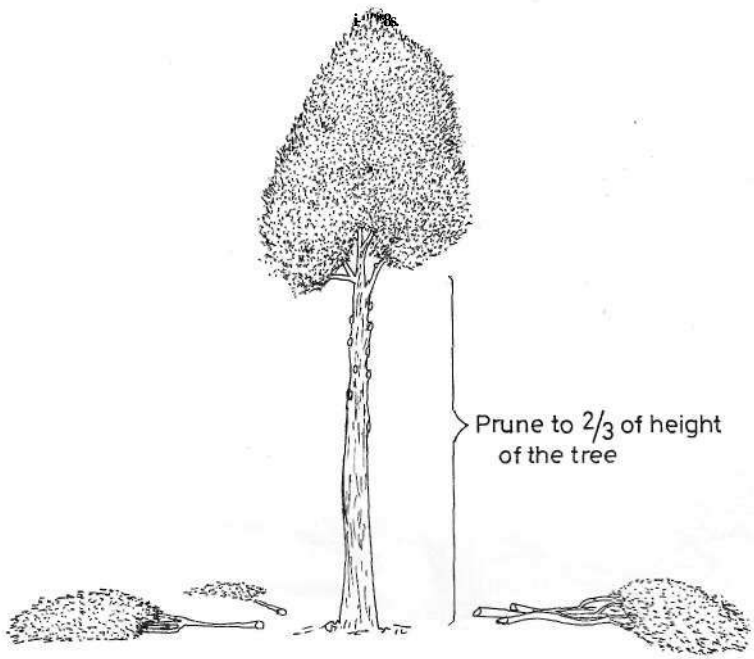


Figure 7 A pruned *tree*

Pollarding

In some situations, it may only be necessary to remove the top (crown) of the tree and the top branches to reduce competition between the trees and companion crops. This is what is known as pollarding. The tops of the trees are cut at about 3m from the base of the tree. Only trees that are known to be able to produce new shoots after pollarding should be pollarded. Such trees include Avocado *(Persea americana),* Grevillea *(Grevillea robusta),* and Muyembe *(Mangifera indica).* The leaves from pollarded trees can be used as mulch or fodder and the branches can be used as fuelwood. Figure 8 shows a tree before and after pollarding.

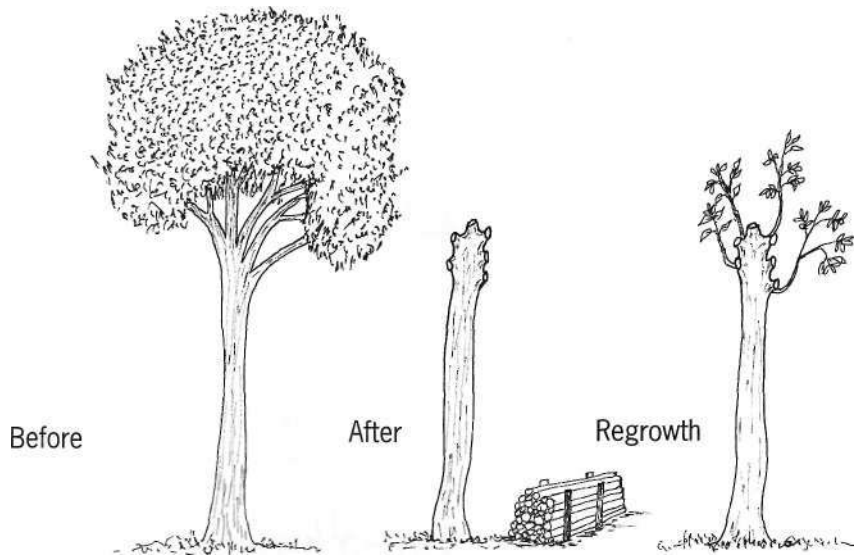


Figure 8 *A tree before and after pollarding*

Thinning

Thinning is a process whereby some of the trees are cut-down with the objective of reducing the number of trees in a plot. Thinning is especially recommended where a commercial woodlot is grown. The starting plant population is deliberately higher than the expected final plant population, depending on the desired final product. For example, a woodlot can be established and trees spaced at 1 m by 1 m apart. After sometime, the spacing can be increased to 2m by 2m. Firewood and small construction wood are some of the products that can be obtained from a woodlot during thinning. Figure 9a and b shows a woodlot before and after thinning.

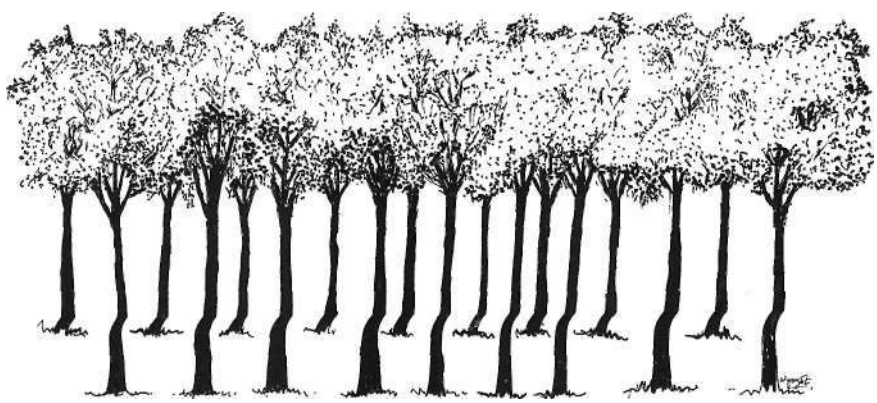


Figure 9a *A woodlot before thinning*

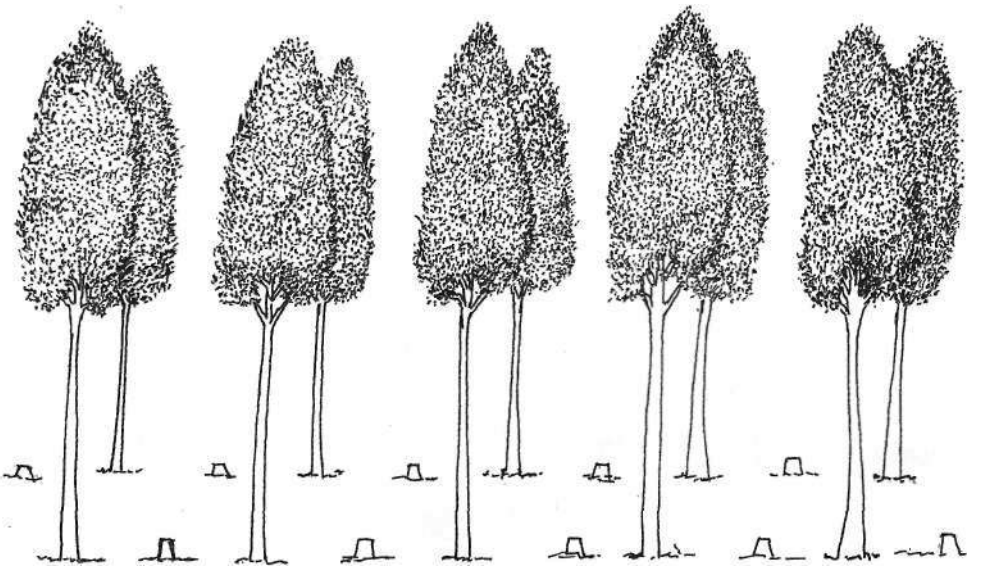


Figure 9b *A woodlot after thinning*

Root pruning

Roots of trees grown together with food crops should be pruned when the trees have grown to heights of 2-5 meters. This should be done at the beginning of the rainy season or at the end of the dry season. The roots are cut at 0.3 to 0.5 meters from the trunk. Root pruning is done on large trees whose roots can compete with companion crops for water and nutrients.

Lopping

Lopping is the cutting of portions of branches from the base of a stem. This is done to obtain fodder or firewood. Only small portions of branches can be cut to allow trees to continue growing well.

Tree species that can be lopped are those that re-grow easily when cut. For example, Grevillea *(Grevillea robusta)* and *Calliandra calothyrsus.*

5 Agroforestry Practices

In this chapter, a series of inter-related agroforestry practices are discussed. The practices are:

- Fodder banks and zero grazing,
- Organic manure and nutrient cycling,
- Home gardens,
- Trees and shrubs for soil and water conservation,
- Multi-purpose trees in banana-coffee gardens
  - Multi-purpose trees
  - Vanilla production, and
- Commercial woodlots and wood production.

Fodder Banks and Zero Grazing

A. Fodder Banks

Many farmers in the banana-coffee zone have adopted zero grazing as a viable enterprise. Due to scarcity of land, production of supplementary fodder through establishment of fodder banks has become necessary. Fodder production for zero grazing involves use of fast growing grasses—*Napier* grass, forage legumes (ebilamba), trees and shrubs—*Calliandra calothyrsus;* Mulberry/Nkenene *(Mortis alba);* Muzimbandeya *(Sesbania sesban)* and others. Common species used in farms with zero grazing units in Mbarara are shown in the table below.

Table 3 Common *forage species and mixtures in Mbarara district*

GRASSES	LEGUMES	FODDERS	POSSIBLE GRASSAEGUME MIXTURES
Chloris gayana, *Brachiara ruziziensis,* *Panicum maximum,* *Themeda triandra,* *Setaria anceps,* *Cynodon dactylon,* *Cenchrus ciliaris*	*Desmodium uncinatum,* *D. intortum,* *Macroptilium atropurpureum,* *Centrosema pubscens,* *Stylosanthes guyanensis*	*Pennisetum purpureum,* *Setaria splendida,* *Tripscum laxum,* *Dolichos labiab,* *Calliandra calothyrsus,* *Sesbania sesban,* *Cajanus cajan*	i) *Chloris gayana,* P. *maximum,* *D. uncinatum,* *M. atropurpureum,* ii) *B. Ruziziensis* *S. anceps* *C. gayana* *S. guyanensis* *D. intorum* iii) C. *ciliaris*

Source: Mwebaza, S. (1999) 'Pasture Improvement Technologies Tested on Farms in Mbarara, Kabale and Mbale Districts of Uganda'. *RELMA Working Paper.*

Expected benefits

- Different types of fodder in the farm ensure an adequate and balanced supply of nutrients for the animals.
- Fodder grasses supply energy, whereas the fodder legumes, trees/shrubs provide protein and minerals.
- When grown along contours on sloping land, grasses, forage legumes and shrubs reduce soil erosion and provide green manure for fertilising crops and stabilizing bunds.
- When grown on fallows, forage legumes and shrubs improve soil structure and fertility.
- The fodder grasses, legumes, trees and shrubs grow vigorously and re-grow after cutting.
- Fodder banks save time and energy as members of the family are not required to herd and graze animals.

Description of the Fodder bank production system

Fodder banks can be grown in pure stands of grasses, shrubs and trees or mixed together as shown in Table 3. Fodder can be established on hedges or blocks depending on land available. Fodder banks that are well managed can be harvested at different intervals and thus maintain a continuous supply of feed to the animals.

Figures 1 Oa, b and c show fodder banks of grass *(Setaria splendida)* and *Calliandra* in farmers' fields.

Establishment of Fodder banks

Fodder banks should be established on a well prepared land. Preparation should consider soil conservation measures. There are different planting methods which are specific to different fodder types. Grasses are grown from cuttings and forage legumes from seed and cuttings. *Calliandra,* Muzimbandeya *(Sesbania sesban),* Ebilamba *(Desmodium)* can be obtained from seed. Mulberry/Nkenene *(Moms alba), Gliricidia sepium* can be grown from cuttings.

Spacing in *Calliandra* and Napier hedges are normally single or double rows with *Calliandra* spaced at 0.5m and Napier and other grasses at 50x100cm or 100x100cm. Strong establishment of legume species requires application of phosphorous fertilizer such as rock-phosphate. Figure 11 shows the establishment of a fodder tree hedge by direct sowing.

Figure 10a *Calliandra only fodder bank*

Figure 10b *Grass only fodder bank*

Figure 10c *Calliandra and grass fodder bank*

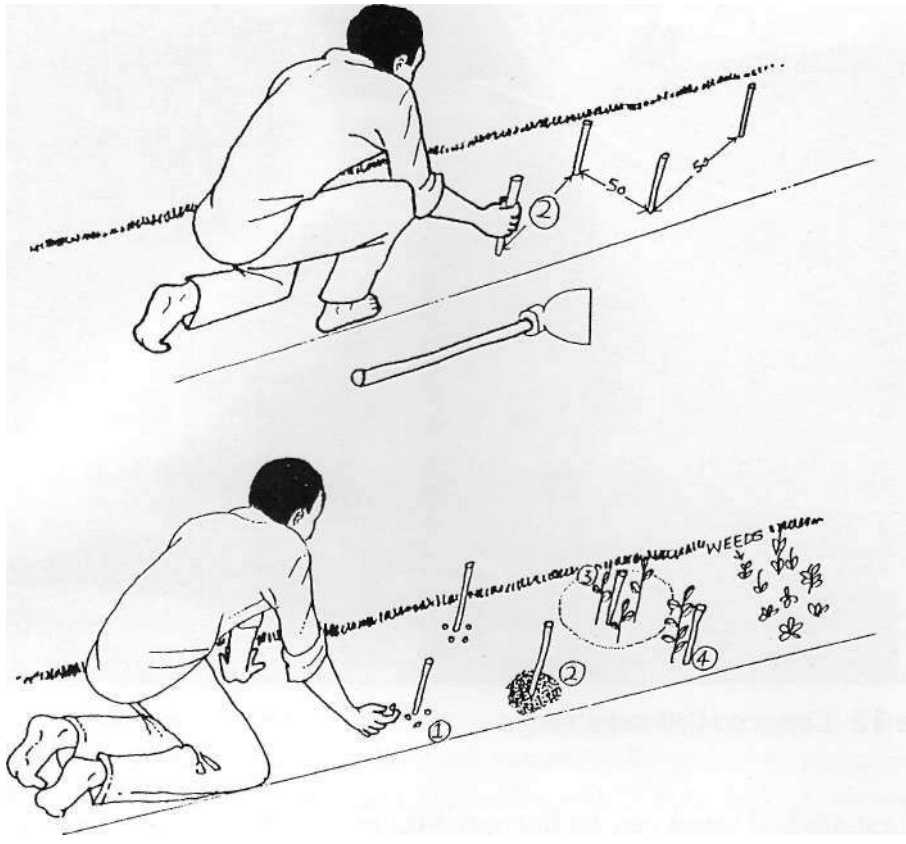


Figure 11 *The spacing of trees in a fodder hedge*

Source: Fodder trees for smallholders. Nakuru and Nyandarua Intensified Forestry Extension Project (Miti Mingi Mashambani). Government of Kenya/FINNIDA, 1992.

Management of Fodder banks

Fodder grasses, forage legumes, trees and shrubs for zero-grazing are usually managed in a cut-and-carry system. For good yields, weed control by hand-picking is required. Cutting heights are specific to different types of fodder and should be followed. For example, Napier grass is cut at 1.5m and *Calliandra* and Lusina *(Leucaena leucocephala)* at 0.5m for good re-growth and supply of fodder material. The first cutting should be done at least six months from the time of planting. Manuring of the fodder banks is important for returning nutrients to the soil.

Calliandra

Harvest: 9-12 months after planting, *Calliandra* will have reached a height of about 2 metres (6 feet) and can be cut back. Figure 12 shows a coppiced *Calliandra* hedge.

Figure 12 *Coppiced* Calliandra *hedge*

A well-established stand can be harvested up to 5-6 times a year, with shorter intervals during the rainy season. The cutting height should be 1 metre above ground, but usually lower in order to minimise the shading effect on crops.

Productivity: Three kilograms of fresh *Calliandra* fodder (about 1 kg dry matter) can replace 1 kg of dairy meal. In general *Calliandra* is fed in addition to dairy meal with *Calliandra* constituting *ty* to **fe* of the total diet.

Productivity of *Calliandra* is, in general, 3 kgs dry matter per metre of single hedge per year. If a farmer wants to feed 1 cow with 6 kg fresh *Calliandra* (2 kg dry matter) every day in a year, the farmer would need a hedge which is approximately 250m long. If the spacing between the trees is 50 cm, the total number of trees required would be 500. Many small-scale dairy farmers have benefited from growing *Calliandra* fodder. The experience of Mrs. Joy Mawanda (Nyabushabe Kabale Two wings agroforestry group), illustrates the benefits of growing *Calliandra* fodder (Box 1).

Box 1 *Fodder banks: the experience of Mrs. Joy Mawanda*

Increases in human population over the years have reduced area of land available for households in rural Uganda. In highly populated areas like Kabale district, grazing land has become limited. This has made it necessary for household to adopt alternative ways of rearing livestock for production of milk. Zero grazing is a livestock rearing technology' that has been adopted by some farmers.

Establishing fodder banks using shrubs with good fodder quality like *Calliandra* has benefited farmers. Mrs. Joy Mawanda, the chairperson of Nyabushabe Two Wings agroforestry group in Kabale has had a benefiting experience with *Calliandra* fodder banks.

Mrs. Mawanda lives in Nyabushabe \dllage, Ndorwa County in Kabale district. She is a subsistence farmer. Her family of seven people depend on the 4 acres (1.8 ha) of land for their livelihood. Mrs Mawanda learnt about the fodder bank technology from the Nyabushabe Two Wings agroforestry group. According to the group members, sharing of knowledge and acquiring of skills are some of the main benefits of association with the Nyabushabe women group. Through the group, they have had contacts with research organisations like the International Centre for Research in Agroforestry (ICRAF). They have been able to travel to Kenya and share experiences with Kenyan farmers who are also collaborating with ICRAF. Indeed, whereas the women appreciated the importance of training materials such as manuals, they said that "seeing is better", therefore study tours and demonstrations should complement written materials.

Mrs. Mawanda planted hedges of *Calliandra* along soil conservation bunds. On a half-acre (0.1 ha) piece of the land, she has grown a pure stand of elephant grass. Although she has only one Friesian cow, this farmer noted that management of the technology is not easy. She cuts the hedges at 1.5m above the ground 3 to 4 months after re-growth. The obtained fodder is not enough for the animal. According to the experience of Mrs. Mawanda, the cow eats the following quantities of food per day:

Type of feed	**Quantity per day**
1. Elephant grass	1 sack (20Kg)
2. Calliandra leaves	5Kg
3. Sweet potato vines	2 sacks (40Kg)
4. Commercial feeds	Variable quantities

The comparative advantage of this technology relative to alternative land use options may be difficult to quantify. However, Mrs Mawanda explained that income from the dairy enterprise supplements the cash and non-cash benefits of the technologies. She

estimated income and other benefits from the technology as follows:

Type of output	**Quantity**	Price/unit	Total cash, income
l.Milk	11 litres/day	300.00	3,300.00/day
2. Irish potatoes	2 bags/season	10,000.00	20,000.00/season

Estimated monthly income 105,700 Ush.

Irish potatoes take about three months to mature. Hence the monthly benefit from Irish potato yields resulting from application of manure from the dairy enterprise is about 6,700 USh per month. In addition, she said that generally ,the fertility of soil in her farm has improved. Yields of other crops like bananas and cabbages also improved. She associates the soil fertility improvement 'with application of manure.

Some of the limitations of the technology, said Mrs. Mawanda, include:

- High demand for labour. The labour is expensive to hire. In her case, she hired labour at 10,000 USh per month.
- Lack of inputs such as seedlings for fodder trees and improved grass.
- Expensive commercial dairy feed.
- Expensive drugs.

The estimated cash and non-cash benefits of the fodder bank technology as narrated by Mrs. Mawanda suggest that despite the limitations of the technology, the growing of fodder shrubs saves livestock feeding costs and is a good source of income and improved nutrition for households.

Napier grass

Napier grass is harvested when it is 90-120 cm (3 to 4 feet high). Enough grass is cut to feed the animals for one day starting progressively at the end of the row. If the livestock do not eat all the grass, the remainder is used as mulch or for composting.

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Limitations of Fodder bank production

- It is costly to establish a good stand of trees and shrubs for fodder.
- It is difficult and expensive to change a fodder bank to other crop production systems.
- Some fodder trees like Lusina *(Leucaena leucocephala)* are susceptible to pests like *Leucaena pssylid;* however, other species of *Leucaena* such as *L. diversifolia* are resistant to the *pssylid.*
- Napier grass can become a weed if not managed properly.

B. Zero-Grazing

Fodder banks support the zero-grazing system where animals are managed under confinement. The animals, like cattle and goats are usually stall-fed.

Introduction

Zero grazing is a livestock management practice, where animals are confined and stall fed as opposed to free grazing. This practice is gaining popularity particularly where land-holding sizes are diminishing and grazing is not an option. Cattle and goats are the most zero grazed livestock species and economic efficiency of this is achieved when high yielding breeds are used. Advantages of associated with the practice are: -

- Exposure to parasites and diseases vectors is reduced.
- Manure is easily collected and distributed in the farm enhancing soil fertility.
- Less energy wasted by animals in walking as compared to free grazing
- Better control on breeding and animal health.

Expected Benefits

- Enables keeping of animals in areas with land shortage.
- Increases land productivity by increasing crop yields through the easier collection of manure.
- Milk, meat and the live animals provide cash income.
- Improved household nutrition from milk, meat and vegetables from the home gardens, and
- Reduced transmission of disease because the animals are closely monitored.

Establishment and Management

It is important to select a good breed of animal for improved productivity. A good shed is designed for ease of management to:

- Facilitate feeding;
- Collection of manure; and
- Comfort of the animal.

The feeding strategy for zero-grazed animals will depend on available feed resources. A good feed resource base should include natural pastures, fodder banks, crop residues and purchased feeds. High yielding breeds normally kept under zero-grazing are susceptible to many diseases so good animal health programmes should be followed. Availability of adequate water is necessary for successful zero-grazing.

Limitations

- High yielding breeds are very susceptible to disease.
- Good animal health programmes are not available in many rural areas.
- Access to drugs and vaccines in rural areas is poor.

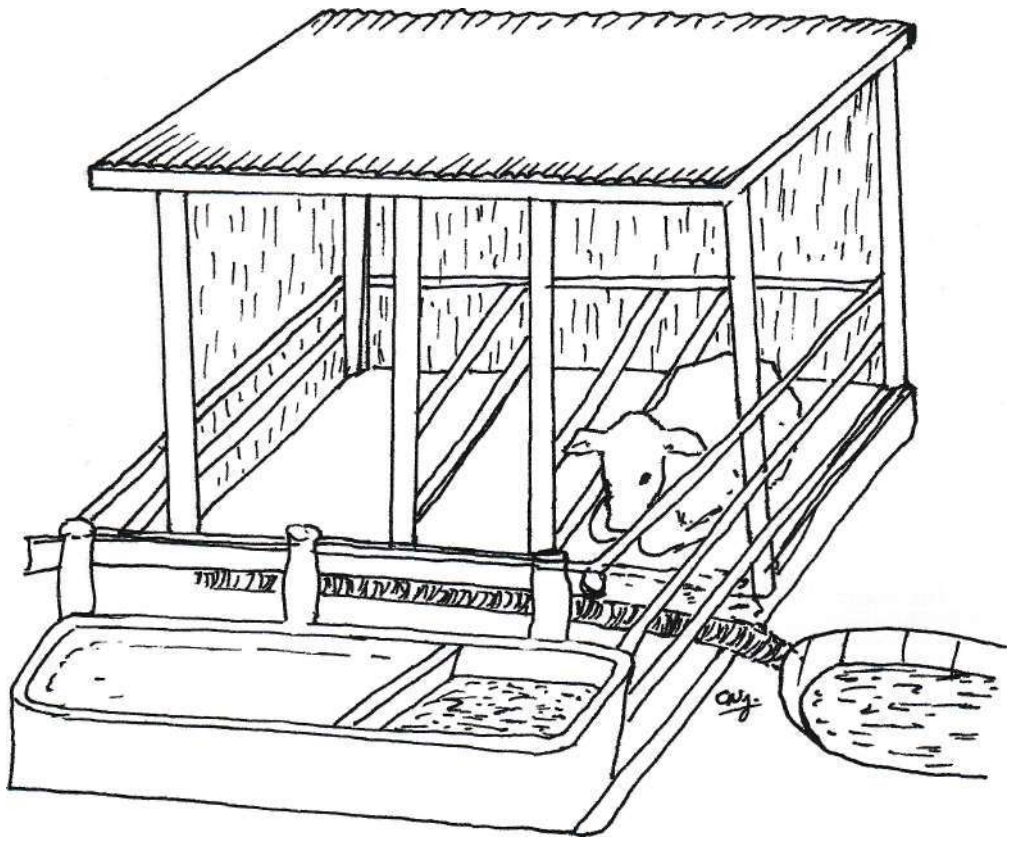


Figure 13 A *well-designed shed*

*adapted from "Integrated smallholder dairy farming manual". Heifer Project International. Kinscy, E. 1*993.

Organic Manures and Nutrient Cycling

Organic manure includes different types of manure obtained from plant and animal waste. Organic manure includes animal manure, compost, liquid and green manure. Animal manure includes dung, urine and other animal waste. Compost is obtained from plant residues and other wastes from home compounds. Liquid manure is prepared from animal dung or from fresh leaves of high-protein leguminous trees. Green manure, like compost, is obtained from plant residues and other wastes from home compounds. In this chapter, the production and benefits of producing organic manure is discussed.

Animal manure

Good handling of animal manure is necessary to avoid loss of volatile nutrients rich in nitrogen. It must therefore be covered with available material like banana leaves or polythene sheets. It should not be applied directly to the field, but should be left to decompose. When applying, the manure, it should be covered in the soil to avoid loss of nutrients and allow for further decomposition. The quality of the manure depends on the quality of the feeds.

Compost manure

During production of compost manure, large amounts of vegetation such as crop remains, garden weeds, kitchen and household waste, hedge cuttings, and garbage are put to good use.

Expected Benefits

- When properly made, compost is immediately available as plant food;
- Compost does not cause excessive weed growth;
- Good crop yields can be obtained without the need for extra chemical inputs;
- All farmers regardless of their financial abilities, can make and use compost;
- Compost manure can be used in all soils with low fertility;
- Compost manure is especially good in areas that receive low rainfall. In such areas, artificial fertilisers cannot be used effectively because of limited moisture;
- Compost manure is also useful in sandy soils which have poor water holding capacity.

Making compost manure

Making compost manure (composting) is the process of converting vegetation

materials such as crop residues, kitchen waste, household waste, hedge cuttings and garbage into valuable plant food called humus which is an organic fertiliser. This type of fertiliser has got balanced plant nutrients.

Description and design

Humus is an important type of manure. In the banana-coffee zone, compost pits are constructed within the home gardens or in the banana farms.

Humus is important because:

- It makes the soil crumbly and therefore easy to cultivate.
- A good soil with crumbly structure is well aired. Air in the soil is needed for growth by crops.
- Good aerated soil is essential for good root growth and decomposition of the humus.
- Humus increases the water holding capacity of the soil because it makes it spongy.

Materials needed for composting include:

- Dry vegetation material (100 parts).
- Green vegetation material (50 parts).
- It is recommended that the green vegetation include leaves of high-protein leguminous trees such as *Calliandra.*
- Animals' or birds' waste if available (6 parts). Cow dung and goat droppings are suitable.
- Ordinary top soil from the garden (7 parts).
- Ordinary wood ash.
- Water and materials for covering.
- Tools: ordinary hand hoe, panga or machete and a stick.

Establishment

Establishing a compost is not difficult. The process described in this section may seem long. However, the process can easily be adapted to suit specific conditions. Mrs Nalwoga Mariam Kasujja, of Nkozi sub-county, in Mpigi district, has successfully practised composting and improved yields of her bananas (Box 2).

Preparing compost

- Select a sheltered place with shade not far from the garden or where the compost will be used. Usually under a tree is better. In drier areas, the pit method is preferred because it conserves moisture. The pit method should not be used in wet areas as the composite may become waterlogged.
- In the pit method, the pit is usually 1.2 metres (4 feet) wide and 0.6 metres

deep (2 feet) and as long as necessary depending on the amount of material available. The pile is then built up in the pit. In the absence of natural shade make a simple artificial shade using locally available materials like grass or banana leaves. The place should be sheltered from wind, rain, sun and runoff.

- Measure out an area 1.5 metres wide and a convenient length depending on the quantity of available materials you can get. You must be able to work on the compost pile without walking on it.
- Loosen out the soil/ground where the compost pile will be constructed to 30 cm deep and water it. Put this soil on one side of the trench because you will need it later. The materials will need close contact with the loose soil at the bottom for good results.

*The Process of making the compost**

The following steps are taken to make the compost.

1. The first layer or course should be of rough dry vegetation materials such as maize stalks, dry grass and leaves or sunflower heads. Chop or cut these materials into small pieces, pile them to make a layer of about 30 cm thick.
2. The second layer should be of dry vegetation, hedge cuttings or grass.
3. Sprinkle water on this layer. The layer should be 10-15 cm thick
4. The third layer should be of animals' or birds' waste or old compost and should be about 10 cm thick. This layer is important as it contains organisms which are necessary for decomposition.
5. Sprinkle some top soil to a thickness of about 5 cm to cover the material.
6. This is followed by a layer of green leaves from high protein leguminous trees like *Calliandra,* Lusina *(Leucaena leucocephala),* Muzimbandeya *(Sesbania sesban)* and *Albizia.* This layer should be 15-20 cm. Where these materials are not available, any green grass or green leaves may be used.
7. Sprinkle wood ashes and top soil on the pile. The ashes contain valuable minerals and neutralise acids produced during decomposition.
8. Water the whole pile well using any container or preferably a watering can.
9. The process of layer preparation can be repeated starting with rough vegetation material, then grass, animal droppings, top soil, green leaves, ash and top soil and water.
10. Build the pile up to 1.5 m high. A well-made pile has almost vertical sides and a flat top.

*

Source: Sustainable Agricultural Practices and Technologies; Guidelines for Farmers. Produced by AFRICA 2000 NetworkAJganda, RSCU, December 1997

11. Take a long, sharp pointed stick and drive it into the pile of compost in a slanting manner.
12. Lastly water the pile slightly. The pile should never be too dry or too wet. Cover it all with a layer of top soil about 10 cm thick. Cover with dry vegetation to reduce water loss through evaporation.

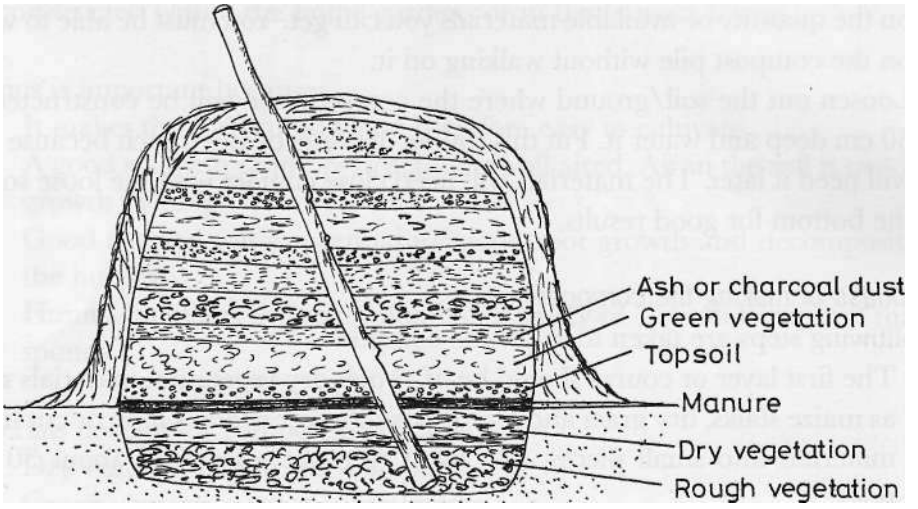


Figure 14 *A typical compost pile*

Box 2 *Making and using compost manure: case of Mrs. Kasujja*

Mrs. Kasujja lives in Nkozi, Mpigi district. She lives on a 4 acre (1.5ha) price of land. The four acres are planted with different crops. Bananas mixed with other annual crops like beans are grown on 1 acre. On another acre, she grows annual crops only. Coffee as a sole crop is grown on 1 acre. The homestead and a small home-garden cover another 1 acre of her land. The land which Mrs. Kasujja cultivates is family land. Her polygamous husband lives elsewhere with another wife. Mrs. Kasujja has therefore been the head of her household and makes all decisions on the use of farm resources.

She learnt about composting after attending a course on soil fertility and banana management by the Ministry of Agriculture in 1996. Her main reason for starting to make compost was to improve productivity of her farm which had started to decline.

Description of practice

The following is a description on how compost manure is made as narrated by Mrs. Kasujja. Her experience compared to the description presented in the previous section demonstrates the adaptation of the composting technology by farmers.

She digs pits approximately 6 ft (2m) wide and 6 ft (2m) deep in one area in the banana plantation. She then pours into the pits materials such as farm waste, kitchen wastes, weeds, poultry droppings, goat droppings, wood ash, and any green vegetation. A stick which is about 1 meter long is dipped into the material. The stick is used for testing the performance of the composting process.

The pit is covered with banana leaves and split banana stems. She then covers it with soil. Later on, the pit is opened and coarse material such as twigs and stones which cannot decompose are removed.

During a rainy season, the compost materials take 12 months to get ready for use as manure. To ensure continuous availability of compost manure, Mrs. Kasujja dug three pits. Each of the pits is filled at different times.

Application rates

According to her, a pit 6ftx6ft (2mx2m) can cover 40 banana stools (about 1 acre of land of a banana plantation).

On mature bananas, she places the manure 2ft away from the base of the banana stem. According to her experience, banana roots are found 2ft away from the stem. So they feed on the introduced manure. She applies about 1 basin full of manure per banana stool. When planting bananas, she first mixes the compost manure with topsoil before putting back into the holes for the bananas.

In the case of green vegetables, Mrs. Kasujja first mixes the compost manure with soil before sowing. She also applies the compost manure in holes before planting clonal coffee.

Cost of the technology

Estimating the cost of the technology can be difficult because most of the necessary resources are found within the farm. Labour for constructing compost pits is the most expensive input.

Mrs. Kasujja said the 6ft x 6ft pit took her sons aged 16 years and 14 years respectively, a total of 4 hours to dig. This is equivalent to one person working for a day which would have cost her Uganda shillings 1,000/=.

Benefits

According to her, practising composting has provided many benefits:

- The compost manure has maintained the bananas for a long time She established the farm in 1960 and its productivity was declining. The compost manure rejuvenated the farm.
- She observes that even in dry season her plantation looks healthier compared to those of her neighbours who do not use: compost.

- Pests such as nematodes have reduced.
- She harvests big bunches.

Limitations

- Compost manure attracts a lot of weevils. But she has learnt a cultural method of controlling them. She splits the banana stems after harvesting and this exposes the weevils. They are hand picked and killed.
- Composting is labour intensive.
- Composting requires a lot of materials. Some have to be got outside the farm and she lacks transport.

Managing the compost

- After 3-4 days, pull the stick out from your pile to see if decomposition is taking place in the pile. If the stick is warm and smells sligfrdy, the pile is decomposing.
- The stick also helps you to check on the condition of the pile from time to time. It will show when the pile is dry or moist. When it becomes cool, that shows that the decomposition has not taken place. The pile is turned for the first time. Sometimes the stick is white. This is caused by a fungus called fire fang which stops decomposition. To overcome this, add water and turn the pile.
- The pile must be watered occasionally, say every three days depending on weather conditions. If it is raining there is no need to water.
- After 2-3 weeks, turn the pile over. Do not add any fresh materials, during turning except water. Turning the pile is important because it mixes the different layers, making the decomposition faster and more complete.
- Make sure that while turning, the bottom part of the pile becomes the top of the new pile.
- The compost should be ready after 4 weeks. Check the condition of the pile. If the stick feels warm when pulled out of the pile, it means that the material is still decomposing and the compost is not ready. Ready compost should have a fresh, earthy smell and contain no grass, leaves or animal manure.
- Store the compost by covering it with a layer of banana leaves or polythene.

Using Compost

- Compost should be placed as close to plants' roots as possible.
- The bigger the amount applied the better the soil and crops.
- For perennial crops, compost should be applied at planting time and during the rains for better results.

Figure 15 *How to test decomposition in a compost pit*

- In case of tree crops make a trench of 3-4 inches (7-10 cm) deep at the end of the canopy and apply the compost. Cover with top soil.
- The earlier the compost is applied to the crop the better the results.
- In general, well decomposed compost should be applied at the rate of 20 tons/ha (8 tons/acre). This is about 2 large hoe-fulls per square metre or enough to barely cover the ground with a layer 1 cm thick.

Limitations to Compost Making and Use

- Compost requires a lot of labour to collect the materials, prepare it and spread it over the farm.
- The nutrient composition of the compost varies a great deal. It depends on the materials used and the preparation methods.
- Not enough vegetation to make compost may be available in drier areas.

Liquid manure*

Liquid manure is an organic fertiliser that is applied in a liquid form. It is applied to plants in their early growing stages after germination. It is prepared from either animal dung or from fresh leaves of high-protein leguminous trees.

Benefits of Liquid Manure

- Cheap source of nitrogen for plants. Increases yield of crops when used, especially on cabbages, tomatoes and eggplants.
- Easy to make.
- Cheap to make.
- Provides a chance to water the crops, especially in dry weather conditions.
- Promotes utilisation of livestock wastes.

Description and design

Liquid manure can be produced easily within a farm (Figure 16).

Materials and equipment needed:

- Chicken, rabbit, goat, pig or cow dung free of saw dust and stones.
- A drum or any similar size of container.
- A strong pole and rope.
- A strong sack/gunny bag.

The following steps are undertaken to produce liquid manure:

- Fill the gunny bag with animal dung about 50kg for $^{3}/4$ full of water in the drum. Tie off the mouth of the bag with a secure strong rope.
- Suspend the bag of dung in the drum of water. Cover the drum to prevent evaporation.
- Leave it to stand for 2 weeks.
- After 3 days and every other day thereafter, stir the drum by lifting the bag several times using the cross poles.
- At the end of two weeks, the water will have turned dark. Most of the plant food contained in the dung will have been washed into the water. Remove the bag and squeeze as much as possible into the drum.
- Dilute the contents of the drum in the ratio of 1:2. To one part of the liquid manure, add two parts of clean water. Then apply to growing plants. Figure 16 shows a drum used for producing liquid manure.

*

Source: Sustainable Agricultural Practices and Technologies; Guidelines for Farmers. Produced by AFRICA 2000 NetworkAJganda, RSCU, December 1997

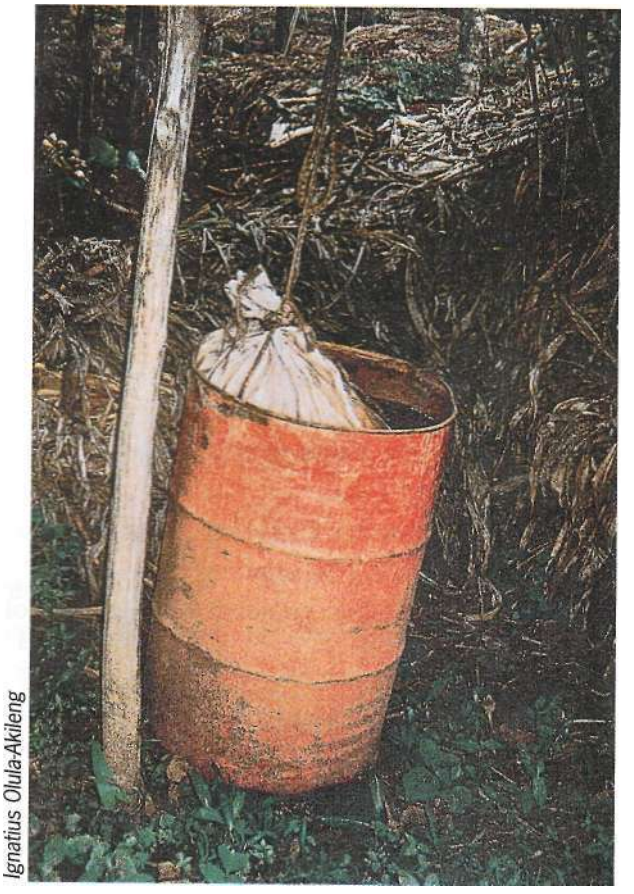


Figure 16 *Producing liquid manure*

How to apply

- Using a watering can, once a week, pour the liquid manure around the stem and not on the leaves of the crops. Water around the roots near the stem.
- Water with the liquid manure for 2 or 3 weeks. It is effective as top dressing fertiliser after planting the crop with the compost manure.

A similar type of liquid manure can be prepared from the leaves of leguminous trees high in nitrogen content. Such trees include Leucaena *(Leucaena leucocephala),* Miizimbandeya *(Sesbania sesban),* Gasiya *(Senna species),* Nongo *(Albizia zygia)* and Ebilamba (forage crops).

Limitations

- It is difficult to prepare and apply to large plots of land.
- Liquid manure splashed on plant leaves can cause damage.
- Poor farmers may not be able to afford the containers.
- Livestock waste may be scarce

Green Manure *

Introduction

Green manure is produced by planting fast-growing leguminous plants on a piece of land to improve soil fertility and protect the soil from erosion. They are normally low, spreading plants that grow fast and cover the soil surface quickly after planting. During or after the growing season, the green-manure plants are slashed and incorporated into the soil, where they decompose, releasing nutrients and improving the soil structure.

Expected *benefits*

- Some types of green manure plants provide food or fodder in addition to conserving and improving the soil.
- Lupin (a fodder legume) is good at recycling phosphorus as well as nitrogen.
- Green manure suppresses weeds by shading them out.
- Relatively little labour is needed, compared to other ways of adding organic matter tc the soil.
- Green manure is cheap to plant and easy to manage.

Green manure conserves and improves the soil in several ways:

- Legumes such as soybeans, green grams, groundnuts and pigeon peas take nitrogen from the air and fix it in a form they can use. When the legume dies and rots, the nitrogen in the leaves, stem and roots is released into the soil, where other plants can use it. The rotting plants also increase the amount of organic matter in the soil.
- Green-manure crops prevent the soil from being washed away by rainwater. If raindrop hits bare soil, the splash dislodges tiny soil particles, which can be washed away easily. The impact of raindrop also compacts the surface, making it harder for the rainwater to seep into the soil. Instead of seeping in, the water runs off the surface, carrying with it the dislodged particles. On gentle slopes, this can cause gullies. The green manure acts as a cover crop. It breaks the fall of raindrops. This prevents compaction and helps the water seep into the soil instead of running off. Roots bind the soil and stop running water from eroding it.
- The green-manure crop protects the soil from the direct heat of the sun, helping it to retain moisture. It breaks the wind and stops soil particles from being blown away.
- The green-manure crop can be grown as a pure stand, to enrich the soil for a cereal crop grown in a subsequent season. It can also be grown as an inter-crop between rows of another main crop, such as maize, sorghum and

millet, or beneath fruit trees. Growing of green manure crops is especially appropriate in the following situations:

- If soils are infertile and in areas with low rainfall, where artificial fertiliser cannot be used effectively because of limited moisture.
- On sandy soils, as deep-rooted legumes help recycle nutrients.
- On heavy clay soils.
- On hilly slopes and places prone to strong winds.

Establishment

To grow a green manure crop, one requires green-manure crop seeds, inoculant (for some types of legumes), a hoe and sand. The sand is mixed with the seeds of the green manure crop before planting to reduce crowding of germinated seedlings.

Planting as a pure stand

The following steps are followed to establish a pure stand of a green manure crop.

1) Prepare a seedbed by digging the soil and removing the weeds.
2) Water the seedbed, and plant the seeds or cuttings of the green-manure crop. Space the plants closely so they cover the ground quickly when they start growing.
3) If necessary, weed the plot regularly to reduce weeds and pests.
4) While the green manure crop grows and flowers, it fixes nitrogen in the nodules on its roots. After flowering, the legume leaves fall off, increasing the amount of organic matter in the soil. Sun hemp is a good type of green manure crop. Turn the sun hemp into the soil just after the plants have flowered.
5) Gut the leaves and stems for fodder if necessary, but do not remove the entire plant or expose the soil surface.
6) Harvest the pods of the green-manure crop to obtain seeds
7) Slash the remaining stalks and leaves and, if possible on the same day, turn them into the soil. Fodder legumes, such as velvet bean and lablab bean, can be left to grow for up to 2 years before slashing them.
8) Wait for at least 7 days before planting the next crop to allow the stalks and leaves to decompose.
9) Plant the next crop as a pure stand of cereal, or inter-crop again with legumes.

Planting green manure as an inter-crop

A green-manure legume can also be planted as an inter-crop between the rows of the main crop. Choose the type of green manure and planting times carefully so it will not grow taller than the main crop and shade it out.

- Choose the type of green manure crop that grows well in your area. For most legume species, plant at the same time as the cereal crop, so the crops can germinate before the heavy rains. Broadcast small-seeded legumes, such as *Sun hemp, stylosanthes,* red gram and *seratro.* Plant larger seeds in rows between the rows of cereal. Plant *velvetbean* and *lablab* bean about 2 weeks after the cereal, as they grow fast and would shade out the cereal if planted earlier.
- Continue with steps 3-9 as outlined for planting pure stands of green manure crop.

Limitations

- The benefits of green manure may be long-term if the practice is not continued
- It can be difficult to incorporate green manure into an existing cropping system.
- Some green-manure crops may compete with the main crop for light and nutrients. It is important to select green manure crops carefully so that they do not interfere with the main crop.
- Some green manure crops may attract new pests and diseases which may attack the crops.
- Some may become weeds by seeding and growing in the crop field during the next season.
- Green manure crops may not grow well in the dry season, especially in drier areas.
- If a green-manure legume has not been grown in the field before, the soil may not contain the bacteria it needs to fix nitrogen.

Home gardens

Introduction

A home garden is an agroforestry practice that is common throughout Uganda. Different types of products and services are obtained from the various tree species and crops grown in a home garden. For example, yields of about 150 kg/ha of beans, 400 kg/ha of un-husked coffee, and 400 kg/ha of bananas; variable quantities of fruits, vegetables, and herbs can be produced.

Some farmers say that home gardens are a good way of using land for a long time without using a lot of labour. The experience of Mr. Charles Ntege of Kiwanga Village in Mukono District illustrates benefit of homegardens presented in Box 3.

Expected benefits

Services

- Improve soil fertility.
- Control of soil erosion.
- Conservation of soil moisture and so improved cropped yields.
- Reduced total crop failure because many types of crops are grown.
- Due to closeness to homesteads, home-gardens are easy and convenient to manage.
- Time and energy saving because the garden is near the home.
- Improved crop yields.
- Improved nutrition for the family.
- Re-use of water from households.

Products

- Food supplies and regular cash incomes from many products (fruits, vegetables and herbs, fuelwood, fodder, timber and poles).

Description and design

Home gardens consist of a diverse mixture of vegetables, fruits, and medicinal plants and also fodder grasses and shrubs in small intensively cultivated plots in and around home compounds. In heavily populated areas like Mpigi, Mukono and Masaka, land owned by households average 0.2 ha. The households inter-crop many different types of food crops and herbs. The density of vegetation in the farm of Ntege (Box 3) illustrates the density of crops in home gardens. The common species in home gardens in the banana-coffee farming system are listed in Table 4.

Box 3 Home *gardens:* Mr. Ntege's case

Mr. Ntege lives in Kiwanga village, Goma sub-county in Mukono District. The land on which he and his family live is a *Kibanja* in *mailo* land. The area of land to which he has user right is three acres. Of this, he established a home garden on one acre. He established the home garden because the land he "owns" is small and he was also interested in growing perennial fruit trees.

To establish the home garden, Mr. Ntege first planted the fruit trees such as jackfruit Fene *(Artocarpus heterophyllus),* Avocado *(Persea americana),* Paapali *(Carica papaya),* and Muyembe *(Mangifera indica).* Later he introduced crops like coffee and bananas as well as napier grass. Trees that grow to large sizes like Nsambya *[Markhamia lutea),* Musizi *(Maesopsis eminii)* and Mlituba *(Ficus natalensis)* were introduced much later. He found some of the Nsambya *{Markhamia lutea)* trees growing naturally on the land. Nsambya *[Markhamia lutea)* regenerates easily through self-seed dispersal.

Although Ntege's land is small, he has 22 Robusta coffee, 10 Paapali, 20 Avocado, 25 Fene, 6 Mutuba, 3 Musizij many Nsambya trees and 30 banana stems. Even though his farm is congested with different types of crops, he uses very little labour in the management of the farm. Apart from periodic introduction of new food crops, he does not prepare for a new season crop because few weeds grow underneath the heavy canopy of trees. Weeding is also minimal. But, he keeps a keen eye on bananas and applies wood ash on bananas just before the rains to control the banana weevil. Soil resilience is possible because of decomposition of the heavy leaf litter.

At 60 years, Ntege looks back and counts many economic benefits that he has obtained from the small farm. He has been able to bring up his seven children; four of whom are now independent adults. He depends heavily on the sale of poles of Nsambya *[Markhamia lutea).* Each pole sells at USh 800. In addition, firewood harvested from Mutuba *(Ficus natalensis)* and other trees covers the domestic needs for fuel and also fuel for firing bricks; a major source of income for Ntege. He has a major plan to build a new house. He will produce about 10,000 bricks for building the house. To fire the bricks, most of the firewood will be harvested from his farm. A fired brick costs USh 80. So Ntege will have saved USh 0.8 million which he would have used to buy the 10,000 bricks for building his house.

The main benefit of home gardens, said Ntege, is that many different products and services can be obtained from the farm for a long time.

Table 4 *Some common trees, shrubs and food crops in home gardens*

LOCAL NAME (LUGANDA)	COMMON NAME	SCIENTIFIC NAME
	A. Trees/Shrubs	
Avocado	Avocado	Persea *americana*
Fene	Jackfruit	*Artocarpus heterophyllus*
Mapeera	Guava	*Psidium guajava*
Mmwanyi	Robusta coffee	*Coffae canephora*
Mucungwa	Oranges	*Citrus species*
Mugavu		*Albizia coriaria*
Mukoge		*Tamarindus indica*
		Vanguria infausta
Mukunyu		*Ficus mucosa*
Mululuza		*Vanguria apiculata*
Musizi		*Maesopsis eminii*
Mutuba		*Ficus natalensis*
Muwafu (Mpafu = fruit)		*Canarium schweinfurthii*
Muyembe	Mango	*Mangifera indica*
Muzimbandeya		*Sesbania sesban*
Nongo		*Albizia zygia*
Nsambya		*Markhamia lutea*
		Psendospondius microcarpa
Paapali	Pawpaw	*Carica papaya*
		Garcinia apiculata

LOCAL NAME (LUGANDA)	COMMON NAME	SCIENTIFIC NAME
	B Food Crops	
Bamya	Okra	*H. esculentus*
Bijanjalo	Beans	*Phaseolus species*
Bitooke	Banana	*Musa spp.*
Enva endirwa	Sour greens	*Hibiscus communis*
Kaloofi	Arrow roots	*Maranta arundinacea*
Kamulali	Hot pepper	*Chilli*
Kasooli	Maize	*lea mays*
Katunda	Passion fruit	Pass/flora *edulis*
Lumonde	Sweet potatoes	*Ipomoea batatas*
Mayuuni, Bira, Ndagu	Yams	*Dioscorea alata*
Mboga	Cabbage	*Brassica oleracea*
Muwogo	Cassava	*Manihot esculenta*
Nanaansi	Pineapples	*Ananas comosus*
Nyanya	Tomato	*Lycopersicon esculenta*

The different types of trees and crops listed in Table 4 are planted in specific areas of the home garden. Figure 11 shows a typical arrangement of crops in a home garden.

Figure 17 *A typical arrangement of crops in a home garden*

Establishment

The establishment of home gardens requires a lot of time and labour. This is because trees in home gardens may be planted or may be managed after they have grown naturally. But after establishment, homegardens require less time for maintenance. There are three main methods for establishing home gardens. These are:

- Adding new tree species to an existing garden,
- Adding vegetables, fruits and root crops, beneath open canopy of existing trees, and
- Planting desired tree species and crop combinations on clean prepared plots.

Management

Home gardens are a complex land use practice whose management varies from farm to farm. With regard to vegetables produced from home gardens such as spinach, nakati and dodo, harvesting can be done every two weeks and sold in

bundles of USh 100, 200 and 400/-. An average sized double-dug home garden bed produces 20 bundles every 2 weeks. This is a source of regular income. With regard to trees in home gardes, the narration by Mr. Ntege in Box 2 shows this.

Limitations

Although home gardens are an agroforestry practice known to farmers, information that can provide general guidelines on management is limited.

Trees and Shrubs for Soil and Water Management

Introduction

The management of soils on a farm includes soil and water conservation and soil fertility management. This section focuses on trees and shrubs for soil conservation throughout the farm and includes a small section on improved fallows for annual cropping land.

Earth works are mainly constructed in areas where land is not flat. In such areas, soil can be washed away by rainwater. After many years, if earth works have not been constructed to prevent soil from being washed away, the soil becomes less fertile and crop yields decline. Earthworks are therefore constructed on slopy ground to prevent run-off of water and soil erosion. Trees, shrubs or grass planted on the earthwork structures stabilise them.

There are many types of earthworks. Some need a lot of labour to construct, others are constructed easily. Even after construction, earthworks should be managed to ensure that they do not break down. In this chapter, two common types of earthworks and their maintenance are discussed. These are "Fanya Juu" and "Fanya Chini".

Expected benefits

- Prevent soil from being washed away by rain water.
- Trees and shrubs occupy space along ditches and on top of ridges. These are areas where crops are not grown. So, total output from the farm is increased.
- Trees and shrubs on earthwork structures can provide crops with light shade, shelter from wind and nutrients from increased leaf litter.
- Increased crop yields because of improved soil moisture availability.
- Different types of products like fodder, timber, medicines and fuelwood can be obtained from trees on earthworks.
- Roots and leaves from the trees stabilise the earth structures and improve soil and water conservation.
- The benefits of earth structures for management of land are many as the discussion with one farmer in Mbarara reveals (see Box 5).

Description and design

Small earthwork structures can be used to slow down runoff water, prevent soil erosion and hence improve water conservation in croplands. When runoff water is slowed down, the water infiltrates the soil and is available to crops. In addition to conservation of both soil and water, earthwork structures provide good planting sites for trees, shrubs and grasses. Figure 18 shows trees on earthwork structures.

Alice A. Kaudia

Figure 18 *Trees on earthworks*

Description of "Fanya Juu" and "Fanya Chini"

It is recommended that "Fanya Chini" should be constructed on the upper part of the farm so as to trap run-off water. "Fanya Chini" may also be constructed in the middle of the farm if the slope of the land is very gentle. "Fanya Juu" should be constructed in the middle and lower sections of a farm especially in areas with very steep land. "Fanya Chini should not be constructed in such areas. Table 5 shows the recommended inter-hedge spacing for different slopes.

Table 5 *Slope of land and distance between hedges*

SLOPE (%)	DISTANCE BETWEEN HEDGES (M)
15	30
20	26
30	22
40	20

Woody plants such as *Calliandra,* Muzimbandeya *(Sesbania sesban),* Lusina *(Leucaena leucocephala)* are planted to stabilise the ridges of soil. Fodder and fuelwood can be

harvested from the trees and shrubs. Other tree species that can be used for stabilising the earthworks include: *Grevillea,* Nsambya *(Markhamia lutea),* Mutuba *(Ficus natalensis)* and fruit trees. Grasses, mainly Napier, *Setaria splendida* and *Tripsacum laxum,* are planted on the ridges of small earthwork structures to stabilise them. The grasses can be harvested periodically for fodder. The grasses can be grown together with the trees and shrubs on the ridges.

Establishment

The "Fanya Juu" trenches are made by digging soil from the trench and throwing it uphill to form a ridge while for "Fanya Chini" the soil from the trench is thrown downhill. Figure 19 illustrates a "Fanya Juu" and a "Fanya Chini" respectively.

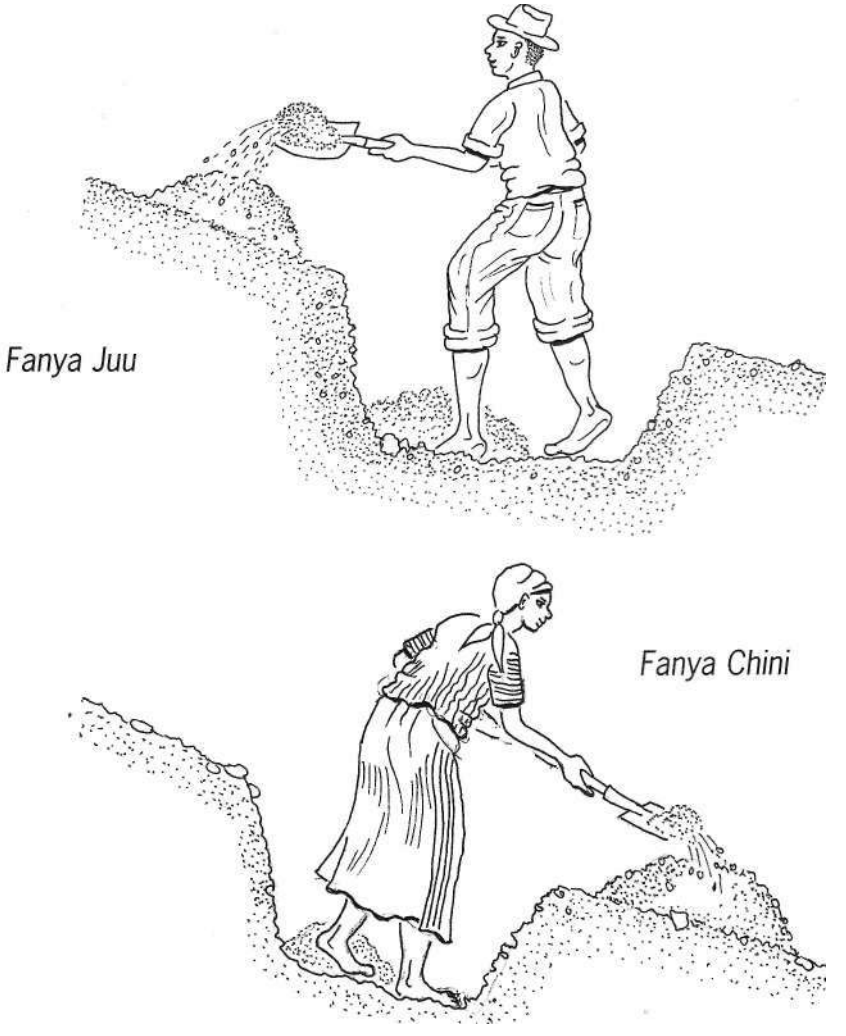


Figure 19 *Fanya Juu and Fanya Chini*

Before constructing the earthworks, careful planning is necessary. This involves determining the slope of the land, the type of earthwork to be constructed, the location of contour lines and the distance between them and their width.

There are two types of tools used for locating the contours and determining the distance between contours. They are the spirit or line level and the A-Frame (Box 4). Only one of these tools is needed. The use of any of these tools requires some skills. In addition, the tools may not be easily available locally. It is therefore advisable to contact the local Agricultural Office for assistance on the laying-out of contours.

Box 4 *Contour farming using the spirit or iine level and A-Frame* *

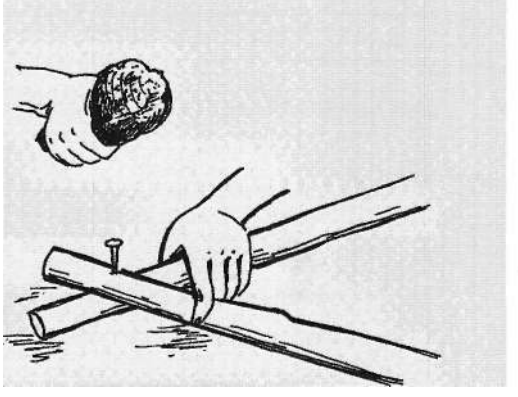
Contour Farming

Soil erosion can be a major problem which, if not controlled, results in loss of the top soil and decline in land productivity. Over time, a number of practices and technologies to control soil erosion have been developed. These involve the creation of barriers along contours which slow the speed of water run-off down the slope and therefore encourage sinking of water into the soil. These practices and technologies require a farmer to first locate contour lines using either a line level or an "A-frame".

Below is a description on how to construct, mark and use an A-frame to establish contours.

Materials

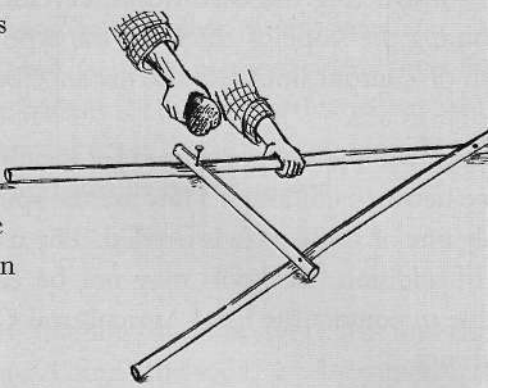
- two strong sticks each, 6 ft (2 m) Ion;
- one stick, 4 ft (1.5 m) long
- three 2-inch (5 cm) nails
- about 4 ft (1.5 m) of strong string
- a fist-sized stone
- two pegs about 2 ft (60 cm) long.



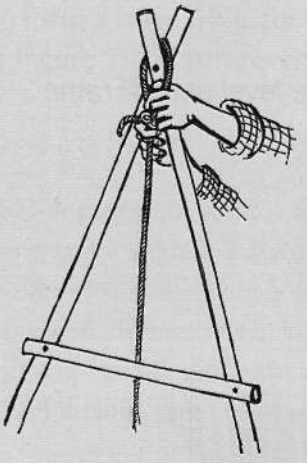
Method

Step 1 Cross the two 6-ft long sticks at the top and nail them together securely.

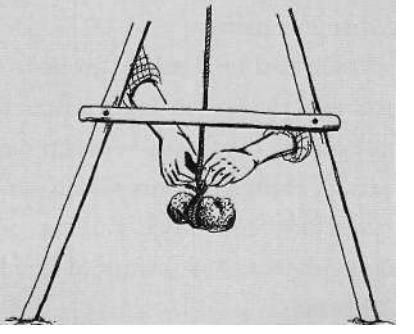
Step 2 Nail the 4-ft-long stick across the other two to form the letter "A".



Step 3 Tie a string to the top of the A-frame and let it hang down below the crossbar.



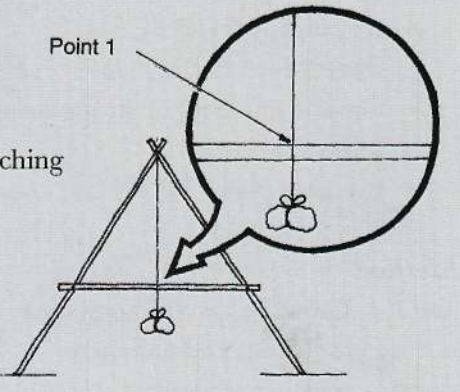
Step 4 Tie a stone to the end of the string, below the crossb



Now the A-frame is almost complete, but before it can be used to mark contours, a point must be found on the crossbar which will indicate when the two legs are in a level position.

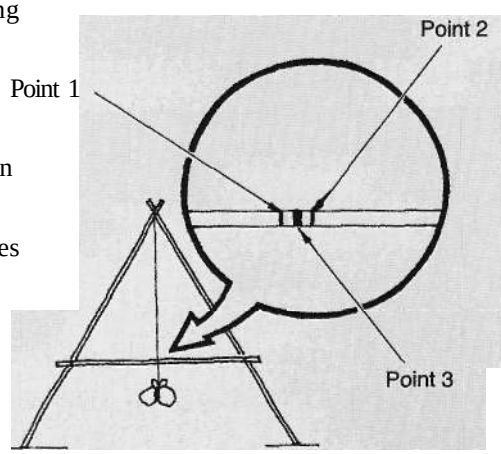
Step 5 Stand the A-frame upright and drive a peg into the ground next to each leg of the A-frame.

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 one touches the second peg and leg two touches the first peg.

Step 8 If the ground is level, the string will settle in the same position as in Step 6. Now move to Step 10. 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 9 Put a third mark (Point 3) halfway between Points 1 and 2. This is the point on the crossbar which will indicate when the two legs are in a level position.

Step 10 Using a panga or knife, make a permanent mark by cuttins a notch *At* the level position.

Step 11 When the weighted string hangs directly in front of the cut notch, the two legs are in a level position.

Now the construction of the A-frame is complete and it is ready to be used to mark contours on sloping land!

Using an A-Frame to Establish Contours

To determine the location of contours using an A-frame, do the following:

Step 1 Study the area of your field on which you want to construct contour barriers. Start at the highest point (upper boundary) of your field. The A-frame should only be used when the ground is firm, like in the dry season when the legs of the A-frame do not enter the soil.

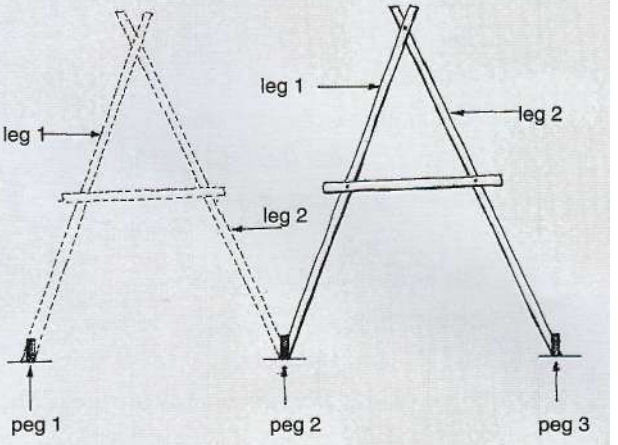
Step 2 First, cut a supply of pegs. These are used for marking level lines where contour barriers will be constructed.

Step 3 Drive the first peg (peg 1) at the uppermost edge of the field. You will begin marking the contour lines at this point.

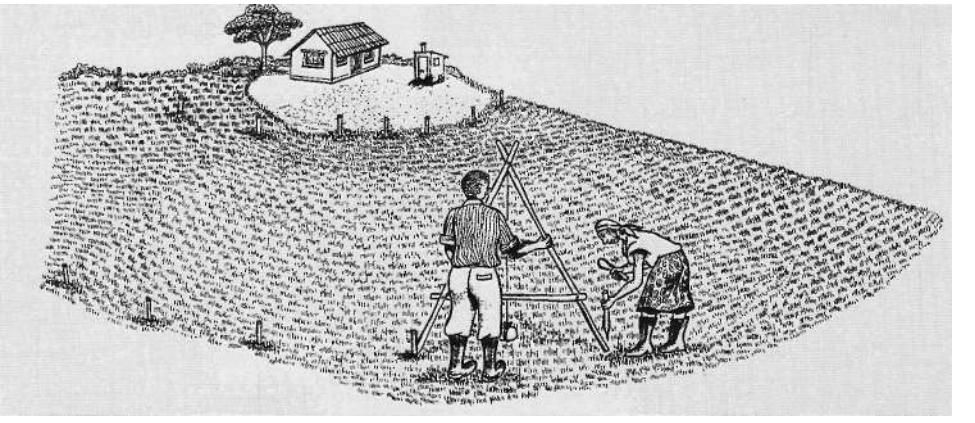
Step 4 Place one leg (leg 1) of the A-frame just above peg 1. Adjust the other leg (leg 2) until the string settles at the position of the notch without touching the crossbar.

Step 5 When the string settles at the position of the notch, drive another peg (peg 2) into the ground just above but touching leg 2 of the A-frame.

Step 6 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 7 Lift the A-frame again putting leg 1 at peg 2. Adjust leg 2 until the string settles at the position of the notch without touching the cross bar as in Step 4 above. Drive another peg (peg 3) just above but touching leg 2 of the A-frame.



Step 8 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 9 Adjust the pegs which are not in line with the others to make a smooth curve.

Source: Sustainable Agricultural Practices and Technologies; Guidelines for Farmers. Produced by AFRICA 2000 NetworKAiganda, RSCU, December 1997

After the positions of contours are marked, the construction of the earth structures follows. The following steps are taken to establish earth structures and the stabilising trees and grass. These can be grass only or grass and trees/shrubs.

- Dig a canal and either, throw the soil above the canal to construct "Fanya Juu" or on the lower side of the canal to construct "Fanya Chini". The width of the canal will depend on the slope of the land. Generally, it is recommended that the canal should be 1.5-2 feet (45cm-60cm) wide and 1.5-2 feet deep;
- On the bands, dig holes 6 inches (15cm) deep and 1-2 feet (3cm-60cm) apart for planting grass/shrubs. Along the same bund, holes 3 feet (lm) deep are dug 10 feet (3m) apart for planting seedlings that grow to big trees like *Grevilka robusta;*
- Plant the grass or tree seedlings/shrubs.

Management

- It is recommended that at the end of the rainy season, the structures should be repaired. With time, soil refills the trenches and should be scooped out.
- Prune the trees and shrubs to reduce possible shading of surrounding crops. The shrubs can be pruned at knee-height at the end of each rainy season.
- Patches without grass should also be re-planted. The topsoil on the band can be covered with banana leaves for a week before re-planting grass. This makes the soil moist and warm so the planted grass establishes easily.

Limitations

- The establishment and management of the earth work structures requires a lot of labour. However, as the explanation by one farmer of Munaku Kaama group of Masaka district and William Matovu (Box 4) of Mbarara suggest, reciprocal labour from clan/women groups can reduce the labour constraints.
- The trees and shrubs may harbour pests and diseases for crops.
- Skills for proper layout and management of the earth works are necessary.

Box 5 *Earthworks for soil and water management: Mr. Matovu's experience*

Degradation of land in most parts of Uganda has reduced crop yields to very low levels. However, by applying soil and water conservation practices, the value of such land can be restored. Mr. Matovu William of Mbarara district has achieved this type of restoration.

Matovu comes from Kashungwe village, Bugamba sub-county in Mbarara district. In 1976, the owner of the land in which Matovu is settled sold the land to him and moved to Bunyoro. The owner sold the land because it was not fertile and yields of crops were too low. Since 1994, Matovu started constructing earthworks to improve his land. "Fanya Chini" is the type of earthwork on Matovus' family farm. His reason for constructing "Fanya Chini" was that they are simpler to construct compared to "Fanya Juu" and other farmers too were constructing the "Fanya Chini". In addition, labour for constructing earth works is expensive and he was relying on group labour.

He belongs to the Kashungwe Farmers Group. This group is comprised of representatives from 16 families in the village. The group was taught the values of soil and water conservation structures on slopy land and how to layout the contours and construct the structures by the Uganda Soil Conservation and Agroforestry Pilot Project (USCAPP). With the help of the group, Matovu constructed "Fanya Chini" on 1-acre portion of the land where he grows bananas. The dimensions of the channels are 60 cm wide and 30 cm deep. Labour provided by the group saved him Uganda Shillings 20,000/= per 30 metres length that he would have paid to hire labour.

The benefits that Matovu family has obtained by constructing the earthworks for soil and water conservation are numerous. From land that could not yield much, he has been able to obtain good income, from various farming activities in his farm.

The 60-year-old farmer has been able to provide for his family of 9 children, his wife and himself. He keeps 16 cattle of local breed and cuts the *Setaria* grass on the bunds 3-5 times a year, depending on the weather, this grass is used to feed his animals.

When the previous owner came back, he saw the improved farm and wished he could get it back. Matovu appreciates the role of earthworks in improving productivity of land, but notes that labour for establishment and management is a major constraint.

Improved fallows in annual cropping land

Some farmers in the banana- coffee farming zone of Uganda currently leave a portion of their land to rest after continuous cropping for long periods, because they have noticed a decline in productivity on these sites. The resting of land is mainly aimed at restoring soil fertility. Legume crops such as Mucuna, lab-lab, Mpinamiti/ Nkoolimbo *(Cajanus cajan)* and legume tree crops such as Muzimbandeya *[Sesbania sesbari),* Calliandra *[Calliandra calothyrsus),* Crotolaria *[Crotolariagrahamiana)* and Tephrosia *[Tephrosia vogelii)* species, are used to improve existing fallow systems. These plants give additional benefits like reducing soil erosion, controlling weeds *[Striga asiatica)* , supplying firewood, nutrient cycling and adding organic matter to the soil. The fallow also provides fodder for animals tethered on the fallow land.

Muzimbandeya *[Sesbania sesbari)* fallows do best in relatively deep soils of medium texture (sandy loam or clay loam), but less well in sandy, shallow or stony soils. Fallows do not establish well in soils that are low in nutrients especially phospohorus. In the first year, trees can be planted and grown with the maize crop. Once established trees are thinned to a lm x lm spacing. The trees are allowed to grow for 2 to 3 years, by this time they will have grown to about 5m tall, and will have produced a large amount of fallen leaves and firewood. The trees are then clear cut, and the field can again be planted to agricultural crops. Best effects have been noted if the fallow is followed by a crop of maize.

Muzimbandeya fallows can be established by direct seeding or with potted or bare-rooted seedlings. Most of the fallow species establish well with seeds. An exception is Calliandra that is best established from seedlings (potted or bare root). To establish fallows from seeds put 2 -3 seeds in a planting hole and cover with little soil. Thin the germinated seedlings after 2 -3 weeks to one per hole.

For a fallow to establish well, a bacteria in the soil called Rhizobium needs to be present. This bacteria is available in places where there are natural stands of Muzimbandeya *[Sesbania sesbari)* or beans . If the fallows are to be planted in lands previously under these crops, they will automatically be infected with Rhizobium. This bacteria, can also be found around well -established wild or planted Muzimbandeya *[Sesbania sesbari)* trees. The bacteria are found in the soil close to the surface (0-15 cm), around the small lumps found on the young roots close to the tree. Surface soil collected from around these well established trees can be mixed into the soil used for potting seedlings, or in bare-rooted beds. It is more difficult to make this bacteria available to seed that has been broadcast in the

field. Soil from around mature Muzimbandeya *(Sesbania sesbari)* trees can be placed in the seed planting holes.

The main benefit of the Muzimbandeya (*Sesbania sesbari)* fallow is that it restores soil fertility. The trees produce 6 tonnes of fallen leaves per year. These leaves provide needed food for the soil. After clearing, the roots of the trees also remain in the soil and as they rot over time also provide food for the soil. The improved soil fertility also greatly reduces the presence of Striga weed in fields that have been fallowed, in some cases getting rid of the weed entirely. The effects of the fallow lasts up to three cropping seasons after it has been clear cut. This agroforestry practice is therefore most effective as part of a regular rotation of crops in annual cropping fields. Muzimbandeya *{Sesbania sesban)* fallows promote nematodes in some soils, especially sandy soils. These nematodes reduce yields of beans and tomatoes if they follow immediately after the Muzimbandeaya *{Sesbania sesbari)* fallow. Maize is not affected by these nematodes. It is therefore recommended to plant maize immediately after the fallow is clear. Beans and tomatoes can be planted again after one season of maize.

Improved fallows may not be the best option for improving soil fertility, for farmers with smaller areas of annual cropping land. For farmers that prefer to grow their crops every year, and not to leave land fallow, composting and organic manures, as described in earlier sections of this book, may be better options.

Multipurpose Trees in Banana-Coffee Gardens

A. Multipurpose Trees

Introduction

Like home gardens, multi purpose trees in banana-coffee gardens is a common agroforestry practice in Uganda. However, the density of trees in banana-coffee system is low compared to the situations in the home gardens. Some of the multipurpose trees and shrubs common in farmlands are listed in Table 6a and 6b. The products and services commonly obtained from these trees are also listed.

Expected benefits

- Provide products of commercial or subsistence value. Some of these are listed in Table 6a and 6b;
- Provide services such as soil fertility improvement, soil and water conservation, improvement of microclimate resulting in increased crop yields;
- Many different types of products and services can be obtained from the same piece of land;
- Products and services can be obtained on a regular basis for a long time. The banana-coffee systems can be sustained for a long period of time.

Description and design

The maintenance of scattered trees on cropland is a traditional practice throughout the banana-coffee farming system. Scattered multipurpose trees on cropland are perceived to compete minimally or not at all with the companion crops. The bark-cloth trees like Mutuba *(Ficus natalensis)* are planted among banana and coffee for production of bark-cloth and provision of services such as windbreaks support for vines, improvement of soil fertility, and creation of a favourable microclimate for crops. Trees suitable for growing in the Lake Victoria Crescent of the banana-coffee farming system are: Mutuba *(Ficus natalensis),* Musizi *(Maesopsis eminii),* Nsambya *(Markhamia lutea),* Muzimbandeya *(Sesbania sesban)* and castor oil trees. Closer to the homesteads fruit trees like Muwafu *(Canarium schweinfurthii), Vanguna infausta,* Mutugunda *(Vangueria apiculata),* Muziru *(Pseudospondias microcarpa), Garcinia apiculata,* Mango/Muyembe *(Mangifera indica),* Guava/Mapeera *(Psidium guajava),* Fene *(Artocarpus heterophyllus),* Avocado *(Persea americana),* and Pawpaw/Paapali *(Carica papaya)* are commonly planted. In the dry areas north of Lake Victoria crescent and in Iganga and Kamuli districts, Mukuyu *(Ficus sycomorus),* Mugavu *(Albizia coriaria),* Muvule *(Milicia excelsa),* and Mukoge *(Tamarindus*

indica) are deliberately retained by farmers on farm lands. In drier parts of Mbarara and Bushenyi, Mukebu *(Cordia ajricanum),* Nsambya *(Markhamia lutea),* Musasa *(Sapium elipticum)* and Castor oil/Ensogasoga *[Croton macrostachyus)* are commonly grown. Other species grown in the banana-coffee farming system include: *Grevillea, Casuarinajunghuhniana* and Musenene *(Podocarpusgracillor).* Scattered trees on cropland may also be combined with earthwork structures for soil and water conservation.

Table 6a *Common multipurpose trees and shrubs and their expected benefits (products)*

PRODUCT	COMMON NAMES AND SPECIES
Food	Fene (Jackfruit), Paapali (Papaya), Avocado *{Persia* americana), Mapeera *(Psidium guajava),* Muyembe *{mangifera indica),* Kitafeli (Morus a/ba/Mulberry), Mucungwa *(Citrus* spp.)
Fuelwood	Nsambya *{Markhamia lutea),* Mugavu *{Albizia coriaria),* Mukebu *(Cordia abyssinica),* Gasiya (Senna *spectabilis),* Musasa *(Sapium elipticum),* Muzimbandeya *(Sesbania sesban),* Musizi (Maesopsis *eminii),* Calliandra *(Calliandra calothyrsus)*
Building poles	Nsabya *(Markhamia lutea),* Grevillea (Grevillia robusta), Mutuba *(Ficus natalensis), Senna* s*amea, Gasiya (Senna spectab/7/sj
Stakes (for banana, passion, tomatoes)	Nsogasoga (Castor oil), Nsambya *(Markhamia lutea),* Mutuba *(Ficus natalensis),* Gasiya (Senna spectab/7/s]
Fodder	Muzimbandeya *(Sesbania sesban),* Calliandra *(Calliandra calothyrsus, Leucaena* spp., Mutuba *(Ficus natalensis),* Enkenene *(Morus alba)*
Gum	Muwafu (Canarium *schweinfurthii),* Mugavu *(Albizia coriaria), Ficus mucosa,* Mutuba *(Ficus natalensis),* Omukapa, Olukone
Oil	Enshogashoga (Caster oil plant), *Croton macrostachyus,* Sunflower
Timber	Mvule (M7/c/a exce/sa), Nongo *(Albizia coriaria),* Musizi *(Maesopsis eminii), Cordia africana,* Musenene *(Podocarpus gracillor),* Nsambya *(Markhamia lutea)*
Bark Cloth	Mutuba *(Ficus natalensis)*
Medicine	Muyovu (Entandrophragma *cylindricum),* Ntasesa/Ngwabuzito *(Prunus africana), Spathodea nilotica*

Establishment

Multipurpose trees scattered on cropland mainly originate from natural regeneration and deliberate planting of seedlings or sowing of seed. The practice involves planting new trees or tending selected wildings from natural regeneration.

Table 6b *Common multipurpose trees and shrubs and their expected benefits (service benefits)*

SERVICE	LOCAL NAME AND SPECIES
Improve soil fertility	Mutuba *[Ficus natelensis),* Mugavu *(Albizia coriaria),* Muvule *[Militia excelsa),* Muzimbandeya *(Sesbania sesban), Calliandra calothyrsus, Leucaena leucocephala*
Improve soil moisture conservation	Muvule *{Melicia excelsa),* Mutuba *(Ficus natalensis), Cordia africana*
Control soil erosion	Nsambya *(Markhamia lutea), Cordia africana, Grevillea robusta, Calliandra calothyrsus,* Muzimbandeya *(Sesbania sesban),* Kiryowa/Kinowa *(Jatropha curcas)*
Shade	Musizi *(Maesopsis eminii),* Mutuba (Reus *natalensis),* Muvule *(Militia excelsa), Cordia africana,* Mugavu *(Albizia coriaria)*
Windbreak	*Grevillea robusta,* Mugavu *(Albizia coriaria),* Musizi *(Maesopsis eminii),* Mutuba *(Ficus natalensis)*
Pest control	Neem *(Azadirachta indica),* Musasa *(Sapium ellipticum)*
Marking boundaries	Nsambya *(Markhamia lutea),* Kiryowa/Kinowa *(Jatropha curcas),* Nkoni *(Euphorbia trucalli),* Luwanji

It is recommended that if trees are being introduced, they should be planted 1 Om by 10m apart. This leaves room for land clearing and weeding activities. Competition between trees and companion crops is also reduced. Naturally growing trees should be cut-down to the recommended spacing. At this spacing, 100 to 200 trees can be planted in lha of land. Figure 20 illustrates the spacing of trees grown together with coffee and bananas.

Management

Scattered trees on cropland are individually managed to obtain products and services desired by a farmer.

The trees need to be protected from animals either individually or by protecting the entire field.

Young trees need to be weeded. Spot weeding is sufficient.

Tree seedlings need to be protected from grazing animals, pests diseases and fire.

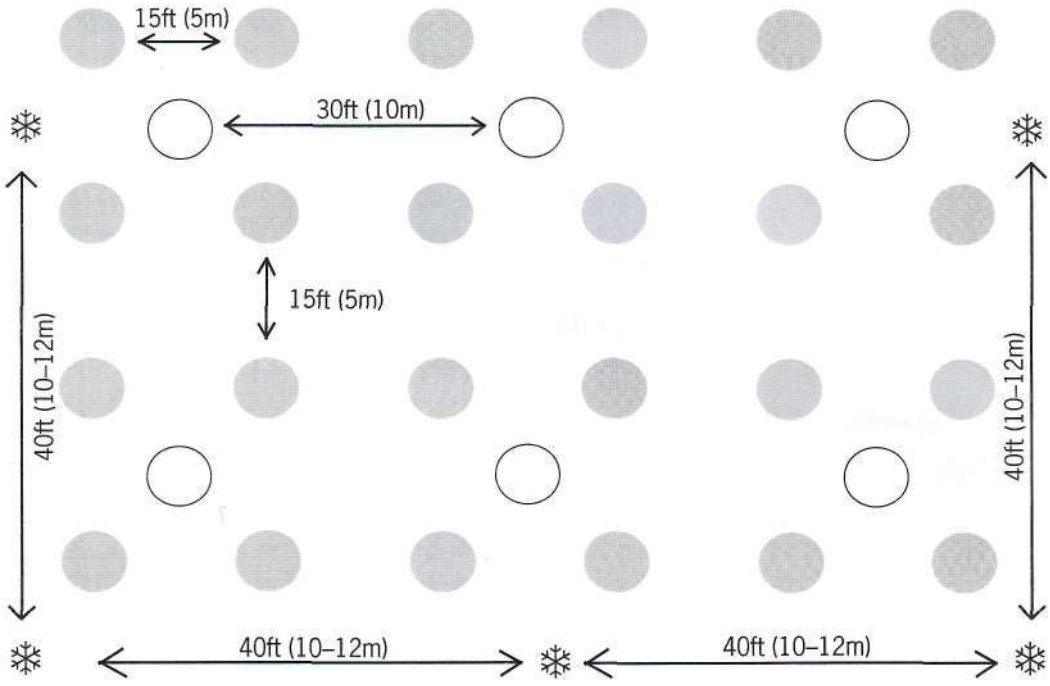


Figure 20 *The spacing of trees in a banana-coffee farming system*

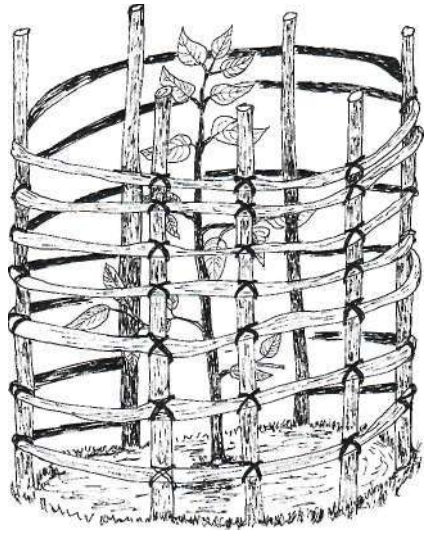


Figure 21 *How trees are protected from damage by animals*

Limitations

- Most trees take along time to mature. This can be discouraging if one needs to meet immediate household consumption requirements.
- Excessive shade from trees can reduce crop yields.
- Some trees attract pigs, birds (Mapeera *(Psidiumguajava))*, and monkeys Mapeera and Mukunyu *(Fiats sycomorus))* which can be pests of crops.
- When felling of trees on farm land is necessary, associated crops like bananas and coffee can be destroyed.
- Some of the trees that do not allow food crops to grow well when planted together with crops are listed in Table 7.

Table 7 *Types of trees that may reduce yield of food crops if grown with crops*

LOCAL NAME	SCIENTIFIC NAME
Cordia africana	*Cordia africana*
Fene/Kifenesi	*Artocarpus heterophyllus*
Kalitunsi	*Eucalyptus* spp.
Kinazi (pine)	*Pinus patula*
Leucaena	*Leucaena* spp.
Mucungwa	*Citrus sp*
Musizi	*Maesopsis eminii*
Muyembe	*Mangifera indica*
Muziru	*Pseudospondias microcarpa*

B. Vanilla Production

Introduction

The vanilla agroforestry system is practised in the banana-coffee zone, and integrated into the coffee, banana and home garden system. Vanilla *(Vanilla jragrans)* is a creeper vine believed to have been introduced into Uganda from the then Ceylon in 1912. Commercial production started in the 1930s. Though production drastically declined during the civil strife in the 1970s, production by small-scale farmers was revived at the beginning of the 1990s, largely because of

increased efforts of agricultural extension and non-governmental organisations. Vanilla is currently grown in areas close to L. Victoria shores in the districts of Mukono, Mpigi, and to a lesser extent, Masaka and Jinja districts.

Benefits from Vanilla system

- Growing of Vanilla does not affect production of companion crops like bananas and coffee. Vanilla can therefore be grown as an additional crop to the main crops on the same piece of land;
- Vanilla is a high value crop with a high potential to generate cash for farmers;
- Vanilla can grow in a wide variety of soils;
- The crop is easy to maintain; and
- It has few pests and diseases.

Description and design

The vanilla agroforestry system consists of upper-storey shade trees, perennial crops like coffee and bananas. The common upper-storey shade trees are Mutuba *(Ficus natalensis),* Nlugavu *(Albizia coriaria), Albizia chinensis,* Musizi *(Maesopsis eminii)* and Kifabakazi *(Spathodea campanulata).*

Vanilla grows best in loamy soils. It is planted under the shade trees amongst coffee and banana trees. It is recommended that Vanilla vines be planted 3-5 meters apart. In the following section, details on how to establish a Vanilla farm are discussed.

Establishment of a Vanilla farm

Support *trees*

Vanilla being a perennial vine requires trees for support. Trees which are planted to provide shade should not be used as support trees.

Kinowa is the best support tree and is used by most farmers. Other support trees include: *Manihot esculenta* (cassava), Mutuba *(Ficus natalensis),* MuLuluza *(Vernonia amuydalina), Gliricidia sepium,* Gasiya *(Senna species)* and *Cedrella odorata.* Sticks and dead branches can also be used but are not durable. There are many reasons why Kinowa (*Jatropha curcas)* is considered the best support tree for Vanilla. Kinowa is easy to propagate using cuttings, and its extensive branches provide shade needed by Vanilla, It does not grow to a tall tree and can be used as a live fence. It is resistant to termites.

Propagation

- Vanilla requires shade and shade trees should be planted early and let to establish before planting Vanilla.
- The support trees should also be planted before planting Vanilla.
- Vanilla vines which are facing upwards are selected as planting material (seed).
- Vanilla is planted using cuttings of one metre in length, during the beginning of the rainy season.
- Maximum yield may be reached after seven to eight years while economic yields can be obtained for 10—20 years.
- Roots of Vanilla are close to the soil surface. They should be protected from possible damage during cultivation and feeding chicken by mulching.

Management

After Vanilla is established, management needs are limited except for pollination which requires a lot of labour and good skills. Flowering and pollination are the most important and difficult processes in Vanilla growing. Flowering is induced by a dry season. Looping and cutting off the tip of the apical shoot of the vanilla improves flowering. Flowering takes place over two to three months. The male and female parts are located on the same flower. The male part is located above the female part. Because there are no natural pollinators, pollination is done by hand. Each flower has to be carefully opened using a sharp object, and the male and female parts brought into contact. Figure 22 shows a Vanilla flower and the type of objects used for opening the flower during pollination.

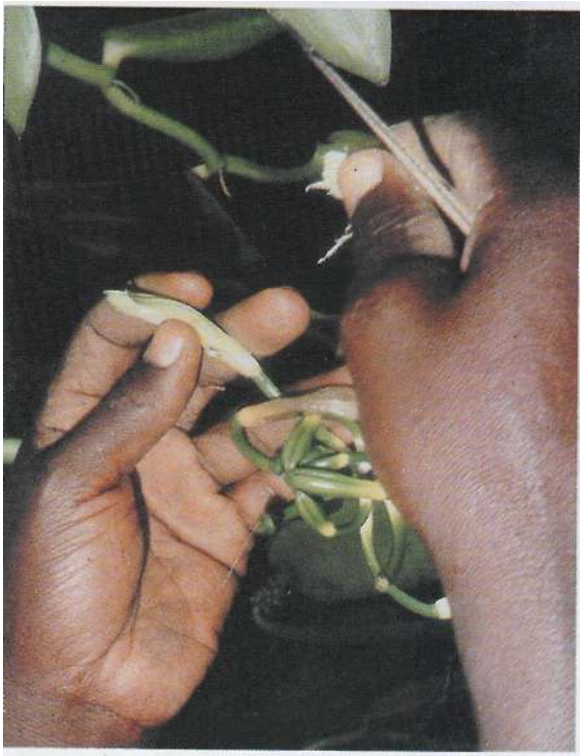


Figure 22 *Pollination of Vanilla*

The flowers are only fertile for a day so they must be pollinated in time. It is best to do pollination in the morning.

When the pods are formed, thinning is necessary to avoid over-bearing. About 6-7 pods give a good vanilla yield.

The pods mature in 9 to 10 months after pollination. They are then harvested just before ripening and sold directly to vanilla processors who export the product.

Pollination of Vanilla

- Locate mature vanilla flowers.
- With a sharp object, cut and expose the female (ovary) and male (anther) parts of two adjacent flowers.
- Make contact between the two parts from the different flowers.
- Allow the flowers to close.

Uses of Vanilla

- Vanilla is grown primarily for the export market for use as flavouring for cakes, sweets and icecream.
- For local use, the mature pod is harvested, dried and used to flavour tea and cakes.

Limitations to vanilla growing

Every flower is pollinated individually and this requires a lot of labour. Skill is also needed during pollination to ensure the correct contact between the male and female parts of the flower. Marketing of vanilla pods is a problem because there are very few buyers. The price of vanilla has reduced from Shs. 10,000/= per kg of raw vanilla beans during 1992-93 period to only Shs. 2,500/= per kg in 1996/97. But, as Kabali Deogratius explains in Box 6, the marketing problem should not discourage farmers from growing vanilla. Growing of vanilla is still profitable because the activity does not exclude cultivation of other crops.

Box 6 *Growing of Vanilla: the experience of Mr. Kabali Deogratius*

Vanilla is a very special crop. It is valued for the flavour produced by the seeds in the pods. The growing of vanilla requires good skills especially for pollination. But for experienced farmers, says Kabali Deogratius, growing of vanilla is not difficult.

Kabali is a farmer from Kabembe village in Kyampisi sub-county, Mukono district. He owns 2 acres (0.8 ha) of land. On 1 acre (0.4 ha), he grows vanilla together with bananas and coffee. The price of vanilla in Uganda has been decreasing. But farmers continue to grow vanilla even though the price has been declining. Kabali Deogratius started growing vanilla in 1992. His main reason for deciding to grow vanilla was the

income from the crop in the early 1990s. He started growing vanilla in 1 acre out of his 2-acre farm. First half acre of vanilla was established in 1992. In 1994, he expanded the area by another half-acre. Although the price of vanilla continued to fall, Kabali still expanded the vanilla farm; and he had good reasons for growing vanilla despite the low market price. The reasons relate to the advantages of vanilla in terms of labour requirements and compatibility with other food crops.

Establishing a vanilla farm

Vanilla requires shade to grow. Therefore, before planting vanilla, crops that can provide shade should be planted first. Kabali established vanilla in a plot that had no trees. To provide shade, he first planted bananas. Bananas can grow and provide shade within three months after planting. Support trees spaced 8ft (2.3m) apart within a row were then planted. Rows can be spaced 6 ft (2m) apart. This spacing is also the spacing of the vanilla vines during planting. Kabali planted Kiryowa/kinowa *(Jatropha curcas)*, a tree used by most farmers for supporting vanilla. Farmers believe that Kiryowa/kinowa *(Jatropha curcas)* has a special good association with vanilla. The smooth bark is said to encourage good growth and yield of vanilla. In the following section, we describe how vanilla is grown and the associated benefits as described by Kabali Deogratius, a vanilla farmer.

Obtaining vine cuttings for planting

It is important to obtain the correct types of vines for planting. Vines for planting should be obtained from those facing upwards. These are the growing vines. Vines, which face downwards are at the stage of producing pods. These should not be used for planting.

Dig holes 2ft deep and 2 ft wide close to the support trees. Cut the vines into sections each of three inter-nodes length. Remove leaves from up to two nodes and bury the vine to cover the two nodes with soil. Tie the vine to the support tree.

Management

When the vines are about 6 feet long, they should be bent and a section buried in the soil. This starts a second growing loop. The Gft height is used so that hand pollination is possible. Six loops can grow in 18 months. Vanilla flowering can be induced either naturally by dry weather or manually by nipping mature buds. Harvesting mature beans is done by hand. The beans are sold fresh.

Pollination

Pollination of vanilla is the most critical management activity and requires good skills. The male and the female parts of the vanilla plant are located on the same flower but in different sections. The flower is enclosed so other pollination agents like insects and birds cannot reach it. It is important to know the location of the male and female

parts and how to handle them during pollination. The male part is located at the top of the column of the flower and the female part is located in the lower part of the same column.

Using the tip of a sharp v-shaped object like a safety pin or a stick, carefully open the column of the flower. Using one finger, bend the funnelled top of the flower and touch it with the female part located on the lower part of the flower column. Press with the thumb to ensure contact.

Pollination should be done in the morning hours. During this period, the pollen containing structures are not soggy and chances of successful pollination are high. If pollination is not successful, the flowers drop after three days.

Pods form after successful pollination. It takes 9 months for the pods to mature. It is therefore important to keep records so as to know the expected maturity period. The pods form a cluster. One cluster can have about 20 pods. It is advisable to leave only 6 to 8 pods in one cluster to obtain good quality vanilla.

Benefits

Although vanilla is a high value crop, the marketing is a problem. Vanilla is mainly an export crop and there are few firms that buy vanilla. Kabali sells his crop at 2,500 UShs per kilogram. This is the price when the product is delivered to the market. Despite the low price, farmers continue to expand acreage of land for growing vanilla. This is because vanilla is just companion crop of other main crops. The income from vanilla therefore supplements income from other crops. For example, in the case of Kabali, in 1994, only two[v] years after planting an acre of vanilla, he earned 40,000/- UShs from selling vanilla at 5000/- per Kg. Kabali suggests that the farm gate price of vanilla can be improved if vanilla-growing farmers organised themselves and formed a marketing co-operative society. This would create a better opportunity for exporting vanilla directly by farmers.

Mr. Kabali Deogratius in his vanilla farm

The other advantage of growing vanilla is that the crop does not require a lot of labour except during pollination. In addition, two crops can be harvested in one year. In 1998, for example, Kabali harvested 100 Kg from his acre farm and earned 250,000 USh. He has known the benefits of growing vanilla and is expanding the farm.

Commercial Woodlots and Wood Production

Introduction

Commercial woodlots can be of a single species or of different types of trees. In Mukono, Mpigi, Masaka and Rakai districts, woodlots of Kalitunsi *(Eucalyptus species),* and stands of different species as well as remnants of natural forests are common. In other districts like Mbarara where farmers own large pieces of land, Pine/Kinazi *(Pinuspatula),* Musizi *(Maesopsis eminii), Grevillea* and *Cupressus lustanica* are grown. In Bushenyi where rearing cattle is a major land use activity, woodlots of Kalitunsi are found interspersed in paddocks and banana-coffee fields. Generally, in the banana-coffee farming zone, Kalitunsi is a common tree planted as a woodlot. This is because it grows fast, re-grows easily after cutting and the products have a ready market. Kalitunsi woodlots are grown to produce poles, fuelwood, and timber.

Expected benefits

Benefits from planted woodlots cannot just be quantified in terms of income only. The experience of one farmer from Mabira village, Nyarubungo II parish, Nyakaizo sub-county in Rwampara county, Mbarara district illustrates the value of woodlots (Box 7). Some of the benefits expected from woodlots are:

- Cash income and other economic gains;
- Security of tenure of both land and trees;
- Provision of tree products including fuelwood for home consumption and sale;
- In the long run, increased income is obtained because of saved labour costs and repeated harvest;
- Improved microclimate;
- Control of soil erosion;
- Soil fertility improvement;
- Use of unproductive sites;
- Beautify landscape;
- Wind breaks;
- Boundary marking.

Woodlots are grown as a form of fallow. Kalitunsi *(Eucalyptus species)* and Nsambya (*Markhamia lutea)* are good trees for establishing woodlots because their products like poles, timber and firewood are easy to market. In addition, Kalitunsi grows well in swampy areas where other crops cannot be grown.

Other trees that can be grown as woodlots apart from Kalitunsi and Nsambya are

Grevillea, Lira *(Melia azedarach),* Mugavu *(Albizia coriaria),* Nongo *(Albizia zygia) , Cedrella odorata,* Umbrella tree *(Terminalia spp.)* and Musenene *(Podocarpus gracillor).* Products from woodlots can be sold or used in the household to reduce expenditure on fuelwood; poles for fencing and construction.

Trees in woodlots are either grown at the same time with food crops, or are planted on their own. Growing food crops in woodlots is only advisable during the establishment phase of trees. Thereafter, because of the high population of trees in woodlots, food crops are out-competed and yields decline. Commercial woodlots can be single or mixed species stands that resemble dense natural growth.

Use of improved stoves combined with production on farm of fuelwood can considerably reduce both time spent searching for fuelwood and the amount of fuelwood used (See Box 7).

Box 7 *Growing commercial woodlots: Augustine Mpuku's case*

Firewood for domestic use is becoming scarce in most parts of Uganda. Most households deliberately grow trees in blocks as woodlots. The benefits of woodlots is known to some farmers, but often, these benefits are not quantifiable in the short-run because trees take a relatively long time to mature compared to agricultural crops. Most farmers therefore get discouraged from establishing large areas of woodlots except for small scale undertaking to meet consumption needs. But woodlots are very profitable as the narration by Augustine Mpuku from Mbarara District shows.

Mpuku is 50 years old. He resigned from formal employment at a prime age of 27 years in 1976. When he was employed, he saved money and bought land. Apart from a small piece of land inherited from his farther, he has been able to increase the total are of land he owns to 20 acres (8 ha). Since he resigned from employment, Mpuku has taken care of his family of 11 people successfully. Sales of products from his farm has enabled him to pay fees for his children. He pays USh 900, 000/= per year for one child and expects to pay three times this amount when two of his children join secondary school in the year 2000.

In 1992, Mpuku attended a World Environment Day meeting convened by the Local District Council. During the meeting, farmers were urged to grow trees especially on hill-tops and steep slopes. These are the main grazing lands for the Banyankole community. The Banyankole mainly depend on livestock which is for production of both milk and beef. Conservation of hills was therefore a major concern from the community who have watched the hills turn bare with time because of over-grazing.

Mpuku took the advice seriously. The following year in 1993, he went to the Forest

Department and bought seedlings. He bought a few of different types of tree seedlings. The price of the seedlings in Uganda shillings were: Kalitunsi *(Eucalyptus species)* (50/=), *Chlorophora excelsa* (200/=), *Cupressus lusitaniea* (200/=), and Pinc/Kinazi *(Pinus patula)* (200/=). To begin with, he bought just a few seedlings because he could not afford many. He then decided to raise his own seedlings. He gathered seeds from nearby fields and obtained some from the Forest Department.

He had several reasons for starting a commercial woodlot. First, he needed to supplement his income from sale of banana and other food crops. But, he also found value in protecting parts of his farm that were exposed to degradation through soil erosion by planting trees. A third reason was that he wanted to respond to the call by local council to set an example and earn the prestige of recognition.

Mpuku depends on his family for labour and only hires limited labour to accomplish specific short-term tasks. To establish the woodlot using minimum labour, Mpuku introduced trees in field prepared for growing food crops. As he grew and tended the food crops, the trees were also tended. In this way, labour for establishing the 5 acre woodlot was provided by the family. During the establishment of the woodlot, Mpuku planned the farm carefully. The woodlot was established in the part of his farm which is generally difficult to farm because the slope is steep. The establishment of the woodlot was started in the less steep part of the farm so that most members of the family including children could provide labour. He also planned and planted the different types of trees in different blocks on the five acres. In this way, he spaced each type of tree species according to his projection of the types of products that he would harvest with time depending on the growth pattern of the trees. For trees like Kinazij Musizi *(Maesopsis eminii), Cupressus lusitaniea,* Musenene *(Podocarpus gracillor), Kliaya anthotheca* and Muvule *(Milicia excelsa),* which he considered to be relatively slow growing compared to Kalitunsi, he spaced the trees at 4m x 4m. The Kalitunsi was spaced at lm x lm so that thinnings could be harvested after a few years.

Growing of food crops in the woodlot was discontinued after competition from trees reduced crop yields. Mpuku continued to manage the woodlot after he discontinued growing crops. He pruned the trees to about two thirds of their height. He also did spot weeding. After a while, labour became constraining because most of his children went to study away from home. He has had to hire labour to slash the undergrowth in the plantations during the wet season. He hires labour at USh 1000/= per day. The slashing takes about three days and is done twice in a year. But, according to Mpuku, labour is still very limiting because he cannot afford to hire labour continuously. Yet, because of the warm and wet climate, weeds grow very fast. Some of his trees were choked by weeds, but weeding bananas is given priority because he sells bananas throughout the year. Bananas also provide food for the family.

Augustine Mpuku in his commercial woodlot

Mpuku is however happy with his efforts in establishing the woodlot. He recounted the benefits from the woodlot with pride. He had been obtaining firewood from the woodlot for household use. He first harvested three lorry loads of firewood for sale from the *Kalitunsi* plot in 1997: only four years after planting. He earned USh 1,050,000/=. People are now aware that Mpuku has a good woodlot. Buyers go to his farm. He sells poles. One pole costs USh 1,000/= at the farm. He had sold 8 of them in early 1999. He also sells whole trees at USh 1,500/= each. He had recently sold 20 and earned USh 30,000/=. In April 1999, he thinned the section of the woodlot with Pine and used the thinnings for constructing a pig rearing unit. This saved him money.

Assuming that 2000 Kalitunsi seedlings planted by Mpuku had been bought, he would have spent USh 100,000/=. Labour was provided by the family and can be assumed to have had no cost to the Mpuku family. Hence the cost of establishing the Kalitunsi section of the woodlot can be estimated at USh 200,000/= including the cost of seeking information from the Forest Department. At the planting density of lm by lm (3ft by 3ft) for Kalitunsi, Mpuku can generate USh 2 million from an acre of land. So for him, his benefits are worth the effort he made.

The success of the Mpuku family has not been easy to achieve. They have experienced some problems with the woodlot. Apart from labour limitations:

- Neighbours have been stealing trees from the woodlot;
- The cattle tracks enforced by the Local Councils expose the woodlot to potential illegal harvesters;
- In distant farms where he started expanding the woodlot enterprise, fires have been a problem. In the case of the Mpuku family, when their neighbours burn their fields, fire often gets to his woodlot and he is not compensated by the neighbours. But other farmers reported that neighbours can also set woodlots on fire to ensure availability of grazing land for their cattle;
- Poor roads and lack of transport make it impossible for the Mpuku family to sell wood products from their woodlots in distant market where they can fetch better prices.

Establishment

A woodlot should be located on the less productive parts of the farm; like on steep slopes and on land with poor soils. When planted near homesteads, it is advisable to plant the trees against the direction of wind as shown in Figure 23. This protects houses and other structures in a home from destruction by wind.

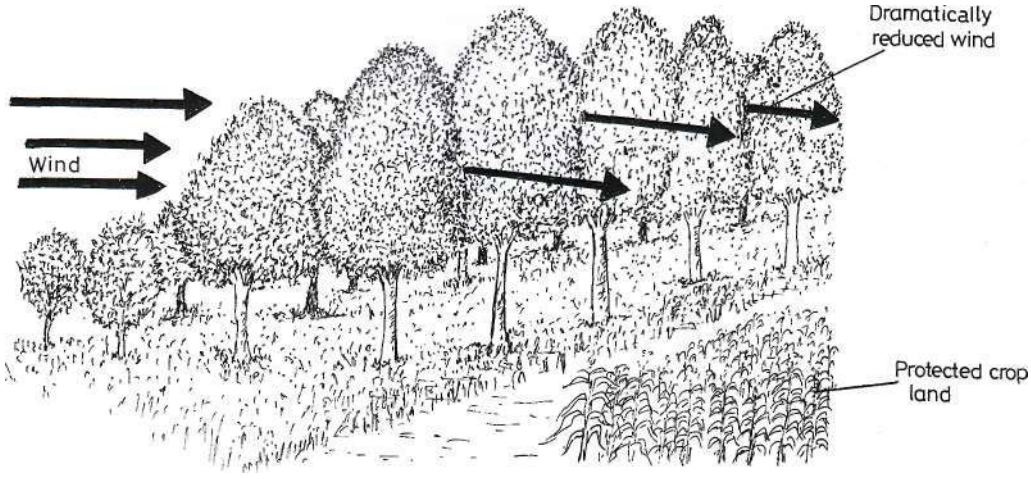


Figure 23 *Trees in woodlot planted against direction of wind*

Establishing a large woodlot requires a lot of resources, especially labour and tree seedlings. But, there is an easier and cheaper method as described by a farmer from Mbarara Box 7. The trees can be established by planting seedlings on a cultivated field or by selectively cutting some of the trees already growing in the field and introducing the desired type of trees. Initially, the trees should be spaced 2m x 2m. The spacing can be increased by thinning.

Management

Weeding, pruning and thinning are the three most important management activities on a woodlot. In Tables 8a and 8b the period when the three management operations should be done during a growing cycle of Kalitunsi *(Eucalyptus species)* and Nsambya *(Markhamia lutea)* are listed.

Table 8a *Management of* Kalitunsi (Eucalyptus grandis) *woodlot*

MANAGEMENT ACTIVITY	WHAT IS DONE	WHEN TO DO
Clear weeding	Cultivate the whole field	1 year after planting
Spot weeding	Weed around the roots of trees	2 to 3 years after planting and during the rainy season
Line slashing	Slashing just along the lines of trees	Preferable during dry season
Thinning/singling	On coppice growth of trees, remove diseased parts of stems and cut all stem re-growth and leave 3-4 stems per stump, depending on management objectives	2 to 3 years after coppicing
Pruning	*Kalitunsi* tends to be self-pruning if grown at the right density	
Harvesting	Cut at 15 cm above the ground to encourage coppice growth	See Table 8
Climber cutting	Removing climbing plants from the trunks of trees	When necessary

Table 8b *Management of a* Nsambya (Markhamia lutea) *woodlot*

MANAGEMENT ACTIVITY	WHAT IS DONE	WHEN TO DO
Clear weeding	Cultivate the whole field	1 year after planting
Spot weeding	Weed around the roots of trees	Every alternate year after planting, during rainy season
Line slashing	Slashing just along the lines of trees	Preferably during dry season
Thinning/singling	Done on coppice growth of trees. Remove diseased parts of stems and cut all stem re-growth and leave 3-4 stems per stump	About 3 years of coppice growth. This depends on initial spacing and intended end use of products to be harvested from the woodlot. If seedlings were planted at 2m x 2m, then remove every second tree 2 to 4 years after establishment of the woodlot.

MANAGEMENT ACTIVITY	WHAT IS DONE	WHEN TO DO
Pruning	Remove lower branches to about % of the height of trees	Two years after planting
Harvesting	Cut at 15 cm above the ground to encourage coppice growth	See Table 8
Climber cutting	Removing climbing plants from the trunks of trees	When necessary

Different trees grow at different rates. Therefore, the period from planting to complete harvesting (rotation cycle) also differs. Table 9 shows the rotation cycle for two common woodlot trees and the types of products that can be harvested after some years.

Table 9 *Types of products from woodlot trees with time*

TYPE OF TREE	YEARS AFTER PLANTING	TYPES OF PRODUCTS	ROTATION CYCLE
Eucalyptus grandis	2-3	Withies, Fitos (tiny)	Short: 2 to 4 years
Kalitunzi	3-4	Poles (construction)	Short: 4 to 7 years
	4-5	Posts (fencing)	15 to 25 years
	6-8	Transmission poles	15 to 25 years
	12-15	Fuelwood, Charcoal	Short to medium rotation
	Over 20	Timber	
Markhamia lutea	$2^1/_2$	Withies	Short: 2 V_2 to 4 years
Nsambya	5	Poles (7 cm diameter)	Short: 4 to7 years
	7	Posts (1 to 12 cm diameter)	Short: 4 to 7 years
	15	Timber	15 to 20 years
	12 to 15	Fuelwood, charcoal	Short to medium

Limitations

It is difficult to remove Kalitunsi *(Eucalyptus species)* and Nsambya *(Markhamia lutea)* stumps after establishment when one wants to change land use to other activities;

On short rotation, of 3 to 4 years, soils planted with Kalitunsi become poor after harvesting trees;

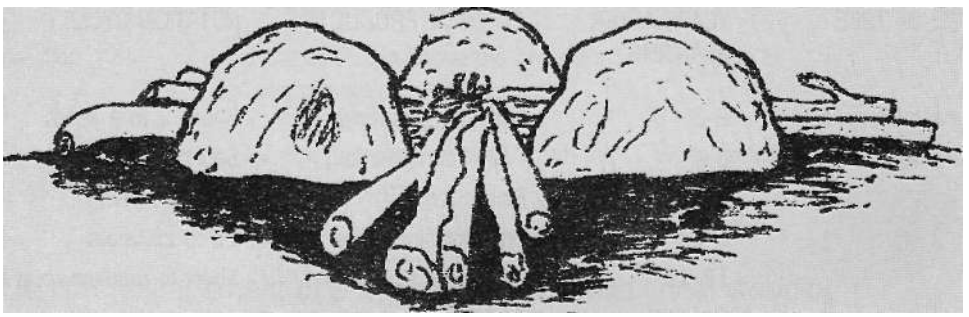
In remote areas, marketing of products, particularly poles is difficult

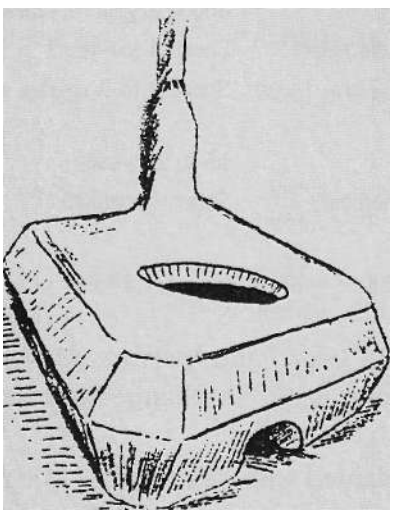
because of poor roads and lack of transport;

- Lack of local markets;
- There is need for fire protection;
- It can be a security problem;
- Pests and diseases.

Box 8 Common *stoves of Uganda*

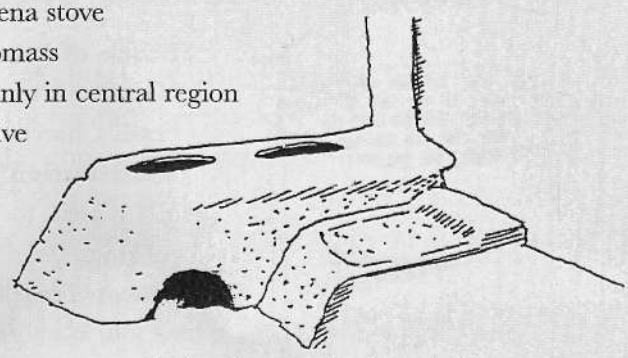
Name **of stove:** Three stone hearth
Fuel: Firewood and other biomass
Distribution and use: Widely used in households, institutions, local breweries.
Advantages: Versatile, portable, free, easy to light.
Limitations: Cook one dish at a time, considered inefficient especially when used outdoors, fire hazard, smoke pollution.

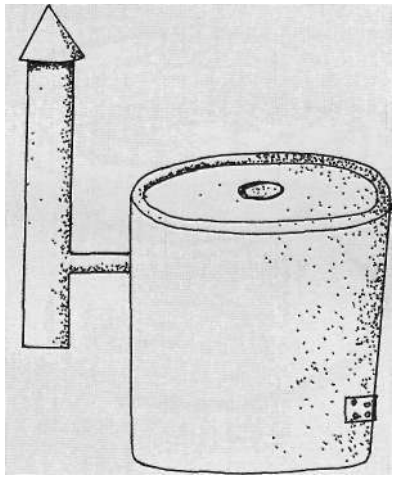




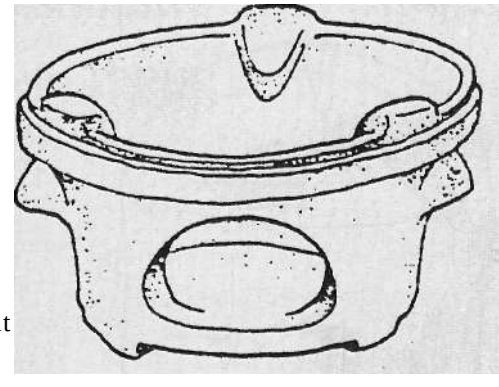
Name of stove: UNHCR or Dembe stove
Fuel: Firewood and other biomass, charcoal if a metal grate is included.
Distribution and use: Mainly in central region for household cooking.
Advantages: Portable, uses a variety of fuels, saves fuelwood, removes smoke from kitchen if chimney is included, owner or group built using mud and a mold.
Limitations: Difficult to light, stove cracks requiring regular repair, can only use certain pot sizes, cooks one dish at a time, chimney cleaning.

Name of stove: "Y" or Lorena stove
Fuel: Firewood and other biomass
Distribution and use: Mainly in central region and areas where there are active YWCA groups. Used for household cooking.
Advantages: Can cook two dishes at the same time, removes smoke (if chimney is included), saves fuelwood, owner or group built using mud mix or bricks.
Limitations: Fixed stove, difficult to light, stove cracks requiring regular repair, can only use certain pot sizes, chimney cleaning.

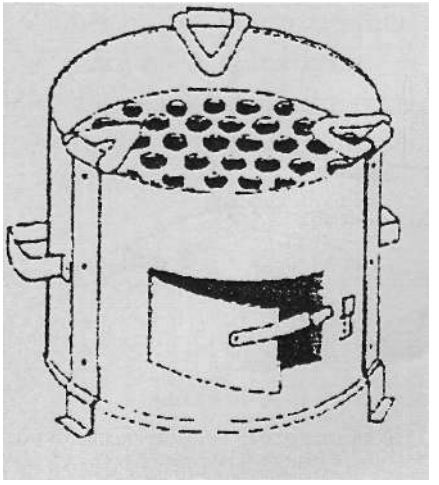




Name of stove: Institutional stove
Fuel: Firewood and other biomass
Distribution and use: In institutions throughout the country. Used for cooking for 20 or more people.
Advantages: Energy efficient, saves fuelwood, removes smoke from kitchen, creates employment (built by stove building companies).
Limitations: Fixed stove, one pot size for given stove, cooks one dish at a time, costly.

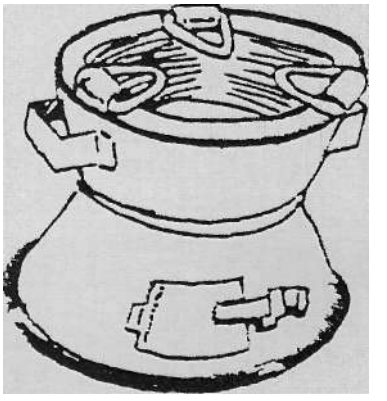


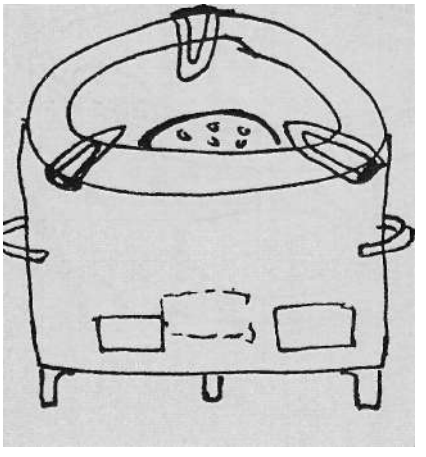
Name of stove: Kabale stove
Fuel: Charcoal
Distribution and use: Mainly central and eastern region, used for household and commercial cooking.
Advantages: Saves charcoal, portable, cheap, easy to light, creates employment (made by potters), different sizes made.
Limitations: Breaks easily, no door to control air inlet



Name of **stove:** Traditional metal stove (Sigiri)
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: Risk burns and scalding, inefficient, stove does not last long.

Name of stove: Kenyan ceramic Jiko/Ugandan ceramic Sigiri
Fuel: Charcoal
Distribution and use: Mainly central and eastern region, used for household and commercial cooking.
Advantages: Energy efficient, creates employment for artisans and potters, portable, can last a long time, different sizes made.
Limitations: Fired clay lining breaks easily if poorly handled, difficult to light, good stoves are expensive.





Name of **stove:** Black power charcoal stove
Fuel: Charcoal.
Distribution and use: Mainly central and eastern region, used for household and commercial cooking.
Advantages: Saves charcoal, creates employment for artisans and potters, portable, can last a long time, different sizes made.
Limitations: Expensive, difficult to light, lining can break if poorly handled, no air control because stove lacks door and has three large air inlets.

6 Pest and Disease Control in Agroforestry

In agroforestry like other types of agriculture, there is risk of pest and disease outbreak. This section outlines the general pest and disease control practices in agroforestry. Pests can affect the companion crops and trees. In this manual, we discuss pests that affect trees in agroforestry. It is considered that control of pests that affect agricultural crops is well covered in other books on agriculture.

Farming practices to prevent pest and disease outbreaks

- *Use healthy planting material*

  Seeds or the planting material can carry some diseases. Therefore, choose only healthy seed and planting material.

  Diseased plants should be removed and destroyed to avoid infecting healthy plants.

- *Choose resistant varieties*

  Select crop varieties that are resistant to common pests and diseases. Local varieties of crops are more resistant to pests and diseases compared to modern varieties.

Plant at the right time

Timely planting, weeding and thinning can be beneficial. It is advisable to plant early so that crops establish well before the peak of the rain season. This is the period when crops are most susceptible to attack by pests and particularly diseases.

Inter-planting

When only one type of crop or variety is grown, it may be completely wiped out by a pest attack. But if different types of crops or several varieties of the same crop are grown, some may be resistant and survive.

In some cases, suitable crops can be inter-planted with locally available toxic or insect repellent plants. For example, Neem *(Azadirachta indica)* has been known to repel insects when inter-planted with maize.

- *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. Instead, grow a different crop each season. This will reduce the number of pests and diseases, since most do not attack different types of crops.

- *Apply organic manure*

  The use of compost, mulch, and green manure crops can have a very positive effect against pests and disease. It has been found that proper mulching of the crops, besides conserving moisture, provides alternative food to pests like termites. This is effective for short term crops like beans, maize and sorghum. Mulch can also cause the pest population to rise thus exposing the crop to a more severe attack.

- *Plant trees or hedges as windbreaks*

  Besides breaking the wind, trees and shrubs moderate the temperature, reduce evaporation and provide shelter and food for useful insects. Trees, such as *Grevillea,* Mubimba/Muzimbandeya *(Sesbania sesban)* and Lusina *(Leucaena leucocephala)* provide good shelter and wind protection. Tithonia *(Tithonia diversifolia)* grown at the edge of plots has indicated positive effects in repelling insects, besides being a potential green manure.

- *Plant different types of crops*

  Crops such as sunflower and finger millet, and also local plants which bloom and bear fruit, attract birds and insects. When such crops are grown at the edge of the field they attract the pests away from the main crop.

Controlling pest and disease outbreaks

Sometimes disease or pest out break 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 large, and they have not become too widespread on the crops. Banana farmers have perfected the method of collecting the banana weevils from harvested banana stems.

Pesticides

Often the insect/disease attack require the use of synthetic pesticides, (e.g., FURADAN is used by farmers to control banana weevils and termites.) However many of these pesticides are very difficult for nature to break down, are expensive and have negative side effects on human health when improperly handled. They should therefore be used as a last resort when a pest outbreak threatens to wipe out the entire crop or for selective spot-control of difficult pests or diseases to prevent them from spreading. Consult a local Agricultural/Forestry Extension Officer before using synthetic pesticides.

Toxic plant extracts

Some plant parts like seeds, fruit, leaves or ashes can be made into solutions that can be sprayed or watered on the crops to prevent or reduce attacks of various insects and diseases. Chilli *(Capsicum annum)* has been used as an effective insect repellent by many farmers against the cut worm and other insects. Many repellents are effective in protecting crops during storage.

Wood ash applied on bean leaves has been shown to control pest infection. A mixture of wood ash and cow urine is known to control banana weevils. Kabale farmers use extracts from *Pyrethrum* flower heads to control pests in beans and maize. Extracts from tobacco, rich in nicotine kill many insect pests. In Box 9 the use of Neem extracts to control pests is described.

Biological control

Some insect infestation can be controlled through use of predatory organisms. However this is yet a relatively new invention.

The wasp *{Epidinocarsis lopezi)* has been used to control the cassava mealy bug. The wasp lays eggs inside adult mealy bug (*Phenacoccus manihoti)* which die as the egg develops.

Phytoseiids (predatory mites) are effective in controlling, by feeding on the cassava green mite *{Mononychellus tanajoa).*

Box 9 *Neem for pest control*

Different parts of the Neem tree can affect many insect species, some nematodes, fungi, bacteria and viruses. Neem contains several active chemicals which work in different ways, therefore, pests are unlikely to become resistant to Neem. One of the active chemicals in Neem is called *azadirachtin.*

Neem is easy to prepare and use and is environmentally safe as well as harmless to man and animals. Neem extracts usually change the insect pests' feeding and life cycle so that eventually they are not able to live and reproduce.

Neem is most useful against pests that feed on plants. It is very effective against grasshoppers, leaf and leaf hoppers. The Neem extract is most effective against beede larvae, butterfly and moth caterpillars. Neem can also be used in grain storage.

A. Use of Neem leaves

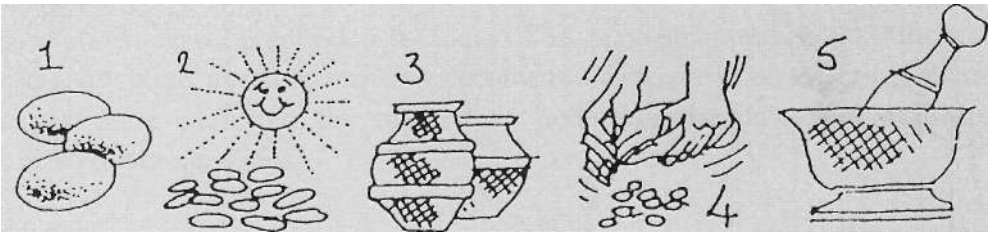
Neem use for storing grain:-

- Dry Neem leaves in the sun so that they stay green.
- Grind the leaves into a powder; mix the powder with clay and water.
- Plaster the inside walls of the storage container with the mixture and allow to dry.
- Place a layer of Neem leaves which have been dried in the shade on the bottom of the container.
- Fill the container with grain; place a layer of dried Neem leaves on top and close the storage container.
- If the grain is stored in sacks, Neem leaf powder can be mixed directly with the grain in the ratio of approximately 1— 2kg powder to 100kg of grain.

B. Use of Neem seed cake

Preparing crushed Neem seed

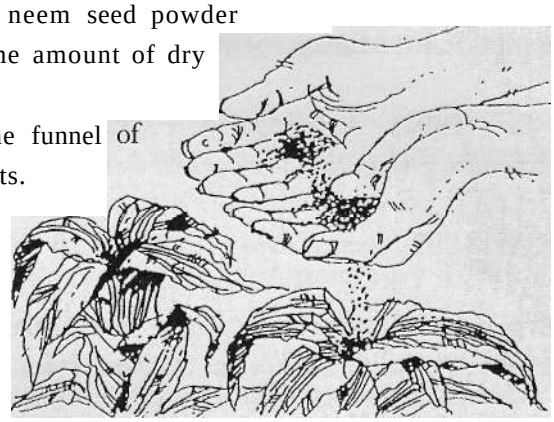
1. The ripe fruit pulp should be removed from the seed as soon as possible after harvest, orherwise the seeds may become covered in mould. In some areas birds or fruit bats eat the pulp leaving the seed on the ground.



2. The seeds should then be laid out in a thin layer in the sun to dry out for a few days. The dried seeds should be stored in containers with plenty of air to stop mould growing.
3. The shells have to be removed using stones or a big mortar. The shells can then be removed by winnowing in the same way as with cereals.
4. The kernels are then ground in a mill or in a mortar.

Use of Neem to control stem borers on young plants:-

1. A small amount of crushed neem seed powder should be mixed with the same amount of dry clay or sawdust.
2. The mixture is placed in the funnel of young maize or sorghum plants.
3. Rain will gradually dissolve the active chemicals in the neem seed.
4. This treatment may need to be repeated every 8 to 10 days until the plants flower.



C. Use of Neem water extract for plant protection

- Prepare 500g of crushed seed kernels as described previously.
- Mix crushed seed with 10 litres of water. It is necessary to use lots of water because the active ingredients do not dissolve easily.
- Stir the mixture well.
- Leave to stand for at least 5 hours.
- Spray the Neem water directly on vegetables using a sprayer or straw brush.

- The effect lasts for 3 to 6 days. If kept in the dark, Neem water will be effective for 3 to 6 days.
- It has been estimated that 20-30kg Neem seed (an average yield from 2 trees), can normally treat one hectare.
- If crops have to be watered, water should go directly on the soil because water running over the leaves of sprayed plants may wash off the extract
- If alcohol is available, 50 times more *azadirachtin* can be dissolved and extracted.

Adapted from: Henry Doubleday Research Association (1995). Neem leaflet

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Appendices

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Glossary

Some common trees, shrubs and other plants in the banana-coffee zone

Luganda Name	Botanical/Scientific Name
Avocado, ovakedo	*Persea americana*
Galliandra	*Calliandra calothyrsus*
Ebilamba	*Desmodium*
Ensogasoga	*Ricinus communus*
Falawo	*Artocarpus*
Fene, Kifenensi, Yakobo	*Artocarpus heterophyllus*
Gasiya	*Senna siamea*
Gasiya, Mukyula	*Senna spectabilis*
Grevillea	*Grevillea robusta*
Kalitunsi	*Eucalyptus spp*
Kasaana	*Acacia spp*
Keiapple	*Dovyalis coffin*
Kifabakazi	*Spathodea campanulata*
Kilowa, Kinowa or Kiryowa	*Jatropha curcus*
Kinazi, pine	*Pinus patula*
Lira	*Melia azedarach*
Lusina	*Leucaena leucocephala*
Lusina	*Leucaena diversifolia*
Mapeera, Guava	*Psidium guajava*
Mpinamiti, Nkoolimbo	*Cajanus cajan*
Mubimba, muzimbandeya, sesbania	*Sesbania sesban*
Mucungwa	*Citrus species*
Mugavu	*Albizia coriaria*
Mukebu	*Cordia abyssinica*
Mukebu	*Cordia africanum*
Mukoge	*Tamarindus indica*
Mukunyu	*Ficus sycomorus*
Mukunyu, Kabalira	*Ficus mucosa*
Mulberry, Nkenene, Enkenene	*Morus alba*
Mulongo	*Albizia zygia*
Mululuza	*Vernonia amuydalina*
Musaali	*Garcinia buchananii*

Musasa	*Sapium elipticum*
Musasa, Musanvuma	*Sapium ellipticum*
Musenene	*Podocarpus gracillor*
Musizi	*Maesopsis eminii*
Musogasoga	*Croton macrostachyus*
Musongole	*Balanites aegyptica*
Mutuba	*Ficus natalensis*
Mutugunda	*Vangueria apiculata*
Muvule	*Milicia excelsa*
Muwafu	*Canarium schweinfurthii*
Muyembe	*Mangifera indica*
Muyirikiti	*Erythrina spp*
Muyovu	*Entandrophragma cylindricum*
Muziru	*Pseudospondias microcarpa*
Neem	*Azadirachta indica*
Nkoni	*Euphorbia trucalli*
Nkulumire, Mbula	*Croton megalocarpus*
Nongo	*Albizia zygia*
Nsambya, Musambya, Lusambya	*Markhamia lutea*
Ntasesa, Ngwabuzito	*Prunus africana*
Paapali, pawpaw	*Carica papaya*
Umbrella Tree	*Terminalla spp*

The Swedish Development Cooperation Agency (Sida) has supported rural development programmes in Eastern Africa since the 1960s. It recognises that conservation of soil, water and vegetation must form the basis for sustainable utilisation of land and increased production of food, fuel and wood.

In January 1998, Sida inaugurated the Regional Land Management Unit (RELMA) based in Nairobi. RELMA is the successor of the Regional Soil Conservation Unit (RSCU), which had been facilitating soil conservation and agroforestry programmes in the region since 1982. RELMA's mandate is to contribute towards improved livelihoods and enhanced food security among small-scale land users in the region, and the geographical area covered remains the same as previously, namely, Eritrea, Ethiopia, Kenya, Tanzania, Uganda and Zambia. RELMA's objective is to increase technical know-how and institutional competence in the land-management field both in Sida-supported programmes and in those carried out under the auspices of other organisations.

RELMA organises training courses, workshops and study tours, gives technical advice, facilitates exchange of expertise, and initiates pilot activities for the development of new knowledge, techniques and approaches to practical land management.

To publicise the experiences gained from its activities in the region, RELMA publishes and distributes various reports, training materials and a series of technical handbooks.

About this book:

The production of this handbook is in response to a request from the forestry department, Uganda to RELMA for assistance in the production of agroforestry extension materials. This handbook is divided into six chapters. Chapter 1 is Introduction; Chapter 2 presents the description of the banana coffee region of Uganda. In Chapter 3, the definition of agroforestry, the benefits of agroforestry and related issues are described. In Chapter 4, sources of seeds and other tree propagation materials, raising of seedlings and management of grown trees are discussed. Chapter 5 represents the core of the handbook and discusses agroforestry practices common in the banana–coffee zone of Uganda. Pest and disease control in relation to trees is the subject of Chapter 6.

Much of the contents of this handbook is drawn from farmers experiences and practices. During preparation of this manual discussions were held with farmers and case studies developed from several districts of Uganda including Mukono, Mpigi, Mbarara, Iganja and Jinja. Institutions in Uganda collaborating in the production of this manual were: Forestry Department, Forest Research Institute (FORI); Ministry of Agriculture, Animal Industries and Fisheries (MAAIF); CARE International , Vi Masaka and ICRAF.

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