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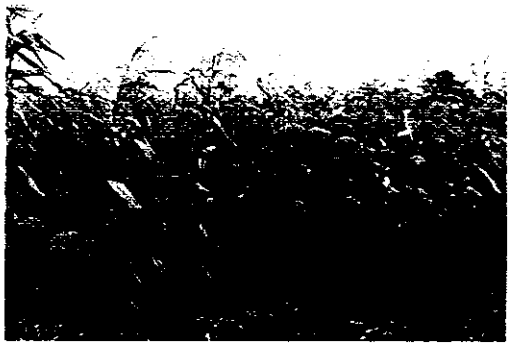
MALAWI AGROFORESTRY

Landcare Practices in Malawi



W.T. Bunderson, Z.D. Jere, I.M. Hayes and H.S. K. Phombeya

MALAWI AGROFORESTRY EXTENSION PROJECT

Publication No. 42

PUBLICATION SERIES NO. 42

LANDCARE PRACTICES IN MALAWI

MALAWI AGROFORESTRY

Malawi Agroforestry Extension Project
A Government of Malawi, U. S. Agency for International Development,
Washington State University
Collaborative Project

Government of Malawi

USAID

WASHINGTON STATE UNIVERSITY
World Class. Face to Face.

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March 2002

This publication was made possible through USAID under Cooperative Agreement No. 690-A-00-92-0056-00. The opinions expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Agency for International Development.

Printed by WSU Printing and Publications, Pullman, Washington 2002

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Note: Figures are only numbered when they are referenced specifically in the text.

ACRONYMS

ADD..... Agricultural Development Division

Bunda..... Bunda College of Agriculture

DARTS..... Department of Agricultural Research and Technical Services

FRIM..... Forestry Research Institute of Malawi

GAP..... Guide to Agricultural Production

GDP..... Gross Domestic Product

GOM..... Government of Malawi

ICRAF..... International Center for Research in Agroforestry

LRCD..... Land Resources Conservation Department

MAFE..... Malawi Agroforestry Extension Project

MNREA..... Ministry of Natural Resources and Environmental Affairs

MAI..... Ministry of Agriculture and Irrigation

PROSCARP.. Promotion of Soil Conservation and Rural Production

UNICEF..... United Nations International Children's Emergency Fund

USAID..... United States Agency for International Development

ACKNOWLEDGEMENTS

This field manual was produced by the Malawi Agroforestry Extension Project (MAFE) through a Cooperative Agreement between USAID and Washington State University under the Department of Land Resources Conservation in the Ministry of Agriculture and Irrigation. The collaboration of the Forestry Department is gratefully acknowledged. The authors are responsible for the views expressed in this manual which may not necessarily conform with those of USAID. Much of the information reflects knowledge gained from research and field-level experiences with farmers over the past 8 years by MAFE and its many partners. There are too many people to thank individually, but their collaboration is greatly appreciated, especially agricultural and forestry staff in government. We also wish to thank individuals and institutions for permission to reproduce illustrations from the following books: *A Field Guide to Lengwe National Park* (1984) by B.Y. Sherry and A.J. Ridgeway; *Trees of Kenya* (1989) by T. Noad and A. Birnie; *Common Fuelwood Crops* by E.L. Little, Jr.; *Trees of Southern Africa* (1977) by K. C. Palgrave; *Useful Plants of Malawi* (1975) by J. Williamson; *A Selection of Useful Trees and Shrubs for Kenya* (1992) by ICRAF; and *On-Farm Tree Nurseries* by the Kenya Woodfuel Development Programme. Each is acknowledged where used.

Proper Citation: W.T. Bunderson, Z.D. Jere , I.M. Hayes and H.S.K. Phombeya (2002). *LandCare Practices in Malawi*. Malawi Agroforestry Extension Project, Publication No.42, Lilongwe.

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FOREWORD

This manual reflects Malawi's current state of the art in soil conservation and agroforestry, and supersedes the Field Manual of Agroforestry Practices in Malawi published in 1995. It marks over 15 years of collaborative research, extension and on-farm adaptation by numerous professionals, organisations and farmers. The support of the Ministry of Agriculture and Irrigation in partnership with USAID and Washington State University has been instrumental in the development of innovative soil conservation and agroforestry technologies to help meet the different needs of Malawi's farmers.

The production of this manual is intended to serve as a practical reference for extension agents to support the adoption of these practices by farmers. It represents an evolutionary process of our current knowledge, but there is much room for improvement since the recommended technologies are not suited to all locations and with all farmers at all times. As we learn more about the interaction of existing and new technologies under different farm and environmental conditions, revisions will be made to reflect changing needs and priorities. We strongly encourage practitioners to be experimental and creative in using the information presented. Additional information on forestry practices and extension is available in the Forestry Extension Kit published by the Forestry Department.

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THE MALAWI AGROFORESTRY EXTENSION PROJECT

Background and Purpose

The Malawi Agroforestry Extension Project (MAFE) is a collaborative grant agreement between USAID and Washington State University under the Land Resources Conservation Department (LRCD) in the Ministry of Agriculture and Irrigation (MAI). The project aim is to improve natural resource management with sustained farm productivity by increasing the adoption of agroforestry and soil conservation practices.

A pre-feasibility study in 1992 identified three key problems affecting smallholder farmers in Malawi:

1. declining farm productivity from widespread soil and forest degradation,
2. low soil fertility from continuous cultivation with little or no use of organic and chemical inputs, and
3. acute wood shortages for basic energy and building needs.

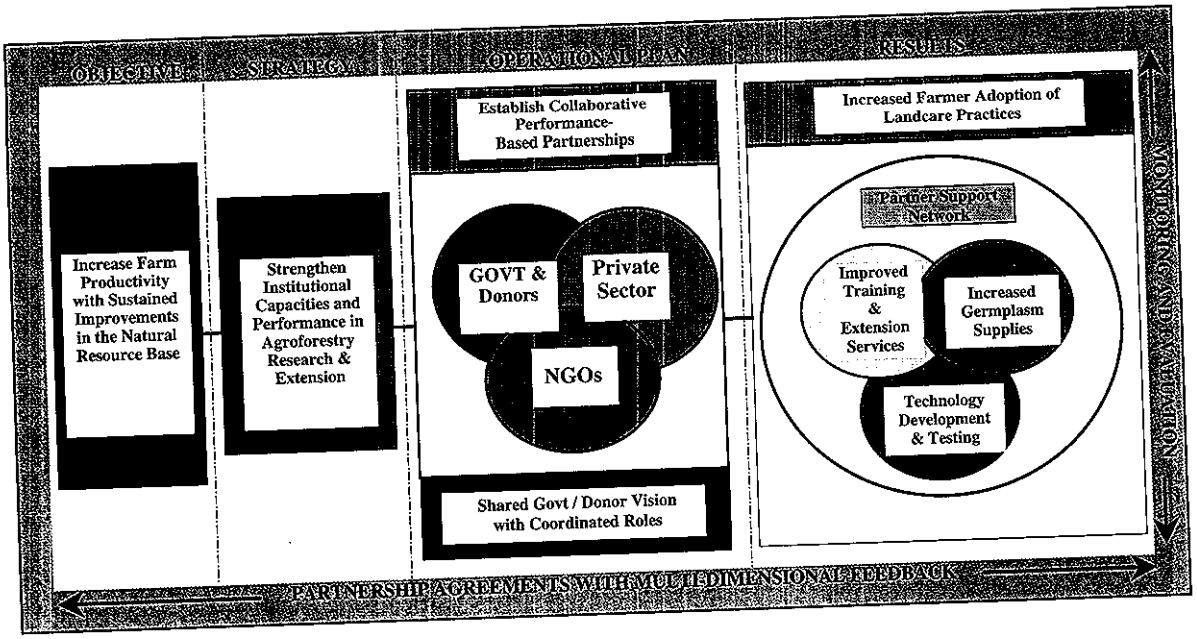
MALAWI AGROFORESTRY

The challenge facing Malawi today is to increase the adoption of production-increasing conservation practices on a national basis. To address this challenge, MAFE engineered a new paradigm of partner support services in 1996 to aggressively expand outreach efforts in a coordinated manner (see **Figure 1**). The goal is to generate fast-track results by providing a range of support services to a broad spectrum of partners on a demand-driven basis. Support currently involves a network of over 40 public, donor, NGO and private sector organizations.

Focus For 2000/02

Growing partner demands are shaping a new vision to expand results. To capitalize on this opportunity, MAFE has established a Resource Center to streamline support services to partners and clients on a semi-commercial basis. It has also taken

Figure 1: MAFE Model for Increasing Adoption of Landcare Practices



over responsibilities for conducting and contracting research to refine/improve technologies and to explore new opportunities. The aim is to build capacity to meet real market demands for sustaining these types of services after MAFE ends.

The Resource Center is located on the ground floor of the Department of Land Resources Conservation, and provides the following facilities:

Customer and Library Services for technical information, germplasm and extension-training materials.

Training Classroom, fully equipped with audio-visual facilities.

Seed Bank for cold and refrigerated storage of tree seed.

Warehouse for storage of nursery supplies and tools.

Offices for the Resource Center Coordinator and Manager.

An overview of support services offered by MAFE is presented below.

Technical and Partner Services

Technology Development and Testing

MAFE has been instrumental in developing, testing and adapting prototype technologies with farmers under different farm and environmental conditions. Based on these results, recommendations have been made on best-bet practices that have proved beneficial and popular among farmers. These practices address inter-related problems of soil erosion and water runoff, declining soil fertility and crop yields, wood shortages and deforestation.

Training

Training is offered to extension staff and farmers, but with a focus on trainers within partner institutions to build capacity for self-sufficiency and sustainable growth. Training covers the following subjects:

Preparation of workplans;

Targeting technologies that match location specific needs of farmers;

Seed collection and handling;

Management of tree and vetiver nurseries;

Agroforestry and soil conservation practices;

Community-based monitoring and evaluation (see details below).

Extension and Training Materials

MAFE produces and disseminates a wide range of extension and training materials to improve the accuracy, consistency and delivery of technical messages to farmers. These materials are targeted at different audiences as shown in **Table 1**.

Germplasm Supplies

Access to quality planting materials is a key factor determining the nature and scale of agroforestry programs. Germplasm support by MAFE falls into three categories:

Vetiver grass: Two major strategies are being used to increase the supply and availability of vetiver grass: 1) contracts for primary nurseries with commercial enterprises, 2) planting material and technical support to farm communities to establish nuclear village-level nurseries for onward disbursement to individuals or groups.

Tree seed: Quality tree seed is provided to partner organizations and farm communities in response to specified demands under a cost-sharing arrangement. The aim is to establish a commercial basis for sustaining this service after MAFE ends. Recipients are also trained in proper methods of seed collection and handling to build self-sufficiency in maintaining and expanding seed supplies at local levels.

Crop seed: MAFE participated in early national efforts to increase the seed supply of improved varieties of grain legumes, notably groundnuts, pigeon peas and soyabeans. Multiplication programs included smallholders and commercial estates. Although MAFE is no longer involved in providing improved crop seed, many other organizations now supply this service.

Monitoring and Evaluation

MAFE took a lead role in developing and institutionalizing community-based

Table 1: Production and Dissemination of Extension and Training Materials

TYPE OF EXTENSION MATERIAL	Numbers	Language
1. Manuals		
A Field Manual for Agroforestry Practices in Malawi	5,000	English
Landcare Practices in Malawi	5,000	English
Field Manual for Treadle Pump Irrigation in Malawi	3,000	English
Community-Based Monitoring and Evaluation -3 systems	100 each	English
2. Booklets		
Best-bet Agroforestry & Soil Conservation Practices	6,000	English
Best-bet Agroforestry & Soil Conservation Practices	3,100	Chichewa
Common Agroforestry Tree Species in Malawi	3,000	English
Tree Seed Collection and Nursery Management	3,000	English
3. Training Kits (Includes Reference Manual + Overhead Transparencies)		
PRAs, Workplan Development & Agroforestry/Soil Cons.	100	English
Small-scale Irrigation with the Treadle Pump	100	English
4. Posters		
Construction/Management of Nurseries (series of 3)	10,000 each	Chichewa
Tree Spacing and Outplanting (series of 2)	10,000 each	Chichewa
Soil Fertility Practices (series of 3)	10,000 each	Chichewa
Soil & Water Conservation (series of 5)	10,000 each	Chichewa
5. Leaflets		
Contour Ridging with the Line Level	40,000	Chichewa
Planting and Managing Vetiver Hedgerows	20,000	Chichewa
Dispersed Systematic Tree Interplanting	20,000	Chichewa
Undersowing *Tephrosia vogelii* with Maize	4,000	English
	20,000	Chichewa
Treadle Pump Irrigation (series of 8)	5,000 each	Chichewa
6. Videos (used by extension service providers)		
Land-use problems and practices to address them	100 each	English & Chichewa

systems to monitor and evaluate agroforestry and soil conservation programs by government, NGOs and donor projects. Systems have been tailored to approaches that operate on a catchment, village, or group / association basis. Results to date demonstrate consistency and efficiency in providing an accurate assessment of the scale and quality of land-use practices. Active community participation with gender sensitivity ensures that programs are responsive to farmer needs. The appeal of the methodology is its adaptability to monitor any NRM or agricultural practice. Recent exposure and strong endorsement by the Land Resources Conservation Department (LRCD), the Ministry of Agriculture and Irrigation (MAI) and many NGOs indicate significant progress toward institutionalizing the systems.

Performance-Based Grants

MAFE undertook a new initiative in developing a model of performance-based grants to produce quality results in research and extension. Grants were targeted initially at government institutions on mutually agreed outputs. Grants have since been expanded to include collaborative agreements with parastatal institutions and private enterprises for specific research and information on natural resource products. To qualify for support and funds, potential grantees must submit a streamlined, results-oriented plan of work and budget that meet the stated objectives. Contributions from the partner institution are desirable to show commitment. Funds are disbursed in tranches upon demonstrating that the planned actions are being carried out with desired results according to a specified timeframe.

This model has already shown results to improve investments in 2 distinct ways.

1. Provision of incentives to produce more and better quality results under a streamlined structure to facilitate planning, implementation and documentation of results.

2. Focus on institutions, enterprises and programs that are successful and worthy of continued funding.

MAFE believes that this model can be successfully adapted to different programs and with different clientele.

Policy Support

MAFE is providing policy support to the Department of Land Resources Conservation and the National Agroforestry Steering Committee in the following areas related to soil conservation and agroforestry:

1. Performance based guidelines to improve extension services at the field level for maximizing results;

2. Collection of relevant information on field-initiatives by different institutions/ organizations for setting and reviewing policies with practical guidelines for implementation;

3. Streamlining the development and communication of sound extension recommendations to ensure consistency and coordination among stakeholders and implementers.

4. Publicizing information on natural resource management (NRM) developments, field results, research needs, extension approaches, and other relevant matters through newsletters, minutes of stakeholder meetings and special reports.

Marketing of Natural Resource Products

MAFE's mandate was widened in 2000 to investigate the production and marketing of value-added natural resource products to increase rural incomes and to accelerate adoption of respective landcare practices. Identifying and developing market niches for NR products will help transform the narrow base of Malawi's smallholder agriculture to a more vibrant, market economy. This is consistent with evolving development plans to increase rural production and incomes. Research and development is being carried out with partners through cooperative agreements and performance–based grants to select and promote products with high commercial value. Investigations are concentrated on products from agroforestry species promoted by MAFE with a focus on tree seed oils and their by-products, botanical pesticides and medicinal compounds. The main species include *Jatropha curcas*, *Moringa oleifera*, *Sclerocarya birrea*, *Schizophyton rautanenii*, *Tephrosia vogelii*, and *Trichilia emetica*.

Key partners include farmer groups, Bunda and Chancellor Colleges under the

University of Malawi, Malawi Bureau of Standards, several regional and national projects, and small-scale private processors.

MAFE also aims to provide technical advice and training to interested parties on setting up commercial ventures for processing and marketing NR products in Malawi.

Results of this initiative will be documented in a separate publication in 2002.

Recommendations To Increase Adoption Rates Among Farmers

MAFE has made significant strides in its partnership network to expand the adoption of sound land management and conservation practices. Although the momentum continues to grow on an exponential scale, partnerships need nurturing as they are still young and vulnerable.

The following recommendations are made to increase the scale and quality of results at the field level, and to help ensure continuity for lasting impacts.

1. Increase policy support to the LRCD and National Agroforestry Steering Committee (NASC). The aim is to coordinate extension delivery services among different providers and to avoid use of inappropriate incentives and conflicting messages.

2. Increase the profile of natural resource management as a national priority by demonstrating the integral link between improvements in the natural resource base and sustained agricultural productivity.

3. Ensure community participation at all stages, from problem identification to implementation and evaluation. An important focus is to support leadership and organization through traditional authorities.

4. Emphasize institutional cooperation to leverage resources for broader and faster results with agreement on desired outcomes and strategies to achieve them.

5. Build capacity and expertise among service providers through quality training and extension materials to

equip trainers and extension staff with tools to transfer skills and knowledge to farmers.

6. Increase the supply of quality germplasm to expand extension services in line with farmer demands. A key aim is to develop strategies to meet national needs on a sustainable basis, with a focus on community self-sufficiency.

7. Set targets that are feasible and sustainable within the time and resources available, taking into account the following factors:

   a. Concentrate resources at the field level for effective extension support to generate early successes within manageable geographic areas. This will attract greater investment and partner commitment so that results can be scaled up as capacity and confidence increase.

   b. Focus on proven technologies and species that address identified farmer needs and interests, recognizing that farmers will not undertake NRM practices simply for the sake of conservation - there must be tangible returns with direct benefits to their lives (incomes, yields, products, better labor efficiency).

   c. Emphasize communal implementation of agreed practices with strong leadership and coordination for broader and more effective impacts.

   d. Provide planting materials and nursery inputs in quantities that match the targets set for timely nursery sowing and field outplanting.

8. Improve the efficiency, reliability and cost of monitoring through community-based systems to track achievements and to identify needed changes for better and faster results.

9. Ensure program continuity to achieve targeted results since changes in direction are disruptive and can destroy valuable partnerships.

INTRODUCTION

Malawi is one of the world's poorest countries. The human population today is estimated at 10 million with a density averaging 105 km^{-2}, one of the highest in Africa.

Land-locked with no significant mineral resources, Malawi's principal assets have been a hard-working people, relatively fertile land, extensive indigenous forests, and abundant fisheries. Reflecting this endowment, agriculture has dominated the economy, contributing 40% of the GDP, 85 to 90% of the foreign exchange earnings, and 85% of the labour force (World Bank 1992). It also provides 60-70% of the inputs to the manufacturing sector, and dominates the commercial and distribution industry. Forests supply 90% of the domestic and industrial energy requirements, while fisheries provide almost 80% of the total animal protein supply.

Agriculture

Characteristics of the agricultural sector are well summarized by Gossage (1997), BDPA (1998) and Orr et al. (1998). Agriculture is strongly dualistic in structure, with *commercial estates* on private land under freehold or leasehold status, and *smallholder farms* under customary tenure with usufructory rights. Smallholders contribute 80% of total agricultural production, while the estate sector controls 90% of the export trade. Major food crops are maize, groundnuts, cassava, pulses, sorghum, and rice. Principal exports include tobacco, tea, sugar, coffee, groundnuts, cotton, and macadamia nuts.

About 7.3 million ha (78% of the total land mass) falls within the customary/ private sector. Of this area, the estate sector lays claim to 1.2 million ha, with 6.1 million ha under customary tenure. The latter involves over 2 million smallholder farm families. An estimated 30% of these households are headed by women, but this percentage increases among the smaller and poorer category of farms. In 1987/88, 56% of all smallholders in Malawi cultivated less than one hectare of land, 31% had 1 to 2 hectares, and the remaining 13% had more than 2 hectares.Within these categories, average holding sizes are 0.5 ha, 1.4 ha, and 2.9 ha respectively, with an average of 1.1 ha.

Crop production is dominated by maize, which is the staple food crop,

accounting for 75% of the total cultivated land, although the area under cassava is now increasing (MAI, 2000). Although farming is mostly subsistence oriented, cash crops are also grown. The most common include several types of tobacco (burley, dark-fired and oriental), beans, soyabeans, groundnuts, sunflower, cotton and various horticultural crops.

SITUATION ANALYSIS

Despite huge efforts to promote technologies to increase productivity, nearly 60% of smallholder households currently live below the poverty line. Many of these farms have chronic labour shortages because of the need to earn income through off-farm work (ganyu). This often coincides with peak periods of work required on their own farms, which forces households into a vicious cycle of increasing poverty and food deficits. Restrictive policies aggravate the situation by suppressing true market forces and incentives for sound resource management. The result is that real incomes and foreign exchange earnings are declining, and the gap in the distribution of income continues to widen as policies favour the privileged few. This is eroding the ability to satisfy basic needs. Although Malawi's democratic government is responding to policy and market distortions, obstacles remain that preclude active participation by farmers in the market place.

Outlooks to reverse this predicament are bleak, with adverse consequences on soil and forest resources.

LAND DEGRADATION

SOILS

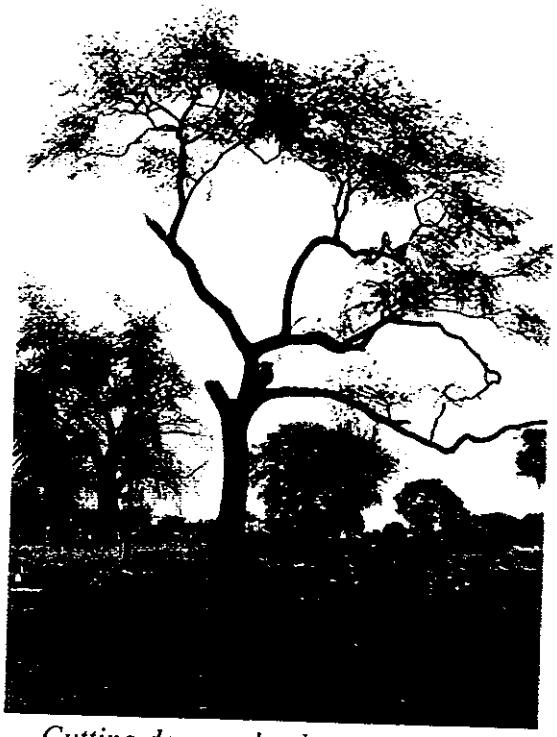
Most households lack the resources and support to integrate sound conservation and agronomic practices into their farming systems. The situation is compounded by increasing land shortages and farm fragmentation, forcing many farmers to undertake continuous cropping in monocultures, often on marginal land. This has led to serious problems of water runoff and soil degradation. The resulting soils are characterised by loss of structure, reduced moisture holding capacity, depletion of nutrients and organic matter, and decreased micro-fauna and flora. Loss of top soil averages over 20 tons / ha per annum (World Bank 1992), with rates more than 50 tons / ha in many areas. The cost to the economy is estimated at 1 to 5% of GDP (World Bank 1992). Annual tillage has aggravated the

problem by reducing soil porosity and organic carbon through oxidation. There is also evidence that conventional tillage has created a hardened layer or "hoe-pan" of reduced permeability. This limits soil water infiltration and retention, causing surface runoff with reduced capacity for recharging groundwater supplies. All these factors contribute to poor crop growth and development, which lowers yields, particularly in drought years.

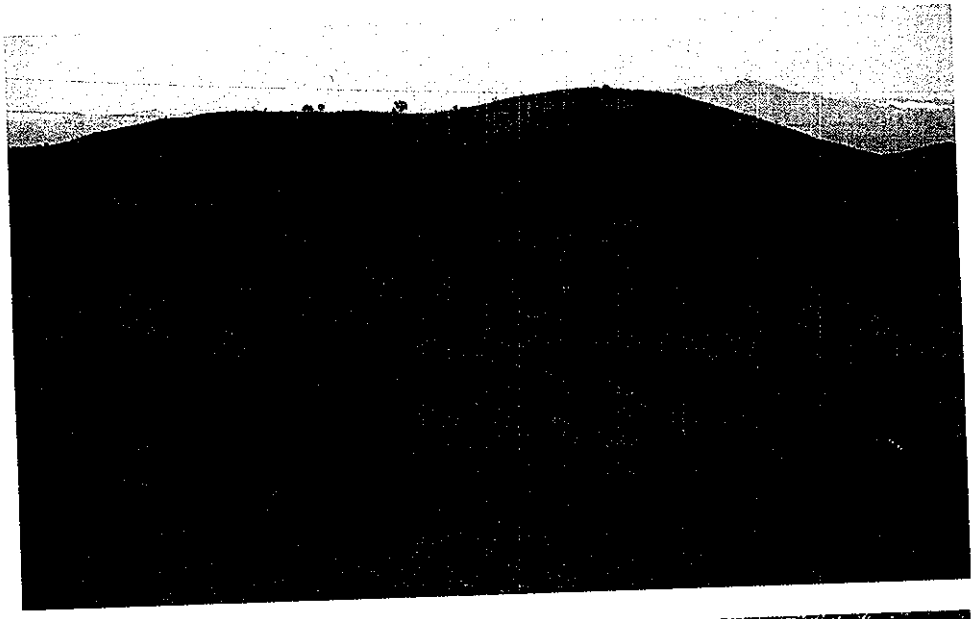
FOREST COVER

Land clearing for agricultural expansion, coupled with high demands for fuelwood and building materials, are the primary causes of deforestation. Between 1972 and 1990, total forest cover in Malawi declined by an appalling 41%, averaging a loss of 2.3% annually (Bunderson and Hayes, 1995). Fuelwood is estimated to account for 93% of the total energy consumed in Malawi (Anon., 1981). Since present policies do little to promote alternative fuels and building materials, continued reliance on wood is threatened by unsustained exploitation of forest resources.

Most deforestation in Malawi has occurred on customary and private land where enforcement of conservation policies is weak. This translates into an annual loss of 3.4% for non-reserve land. The attendant loss of biodiversity is often accompanied by adverse changes in climatic and hydrological regimes. This leads to diminished stream flows, and the siltation of rivers, dams, and lakes. Protection of important water catchments is now at risk. Combined with



Cutting down valued trees such as **Faidherbia albida** *is a sure sign that wood is in short supply*



Deforestation of hillside with early signs of erosion.

Severe gullying can occur from poor cultivation practices.

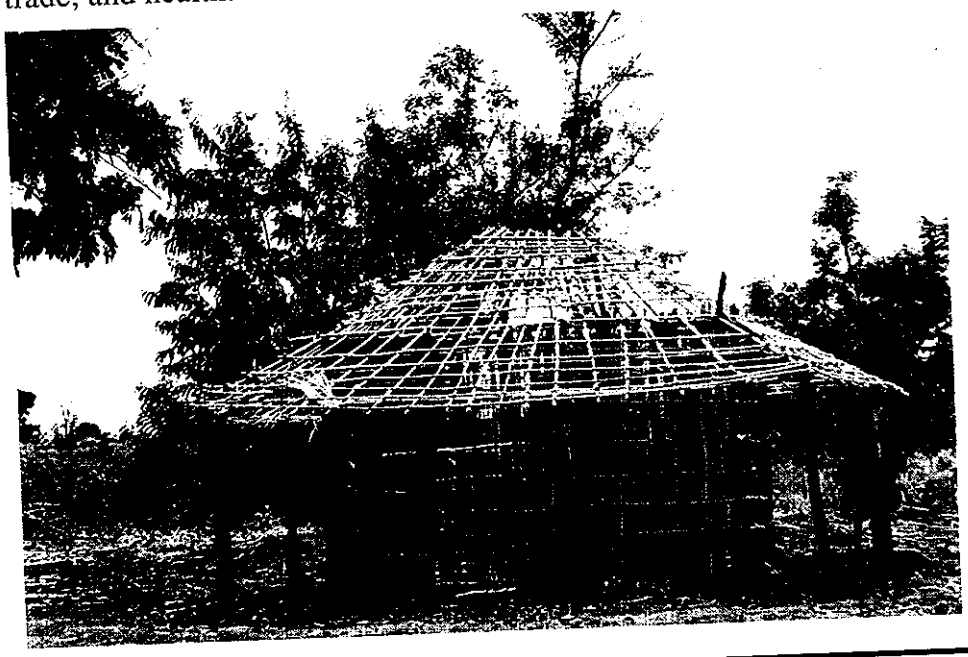
Forest cover of Nsanjika Mountain in Ntcheu, 1987.

Same hillside in 2001 showing effects of deforestation.

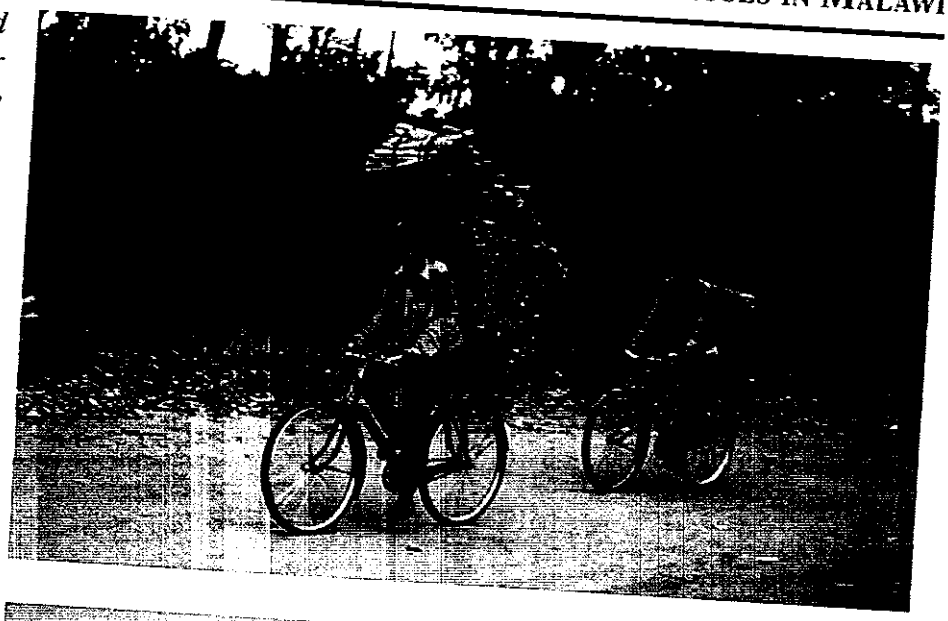
Farmer carrying firewood

the added danger of flooding, these problems have far-reaching effects on agriculture, fisheries, hydro-electic power, industry, trade, and health.

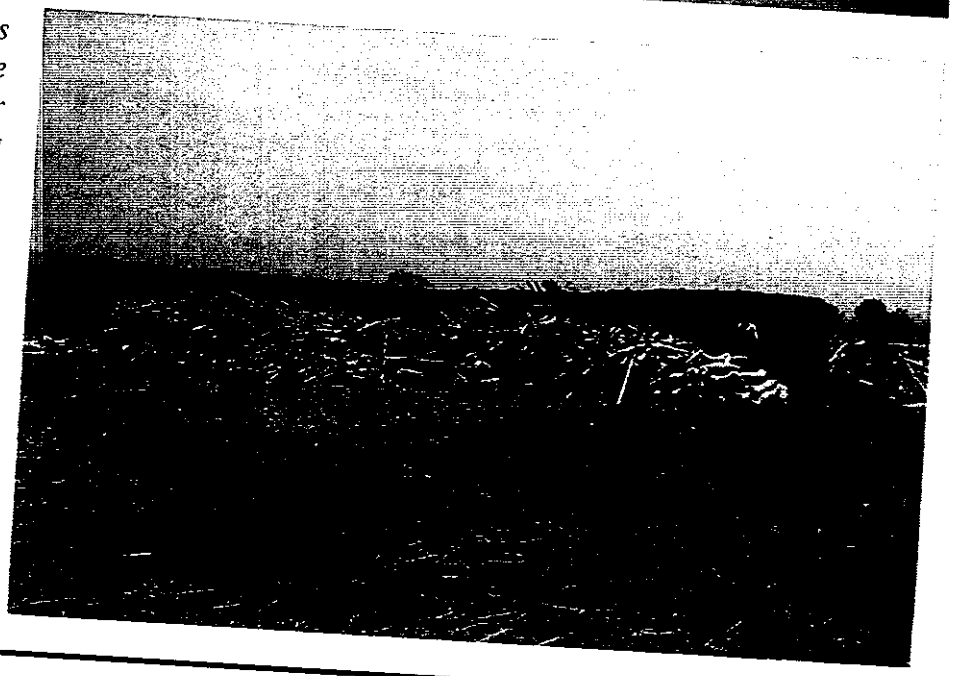
A major cause of deforestation is that wood is regarded as a free resource taken from land with open access. Another contributor is the fast growth of estates, which increased from 229 in 1970 to 37,000 in 1995 (World Bank, 1995). Tobacco is a special concern because of the vast amounts of wood needed for leaf curing and shed construction. This is estimated at over 1 million m^3 of wood per annum. Government policies aggravate the problem by subsidising forestry nurseries (the Forestry Department started privatising these nurseries in 1994/95 because of their high running costs and low effectiveness) and by setting prices of



Demands for building material contribute to deforestation



Fuelwood demands for domestic use contribute to deforestation.



Vast quantities of wood are used for curing building bricks.

Horticultural produce from beneath **Faidherbia albida** *trees.*

Soils under **Faidherbia albida** *remain productive even without fertilizer. Note the greener maize beneath the canopy.*

plantation wood at artificially low levels. These factors impede development of private initiatives for efficient tree-based markets. Since wood prices are lower than production costs, incentives to plant trees are limited. This has increased problems of deforestation, particularly around urban centres where demands for wood are growing.

Problems of deforestation are aggravated by the proliferation of enterprises engaged in harvesting trees for fuelwood and building materials, beer brewing, smoking fish, lime production, and brick-making. These non-farm activities are among the few options available for resource-poor households to earn cash for food and other basic needs, but long-term prospects are threatened by unsustainable, indiscriminant tree cutting.

EFFECTS ON AGRICULTURE

The rising scarcity of trees has direct impacts on agriculture. Many species help to counter adverse climatic conditions by reducing damage from heavy winds and rainstorms on soils and crops, while improving water infiltration and its availability to plants. Some species help recycle nutrients from deep soil depths to the surface. Those that are nitrogen fixing act as natural fertilisers by absorbing and fixing nitrogen from the air. Certain species are cultivated commercially for fruits, oils, timber, fuelwood, latex, dyes, tannins, and gums, while others have important medicinal and insecticidal properties. These products provide useful income and contribute to the local economy and export earnings, but their potential needs to be developed.

Loss of tree cover causes organic matter to mineralise and leach more quickly from the topsoil, with long-term effects on fertility. Wood shortages force people to use alternative sources of fuel and building material. In parts of the south, maize stover and animal manure are used for cooking, which deprives livestock of valuable feed, and soils of needed organic matter. Farm households (mostly women and children) must walk greater distances and spend more time gathering wood. This detracts from more productive activities for farming, child rearing, education, nutrition and health.

The low productivity of smallholder livestock is primarily a result of disease and poor nutrition. Animals most affected are breeding and young stock, which commonly

exhibit deficiencies in energy, protein and sometimes phosphorous. Of critical concern is the supply of dry-season forage, which is generally below animal maintenance requirements. This problem is becoming more acute due to the declining abundance of browse from expanding cultivation, widespread burning, tree-cutting, and shortened fallows.

PROBLEM SUMMARY

Malawi faces complex social, economic and environmental problems that threaten a steepening dependency on foreign aid. The heart of this crisis is the nation's high and growing population coupled with the devastating effects of diseases, malnutrition and HIV. Recurrent drought, reduced export earnings and declining terms of trade have magnified these problems in recent years. Increasing pressure on agricultural land, the country's most important natural resource, is the major constraint to sustainable agriculture. The influx of one million Mozambican refugees during the 80s and early 90s has further degraded Malawi's scarce resources. A similar problem is occurring now with refugees from Somalia and the Democratic Republic of the Congo. The overall result is that land holdings are shrinking and becoming more fragmented. Traditional practices that preserved the integrity of the natural resource base are dying out. Marginal areas have been brought under cultivation, and fallowing is almost non-existent. Continuous cropping is now the norm with few if any inputs. The challenge today is to find sustainable ways to increase agricultural growth at a rate faster than that of the population.

LANDCARE PRACTICES

As a nation whose livelihood depends on agriculture, Malawi recognizes the urgency to develop production-increasing technologies that preserve the integrity of natural resources.

In the context of this manual, landcare practices constitute improvements in the management of land resources for sustained increases in farm productivity with reduced soil and forest degradation.

The landcare practices described here have proved effective in maintaining crop and animal yields by improving the soil, water and vegetative base, and by mitigating harmful environmental, pest and disease problems.

As the major user of land and water resources, farmers play a vital role in the conservation of natural resources. Helping them adopt sustainable landcare practices will bring significant economic benefits while maintaining the multiple values and biodiversity of natural woodlands and forests.

This manual describes how to establish and manage recommended landcare practices to improve and sustain farm productivity. It also outlines methods for effective extension and planning to ensure community understanding and responsibility for action.

The relevant chapters are organized as follows:

Chapter 2: Developing Community-Based Action Plans

This chapter discusses simple methods for working with communities in identifying priority problems related to land use, and possible strategies to address them. It culminates with steps needed to develop a community-based action plan.

Chapter 3: Tree Propagation and Outplanting

This chapter discusses propagation techniques to help farmers grow more trees on their farms. It includes sections on seed collection, nursery design and management, and proper methods for outplanting.

Chapter 4: Soil and Water Conservation

Loss of topsoil and water runoff from poor farming practices is a major factor affecting the sustained productivity of agriculture and the natural resource base. The problem is becoming more acute with increasing pressure on land.

This chapter presents information on the following practices to improve soil and water conservation:

ridging on the contour
tied and box ridges
raising farm footpaths and boundaries
gully control measures
streambank protection
planting vetiver hedges on contour

Chapter 5: Trees to Improve Soil Fertility

A widespread problem facing Malawi's smallholders is declining soil fertility from continuous cultivation with few if any chemical and organic inputs. This chapter describes a range of agroforestry practices to improve soil fertility and crop yields, while providing other services and products. Four of these have broad-based application in Malawi.

Dispersed systematic interplanting of *Faidherbia albida, Acacia galpinii* and *Acacia polyacantha* with crops.

Natural regeneration of soil-improving trees in crop land.

Annual undersowing or inter-cropping of *Tephrosia vogelii* with maize.

Improved fallows with soil, improving trees and shrubs.

Other practices have limited application due to intensive labour and management requirements, even though fertility benefits are substantial. These include:

Alley cropping and mixed tree intercropping

Green manure banks

Chapter 6: Trees for Wood and Other Products

Demands on trees for wood, fruit and fodder continue to outstrip supplies at an increasing rate with the attendant impacts on farm and natural resources. To help address the problem, this chapter explains several forms of tree planting among rural communities. The most popular include:

Planting multi-purpose trees in woodlots, on boundaries and around the homestead for a variety of domestic uses and sales for cash.

Fodder banks of trees and shrubs to increase energy and protein levels in livestock.

Live fences and live farm sheds to reduce costs of building and maintaining expensive structures that rely on external materials.

Chapter 7: Common Agroforestry Species

In this chapter, common agroforestry species are described for planting in different practices. It includes an illustration on each species with a brief on botanical characteristics and uses.

CHAPTER 1 QUESTIONS: LANDCARE ISSUES IN MALAWI

1. Identify two major problems that characterize smallholder agriculture in Malawi.

2. What is the immediate effect of loss of forest cover?

3. What are the beneficial effects of forest on agriculture?

4. Explain how siltation of rivers (e.g. Shire) affect the supply of electricity in Malawi.

5. Mention four poor land use practices that aggravate soil erosion in Malawi.

(For correct answers refer to Page 245 in the annex)

INTRODUCTION

This chapter provides guidelines for planning and implementing landcare practices with a community at a selected site or catchment. It includes information on the following topics:

- Site Selection and Needs Assessment
- Extension Approaches and Community Participation
- Coordination and Training
- Workplan Development

SITE SELECTION AND NEEDS ASSESSMENT

Purpose

Conduct participatory rural appraisals to describe and assess the farming, socio-economic, and ecological characteristics of the area. The aim is to evaluate the potential success of each site for relevant interventions, which will be incorporated later for agreement with the community on a course of action.

Key Criteria for Site Selection

- The nature and scale of the problems that can be addressed through specific landcare practices, and whether these potential interventions meet priority needs.
- Expressed commitment and willingness of the community to address these problems in a participatory atmosphere.
- Presence of potential "leaders and participants" in the community to facilitate oversight, adoption, feedback and spread.
- Motivation, commitment and ability of the local extension staff to support a participatory landcare program.
- Probability of demonstrable success based on the potential to adopt/adapt relevant landcare practices under local conditions.
- Extent to which the socio-cultural and agro-economic characteristics of the sites represent the target area/ populations of the region.

- Logistics for management and coordination, and the scope for expansion and replication.
- Presence of other projects and/or NGOs that could cause potential programmatic and operational conflicts.
- Potential for buy-in and spread by GOM, NGO, CBO, donors and/or other programs.

Relevance to Landcare Problems

It is important to explain to community leaders and farmers at the outset that a landcare program of this nature accommodates needs related only to agriculture and land use. Services provided are designed to help farmers take better care of their land to generate the following types of benefits to improve farm productivity and incomes on a sustainable basis:

- Improved soil fertility and crop yields.
- Increased supplies of wood and other tree products/uses.
- Reduced water runoff and loss of top soil.
- Reduced rates of deforestation.

Services include training and technical support, and provision of nursery supplies, germplasm and extension materials. No other incentives, such as improved crop seed, chemical fertilizers or pesticides, are provided to reward any form of community or farmer participation as this is unsustainable and detracts from the real merits of the interventions implemented.

Identifying Problems and Potential Solutions

The community should lead the process of problem identification with facilitation by extension staff. To avoid domination by a few individuals, split the community into 2-3 social groups according to age, gender or status. Each group should identify, prioritize and report on 3-4 major problems. Symbols should be used to represent each problem, identifying consequences and cause-effect relationships by drawing a problem tree. A sample of a problem tree is shown below in **Figure 2**. Thereafter, groups should identify and evaluate options to address specific problems by considering the following:

- Does the proposed solution address the problem directly?

- Is it realistic in terms of management, time, labour, cost and required inputs?
- Is it short or long-term, i.e., when can benefits be expected?
- Who will benefit?
- Does it require outside assistance? If so, specify what type of assistance.
- Is it beyond the scope of the program of landcare interventions? If so help identify other organizations that could offer assistance.

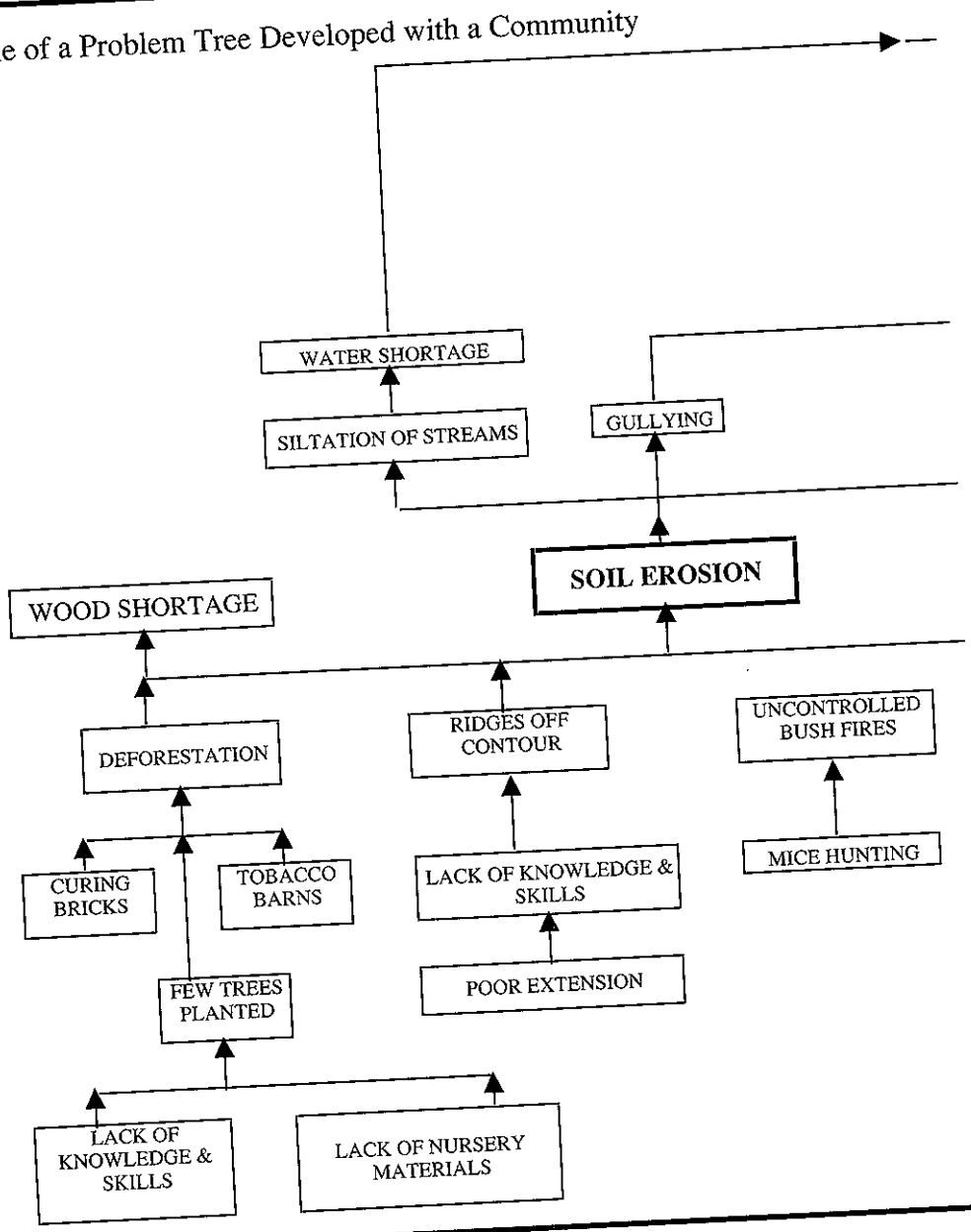
After undertaking this exercise, extension staff can propose and describe specific landcare interventions if these were not already listed. Thereafter, each group prioritizes the options identified for presentation in a plenary session. During the ensuing discussions, it should become clear what the villagers can do and what assistance is needed from the extension service providers.

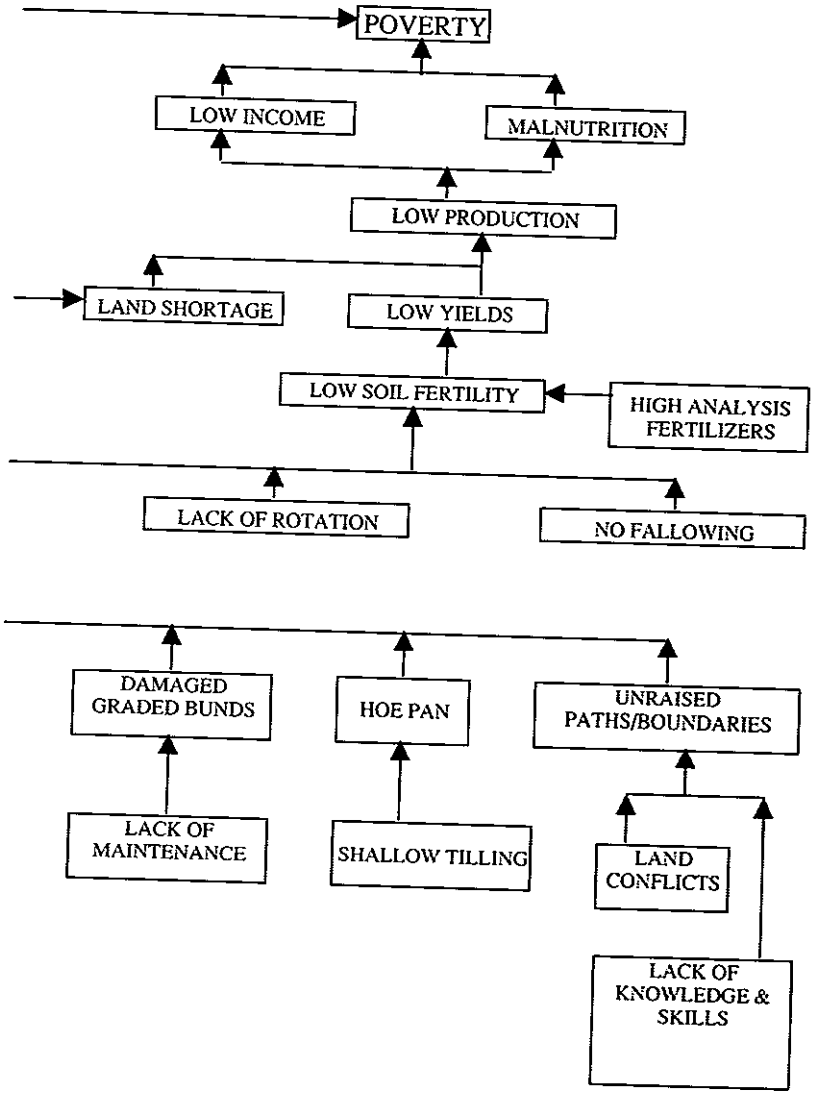
EXTENSION APPROACHES AND COMMUNITY PARTICIPATION

Problems with Top-Down Extension

A primary constraint to adoption has been the government's centralised, top-down approach of extension. This is the Block Extension System (BES), which was introduced in the early 1980s under a modified Training and Visit approach. Similar structures are used by some NGOs. The MAI's system involves a geographical and hierarchical division of the country (ADDs, RDPs and EPAs). EPAs are further divided into Sections, each with eight sub-divisions called Blocks. At each level in the chain, from the ADD down to the Section, there are corresponding levels of staff to facilitate the transfer of messages to farmer groups. These groups are expected to meet fortnightly at Block Centers and demonstration sites. At this level, direct contact and interaction with farmers is made through Field Assistants (FA) representing different subject matters. There is a Land Husbandry Assistant at each EPA responsible for soil and water conservation as well as agroforestry activities.

Figure 2: Sample of a Problem Tree Developed with a Community




POVERTY
LOW INCOME
MALNUTRITION
LOW PRODUCTION
LAND SHORTAGE
LOW YIELDS
LOW SOIL FERTILITY
HIGH ANALYSIS FERTILIZERS
LACK OF ROTATION
NO FALLOWING
DAMAGED GRADED BUNDS
HOE PAN
UNRAISED PATHS/BOUNDARIES
LACK OF MAINTENANCE
SHALLOW TILLING
LAND CONFLICTS
LACK OF KNOWLEDGE & SKILLS

The BES approach reflects many of the weaknesses of a rigid technology-transfer model that is very "top down". It has proved to be unresponsive to farmer needs and priorities. Extension services of the Ministry of Agriculture and Irrigation (MAI) currently reach only 25% of smallholder farmers. Although the block system remains official Government policy, the MAI is reviewing the whole extension service to make it more demand-driven with the inclusion of *participatory extension methods* (PEM). The intent is not to replace the block approach, but rather to strengthen it by emphasizing farmer participation to identify and solve their problems.

Participatory Extension Methods

Participatory extension methods are encouraged to improve extension services. These methods emphasize active community involvement at all levels. The aim is to create a sense of local ownership and responsibility for problem-solving. This process should be planned and conducted through existing and accepted social structures rather than setting up new ones.

The premise is to implement a service delivery system that empowers communities to address priority problems in harmony with their environment. This calls for a farmer focus that is adaptable, practical and responsive to identified needs.

In short, farmers must play a dominant role in addressing their own problems.

Key activities to foster community participation and interest include the following:

- ***Awareness campaigns:*** Explore best-bet options to address farmer problems through educational campaigns to create village awareness of the issues and potential solutions. This requires open dialogue with farmers - getting them to discuss their problems, what they can or wish to do about them, what external assistance is needed, and how they view the various landcare options as alternatives or complementary practices.

- ***Establishment of village conservation committees:*** These committees provide a focal point for community organization and interaction. Committees comprise

local leaders and influential farmers to lead the initiative. Membership is based on farmer-elected officials and representatives under a structure that includes a chairman, vice chairman, secretary, treasurer and 6-8 other farmers active in the community. The village headman is generally included as an ex-officio member. Strong leadership is emphasized for effective communication and organization. Training in leadership skills and group dynamics is provided as needed.

- ***Participation by women:*** Special efforts are needed to encourage active participation by women at all stages. Experience has demonstrated quality and lasting results in sites where women are involved due to a high level of interest based on the key role they play in most if not all farming activities.

- ***Cross-farm study tours:*** Conduct cross-farm visits with farmers to sites where successful initiatives have been implemented by farmers with similar problems. Clearly define the objectives before embarking on these visits. Such tours should include local leaders and influential farmers in the community to provide leadership in the whole initiative when they return home. Following each visit, discuss observations with farmers to help direct field plans based on expressed community interests. Joint assessments enable various interventions to be compared for their ability to address the problems identified.

- ***Matching technologies to farmer needs:*** While a menu of technology options is desirable to address different priorities, there is a risk of creating confusion and overburdening both staff and farmers. Avoid this by focusing initial efforts on fewer interventions, emphasizing those with a quick payoff. Visible benefits will encourage farmers, and will strengthen relationships with extension staff. Prioritize expressed areas of interest as adoption will be poor if farmers are not genuinely interested in a technology. Efforts can later concentrate on technologies having slower returns with encouragement through on-farm demonstrations and extension media.

- ***Frequent farmer meetings and follow-ups:*** These are organized and encouraged by extension staff to inform and reinforce messages to farmers. They take several

forms, operating through the committee, block or special interest groups, to one-on-one interaction. Arrange and confirm meetings in advance with a specific date, time and venue selected by the targeted audience. Review meetings should be conducted quarterly.

- ***Support:*** Support is provided in forms that assist and encourage farmers to implement the practices chosen, especially during the start-up phase. This includes the following:

  - ***Hands-on training*** to transfer skills and knowledge to farmers.

  - ***Extension and training materials*** for both farmers and extension staff to provide ready access to information on how to establish and manage each practice.

  - ***On-farm demonstrations*** through good, volunteer farmers of each targeted practice to illustrate correct management methods and benefits.

  - ***Initial input support*** of tree seed, polythene tubes, and basic nursery tools as a one-off disbursement during the nursery-start-up phase. In special cases, materials are provided to construct shallow wells for tree nurseries, but built by farmers on a self-help basis. Other assistance at start-up includes transport of planting material for vetiver to enable establishment of local nurseries.

- ***Field follow-ups*** to correct problems as they occur and to provide encouragement to the community and to individual farmers. Field staff should work directly with farmers in the field to ensure proper implementation.

COORDINATION AND TRAINING

Lack of coordination between line Ministries and NGOs has led to a multiplicity of extension approaches, often with conflicting messages targeted at the same clientele. Extension agents are often inadequately trained within both government and non-government organizations. If landcare technologies are to be extended effectively, training and collaboration need to be improved to broaden the scope for impact. Beginning small obviates intrinsic errors in undertaking a massive programme

prior to pre-testing in the field. The potential for scaling up can then be evaluated, along with opportunities to link with other promising projects or institutions. During this pilot phase, refinements and modifications can be made as appropriate for subsequent replication nationwide.

Core areas of focus include:

- Consistency in extension approaches and technical messages, with emphasis on a targeted program of partner training;
- sharing experiences and ideas to reduce duplication and to maximise impacts;
- research support to adapt technologies to local conditions, to improve management and benefits, and to identify new opportunities;
- agreement on appropriate forms of incentives limited to providing technical support, hands-on training, and basic inputs such as tree seed, polytubes and nursery tools; support should not include any form of rewards for farmer participation (e.g., providing food, fertilizers, improved crop seed, or money).

The following mechanisms are encouraged for improved cross-institutional linkages:

- ***Bi-annual meetings or workshops*** (1) to exchange experiences and information on approaches, methods, interventions and results, (2) to review past activities, problems and successes, and (3) to make plans that identify areas of beneficial collaboration.
- ***Wide dissemination of progress reports*** or other relevant documents on methodologies, extension messages promoted, workplans, and findings.
- ***Joint production of newsletters*** to better communicate activities and information.
- ***Joint field collaboration*** in sites where several organizations are working in the same area with similar objectives. Responsibilities for different activities can be organized according to the comparative advantage for specific types of services or inputs.
- ***Feedback*** to the Land Resources Conservation Department and National Agroforestry Steering Committee to review and update policies.

Participatory rural appraisal in action

WORKPLAN DEVELOPMENT

Prepare workplans carefully to organize interventions with farmers according to their importance as they relate to:

1. the problem being addressed,
2. how quickly benefits are likely to occur, and
3. the timing, scale and method of establishing targeted practices.

These factors affect all activities from the nursery operations to establishing and managing the interventions.

Key activities in developing a community-based workplan include the following:

- Assisting the community to set targets for each practice and species using MAFE's target guidelines and Partnership Forms 1 and 2 on what an average household can accomplish each season (see **Annexes 1 and 2**).

- Matching targets for each practice based on expressed household interests and available resources.
- Identifying tasks needed to meet the targets from farmer training to implementation.
- Defining farmer and staff responsibilities.
- Setting a practical timeframe to carry out each task in the form of a calendar for discussion with the community.
- Establishing demonstrations for each targeted intervention with selected farmers to explain proper management practices.

Planning Needs for Different Practices

The following considerations are useful in planning the implementation of different practices:

Required Materials and Equipment

- Extension materials as a handy reference (e.g., manual, posters, booklets).
- Suitable instruments for pegging marker ridges (line levels, A-frames, etc.).
- Accurate scales to weigh seed.
- Small plastic bags for distributing seed to individuals.
- Hoes and pangas (farmers and nursery).
- Cloth bags to soak certain types of seed in cold water (use rock to submerge the bag).
- Wooden stakes for pegging, and to mark planting holes, tree seedlings, and hedgerows (to prevent removal/ trampling when weeding).
- Pens, data forms, flipcharts and stationery.

Soil and Water Conservation

Many landcare practices are best established on the contour to improve their function and effectiveness. This helps to reduce soil loss and runoff, while improving water infiltration. A catchment-area approach is recommended to minimize negative 'knock-on' effects from farmers who have not adopted the practices. Early

planning is needed to train and equip farmers to establish physical measures well before the rains. Details on each practice are presented in Chapter 4.

Germplasm Supplies and Nursery Preparation

Timely preparation: Late preparation of tree/grass nurseries, as well as seed banks, leads to delayed establishment of targeted practices. Early evaluation and distribution of nursery and germplasm needs for each practice and species ensures timely outplanting to take full advantage of the growing season.

Seed self-sufficiency: The present supply of tree seed is insufficient to meet demands. This situation will worsen if the problem is not addressed now. Allocating land for propagating certain species should be an immediate priority, focusing on *Tephrosia* and vetiver grass since large quantities of these are needed and supplies are limited. Community or individual self-sufficiency in planting material can be encouraged, through the establishment of farm, group and individual nurseries and seed banks.

Tree nurseries: Discussions with farmers indicate a general preference for nurseries that are owned and managed by villages, rather than by individuals or groups. Access to reliable water is essential, which may require developing additional sources such as shallow wells if perennial streams are not available.

Vetiver planting material: Vetiver grass is often collected and transported from distant sites at high cost. It is vital to plant this material in nurseries to ensure a ready supply for the future and to avoid losses caused by delays in planting hedges on individual farms. Details on establishing vetiver nurseries and hedgerows are contained in Chapter 4.

Agroforestry Technologies

- Consult Chapters 5 and 6 to help implement recommended practices. Reference tables at the end of Chapter 6 and in Annexes 1 and 2 provide information to help set realistic targets and input needs by practice and species.

- Help organize farmers to prepare nurseries so that outplanting can begin

with the start of the rains to ensure good establishment and fast growth.

- Inform supervisors on technical, logistical or other matters that cannot be resolved locally.

- Many interventions can be established on the **same** land. For example, areas between contour grass strips can be undersown with *Tephrosia* or systematically interplanted with msangu. Live fences and boundary planting of trees can be established around all practices, including nurseries.

Community-Based Calendar of Tasks

Assist the community to develop a clear calendar of tasks for each practice to ensure that activities are followed in the correct sequence and time for best results (see sample in **Figure 3**). Tick off tasks as they are done, and note any deficiencies/ problems so that they can be resolved in a timely and proper manner.

A community-based system of monitoring and evaluation is recommended to track progress and to identify strengths and weaknesses to improve extension service in subsequent seasons. Details of M&E systems for village and catchment based sites are presented in MAFE Publications No. 24, 26a and 26b.

Figure 3: Sample of a Community-Based Action Plan

	ACTIVITY	Respons	TIMEFRAME											
			Year 1							Year 2				
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1.0	**Group Formation**													
1.1	Train leaders in group dynamics	FA												
1.2	Form sub-committees	FA												
1.3	Orient sub-committees	FA												
2.0	**Contour Ridging**													
2.1	Prepare gardens	Farmers												
2.2	Train farmers in pegging CMR	FA												
2.3	Supply line levels	FA												
2.4	Supervise pegging & construction	FA												
2.5	Rea-align ridges following CMR	Farmers												
2.6	Construct footpaths/boundaries/ box ridges	Farmers												
2.7	Supervise ridge-realignment	Farmers												
3.0	**Vetiver Grass Hedgerows**													
3.1	Train farmers on VGH	FA												
3.2	Supply vetiver grass material	FA												
3.3	Establish vetiver nurseries	Farmers												
3.4	Plant vetiver hedgerows	Farmers												
3.5	Trim vetiver grass	Farmers												
4.0	**Gully Control**													
4.1	Identify gullies to be controlled	Farmers												
4.2	Demonstrate construction of check dams	FA												
4.3	Construct check dams	Farmers												
4.4	Supply vetiver grass material	FA												
4.4	Plant vetiver in & along gullies	Farmers												
5.0	**Nursery Management**													
5.1	Identify nursery sites	Farmers												
5.2	Train farmers in nursery mgt	FA												
5.3	Construct nursery fence	Farmers												
5.4	Collect soil, manure & fill pots	Farmers												
5.5	Supply nursery materials	FA												
5.6	Seed treatment & sowing	Farmers												
5.7	Watering, weeding & root pruning	Farmers												
5.8	Supervise nursery work	FA												

Figure 3: Sample of a Community-Based Action Plan (continued)

	ACTIVITY	Respons	TIMEFRAME											
			Year 1							Year 2				
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
6.0	**Undersowing of Tephrosia**													
6.1	Train farmers in undersowing	FA												
6.2	Supply seed	FA												
6.3	Undersow Tv same time with maize	Farmers												
6.4	Collect seed from Tephrosia plants	Farmers												
6.5	Cut Tv plants and bury leaves	Farmers												
7.0	**Dispersed Sys. Interplanting**													
7.1	Train farmers on air pruned seedling	FA												
7.2	Supply nursery materials	FA												
7.3	Raise air-pruned seedlings													
7.4	Ouplanting & protect seedlings	Farmers												
8.0	**Homestead/Boundary/Live Fences**													
8.1	Train farmers on HBP/LF	FA												
8.2	Demarcate outplanting sites	Farmers												
8.3	Dig pits	Farmers												
8.4	Supply fruit trees	FA												
8.5	Ouplant & protect seedlings	Farmers												
8.6	Weed regularly	Farmers												
9.0	**Live Farm Structures**													
9.1	Identify farmers to demonstrate	FA												
9.2	Train how to establish LFS	FA												
9.3	Establish LFS	FA												
10.0	**Monitoring & Evaluation**													
10.1	Conduct transect survey	FA												
10.2	Assess effectiveness of program	Farmers												
10.3	Produce CBM&E results	FA												
10.4	Discuss results with communities	FA												
10.5	Produce year 3 action plan	Farmers												

CHAPTER 2 QUESTIONS: DEVELOPING COMMUNITY-BASED ACTION PLANS

1. Identify three criteria in selecting two sites out of five that have similarities in environmental and farming conditions.

2. Name four factors in prioritizing problems/solutions identified by beneficiaries of an NRM program.

3. Identify four activities that would catalyze community participation in an agroforestry/ soil conservation program.

4. Name three steps involved in developing a workplan.

(For correct answers refer to Page 246 in the annex)

INTRODUCTION

This chapter discusses nursery techniques to help and encourage farmers to grow more trees on their farms. The chapter is organized in sections dealing with seed collection and handling, nursery design and construction, nursery management, outplanting, and other methods of propagation. The focus is on simple techniques of propagation using local materials.

Need for Tree Planting

Tree planting in rural Malawi is becoming increasingly urgent to address escalating problems of environmental degradation. This includes deforestation, soil erosion and runoff, overgrazing, declining soil fertility, diminishing groundwater supplies, loss of biological diversity, and shortages of fruit trees, animal fodder, and wood for fuel and building materials. Past efforts to meet these needs have concentrated largely on centralised government nurseries. It is now clear that government organisations alone cannot overcome the magnitude of Malawi's environmental concerns. The rural farming population must be actively involved. This requires complementary approaches for tree propagation that reflect prevailing resource constraints and differing priorities of individual farmers country wide.

The goal must be to improve the efficiency of tree production by educating and motivating farmers to become self-sufficient in collecting seed and raising seedlings. This will increase ownership, knowledge and resources at local levels for responsibility in planting and managing trees on a sustainable basis. With widespread adoption, successful tree propagation will lead to great increases in the stocks of trees in rural areas to meet local needs.

Germplasm Screening

A major limitation of current agroforestry technologies is the narrow availability of suitable species and varieties of trees. Several institutions in Malawi are investigating the potential of other species, provenances and varieties of trees that may prove better suited to Malawi farm conditions (e.g., Bunda College of Agriculture, the International Center for Research in Agroforestry - ICRAF, the Department of Agricultural Research and Technical Services - DARTS, and the Forestry Research Institute of Malawi - FRIM)

Improved methods of propagation are also under research for many tree species to increase their survival and growth in the field. Results of this research will be documented as findings become available.

SEED COLLECTION

Planning for Seed Collection

Seed is the main method of plant reproduction in nature. Most trees produce seed, except those that bear only male-flowers, for example *Sclerocarya birrea*, which can be distinguished from the seed-bearing female trees only when in flower. Do this by inspecting the flower for male parts (stamens and anthers) vs. female parts (pistils and stigmas).

Actions needed in preparing a program for seed collection:

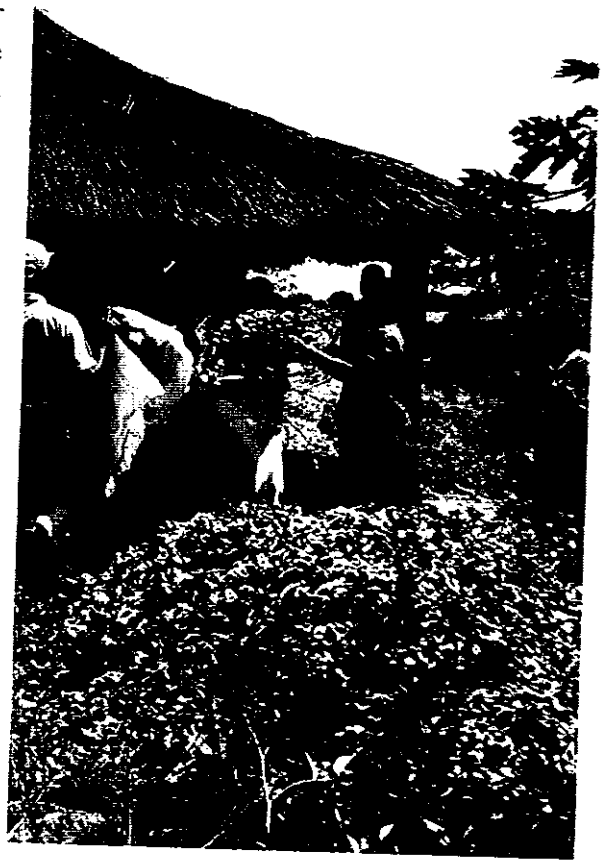
- Assess the tree species and the quantity to collect according to current demand and seed availability.
- Plan seed procurement in a participatory manner with field staff and farmers so that the demand is well understood.
- Provide details on each type of seed including when, where, and how much to collect, and by whom.
- Determine seed maturity before embarking on a collection trip.
- Identify storage needs for different seeds to ensure proper handling as some seeds can be stored for years, while others stay viable for only a short period of a few weeks.
- Make a checklist of equipment needed and take forms to record details on seed location, altitude, soils and climate for future reference.
- Estimate seed yield and maturity by conducting surveys with experienced personnel.

Seed Quality and Site Selection

Follow the guides below to ensure collection of quality seed for raising vigorous tree seedlings.

- Verify the species of targeted trees by sending a herbarium specimen for identification.

- Locate collecting sites that have similar eco-climatic conditions to those where the trees will be grown to help ensure environmental adaptability.
- Identify robust mother trees that are good seed producers.
- Collect seed from healthy stands of the same species involving at least 25 trees, each at least 100 m apart to avoid seed from related trees. These considerations will improve offspring vigor and genetic diversity.
- Avoid collection from trees that are young, diseased, isolated, poorly shaped, or low seed producers as these traits may be carried into new generations.
- Timber trees should be tall, cylindrical and straight with light branching and no forks.
- Trees for fodder should be shorter, with a large crown and dense foliage.
- Fuelwood trees should have abundant branching.



Local collection of seed from **Pterocarpus angolensis** *(photo courtesy of FRIM)*

- All selected trees should have a reasonable amount of pods/fruits.

Table 2: Calendar for Collecting Seed from Common Agroforestry Species

Common Tree Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Acacia galpinii (Nkunkhu)						■	■	■				
Acacia polyacantha (Mthethe)						■	■	■	■			
Acacia sieberiana (Minganzolo)						■	■	■	■			
Afzelia quanzensis (Msambamfumu)					■	■	■	■				
Albizia lebbeck (Mtangatanga)						■	■	■	■			
Albizia versicolor (Mtangatanga)						■	■	■	■			
Bauhinia thonningii (Chitimbe)						■	■	■	■			
Bridelia micrantha (Mpasa)	■	■	■							■	■	■
Cordyla africana (Mtondo)												
Erythrina abyssinica (Muwale)	■	■								■	■	■
Faidherbia albida (Msangu)							■	■	■			
Ficus natalensis (Kachere)				■	■	■	■	■	■			
Gliricidia sepium (Gliricidia)										■	■	■
Jatropha curcas (Kamsatsi)			■	■	■	■						
Khaya nyasica (Mbawa)								■	■	■	■	
Leucaena diversifolia (Lukina)						■	■	■	■			
Melia azedarach (Indya)					■	■	■					
Moringa oleifera (Chamwamba)						■	■	■	■			
Senna siamea (Keshya wa milimo)							■	■	■			
Senna spectabilis (Keshya wa maluwa)							■	■	■			
Terminalia sericea (Napini)			■	■	■	■	■					
Toona ciliata (Sendrella)	■										■	■
Trichilia emetica (Msikidzi)	■										■	■
Ziziphus abyssinica (Kankhande)					■	■	■					
Ziziphus mauritiana (Masawo)						■	■	■				
Ziziphus mucronata (Kankhande)					■	■	■	■				

Timing of Seed Collection (see Table 2)

Phenology: The time of seed collection is critical and depends largely on phenology. The best time to harvest seed is when the seed is mature. Phenological studies have been carried out mainly on the exotic species, and much is unknown about indigenous species. Harvesting prematurely means that the seed will be poorly developed, thin, shrunken and light in weight from insufficient time to build food reserves. This affects viability and leads to low germination and poor seedling development. Whatever harvesting method is employed, collect seed from fully ripened fruits picked directly off the tree, or from those that have recently fallen to the ground. Avoid fruits or seeds that have been damaged by insects or mould. If not collected as soon as they are

ripe, many fruits may be eaten or spoiled by birds, insects or animals.

Methods to check maturity: Natural shedding of fruits/seeds is the most common method, but may be unreliable as shedding could occur due to pests and diseases. A better method is to extract and cut open a few seeds. They should be well developed and firm inside, and should fill the seed coat. Other methods include change of colour and tests for moisture content. Some types of seed will not germinate if they remain too long on the tree. Other trees have dehiscent fruits with seeds that are light and easily blown away by the wind, e.g., *Toona ciliata*.

Periodicity: For many species, seed bearing is irregular from year to year, a phenomenon known as periodicity. Heavy crop years are better for collection than poor crop years, not only because of the quantities involved, but because they have a broader genetic base. For such species, it is best to collect enough seed during the good year to meet demands for the poor years as well, provided that the seed can be stored well.

Appropriate Species for Collection

Trees species such as *Eucalyptus* and *Pinus* need certification by FRIM in order to collect seed. Various considerations

Seed collection by inducing seed fall

are taken into account when certifying seed sources such as the genetic diversity of the stand and level of genetic improvement.

For other species, seek advice from FRIM on how to collect seed, and provide information on the origin of the seed to identify the source. It is desirable to register seed source of indigenous species with FRIM. If the seed source is known to be improved, it can be called a seed stand. For species like *Gliricidia sepium*, FRIM offers tested provenances that have higher productivity.

Methods of Seed Collection

Various methods may be used to collect seed of different species. The method should be safe for the collector and should ensure the physiological quality of the seed.

Natural or induced seed fall: Collecting fallen fruits on the forest floor is common practice for species like *Khaya nyasica, Afzelia quanzensis*, and *Faidherbia albida*. This is the simplest method since no special skills are needed, only a broom, rake, sieve and seed container. Large plastic sheets, canvas or blankets may also be spread under the tree for collecting seeds. Shaking the branches helps the seed pods or fruits to fall. Alternatively, keep the ground clean of leaves, branches and undergrowth to facilitate seed collection. Collect seeds daily to minimise insect attack and fungal infection.

Picking fruits from trees: Fruits may be picked directly off the tree by hand. Fruits may be reached from the ground if the trees are small. Poles fitted with hooks may also be used to shake branches to dislodge the fruits, taking care not to damage the tree. Try to collect seed from the entire crown since lower branches may contain seed of poor quality.

Climbing trees: Seed may often be collected by climbing trees using equipment such as spurs, tree bicycles, ladders and ropes. Because of the danger involved, this is recommended only for experienced tree climbers.

Seed Sources and Documentation

Conduct seed crop surveys before collection to assess how much seed can be expected. Such a survey may be combined with an assessment of seed maturity which can also be done when the trees are in flower. The location where seed is collected

is known as the provenance of the particular seed lot. Trees often grow better when they are planted in sites similar to their origin because they are adapted to conditions at that particular site.

Information on seed lots is important. A seed lot is seed collected from a particular source at a particular time. For each seed lot, label bags on the inside and outside with information on the seed source and year of collection. All seed sources need to be documented and given an identity number for easy tracking of seed. Critical information to record includes:

- the species name
- the identification number of the seed source,
- the type of the seed source (seed orchard, natural stand or breeding seed orchard),
- the exact location and a file reference to enable use of a map to locate the site,
- the latitude, longitude, altitude of the site
- average rainfall and climate zone,
- number of seed trees, and area in hectares,
- day, month and year of collection,
- fruit weight, to calculate the ratio of fruit to seed weight needed for planning purposes

Record dates of seed crop surveys for each collection for information on phenology to help draw up collection calendars for each species. Give each seed lot an identity number unique to that lot and the collecting organization. If seed was obtained from another supplier, enter the supplier's number as a reference not a seed lot number. A simple serial numbering system is encouraged. Some computer

Village stocks of tree seed may be kept in traditional food stores

packages have been developed for managing seed databases such as SISTEM+ which could be used by large collection programs.

SEED PROCESSING AND STORAGE

Seed processing and storage affect seed viability, but techniques used vary by species. Moisture and temperature are important factors. Drying is one of the first steps. The most common method is to spread the seed out in a well ventilated site, and sun-dry gradually over a few days. Other seeds need mechanical operations such as threshing or pounding to release the seed. It then needs winnowing and manual cleaning to remove the chaff.

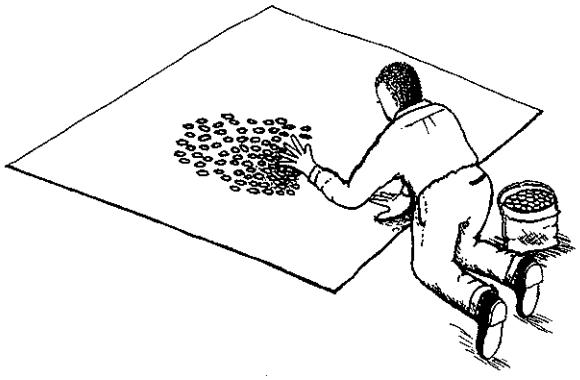
Never expose seed directly to fire which may damage or kill it. After drying and winnowing, place the seed in an air-tight tin, plastic bag, or other suitable container.

Protect stored seed from natural physiological deterioration, fungi and insects. Good storage conditions and containers facilitate longevity of stored seed. Common methods of processing are described below for different types of seed.

Orthodox or Normal Types of Seed

Most types of seed can be dried to a low moisture content (6-8%) and kept for long periods without losing viability. Orthodox seeds come in different forms as described below.

Pod Fruits: Many leguminous trees have fruits in the form of pods which may be dried so that they open up more quickly to release the seeds. They need to be covered at night to prevent re-absorption of moisture. Examples include many leguminous trees, such as species of *Acacia, Albizia, Senna, Afzelia quanzensis* and *Faidherbia albida.* After drying, the fruits or pods of many



Laying out tree seed to dry in the sun.

species may be shaken or beaten to remove the seed. For the latter, place the fruits in a sack or bag, then beat it with a heavy stick. Be careful not to damage or break the seed, which may increase susceptibility to disease and rot.

Capsule fruits: For species such as *Eucalyptus* and *Toona*, the first step is carried out in the field by collecting and drying the capsules on polythene sheets in the open air. They are then shaken onto a sieve to separate the seed and the chaff from the capsules.

Hard-coated fruits: For some species with hard fruits like *Pterocarpus angolensis*, soak the fruit in water for several days to soften the prickly-covered seed coat. Then beat the fruit against a stone to release the seed, or extract the seeds using a secateur.

Pulpy fruits: Pulpy fruits with stones such as *Gmelina*, *Melia* and *Ziziphus* species may be pounded in a mortar followed by thorough washing of the stones in water. The stones may be air-dried and tested for moisture content. Extraction and cleaning of pulpy fruits without stones may require the fruits to be dried and then pounded to release the seed. The seed is then separated from the debris manually using sieves.

Note: For *Ziziphus*, pounding the nut often damages the seed inside. So it is best to leave the nut intact until ready for sowing. Then pre-treat the seed as recommended on page 52.

Recalcitrant (difficult) Seeds

Recalcitrant seeds naturally have a short life span (from a few hours to a few months). It is generally a good policy to sow recalcitrant seeds immediately after collection. Examples include *Azadirachta indica*, *Cordyla africana*, *Syzigium spp.*, and *Uapaca kirkiana*. These seeds respire actively and therefore require good ventilation and medium storage temperatures (15-25º C). Recalcitrant seeds usually have a high moisture content and require storage in cloth bags to facilitate aeration. They should not be closely packed as this generates heat, which eventually activates germination. The seeds could then die in the absence of favorable conditions for normal growth (e.g., soil media and moisture).

Spread such seeds evenly on a mat in a room away from direct sunlight immediately after extraction to avoid excessive drying. Pack the seed in cloth

bags and store at ambient temperatures (20-30°C). Seeds of species like neem will suffer from chilling injury if stored at temperatures lower than 1°C.

Assessments of Purity

Tree seed samples contain impurities such as leaf and twig particles and seeds of weeds or other tree species. The aim of purity analyses is to determine the composition by weight of the seed sample. Purity also influences the number of seeds per kilogram.

Assessments of Moisture Content

Moisture content is probably the most important factor in determining seed longevity. Reduction in moisture content causes a reduction in respiration and thus slows down ageing of the seed which prolongs viability. Moisture contents below 8% reduce insect activity and sealed storage is safe at 4-8%. Moisture content is calculated by weighing the seed before and after oven drying.

Assessments of Germination

Germination tests are important to determine the potential germination of the seeds. The aim of a laboratory germination test is to estimate the maximum number of seeds that germinate in optimum conditions. Nursery tests give an estimate of the germination potential where environmental conditions apply.

Considerations for Seed Storage

Always aim to sow or dispatch seed soon after acquiring it. In some cases, seed needs to be stored for future use. The longer the seed is stored, the greater the probability that it will lose viability. A general rule is to store seed in a cool, dry and dark place, as heat, light and moisture may activate seed germination.

Use the checklist below before storage:

- Find out what conditions are best for the type of seed, and its expected viability.
- Check for and discard empty or damaged seed.
- Use clean, air-tight containers and ensure the seed is properly dried. This will minimize attack by fungi and insects.

Mixing the seed with ash provides more protection, and is much cheaper than chemicals.

- Open seed containers only when necessary.
- Label the container on the inside and outside with the species name, date and location of collection.
- Specify the length of viability and quantity of viable seed per kg.

The shelf-life of seed varies from a few weeks to years depending on the species. For example, seed from *Trichilia emetica* rots quickly after falling on the ground due to its high oil and moisture content, while seed from *Senna spectabilis* will remain viable for years due to its hard protective cover. Although seeds of most trees have a limited life-span and need to be sown soon after harvesting, the above practices help to increase their shelf-life.

CALCULATING SEED NEEDS

An important element in planning a tree planting program is to know the following information for each desired type of seed:

- Number of plants (seedlings) required
- Yield of fruits from trees
- Yield of seeds from fruits
- Number of seeds per kilogram
- Germination percentage

Seed demand can be expressed as number of seedlings by calculating the number of viable seeds per kilogram from a particular seed lot. This can vary from one seed lot to another. For example, the number of viable seeds in one kilogram of *Faidherbia albida* could range between 5,000 and 8,000. It is important to know the number of seedlings required so that the exact amount in kilograms can be calculated. This will reduce waste of valuable seed. For large planting programs, knowledge of the intended tree spacing and the land area targeted are useful to cross check seed requirements.

Working Example 1

A farmer wishes to plant a woodlot of *Acacia polyacantha* at a spacing of 2 x 2 m. She has an area of 0.25 ha. Calculate her seed needs to the nearest kilogram given that *A. polyacantha* has 9,900 seeds per kilogram and requires 3 seeds/pot. Allow an extra 25% seed for losses.

Solution 1:
10,000 m2 / (2 x 2 m) = 2,500 trees/ha
2,500 x 0.25 ha = 625 trees required
625 x 3 seeds/pot = 1,875 seeds
1,875 / 9,900 seeds/kg = **189 g of seed**
189 x 1.25 (25%) = **236 g seed required**

Working Example 2

A farmer wishes to plant trees around the perimeter of his farm using *Afzelia quanzensis* at a spacing of 4 m. The total perimeter is 800 m. Calculate the amount of seed required to the nearest gram given that *Afzelia quanzensis* has 250 seeds per kilogram and needs 1 seed/pot. Allow an extra 15% seed for losses.

Solution 2:
800 m / 4 m = 200 trees for entire perimeter
200 x 1 seed/pot = 200 seeds
200 / 250 seeds/kg = 0.8 kg or 800 g of seed
800 x 1.15 (15%) = **920 g seed**

NURSERY CONSTRUCTION AND MANAGEMENT

This section applies to both bare-rooted and containerized seedlings. Sound nursery techniques are essential for raising strong, healthy seedlings. These include careful tending such as regular watering, weeding, and root pruning, as well as protection from browsing animals. Good practices also reduce risks of pests and diseases, and minimize the need for remedial measures.

Basic Components of On-Farm Nurseries

Sound nursery management begins with good design. Permanent nurseries require extra planning to allow for efficiency in management and labour, access to water, and adequate space for work, storage and expansion. The nature and scope of planned tree planting activities determine the type and size of nursery required. The most common nursery recommended is small (100 - 300 m^2), inexpensive, flexible, and sustainable by farmers. Nursery owners may involve one or more families, organised groups of farmers, or special interest groups such as clubs, women, schools or cooperatives.

Key Points for Planning

- ***Practicality:*** Nursery design and layout are critical for ease of management, cost, and labour efficiency. Organize nurseries to reflect the number and type of trees required, with proximity to water and the household(s) involved. Use local materials to minimize costs of external inputs. Establish nurseries during the dry season to reduce conflicts with farm activities, and to produce seedlings ready for outplanting at the start of the rains.

- ***Nursery soil:*** Use fertile topsoil, enriched with animal or compost manure. A loamy texture is preferred, which may require the addition of sand for clay soils.

- ***Propagation techniques:*** Simple but sound management practices are outlined for both potted seedlings and bare-rooted stock in raised seedbeds. Pros and cons of each are presented as dictated by local conditions and constraints.

- ***Care and management:*** Nurseries need careful tending, including regular watering, weeding, and protection from browsing animals, pests and diseases. Newly germinated seedlings may also require protection from direct sunlight and rain.

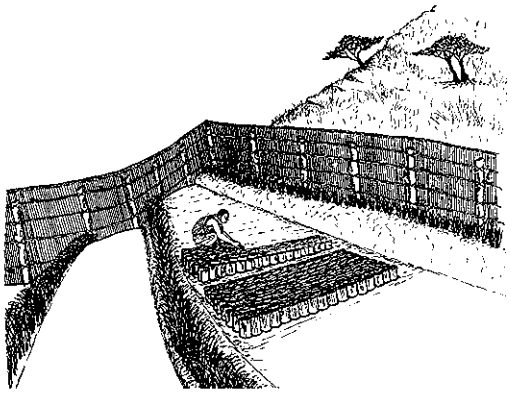
- ***Root pruning:*** Regular root pruning of side and tap roots encourages dense, sturdy root systems that resist damage when moving or outplanting seedlings. This leads to better seedling growth and survival.

- ***Alternatives to root pruning:*** Some tree species such as *Faidherbia albida* are susceptible to damage by root pruning. Outplant these species when young before their roots grow through the pot into the ground. A better practice is to raise them in open tubes on elevated platforms which prevents their roots from growing through the tubes, hence no damage from root pruning.

- ***Quality seed:*** Collecting and storing good quality seed from local sources is vital for sustainability and cost efficiency (see above).

- ***Seed treatment and sowing:*** Methods to pre-treat and sow seed are described to ensure uniform and rapid germination for different types of trees.

Terraced nursery on steep slope.



Site Selection and Preparation

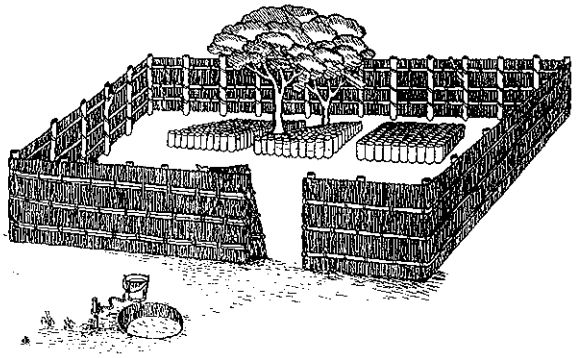
Set up tree nurseries 4-5 months before the rains. This allows outplanting in the field to start soon afterwards (i.e., December).

Select a shady site with firm, level ground close to permanent water and the village for easy care and watering. Remove grass stones and other unwanted material. The site may require levelling with a hoe. Stamp the ground to compress loose soil, remembering that it will not be used for growing the seedlings. A cambered slope will encourage drainage of excess water to avoid fungal attack or damping off. If the slope is more than 10%, make terraces at least 5 m wide to allow space for 2 or more beds, including access paths. Stabilize the banks with binding grasses, such as vetiver or napier. Terrace banks may serve a dual role for multiplying these grasses.

Sites close to the outplanting area will reduce labour in transporting seedlings, but the nursery may suffer from lack of attention if located far from people's homes or water.

Water Sources

A ready, cheap supply of water is critical for good nursery care. Permanent village streams are ideal, but are not always available. Wells are sometimes necessary, costs of which are reasonable where ground water is shallow. Simple hand or treadle



Nursery location and protective fence.

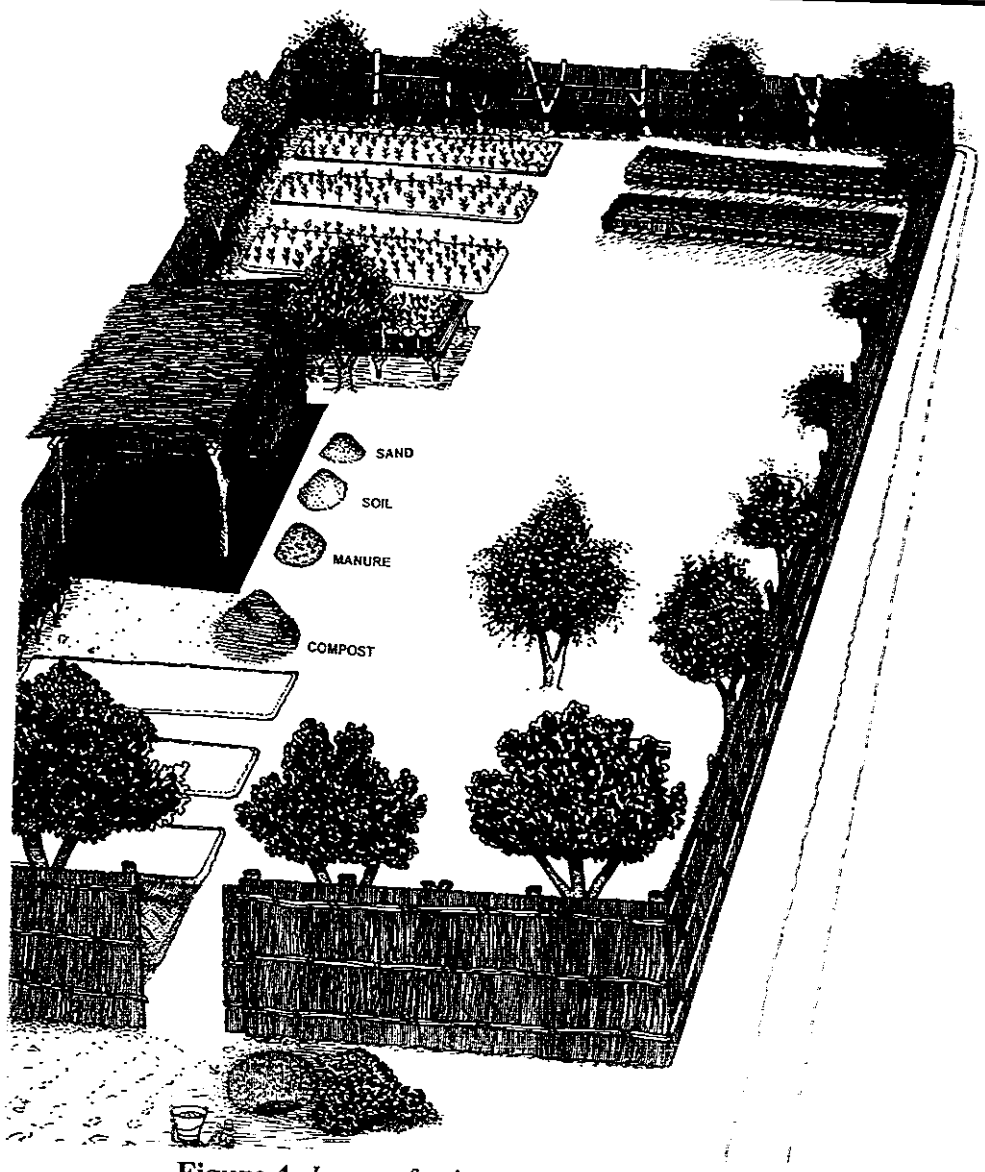


Figure 4: *Layout for larger communal nurseries.*

pumps may ease water lifting, especially if large quantities are needed. Whatever the source of water, it must be reliable, particularly during the dry season when watering is most critical. If water is to be carried in a watering can, the source must be within easy walking distance.

Nursery Size and Layout

Nursery size depends on the number of seedlings needed. A sketch of the nursery layout is useful, showing the size and location of seedbeds, potted seedlings, compost piles, pathways, storage space, and water sources. A typical layout is shown in **Figure 4**. Plan an area of 10 x 1 m for every 1000 seedlings. This includes space for walkways at least 60 cm wide between beds for ease of weeding, watering, etc. Thus, an area of 10 x 10 m is needed for 10,000 seedlings. Double this if large pots are used. Add another 20 m^2 for work and storage space.

Nursery Protection

A rough fence of sticks or thorn branches may be erected around small nurseries to protect the seedlings from trampling and browsing. If rodents or rabbits are a problem, make the fence thicker and denser. For larger nurseries, a well-constructed straw or reed fence may be necessary, until a live thorn-fence can be established on the inside. (See Live Fences in **Chapter 6**.) Live fences are more permanent, cheaper, and offer multiple uses, such as fodder, wood, fruits and thorny material.

Construct a fire break 1-3 m wide around the nursery perimeter to reduce the risk of damage from fires. If possible, select a site protected from prevailing winds. A large tree in one or two corners of the nursery is useful to provide shade for workers and to protect young seedlings from extreme weather. Shade for seedlings is discussed later in this chapter.

Nursery Soil

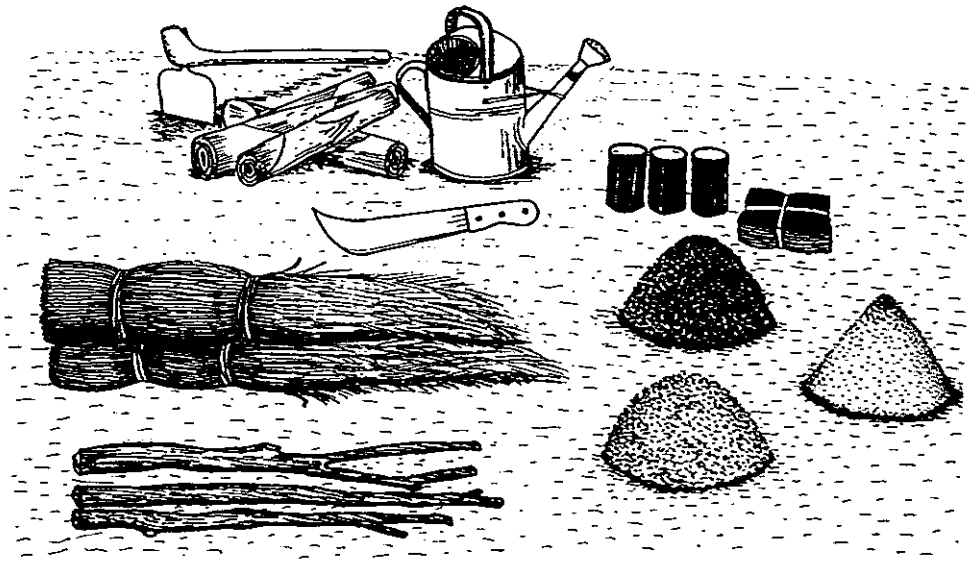
Fertile soil is desirable to grow healthy seedlings. Prepare the soil mixture within the nursery or close to it. Nursery soil should maintain a balance for good drainage and nutrient content. Mix 2 parts fertile topsoil to 1 part compost or manure, then add 1 part sand for good drainage. If manure is not available, use fertile, fine-grained sandy-loam soil from the garden, or

from beneath acacias or other soil-improving trees. Avoid soils infested with worms or other pests. Too much organic matter may also cause disease. The key point is to avoid extreme materials. Pure sand retains little moisture and has few nutrients, while pure clay becomes water-logged when wet, and hard when dry. A sandy loam is ideal because it is intermediate in texture and is well-drained. These characteristics are important for root development.

Seedbeds for bare-rooted stock need well drained, fertile soil. The best soils are loamy in texture, with a loose crumbly structure. In permanent nurseries, change the seedbed soil, or treat it with fungicide before each planting to reduce risk of disease.

Tools and Construction Materials

Materials to construct and manage a nursery include hoes, pangas, watering cans, fence posts and grass, topsoil, sand, manure, tree seed and polytubes or other pots like used *chibuku* packets. Pails or large tins with holes in the bottom can also serve as watering cans.



Nursery tools and materials.

Table 3: Advantages and Disadvantages of Containerized vs. Bare-Rooted Seedlings

Containers

Advantages

- Less space to raise seedlings
- Shorter time in nursery.
- Containers can be moved to sites before outplanting if watering can be continued.
- Container protects roots during transport and minimises drying out by direct exposure
- Better survival with fewer root diseases

Disadvantages

- Pots are expensive and labour demanding.
- Pots are more difficult to transport because of their size and weight.
- Seedlings often require frequent root pruning, which is labour intensive with risk of root damage.

Bare-Rooted Stock

Advantages

- Less bulk/weight to transport.
- Transplanting takes less time.
- Less care needed in the nursery.
- Container costs are absent.
- Seedlings are usually larger and require less protection after outplanting.

Disadvantages

- Seedlings need more space, and more time in the nursery.
- Nursery conditions and soil must be of good quality.
- Risk of damage to seedlings is higher during transport since the roots are exposed to air after extraction from the seedbed.

Seed

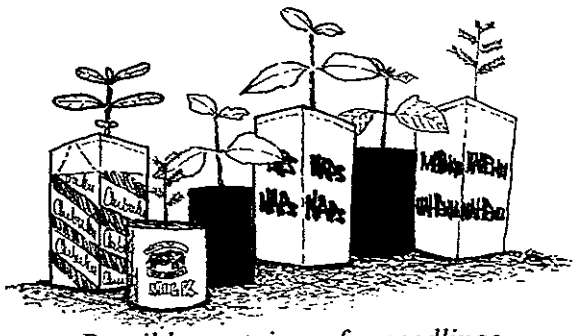
An adequate supply of quality seed is needed for the desired species of trees. Details on seed collection, storage, and treatment are discussed earlier in the chapter.

Type and Choice of Seedlings

Seedlings may be raised in two basic ways, bare-rooted or containers. Pros and cons of these are shown in **Table 3**.

Containerized Seedlings

Nursery containers ease the task of transporting seedlings over long distances. They also minimise the risk of drying out and disturbance to the roots. Seed is often sown directly into containers to avoid the need to prick out and transplant seedlings from germination beds. Such beds are recommended for very small seeds, e.g., *Eucalytus* spp., and *Burttdavya nyasica*, or for seed that germinates erratically. Direct sowing such seed into containers can be costly and inefficient because of poor germination. Containers are recommended in areas with dry climates and long travelling distances.



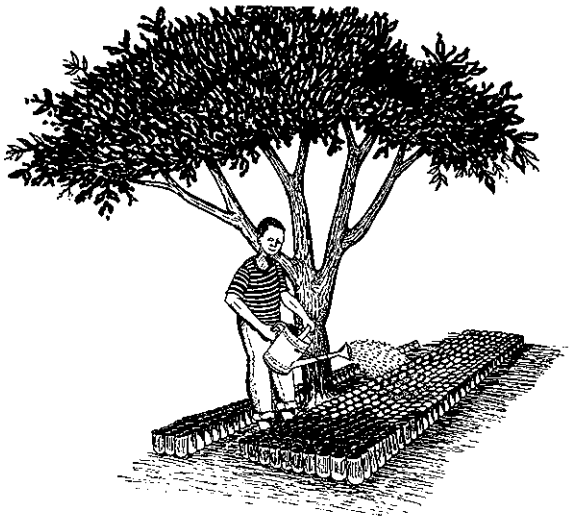
Possible containers for seedlings.

Type of containers: Use containers that are free draining. The most common containers are open ended tubes and closed ones made from black plastic. Open ended containers are generally preferred over closed pots because they allow better drainage and help reduce the risk of root deformities. If closed containers are used, perforate the bottom to prevent water stagnation which causes rot and fungal problems. Tin cans and discarded *chibuku* packets may also be used. Other types of containers include pots made of ceramic, wood, or banana leaves and stems.

Wooden boxes, plastic washbasins and other containers at least 15-20 cm deep may also be used as seedbeds for later transplanting to individual containers.

Filling open-ended polytubes.

Watering block of filled pots before topping up with nursery soil.



Size of containers: The preferred size of the open-ended containers is 20 cm deep by 15 cm wide when placed flat, although tubes 15 x 10 cm are commonly used. Seedlings raised in smaller containers generally perform less well when outplanted because of their small size. Containers with closed bottoms 25 x 20 cm in size are best suited for fruit trees and species such as *Khaya nyasica* and *Trichilia emetica* which require a longer time in the nursery for good establishment in the field.

Durability of containers: Containers must be tough enough to last 3 or more months, or the time needed to be ready for outplanting.

Filling containers: Make a plug at the bottom of the container with wet friable soil by pressing it against the ground. Then fill the containers to the top with prepared nursery soil. After arranging the containers in blocks of 500 (see below), water immediately and top the tubes up with more soil. This keeps the sides from collapsing inward, which prevents adequate watering.

Fill closed containers in the same manner except that there is no need for a soil plug at the bottom. After seedlings emerge, add more soil if the root collar drops below the top.

Arrangement of containers: Set up the containers in blocks of 500, arranged 10 containers wide by 50 containers long. Blocks arranged in this manner make work easier, and facilitate assessments of germination and stock taking. Stand containers upright in straight, even rows for uniform watering and good growth. If possible, orient the long dimension east-west to give seedlings more unif orm exposure to the sun. Bank soil around each block to keep the containers upright and to avoid excessive heat for those on perimeter.

Bare-Rooted Seedlings

Bare-rooted seedlings are grown by sowing seed directly into a specially prepared seedbed, from which seedlings are later extracted for outplanting. Use of bare-rooted stock simplifies nursery operations by eliminating the costs and labour involved with containers. They are especially convenient where distances between the nursery and planting sites are short. Remember that bare-rooted seedlings require more time in the nursery, so good planning is critical.

Type of seedbed: The type of seedbed recommended is a raised bed modeled after the Swaziland Bed. Prepare the seedbed on level ground, enclosed by a frame of wooden boards or planks, tree branches, palm fronds, sisal poles, or sections of banana stems with a diameter of 20 cm. The frame prevents crumbling and erosion of the seedbed sides. Make the seedbed 60-90 cm wide by 1 m or more long. This will produce about 100 seedlings. If the seedbed is intended for long-term use, make the sides of rock, bricks, concrete blocks, or pretreated, well-seasoned wooden planks to avoid rotting, insect attack, and fungal growth. Secure the sides with wooden pegs of sharpened sticks about 30 cm long. Raise the base of the sides about 1 cm above ground level to facilitate horizontal root pruning.

After constructing the seedbed, fill the frame with prepared nursery soil (see above), keeping the surface level with the top of the frame. Allow the soil to settle for a few days, and add more soil if necessary.

Seed Pre-Treatment

To improve germination, it is often necessary to break dormancy by artificial means. Seed dormancy is a plant strategy to increase germination under times and conditions favorable for seedling survival. It usually operates through a chemical or physical inhibitor to delay germination, e.g., a tough seed coat. The fleshy pulp around some seeds may also contain inhibitors that prevent germination. Treatment of seed is needed for many tree species just before sowing to allow fast entry of water for good germination. **Table 4** shows treatments recommended for different species.

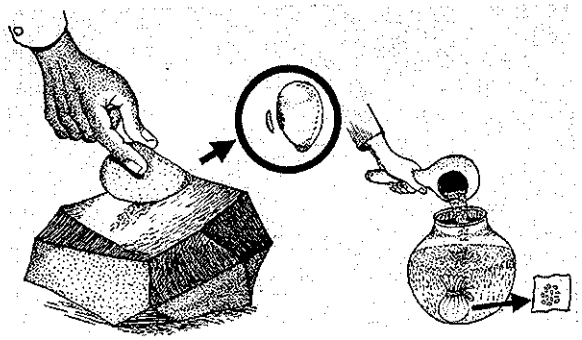
Recommended Methods of Pre-treatment

1. *None:* Seeds of some species require no treatment, but it is best to plant fresh seed due to short viability. Examples are *Gliricidia sepium* and *Tephrosia vogelii*.

2. *Nicking:* Scarify the tough seed coat by nicking one side away from the micropyle. Use a knife or nail clippers, or rub the seed against a rough stone (see illustrations). This allows entry of water for germination, and is extremely effective for most species, but requires care. Do not soak the seed in water after nicking or scarifying as rot and fungi may set in if not planted right away. Examples include *Acacia polyacantha, Faidherbia albida* and *Senna spectabilis*.

3. *Soaking in cold water:* Soften the seed coat of these species by soaking in tap or stream water at room temperature for 24-48 hours. Plant the same day. Examples include *Khaya nyasica* and *Melia azedarach*.

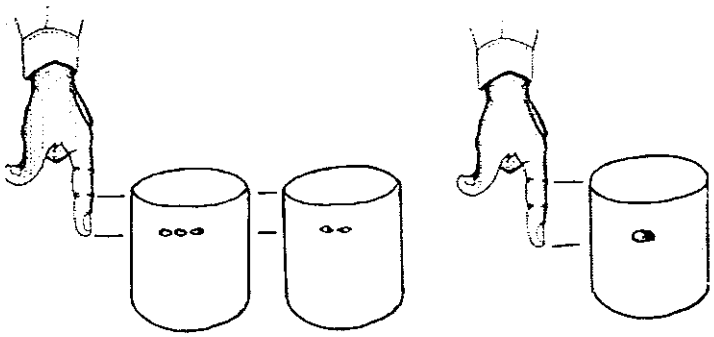
4. *Remove fleshy pulp, outer shell or aril:* Remove the outer fleshy pulp, shell or aril, then dry and plant the same day. Examples of fleshy seed include *Azadirachta indica, Bridelia macrantha, Syzygium cordatum,* and *Cordyla*



Nicking and cold water soaking treatments

Table 4: Treatment and Nursery Times for Common Agroforestry Tree Species

Common Tree Species	Seed Treatment	Seeds/tube	Planting Depth	Nursery time
Acacia galpinii (Nkunkhu)	Nick	2	1.5 – 2 cm	8-12 weeks
Acacia polyacantha (Mthethe)	Nick	3	1.5 – 2 cm	8-12 weeks
Acacia sieberiana (Minganzolo)	Nick	2	1.5 – 2 cm	8-12 weeks
Afzelia quanzensis (Msambamfumu)	Remove aril	1	4 cm	10-16 weeks
Albizia lebbeck (Mtangatanga)	Nick	3	1.5 – 2 cm	8-12 weeks
Albizia versicolor (Mtangatanga)	Nick	2	1.5 – 2 cm	10-16 weeks
Bauhinia thonningii (Chitimbe)	Nick	3	1.5 – 2 cm	10-16 weeks
Bridelia micrantha (Mpasa)	Remove fleshy pulp	3	1 cm	10-16 weeks
Cordyla africana (Mtondo)	Remove fleshy pulp	1	3 cm	10-16 weeks
Erythrina abyssinica (Muwale)	Nick	3	1.5 – 2 cm	10-16 weeks
Faidherbia albida (Msangu)	Nick	2	1.5 – 2 cm	5-12 weeks
Ficus natalensis (Kachere)	Remove fleshy pulp	3	1 cm	10-16 weeks
Gliricidia sepium (Gliricidia)	Nick	2	1.5 – 2 cm	8-12 weeks
Jatropha curcas (Kamsatsi)	Remove from shell	3	3 cm	8-12 weeks
Khaya nyasica (Mbawa)	Remove from shell, soak 48 hrs	5	3 cm	10-16 weeks
Leucaena diversifolia (Lukina)	Nick	3	1 cm	8-12 weeks
Melia azedarach (Indya)	Remove pulp, soak 24 hrs	3	3 cm	10-16 weeks
Moringa oleifera (Chamwamba)	Remove from pod/shell	3	1.5 – 2 cm	8-12 weeks
Senna siamea (Keshya wa milimo)	Nick	3	1.5 – 2 cm	8-12 weeks
Senna spectabilis (Keshya wa maluwa)	Nick	3	1 cm	8-12 weeks
Terminalia sericea (Napini)	Trim wings	5	1.5 – 2 cm	10-16 weeks
Toona ciliata (Sendrella)	None	5-10	0.5 cm	10-16 weeks
Trichilia emetica (Msikidzi)	Remove aril	3	1.5 – 2 cm	10-16 weeks
Ziziphus abyssinica (Kankhande)	Remove pulp and crack nut	3 nuts	1.5 – 2 cm	10-16 weeks
Ziziphus mauritiana (Masawo)	Remove pulp and crack nut	3 nuts	1.5 – 2 cm	10-16 weeks
Ziziphus mucronata (Kankhande)	Remove pulp and crack nut	3 nuts	1.5 – 2 cm	10-16 weeks



Number and sowing depth for different sizes and types of seed.

Marking out the area in which to arrange the filled containers.

Fenced village nursery with filled containers laid out in blocks.

Senna siamea *and* **Acacia polyacantha** *seedlings soon after germination.*

Well-established seedlings ready for outplanting.

africana. Seed in shells include *Jatropha curcas* and *Khaya nyasica*. Seed with arils include *Afzelia quanzensis* and *Trichilia emetica*.

5. *Crack Nuts:* Crack the outer hard shell. Plant the seed with the shell on the same day since attempts to extract the seed usually damage the seed. Examples include *Ziziphus abyssinica* and *Z. mauritiana*.

NOTES:

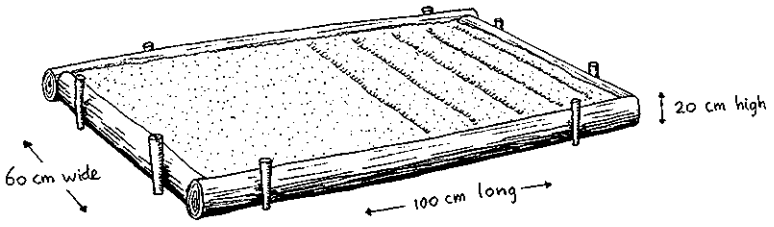
1. Hot water treatment is **not** recommended for **any** species as it gives variable results, and often kills the seed when the time and temperature are not controlled.

2. Species that require inoculation with rhizobia are not recommended because of practical concerns in acquiring and properly using the rhizobia. Parties interested in such species may contact Soil Microbiology at Chitedze Agricultural Research Station.

Sowing Time

Water seed beds and containers two weeks before sowing so that germinating weeds can be removed to reduce competition. Sowing details are described below for bare-rooted and containerized seedlings.

The time of sowing varies by species since some trees need a longer time in the nursery. A staggered system of sowing is recommended to cater for the needs of different species. The critical point is to ensure that all seedlings are ready for early outplanting to give them sufficient moisture and time to become well-established before the dry season. During the period of nursery



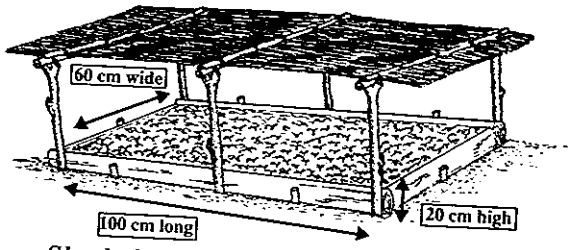
Marked planting furrows in a bare-rooted seedbed.

production, conflicts with farming are lower, allowing time for good nursery care. There are also fewer pests at this time.

The recommended time in the nursery for different types of trees is shown in **Table 4**. Early sowing 4 months before the rains is needed for species that have slow initial growth, such as *Albizia*, *Bauhinia thonningii*, *Cordyla africana*, *Khaya nyasica*, *Kigelia africana*, *Terminalia sericea*, *Toona ciliata* and *Trichilia emetica*. Other trees like species of *Acacia*, *Gliricidia*, *Faidherbia albida* and *Senna* need only 8-12 weeks in the nursery. Sow these species later so that they do not overgrow before outplanting in the field.

Sowing Seed

Containerized Seedlings: Lay the seeds flat (except seed of *Anacardium occidentale* which is planted upright). Sow seeds in the middle of each container. **Table 4** shows the number of seeds per container and depth of planting for different species. Push seeds into the soil with a finger or stick to the required depth based on the species (see **Table 4**).



Shaded seedbed for bare-rooted stock.

Bare-Rooted Seedlings: Use a small stick or finger to make furrows about 10 cm apart along the width of the seedbed. Leave a space of 5 cm away from the seedbed frame. Tie strings across the seedbed as a guide for making furrows and sowing seed. This ensures regular spacing to reduce competition. It also makes cultivation and extraction easier.

Furrow depth is critical and depends on the size of the seed. If too shallow, the seed may be exposed to the sun and dry out. If too deep, emerging plants may choke and die. Furrow depth should be 2-3 times the smallest diameter of the seed. Make furrows about 1 cm deep for medium-sized seed such as *Senna siamea* and *Faidherbia albida*. For larger seed such as *Gliricidia sepium* and *Acacia galpinii*, make furrows 1.5 cm deep. For small seed such as *Sesbania sesban* and *Toona ciliata*, make furrows 0.5 cm deep.

Starting at one end of the seedbed, sow seeds 5 cm apart. For seeds of low viability, sow 2-5 seeds together in case some fail to germinate. Cover the seed with soil and compress the surface lightly. Tiny seed may be mixed with sand and sprinkled evenly along the furrow.

Replanting

Two weeks after germination starts, separate containers with seedlings from those without. Then resow the latter containers with new seed after treatment as required for the species involved.

Note: Poor germination occurs if sowing is deeper or shallower than recommended. If seeds rise to the surface after watering, push them back to the correct depth immediately.

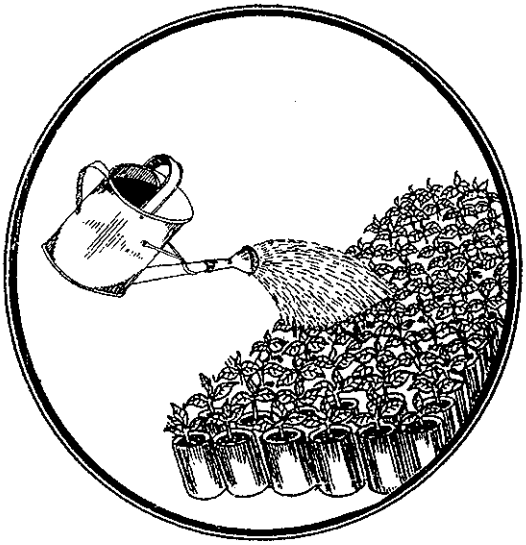
Mulching

After sowing, mulch the seedbeds or cover sown containers with leaves or grass to maintain good soil texture, and to reduce temperatures, evapo-transpiration and erosion. Mulch also inhibits weed growth. Choose material that does not rot easily, or attract insects like termites.When the seedlings emerge, remove the mulch, which may be re-used for nursery shade.

Transplanting into Containers

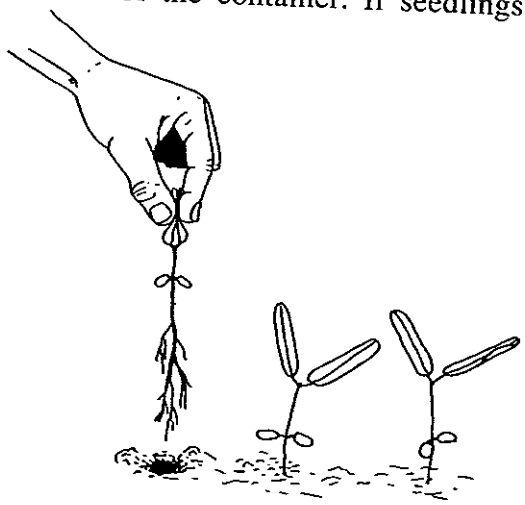
Transplant seedlings under shade on a wet, windless day, after the germination bed and containers have been thoroughly watered and softened. Lift the seedlings out by holding the top leaves after loosening the soil below the roots with a knife or trowel. Note that holding the stem when lifting out

Water seedlings thoroughly



could damage or kill the plant. Prick-out in this way when seedlings have one set of leaves above the cotyledons (the fat "seed leaves"). At this stage, they should be 3-8 cm tall and 3 to 5 weeks old, although age varies with species. Earlier than this, seedlings are too delicate to be handled. Later, they may be weakened by crowded conditions in the seedbed. Root prune any tap roots so they do not bend on transplanting, which may later interfere with growth.

Transplant the pricked-out seedlings right away into a hole made with a finger in the middle of the container. If seedlings cannot be planted immediately, keep them in moist soil under shade. Exposure to sun and dry winds can kill seedlings in a matter of minutes.



Prick-out seedlings from a germination bed by holding thefirst set of leaves.

Watering

Water seedbeds and containers straight after sowing every morning and afternoon. Take care that seeds are not left exposed to the sun, or washed to the side of containers. Continue this watering regime after germination until the seedlings are 4 weeks old. Thereafter, reduce watering to mornings only. On average, 3 to 4 watering cans are needed to water 1000 seedlings.

A word of caution: use common sense when watering since this depends on the state of the soil and condition of the seedlings. For example, during exceptionally hot and windy days, it may be necessary to water twice daily. Do not water at midday when evaporation is at its highest because the seedlings may be shocked, especially if cold water is used. If the seedlings begin to wilt, they need watering immediately to avoid damage. A common mistake is not to water when the rains arrive. Check germination beds and pots/tubes regularly for adequate moisture to a depth of 20 cm. Never allow

moisture levels to drop near the wilting point. Underwatering leads to poor root development and growth, while overwatering may encourage fungal diseases (see **Problems** below).

Common problems of watering:

1. Perimeters of seedbeds and blocks of containers receive less water than the middle areas. Ensure that watering is uniform.

2. Watering is often neglected for days after a rainstorm, but seedlings need water **daily**, regardless of the source.

3. Heavy watering can wash away sown seed and soil; it may also damage young seedlings. Add water slowly, so that it can soak into the soil and not run off. To reduce the impact of watering, use a watering can fitted with a rose and place a bundle of grass or leafy branch over the containers or germination bed.

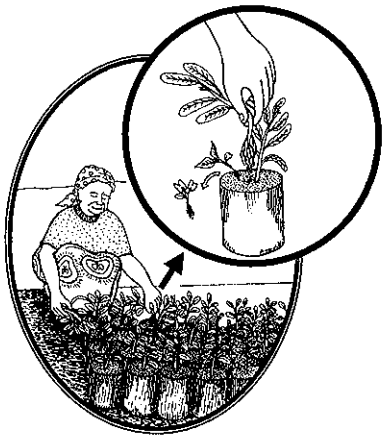
Weeding

Keep containers weed-free at all times to reduce competition for nutrients, water, and light. Aggressive weeds may dominate, weaken and even kill tree seedlings. Failure to weed regularly may result in deep-rooted weeds, which are hard to extract without damaging the seedlings. Weeding also reduces the incidence of insect pests that may be harboured by the weeds.

Thinning

Good germination from densely sown seed may cause overcrowding and competition, which weakens the plants and makes them vulnerable to damping off. Thin containers to one seedling 1-2 weeks after germination, without disturbing the plant left. For bare-rooted seedlings, thin to the

Carefully thin seedlings to one per container 1-2 weeks after germination



standard density of 5 cm between plants per row. When done early and correctly, thinned plants may be used to fill gaps in the seed bed, or containers where germination has failed.

NOTE: If there are more than 2 true pairs of leaves, cut the surplus seedlings with a sharp blade at the level of the root collar. Do not attempt to pull them out as this will damage the roots of the remaining seedling. Always thin surplus *Faidherbia albida* seedlings using a blade due to their sensitive roots.

Root Pruning

Root pruning involves frequently trimming tap and side-roots while the seedlings are in the nursery. It reduces development problems with long taproots, J-shaped or "corkscrew" spiral roots by encouraging a dense, fibrous, lateral rooting system. This type of root binds the soil together better, which improves survival when outplanted. Shorter, dense roots also make outplanting easier, and minimize root deformities caused by bending or breaking longer roots. Left unpruned, tap roots may grow into the ground beneath the nursery bed. This makes it difficult to remove seedlings without damaging the roots. Such seedlings are unlikely to grow or survive well, even if they appear healthy in the nursery.

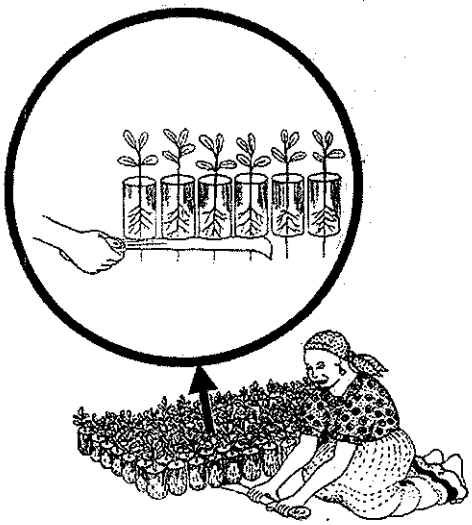
Frequency of root pruning: Root prune once a week after germination until time for outplanting. This is best done on a set day of the week (e.g., Mondays) so that it becomes a routine practice. Always soften the soil by watering to make cutting easier. To minimize stress, prune early in the morning, or in the evening when evapotranspiration is low to reduce risk of wilting. Make the final pruning 3-4 days **before** outplanting to allow recovery.

Containerized seedlings: Prune small roots protruding through the bottom of containers by lifting them off the ground. Prune larger roots by sliding a sharp panga or knife under the containers.

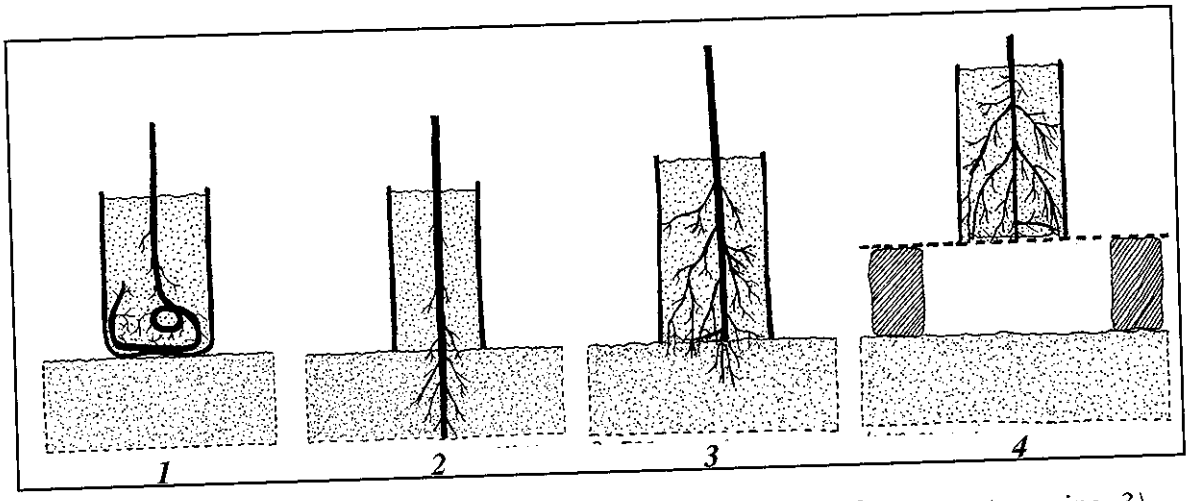
Bare-rooted seedlings: Root prune seedlings by running a thin wire or panga beneath the seedbed at ground level. Remove pegs or stones that may interfere with this operation. Using a wire requires 2 people holding it taut while moving it down the length of the seedbed. A sharp panga or knife needs only one person to cut the roots along each side of the seedbed. Prune side roots by slicing

Root prune every week.

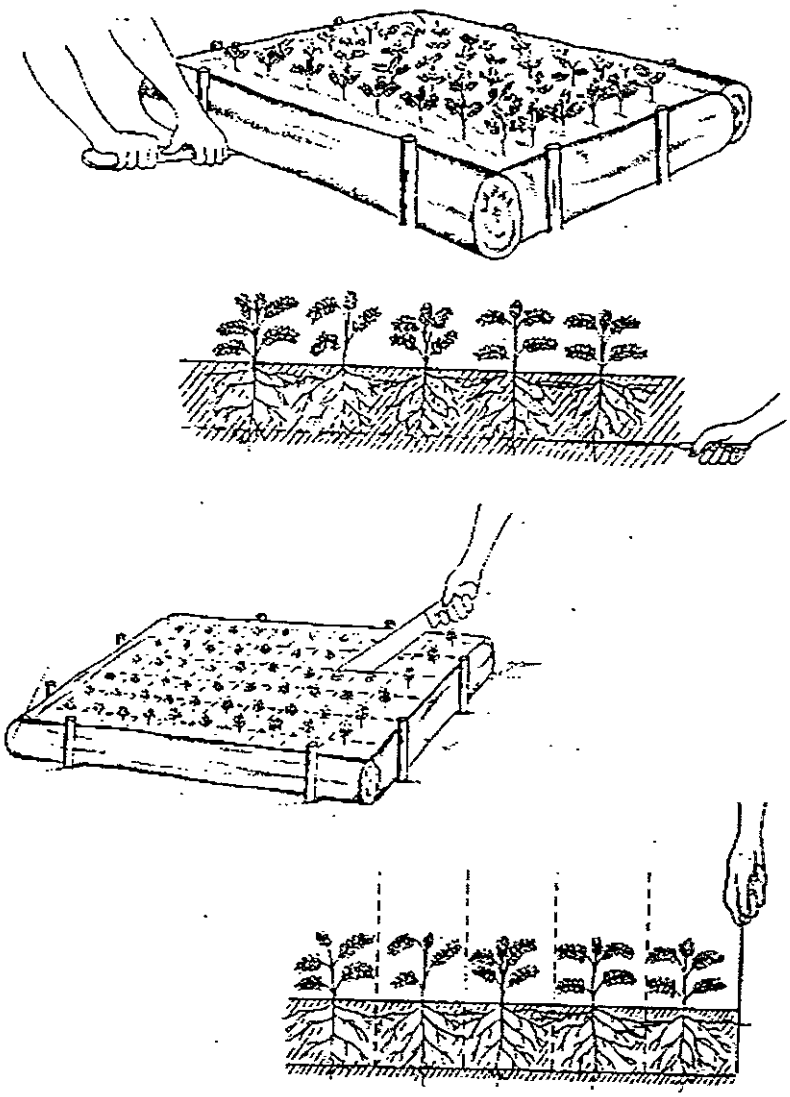
Gently lifting tubes off the ground.



Using a sharp panga



Root problems: 1) closed pot with bent root, 2) open-ended tube, no root pruning, 3) frequent rootpruning, 4) elevated tube, air pruning



Horizontal and vertical root pruning of a bare-rooted seedbed using a panga. (from Kenya Woodfuel Development Programme in Mungala et al. 1988)

the soil vertically with a knife or panga along and across the rows (see illustrations). This forms a "cube" around each plant usually 6-8 cm wide and 15 cm deep.

NOTE: Root pruning shocks seedlings, especially if delayed or if the roots have grown too deep. Removing root tips affects the uptake of water, which may cause temporary wilting. Seedlings need 3-4 days with good watering to recover from root pruning.

Alternatives to Root Pruning

Some species do not respond well to root pruning due to a fast growing root system that is sensitive to disturbance. Examples include *Faidherbia albida* and most species of *Acacia*. Two methods are recommended to minimize interference with the root system for good growth and establishment:

Early outplanting: Outplant 4-6 weeks after germination before the roots grow through the bottom of the container into the ground below.

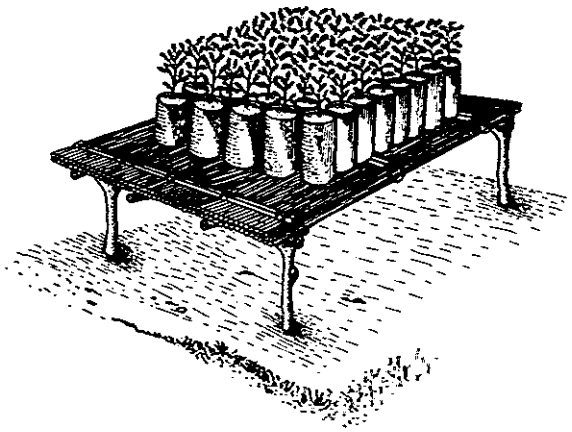
Air pruning: Raise seedlings in open-ended containers on platforms elevated off the ground. The roots cease growing as soon as they make air contact upon reaching the bottom of the container. This practice prevents interference with the root system, and fine lateral roots will develop in the containers. A frame of 100 x 100 cm will support 150 seedlings using containers 20 x 15 cm in size. Platforms may be made of expanded metal for strength and durability, but use of wood and reeds or bamboo is effective and cheaper.

Shade

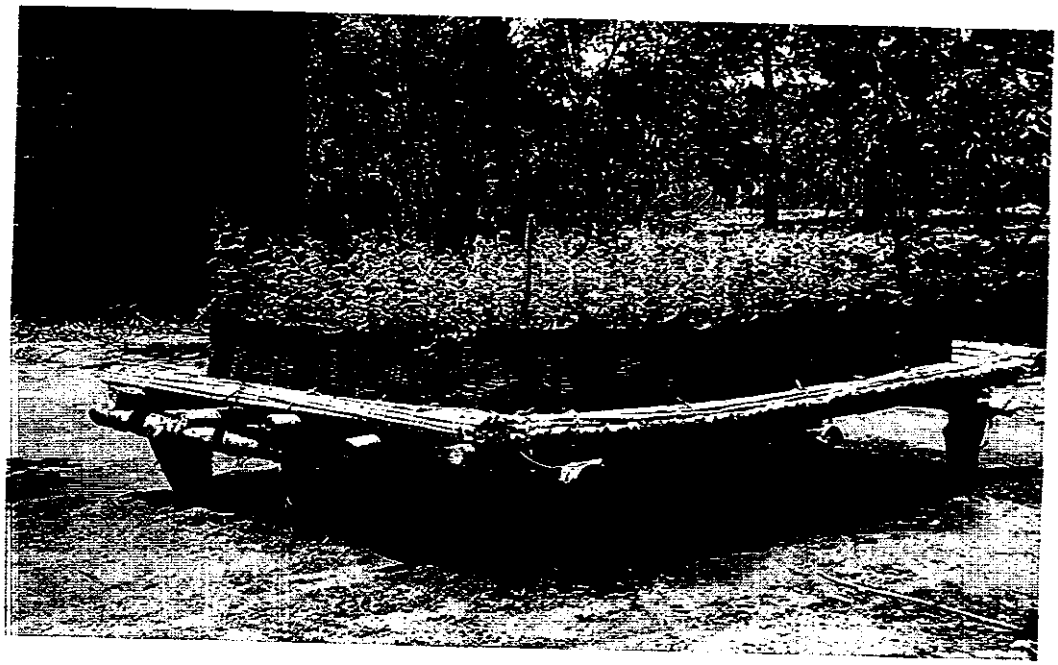
Shade may be needed to protect seedlings from sun scorch and water loss (evapotranspiration) during the first weeks in the nursery. This is critical after transplanting from germination beds to containers. Shade is more important for lower, hotter altitudes (e.g., the Lakeshore). It is needed for only a short time, since most species adapt early and well to full sunlight. Shading should be about 75 cm above germination beds and containers and may be fashioned out of banana or palm leaves, grass or split bamboo. Avoid heavy shade and opaque materials like black plastic as deep shade causes seedlings to be weak and spindly.

Insect pests and diseases

A variety of pests and diseases may attack seedlings. In small-scale nurseries, serious losses from pests and diseases are rare, particularly if indigenous trees or a mix of species are used. Chemical treatments are not recommended due to cost, the danger of poisoning people and animals, and risks of environmental pollution. Persistence of chemicals in the soil could also threaten beneficial organisms. The best method to minimize pests and disease is to maintain



Local platform of wood and reeds to raise air-pruned **Faidherbia albida** *seedlings.*



high standards of hygiene as recommended below:

Ants and termites: Some types of trees are attacked by ants or termites, especially at the juvenile stage. This may occur even with healthy seedlings of species adapted to the planting site. Reduce this risk by keeping seedbeds and containers free of sticks, weeds, and other debris. Replace rotten seedbed frames, and remove dead or dying seedlings. Keep seedlings well-watered to prevent wilting, and thin out overcrowded seedlings. If termites persistently attack seedlings, a possible remedy is to treat the seedlings with woodash, which repels termites. This may be done by establishing a 5 cm layer of woodash on the seedbed site. If heavy rains are expected before the seedbed is prepared, cover the bed with mulch to prevent the woodash from washing away. Tree seedlings may also be protected after outplanting by placing woodash into the planting pit.

Cutworms, beetles, caterpillars, and sucking insects: Remove and destroy badly infected seedlings. Good nursery hygiene with frequent checks will reduce these problems. Seedlings with cut stems may indicate cutworms, which should be dug up and destroyed. Leaf-eating caterpillars and beetles should also be removed and killed. Aphids and other sucking insects may be sprayed effectively with a solution from crushed *Tephrosia* leaves soaked overnight in a dark room. The recipe calls for about 2 kg of freshly crushed/pounded leaves in a pail of water. Use the filtered solution as a spray the next day. Then repeat the application 2-3 times at weekly intervals.

Diseases: Damping-off is a common nursery disease caused by fungi such as *Phytophora, Pythium* and *Fusarium* spp. It may be pre-emergent, when the seed rots in the soil before germinating, or post-emergent when the young shoots rot at soil level. A common indicator is an outward, circular spreading of infected centers. The cause is usually poor nursery hygiene and management.

Common problems and remedies:

- *Soil too rich in organic matter, which encourages fungi growth:* Remedy: Reduce the ratio of manure to soil to 1:4.
- *Overwatering:* Remedy: Water well but do not cause water-logging conditions.

- *Seed sown too densely with overcrowding of seedlings:* Remedy: Space seeds wider, and thin out soon after seedlings emerge.

- *Dirty tools and rough handling:* Remedy: Keep tools clean, and treat plants with care to avoid injuries that provide entry points for fungi.

- *Weedy conditions in the nursery cause competition with seedlings and may harbour destructive insects or other pests:* Remedy: Keep the nursery free of weeks to avoid this risk.

Hardening Off

Hardening off is the gradual reduction of water and shade to prepare seedlings for the sunnier, hotter, and dryer conditions when outplanted. Without hardening, seedlings will experience shock when moved suddenly to a harsher environment.

Water: Reduce watering from twice to once a day 4 weeks after germination (see page 59).

Shade: Cut use of shade in half 4 weeks after germination. After another 3 weeks, remove it completely to expose seedlings fully to the conditions they will face after outplanting.

Timeframe of Key Nursery Activities

May-December: Collect and process quality seed as dictated by the time of maturity for different species. Then store as needed.

July-August: Build the nursery near households and water supply and construct a protective fence; collect seed, soil, sand, manure and potting material.

September: Prepare soil, fill tubes, pretreat seeds according to recommendations and sow; then water, weed and root prune on a regular basis.

October-December: Continue watering, weeding and root pruning.

OUTPLANTING

Preparation

Outplant with care and foresight to minimize damage to young, delicate seedlings, for optimal growth and survival. Timely outplanting means planning the

nursery well in advance to give seedlings the best conditions for good establishment before the onset of the dry season.

A good guide is to outplant when seedlings are the same height as the container (i.e. equal to root length), with a stem at least the thickness of a pencil. Do not allow seedlings to overgrow in the nursery, especially in closed plastic containers. Those with shoots much longer than the roots may die back during a dry spell because the root system is insufficient to support the water and nutrient needs of the plant. This may cause root deformities, which increase the risk of root diseases, leading to poor growth and development.

Note: Always remove the container for good root growth and access to soil moisture and nutrients at the planting site.

Planting Pits (see Figures 5 and 6)

Dig pits before the rains start 60 cm in diameter and 60 cm deep. Loosen the soil at the base of the hole to reduce waterlogging after storms and to enhance deep root growth after the seedling is outplanted. Replace the soil loosely in the pits. Start with the top soil, then add the subsoil to encourage roots to grow deeper and more quickly.

Time of Outplanting

Outplant seedlings with the start of the rains in the wet soil of prepared pits by mid December or early January. This encourages good root growth for survival over the dry season. Choose a wet day for planting, preferably early morning or late afternoon to avoid midday heat and risk of wilting. Before outplanting, water the seedlings well, and make sure they have recovered from any root-pruning.

How to Outplant Containerized Seedlings (see Figures 7-8)

Use a basket or box to carry seedlings to planting sites. Make a hole in the loose soil of the pit large enough to fit the seedling. For containerized seedlings, squeeze the container so that it can be lifted off easily after placing it in the hole with the root collar level with the ground. Partially fill soil around it, then carefully pull the container up and over the seedling. Continue filling soil around the seedling up to the root collar. Then **firmly pack down** the loose soil with the heel of your foot. Take care

Figure 5: Dig pit 60 cm deep and 60 cm in diameter separating the topsoil from the subsoil.

throughout to minimise damage to the roots and loss of nursery soil.

For closed containers, cut the bottom with a sharp knife. Then follow the instructions as for seedlings in open-ended containers.

How to Outplant Bare-Rooted Seedlings

Figure 6: Fill in the hole starting with the topsoil.

Remove seedbed frames. Carefully slice up the bed so that each seedling is extracted with its cube of soil to protect the roots from damage and drying out. Seedlings may also be lifted with their root/soil mass wrapped in large leaves, wet newspapers, hessian cloth, or other material for transport to the planting site. Handle seedlings with care during transport using buckets, boxes or other suitable containers to minimize disturbance to the soil/root mass. To reduce damage and wilting, transport only enough seedlings at a time to outplant in 1-2 hours. Keep the ball of soil around the roots when outplanting. If the seedlings cannot be planted right away, keep them shaded and covered with wet straw or grass.

Figure 7: Transport seedlings to the planting site in a basket.

A word of caution: Overgrown seedlings that have not been root-pruned regularly have a lower rate of survival than smaller

Figure 8: Make a hole in the center of the planting pit, place the seedling in the hole, remove the container and then firm the soil around the seedling.

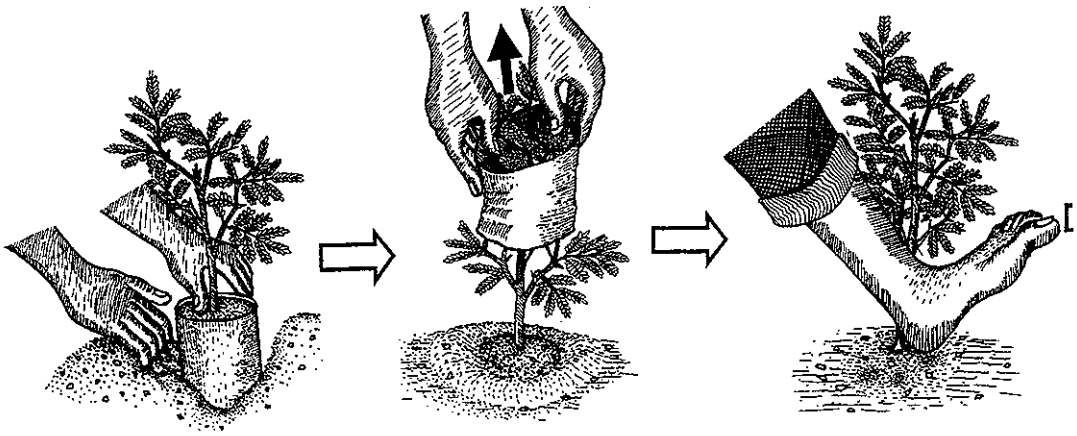


Figure 9: After weeding 1m around the base of seedlings, slash the area between them.

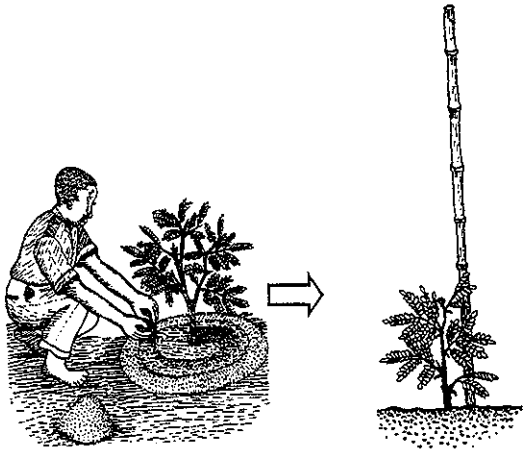


Figure 10: Add a double-handful of manure around each seedling and then mark clearly with a stake.

Outplanted **Afzelia quanzensis** *seedling. Note that the container has been removed.*

seedlings with undisturbed roots. This may indicate that the tap roots have grown too deep, risking damage when lifted, and reducing survival after outplanting.

How to Improve Survival and Growth (see Figures 9-10)

Clear a 1 m^2 area around the seedling and create a small micro-basin for water retention. If possible, water the seedlings well, then add a double-handful of manure with mulch to the soil surface around each seedling to encourage good growth and establishment. Weed 3 times during the first 2 growing seasons to improve growth. At the end of the rains, slash the ground between seedlings to reduce risks of fire damage. Crops may be grown with the trees during the first season to make better use of the available land and to ensure weed-free conditions for good seedling growth.

Protecting Seedlings (see Figures 11 and 12)

Mark seedlings with stakes to minimize accidental weeding or trampling. At harvest time, erect a protective fence around each seedling if livestock are a risk. Make firebreaks to protect woodlots and other plantings from damage by fires. Add mulch or thatching grass around the base of the tree to help conserve soil moisture around the tree. Make sure the mulch is clear of the tree trunk to minimize termite attack. In the event of disease or pest attacks, seek advice from the nearest Forestry Office.

Pruning (see Figure 13)

Prune bottom branches of seedlings after the first season to promote straighter, healthier trees, and to reduce interference with field operations. Prune when trees begin active growth to reduce die-back, fungal diseases and termite attack. This is April-May for *Faidherbia albida* and September-October for other species. Make clean angled cuts with a sharp blade or saw to reduce injury to the tree. As trees grow to maturity, a few branches may be

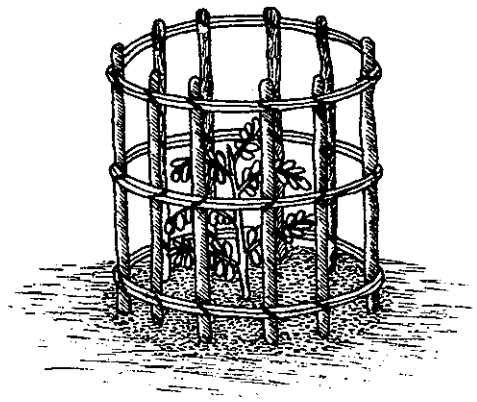


Figure 11: Erect a protective fence around your trees to protect them from livestock damage.

Figure 12: Protecting young soil-improving tree seedlings in a maize field.

selectively lopped to reduce the density of the canopy. Spread the cut foliage on the ground to act as green manure, or use it as animal feed if the tree is a good fodder species. Collect the wood for fuel or other uses.

Timeframe of Key Activities

July - October: Prepare planting pits before the rains 60cm deep and 60cm in diameter.

November - January: Plant seedlings with the rains in the wet soil of prepared pits.

January - May:

1) Weed 1 m^2 around the base of each seedling 3 times during each of the first 2 seasons to improve growth, and to reduce risks of fire damage.

2) Erect a protective fence around each seedling if livestock are a risk. Mark other seedlings with stakes to minimise accidental weeding or trampling.

May - June: Make firebreaks to protect planted areas from fires.

Figure 13: Pruning a young tree to improve its growth form.

OTHER METHODS OF TREE PROPAGATION

Direct Sowing

Direct sowing is recommended only for *Cajanus cajan* and *Tephrosia vogelii*. Direct sowing other species gives poor results in the field, largely due to late sowing and poor protection from weeds and animals.

Propagation from Cuttings

Some tree and shrub species can reproduce from portions of stems, leaves or roots taken from a parent plant. When planted under favourable conditions, roots and shoots will grow into a new plant. This section focuses on species known to be successful from cuttings, but it is likely that many other species could be raised in this manner. Little research has been conducted on cuttings, especially with indigenous trees. The advantage over seed is the early, quick start from a plant already of reasonable size that has a genetic make-up identical to the mother plant.

Timing and selection: It is generally best to take cuttings from trees late in the dry season when the tree is dormant, i.e. before the sap has started to rise, and when the tree is not in flower or fruit. Always select mature healthy trees of the type and form desired since material from weak, ill formed or diseased trees will produce weak, diseased

plants. Most cuttings in Malawi are taken from deciduous trees as follows:

1. *Deciduous hardwoods*: Take cuttings from mature stems late in the dry season just before new shoots or leaves appear. Select young vigorously growing branches that have had one full year's growth. e.g., *Pterocarpus angolensis.*

2. *Deciduous or evergreen softwoods:* Take cuttings from the soft new growth consisting of a portion of stem with two or more leaves at the top. Softwood cuttings need more care as they are soft and more succulent, making them prone to drying out.e.g., *Ficus natalensis.*

How to make cuttings:

- Take cuttings early in the morning when transpiration is low to reduce the risk of drying out. Stem cuttings should be about 1 to 2 cm in diameter.

- Move the freshly cut branches to a cool shady spot for preparing the cuttings.

- Select the section of stem with several nodal points from which new branches and roots will sprout. Cut 1-2 cm off the base with a sharp knife, since ends exposed to air are less likely to regenerate. The ideal length for hardwood and semi-hardwood cuttings is 100 -150 cm, and 50-100 cm for softwoods.

- Except for 2-3 leaves at the top, remove other leaves and any flower buds to reduce water loss from transpiration. They also tend to inhibit vegetative resprouting.

- Make a clean angled cut at the top end to reduce fungal infection, and a horizontal cut at the bottom just below a node.

- Mark the bottom or rooting end to distinguish it from the top when the cutting is bare of leaves. The horizontal cut will help identify the bottom.

- Dip cutting into a rooting hormone powder or solution if available to encourage root sprouts.

Nursery Care of Cuttings

Although it is more practical to plant cuttings directly in the field, some species

need initial nursery care in containers or cutting beds. Use well-drained media that is free of weeds and nematodes, and able to support the cuttings physically and nutritionally.

Media for cuttings: Many media are available commercially, but their use is limited by cost concerns. Coarse sand or sandy loams are the most popular. They must be clean and free draining as moisture retention may lead to rot.

Management: Cuttings require regular watering and adequate light. Ideal temperatures are between 18-28° C. Limit loss of water from transpiration by keeping conditions humid in the surrounding environment, e.g., use of a mist spray in a glass house. The time of rooting differs by species, averaging about 3 weeks. Once rooting has started, harden off the cuttings by gradually exposing them to the real environment where they will be planted. This means steadily reducing the frequency of watering and application of mist spray, while increasing sunlight. Once acclimatized, the cuttings are ready for outplanting.

Outplanting

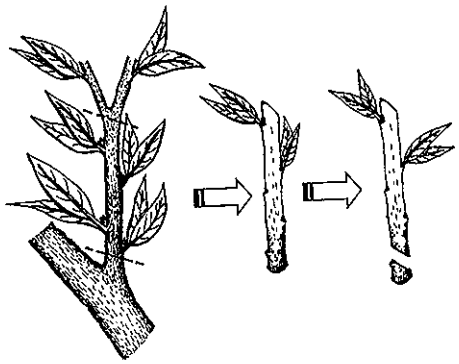
It is usually best to plant cuttings as soon as possible within 24 hours, whether in a nursery bed or direct in the field. Plant the root end, with at least two nodes, at an angle into well-prepared, wet soil to a depth of 20-30 cm. This speeds up the growth of shoots and roots. Replace and firm down the soil. Keep cuttings well watered until roots develop. Common species that can be grown from cuttings include *Commiphora africana*, *Erythrina abyssinica*, *Ficus natalensis*, *F. capensis*, *Jatropha curcas*, *Kirkia accuminata*, *Moringa oleifera* and *Sclerocarya birrea*.

Truncheons

A truncheon is simply a large cutting, usually taken from a branch of a tree. Many indigenous trees grow well from truncheons. The advantage is that the new plant is a tree already 1 m or more in size, and truncheons require no nursery costs or facilities as they are planted directly *in situ*.

Preparing truncheons:

- Cut off a branch where it meets the trunk.
- Select a section 1 m or more in length and not less than 5 cm in diameter.



Propagation by cuttings: 1) take one year old branch, 1 -2 cm in diameter, 40-80 cm long; 2) mark bottom end, remove leaves; 3) just before planting, cut off 1 - 2 cm from end.

- Strip off leaves and twigs to limit water loss from transpiration, but leave a few at the top.
- Truncheons with milky latex or thick fleshy bark should be allowed to dry for a few days before planting, e.g., *Ficus, Erythrina,* and *Sclerocarya.*
- Plant truncheons at the desired field site to a depth of 30-60 cm depending on the size. Place river sand at the bottom of the hole for good drainage to prevent fungal attack or rot, and to stimulate root growth.

CHAPTER 3 QUESTIONS: TREE PROPAGATION AND OUTPLANTING

1. Why is self-collection of tree seed important?
2. What is the importance of conducting a seed germination test?
3. Identify two factors for calculating tree seed requirements.
4. Given that a farmer wishes to plant 200 *Acacia galpinii* trees along his farm boundary at a spacing of 4 meters between plants, how much seed does he/she require in grams with an allowance of 35% for losses? There are 4,800 seeds per kilogram of *A. galpinii.*
5. What is the recommended seed treatment for hard-coated seeds, and why is this necessary?
6. Why is air pruning recommended for *Faidherbia albida*?
7. When should the final root pruning be done before outplanting and why?
8. What are the recommended dimensions for tree planting pits?
9. When is the best time to plant trees and why?

(For correct answers refer to Page 247 in the annex)

INTRODUCTION

This chapter describes soil and water conservation practices at the farm level to:

- reduce water run-off and soil erosion
- conserve soil moisture for plant growth
- improve soil physical conditions
- improve crop and pasture yields
- increase ground water supplies
- reduce siltation and flooding.

The practices in this chapter include:

- Contour ridging
- Gully control
- Streambank protection
- Contour vegetation strips

CONTOUR RIDGING

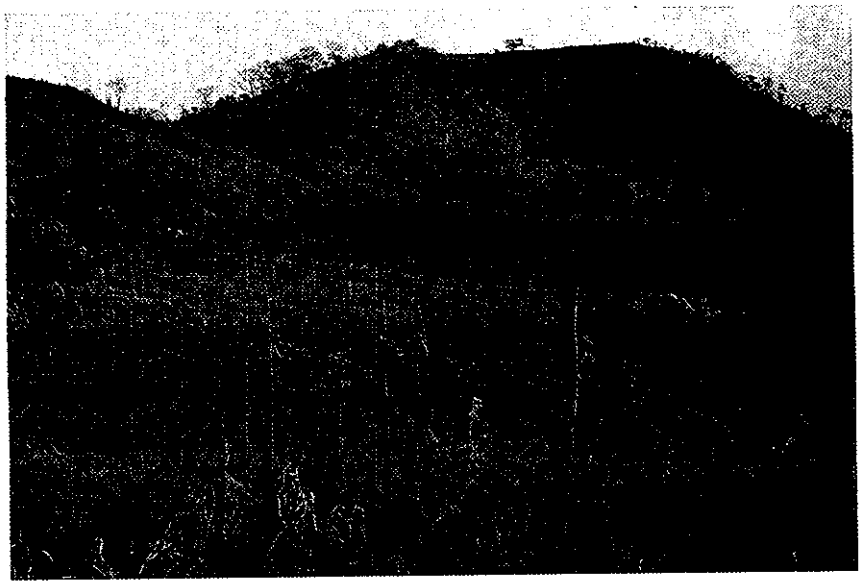
Annual ridging by hand-hoe is the common method of land preparation in Malawi. Since few farmers cultivate on the contour, ridges tend to channel water, which aggravates surface run-off and erosion. Contour ridging is a simple practice to reduce such negative impacts. To do this, peg and construct contour marker ridges as guides to re-align planting ridges. Marker ridges are best made during the dry season to allow time for re-aligning ridges before the next season.

Implementation is best done on a catchment basis involving the entire community to avoid compromising the results since run-off and erosion are not problems specific to individual farms. Other practices can then be incorporated on the contour to enhance the effectiveness of contour ridging while offering additional benefits and products.

Up until the 1990s, marker ridges were delineated by land husbandry staff, but impacts were low due to resource and personnel limitations. Recognizing the problem, a policy change was made by LRCD to scale-up the land area under contour by empowering communities to make their own marker ridges. This is being achieved through annual conservation campaigns, training, and the formation of village conservation committees.

INSTRUMENTS FOR MARKING CONTOUR LINES

Several instruments are used to mark contour lines, but some are expensive and require special skills not appropriate for use under smallholder conditions (e.g., the abney



Contour ridging to reduce soil erosion. Note the tied ridges.

Re-aligning the field on contour is necessary before planting crops and trees.

and dumpy/quickset levels). More suitable tools are the line level, A-frame and Phirilino frame. Each of these is described below.

The Line Level

The line level is a cheap, accurate and quick tool for marking contour lines. It consists of a miniature spirit level that hangs from a taut string between two poles. Details of its use follow.

Equipment and People (see Fig. 14):

- 1 line level
- 5 m of string
- 2 sturdy straight sticks, 1.6 - 2.0 m long with flat ends
- 1 knife
- Pegs to mark contour lines with an optional carry-bag (about 100 pegs/ha for flat and gentle slopes; 150/ha for medium slopes; and 200/ha for steep slopes)
- 1 hammer or stake to drive pegs into the ground
- 3 people: two to hold the sticks, and a leader who will read the line level. They will be referred to as A, B, and C, respectively.

Equipment Set Up and Testing:

1. Trim the ends of the sticks to make them flat. Then stand them upright on level ground, preferably the floor of a building.

2. Cut a groove around each stick at exactly the same height (about 1.2 to 1.6 m or chest-level to make reading easy).

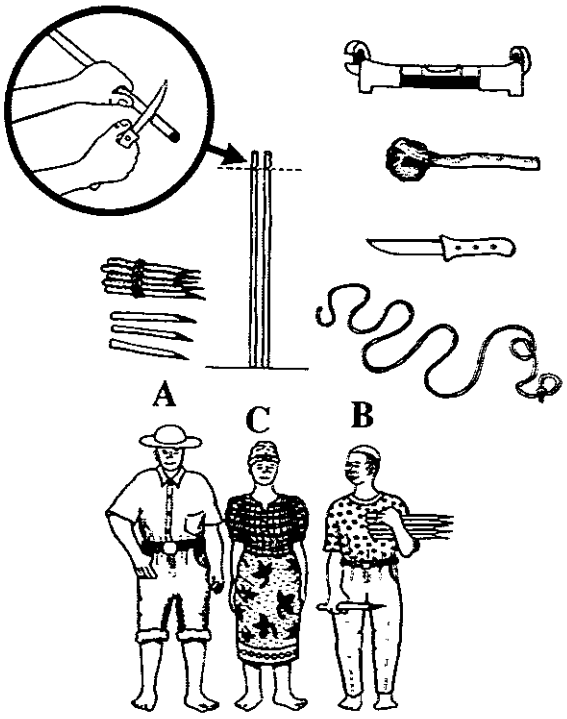


Figure 14: Materials and people needed to use a line level.

3. Hang the level between 2 knots tied in the center of the string to stop it from sliding.

4. Tie the string ends in the groove of each stick.

5. Set the 2 sticks upright on a level surface (e.g., floor) with the string tight. Mark their exact positions on the floor and read the line level. Then switch the positions of the sticks and read the level again.

6. If the bubble is not perfectly centered both times, check that (a) the floor is **level**, (b) the groove heights of both sticks are **identical**, and (c) the level is hanging **properly**. Correct any problems as needed.

7. If the checks above are correct, the line level itself is faulty and must be replaced before continuing.

Using the Line Level (see Fig. 15)

1. Start at the top of the field about 20 m below the upper corner.

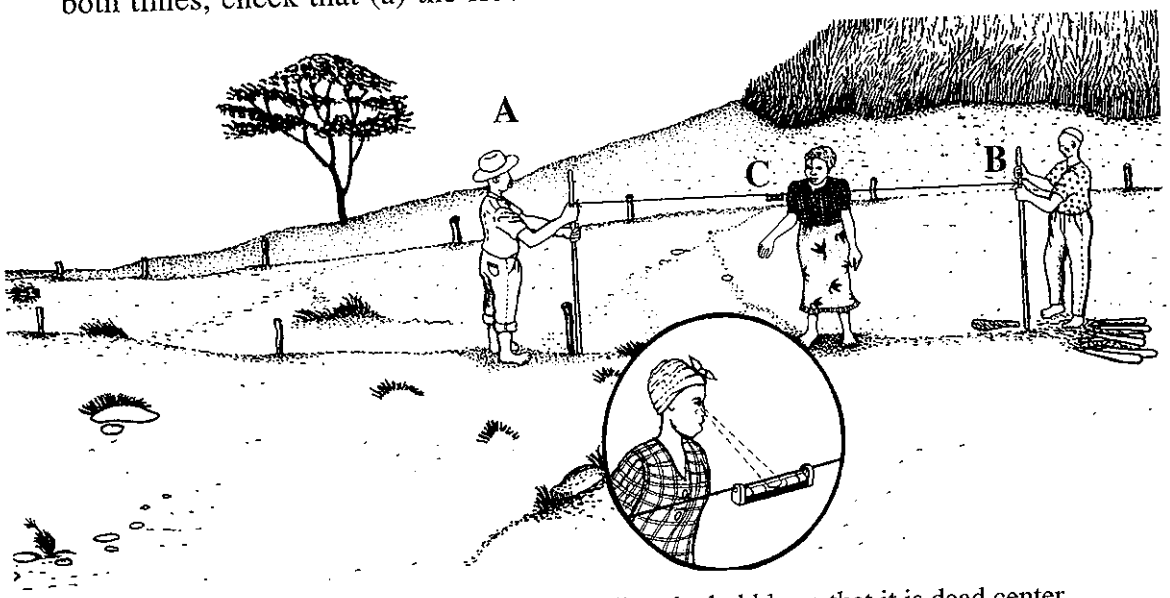


Figure 15: Using the line level in the field and reading the bubble so that it is dead center

2. The leader, **C** instructs **A** to insert a peg by his stick to locate the starting point. Avoid placing the sticks on rocks, ridges and termite mounds, or in holes and depressions. If a large anthill is encountered, stop pegging at its base, then continue from the other side. Ridges should also be made in concentric circles on anthills to reduce heavy runoff.

3. **C** then instructs **B** to move along the estimated contour line with the string tight.

4. **C** reads the position of the bubble. She instructs **B** to move up or down the slope until the bubble is precisely centered. **B** inserts another peg at the precise location of his stick.

5. With **B** in place, **A** moves past **B** to locate the next peg. **C** instructs **A** to move up or down the slope while reading the line level.

6. Follow Step 4. When the bubble is perfectly centered, insert another peg at **A**'s stick.

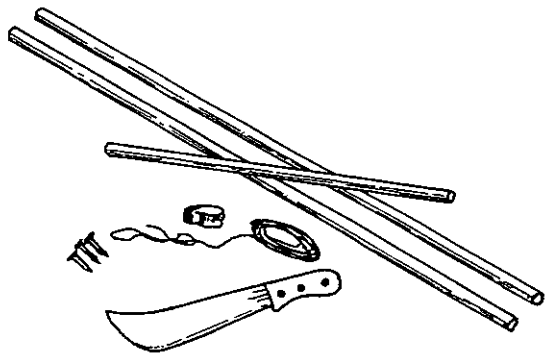


Figure 16: Materials to make an A-frame

7. Repeat the above steps, inserting pegs at each point till the end of the field is reached.

8. The team then moves downslope from the first contour line. The interval depends on the slope of the field, i.e., 20 m apart for gentle slopes, 15 m for medium slopes and 10 m for steep slopes. Repeat steps 2 to 7 until the whole field is pegged.

The A-Frame

The A-frame, shaped like the letter A, is a simple, low-cost tool for marking contour lines. Details of its construction and use follow.

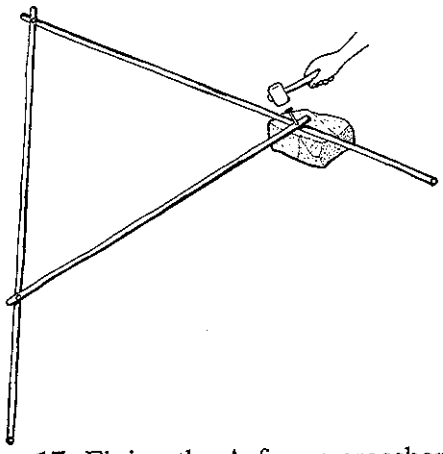


Figure 17: Fixing the A-frame crossbar in place

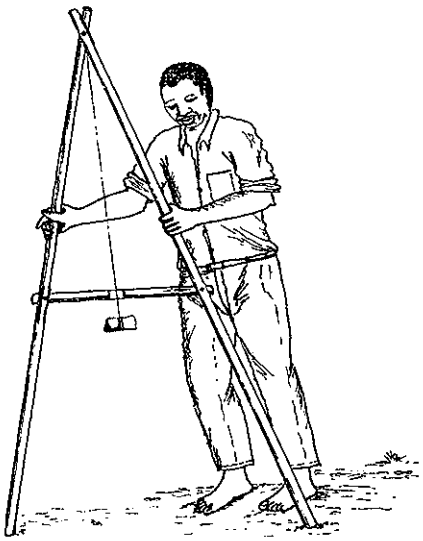


Figure 18: Assembled A-frame with center point marked

Equipment and People (see Fig. 16):

- 2 m of string
- 1 stone
- 3 nails or string to tie the frame together
- 2 wood sticks with flat ends 3 m long, and one cross stick 2 m long
- 1 panga knife
- Pegs to mark contour lines with an optional carry-bag (about 165 pegs/ha for gentle slopes; 250/ha for medium slopes; and 330/ha for steep slopes)
- 1 hammer or stake
- Two people.

Equipment Setup and Testing:

1. Trim the ends of the two 3 m sticks to make them flat and tie or nail their tops together. Then tie or nail the cross-bar to the upright sticks 1 m from the bottom to form an A shape (see **Figure 17**). Ensure that the bottom ends of the uprights are as far apart as possible to increase the inter-peg distance.

2. Hang a string from the top of the two upright sticks with a stone tied to the end so it hangs 5-10 cm below the cross-bar.

3. Stand the A-frame on level gound (e.g., floor). Let the string settle, then mark the **exact** spot where it crosses the horizontal stick (see **Figure 18**). The A-frame is **perfectly** level when the string hangs **precisely** over this center point. Mark the leg positions of the 2 uprights on the floor. Then switch the positions of the frame legs. If the calibration is correct, the string will hang exactly over the center point.

4. If the string is not perfectly centered both times, check that (a) the floor is level, and (b) the frame is tied securely. Adjust the set up by repeating step 3 above.

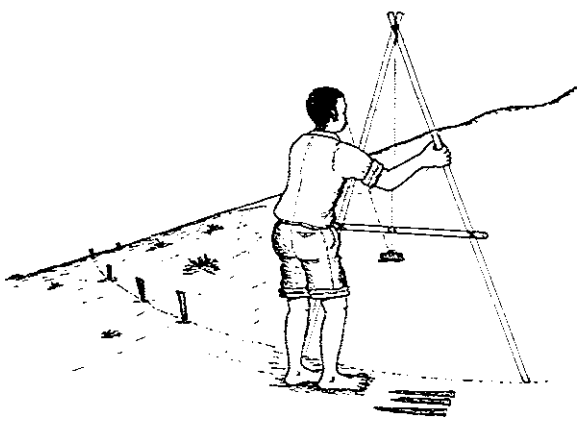


Figure 19: Marking contour lines with an A-frame

Using the A-Frame (see Fig. 19):

Choose calm days for using the A-frame as wind affects the position of the hanging stone.

1. Start pegging the field about 20 m below the upper corner.

2. Insert a peg at the starting point of the line, and position one leg of the A-frame next to it. Avoid holes and depressions, or stones, ridges and humps. If a large anthill is encountered, stop pegging at its base, then continue from the other side. Ridges can also be made in concentric circles up the anthill to reduce heavy runoff.

3. Holding this leg in place, move the other one up or down slope until the string hangs **precisely** over the mark on the cross pole. Insert a peg at this point.

4. While holding the second leg in place, pivot the first one round and move it up or down slope until the string hangs **exactly** over the mark again. Drive another peg into the soil at this point. **Note:** The pivoting process is important because it evens out errors if the A-frame is not calibrated perfectly.

5. Continue pivoting across the slope until you reach the end of the field, pegging the positions of the legs as you go.

6. Then move downslope to the next contour line, the interval of which depends on the slope of the field. i.e., 20 m apart for gentle slopes, 15 m for medium slopes and 10 m for steep slopes. Repeat steps 2 to 5 until the whole field is pegged.

The Phiri-Lino Frame

The Phiri-Lino frame was designed by Mr. Jeremeya Phiri, a farmer at Chijere Village in Nkhata-Bay District. It is similar to an A-frame except that it uses a line level superimposed on a string tied to both legs of the frame instead of a pendulum. It combines the advantages of the line level and A-frame, which makes it simpler and faster to use.

Equipment and People:

- Line level
- 2.5 m of strong string
- 4 wood poles with flat ends, two 3 m long, one 2.5 m long and the other 2 m long
- 1 panga knife
- 1 hammer, rock, or large stake for driving pegs into the ground
- Pegs to mark contour lines with an optional carry-bag (about 165 pegs/ha for flat and gentle slopes; 250/ha for medium slopes; and 330/ha for steep slopes)
- Two people.

Equipment Setup and Testing:

1. Trim the ends of the two 3 m sticks to make them flat and tie their tops together. Tie the 2.5 m stick across the other 2 sticks about 1 m from the bottom to form an A shape. Then tie the 2 m cross stick parallel to the other one but 0.5 m above it to make the frame strong.

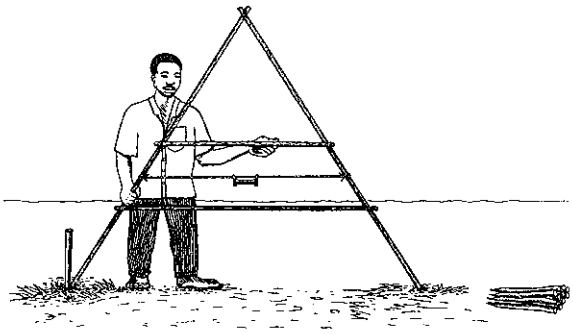


Figure 20: Using Phiri-Lino frame in the field

Ensure that the bottom ends of the 3 m sticks are as far apart as possible to increase the inter-peg distance.

2. Cut a groove around each of the 3 m sticks at exactly the same height above the ground half-way between the 2 cross sticks.

3. Tie the ends of the string in each groove.

4. Hang the level between 2 knots in the center of the string to stop it from sliding.

5. Test the equipment by setting the frame upright on a level surface. Mark the positions of each leg on the floor and read the line level. Then switch the positions of the legs and re-read the level.

6. If the bubble is not perfectly centered both times, check that (a) the floor is **level**, (b) the groove heights of both sticks are **identical**, and (c) the level is hanging **properly**. Correct any problems as needed.

7. If these checks are correct, the line level is faulty and must be replaced.

Using the Phiri-Lino Frame (see Fig. 20):

Using the Phiri-Lino frame is similar to the A-frame but readings are made on the spirit level on a string fixed to the frame. This allows use on windy days, and eliminates the need to stretch the string when repositioning the frame as needed for the line level.

SMOOTHING CONTOUR LINES

Pegged contour lines may be smoothed out to reduce sharp angles between pegs. This simplifies building marker ridges and re-aligning planting ridges.

When to smooth the contour line:

Smooth pegged lines from their starting point only on uniform terrain. Do this by moving certain pegs as follows (see **Fig. 21**):

1. Three people each stand by the first 3 pegs in the line (pegs 1, 2 and 3). Move the middle peg (no. 2) so that all 3 pegs are in a straight line.

2. All 3 people then move two pegs forward i.e., to pegs 3, 4 and 5. Move the middle peg (no. 4) so that pegs 3, 4 and 5 are in a straight line. Repeat this till the line is finished. The line will now follow the gradual curves of the contour.

When not to smooth the contour line:

Do not smooth contour lines on irregular terrain as it could cause runoff problems. When pegging across depressions or undulating terrain, shorten the string with the line level to half its length (about 2.5 m) to reduce the pegging interval for accuracy. This is not necessary for the A and PhiriLino frames since both already have a shorter pegging interval.

HOW TO RIDGE ON CONTOUR

Building marker ridges

Build the pegged contour line into a ridge. The marker ridges simply serve as guides to re-align planting ridges, and need not be bigger than other ridges if they are clearly marked.

Re-aligning crop ridges

Re-align crop ridges between 2 marker ridges by aligning the top half of the area to the top marker ridge, and the bottom half to the lower marker ridge (see **Fig. 22**). This keeps the ridges more on contour.

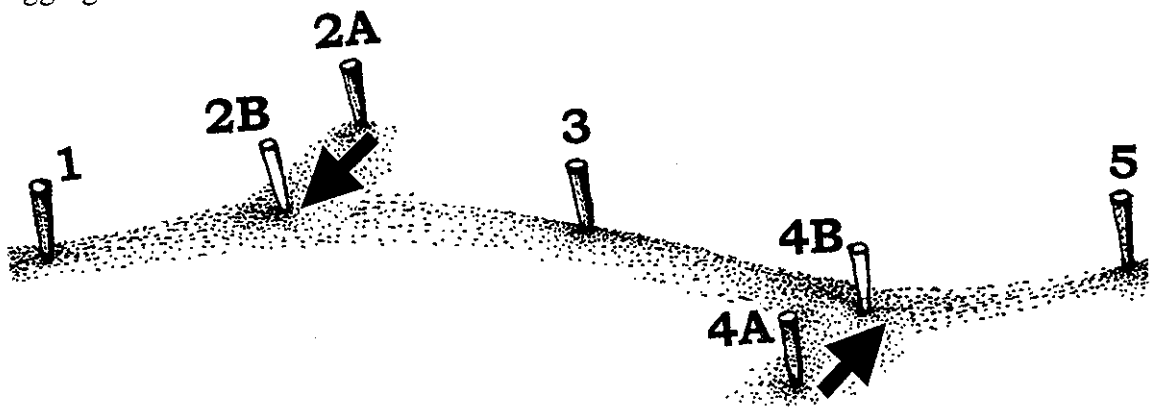


Figure 21: Smoothing the contour line

TIED/BOX RIDGING

Build tied/box ridges across planting ridges to create "microcatchments" to increase water infiltration and to reduce erosion. Tied/box ridges are best suited to land on contour, but they can often be effective where ridges have not been re-aligned.

Building tied/box ridges (see Fig. 23):

1. Construct tied/box ridges across the entire furrow perpendicular to crop ridges, but slightly lower to allow spill-over. Space them 1-3 m apart depending on the terrain and rate of water flow within the field.

2. Move to the next furrow and repeat step 1 but locate the tied/box ridges half-way between those in the previous furrow.

3. Repeat steps 1 and 2 until the whole field is covered. (see **Fig. 23**)

RAISED FOOTPATHS AND FIELD BOUNDARIES

Footpaths and field boundaries can aggravate the formation of rills and gullies if not well constructed. Raising them above the level of the surrounding fields is a basic conservation practice to reduce water runoff and soil erosion. This practice is best suited to fields with contour ridges (see **Fig. 23**), but it may often be effective where this has not been done.

Steps to raise footpaths and boundaries

1. Mark designated footpaths and boundaries with pegs from top to bottom, perpendicular to or at an angle to the crop ridges.

2. Construct a path 50 cm wide along the pegged line slightly above the crop ridges. Do this by collecting soil from the furrows between ridges.

3. Maintain raised paths and boundaries to prevent any channeling.

4. Ensure that all ridges are tied adjacent to the edges of gullies, footpaths and farm boundaries to prevent water from causing more erosion damage in these areas.

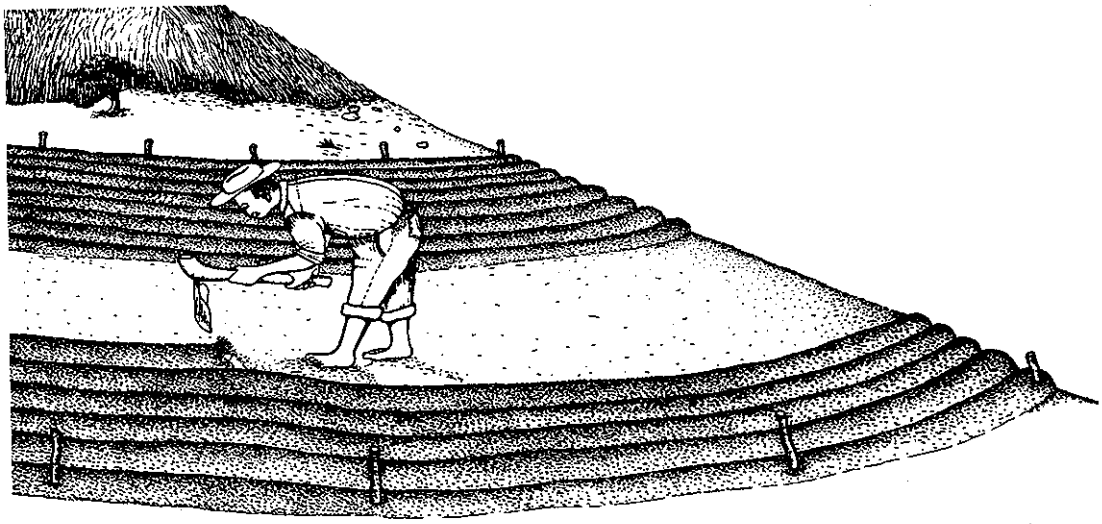


Figure 22: Ridge re-alignment between pegged contour lines: align top half to the upper line, and bottom half to the lower line

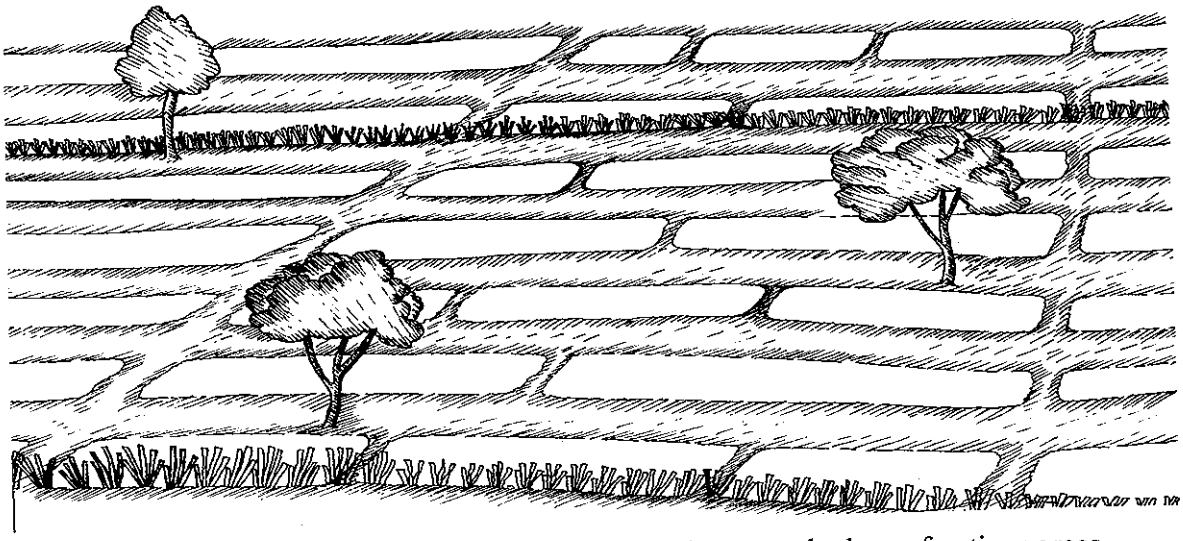


Figure 23: Tied/box ridges with raised footpaths and contour hedges of vetiver grass

GULLY CONTROL

Gullies are among the most severe forms of erosion in Malawi. They affect not only farm land, but settlements, grazing land, streams/rivers, wetlands, roads, and bridges. Gully formation is aggravated by cultivating steep slopes and streambanks; ridging off contour; use of unraised footpaths and field boundaries; overgazing; land clearing and deforestation; and poorly constructed roads, drains, dam spillways and physical conservation measures. Gully problems become more acute when water is channeled in from surrounding lands.

Prevention of gully formation

The best way to prevent gully formation is to promote sound land-use practices that increase water infiltration and reduce run-off. Recommended measures include contour and tied/box ridges, raised footpaths and field boundaries, vegetative barriers on contour, and tree planting.

Simple techniques to control gullies

Identify the cause(s) of the gully, then take proper remedial action before the problem worsens. The following techniques may be used to reclaim small gullies on farm land:

CHECK DAMS OF BRUSHWOOD

Check dams of brushwood and bamboo (see **Figures 24 and 25**) are temporary structures that are easy to build. They provide the first line of defence before planted vegetation becomes fully established.

Materials required:

small diameter poles placed across the gully and extending beyond the gully walls;
stakes to hold the cross poles in place;
string/nails to tie cross poles to the stakes;
2-3 anchors to attach to the stakes;
hammer/stone for driving in the stakes.

Constructing a check dam:

1. Drive pairs of stakes into the bed of the gully, with a gap between them wide enough to fit the cross poles. Insert the stakes across the width of the gully up to the top of the walls, and spaced close enough to each other for strength. 3-4 pairs of stakes are sufficient for small gullies.

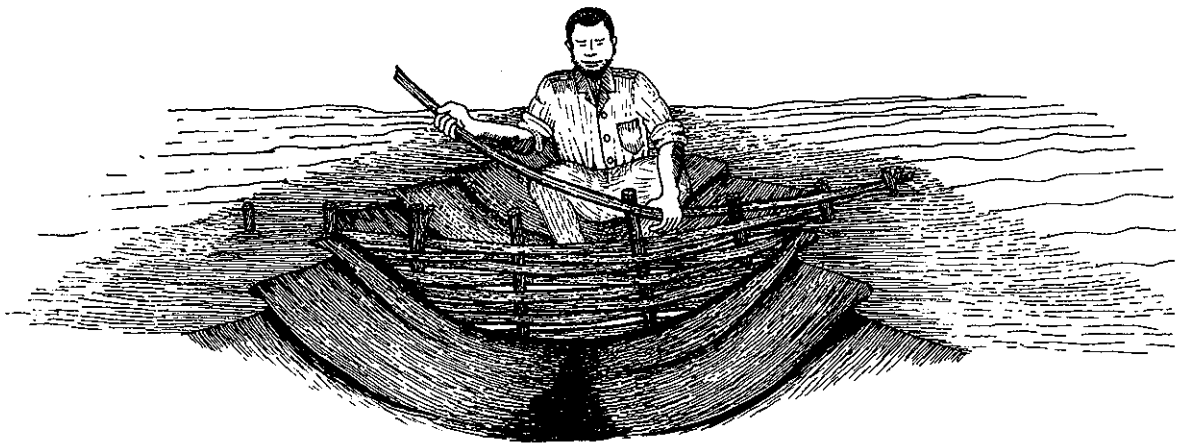


Figure 24: Construction of woven brushwood check dam

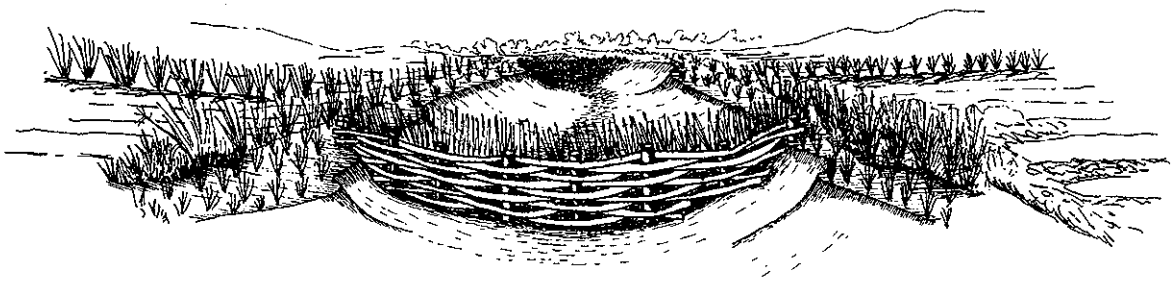


Figure 25: Check dam of woven brushwood with newly established vetiver hedges

Figure 26: Construction of stone check dam

Figure 27: Check dam constructed by stone pitching with vetiver planted above it

2. Lay poles between the stakes from the bed to the wall of the gully. Make sure the center is lower than the ends to act as a spillway so that the sides of the gully are not undercut.

3. Nail or tie cross poles to the stakes, which can be anchored for strength.

4. An alternative method is to weave freshly cut cross poles in between single stakes from the base to the top of the gully in the same manner as done in making fish traps, baskets or granaries (see **Figures 24 and 25**).

5. Space check dams along the bed of the gully according to the gully gradient (i.e., 5-10 meters); narrow the interval for gullies with steeper gradients.

CHECK DAM OF STONES

Where abundant, stones may be used to build check dams by pitching (see **Figures 26 and 27**). Stone pitching extends to the gully walls, with the center lower than the ends to form a spillway in the manner described for brushwood dams.

NOTE: Construct check dams before the onset of the rains to allow silt to build up behind the dam with the first runoff.

VEGETATIVE BARRIERS

Vetiver grass and trees may be established as permanent vegetative barriers in the bed of the gully to slow runoff. They also trap sediment and organic matter behind the barrier, which enhances vegetation regrowth and terrace formation within the gully.

Establishing vetiver grass (see Figs. 25 and 27):

1. Construct a check dam of brushwood or stones in the gully (see Check Dams above).

2. Plant slips of vetiver 10 cm apart each with 5-10 tillers to form dense hedges across the entire width of the gully, and above the check dam to make use of sediment deposits (For methods to plant vetiver see **Contour vegetation strips**). Space hedges according to the gradient of the gully (i.e., 5-10 m) starting above the head of the gully. Plant with the first

rains to allow fast growth and early establishment.

3. Trim vetiver regularly to promote a dense permanent barrier and fast growth.

Reducing water flow into gullies (Fig. 28):

Reduce water flow into gullies to prevent increase in size by following the steps below:

1. Construct tie/box ridges in fields on both sides of the gully.

2. Leave a strip of uncultivated land along the gully, then plant a vetiver hedge on both edges with 10 cm between planting slips to prevent the gully walls from collapsing (see **Figs. 25 and 27**).

NOTE: To reclaim big gullies, consult local land husbandry staff and Land Husbandry Manual.

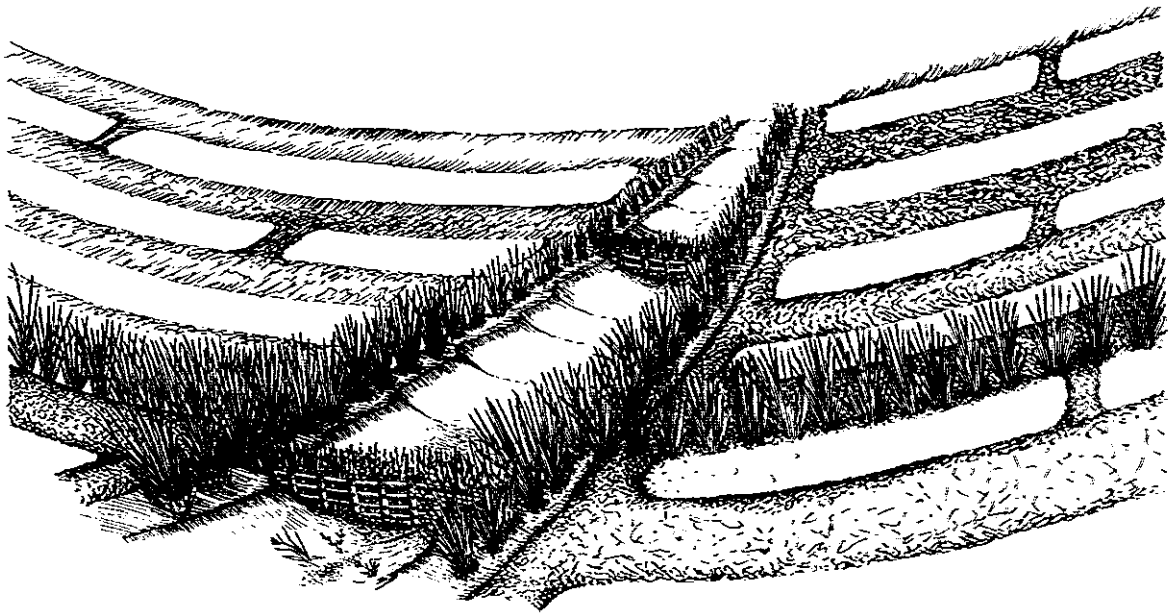


Figure 28: Reduce water flow into gullies with tied ridges, check dams, and vetiver on the sides

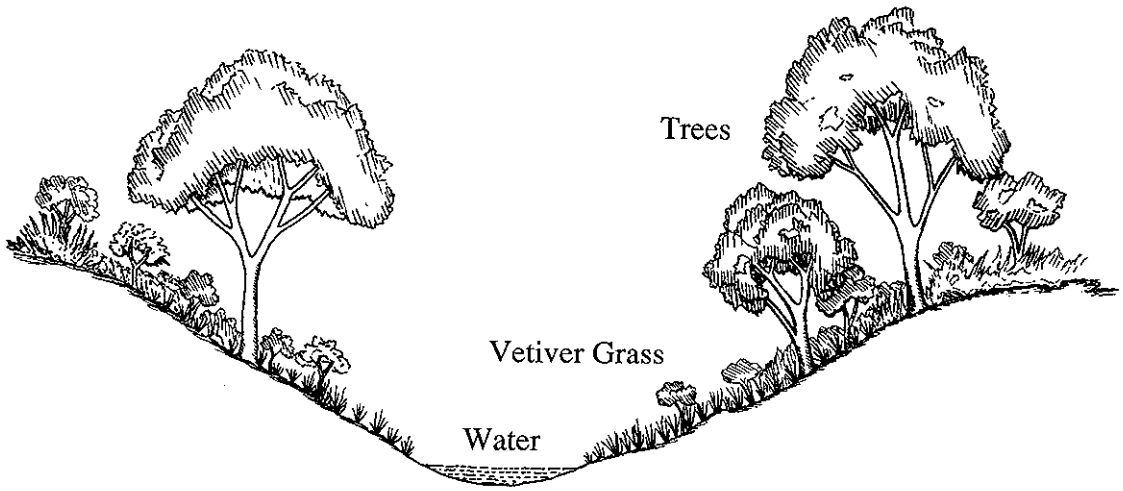


Figure 29: Protecting streambanks with planted grass and trees

STREAM BANK PROTECTION

Stream banks are the most vulnerable land areas in Malawi. They have long been cultivated due to fertility from sediments deposited by regular flooding. Despite this, stream bank soils typically have low cohesion and hence are prone to degradation. Protection is vital to stabilize stream flow and to reduce the risk of flooding, siltation, land slides and loss of arable land (see **Fig. 29**).

Prevention is the simplest and best form of protection. Ideally, stream banks should not be cultivated but left with natural vegetation, which provides better and more permanent protection than physical structures. Planting vegetation is a good alternative where land has been cleared for cultivation or other reasons.

Establishment of vegetation:

1. Demarcate a strip to cover both banks of the stream channel. The width depends on the size of the stream, e.g., 5 m for small streams; 15-30 m on the upper reaches of bigger rivers, and 30-40m further down stream.

2. **Grasses:** Plant vetiver, napier or bamboo inside the strips. Space vetiver and napier at 0.45 x 0.45 m, and bamboo at 1 x 1 m.

3. **Shrubs:** *Sesbania sesban* is ideal at a spacing of 1 m x 1 m.

4. **Trees:** Planting is recommended in strips at 2 x 2 m. Species recommended include: *Acacia galpinii*, *A. polyacantha*, *A. seiberiana*, *Faidherbia albida*, *Ficus natalensis*, *F. capensis*, *F. sycomorus*, *Khaya nyasica*, *Rauvolfia caffra*, *Syzygium cordatum*, *Trichilia emetica*, *Ziziphus abyssinica*, *Z. mauritiana* and *Z. mucronata*.

NOTE: Where trees and shrubs are used, leave a 1 m strip on each side of the channel for grass regeneration to increase surface roughness for reducing water run-off.

Timeframe of Key Activites

June-October:

1. Select a suitable tool for marking contour lines and set it up for correct use in the field. Then mark/peg and ridge all contour lines at intervals based on the slope of the field.

2. Re-align planting ridges to the marker ridges.

3. Build tied and box ridges, and raise footpaths and boundaries where needed.

4. Identify gullies that need reclamation, and build the check dams.

5. Organize production of nursery seedlings for planned stream bank protection.

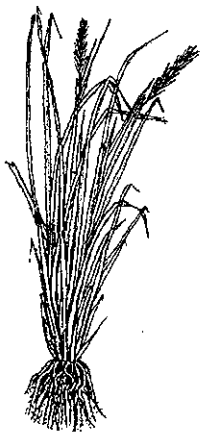
November-January:

1. Collect vetiver material for planting along gully banks, as well as across gullies above check dams to reinforce their effectiveness.

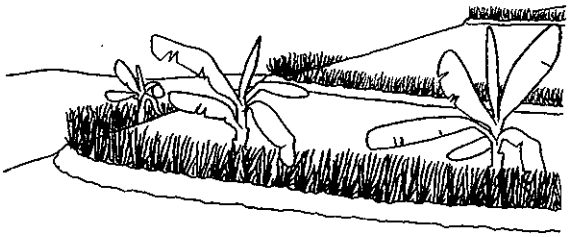
2. Plant selected tree seedlings and grasses in identified areas to protect stream banks.

CONTOUR VEGETATION STRIPS

Erosion and runoff from deforestation, overgrazing, fires, and poor agronomic practices are serious threats to the environment and agricultural production. Planting perennial bunch grasses on the contour provides a good barrier against erosion and runoff. With proper spacing and management, natural terraces form between the contour hedges through soil accumulation on the upper side of the hedge. Contour hedges also slow down and retain water that would otherwise be lost through surface run-off. Multi-purpose trees or shrubs may be planted above the hedges.



Vetiveria zizanioides



Hillside with contour vetiver hedges and bananas

Recommended Species

The main grasses used are vetiver (*Vetiveria* spp.) and napier (*Pennisetum purpureum*). Two species of vetiver are found in Malawi. *Vetiveria nigritana* occurs naturally in the Shire Valley, and has been planted around farmers' fields. The other is *Vetiveria zizanioides*, which is now available in many parts of Malawi from initiatives of government programs, NGOs and several estates. Both are fast growing, deep-rooted perennial grasses well adapted to all agro-ecological zones in Malawi. They are not competitive with crops and are not known to host pests and diseases of concern to agriculture. Vetiver seed has low viability, so there is little chance of it becoming a weed. It is easy to establish and maintain, and it makes good thatching, mulch, and bedding material for livestock. *V. zizanioides* is preferred over *V. nigritana* because it grows faster, forms a denser and more leafy hedge, and is less susceptible to termite attack.

Napier grass is a tall, thick-stemmed perennial growing to 4 m in height. It is also widely adaptable, but grows best in areas with rainfall over 1000 mm/annum. Napier is commonly used as a fodder for cattle. It grows taller than vetiver but is not as effective for soil moisture conservation. Napier tends to spread and compete more with crops, so it requires more trimming.

NOTE: Grass hedges are used to reduce runoff and erosion; they are NOT designed to stabilise marker ridges which are simply guides to re-align planting ridges on contour.

Sources of planting material: This is best collected from nurseries established for this purpose (see **Vetiver Nurseries** below). Material may also be collected from the edges and sides of well established hedgerows, but make sure the hedge is left intact with no gaps to allow full recovery (see details later).

Vetiver Nurseries

Due to the short supply of vetiver, encourage communities and individuals to establish local nurseries near planting sites before planting hedges in fields. Small nurseries are easier to manage and maintain, and should be based on farmer demands to avoid confusing the value of vetiver with monetary incentives. This is in line with LRCD policy.

Establish nurseries as follows:

1. Choose dambos as the best nursery sites.
2. Collect enough clumps for the planned nursery. A 7 ton truckload will plant 0.5 ha.
3. Plant slips 45 x 45 cm apart and press the soil firmly around each; if farmers wish to intercrop beans or cowpeas on the ridges, plant slips in the furrow 90 x 45 cm. Competition will be low as the vetiver is newly planted or regenerating.
4. Trim vetiver to 30 cm tall in May/June and again in December or January to promote tillering and fast growth.
5. Plant early in suitable sites so that material can be collected after one season.

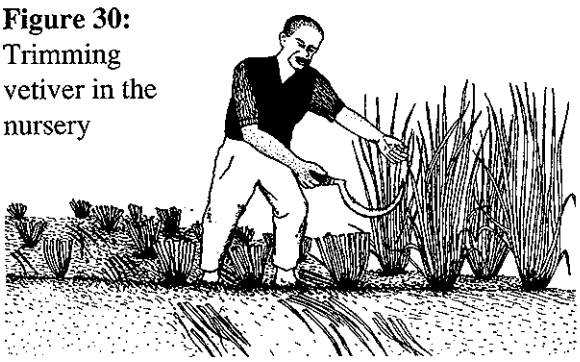


Figure 30: Trimming vetiver in the nursery

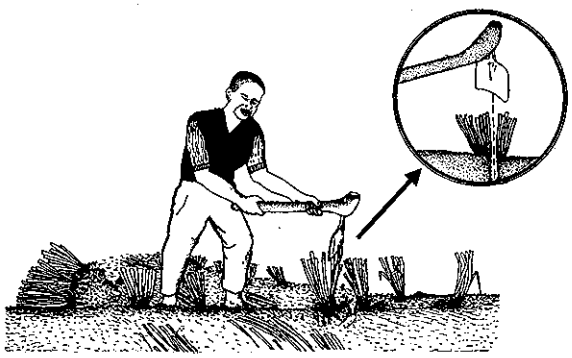


Figure 31: Digging clumps in the nursery

Figure 32: Trimming clumps and making splits

Preparing vetiver slips for planting:

1. Collect planting material from healthy, established clumps after the rains start.

2. Trim to 30 cm before digging up **(Fig. 30)**.

3. Make vertical cuts to dig out clumps with roots but leave 30% of each clump for nursery regeneration **(Fig. 31)**.

4. Plant within **48 hours** of collection. Keep clumps upright in shade and away from wind. If planting is delayed, water collected material so it does not dry out.

5. Trim leaves of clumps to 15 cm to reduce transpiration and to encourage tillering; then divide them into slips each with 3-4 tillers and 5-10 cm of roots **(Fig. 32)**. The slips are now ready for planting in nurseries or as contour hedges. Use larger slips with 5-10 tillers for planting inside gullies.

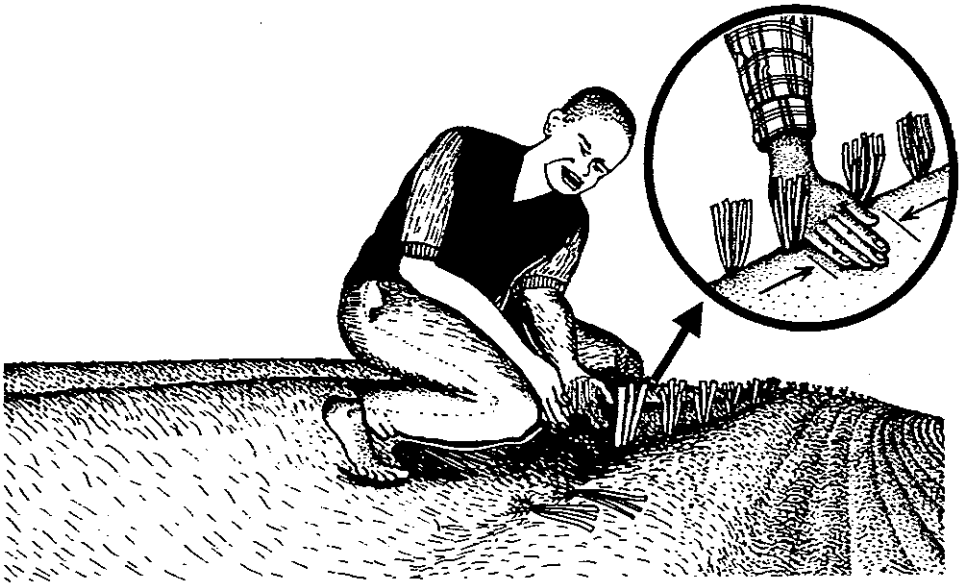


Figure 33: Planting vetiver on the contour

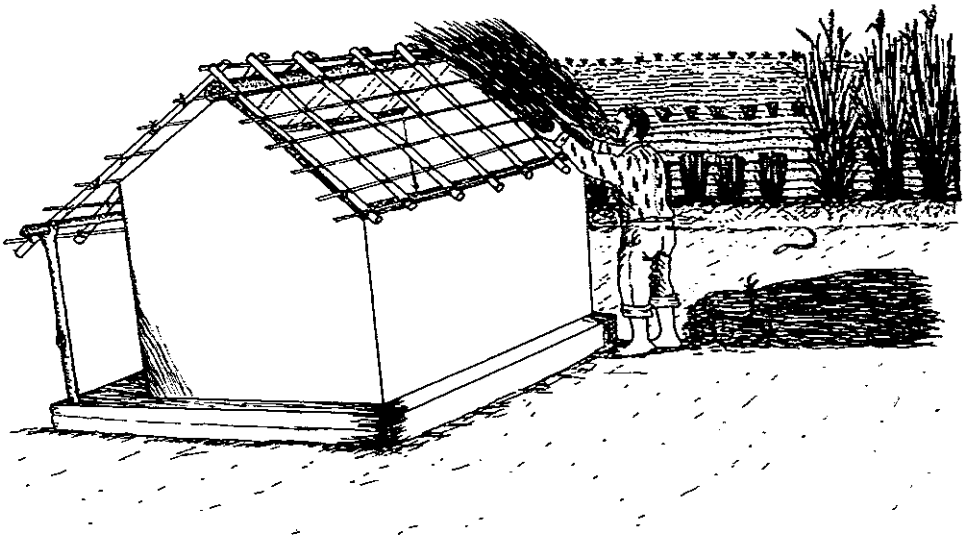


Figure 34: Using trimmed vetiver grass as thatching material

A well-weeded individual vetiver nursery recently established.

A well established 0.1 ha nursery provides material to plant 50,000 slips or 5 km of hedges.

A well established contour hedge of vetiver grass with contour ridging before planting time.

A well established contour vetiver hedge with crops in the field.

How to estimate planting needs:

No. of clumps per ha of nursery = 50,000
No. of slips per clump = 10
No. of slips per ha of nursery = 500,000
No. of slips per 100 m hedge = 1000
No. slips/ha needed for different slopes:
Steep = 20 hedges x 1000 slips = 20,000
Medium = 10 hedges x 1000 slips = 10,000
Gentle = 7 hedges x 1000 slips = 7,000

Thus, a well established 1 ha nursery will conserve about 25 ha on steep slopes (500,000 / 20,000), 50 ha on medium slopes and 70 ha on gentle slopes.

Planting contour vetiver hedges:

1. Plant vetiver on the contour at 5 m intervals on steep slopes, 10 m on medium slopes and 15 m on gentle slopes. **Note:** Hedges need not coincide with marker ridges which are used only to guide ridge re-alignment.

2. Plant slips in the furrows. Space each slip a hand width apart (10 cm) in wet soil after the rains start (**Fig. 33**). Press firmly around each slip with its flat side perpendicular to the slope (facing downwards) to encourage dense lateral growth which minimises gaps in the hedge.

3. Fill any gaps early in the season (see **Plugging Gaps** below).

4. Multi-purpose trees or shrubs (e.g., msangu, mthethe, nkunkhu, fruit trees, *Tephrosia* or pigeon peas) may be planted 1-2 m above and parallel to vetiver hedges (see **Contour Tree Lines** below).

5. After good establishment, trim hedges to 30 cm in May/June and again in December/January to encourage dense growth.

6. Use trimmings for thatching, mulch or bedding for livestock (see **Fig. 34**).

Plugging Gaps in Vetiver Hedges

Gaps in hedges need to be filled in to prevent erosion problems from water movement through the gaps. Do this by following the steps below:

1. Choose a wet day and prepare enough planting slips to fill in the gaps.

Plugging a gap in a contour vetiver hedge

2. Trim the vetiver edges of the gap, then dig a trench 20 cm deep across the entire gap.

3. Plant the slips in the trench 10 cm apart beginning at the edges of the gap.

4. Firm the soil around the slips, then water and mulch to encourage good establishment.

Planting Napier Grass

Napier is established from stem or root cuttings as it produces little viable seed. The main varieties are Gold Coast, Cameroon, and Congo. All are established as follows:

1. Collect fresh material by digging up healthy plants as done for vetiver grass. Cuttings should be 20-30 cm long with 4-5 nodes.

Coffee bushes planted along well established vetiver hedges

Faidherbia albida *tree line planted along a trimmed contour vetiver hedge soon after maize planting*

2. Push stem cuttings into the soil at a 45 degree angle with at least 2 nodes buried. Space them 20 cm apart in contour lines.

3. Plant root cuttings to a depth of 8 - 10 cm and compact the soil around the roots. Use the same spacing as for stem cuttings.

4. Fill any gaps early in the season.

5. After good establishment, trim the grass to 40 cm to encourage tillering. If the plants are not well established, wait until the onset of the next rainy season. Napier grass needs to be trimmed frequently to avoid shading and competition. The trimmed material may be used as fodder.

Contour Tree Lines

Farmers may choose whether shrubs or trees are preferable for their contour strips. Leguminous shrubs such as *Tephrosia vogelii* and *Sesbania sesban* provide fuelwood, green manure and/or fodder. *Cajanus cajan* also provides useful food. These species may be planted 45 cm apart 90 cm above each strip, but will need replanting every 2-5 years as they are short-lived plants. Fruit trees provide valuable nutrition or income to the household. Consult local extension staff on recommended varieties that are resistant to common diseases. If bananas are used, plant 90 cm above and parallel to the grass strip, with plants 2 m apart. Plant other fruit trees at 4 m intervals along the upper side of each strip, or along alternate strips.

Other multi-purpose trees may be grown in the same manner such as *Acacia polyacantha, Albizia lebbeck, Faidherbia albida, Gliricidia sepium* and *Leucaena diversifolia*. All provide useful fodder, although pods from *F. albida* will not develop until the tree is 10 years old. Feed wilted or sun-dried *Gliricidia* leaves only to ruminant livestock.

Management of Tree Lines: Prune tree lines to reduce competition with crops, and to provide green manure, fuelwood or fodder. Prune at the start of the second growing season if trees are greater than 1 meter so that they are big enough to recover from pruning. Prune branches with a clean, upward slanting cut to minimise damage to the trees. During the growing season, prune trees whenever shading or competition become a risk. Branches may be used for fuel, and leaves as green manure or fodder, depending on the species.

Availability of Planting Material

Consult your local extension staff for assistance on sources of *Vetiveria nigritana* and *V. zizanioides*. Napier grass is generally available locally.

For tree material, see Chapter 3, or contact your local agricultural or forestry extension agent.

Timeframe of Key Activites

July-October: Identify the size and location of planting sites for nurseries and contour hedgerows.

November-January:

1. Collect sufficient planting material from identified sources, then prepare it for immediate planting in the selected sites, or to fill any gaps in existing hedgerows.

2. Trim established hedges to a height of 30 cm to promote tillering for a denser hedge.

February-March: If the owner has no intention of using or selling the cut grass for thatching or other purposes, trim hedges again to 30 cm tall to reduce shading effects on nearby crops, and to promote further tillering.

April-June: Trim hedges after the crop harvest for thatching, mulch or other uses.

CHAPTER 4 QUESTIONS: SOIL & WATER CONSERVATION

1. In smoothing a pegged contour line, do you start at the beginning or end of the line? Explain your answer.

2. What is the function of a contour marker ridge?

3. How do you re-align crop ridges between 2 marker ridges, and why is it done in this way?

4. In a field with a medium slope, the interval between marker ridges is 15 meters. What should be the interval between vetiver hedgerows in the same field?

5. Where do you plant vetiver hedgerows in a field; aligned on the contour, on top of the ridge, in the furrow, or on the side? Explain your answer.

6. How many vetiver slips are needed to plant 1 ha of hedgerows spaced 10 m apart.

7. Identify three factors that may lead to gully formation?

8. What is the best way to avoid streambank erosion?

(For correct answers refer to Page 249 in the annex)

INTRODUCTION

Agroforestry shows high potential as a complementary, low-cost approach to sustain agricultural production and reduce environmental degradation. Its universal appeal lies in the multi-purpose functions of trees, where farmers actively participate in identifying practices and species best suited to their needs.

Research on certain forms of tree intercropping and improved fallows shows that maize yields can improve by 50-200%, and that supplemental chemical fertilizers can boost yields further by 50-100% (Bunderson and Hayes 1995; Bunderson et al., 1991, 1994; Hayes 1991; 1995; 1999; Hayes et al., 1997; ICRAF 1994; Jones et al., 1993; Kwesiga et al., 1994; 1995; Leach 1994; Saka et al., 1994, 1995; Simler 1992). Many agroforestry practices also supply essential organic matter and other nutrients such as Mg, K, Ca, and S (Jones et al., 1996; Wendt et al., 1996). These nutrients can be limiting under the common practice of continuous monocropping in Malawi, which has implications for the current policy of importing high-analysis N and P fertilisers.

Most agroforestry practices provide complementary effects on soil and water conservation by improving soil structure and providing denser ground cover. They also offer secondary products such as fuelwood, food, quality fodder, and shade. Certain agroforestry species are also reputed to decrease infestation by *Striga*, a common parasitic weed of cereal and legume crops in Africa.

BEST-BET PRACTICES

The first section of this chapter focuses on practices and species that have proved popular, easy to manage and beneficial to farmers. They include **1) dispersed systematic tree interplanting; 2) regeneration of natural soil-improving trees; 3) annual undersowing; and 4) improved fallows.**

Other practices that have produced good yield responses but which have low potential for adoption due to high labor and management costs are described later in the chapter. These include **1) alley cropping, 2) mixed tree intercropping, and 3) green manure banks.**

DISPERSED SYSTEMATIC INTERPLANTING

Purpose and Recommended Species

Most farmers in Malawi retain or plant trees on their farms for a variety of reasons - fuelwood, poles, fruits, fodder, soil fertility, medicines, and various cultural uses. However, supplies of these products are dwindling from rising pressures on the natural resource base. Dispersed systematic interplanting involves planting certain types of trees with crops at a wide spacing (see **Figure 35**) for a range of different uses and products:

- To improve soil fertility and crop yields
- To supply fuel, building material, fodder and other products for use or sale.

Faidherbia albida (msangu) is the tree most commonly recommended for this practice, but *Acacia polyacantha* (mthethe) and *A. galpinii* (nkunkhu) are also valuable. All are large, fast-growing leguminous trees, indigenous to Malawi, and well adapted to a wide range of habitats. They have multiple uses, and are easy to raise from seed, sources of which are abundant and easy to collect.

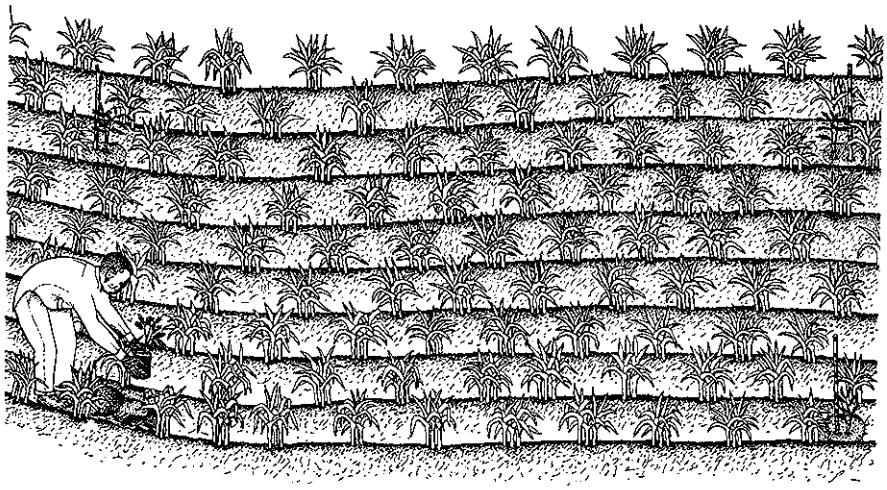
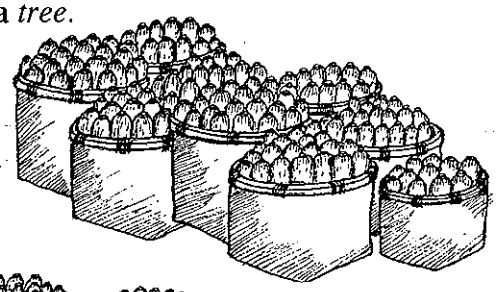


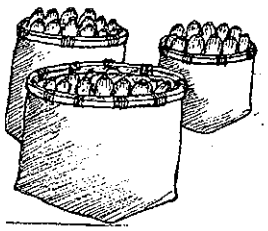
Figure 35: Systematically interplanting and marking young ***Faidherbia albida*** seedlings at 10 x 5 m

Traditional cultivation under **Faidherbia albida** *(note the vigorous, green maize under the canopy).*

Systematic tree inter-planting of **Faidherbia albida** *with a healthy stand of beans.*

Relative maize yields with a **Faidherbia albida** *tree.*





And without a **Faidherbia albida** *tree.*

Planting trees in a wide but systematic manner provides uniform coverage of the area, and facilitates farm operations including use of ox-drawn implements. This practice is popular with smallholders because it builds upon traditional agroforestry practices to sustain farm productivity over the long term, while providing other useful tree products to meet different farmer needs.

Note on *Faidherbia albida* Trees

This tree is particularly beneficial for soils and crops from its unique feature of dropping nutrient-rich leaves by the start of the rains. Its bare canopy and leaf fall at this time offer light and soil conditions ideal for good crop growth. Farmers in Malawi and elsewhere in Africa have maintained crop yields beneath *Faidherbia albida* trees for long periods without adding fertilizers. Maize production under mature trees is commonly 50% to 250% higher than outside the canopy (Saka et.al., 1994). Variation in yield depends on the crop variety and husbandry practices used, particularly early planting and weeding. *Faidherbia albida* also has other uses including fuelwood and building material, shade during the hot dry season, and high quality fodder from its abundant yields of nutritious pods.

Nursery Production and Outplanting

Follow the instructions in Chapter 3 on Tree Propagation and Outplanting which gives details on preparing planting pits, time and method of outplanting, and measures to improve seedling survival and growth. This will ensure that healthy seedlings are raised and ready to outplant with the start of the rains. Nursery stock is recommended for all 3 species. Direct sowing is strongly discouraged due to poor field results.

Comparison of one month old **Faidherbia albida** *air-pruned seedlings raised in small (at top) vs. large open-ended containers (bottom)*

Three-year old **Faidherbia albida** *trees planted at a spacing of 10 x 5 m*

Systematic Interplanting of **Faidherbia albida** *with cotton (12 year old stand)*

NOTE:

1. Since *Faidherbia albida* seedlings are sensitive to root pruning, raise seedlings off the ground on platforms made of wood and reeds or bamboo (see Chapter 3). This eliminates damage from the need to root prune. Use medium to large open-ended tubes, i.e., 25 cm tall x 20 cm wide.

2. First season growth is better when planted with short coprs like soya beans or ground nuts relative to maize or tobacco.

Spacing of Outplanted Seedlings

A spacing of 10 x 5 m with 200 seedlings/ha is recommended to help ensure an adequate density of healthy surviving trees. It also provides a faster benefit to the crop when the trees are still young.

Thinning

Use the regime below to thin trees as they grow in size to prevent crowding and to supply wood and fodder.

Thinning Regime after Initial Planting

Tree Canopy Radius	Recommended Spacing	Recommended Density
3 meters	10 x 5 m	200 trees / ha
5 meters	10 x 10 m	100 trees / ha
8 meters	10 x 20 m	50 trees / ha
> 10 meters	20 x 20 m	25 trees / ha

Timeframe of Key Activities

August - November: Prepare nursery, collect inputs and raise seedlings; identify outplanting sites and dig pits in the field at the right spacing. Remember to use air-pruned seedlings for *Faidherbia albida* in 20 x 15 cm open ended containers.

November - January: Outplant seedlings in wet soil with the rains; use a stake to clearly mark each seedling to reduce losses from accidental weeding and trampling.

January - Onwards: Keep seedlings well weeded with the crop and protect them from animals and fire during the dry season.

April - October: Prune lower branches to encourage an upright growth form and to reduce interference with field operations. Do this in April/May for *F. albida* and September/October for the other species.

Availability of Planting Material

See Chapter 3, or contact your local agricultural extension agent.

REGENERATION OF NATURAL TREES

Encourage farmers to protect naturally regenerating trees in their fields. This is the **easiest** agroforestry system to adopt as it requires no tree nurseries or outplanting, and the trees are already adapted to the area.

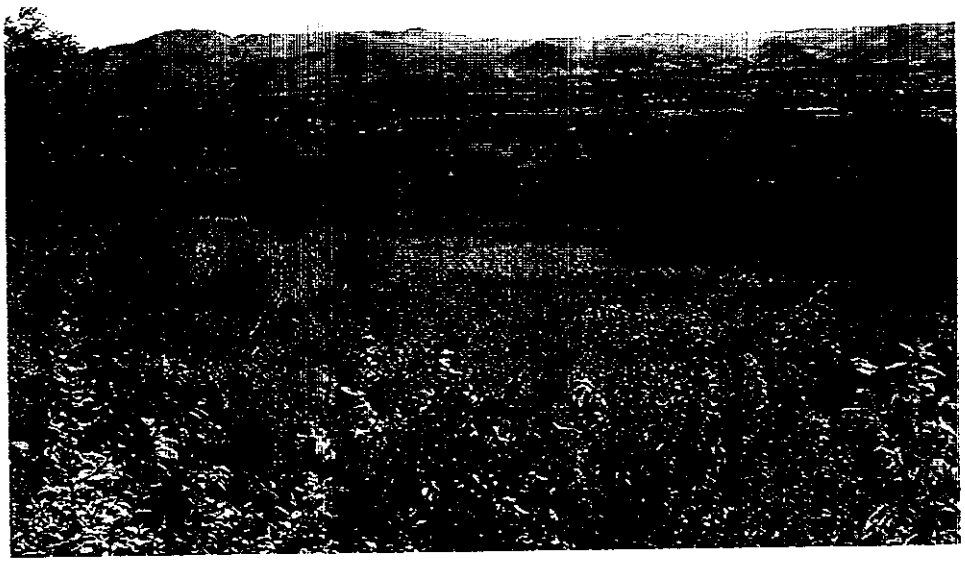
Recommended Species

Choice of species depends on individual farmer preferences. Soil improving leguminous trees are recommended as this is the primary aim. Suitable species include *Acacia galpinii, A. nigrescens, A. polyacantha, A. tortilis, Albizia versicolor, Bauhinia thonningii, Brachystegia spiciformis, Erythrina abyssinica, Faidherbia albida, Lonchocarpus capassa, Pericopsis angolensis* and *Pterocarpus angolensis.* Non-leguminous trees are also retained on cropland by farmers for a variety of uses, although their effect on soil fertility is lower. Common species include *Annona senegalensis, Azanza garkeana, Combretum* spp., *Ficus natalensis, Kigelia africana, Melia azedarach, Sclerocarya birrea, Terminalia sericea, Uapaca kirkiana* and *Ziziphus mauritiana.*

Management

Natural trees need care from weeds, fires and animals just like planted ones. As they grow in size, they also need attention to minimize shade effects on crops, and to supply wood and other products desired by the household. Follow the pruning practices specified above for healthier, straighter growing trees, taking care to avoid over-pruning which retards the ability of trees to regenerate.

Naturally regenerating **Faidherbia albida** *trees*

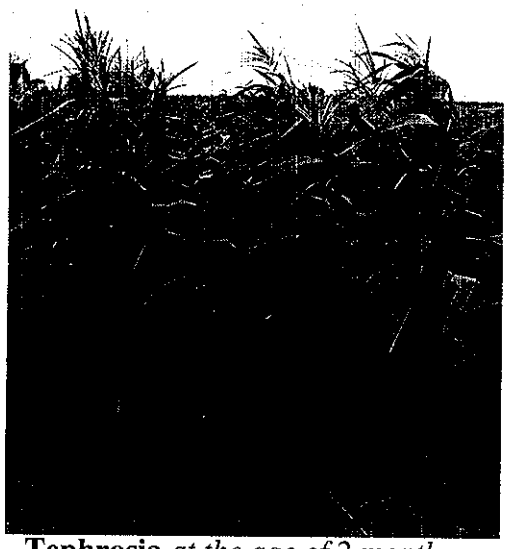


Natural trees protected in a farmer's field.

ANNUAL UNDERSOWING

Purpose

This technology aims to restore crop productivity by improving the chemical, physical, and biological properties of the soil with fast growing, nitrogen fixing shrubs. It entails intercropping the shrub with maize when the rains start, followed by harvesting it just before land preparation at the start of the next rains. This practice continues every year.



Tephrosia *at the age of 2 months planted at the same time as maize*

Key benefits of *Undersowing* include:

- Fast restoration of soil fertility and structure from high biomass yields. Deep roots help break through hardpans to improve water infiltration and root development in crops.
- Soil and water conservation from good vegetative cover and litter combined with suppression of weeds, *Striga* and termites.
- Abundant fuelwood, although of low quality.
- Prolific seeding to meet growing demands for this practice.

Recommended Species

Tephrosia vogelii shows the best potential because it is easy to establish and manage, is similar to intercropping with pigeon peas and gives a better crop response. *Tephrosia* is also used in controlling pests such as stem borers, aphids, leaf eaters, and fleas. A simple recipe is to crush 2 kg of fresh leaves, soak them in water for 12 hours away from sunlight, then filter off the solution for use as a spray. Crushed leaves mixed in granaries are also effective against weevils.

Other species used include *Cajanus cajan* and *Sesbania sesban*. *Cajanus* has value

as a food crop, but effects on soil fertility are less dramatic. Limitations of *Sesbania* are poor germination from direct sowing and damage by goats and leaf-eating pests. *Crotalaria* species also show promise but more research is needed before making recommendations.

Caution: Since *Cajanus, Sesbania* and *Tephrosia* are host to root-knot nematodes, do not undersow them in rotation with crops susceptible to nematode attack like tobacco.

Time and Method of Sowing

Sow seed directly into the top of every ridge with the start of the rains on **the same day** as crop planting. Do not plant *Tephrosia* in furrows as it is susceptible to waterlogging.

NOTE: The species recommended do not compete with crops because of their slower development. Failure to plant early limits the length of the season for good establishment and growth. It also makes the shrubs vulnerable to competition from the crop, as well as to pests

Planting **Tephrosia** *at the same time as maize.*

Tephrosia *at the age of 6 weeks planted at the same time as maize*

Tephrosia *in the 1st season at maize maturity*

and diseases. This may make it necessary to retain the trees as a fallow in the 2nd season to produce adequate biomass (see **Improved Fallows** below).

Seed rate with 10% to fill gaps:

Cajanus:	7.5 kg/ha
Sesbania:	2 kg/ha
Tephrosia:	5 kg/ha

Seed depth and number:

Cajanus/Tephrosia: 1.5-2 cm, 3 seeds/station.
Sesbania: 1 cm, 5-8 seeds/station.

NOTE: Planting too deep will limit germination.

Spacing for direct sowing: With maize on ridges 75 - 90 cm apart and 90 cm within the row, sow 2 stations 30 cm apart between maize stations on every ridge:

```
                x o o x o o x o o x
75-90 cm  |
                x o o x o o x o o x

                x maize    o Tree species
```

Do not undersow at closer spacings of maize (e.g., 75 x 25 cm) as the high crop population is too competitive for the shrub.

Undersowing **Tephrosia** *can more than double average farm maize yields of 1 ton/ha by the 3rd season (see maize control at left vs. maize after undersowing at right)*

parties. Another option is to maintain plants on the perimeter of their undersown plots for seed.

Seed Supply and Cost

Sesbania and *Tephrosia* seed is short in supply, so their wise use is critical. Farmers presently sell *Tephrosia* seed to Projects and NGOs at MK15/kg. This excludes packaging, storage, transport and supervision, which would raise the seed price to MK30/kg. *Sesbania* seed is 4 times this cost.

Timeframe of Key Activities

November - December: Undersow (intercrop) shrubs at the start of the rains on the **same day** as planting the crop; plant on the top of every ridge at the correct spacing and depth for good establishment. Continue this practice annually.

May - September: Leave shrubs to continue growing after the crop harvest.

October - November: Collect seed, then cut shrubs down at ground level. Bury leaf biomass in the ridges, or lightly cover with soil to avoid loss of quality. Always remove woody stems.

Availability of Planting Material

See information contained in **Chapter 3**, or contact your local extension agent.

IMPROVED FALLOWS

Purpose

Improved fallows of fast-growing trees speed up soil restoration, and yield secondary products. The best species are those that fix nitrogen and that provide good ground cover. Improved fallows generally produce a higher crop response than other agroforestry systems because of the higher biomass generated.The drawback is the need for larger land holdings and loss of crop production during the fallow period. These are important factors limiting adoption among farmers in Malawi.

Improved fallows may be short or long term, and may be combined with other practices on the same land, e.g., boundary planting and vetiver hedges. Both types of fallows require targeting farmers who have adequate land to to fallow, or to leave idle in the following season.

FALLOWS WITH SHORT-LIVED SHRUBS

First Year

Intercrop fast-growing shrubs with maize when the rains start so that trees can be established on the same land with little extra labor.

Recommended species: *Tephrosia vogelii* has proved the most successful, but *Cajanus cajan* and *Sesbania sesban* may also be used.

Establishment of *Cajanus* and *Tephrosia:* Direct sow on every ridge with 3 seeds per station. For maize on ridges 75-90 cm apart and 90 cm within the row, sow 2 stations 30 cm apart between maize stations on every ridge:

```
75-90 cm | x o  o x o  o x o  o x
         |
         | x o  o x o  o x o  o x
```

x maize o *Tephrosia* or *Cajanus*

Establishment of *Sesbania:* *Sesbania* is best grown from bare-root seedlings on every ridge between maize stations. For maize 90 cm apart, outplant one seedling between each station:

```
75-90 cm | x o x o x o x o x
         |
         | x o x o x o x o x
```

x maize o *Sesbania*

If direct sowing is attempted with *Sesbania*, plant 5-8 seeds per station between maize as shown for *Tephrosia* and *Cajanus* above. Sow the seed at a depth of 1 cm.

Second Year

Abandon cultivation after the first year, leaving the trees as a fallow for the 2nd season to restore soil fertility from the high biomass of foliage and roots. With good establishment in the first year, weeding the fallow is often not necessary. Before cultivation resumes, cut the shrubs down at ground level during land preparation, and bury the leaves when dry enough to shake off. Collect woody material for fuel or ties.

Third and Fourth Years

Resume annual crop cultivation during the 3rd year with much improved yields. Then repeat the whole cycle in the 4th year starting with the undersowing phase. Although cropland is lost for 1 season during the fallow

Tephrosia *fallow at the age of 14 months.*

Collecting wood after cutting down **Tephrosia.**

period, it involves only a small amount of land. Gains in crop yields, wood and seed sales will compensate for this loss.

Timeframe of Key Activities

Year 1:

November - December: Undersow (inter-crop) shrubs with maize on the top of every ridge at the start of the rains; plant at the correct depth for good germination.

May - October: Leave shrubs to continue growing after the crop harvest.

Year 2:

November - October: Keep the shrubs as a fallow for the next full season. Collect seed, then cut the shrubs down at ground level. Bury leaf biomass in the ridges, or lightly cover with soil to avoid loss of quality. Always remove woody stems.

Year 3:

November - May: Resume crop cultivation.

Year 4:

November - October: Undersow as in the first year, and repeat the whole cycle.

FALLOWS WITH LONG-LIVED TREES

Larger and longer-lived trees may also be used in fallows to improve soil fertility. Soil improvement may take longer because the trees are slower growing, but they offer better quality wood and a greater range of products.

Recommended Species

Soil-improving leguminous species are recommended including *Acacia galpinii, A. nigrescens A. polyacantha, Albizia lebbeck, A. versicolor, Bauhinia thonningii, Erythrina abyssinica, Gliricidia sepium,* and *Leucaena diversifolia.* If wood is a higher priority, *Azadirachta indica, Senna siamea, S. spectabilis* and *Toona ciliata* may be used.

Years 1 and 2

Interplant crops with the trees for the first 1-2 years as there will be little or no competition while they are still young. This makes good use of land, and guarantees weed-free conditions for good tree growth.

Young pigeon pea crop, doubling as a short-term fallow.

Sesbania sesban *fallow after 2 seasons of growth.*

Year 3 and Beyond

Leave the trees to grow until fertility is restored, or until they reach a size for harvesting the desired wood products. Cultivation may resume after removing the trees, or while allowing them to regenerate after pollarding or coppicing. Some trees may need to be thinned out, wood from which may be used for fuel, building purposes, or for sale.

Tree Spacing

Space trees 1.8 x 1.8 m apart.

Availability of Planting Material

See information contained in **Chapter 3**, or contact your local extension agent.

OTHER PRACTICES

This section describes other practices that have produced good results on soil fertility and crop yields, but which are not being widely adopted because of their complexity and management-intensive needs. Promoting these practices should be limited to programs which are capable of targeting farmers with the interest and resources to adopt the technology.

ALLEY CROPPING AND MIXED TREE INTERCROPPING

Purpose and Uses

These two practices are combined here because of their close similarity in terms of establishment and management, and both involve cultivating annual crops between rows of woody plants. The difference is the spacing arrangement. Alley cropping involves planting hedgerows 4-5 m apart with 45-90 cm between plants. Mixed tree intercropping has rows 1.8 m apart and an interplant spacing of 0.9 m.

The major aim of the two practices is to improve soil fertility and crop yields. They also complement chemical fertilizers

to reduce costs and rates used. Hedges are pruned two or three times during the year to minimize shading and competition, and to provide leaf biomass for soil fertility, weed suppression and soil conservation. Pruned branches make useful fuelwood or racks for drying crops. The foliage of some species is good fodder.

MAFE's recommendations below have been refined after 8 years of field experience.

Recommended Species

Species recommended are *Gliricidia sepium, Leucaena diversifolia, Senna spectabilis,* and *Tephrosia vogelii.* All are fast-growing, high yielding leguminous species with nutrient-rich foliage. Choice of species depends on the environment and products desired (see **Table 5 on page 133**). *Tephrosia* is shorter-lived than the other species, but it is faster growing, and can be direct sown.

Direct Sowing of *Tephrosia*

Direct sowing greatly reduces costs of raising and transplanting nursery seedlings, but only *Tephrosia* has proved consistently successful.

Sowing time and depth: Sow seeds at the same time as the crop to a depth of 1.5 to 2 cm with 3 seeds/station.

Seed rate: Both practices require a seed rate of 1.2 kg/ha for maize spaced 90 x 90 cm.

Spacing for alley cropping: Sow on the top of every 4th ridge. For maize spaced 90 cm apart, sow 2 stations between maize stations.

Spacing for mixed tree intercropping: Sow seeds on the top of every other ridge. For maize spaced 90 cm apart, sow 1 station of *Tephrosia* between maize stations.

NOTE:

1) Alley cropping and mixed intercropping are not recommended for close spacings of maize, e.g., 75 x 25 cm.

2) *Tephrosia* does not compete with crops in the first season due to its slow initial growth. Failure to plant early limits the length of the season for good establishment and growth. It also makes the shrubs vulnerable to competition from the crop, as well as to pests and diseases.

Alley cropping maize with **Tephrosia** *hedges*

Small holder alley cropping of maize with **Leucaena** *hedges to improve soil fertility.*

Establishment with Nursery Seedlings

Use nursery seedlings for *Gliricidia, Leucaena* and *Senna* since direct sowing gives poor results. Plant seedlings at the start of the rains, or right after planting the crop. The spacing for each system is specified below.

Inter-row Spacing:

- Every 5th furrow for Alley Cropping
- Every other furrow for Mixed Intercropping

Within Row Spacing: 90 cm apart for both practices.

NOTE: Count ridges when deciding where to plant hedges, but ignore marker ridges and vetiver strips.

Number of Seedlings Needed:
2,500 seedlings/ha for Alley Cropping
6,200 seedlings/ha for Mixed Intercropping

Management during the 1st Year

This section applies to both alley cropping and mixed tree intercropping.

Planting: Plant hedges early otherwise the taller and faster growing crops may retard hedge growth from shade and competition. To minimize this risk in year one, plant hedges with short-growing or late planted crops such as groundnuts, soyabeans, cassava, or sweet potatoes. The growth of the young hedges will benefit from weeding and fertilising the crop.

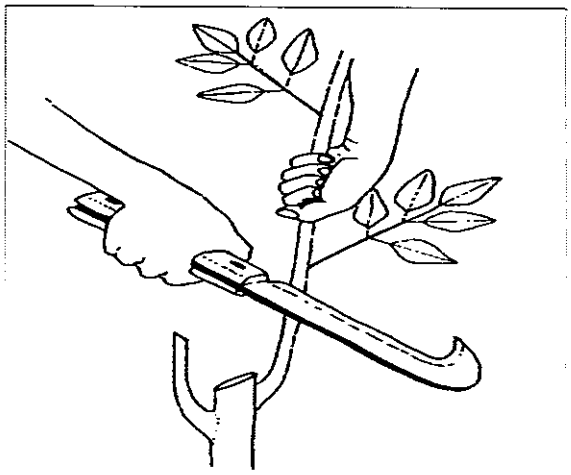
Management: Hedges need protection from browsing animals and trampling. To do this, control animal movements, or establish dead or living fences around the plots (see **Chapter 6**). Hedges may also be marked with stakes to make them more visible so that they are less likely to be mistaken for weeds. Finally, because establishing hedges is labour-intensive, encourage farmers to start small, say 0.05 ha. This may be increased gradually to match the desired target area.

Management from Year 2 onwards

Pruning and Biomass Management: Begin pruning in the second season if hedges are more than 1 metre tall. This indicates sufficient resilience for recovery after pruning. Prune branches with a clean, upward slanting cut **within 2 weeks** of planting the crop. Timing is critical to reduce

shade and competition. The most useful tool for pruning is the tea knife (see illustration). Distribute the fresh prunings in the furrows and along the maize ridges. After the leaves fall off, collect all woody branches for fuelwood or tobacco ties. A mid season pruning is needed only if shading is apparent.

Prune again just after crop harvest. This pruning supplies most of the biomass produced. Distribute the prunings evenly over the furrows, and remove all woody stems after the leaves fall off. Cover the green biomass with soil, or bury it in the ridges with the crop residues. Do this right after pruning to avoid nutrient losses from leaching and exposure to the sun, rain and wind.



Prune hedges with a tea pruning knife.

NOTE: If the biomass is low, concentrate it on half the area, otherwise it may be spread too thinly for the desired impact.

Fertilizer Supplements: Hedges contribute considerable organic matter, nitrogen, potassium, calcium, magnesium, and sulphur. If resources permit, supplemental chemical fertilizers will boost crop yields. During the first 2-3 years, N fertilizer is recommended at 30 kg/ha until the biomass meets the demands of the crop. Use 20-30 kg P/ha every other year in phosphorous deficient soils, since trees return small quantities of P.

Re-Ridging: Rebuild the same ridges each year to maintain the correct spacing and to avoid losing land for crop production.

Timeframe of Key Activities

Year 1:

November - December: Establish the hedgerows at the correct spacing with the start of the rains.

January - May: Allow the hedgerows to grow with the crop for the whole season.

June - October: Protect the hedgerows from livestock and fires.

Year 2 and onwards:

November - December: Prune in the correct manner 2 weeks after planting the crop. Distribute the fresh prunings evenly along all the crop ridges as green manure. After the leaves fall off, remove the stems for fuel or other uses.

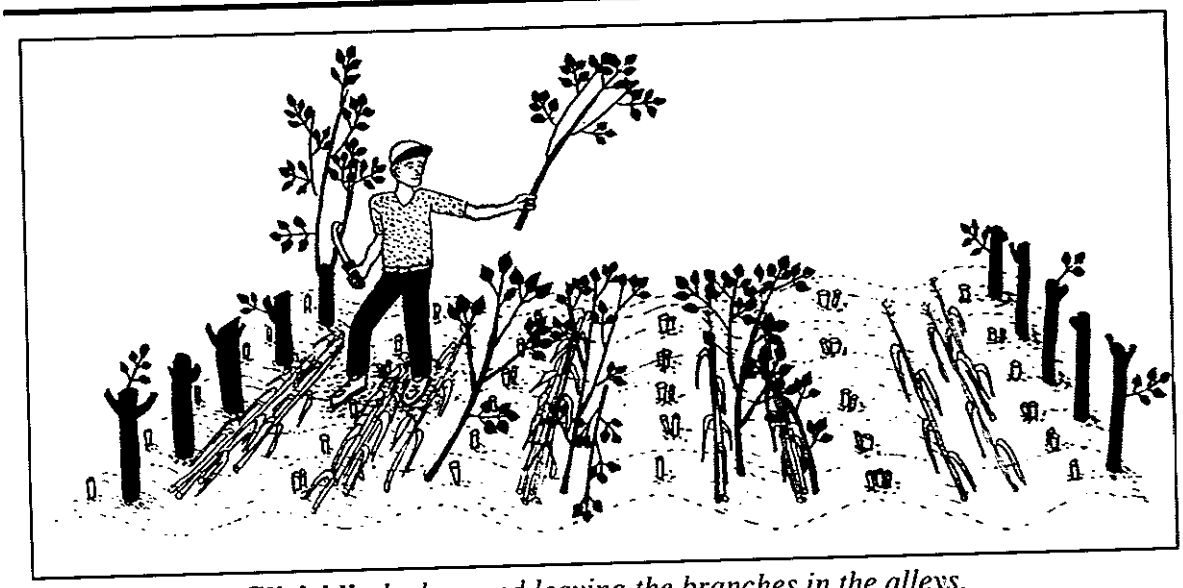
January - February: Prune hedgerows again at mid season **only** if they are shading or competing with the crop. Distribute the prunings as done for the first pruning.

May - June: Prune hedgerows after the crop harvest. Distribute the prunings evenly over the furrows, and cover the leaf material with soil as soon as the leaves fall off after removing the stems. Leaf biomass may also be buried in the ridges with the crop residues. Burying or covering leaves with soil must be done soon after pruning to avoid loss of nutrients.

July - October: Protect the hedgerows from fire and livestock.

Availability of Planting Material

See information contained in **Chapter 3**, or contact your local extension agent.



Above: Pruning **Gliricidia** *hedges and leaving the branches in the alleys.*
Below: Shaking off the leaves, collecting firewood, re-ridging and incorporating the leaves in the soil.

Pruning and application of biomass with crop residues after maize harvest.

Regrowth of **Senna spectabilis** *hedges in the dry season.*

Table 5: Recommended Hedge Species With Characteristics, Uses and Management

	Leucaena diversifolia	*Senna spectabilis*	*Gliricidia sepium*	*Tephrosia vogelii*
Rainfall	500-1500 mm	600-2000 mm	500-1200 mm	800-2000 mm
Soils	basic or neutral fertile soils	most types of neutral to basic soils;	basic or neutral fertile soils	most soil types with no waterlogging
Altitude Range	800-2000 m.a.s.l.	500-2000 m a.s.l.	0-1200 m a.s.l.	500-2000 m.a.s.l.
Life Span	> 10 years	> 10 years	> 10 years	3 to 6 years
Growth Rate	Medium	Medium to fast	Medium	Fast
Biomass Yield	Medium	High	Medium to high	Medium to high
Nutrient Content	High	Medium to High	High	Medium to high
Forage Value	High	None	Good for ruminants but only use dry or wilted leaves	None
Wood & Other Uses	Good fuelwood and small poles	Good fuelwood and small poles	Good fuelwood and small poles	Poor quality wood Foliage used as an insecticide
Soil/Pest & Disease Problems	Adapted to most soils; tolerant of acidic conditions; resistent to psyllid & aphids	Appears affected by acidic soils and certain nutrient deficiencies	Appears affected by acidic soils and certain nutrient deficiencies; some leaf damage from beetles	Prone to root nematodes which could harm current or subsequent crops such as tobacco
Seed Treatment	Nick	Nick	None or nick	None
Direct Sowing	Poor	Poor	Poor	Excellent
Pruning Management				
• *Height*	← 30 to 40 cm →			75 cm. Leave 2 to 3 lateral branches to improve regeneration
• *Method/Tools*	Use a sharp panga or tea pruning knife to make a clean upward slanting cut. Prune secondary or lateral branches 10 to 15 cm from the primary or main stem.			
• *Time and Frequency*	The first pruning is done when the plants are at least 1 metre tall (usually 12 to 18 months of age).Within 2 weeks of planting the crop and again after crop harvest. Prune at mid-season only if the crop shows effects of shade or competition from the hedge.			

GREEN MANURE BANKS

Purpose and Recommended Species

Tree banks may be established for green manure using species such as *Leucaena, Sesbania, Tephrosia, Gliricidia and Senna spectabilis*. The pruned leaves are collected and transferred to cropping areas for use as fertilizer by applying the leaf matter to the soil.

Spacing

Tephrosia: 0.90 x 0.45 m
Gliricidia, Leucaena, Sesbania: 0.9 x 0.9 m
Senna: 1.8 x 1.8 m

Pruning

Prune branches at the start of the growing season to supply fresh leaf material for direct application to the desired crop. Prunings at the end of the rainy season provide

Green manure harvested from **Leucaena diversifolia** *banks.*

the bulk of the biomass produced during the year. After sun-drying the branches for a few days, shake off the leaves and store for use next season. Stems may again be collected for fuelwood or other uses.

Application of Leaf Manure

Bury or apply fresh or dry leaves on the surface around the planting stations within 15 days of crop emergence. Apply leaves at a minimum rate of 1.5 tons/ha or roughly a double handful per station (120g/station).

Once the green manure bank is fully established and producing 2 or more tons per hectare, a less labour-demanding system of application may be used. Leaves shaken off the pruned branches at the end of the crop season may be incorporated into the ridges with crop residues. It is important to do this immediately after pruning to avoid nutrient losses from leaching and volatilization.

When the bank has outlived its usefulness in terms of productive biomass, farmers may opt to remove the bank to cultivate crops, or to replant the bank.

Availability of Planting Material

See information contained in **Chapter 3**, or contact your local extension agent.

Timeframe of Key Activities

Year 1:

November - December: Establish the selected species at the correct spacing with the start of the rains.

January - May: Allow the green manure bank to grow for the whole season.

June - November: Protect the bank from livestock and fires.

Year 2 and onwards:

December - January: Allow the bank to fully leaf out for fresh quality biomass. Replant sections that have any gaps.

January - February: Prune the bank and distribute the leaf biomass collected along the ridges of the targeted crop area at a minimum rate of 1.5 tons dry matter per ha. Woody stems may be collected for fuel or other uses.

May - June: Prune the bank again after the crop harvest to take full advantage of the biomass produced before it falls as leaf litter. Distribute the collected leaf biomass evenly over the furrows in the targeted crop area, and cover it with soil. The biomass may also be buried in the ridges with the crop residues. This must be done soon after pruning to avoid loss of nutrients. Woody stems may again be collected for fuel or other uses.

June - November: Protect the bank from livestock and fires.

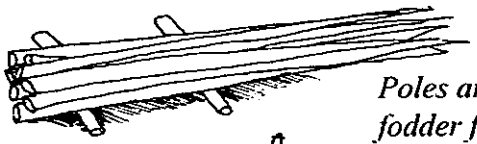
CHAPTER 5 QUESTIONS: TREE PLANTING FOR SOIL FERTILITY

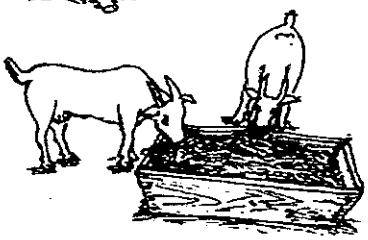
1. Identify two management practices to avoid negative agroforestry effects on crops.
2. What is the recommended method to raise *Faidherbia albida* seedlings, and what is the spacing at outplanting time under Dispersed Systematic Interplanting?
3. When should *Tephrosia vogelii* be undersown with maize and why?
4. How much *Tephrosia* seed is needed to undersow 10 ha with maize? Show calculations.
5. What do you do with the woody stems of *Tephrosia* after cutting it down and why?
6. Why is natural tree regeneration an easy practice?
7. What management steps are needed to encourage natural regeneration of trees?

(For correct answers refer to Page 250 in the annex)

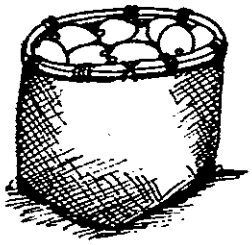
INTRODUCTION

The majority of trees planted by farmers in Malawi are for fuelwood and building poles in response to the rapid rate of deforestation. Farmers are spending more and more time in search of wood and are now convinced of the benefits of planting trees for this purpose around homesteads, on farm boundaries and in woodlots. Farmers are also planting trees, although less commonly, for other products including fruit, animal fodder, green manure, live fencing, and live farm sheds.

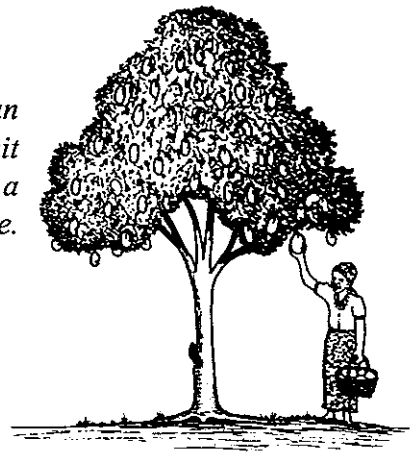




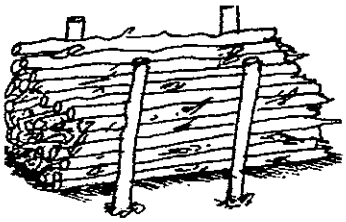
Poles and fodder from homestead trees.



Fruit gathered from homestead trees.



A woman picking fruit from a mango tree.



Fuelwood from homestead trees.

HOMESTEAD, BOUNDARY AND WOODLOT PLANTING

Homestead planting is the most popular form of tree planting in Malawi because it is easy to establish and manage, and generates many useful products for household use and sale. Fruit and other multi-purpose tree (MPT) species may be planted along boundaries of farms, roads, homesteads, or simply scattered around the homestead. Trees may also be planted in small woodlots or orchards, depending on available land, or integrated in *dimba* and home gardens.

Table 6: Common Non-fruit Tree Species for Homestead Planting and their Uses

Botanical Name	Local name	Fuelwood	Timber/ Furniture	Fodder	Medicine	Growth Rate
Acacia galpinii	Nkunkhu	x	x	x		Fast
Acacia polyacantha	Mthethe	x	x	x	x	Fast
Acacia sieberiana	Minganzolo	x	x	x		Medium
Afzelia quanzensis	Msambamfumu	x	x	x	x	Medium
Albizia lebbeck	Mtangatanga	x	x	x		Fast
Albizia versicolor	Mtangatanga	x	x	x		Fast
Bauhinia thonningii	Chitimbe	x		x	x	Medium
Erythrina abyssinica	Muwale			x	x	Medium
Ficus natalensis	Kachere		x	x	x	Fast
Jatropha curcas	Kamsatsi	x			x	Fast
Khaya nyasica	Mbawa	x	x		x	Fast
Melia azedarach	Indya	x			x	Fast
Moringa oleifera	Chamwamba			x	x	Fast
Senna siamea	Keshya wa milimo	x	x		x	Fast
Senna spectabilis	Keshya wa maluwa	x	x			Fast
Terminalia sericea	Napini	x	x		x	Medium
Toona ciliata	Sendrella	x	x		x	Fast

Planting trees in this manner generates important sources of food, fuelwood, poles, fodder, and income to complement other household and farming activities. Some tree species also have valuable medicinal, pesticide, or cultural values.

Recommended Tree Species

Any fruit tree such as citrus, avocado, banana, papaya, mango, guava, and custard apple is recommended. Temperate fruit trees may be used in high, cool areas, especially apples, peaches, and plums.

General homestead planting

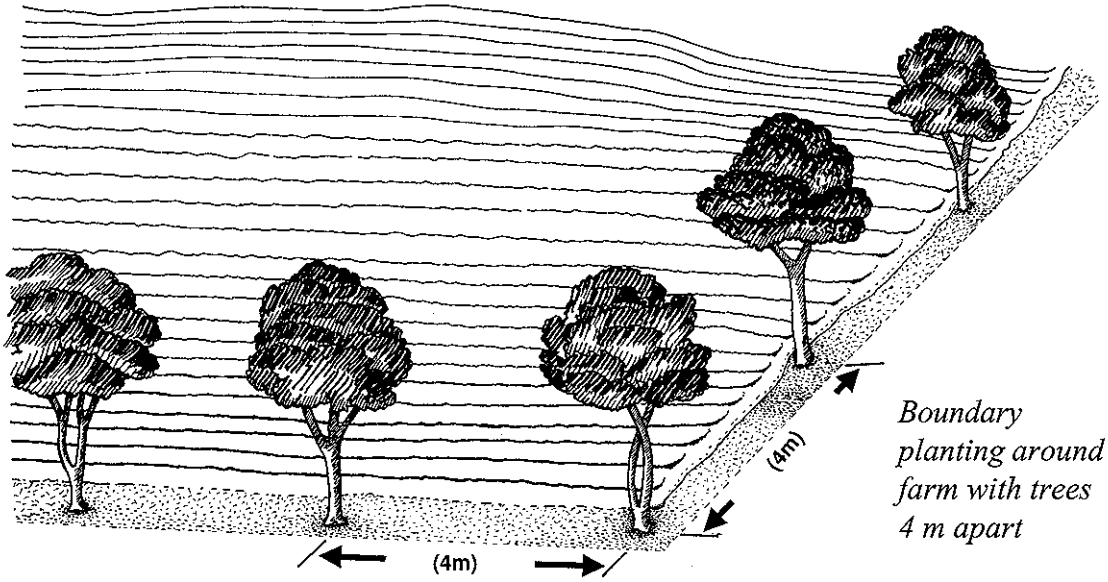
Some common non-fruit MPT species and their uses are listed in **Table 6**. These include many fast-growing trees that are adapted to a wide range of environments. Species well suited to low and medium elevations include *Acacia galpinii, A. sieberiana, Afzelia quanzensis, Albizia lebbeck, A. versicolor* and *Terminalia sericea.* Trees that have widespread adaptation include *Acacia polyacantha, Bauhinia thonningii, Erythrina abyssinica, Ficus natalensis, Khaya nyasica, Senna simaea, S. spectabilis* and *Toona ciliata.*

Nursery Production and Outplanting

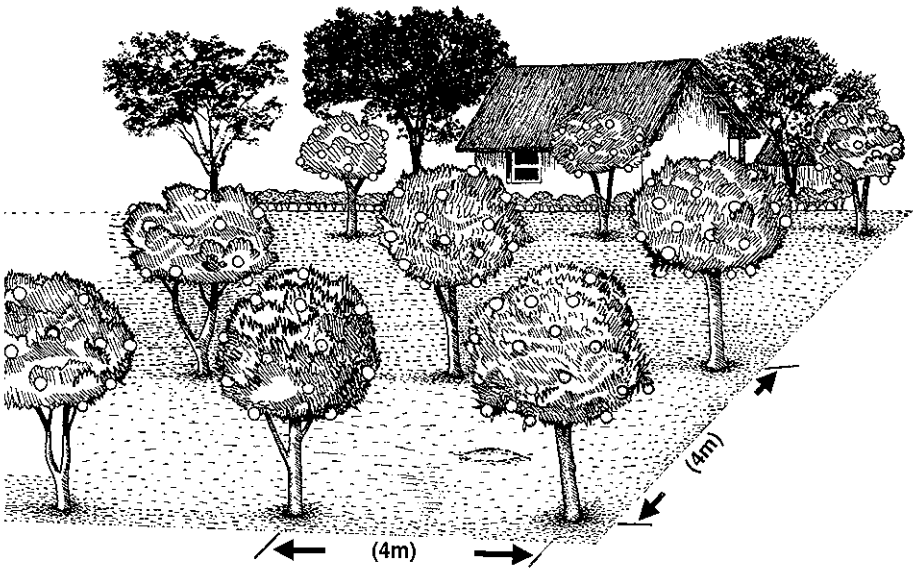
Follow the instructions in **Chapter 3** on Tree Propagation and Outplanting which gives details on preparing planting pits, time and method of outplanting, and measures to improve seedling survival and growth.

Tree Spacing

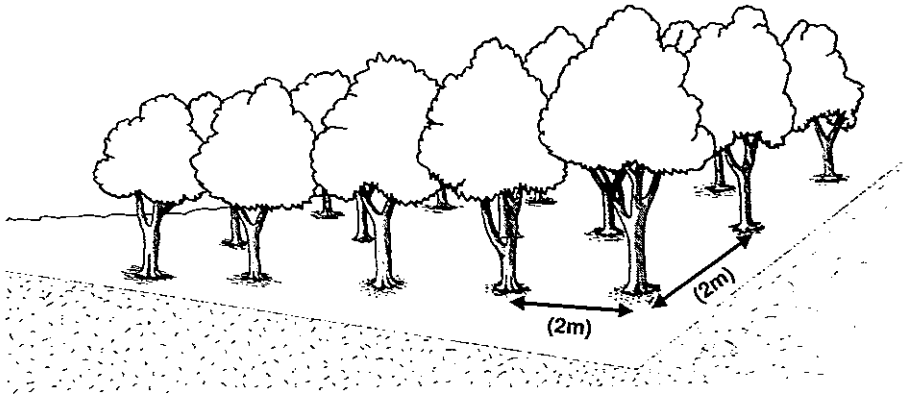
- Woodlots: 2 x 2 m for fuel; 1 x 2 m for poles
- Around homesteads: 4 x 4 m
- Along boundaries: 2 - 4 m apart
- Fruit orchards: 4 x 4 m



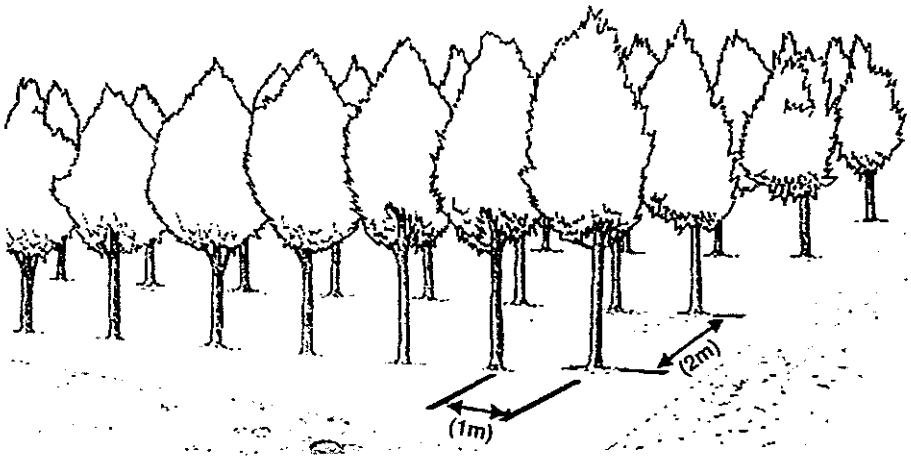
Boundary planting around farm with trees 4 m apart



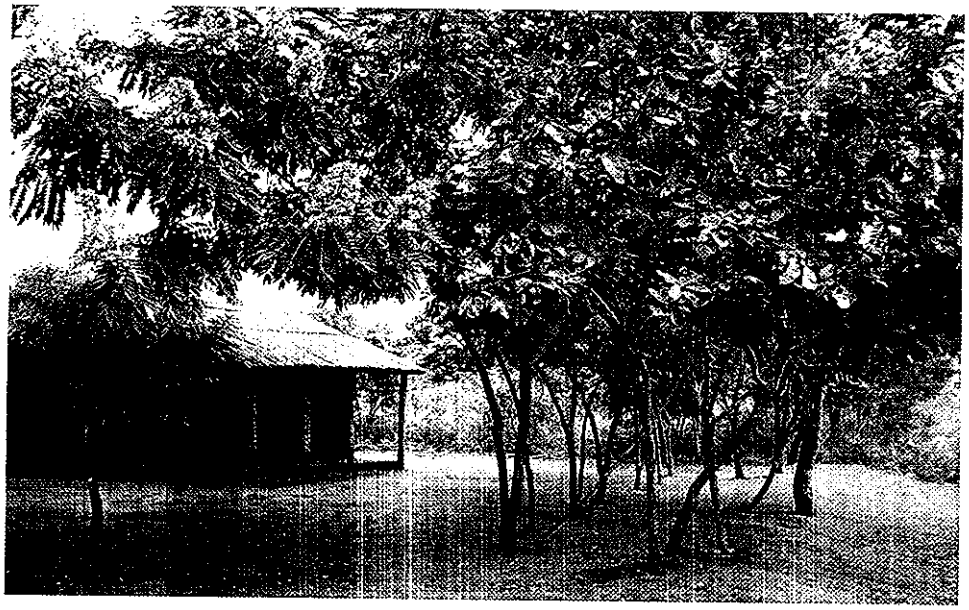
Homestead fruit tree orchard 4 x 4 m



Woodlot planting for fuelwood 2 x 2 m



Woodlot planting for poles 1 x 2 m



Multi-purpose trees planted around homestead.

Senna siamea *woodlot 18 months after planting with a perimeter fire break*

Field boundary planting of **Senna siamea**

Household woodlot of 4 year old **Azadirachta indica**

Homestead planting of multi-purpose trees for firewood and building material

Timeframe of Key Activities

July-November: Prepare nurseries and raise seedlings as indicated in **Chapter 3** on Tree Propagation. Dig planting pits at the correct spacing before the rains.

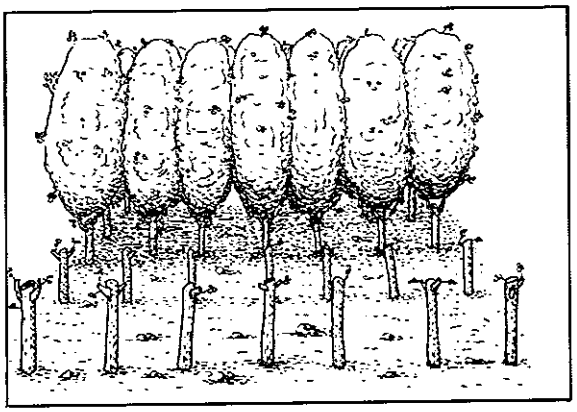
December-January: Outplant seedlings in wet soil once the rains start, and clear 1 m^2 around each seedling.

January Onwards: Weed and protect seedlings from animals and fire. Manage the trees to provide the desired products on a sustainable basis. This will require pruning, coppicing and replanting as needed.

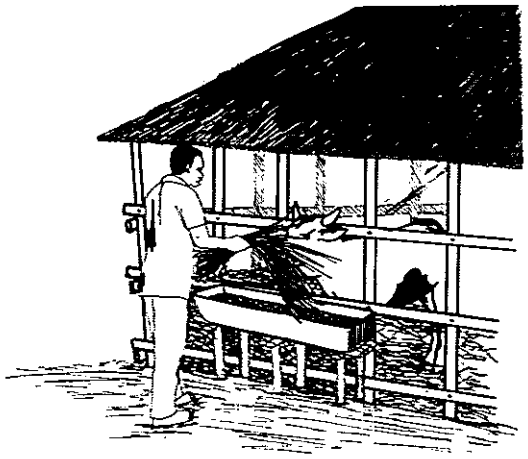
FODDER BANKS

Purpose and Recommended Species

Fodder banks are small plots of high yielding plants with nutrient-rich foliage and/or pods ideal for farmers with intensive livestock production. The fodder is most beneficial as a dry season feed supplement, with fuelwood and poles as useful by-products. Recommended species are *Gliricidia sepium, Leucaena diversifolia,* and *Sesbania sesban* planted in pure stands. ***Note:*** Feed *Gliricidia* wilted or dried, and only to ruminant animals, i.e., cattle, sheep and goats.



A fodder bank of trees, half of which have been pruned to feed livestock.



Feeding pruned napier and **Leucaena** *leaves to livestock.*

Nursery Production and Outplanting

Follow the instructions in **Chapter 3** on Tree Propagation and Outplanting which gives details on preparing planting pits, time and method of outplanting, and measures to improve seedling survival and growth.

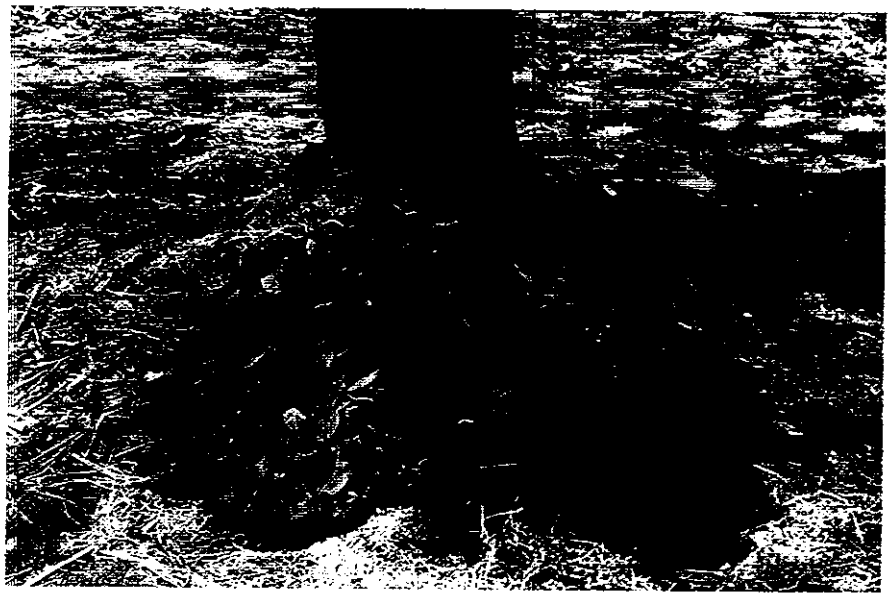
Tree Spacing: Plant trees at 0.9 x 0.9 m.

Pruning: Begin pruning at the start of the second growing season when the trees are greater than 1 m tall. This size allows the trees to recover from pruning. Prune branches of *Leucaena* and *Gliricidia* to 30-40 cm with a clean upward slanting cut 1 to 2 weeks after

Well established **Gliricidia sepium** *fodder bank.*

Cattle grazing in fodder bank.

Cattle eating fodder cut from a **Leucaena** *fodder bank.*



Bauhinia thonningii *pods collected for fodder*

crop planting. Prune *Sesbania* at 75 cm using the same angled cut, but leave 2-3 lower branches for faster recovery. Prune trees again shortly after the crop harvest. Trees may also be pruned during the rainy season for additional fodder. Pruned material may be dried and fed to livestock, with the branches used as fuelwood or poles. For optimal forage quantity and quality, prune 3 times per year: December, February and June. Fodder may also be harvested and fed as needed on a daily basis.

Tree Pods for Fodder

Pods from various trees can be used as a dry season feed supplement, including *Acacia sieberiana, Bauhinia thonningii, Dichrostachys cinerea,* and *Faidherbia albida* all of which produce substantial quantities of nutritious pods when mature. Pods may be harvested in the dry season (July - September) from the ground under mature trees and stored in bags for later use as a feed supplement. Pods are best fed to breeding stock, especially those in calf and lactating females to ensure that they meet their protein and energy requirements. The pods should make up at least 30% of the total intake during the last 2-3 months of the dry season.

Timeframe of Key Activities

Year 1:

November - December: Establish the selected species at the correct spacing with the start of the rains.

January - May: Allow the fodder bank to grow for the whole season.

June - November: Protect the bank from livestock and fires.

Year 2 and onwards:

December - April: Allow the bank to fully leaf out for fresh quality biomass. Replant sections that have any gaps.

May - December: Selectively prune the bank for fodder as needed. Use the woody stems for fuel or other uses. Protect the bank from fires and damage by livestock.

Availability of Planting Material

See information contained in **Chapter 3**, or contact your local extension agent.

LIVE FENCES

Purpose and Uses

Live fences are permanent or semi-permanent structures that serve a variety of purposes. Their main function is to eliminate the cost of constructing, maintaining and replacing other types of fences. Most often, live fences are planted to keep out domestic or wild animals where they are not well controlled. The live hedge is also used to mark boundaries of farm plots, gardens, or homesteads. Some live fences are used to enclose animals in the form of a **khola**. Depending on the species used, they provide other products and uses such as fodder, green manure, fruits, wood for fuel and farm tools, as well as privacy.

Recommended Species

Species recommended for most environments in Malawi include: *Acacia galpinii, A. polyacantha, Agave sisalana, Caesalpinia decapetala, Ziziphus abyssinica, Z. mauritiana*, and *Z. mucronata*. These are thorny species that provide effective protection against unwanted intrusions. Other species that do well in the Lakeshore Plains and Shire Valley are *Acacia nigrescens* and *Prosopis juliflora*, while *Pyracantha coccinea* also grows well in the mid to high elevations. The *Acacia* and *Ziziphus* species need protection during the first year of growth as they are palatable to livestock.

Several species can be grown from truncheons to make live posts for supporting a fence. These include species of *Commiphora, Erythrina, Ficus, Jatropha curcas, Kirkia acuminata, Moringa oleifera* and *Sclerocarya birrea*.

Nursery Production and Outplanting

Follow the instructions in **Chapter 3** on Tree Propagation and Outplanting for details on outplanting and protecting trees.

Farmer trimming hedges to encourage low and dense lateral branching.

Tree Spacing

Nursery Seedlings: 40 cm apart
Truncheons: 1 m apart

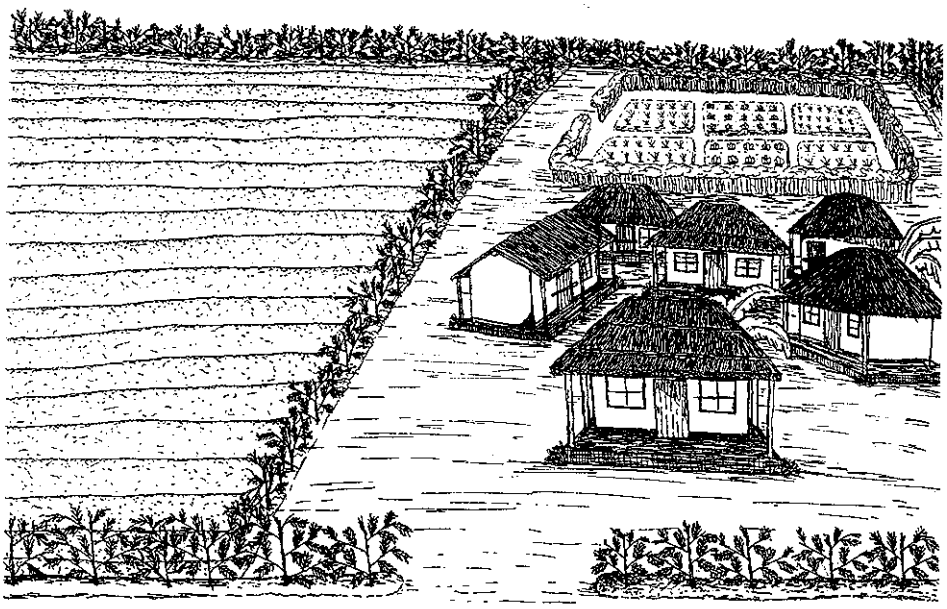
If desired, thorny species may be planted as live hedges between truncheons.

Trimming

At the onset of the second or third season, trim hedges to 50-75 cm high to encourage low and dense lateral branching. One plant may be left untrimmed every 5-10 m for production of seed, fruit, fuelwood, poles or fodder, depending on the species used. Trim sides and tops of plants to 1 m to 1.5 m periodically to prevent excessive spreading growth. Trimmed branches can provide fuelwood, fodder, and thorny material for protecting other seedlings or crops. *Caesalpinia* needs frequent pruning to avoid overgrowing and the risk of becoming a weed from prolific seed production.

Availability of Planting Material

See information contained in **Chapter 3**, or contact your local extension agent.



Living fences around a homestead, field, and home garden.

Live fence of **Ziziphus mucronata** *around a farm in the dry season.*

Live fence of **Acacia polyacantha** *protecting a maize field.*

Live fence enclosure of vetiver nursery from truncheons of **Jatropha curcas** *trees.*

Live homestead fence from truncheons of **Moringa oleifera** *trees.*

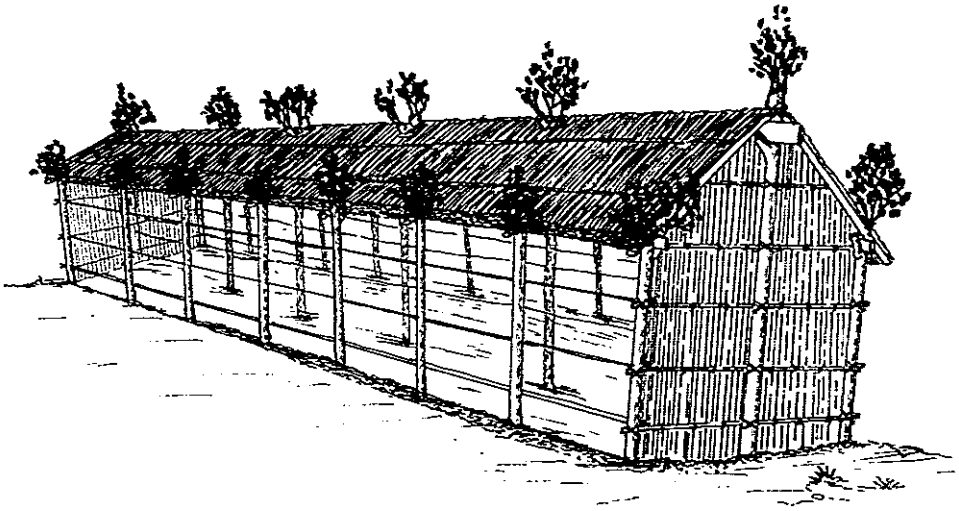
LIVE FARM SHEDS

Purpose and Recommended Species

Most farm sheds in the smallholder sector are constructed using dry wood poles which have to be replaced every 2-3 seasons because of termite damage. The volume of wood required exacerbates deforestation.

A sustainable solution is to encourage farmers to use live trees in place of upright poles. The trees may be allowed to grow above the roof during the dry season, and coppiced before or during the rains. Cut branches may be used for crop ties or other purposes. Since a typical "dead" shed lasts only 3 years, live farm sheds reduce labour and maintenance, as well as deforestation. A 30 m shed with 45 live poles is sufficient to cure 300 kg of tobacco.

Although the concept of live farm sheds is new to smallholders, some tenant farmers on tobacco estates are using this technology. *Gmelina arborea* is the most common species used and is raised mainly from seedlings. *Eucalyptus* species have also been used but with mixed results from poor coppicing ability. Few other species have been tested, but a list of promising species is shown in **Table 7**.



Live farm shed using living trees for upright poles.

Table 7: Tree Species Suitable for Live Farm Sheds

Species	Local Name	Range	Method of Establishment
Acacia polyacantha	Mthethe	Wide	Seedlings
Bridelia micrantha	Mpasa	Low to medium	Seedlings
Commiphora africana	Khobo	Low to medium	Seedlings, cuttings
Erythrina abyssinica	Muwale	Low to medium	Seedlings, cuttings
Ficus natalensis	Kachere	Wide	Seedlings, cuttings
Ficus capensis	Mkuyu	Low to medium	Seedlings, cuttings
Gmelina arborea	Malaina	Wide	Seedlings, cuttings
Kirkia accuminata	Mtumbu	Low to medium	Seedlings, cuttings
Pterocarpus angolensis	Mlombwa	Low to medium	Seedlings, cuttings
Sclerocarya birrea	Mfula	Low to medium	Seedlings, cuttings
Senna siamea	Keshya wa milimo	Low to medium	Seedlings
Senna spectabilis	Keshya wa maluwa	Wide	Seedlings

Nursery Production and Outplanting

Follow the instructions in Chapter 3 on Tree Propagation and Outplanting which gives details on preparing planting pits, time and method of outplanting, and measures to improve survival and growth of seedlings and truncheons.

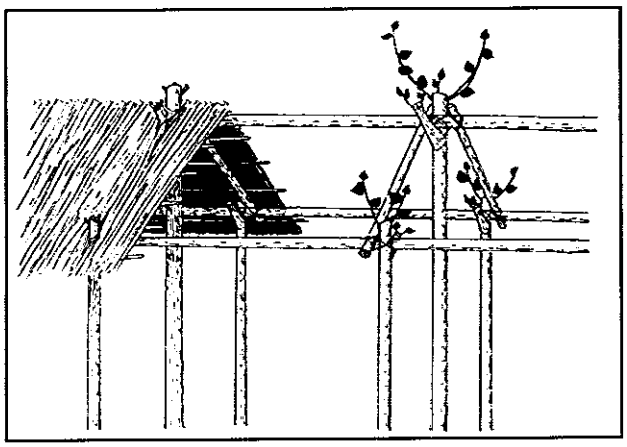
Guidelines for establishing and managing live farm sheds are as follows:

- Carefully match species with the local environment, farmer preferences and availability of planting material. Select species that are fast growing with good coppicing ability; ideal species are ones that grow well from truncheons to speed up shed construction and use.
- Organise farmers in each participating club to raise their own nursery seedlings. This can be done adjacent to their crop nurseries or dimba gardens.
- If truncheons are used, identify species and sources of material before the start of

the rains. Cuttings are best taken when the tree is dormant before new leaves appear and not when in flower or fruit. Consult **Chapter 3** on Tree Propagation and Outplanting for details on preparing cuttings.

- Provide stake supports and prune branches to encourage a straight-growing trunk.
- Locate the shed near the house or farm, preferably not on good farm land. Establish seedlings or truncheons in the configuration of a typical shed, 2 x 2 m in 3 lines. The center line poles are 2.5 to 3 m tall, while the outside poles are 1.5 to 2 m tall.
- Protect young trees from browsing/other damage to avoid uneven or mis-shapen

Live farm shed: Construction of roof on live poles.



Configuration of a Live Farm Shed showing 2 x 2 m spacing of seedlings/truncheons

```
     o-- 2m -o    o    o    o    o    o    o    o    o    o
2m   |
     o    o    o    o    o    o    o    o    o    o    o

     o    o    o    o    o    o    o    o    o    o    o
```

poles. Fill in gaps where seedlings have died, or where truncheons have failed to grow.

- Construct the shed only when the living trees are large and strong enough to support the roof. If truncheons are used, allow 1-2 years for roots and foliage to develop before building the roof. Ensure coppicing is done evenly so that the roof is uniform, sloping from the center down each side.

- Coppice/pollard trees when well established, timed to provide crop ties and to minimize roof damage from winds. Encourage a fork to form where the roof beams will sit (see illustration). Coppiced branches may also be used for fuelwood and fodder depending on the species. The bark of some trees may also be stripped from cut branches for use as rope.

Availability of Planting Material

See information contained in **Chapter 3**, or contact your local extension agent.

Timeframe of Key Activities

This section refers to live fences and live farm sheds.

July-November: Identify species desired and sources of planting material. Prepare nursery and raise seedlings as indicated in Chapter 3 on Tree Propagation. Dig planting pits at the correct spacing. If truncheons are selected, collect and plant them before the rains start.

December-January: Outplant nursery seedlings in wet soil once the rains start, and clear 1 m^2 around each seedling.

January Onwards: Weed and protect seedlings from animals and fire. Manage the trees so they grow in the form needed as a shed to support a roof. This will require pruning, coppicing and replanting as needed.

CHAPTER 6 QUESTIONS: TREE PLANTING FOR WOOD & OTHER PRODUCTS

1. Can a smallholder farmer with 0.4 ha land plant trees for wood/other uses? If yes explain how and if not, explain why.

2. What is the spacing of trees grown for the following products?

a) Poles
b) Fuelwood
c) Fruits

3. Why is tree pruning important?

4. Why should you prune trees when they begin active growth?

5. Identify three species suitable for establishing living farm structures (use scientific names).

(For correct answers refer to Page 251 in the annex)

INTRODUCTION

This chapter is intended as a practical field guide to some common fast-growing agroforestry species used in Malawi. It is by no means a comprehensive list, since research is continually identifying other species.

SPECIES DESCRIPTIONS

The plants listed are organized alphabetically by family according to botanical name. Common English and Chichewa names are included. A brief illustrated description is provided of each species, along with notes on uses, products, and any special notes. Several reference tables are included after the end of this chapter for more detailed information on species characteristics, uses and planting requirements for different technologies. The tables include the following:

Table 8: Agroforestry Species: Technology, Size and Altitude Range

Table 9: Plant Spacing and Density/ha for each Technology

Table 10: Agroforestry Species: Wood, Medicinal and Other Uses

Table 11: Planting Material Requirements by Technology and Species

Table 12: Index of Species

The index lists species alphabetically by botanical, Chichewa and English names.

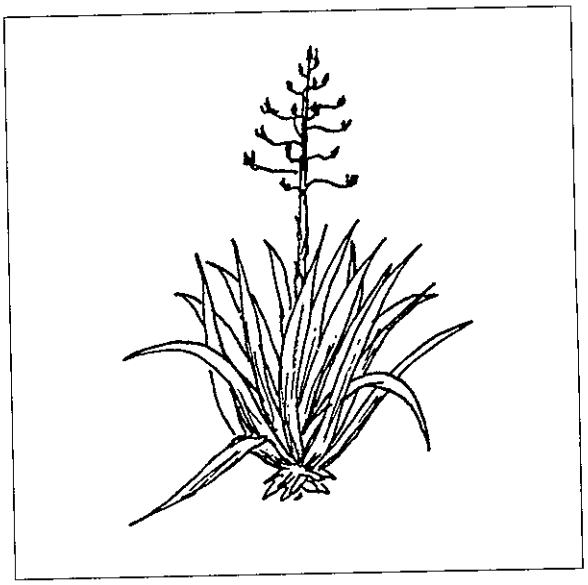
FAMILY: AGAVACEAE

Agave sisalana
Sisal **Khonje**

Description: Native of Mexico, now widely planted in the tropics. A medium-sized succulent, **leaves** large, dark green, and spiny, 2 m long; **flowers** creamy-yellow, in branched clusters along a 4-6 m woody pole, produced when 7-12 years old, after which the plant dies.

Uses/Products: An important producer of fibre for ropes, twine, mats, baskets, and sandals, and once grown widely on a commercial scale. The flesh from the leaves makes good fodder, and can be composted for organic manure; waxes, sodium pectates, alcohol, methane and hecogenin can be extracted from sisal waste.

Special Notes: Propagated from suckers growing on rhizomes at the base of the bole, or preferably from bulbils which are miniature sisal plants borne on the flowering stalk (bulbils are easier to collect and grow more uniformly). Sisal makes a good live fence, but its shallow, spreading adventitious root system can be competitive with nearby crops.



Agave sisalana

from: Useful Plants of Malawi, 1975. J. Williamson. ill: M. M. Moss

FAMILY: ANACARDIACEAE

Sclerocarya birrea
Marula **Mfula**

Description: Indigenous. A medium-large handsome deciduous tree up to 15 m high with spreading crown. **Bark** grey, rough, and flaking in patches; **leaves** compound with oval to elliptic leaflets, dark green above, blue-green below; sexes separate with pistillate trees conspicuous in May with yellow, plum-size fruits, while staminate trees have red catkins appearing before the leaves in October; **fruit** yellow, fleshy, and spherical, up to 3.5 cm in diameter.

Sclerocarya birrea

Uses/Products: Edible fruits are high in vitamin C, are richly scented and can be made into jams, juices, and an alcoholic drink; the stone inside the fruits has 2-3 edible kernels containing a protein-rich oil which burns like a candle. The wood is used for carvings, furniture, flooring, and match-making; bark produces a brown dye, and is used for rope/string, also has a proven antihistamine and anti-diarrhoea properties; cut truncheons are grown as live fence posts; foliage and fruits make good browse for all stock. The tree has many medicinal and cultural uses, and is highly valued in many parts of Africa.

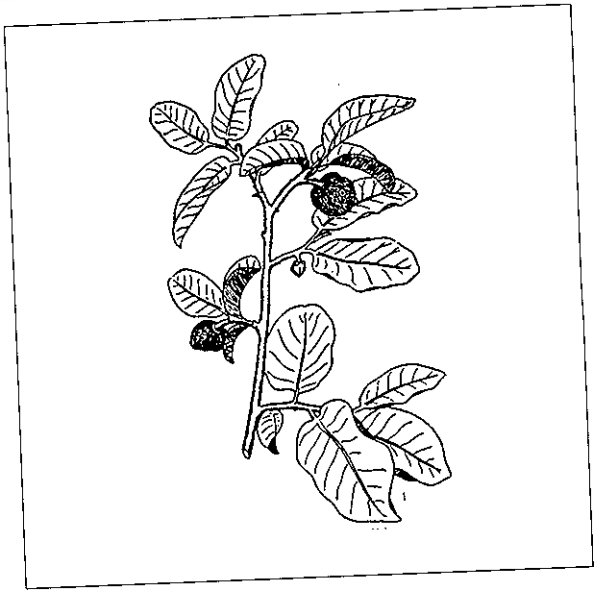
Special Notes: Best propagated from cuttings/truncheons. Food value of fruits is high, but not eaten much in Malawi. Fruits have commercial value for jams, juices and liqueurs in South Africa, Botswana and Zimbabwe. Kernels of the stones are edible and highly nutritious, but difficult to remove intact.

FAMILY: ANNONACEAE

Annona senegalensis
Wild Custard Apple **Mposa**

Description: Indigenous. A deciduous, spreading shrub or tree 3-8 m high. **Bark** grey, smooth to roughish with circular flakes; **leaves** large and oval, green to blue-green, often softly hairy below; **flowers** inconspicuous and greenish arising from leaf axils; **fruits** fleshy, lumpy and spherical, yellow orange.

Uses/Products: Edible fruit, regarded as the best of indigenous fruits in some parts of Africa; rope from bark; many medicinal uses: leaf tips and bark for colds, leaf poultices for pneumonia, roots boiled with sour oranges for stomach ache.



Annona senegalensis

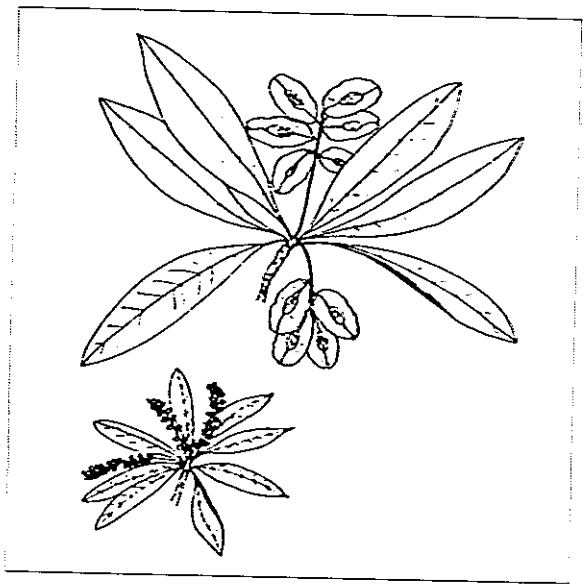
from: Useful plants of Malawi, 1975. J. Williamson.

FAMILY: COMBRETACEAE

Terminalia sericea
Silver Terminalia **Napini**

Description: Indigenous. A handsome, deciduous medium-large tree 10-15 m tall, with spreading branches. **Bark** grey-black, deeply fissured, slender branches brown or purplish flaking in strips; **leaves** oblong-ovate, clustered at ends of branchlets pale green and covered in silvery hairs; **flowers** small, creamy-yellow in axillary racemes, sweet scented; **fruit** winged, rose-red when mature and drying to red-brown.

Uses/Products: Wood hard and durable, providing good fuel, furniture, tool handles and general-purpose timber; the tree has many local medicinal and cultural uses. Common ones include taking a decoction of the roots to cure diarrhea, and to relieve colic, also applied as an eyewash, while pneumonia is treated with a fomentation from a hot infusion of the outer parts of the roots.

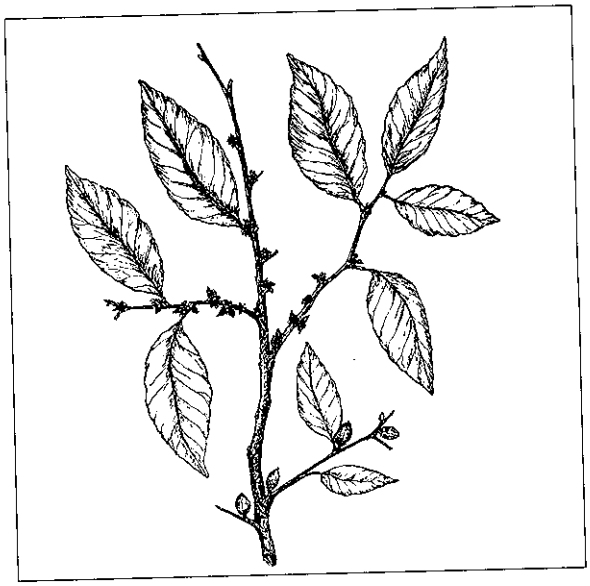


Terminalia sericea

from: Useful Plants of Malawi, 1975. J. Williamson.

FAMILY: EUPHORBIACEAE

Bridelia macrantha
Bridelia **Mpasa**



Bridelia macrantha

from: Fifty common trees of Zambia. 1968. Forest Department Bulletin No. 5.

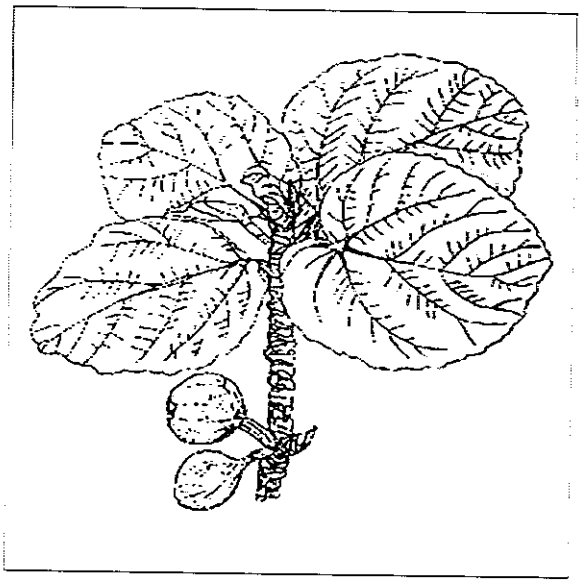
Description: Indigenous. A small to medium tree 7-12 m tall, with a dense, spreading canopy. Widely distributed in open woodland and riverine forests from 50-2000 m. above sea level. **Bark** brown to grey, rather flaky, becoming rough with age; **leaves** large, elliptic to obovate, usually 7 to 8 x 3.5 to 4 cm, dark, glossy green above, paler green below sometimes with sparse hairs, veins go right to the margin entire, wavy or scalloped; apex shortly attenuate, base broadly tapering to rounded; leaves develop bright colors in autumn; **flowers** very small, yellowish in tight clusters in the leaf axils; **fruit** ellipsoidal, 8 x 4 mm, black when mature, edible and sweet.

Uses/Products: The leaf sap is used to sooth sore eyes; root used as a purgative and to relieve stomach pains and ulcers. It is also powdered and rubbed with oil/fat into the head to cure headaches. The wood makes fine furniture, is dark brown, naturally lustrous, fine grained, very durable and termite-resistant. This is a fast growing, shady and beautiful tree, easy to raise from seed that is planted fresh.

FAMILY: EUPHORBIACEAE

Jatropha curcas
Physic nut **Kamsatsi**

Description: Native to America. Shrub or tree to 6 m with spreading branches and stubby twigs, has a milky exudate. **Bark** greyish-green, flaky; **leaves** deciduous, alternate, apically crowded, ovate, acute and cordate, 3 to 5 lobed, 6-40 cm long, 6-35 cm broad; **flowers** several in greenish cymes, bell-shaped, yellowish sepals; **fruit** capsule, 25 to 4 cm long, drying and splitting into 3 valves, each usually containing a black seed.



Jatropha curcas

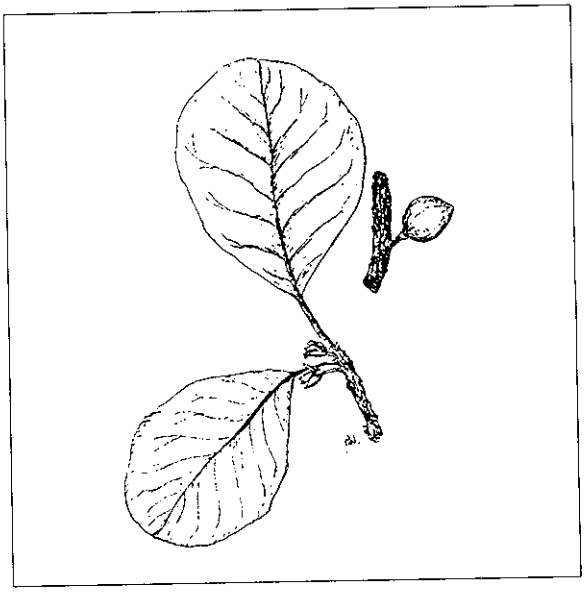
Uses/Products: Many households grow the tree from truncheons as live fence posts for livestock enclusres and around toilets and bathing areas. Oil expressed from the seed has been used for illumination, soap, candles. The plant is reputed to have varied medicinal properties. Latex may be used to treat bee and wasp stings, and to dress sores, and ulcers.

FAMILY: EUPHORBIACEAE

Uapaca kirkiana
Wild Loquat **Masuku**

Description: Indigenous. A smallish, much-branched evergreen tree 5-12 m tall, with typical rounded crown. **Bark** dark grey and rough; **leaves** distinctive, clustered at branch tips, large and leathery, shiny dark green above, covered below with wooly hairs; **flowers** greenish-yellow to white, inconspicuous in terminal clusters; **fruit** round, fleshy, rusty-yellow, 2-3 cm diameter.

Uses/Products: Fruit edible and delicious, produces a good wine; wood is fairly durable and borer proof, easy to work and polishes well; stems used as tooth brushes; a good general-purpose wood, makes good fuel, used for lids of grain stores; the tree has many medicinal uses: an infusion of the roots is used for abortions; and mixed with other plant species to treat many ailments, including rheumatism, colds, coughs, skin diseases, and yaws.



Uapaca kirkiana

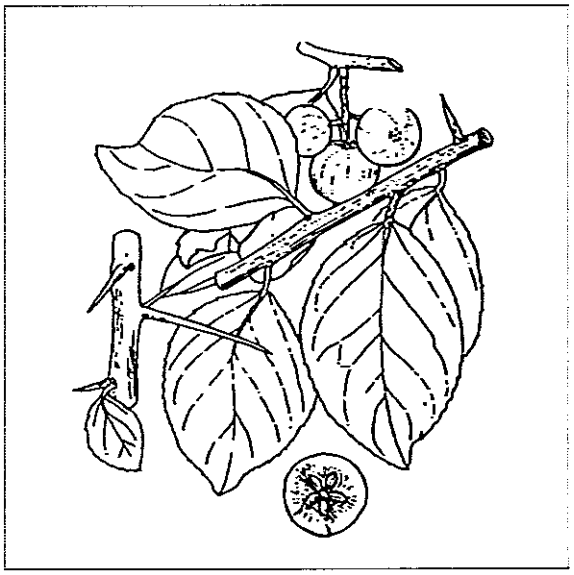
from: Useful Plants of Malawi, 1975. J. Williamson.

FAMILY: FLACOURTIACEAE

Flacourtia indica
Indian Plum **Nthudja, Nthudza**

Description: Indigenous. A much-branched small tree, usually spiny 3-10 m high. **Bark** pale grey and smoothish, sometimes darker and flaking to reveal pale orange patches; **leaves** simple, oval to elliptical, light to dark green, turning colour in autumn and becoming brilliant red, plum coloured and purplish black; **flowers** greenish-yellow flushed with dull red, sometimes solitary or in short racemes or panicles; **fruit** berry-like, fleshy, 1-2.5 cm diametre, dark red-purple.

Uses/Products: Fruit edible with a pleasant flavour but acidic; tree has many medicinal uses from decoctions of the leaves and roots (intestinal worms, screw-worms in cattle, general body pains), and infusions of the bark and roots for treating pneumonia, sore throats, and rheumatism.



Flacourtia indica

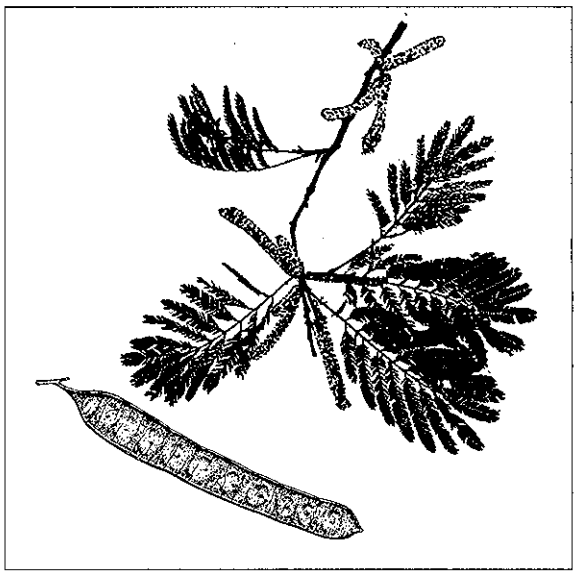
from: Useful Plants of Malawi. J. Williamson. ill: G. Jackson.

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Acacia galpinii
Monkey Thorn **Nkunkhu**

Description: Indigenous. A fine, large deciduous tree up to 25 m high. **Bark** yellow-brown, rough and furrowed, paired thorns on branches and main trunk are dark, strong, and hooked; **leaves** 9-14 pairs of pinnae, 13-40 pairs of leaflets each; **flowers** in slender creamy spikes with red sepals that are a distinguishing feature; **fruit** a straight purple-brown pod.

Uses/Products: Hard, heavy wood, valued for furniture, poles, and fuel; leaves are good fodder.



Acacia galpinii

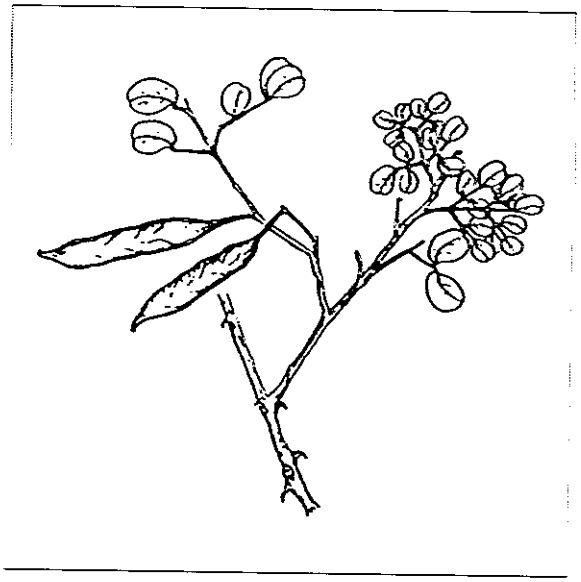
from: Trees of Southern Africa, 1977. K. O. Palgrave. ill: Terry Duggan, O. Anderson.

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Acacia nigrescens
Knobthorn **Mkunkhu**

Description: Indigenous. A medium size deciduous tree 10-15 m tall with a rounded canopy, raised knobby thorns on trunk and branches; **bark** dark brown; **leaves** 1-3 pairs of pinnae, 1-2 pairs of circular leaflets each; **flowers** creamy in long conspicuous spikes; **fruit** is a straight dark-brown pod.

Uses/Products: Considered an indicator of good ranching country with valuable fodder but very thorny. Wood very hard, fire and termite resistant. Makes good fuelwood, furniture (though difficult to work), mine props, sleepers, fence posts, and parquet floorings.



Acacia nigrescens

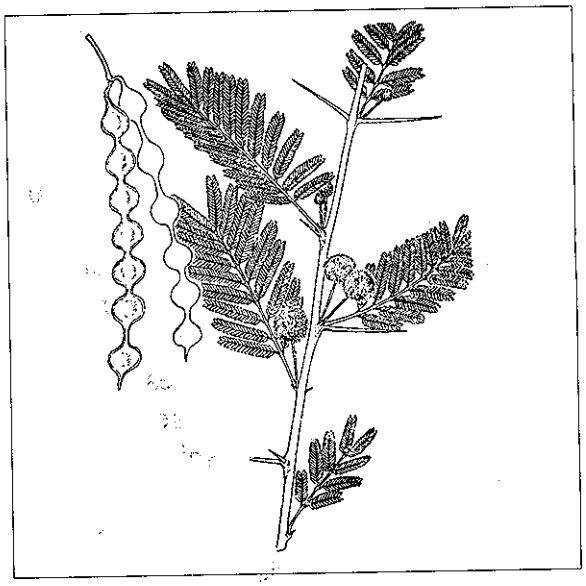
from: Useful Plants of Malawi, 1975. J. Williamson.

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Acacia nilotica
Scented Thorn **Mpampa, Ngagaga**

Description: Indigenous. A small deciduous tree up to 10 m tall, usually smaller; **bark** smooth reddish-brown when young, rough blackish-grey with age. White or reddish long straight spines; **leaves** 2-11 pairs of pinnae, 7-25 pairs of leaflets each; **flowers** in yellow balls; **fruit** long, thickish and slightly curved, green when young, becoming dark or black.

Uses/Products: Wood is reddish, hard, and durable, good for fuel and fence posts; gum exudations for adhesive and confectionery; pods valuable fodder and sometimes used for dyeing cloth black; a decoction of the bark and roots used to treat impotence, and leaves for pneumonia.



Acacia nilotica

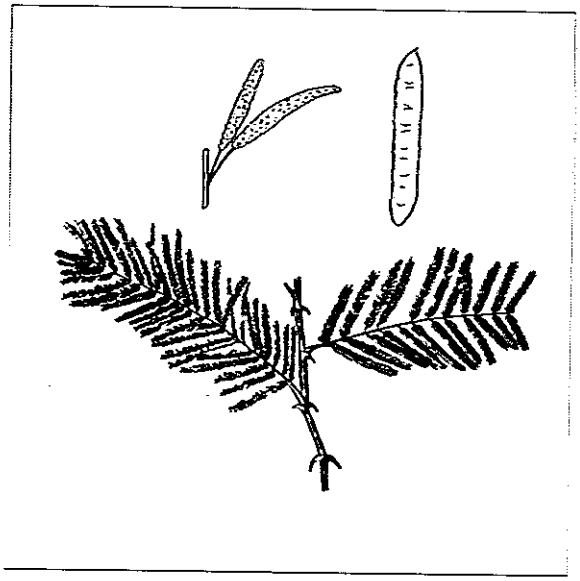
from: Common Fuelwood Crops. Elbert L. Little, Jr. ill: Sahni.

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Acacia polyacantha
White Thorn **Mthethe**

Description: Indigenous. A large, handsome deciduous tree to 20 m. **Bark** pale yellow-white and flaking, with strongly hooked prickles in pairs on branches, sometimes on trunk; **leaves** 13-40 pairs of pinnae, 25-65 pairs of leaflets each; **flowers** in long white spikes; **fruit** a straight longish, brown pod.

Uses/Products: Regarded as an indicator of fertile soils; good fuelwood and fodder; wood is hard and resistant to borers; used for mine shafting, building materials, and tool handles; gum is good quality for confectionery; roots used to ward off snakes and to treat snakebites.



Acacia polyacantha

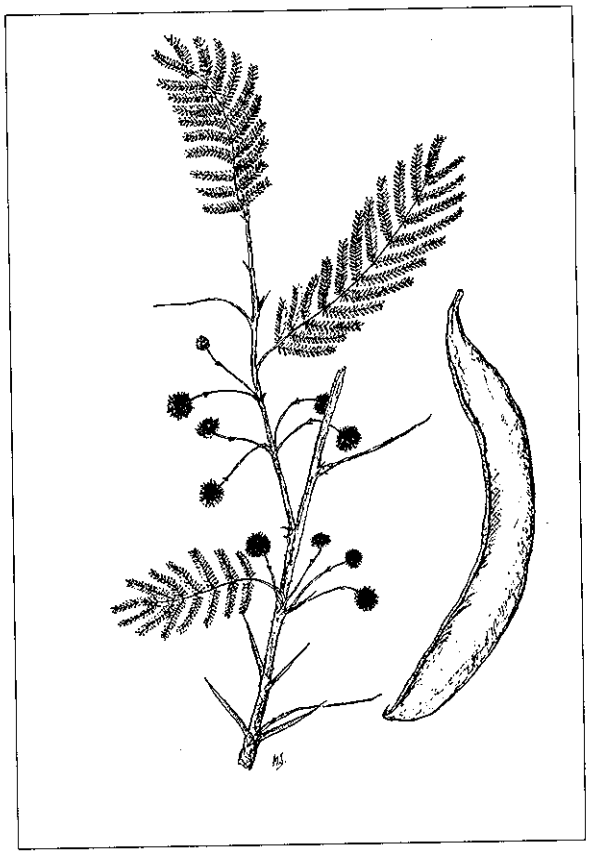
from: A Field Guide to Lengwe National Park, 1984. B.Y. Sherry and A. J. Ridgeway.

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Acacia sieberiana
Paperbark acacia **Minganzolo**

Description: Indigenous. A common flat-crowned thorn tree up to 17 m tall occurring in woodland and wooded grassland, often along rivers and in foodplains. **Bark** greyish-yellow, a little corky, sometimes peeling in papery strips. Stipules spinescent, the spines white, straight up to 9 cm long, no swellings; **leaves** 6-23 pairs of pinnae, each with 14-45 pairs of leaflets, which are narrowly oblong, 2 to 6.5 x 1 mm; **flowers** in white or cream balls; **fruit** a pod 20 x 3.5 cm, without hairs to densely velvety, brown, straight to curved, reluctantly dehiscent, thick and woody.

Uses/Products: Wood light and soft, the trunk can be made into mortar to press seeds for oil. Leaves and pods valuable fodder.



Acacia sieberiana

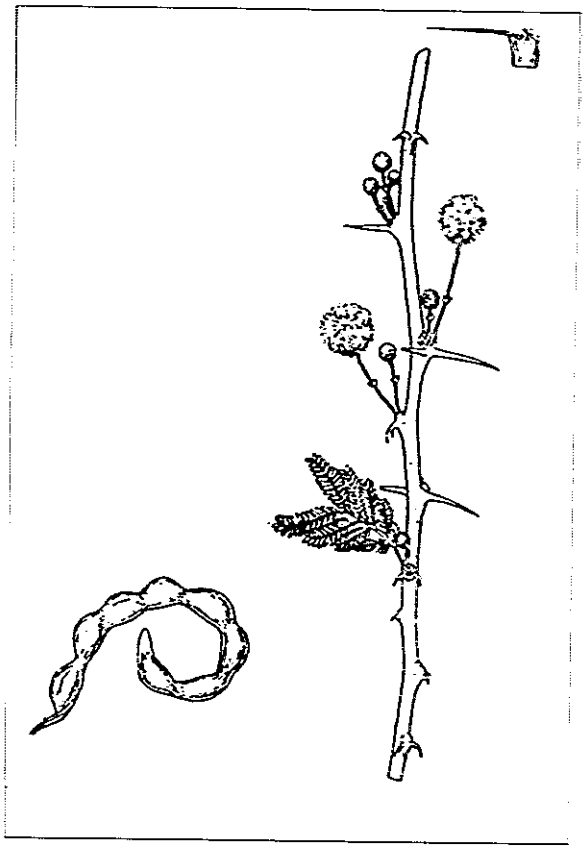
from: Fifty common trees of Zambia. 1968. Forest Department Bulletin No. 5.

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Acacia tortilis
Umbrella Thorn **Nchongwe**

Description: Indigenous. A flat-crowned deciduous tree 6-15 m tall. **Bark** grey to dark brown and fissured, spines variable, sometimes hooked, or long and straight both often found on same tree; **leaves** blue-grey green, 2-10 pairs of pinnae, 6-19 pairs of leaflets each; **flowers** in cream or yellow balls; **pod** narrow, small and spirally contorted.

Uses/Products: Leaves and pods valuable fodder; wood makes good fuel; bark used for string.



Acacia tortilis

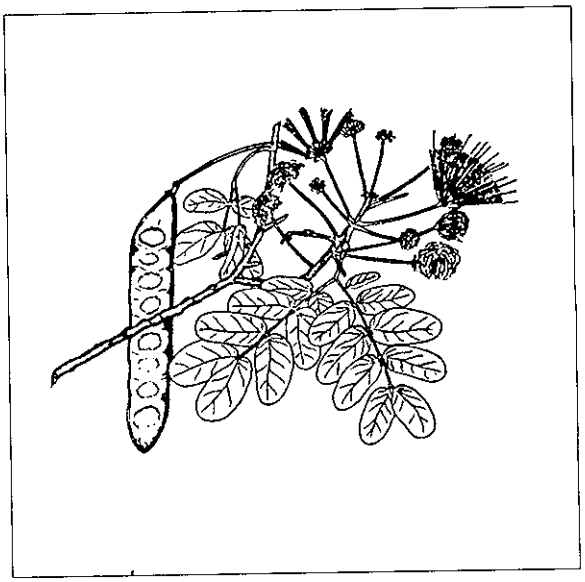
from: Common Fuelwood Crops. Elbert L. Little, Jr..

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Albizia lebbeck
Woman's Tongue **Mtangatanga**

Description: Native to tropical Asia, now naturalised in Malawi. A deciduous tree 6-12 m tall, usually a short trunk. **Bark** grey and smoothish becoming rough or fissured; **leaves** large and compound with oblong leaflets; **flowers** greenish-yellow clustered in long stalked heads; **pods** broad and oblong, straw-coloured, papery and flat, rattling continuously in the wind.

Uses/Products: **Wood** medium hard, heavy and durable; good furniture, paneling, general construction, and carving but not easy to work by hand. Bark used in tanning; good fuelwood and fodder; attractive to bees for honey; used widely for shade and ornamental along roads, gardens and plantations.



Albizia lebbeck

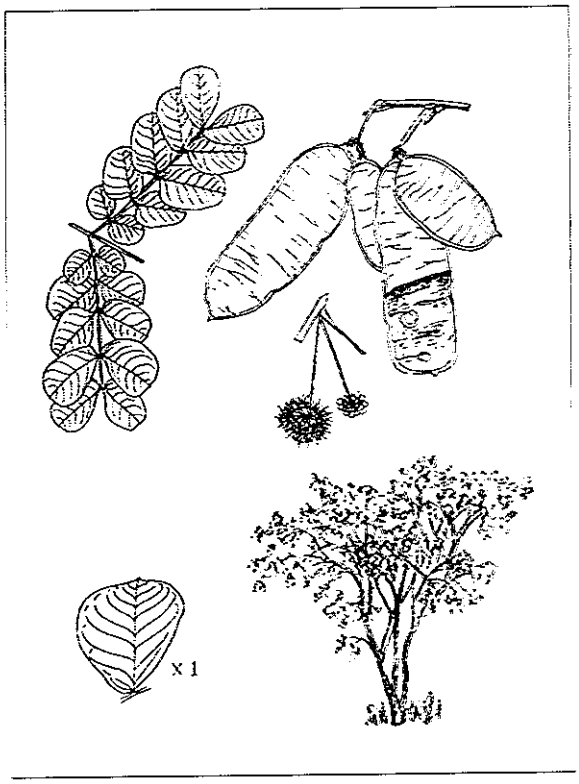
from: Useful Plants of Malawi, 1975. J. Williamson.

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Albizia versicolor
Poison-Pod Albizia **Mtangatanga**

Description: Indigenous. A medium-large deciduous tree 10-18 m tall. **Bark** grey-brown and rough; **leaves** with 1-3 pairs of pinnae, each with 3-5 pairs of leaflets, which are large, oblong to ovate, 5 x 3 cm, under surface with dense rusty hairs, apex rounded, base broadly tapering, margin entire; **flowers** in large semi-spherical heads, creamy-white; **fruit** a large red-brown pod up to 25 x 6.5 cm.

Uses/Products: The seeds and pods are toxic to livestock. The root and bark make a good soap. The wood resembles *Pterocarpus angolensis*, is hard, heavy and durable; used for furniture, drums and mortars.



Albizia versicolor

from: Fifty common trees of Zambia. 1968. Forest Department Bulletin No. 5.

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Faidherbia albida
Winter Thorn **Msangu**

Faidherbia albida

from: ICRAF 1992: A Selection of Useful Trees and Shrubs for Kenya.

Description: Indigenous. A majestic deciduous tree, 18-25 m high with a rounded crown and spreading branches. **Bark** white when young, turning grey and fissured; **leaves** feathery and grey-green, thorns white, straight and thick; **flowers** in creamy-white spikes; **fruits**, a thick and often spirally twisted pod, orange-brown when dry.

Uses/Products: Loss of nutrient-rich leaves during the rainy season improves soil fertility and allows farming beneath the canopy with good benefits to crop yields. Trunks and branches used for fuelwood, canoes, pestles and mortars; pods and leaves are excellent fodder; in times of famine, people can eat the seeds after repeated boilings; flowers attract bees for honey-making, and hollow trunk or branches make good bee-hives; bark is boiled and drunk to cure diarrhea; leaf growth provides good shade during hot, dry season.

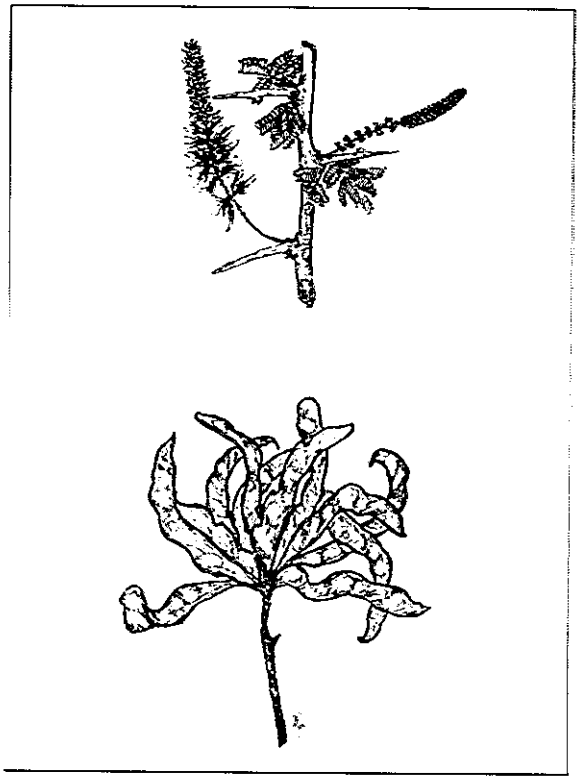
Special Notes: Ideal agroforestry tree and widely appreciated by farmers, but return on investment may be fairly long-term (over 7-10 years) due to variable growth rate. Fast growing tap-root can be deformed in nursery or when out-planting due to mismanagement. Young seedlings need protection from browsing and weeds, and should be marked for visibility due to small size. Increased land and grazing pressures are reducing natural regeneration.

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Dichrostachys cinerea
Sickle Bush **Chimphongala**

Description: Indigenous. Shrub or small tree 5-6 m tall, found in low to medium altitudes in wooded grassland, sometimes forming secondary thickets on impoversihed soils, which could be an indicator of overgrazing. **Bark** dark grey-brown, stems often twisted with intertwined branches, dwarf lateral shoots modified to form compact spines; **leaves** compound paripinnate, with 4 to 13 pairs of pinnae, each with up to 27 pairs of leaflets, which are narrowly obovate to lanceolate up to 10 x 3 mm, dark green, glossy above, dull below; **flowers** in axillary spikes, all parts in fives, the spike is 2-colored with pink sterile staminoids and a short yellow catkin of fertile flowers; creamy-white spikes; **fruits**, a cluster of twisted pods, each up to 10 x 1 cm.

Uses/Products: Pods are valuable, nutritious fodder for livestock and wildlife. Roots and leaves are chewed and placed on the sites of snakebites and scorpion stings. The leaves are also used as an anesthesia, and a remedy for sore eyes and toothache. Wood extremely hard and durable for poles and tools, but use limited by the small size of the tree. Excellent firewood and charcoal.



Dichrostachys cinerea

from: Fifty common trees of Zambia. 1968. Forest Department Bulletin No. 5.

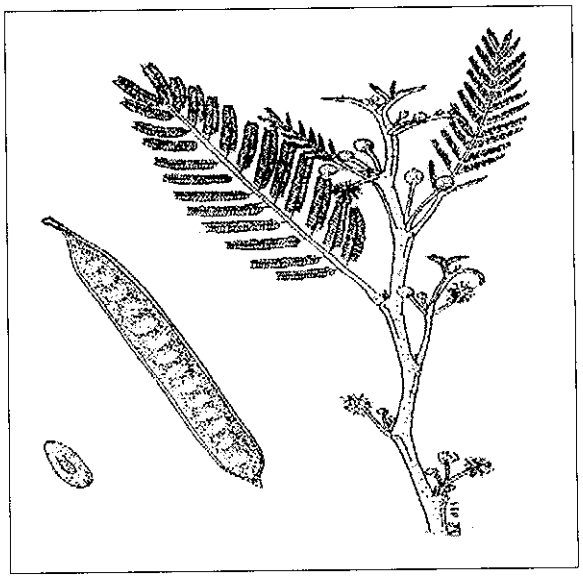
FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Leucaena diversifolia
Leucaena **Lukina**

Description: Native to Mexico and Central America. A medium-sized tree 10 to 20 m tall. **Bark** grey-brown and smooth, **leaves** dark green and compound with large numbers of small leaflets, each 1 to 2 mm wide and 1 cm long, the apex is usually off-center and pointed; **flowers** bright red to light pink, borne in clusters at leaf axils and average under 1 cm diameter; **fruit** a pod slender and red-brown.

Uses/Products: Nutritious fodder with low mimosine content, but levels of more than 50% of the forage in animal diets are not recommended. Makes good firewood and poles.

Special Notes: Better adapted to most parts of Malawi than *Leucaena leucocephala*, especially the medium to higher altitudes. Also more resistant to psyllids and termites. Very fast-growing, drought-resistant, nitrogen-fixing tree that coppices readily; used extensively for green manure, soil conservation and livestock feed.



Leucaena diversifolia

from: NFT Highlights

NFTA 92-05, October 1992

FAMILY: LEGUMINOSAE
Sub-Family: Mimosoideae

Prosopis juliflora
Mesquite

Description: Native of tropical America. Small to medium semi-evergreen spiny tree, or multi-stemmed shrub, 3-12 m high, short trunk with open flat-topped or rounded crown of spreading branches; bark dark brown or grey, furrowed, twigs with single or paired stout straight spines; **leaves** compound and green to pale green; **flowers** greenish-white to pale yellow in clustered spikes; **fruits** long, narrow, slightly curved pods, yellow to brown, seeds in a 4-angled case.

Uses/Products: Wood hard, heavy, and durable, excellent for fuel; used for fence posts, door and window frames and other light carpentry; pods valuable livestock feed, and can be ground into flour for human consumption; flowers good source for honey.

Special Notes: A fast-growing, deep-rooted, nitrogen-fixing tree that coppices readily, used for improving soil fertility, dune stabilisation, and providing fuelwood and fodder. Foliage is unpalatable so it can become a weed if grazing and land-use pressures are low.

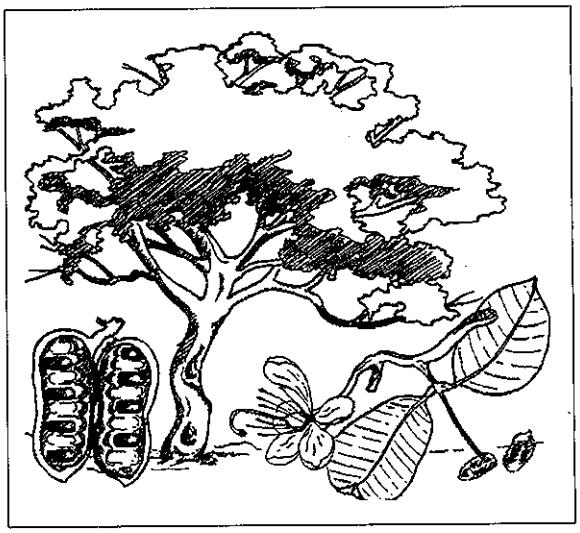
Prosopis juliflora

from: Common Fuelwood Crops. Elbert L. Little, Jr.

FAMILY: LEGUMINOSAE
Sub-Family: Caesalpinioideae

Afzelia quanzensis
Pod Mahogany **Msambamfumu**

Description: Indigenous. Medium to large tree with a spreading crown up to 24 m, occurring in low-medium altitudes, semi-arid woodland, often on deep sand. **Bark** flaking in thick roundish scales, greyish-white; **leaves** paripinnate, glossy dark green above, margin wavy, petioles twisted; **flowers** with a single large streaked pink-red petal; **fruit** a large, thick flatish pod, deshiscing while on tree, seeds black with scarlet aril.



Afzelia quanzensis

from: Indigenous multipurpose trees of Tanzania. Uses and economic benefits for people.

Uses/Products: Wood very durable and fairly resistant to termites, used for quality joinery, doors, window frames, floors and starcases. Leaves and pods are valued as fodder. The leaves are edible for humans. Roots used to treat chest pains, kidney problems and snakebites.

FAMILY: LEGUMINOSAE
Sub-Family: Caesalpinioideae

Caesalpinia decapetala
Mauritius Thorn **Kapitagwilere /Mlunguzi**

Description: Native of India. A scandent thorny shrub up to 7 m high; **leaves** compound and dark grayish-green; **flowers** yellow in long attractive racemes; **fruit** a roundish pod, in clusters, pointed, brown, oblong and somewhat woody.

Uses/Products: Makes an impenetrable live hedge, planted around vegetable gardens or kholas as livestock enclosures.

Special Notes: Needs careful management to keep it from overgrowing and becoming a weed, but this is difficult as it is so thorny.

Caesalpinia decapetala

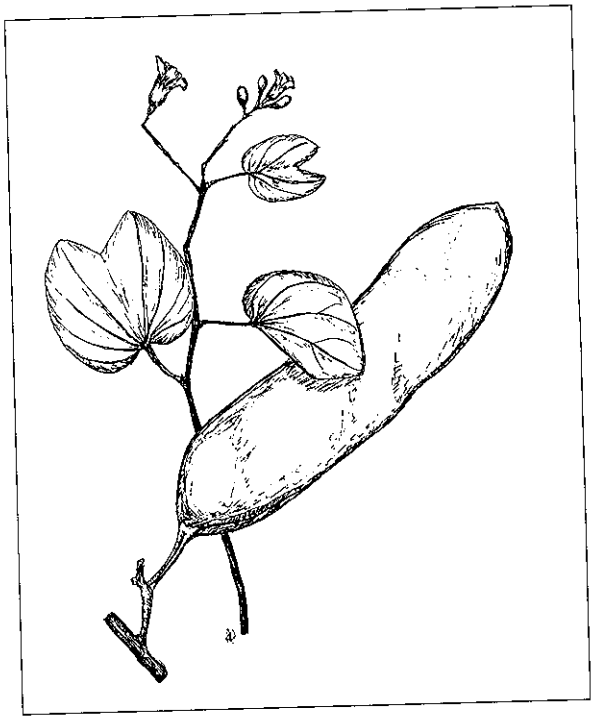
from: Trees of Kenya, 1989. T. Noad and A. Birnie. ill: A. Birnie

FAMILY: LEGUMINOSAE
Sub-Family: Caesalpinioideae

Bauhinia thonningii
Monkey Bread, **Chitimbe**
Camel's Foot

Description: Indigenous. A small to medium sized, deciduous tree with rounded crown up to 10 m. **Bark** dark brown and furrowed; **leaves** large 2-lobed, wing-shaped and leathery; **flowers** white and small in racemes opposite the leaves, sexes separate; **fruit** a large, thick pod becoming woody at maturity.

Uses/Products: Bark used for string and rope; wood for fuel, poles, and tool handles; green pods used as a soap-substitute; whole pods excellent animal fodder, and can be ground for human consumption, the softer inside can also be eaten; the leaves, roots, and bark have various medicinal values including treatment of stomach ache, rheumatism, gum infections, eye inflammation, and venereal diseases.



Bauhinia thonningii

from: Fifty common trees of Zambia. 1968. Forest Department Bulletin No. 5.

FAMILY: LEGUMINOSAE
Sub-Family: Caesalpinioideae

Senna siamea
Cassia **Keshya wa Milimo**

Description: Native of southeast Asia. Medium-sized evergreen tree to 18 m high, straight trunk, dense upright crown often irregular and spreading. **Bark** grey, smooth to slightly fissured; **leaves** compound, long, shiny green on top, sometimes tinged with red-brown; **flowers** yellow in upright showy clusters; **fruit** long, narrow, flat pods hanging in clusters.

Uses/Products: Wood excellent but smoky fuel, susceptible to dry-wood termites, also used for posts, construction, and furniture; widely grown as plantation tree in Africa; popular fast-growing tree for reforesting hills and waste land; common as a shade and ornamental tree along roads, parks and gardens.

Senna siamea

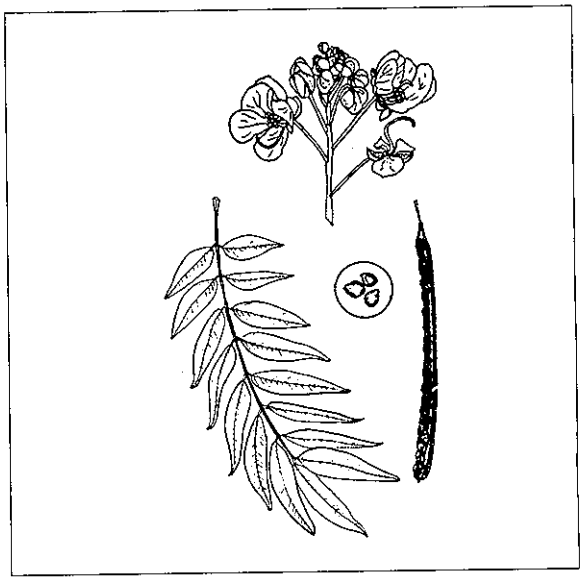
from: Common Fuelwood Crops. Elbert L. Little, Jr.

FAMILY: LEGUMINOSAE
Sub-Family: Caesalpinioideae

Senna spectabilis
Cassia **Keshya wa Maluwa**

Description: Native of tropical America, widely planted elsewhere in the tropics. A rounded deciduous tree to 10 m. **Bark** smooth grey; **leaves** compound, long, and dark green with narrow elliptic leaflets; **flowers** bright yellow in showy clustered spikes; **fruit** long, cylindrical pods with honey-combed horizontal seed chambers, green turning black.

Uses/Products: Popular as a shade and ornamental tree along roads, parks and gardens; fast-growing with good fuelwood, and poles for light construction; coppices readily; not good fodder, can be poisonous to pigs and horses. Can also be used as a green manure bank.



Senna spectabilis

Trees of Kenya, 1989.
T. Noad and A. Birnie. ill: A. Birnie

FAMILY: LEGUMINOSAE
Sub-Family: Papilionoideae

Cajanus cajan
Pigeon Pea **Nandolo**

Description: Native range uncertain, perhaps southeast Asia, East Indies, or northeast Africa, widely cultivated throughout the tropics and sub-tropics. Deciduous upright, bushy, and much-branched shrub 1-3.6 m tall, generally short-lived 2-7 years; **leaves** dark grey-green, compound with 3 lance-shaped leaflets; **flowers** in clustered racemes, pea-shaped, usually yellow or orange; **fruit** abundant, oblong 5-8 cm long pods, green turning pale brown.

Uses/Products: Nutritious, high-protein seed, cooked or eaten fresh; pods, seeds, and dried foliage good livestock feed; woody stems have some fuelwood value.

Special Notes: Widely grown for food, and for improving soil fertility through its deep root system and nitrogen fixing nodules, commonly used for green manure, soil conservation, and hedge windbreaks. Many varieties have been bred for different purposes and environments. Plants are often susceptible to root nematodes and fusarium wilt.

Cajanus cajan

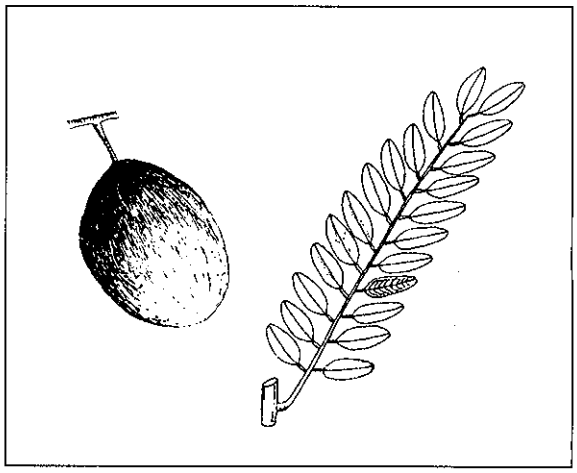
from: Useful Plants of Malawi, 1975. J. Williamson. ill: M. M. Moss.

FAMILY: LEGUMINOSAE
Sub-Family: Papilionoideae

Cordyla africana
Wild Mango **Mtondo**

Description: Indigenous. A large spreading tree up to 25 m, occurring at low altitudes in hot areas, often part of riverine vegetation. **Bark** brown and rough; **leaves** alternate, compound and imparipinnate with 11 to 28 pairs of leaflets and a terminal one, 2 to 5 x 1.8 cm, with rounded apex, slightly notched, base rounded, margin entire; **flowers** a semi-sperical head of orange-yellow stamens 2.5 cm long, flowers in axillary sprays, petals absent; **fruit** a very unusual pod, spherical and fleshy, 4 to 8 x 3 to 6 cm, thin walled, indeshiscent, yellow when ripe with seeds imbedded in the pulp.

Uses/Products: Fruts are high in vitamin C, can be eaten fresh or cooked. The heartwood is brown and hard, used for building and making drums.



Cordyla africana

from:Trees of Southern Africa, 1977. K. O. Palgrave.

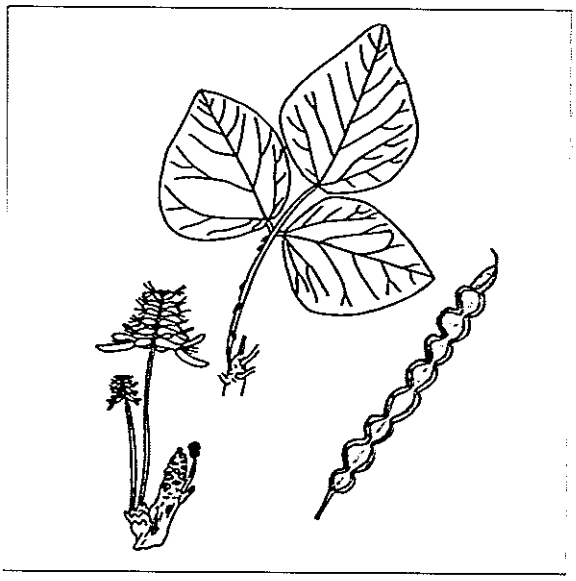
FAMILY: LEGUMINOSAE
Sub-Family: Papilionoideae

Erythrina abyssinica
Red-Hot Poker Tree **Muwale**

Description: Indigenous. A deciduous, thorny tree 8-15 m tall, often with a rounded crown. **Bark** thick, corrugated, and corky; **leaves** compound with 3 large, broad leaflets; **flowers** in red showy racemes before leafing out; **fruit** a woody constricted pod, seeds bright red with a black aril.

Uses/Products: Wood soft and pithy, used for carving spoons, pestles, drum barrels, toys and beehives; good for live fence posts cut from truncheons before flowering; regarded as a soil improving tree from nitrogen fixation and abundant leaf-fall. Colorful seeds used in bracelets and necklaces; seeds contain a poison that can be fatal if swallowed but is likely to pass through undigested because of their hardness; tree has various local medicinal and cultural uses.

Special Notes: A valued tree, best grown from truncheons, also raised from seed.



Erythrina abyssinica

from: Useful Plants of Malawi, 1975. J. Williamson.

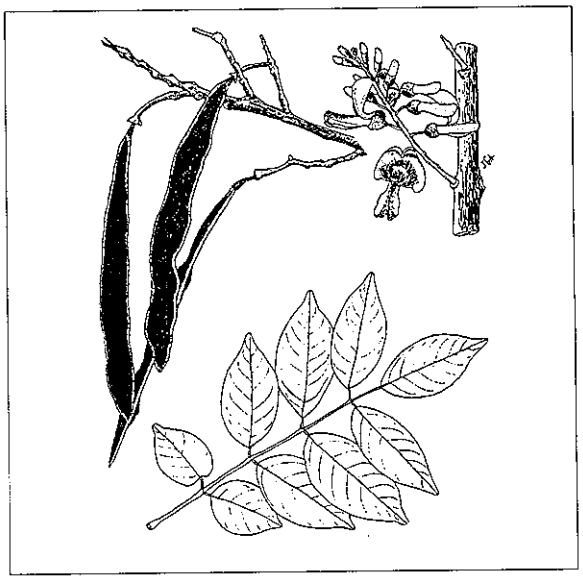
FAMILY: LEGUMINOSAE
Sub-Family: Papilionoideae

Gliricidia sepium **Gliricidia**
Mexican-Lilac

Description: Native to tropical America. Small deciduous tree 6-10 m tall with irregular, spreading crown and thin canopy. **Bark** grey, smooth; **leaves** compound, 15-40 cm long, dull green or grey green, slightly hairy underneath; **flowers** whitish-pink, pea-shaped in clustered racemes along branches, **fruit** a narrow, flat pod 10-15 cm long, yellow-green turning blackish at maturity.

Uses/Products: Wood hard and heavy, good fuelwood, used for posts, construction, furniture, tool handles; stem cuttings grown for living fences; used for cattle fodder, green manure, shade for coffee and cocoa plantations, reforestation, and as a support for vanilla and black pepper vines; enriches soil by nitrogen-fixation in root nodules; flowers good for honey making.

Special Notes: Seed availability in Malawi is presently limited. Bark, roots, seeds, and leaves contain poisons used to kill rodents. Fresh foliage should not generally be browsed by animals, especially monogastrics like pigs and horses, due to toxic compounds which break down considerably when dried or wilted.



Gliricidia sepium

from: NFT Highlights. Little and Wadsworth, 1964.

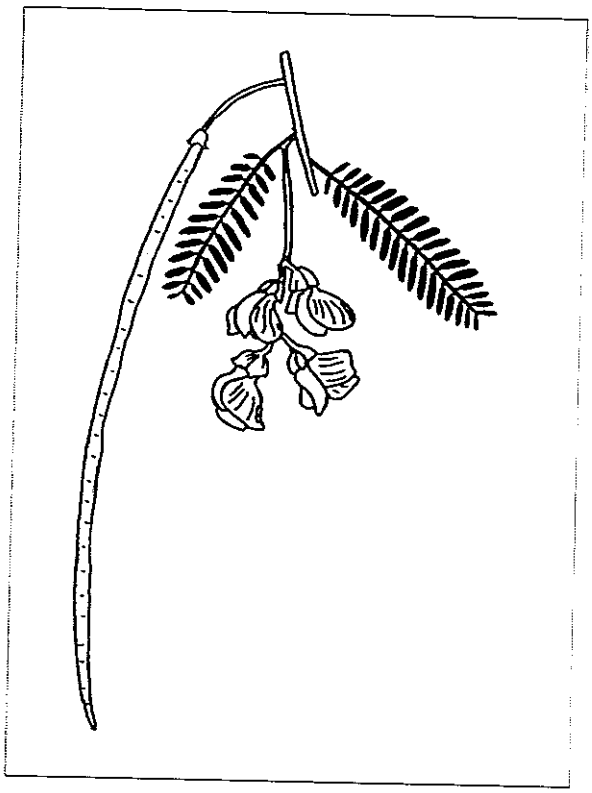
FAMILY: LEGUMINOSAE
Sub-Family: Papilionoideae

Sesbania sesban
River Bean **Jelejele, Binu**

Description: Indigenous. A deciduous shrub or small tree 4-8 m tall, short-lived. **Bark** reddish-brown; **leaves** compound with small, oblong blue-green leaflets; **flowers** yellow, pea-shaped, the standard petal veined with dark maroon, in sprays 15 cm long; **fruit** a slender, curved, pale-brown pod up to 20 cm long and cylindrical.

Uses/Products: The wood is light and soft, but makes good firewood and useful for light construction; good fodder and green manure; tree has various medicinal uses.

Special Notes: Easy to establish and very fast-growing from seed on a wide range of soils; deep root system and nitrogen-fixing nodules improve soil fertility. Problems include short-lived nature, susceptibility to root nematodes, and poor response to pruning.



Sesbania sesban

from: Trees of Kenya, 1989. T. Noad and A. Birnie.

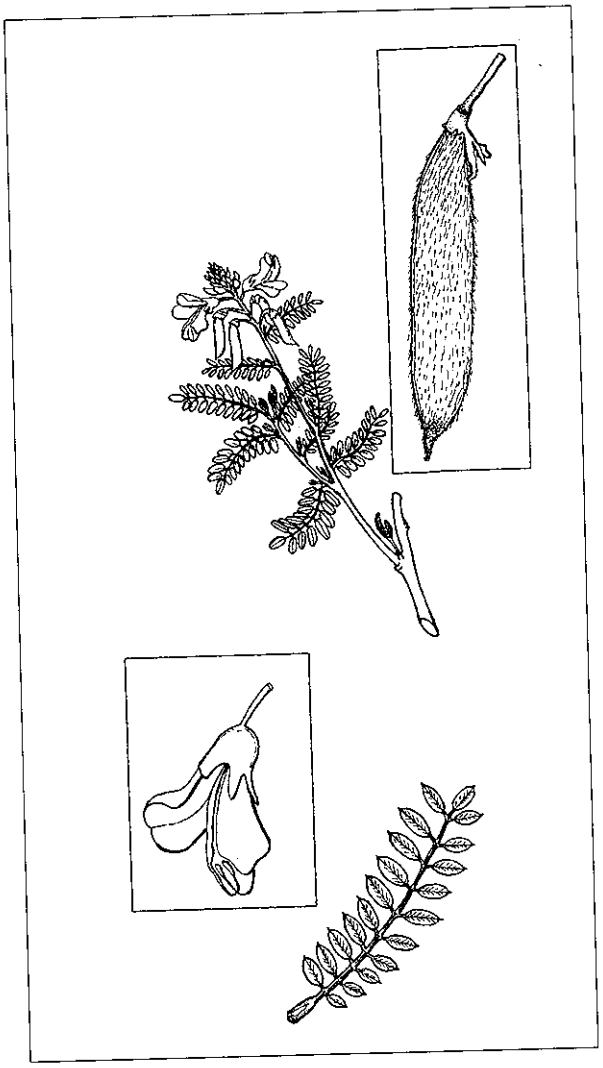
FAMILY: LEGUMINOSAE
Sub-Family: Papilionoideae

Tephrosia vogelii
Fish Bean **Mthuthu, Mtetezga**

Description: Possibly indigenous, but may have been introduced long ago, now naturalised. A herbaceous shrub 2-3 m tall, with dense covering of yellowish hairs. **Bark** smooth, greenish turning dark grey; **leaves** compound, blue-green and velvety; **flowers** in dense racemes of red, purple or white flowers; **fruit**, a furry pod, hanging in clusters with numerous black and white seeds.

Uses/Products: Leaves, branches and pods pounded and thrown on water to stun or kill fish, which rise to the surface to be collected and eaten; valuable insecticide with leaves containing 15% tephrosin and seeds 30%, locally used to treat stem borers in maize; used as a shade-windbreak tree for tea and coffee.

Special Notes: Easy to establish and very fast-growing from seed on a wide range of soils, best at medium to high altitudes; deep root system, heavy leaf-fall and nitrogen-fixing nodules improve soil fertility. Problems include short-lived nature, susceptibility to root nematodes, and poor response to pruning.



Tephrosia vogelii

ill: D. Chimutu

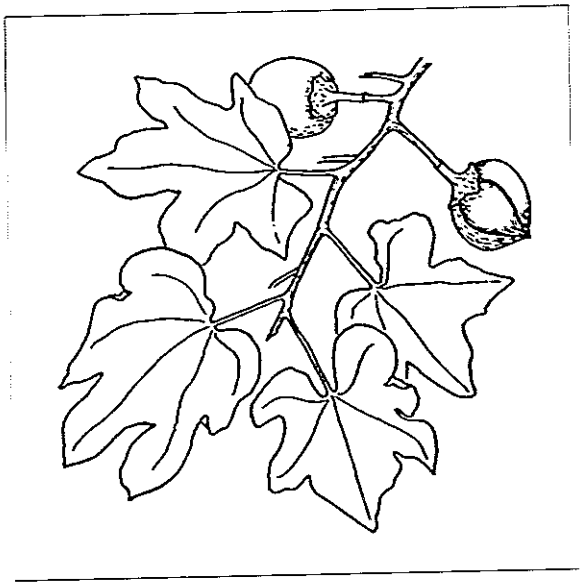
FAMILY: MALVACEAE

Azanza garckeana
Snot Apple **Mtowo**

Description: Indigenous. A bushy shrub or smallish tree 3-10 m high. **Bark** brown and rough, branchlets with shaggy wooly hairs; **leaves** hairy, simple, 3-5 lobed up to 20 cm x 20 cm, usually smaller; **flowers** showy, not opening fully, aging from yellow to orange-red; **fruit** a woody, hairy spherical capsule 2.5-4 cm divided into 5 clear sections, yellow to brownish-green when mature.

Uses/Products: Fruits edible, eaten like chewing gum; wood used for tool handles, and the inner bark provides a fibre.

Special Notes: Tree is host to the cotton stainer, therefore unpopular in cotton-growing areas.



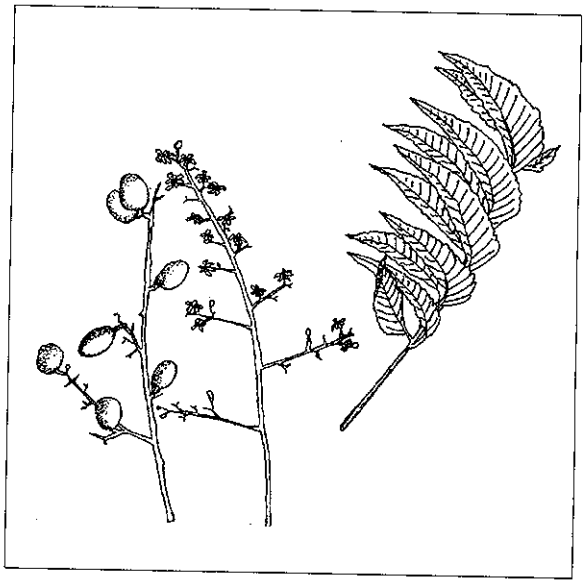
Azanza garckeana

from: A Field Guide to Lengwe National Park, 1984. B.Y. Sherry and A.J. Ridgeway.

FAMILY: MELIACEAE

Azadirachta indica
Neem **Nimu**

Description: Native of Burma and India, now widely planted throughout the tropics in Asia and Africa. A semi-evergreen, medium-sized handsome tree, 10-15 m tall, with straight short trunk and spreading branches forming a dense rounded crown. **Bark** grey-brown, thick with scaly plates; **leaves** compound at ends of twigs 20-35 cm long, leaflets lance-shaped, pointed with saw-tooth edges, dull green above, paler below; **flowers** fragrant, small and white in clusters; **fruit** a fleshy drupe, numerous, oblong 1.3-2 cm long, light yellow turning purple, 1-seeded.



Azadirachta indica

from: Trees of Kenya, 1989. T. Noad and A. Birnie.

Uses/Products: The wood is moderately heavy, hard and durable; resistant to decay and attack by insects; excellent fuel; used for construction, poles, lumber, furniture, farm tools, and carving; most parts of the tree yield commercial by-products, and nearly all have medicinal uses; oil from the seed used in soaps, disinfectants, drugs, cosmetics, and lubricants; seed cake is an excellent fertiliser; used for shade and windbreaks along streets and pastures, and for reclamation of arid lands.

Special Notes: Neem is a fast growing tree that coppices readily. Azadirachtin from the seed and leaves is a promising insect repellant. Dried leaves are used to protect stored crops, cloth and books from insect attack. Leaves and twigs have been used as mulch and green manure. Without proper storage, seed has short viability, so needs to be planted quickly in pots or as bare-root stock.

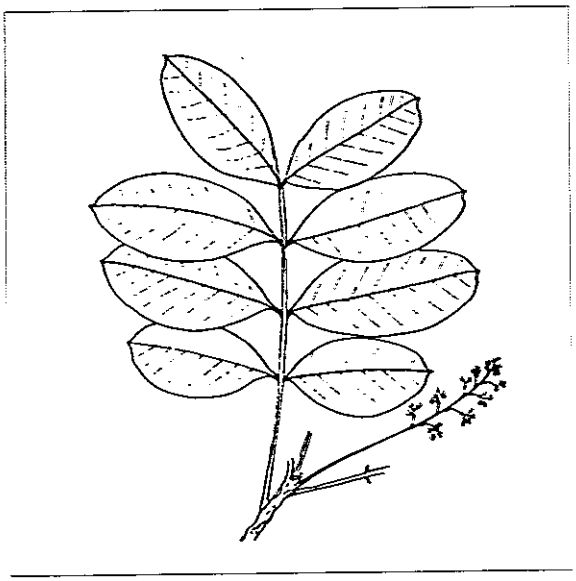
FAMILY: MELIACEAE

Khaya nyasica (anthotheca)

Red Mahogany **Mbawa**

Description: Indigenous. A large handsome tree up to 45-60 m tall, with long straight trunk and enormous rounded crown of glossy foliage. **Bark** grey, mostly smooth but flaking; **leaves** compound and large; **flowers** small, white and inconspicuous in many-flowered panicles; **fruit** an oval woody capsule 3-5 cm, splitting into 4-5 valves that release many winged seeds.

Uses/Products: An important timber species, used extensively for furniture, doors, cabinets, and panelling as it works easily and takes a fine polish; infusion of the bark to relieve colds.



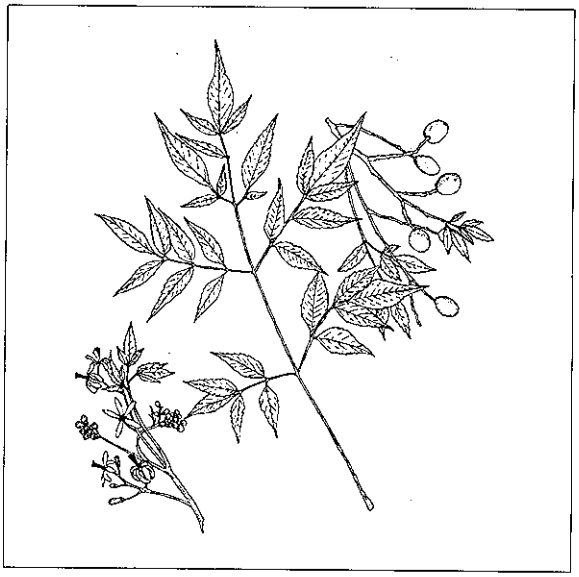
Khaya nyasica

from: Useful Plants of Malawi, 1975. J. Williamson.

FAMILY: MELIACEAE

Melia azedarach
Persian Lilac, Chinaberry **Indya**

Description: Native of southern Asia, widely planted as an ornamental throughout the tropics. A small to medium size deciduous tree 6-15 m tall with spreading branches and hemispherical crown. **Bark** grey and smooth becoming brown and furrowed with age; **leaves** compound 20-40 cm long, leaflets lance-shaped, long-pointed with saw-toothed edges, dark green above, paler below; **flowers** pink-purple, showy, fragrant, and numerous on slender stalked panicles; **fruits** a fleshy yellow berry about 1 cm diametre, hanging in persistent clusters, stone hard with 3-5 seeds.



Melia azedarach

Common Fuelwood Crops.
Elbert L. Little, Jr.

Uses/Products: Wood used for fuelwood, roofing poles on houses, furniture, and tool handles; has insecticidal properties for locust control and protecting stored clothing and books; various tree parts have medicinal uses.

Special Notes: Berries are extremely poisonous to people and some livestock.

FAMILY: MELIACEAE

Toona ciliata
Toon Tree **Sendrella**

Description: Native of tropical Asia, now widespread in the tropics. A large, spreading deciduous tree with thick trunk up to 20-25 m. **Bark** dark grey-brown, rough, furrowed and cracking in squares; **leaves** compound and large up to 90 cm long with narrow leaflets up to 15 cm long; **flowers** small, white, bell-shaped, and inconspicuous; **fruit** an oblong brown capsule splitting into star shapes, releasing small winged seeds.

Uses/Products: Good fuelwood; used for light construction and furniture; often planted as a street or park tree, also in plantations and for afforestation.

Toona ciliata

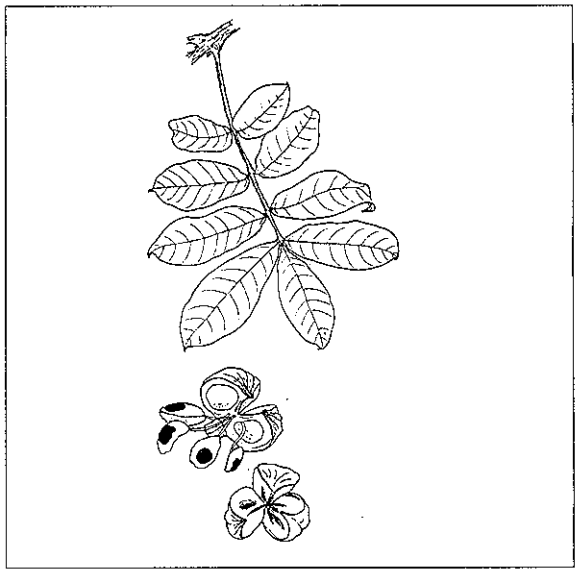
from: Trees of Kenya, 1989. T. Noad and A. Birnie. ill: A. Birnie.

FAMILY: MELIACEAE

Trichilia emetica
Natal Mahogany **Msikidzi**

Description: Indigenous. A handsome medium-large evergreen tree 8-20 m high, with dark hanging foliage and dense rounded crown. **Bark** dark grey to brown, smoothish to rough; **leaves** compound, up to 45 cm long, leaflets oval up to 15 cm long, dark glossy above with dense curly hairs below; **flowers** inconspicuous, dull white, fragrant, in axillary clusters; **fruit** a round, velvety brown capsule, 3 cm diameter, splitting into 3-4 valves, black seeds enclosed with a brilliant orange aril.

Uses/Products: Good fuelwood, works well but needs treatment against borer attack; used for furniture, household utensils, shelving and dug-out canoes; bark soaked in warm water and used as an emetic; boiled seed that has been ground and pounded produces a superior oil for anointing the body and hair; it is also rubbed into cuts and bruises to aid healing; can also be taken internally for rheumatism and the high fat content of the seeds is used for cooking and soap-making.



Trichilia emetica

from: Trees of Kenya, 1989. T. Noad and A. Birnie. ill: A. Birnie.

Special Notes: This is a fast-growing tree with many uses. Plant the seeds quickly after removing the orange aril as viability is short.

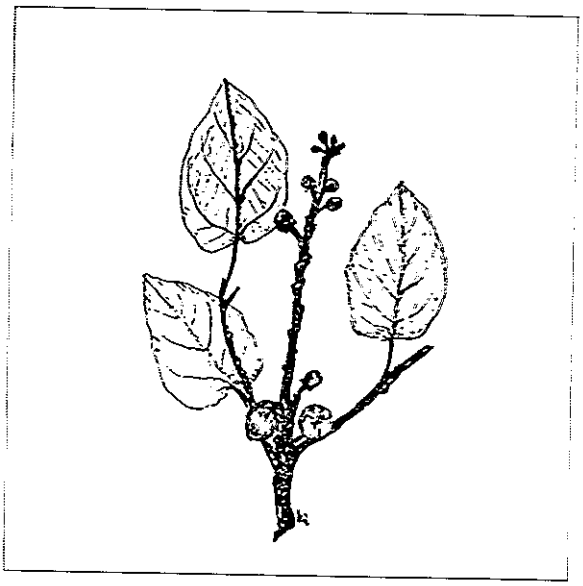
FAMILY: MORACEAE

Ficus capensis
Cape Fig **Mkuyu**

Description: Indigenous. A large spreading tree 12-25 m tall. **Bark** grey, smoothish; **leaves** large and ovate up to 23 x 12 cm, greenish-grey but conspicuously red when young; **flowers** small, inconspicuous; **fruits** in large, heavy branched clusters or fascicles on stems and trunk, each 3-4 cm in diameter.

Uses/Products: Fruit is edible and can be made into jams; leaves used for sandpaper; wood for making drums and mortars; the tree has many medicinal uses: latex used to treat burns and septic conjunctivitis; leaf and bark infusions are given to cows to increase milk yields, and there are many cultural values and beliefs ascribed to the tree.

Special Notes: A good shade tree growing well from truncheons.



Ficus capensis

from: Trees of Kenya, 1989. T. Noad and A. Birnie. ill: A. Birnie.

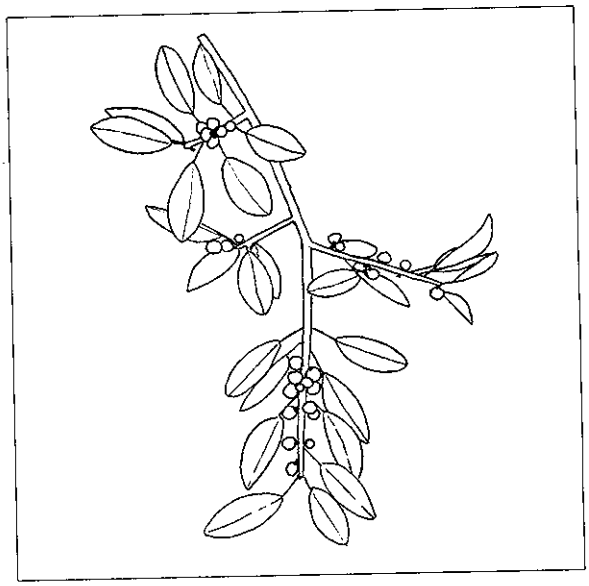
FAMILY: MORACEAE

Ficus natalensis
Common Wild Fig **Kachere**

Description: Indigenous. A much branched deciduous tree, variable size, up to 20 m with a rounded crown, sometimes a strangler of other trees. **Bark** grey, smoothish, often with aerial roots hanging down; **leaves** variable, mostly narrow-oblong and dark green; **flowers** small, inconspicuous; **fruits** about 1 cm diameter, smooth and solitary or paired.

Uses/Products: Fruits eaten by animals and birds; bark is used for cloth, to induce lactation and to treat influenza; the tree may have other medicinal or cultural uses.

Special Notes: A good shade tree; growing well from truncheons.



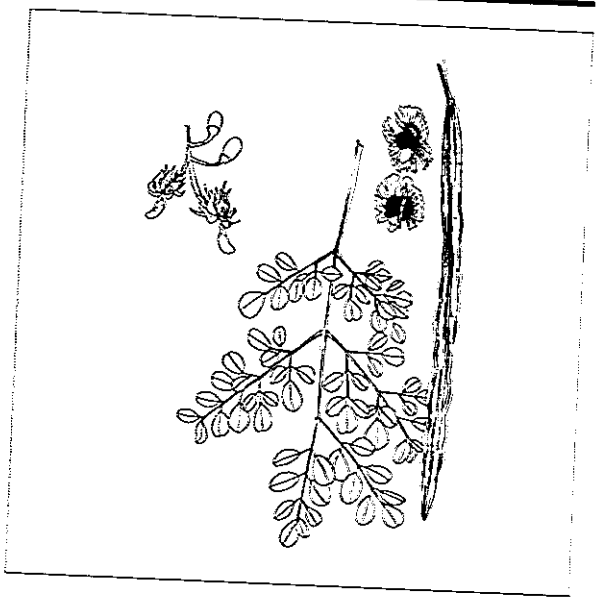
Ficus natalensis

from: Trees of Southern Africa, 1977. Keith Coates Palgrave. ill: Terry Duggan.

FAMILY: MORINGACEAE

Moringa oleifera
Horse-radish Tree

Chamwamba, Kangaluni



Moringa oleifera

from: Common Fuelwood Crops. Elbert L. Little, Jr.

Description: Native of India and Arabia, now naturalised in many areas of the tropics. A small deciduous tree 5-10 m tall with a light canopy. **Bark** pale grey, thick and corky; **leaves** pale green, compound 30-60 cm long, leaflets small and oval 1-2 cm long; **flowers** creamy-white, fragrant, in long sprays; **fruit** a long, triangular shaped capsule, splitting to release 3-winged seeds.

Uses/Products: Foliage is good fodder; leaves, flowers and young fruit are cooked after pounding and used as a relish in a solution of potatoes, also used in flavouring curries; oil from the seeds known as Ben oil used in salads, skin poultices, soap-making, lubricating machinery, and in cosmetic and textile industries. Pressed seed cake has potential as a livestock feed. Powder ground mostly from the seeds makes an excellent water purifier, replacing alum; also used as a cure for scurvy.

Special Notes: A useful fast-growing tree, mostly grown from truncheons, but also from seed.

FAMILY: MYRTACEAE

Eucalyptus camaldulensis **Bulugama**
Gum

Description: Native to Australia, now widely planted around the world. Large, 25-40 m tall, aromatic evergreen tree. **Bark** smooth white-grey with patches of darker gray and red, peeling in long strips. **Leaves** alternate, lance-shaped, often curved, hairless, drooping along twigs. **Flowers** 5-10 in cluster at leaf base. **Fruits** consist of hard seed capsules that open at top with many small seeds.

Eucalyptus camaldulensis

from: Common Fuelwood Crops. Elbert L. Little, Jr. ill: Mueller, 1879.

Uses/Products: Planted as windbreak. Red hardwood resistant to termites, used for firewood, charcoal, construction wood and poles.

Special Notes: The Genus consists of many different species adapted to different climates. For the following four species the recommended environment is given: *E. camaldulensis*, wide range of environments; *E. cloeziana*, medium altitude on flat good soils; *E. grandis*, higher elevations, like Viphya; *E. tereticornis*, wide range of environments.

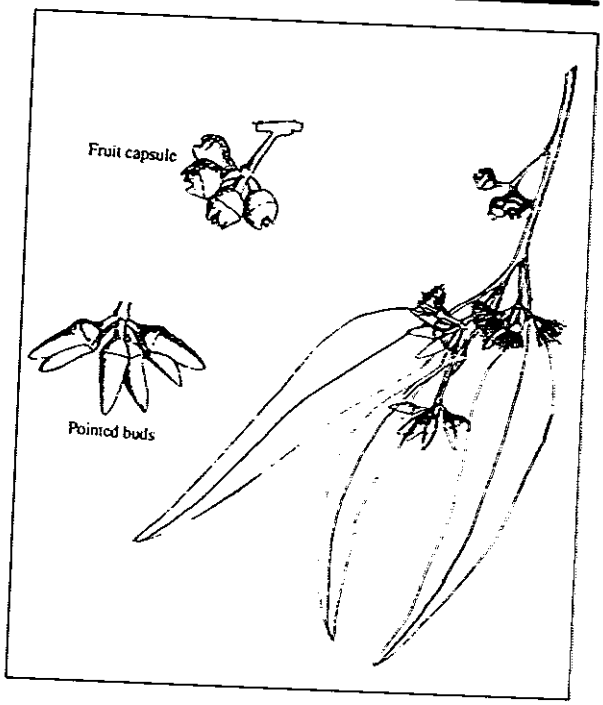
Although very popular for its fast growth, trees of this genus have the disadvantages of exhausting the soil of nutrients and water, due to this fast growth and to storing nutrients in the stem. Eucalyptus trees are not suitable for association or rotation with crops.

FAMILY: MYRTACEAE

Eucalyptus tereticornis
Forest Red Gum **Bulugama**

Description: Native to Australia, now widely planted around the world. Evergreen tree 18–46 m high with straight stout trunk 1–1.8 m in diameter, large and open or fairly dense crown. **Bark** smooth, whitish, peeling in irregular thin sheets or large flakes, becoming mottled with white, gray, or blueish patches; **leaves** alternate, lanceolate, 10–21 cm long, 12–25 mm wide, often curved, acuminate, acute at base, slightly thickened, shiny green on both surfaces, glabrous; **flowers** 5–12, spreading on equal stalks on 5–7 mm, stamens many, threadlike, white, 10–12 mm long; **fruit**, a capsule, hemiglobose or turbinate, 6–9 mm long, 8–10 mm in diameter, containing many tiny seeds, shiny dark brown to black.

Uses/Products: Planted for shade and as windbreak. Red heartwood, hard, durable and resistant to termites. Used for fuel, pulp, pilings, fiberboard, and construction; also for crossties and fenceposts.



Eucalyptus tereticornis

from: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Special Notes: The Genus consists of many different species adapted to different climates, but generally not suitable for growing with crops.

FAMILY: MYRTACEAE

Syzygium cordatum **Katope**
Water Berry

Description: Indigenous. Medium to large evergreen tree 8 to 15 m often with crooked stem and rounded crown, nearly always close to water. **Bark** dark brown, rough and fissured; **leaves** elliptic to circular, bluish green, 8 x 6 cm, successive pairs set at right angles to each other; **flowers** in dense heads at the ends of branches, white to pinkish, with numerous fluffy stamens, sweet scented; **fruit** ovoid, fleshy 1.5 cm long, purple when mature, edible but acidic.

Uses/Products: Wood pale reddish brown, hard, heavy and very durable, used for beams, rafters and boat building. Bark produces a brown dye. An alcoholic drink is made from the fruits.

Syzygium cordatum

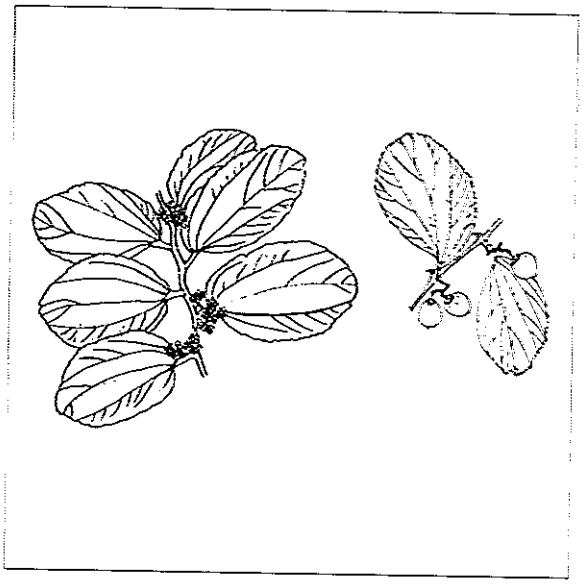
from: Fifty common trees of Zambia. 1968. Forest Department Bulletin No. 5.

FAMILY: RHAMNACEAE

Ziziphus abyssinica
Jujube **Kankhande**

Description: Indigenous. A wickedly armed shrub or small tree to 7 m high, with rounded crown and drooping, tangled branches having scattered recurved thorns. **Bark** grey-brown, becoming rough and fissured; **leaves** ovate up to 8 x 5 cm, 3-veined from base, dark green above, paler below due to dense furry hairs; **flowers** yellow and small in tight axillary clusters; **fruit** round, shiny red-brown, 2-3 cm in diameter.

Uses/Products: Fruit edible; foliage and fruits valued fodder/browse; wood moderately durable, hard, and heavy; excellent fuelwood; used for light construction, making tool handles, farm implements, posts, bedlegs.



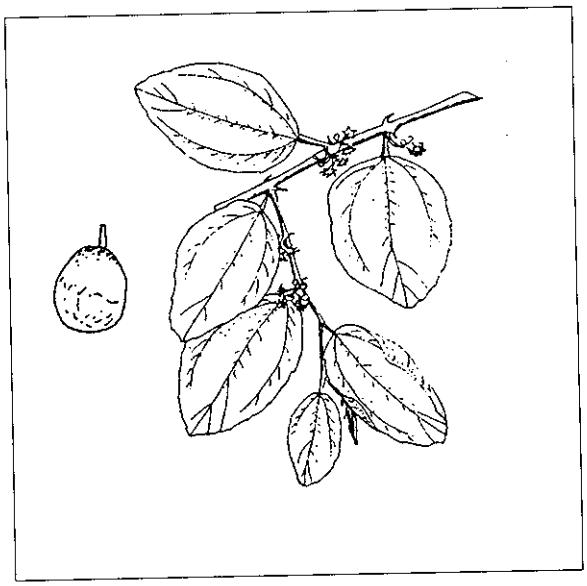
Ziziphus abyssinica

from: Trees of Kenya, 1989. T. Noad and A. Birnie.

FAMILY: RHAMNACEAE

Ziziphus mauritiana
Jujube **Masawo**

Description: Native of southern Asia, now widely naturalised in much of the tropics and sub-tropics. A semi-evergreen, small-medium tree 6-20 m tall, with rounded spreading crown, drooping branches, and recurved thorns. **Bark** dark grey, irregularly fissured; **leaves** oval to elliptical 2-6 cm long, shiny green above, softly hairy below; **flowers** yellow, small and fragrant; **fruits** round and yellow, turning brown, about 1-2 cm in diametre.



Ziziphus mauritiana

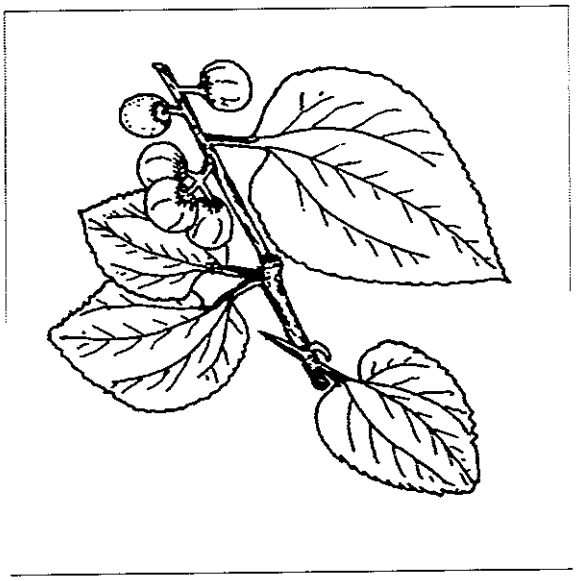
from: Trees of Kenya, 1989. T. Noad and A. Birnie.

Uses/Products: Fruit edible and marketed locally; also made into a refreshing drink and alcoholic spirit; foliage and fruits valued fodder/ browse; wood moderately durable, hard, and heavy; excellent fuelwood; used for light construction, making tool handles, farm implements, posts, beds.

FAMILY: RHAMNACEAE

Ziziphus mucronata
Buffalo Thorn **Kankhande**

Description: Indigenous. A deciduous shrub or small tree to 10 m high with rounded crown and branches with paired thorns, one straight to 2 cm long, the other recurved. **Bark** dark grey, irregularly fissured; **leaves** oval 3-6 cm long, shiny green on both sides, apex tapering and margin finely toothed; **flowers** yellow, small and inconspicuous; **fruits** round and red-brown, about 1-1.5 cm in diameter.



Ziziphus mucronata

from: Trees of Kenya, 1989. T. Noad and A. Birnie.

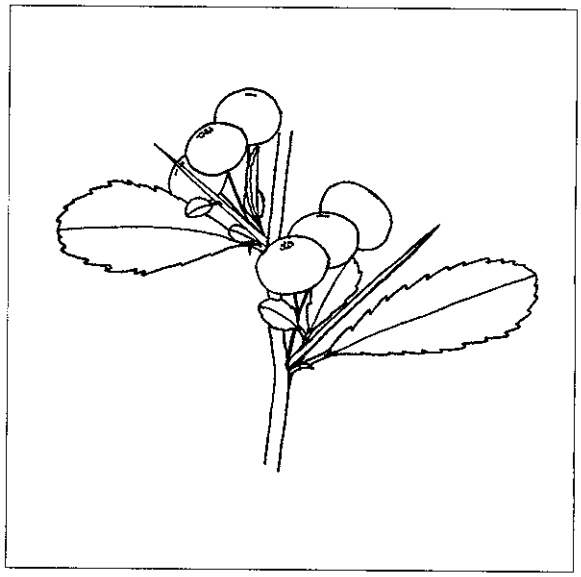
Uses/Products: Fruit edible but pulp is rather dry and mealy; also made into an alcoholic spirit; foliage and fruits valued fodder/browse; wood moderately durable, hard, and heavy; excellent fuelwood; used for light construction, making tool handles, farm implements, posts, beds. This tree has many medicinal and cultural values: a remedy for almost any pain is made from a poultice of powdered and baked roots which are eaten afterwards; a leaf paste is used to treat boils and other skin infections; an infusion of the root is used to treat dysentery and lumbago; powdered leaves and bark to treat chest complaints, and an infusion of the bark to cure coughs.

FAMILY: ROSACEAE

Pyracantha coccinea
Fire Thorn **Mchende**

Description: Shrub, native to S.E. Europe and W.Asia, now widely planted as ornamental hedge. Does well in cool, wet areas; **Leaves** simple, small, obovate with toothed margin, in alternate clusters, on dwarfed lateral shoots that form thorns; **Flowers** white, in clusters at intervals along the stem; **Fruits** clusters of red berries, about 7 mm in diameter.

Uses / Products: Planted as a live fence and ornamental hedge.



Pyracantha coccinea

ill. F. Bodnar

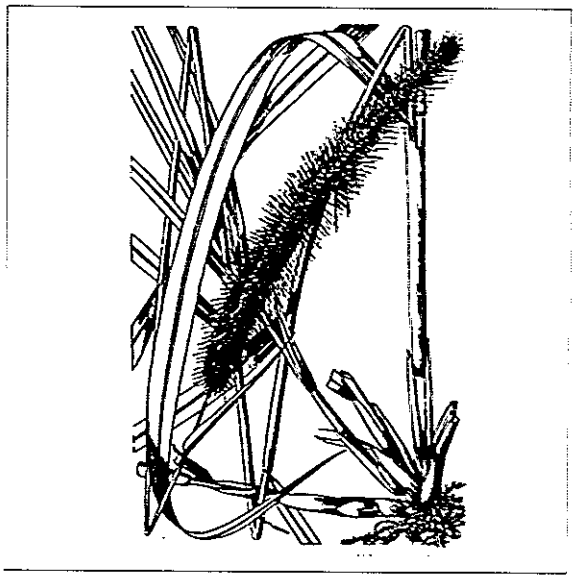
FAMILY: GRAMINACEAE

Pennisetum purpureum
Napier Grass **Nsenjere**

Description: Indigenous. A perennial grass with reed-like stems 2.5 cm in diameter, up to 4.5 m tall. **Leaves** sharp-edged; **flower** a bulrush-like spike, sometimes not producing seed.

Uses/Products: Stout stems used for hut walls and fences, sometimes thatching; provides useful fodder, making good hay if cut when less than 1.3 m high; also makes good quality paper.

Special Notes: Since napier grass rarely produces viable seed, it is established from stem or root cuttings. Stem cuttings are pushed into the soil at an angle of 45 degrees, burying at least 2 nodes. Root cuttings are planted 7.5 cm deep. Although very productive, repeated cuttings cause yields to decline, requiring replanting after 4 years. Napier is fairly disease resistant, but susceptibility to nematodes precludes its use in tobacco rotations.



Pennisetum purpureum

from: Useful Plants of Malawi, 1975. J. Williamson.

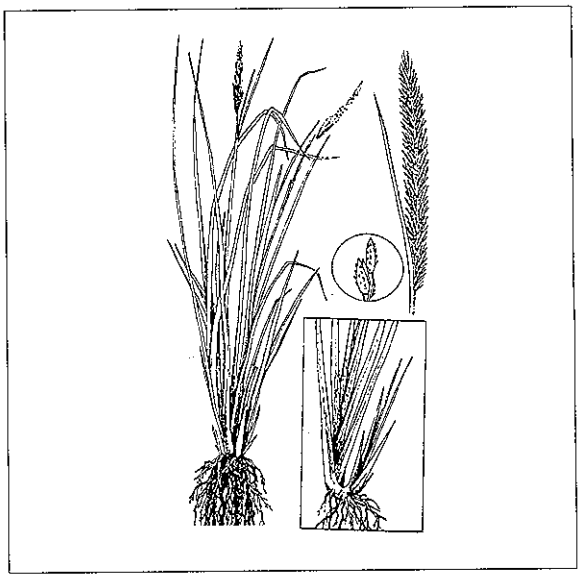
FAMILY: GRAMINACEAE

Vetiveria zizanioides
Vetiver Grass **Thedzi**

Description: An introduced grass aimed at erosion control. Vetiver is a densely tufted, awnless, wiry, deep-rooted perennial. It grows in large clumps from a much-branched spongy root-stock with erect culms 1-2.5 m tall. **Leaves**, are stiff, narrow and up to 100 cm long, **flower heads**, purple with panicles 15-30 cm long, some cultivars rarely flower.

Uses/Products: Cultivated mostly for erosion control and to stabilise road/dam embankments; makes good thatching; generally unpalatable but will be grazed when other forage is limiting; roots used for baskets and other woven crafts, which also yield an oil used in the cosmetics industry.

Special Notes: Since vetiver grass rarely produces viable seed, and has no stolons or rhizomes, it is propagated from root divisions or "slips".



Vetiveria zizanioides

from: Mickey Patel & Co, 1987.

Table 8: Plant Spacing and Density/HA for Each Technology

TECHNOLOGY		DIRECT SOWN SEEDS		NURSERY SEEDLINGS	
		Field Spacing	Plants/ha or /km	Field Spacing	Plants/ha or /km
Undersowing	Tephrosia and Cajanus	0.9 x 0.45 m	24,691 /ha	NA	NA
	Sesbania	NA	NA	0.9 x 0.9 m	12,346 /ha
Short Term Fallows	Long-Lived Trees	NA	NA	1.8 x 1.8 m	3,086 /ha
	Sesbania sesban			0.9 x 0.9 m	12,346 /ha
	Tephrosia and Cajanus	0.9 x 0.45 m	24,691 /ha	NA	NA
Dispersed Systematic Interplanting		NA	NA	10 x 5 m	200 /ha
Green Manure Banks	Tephrosia and Cajanus	0.9 x 0.45 m	24,691 /ha	NA	NA
	Senna spectabilis	NA	NA	1.8 x 1.8 m	3,086 /ha
Fodder Banks	Leucaena, Gliricidia and Sesbania	NA	NA	0.9 x 0.9 m	12,346 /ha
Alley Cropping	Tephrosia	3.6 x 0.45 m	6173 /ha	NA	NA
	Gliricidia, Leucaena and Senna	NA	NA	4.5 x 0.9 m	2469 /ha
Mixed Tree Intercropping		1.8 x 0.9 m	6,173 /ha	1.8 x 0.9 m	6,173 /ha
Homestead / Farm Boundaries	Small and medium trees	NA	NA	2 m	500 /km
	Large trees			4 m	250 /km
Woodlots	For Poles	NA	NA	1 x 2 m	5,000 /ha
	For Fuelwood			2 x 2 m	2,500 /ha
Live Fences	Tree seedlings	NA	NA	0.4 m	2,500 /km
	Tree truncheons			1 m	1,000 /km
	Sisal			1.0 m	1,000 /km
Live Farm Sheds	Seedlings and Truncheons	NA	NA	2 x 2 m	NA
Tree Seed Orchards		NA	NA	4 x 4 m	625 /ha
SOIL AND WATER CONSERVATION					
Contour Strips *	Vetiver Slips / Napier Cuttings	NA	NA	0.10 m	10,000 /km
	Large Multipurpose Trees	NA	NA	5 m	200 /km
	Small trees like Sesbania	NA	NA	1 m	1,000 /km
	Tephrosia, Cajanus	0.4 m	2,500 /km	NA	NA
Vetiver Grass Nurseries (pure stand)		NA	NA	0.45x 0.45 m	49,383

After establishment, thin out trees so that there is only one seedling per station.
Carefully done at an early stage, thinned plants can be transplanted into containers where seeds failed to germinate.
Numbers of seeds to sow per station depends on the species used (see Table 11 for more information).
* Distance between grass strips varies from 15 m on gentle slopes. 10 m on medium slopes and 5 m on steep slopes.

Table 9: Agroforestry Species: Technology, Size and Altitude Range

SPECIES			Technology [1]	Size [2]	Altitude Range [3]
Botanical Name	**Chichewa**	**English**			
Acacia galpinii	NKUNKHU	Monkey thorn	BH, SI, FA, WL, LF, SB	L	L-M
Acacia nigrescens	MKUNKHU	Knob thorn	BH, FA, WL, LF	M	L
Acacia nilotica	MPAMPA	Scented thorn	BH, FA, WL, LF, SB	S-M	L-M
Acacia polyacantha	MTHETHE	White thorn	BH, SI, FA, WL, SB	M	W
Acacia sieberiana	MINGANZOLO	Paperbark acacia	BH, FA, WL, LF, SB	M	W
Acacia tortilis	NCHONGWE	Umbrella thorn	BH, FA, WL, LF	S-M	L
Agava sisalana	KHONJE	Sisal	LF, BH	-	L-M
Afzelia quanzensis	MSAMBAMFUMU	Pod Mahogany	BH, WL	L	L-M
Albizia lebbeck	MTANGATANGA	Woman's tongue	BH, FA, WL	M	L-M
Albizia versicolor	MTANGATANGA	Poison-pod albizia	BH, FA, WL, SB	M	W
Annona senegalensis	MPOSA	Wild custard apple	BH	S	L-M
Azadirachta indica	NIMU	Neem	BH, WL	M	L
Azanza garkeana	MTOWO	Snot apple	BH, SI	S	W
Bauhinia thonningii	CHITIMBE	Monkey bread	BH, FA, SB	S-M	W
Bridelia micrantha	MPASA	Bridelia	BH, WL	S-M	M
Caesalpinia decapetala	KAPITAGWILERE	Mauritius thorn	LF	S	W
Cajanus cajan	NANDOLO	Pigeon Pea	AC, US, FA, CS	SS	W
Combretum imberbe	MNANGALI	Leadwood	BH, WL	M-L	L
Cordyla africana	MTONDO	Wild mango	BH, SB	L	L
Dichrostachys cinerea	CHIMPHONGALA	Sickle bush	F/MB	S	L-M
Erythrina abyssinica	MUWALE	Red-hot poker tree	BH, FA, LF	M	W
Eucalyptus species	BULUGAMA	Gum	BH, WL	L	W
Faidherbia albida	MSANGU	Winter thorn	BH, SI, FA, SB	L	W
Ficus capensis	MKUYU	Cape fig	BH, LF, LFS, SB	M-L	W
Ficus natalensis	KACHERE	Common wild fig	BH, LF, LFS, SB	L	W
Flacourtia indica	NTHUDZA	Indian plum	BH	S	W

[1] Technologies: AC=Alley Cropping; BH=Boundary Homestead; CS=Contour Vegetation Strips; FA=Fallows; F/MB=Fodder / Green Manure Banks; LF=Live Fences; LFS=Live Farm Sheds; MTI=Mixed Tree Intercropping; SB=Streambank Planting; SI=Systematic Interplanting; US=Undersowing; WL=Woodlots

[2] Tree size: SS small shrub; S=small; M=medium; L=large.

[3] Altitude range: W=Wide range; L=Low altitudes; M=Medium altitudes; H=High altitudes.

Table 9 continued: Agroforestry Species: Technology, Size and Altitude Range

SPECIES					
Botanical Name	Chichewa	English	Technology [1]	Size [2]	Altitude Range [3]
Gliricidia sepium	GLIRICIDIA	Mexican lilac	AC, F/MB, FA, MTI, CS, WL	S-M	W
Khaya nyasica	MBAWA	Red mahogany	BH, WL, SB	L	W
Leucaena diversifolia	LUKINA	Leucaena	AC, F/MB, FA, CS, WL	S	L-M
Melia azedarach	INDYA	Persian lilac, China berry	BH, WL	S-M	W
Moringa oleifera	CHAMWAMBA	Horse-raddish tree	BH, LF	S	L-M
Pennisetum purpureum	NSENJERE	Napier grass	CS, F/MB	-	W
Prosopis juliflora	-	Mesquite	BH, LF, FA, WL	S	L
Pyracantha coccinea	MCHENDE	Fire thorn	LF	SS	M-H
Sclerocarya birrea	MFULA	Marula	BH, LF, LFS, SB	M-L	L-M
Senna siamea	KESHYA WA MILIMO	Cassia	BH, WL, LFS	M	L-M
Senna spectabilis	KESHYA WA MALUWA	Cassia	AC, BH, CS, WL, LFS	S-M	W
Sesbania sesban	JELEJELE	River bean	US, FA, CS, F/MB, SB	SS	W
Syzygium cordatum	KATOPE	Water berry	BH, SB	M	W
Tephrosia vogelii	MTHUTHU	Fish bean	AC, BH, US, FA, CS	SS	M-H
Terminalia sericea	NAPINI	Silver terminalia	BH, WL	M-L	L-M
Toona ciliata	SENDRELLA	Toon tree	BH, WL	L	W
Trichilia emetica	MSIKIDZI	Natal mahogany	BH, WL, SB	M-L	L-M
Uapaca kirkiana	MSUKU	Wild loquat	BH	S	M-H
Vetiveria zizanioides	THEDZI	Vetiver grass	CS	-	W
Ziziphus abyssinica	KANKHANDE	Jujube	BH, WL, LF, SB	S	M-H
Ziziphus mauritiana	MASAWO	Jujube	BH, WL, LF, SB	S	L-M
Ziziphus mucronata	KANKHANDE	Buffalo thorn	BH, WL, LF, SB	S	W

[1] Technologies: AC=Alley Cropping; BH=Boundary Homestead; CS=Contour Vegetation Strips; FA=Fallows; F/MB=Fodder / Green Manure Banks; LF=Live Fences; LFS=Live Farm Sheds; MTI=Mixed Tree Intercropping; SB=Streambank Planting; SI=Systematic Interplanting; US=Undersowing; WL=Woodlots

[2] Tree size: SS small shrub; S=small; M=medium; L=large.

[3] Altitude range: W=Wide range; L=Low altitudes; M=Medium altitudes; H=High altitudes.

Table 10: Agroforestry Species: Wood, Medicinal and Other Uses

Species	Origin	Fuelwood	Timber/ building	Furniture	Tools/ Carvings	Rope/ Textiles	Animal Fodder	Edible Parts	Medicine/Other
Acacia galpinii	I	++	+	++			+		
Acacia nigrescens	I	++	+	++			+		
Acacia nilotica	I	+	++	++			++	Gum	DY,IM,RP
Acacia polyacantha	I	++	++	+	++		++	Gum	VD,SN,TR
Acacia sieberiana	I	+	+	o	o		++		
Acacia tortilis	I	++				+	+		
Afzelia quanzensis	I	+++	+++	+++	+++		+		
Agava sisalana	E						+		
Albizia lebbeck	E	++	+++	++	++		++		TN
Albizia versicolor	I	+++	+++	+++	+++		++		SP, Pod are Poisonous
Annona senegalensis	I	+	+		+	+		fruit/root	RP,ST,TR
Azadirachta indica	E	+++	++	++	++		o		OL,IN,MM
Azanza garkeana	I	+			+	+		Fruit	Host to cotton stainer
Bauhinia thonningii	I	+	o		o	++	+++	Pods	GP,DY,SP,BP,RU,CN
Bridelia macrantha	I	+++	+++	+++	+++				BP, GP, PE, ST,
Caesalpinia decapetala	I								
Cajanus cajan	E	o					++	Pods	
Combretum imberbe	I	+++	++	o	++				SP,CO,RP
Cordyla africana	I	+++	+++	+++	+++		+++	Fruit	Gum-resin
Dichrostachys cinerea	I	+++			+++		+++		SN, BP, GP
Erythrina abyssinica	I				o				PO
Eucalyptus species	E	+	++						
Faidherbia albida	I	++	+	+	+		+++	Seeds	TN, ST
Ficus capensis	I	o	o			++	++		SK

Origin: I = Indigenous, E = Exotic

Use Ratings: +++ Excellent; ++ Very Good; + Good; o Fair

Blanks: Poor or unknown

Medicinal and other uses:

AB: Aboricide
BP: Head/Body pains
CN: Contraceptive
CO: Cosmetic
DY: Dyes
GP: General purpose medicine
IM: Impotence
IN: Insecticide
MAL: Malaria
MM: Multi medicinal
OL: Oil
PE: Purgative / Enema
PO: Poisonous
RP: Respiratory / Colds
RU: Rheumatism
SK: Skin disorders
SN: Snake bites
SP: Soap
ST: Stomach disorders
TN: Tannins
TR: Traditional beliefs
VD: Venereal diseases
WT: Water treatment

Table 10 continued: Agroforestry Species: Wood, Medicinal and Other Uses

Species	Origin	Fuelwood	Timber/ building	Furniture	Tools/ Carvings	Rope/ Textiles	Animal Fodder	Edible Parts	Medicine/Other
Ficus natalensis	I	o	o			++	++	Fruit	RP, GP
Flacourtia indica	I							Fruit	BP,GP,RP,RU,ST
Khaya nyasica	I	++	+++	+++	++				RP
Leucaena diversifolia	E	++	o				++	Leaves	
Melia azaderach	E	++	o	o					PO,IN
Moringa oleifera	E	o				+	++	All	CO,OL,SK,SP,WT
Pennisetum purpureum	I						++		
Prosopis juliflora	E	+++	+	o	+		++	Pods	
Pyracantha coccinea	E								
Sclerocarya birrea	I	+	++	++	++		++	Fruit	OL,CO,MAL,GP,TR,ST
Senna siamea	E	++	+	+					PO
Senna spectabilis	E	+	+	+					PO
Sesbania sesban	I	o					+++		
Syzygium cordatum	I	++	+++	++	++		++	Fruit	
Tephrosia vogelii	I/E								
Terminalia sericea	I	++	+++	++	++				GP,ST,RP,TR
Toona ciliata	E	++	+	+					
Trichilia emetica	I	+	+	+	+				PE,BP,GP,RU,SP,OL,PO
Uapaca kirkiana	I	++	++	++	++			Fruit	AB,RU,RP,SK
Vetiveria zizanioides	E						o		
Ziziphus abyssinica	I	+++	+	+	+		++	Fruit	RP
Ziziphus mauritiana	E	+++	+	+	+		++	Fruit	
Ziziphus mucronata	I	+++	+	+	+		++	Fruit	GP,TR,ST,RP,SK

Origin: I = Indigenous, E = Exotic

Use Ratings: +++ Excellent; ++ Very Good; + Good; o Fair; Blanks: Poor or unknown

Medicinal and other uses:

AB: Aboricide
BP: Head/Body pains
CN: Contraceptive
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MAL: Malaria
MM: Multi medicinal
OL: Oil
PE: Purgative / Enema
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RP: Respiratory / Colds
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SP: Soap
ST: Stomach disorders
TN: Tannins
TR: Traditional beliefs
VD: Venereal diseases
WT: Water treatment

Table 11: Planting Material Requirements by Species and Technology

SPECIES	Planting Method [1]	Treat-ment [2]	Seed /hole	Seeds per Kg	AC g/ha DS	AC g/ha NS	MTI g/ha NS	IF g/ha DS	IF g/ha NS	CVS g/km DS	CVS g/km NS	F/GMB g/ha NS
Acacia galpinii	NS	1	2	4,800					1,415		115	
Acacia nigrescens	NS	1	2	4,800					1,415			
Acacia nilotica	NS	1	2	6,329					1,073			
Acacia polyacantha	NS	1	3	9,900					1,029		83	
Acacia sieberiana	NS	1	2	9,000								
Acacia tortilis	NS	1	3	13,330					764			
Afzelia quanzensis	NS	1	1	250					13,580			
*Agava sisalana**	SU, BU	NA	NA	NA								
Albizia lebbeck	NS	1	3	9,000					1,132		92	
Albizia versicolor	NS	1	2	4,800					1,415		115	
Annona senegalensis	NS	0, F	3	12,500								
Azadirachta indica	NS	3, F	2	11,000					617			
Azanza garkeana	NS	3, F	2	4,000								
Bauhinia thonningii	NS	1	3	6,100					1,670			
Bridelia micrantha	NS	2	2	11,000								
Caesalpinia decapetala	NS	1	2	3,380								
Cajanus cajan	DS	0	3	12,000				6,790		688		
Combretum imberbe	NS	0, F	3	7,300								
Cordyla africana	NS	3, F	1	200								
Dichrostachys cinerea	NS	1	3	13,000								
Erythrina abyssinica	CT, NS	1	2	6,800					999		81	
Eucalyptus camaldulensis	NS, SB	0	5	500,000								
Eucalyptus tereticornis	NS, SB	0	5	1,000,000								
Faidherbia albida	NS	1	3	6,900							120	
*Ficus capensis**	CT	NA	NA	NA								
*Ficus natalensis**	CT	NA	NA	NA								
Flacourtia indica	NS	3, F	5	22,000								

Technology Codes: AC=Alley Cropping; CVS=Contour Vegetation Strips; DSI=Dispersed Systematic Interplanting F/GMB=Fodder/Green Manure Banks; H/BP=Homestead/Boundary Planting; IF=Improved Fallows; LF=Live Fenses; LFS=Live Farm Sheds; MTI=Mixed Tree Intercropping; SBP=Streambank Planting; WL=Woodlots

[1] *Planting Method:* DS=Direct sowing; NS=Nursery seedlings; SB=First sown in seedbed; CT=Cuttings; SU=Suckers; BU=bulbils; SL=Slips.

[2] *Seed treatments:* 0=no treatment; 1=nick side of seed with knife or nail clippers; 2=soak in cold water for 24-48 hrs; 3=remove fleshy pulp, capsule or aril; 4=crack shell of nut; F=Plant fresh

* No.of slips or cuttings Vegetative propagation material underlined.

Figures that are underlined indicate no. of cuttings/slips or truncheons

Table 11 continued: Planting Material Requirements by Species and Technology

SPECIES	DSI g/ha NS	US g/ha DS	US g/ha NS	H/BP & SBP g/km Small	H/BP & SBP g/km Large	WL g/ha Fuel	WL g/ha Poles	LF g/km NS	LFS No./km NS
Acacia galpinii	92				115	1,146	2,292	1,146	
Acacia nigrescens				229		1,146	2,292	1,146	
Acacia nilotica				174		869	1,738	869	
Acacia polyacantha	67			167		833	1,667	833	167
Acacia sieberiana					61	611	1,222	611	
Acacia tortilis				124		619	1,238	619	
Afzelia quanzensis					1,100	11,000	22,000		
*Agava sisalana**					500				1,000
Albizia lebbeck				183		917	1,833		
Albizia versicolor					115	1,146	2,292		
Annona senegalensis				132					
Azadirachta indica				100		500	1,000		
Azanza garkeana				275					
Bauhinia thonningii				270		1,352	2,705		
Bridelia micrantha				100		500	1,000		
Caesalpinia decapetala								1,627	
Cajanus cajan		6,790							
Combretum imberbe					113	1,130	2,260		
Cordyla africana					1,375	13,750	27,500		
Dichrostachys cinerea						635	1,269		
Erythrina abyssinica				162		809	1,618	324	162
Eucalyptus camaldulensis				6		28	55		
Eucalyptus tereticornis				3		14	28		
Faidherbia albida	96				120				
*Ficus capensis**					250				1,000
*Ficus natalensis**					250				1,000
Flacourtia indica				125		625	1,250		

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[1] *Planting Method:* DS=Direct sowing; NS=Nursery seedlings; SB=First sown in seedbed; CT=Cuttings; SU=Suckers; BU=bulbils; SL=Slips.

[2] *Seed treatments:* 0=no treatment; 1=nick side of seed with knife or nail clippers; 2=soak in cold water for 24-48 hrs; 3=remove fleshy pulp, capsule or aril; 4=crack shell of nut; F=Plant fresh

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Table 11: Planting Material Requirements by Species and Technology

SPECIES	Planting Method [1]	Treat-ment [2]	Seeds /hole	Seeds per Kg	AC g/ha DS	AC g/ha NS	MTI g/ha NS	IF g/ha DS	IF g/ha NS	CVS g/km DS	CVS g/km NS	F/GMB g/ha NS
Gliricidia sepium	CT, NS	0, F	1	7,000		388	970		1,940		39	1,940
Jatropha curcas	CT, NS	4	3	1,670								
Khaya nyasica	NS	0, F	5	2,980								
Leucaena diversifolia	NS	1	3	22,500		362	905		1,811		37	1,811
Melia azedarach	NS	3, F	3	1,750								
Moringa oleifera	CT, NS	0, F	3	4,500							183	
Pennisetum purpureum	CT	NA	NA	NA							5,000	24,691
Prosopis juliflora	NS	1	3	10,900					3,738		76	3,738
Pyracantha coccinea	NS, SB	3	10	370,400								
Sclerocarya birrea	CT, NS	4, F	3	100								
Senna siamea	NS	1	3	33,000								
Senna spectabilis	NS	1	3	32,000		255			318		26	318
Sesbania sesban	NS	2	5	82,305					825		167	825
Syzygium cordatum	NS	3, F	2	3,000								
Tephrosia vogelii	DS	0	3	17,500	1,164			4,656		429		4,656
Terminalia sericea	NS	0, F	5	3,906								
Toona ciliata	NS, SB	0, F	5	300,000					57			
Trichilia emetica	NS	0, F	2	1,200								
Uapaca kirkiana	NS	3, F	2	2,860								
*Vetiveria zizanioides**	SL	NA	NA	NA							10,000	
Ziziphus abyssinica	NS	4	2	250							2,200	
Ziziphus mauritiana	NS	4	2	1,500							367	
Ziziphus mucronata	NS	4	2	1,100							500	

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Table 11 continued: Planting Material Requirements by Species and Technology

SPECIES	DSI g/ha NS	US g/ha DS	US g/ha NS	H/BP & SBP g/km Small	H/BP & SBP g/km Large	WL g/ha Fuel	WL g/ha Poles	LF g/km NS	LFS No./km NS
Gliricidia sepium				79		393	786		
Jatropha curcas				988				1,976	988
Khaya nyasica					461	4,614	9,228		
Leucaena diversifolia				73		367	733		
Melia azedarach				943		4,714	9,429		
Moringa oleifera				367				1,833	367
*Pennisetum purpureum**									
Prosopis juliflora				151		757	1,514	757	
Pyracantha coccinea								74	
Sclerocarya birrea					8,250				16,500
Senna siamea				50		250	500		50
Senna spectabilis				52		258	516		52
Sesbania sesban			825						
Syzygium cordatum				183					
Tephrosia vogelii		4,656							
Terminalia sericea				352		3,520	7,040		
Toona ciliata					5	46	92		
Trichilia emetica					458	4,583	9,167		
Uapaca kirkiana				385					
*Vetiveria zizanioides**									
Ziziphus abyssinica				2,000		22,000	44,000	22,000	
Ziziphus mauritiana				333		3,667	7,333	3,667	
Ziziphus mucronata				455		5,000	10,000	5,000	

Technology Codes: AC=Alley Cropping; CVS=Contour Vegetation Strips; DSI=Dispersed Systematic Interplanting
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Table 12: Index of Species

Latin names in italics
CHICHEWA NAMES in CAPITALS
English names in bold and not capitalized.

Species	page	*Species*	page	*Species*	page
Acacia galpinii	172	**China Berry**	198	KAMSATSI	169
Acacia nigrescens	173	CHITIMBE	186	KANGALUNI	203
Acacia nilotica	174	**Common Wild Fig**	202	KANKHANDE	207/209
Acacia polyacantha	175	*Cordyla africana*	190	KAPITAGWILERE	185
Acacia sieberiana	176	*Dichrostachys cinerea*	181	KATOPE	206
Acacia tortilis	177	*Erythrina abyssinica*	191	KESHYA WA MALUWA	188
Afzelia quanzensis	184	*Eucalyptus camaldulensis*	204	KESHYA WA MILIMO	187
Agava sisalana	164	*Eucalyptus tereticornis*	205	*Khaya nyasica*	197
Albizia lebbeck	178	*Faidherbia albida*	180	KHONJE	164
Albizia versicolor	179	*Ficus capensis*	201	**Knob Thorn**	173
Annona senegalensis	166	*Ficus natalensis*	202	**Leucaena**	182
Azadirachta indica	196	**Fire Thorn**	210	*Leucaena diversifolia*	182
Azanza garkeana	195	**Fish Bean**	194	LUKINA	182
Bauhinia thonningii	186	*Flacourtia indica*	171	**Marula**	165
BINU	193	**Forest Red Gum**	205	MASAWO	208
Bridelia	168	GLIRICIDIA	192	MASUKU	170
Bridelia macrantha	168	*Gliricidia sepium*	192	**Mauritius Thorn**	185
Buffalo Thorn	209	**Gum**	204	MBAWA	197
BULUGAMA	204/205	**Horse-Raddish Tree**	203	MCHENDE	210
Caesalpinia decapetala	185	**Indian Plum**	171	*Melia azaderach*	198
Cajanus cajan	189	INDYA	198	**Mesquite**	183
Cape Fig	201	*Jatropha curcas*	169	**Mexican Lilac**	192
Cassia	187/188	JELEJELE	193	MFULA	165
CHAMWAMBA	203	**Jujube**	207/208	MINGANZOLO	176
CHIMPHONGALA	181	KACHERE	202	MKUNKHU	173

Table 12: Index of Species

Latin names in italics
CHICHEWA NAMES in CAPITALS
English names in bold and not capitalized.

Species	page	*Species*	page	*Species*	page
MKUYU	201	NIMU	196	**Snot Apple**	195
MLUNGUZI	185	NKUNKHU	172	*Syzygium cordatum*	206
Monkey Bread	186	NSENJERE	211	*Tephrosia vogelii*	194
Monkey Thorn	172	NTHUDJA, NTHUDZA	171	*Terminalia sericea*	167
Moringa oleifera	203	Paperbark acacia	176	THEDZI	212
MPAMPA	174	*Pennisetum purpureum*	211	**Toon Tree**	199
MPASA	168	**Persian Lilac**	198	*Toona ciliata*	199
MPOSA	166	**Pigeon Pea**	189	*Trichilia emetica*	200
MSAMBAMFUMU	184	**Pod Mahogany**	184	*Uapaca kirkiana*	170
MSANGU	180	**Poison Pod Albizia**	179	**Umbrella Thorn**	177
MSIKIDZI	200	*Prosopis juliflora*	183	**Vetiver grass**	212
MTANGATANGA	178/179	**Pulsa nut**	169	*Vetiveria zizanioides*	212
MTETEZGA	194	*Pyracantha coccinea*	210	**Water Berry**	206
MTHETHE	175	**Red Mahogany**	197	**White thorn**	175
MTHUTHU	194	**Red-Hot Poker Tree**	191	**Wild Custard Apple**	166
MTONDO	190	**River Bean**	193	**Wild Loquat**	170
MTOWO	195	**Scented thorn**	174	**Wild Mango**	190
MUWALE	191	*Sclerocarya birrea*	165	**Winter Thorn**	180
NANDOLO	189	SENDRELLA	199	**Woman's Tongue**	178
Napier grass	211	*Senna siamea*	187	*Ziziphus abyssinica*	207
NAPINI	167	*Senna spectabilis*	188	*Ziziphus mauritiana*	208
Natal Mahogany	200	*Sesbania sesban*	193	*Ziziphus mucronata*	209
NCHONGWE	177	**Sickle bush**	181		
Neem	196	**Silver Terminalia**	167		
NGAGAGA	174	**Sisal**	164		

GLOSSARY

Acid: (soil) A soil having a pH of less than 7.0. A soil with a higher pH is called basic or alkaline. Some plants, such as *Leucaena leucocephala*, do not grow well in strongly acid soils (pH less than 5.5). Limestone (a basic rock) is often ground and added to soils to reduce their acidity.

Adoption: A farmer has adopted a technology or practice when he has established it for long term use on a scale that produces significant or visible benefits.

Agroforestry: A practice of deliberately growing or retaining trees or shrubs within an agricultural or pastoral land-use system, either under the same form of spatial arrangement or in temporal sequence. There are both ecological and economic interactions between the various agroforestry components. A more simple definition is any deliberate planting or use of a tree by a farmer.

Alley cropping: Cultivation of crops between hedgerows of woody legumes that are pruned periodically to prevent shading the crop, and to improve soil fertility/yields from prunings; may also supply fodder and fuelwood.

Alternate: (of leaves) alternating along the stem; not opposite.

Annual: A plant that grows for only one season (or year) before dying, in contrast to a perennial, which grows for more than one season.

Arid: A climate characterized by so little rainfall that cultivation is possible only if supported by water management.

Aril: An extension, sometimes fleshy, from the placenta at the base of the seed, partially or completely enveloping the seed.

Bare-root nursery: A nursery in which seed is sown at regular spacings in open beds, and the seedlings are uprooted from the soil before outplanting. Containers are not used.

Berry: A soft, juicy fruit with pulp surrounding the seeds.

Biodiversity: Diversity of living plants and animals in the same area.

Biomass: The weight of material produced by a living organism or collection of organisms. It may include the entire plant, or it may be qualified to include only certain parts of the plant, e.g. above-ground or leafy biomass. Biomass is expressed in terms of fresh weight or dry weight.

Broadcast sowing: The sowing of seed by scattering it over a wide area, without the use of drills or holes.

Browse (noun): The buds, shoots, leaves, flowers and fruits of woody plants which are eaten by livestock or wild animals. Used as a verb, to browse is the act of eating woody plants by animals.

Bund: A ridge of earth placed in a line along the contour or across the slope to control water runoff and soil erosion.

Capsule: A dry fruit, releasing seed from pores or breaking open when ripe.

Clump: A close grouping of stems or trees, bushes or grasses.

Compost: Organic residues from plants and animals, sometimes mixed with soil, that are piled, moistened and allowed to decompose. Used to improve soil fertility when incorporated into the soil, often in small, intensive gardens.

Compound (leaf): A whole leaf made up of similar leaflets; not simple.

Containerized seedlings: Nursery seedlings raised in individual polythene tubes, pots or other type of container. The seedlings are easy to handle, but are heavy and difficult to distribute.

Contour: Linking points in a field at the same altitude so that it forms a contour line.

Coppicing: Cutting certain tree species close to ground level to produce new shoots from the stump. Also occurs naturally in some species if the trees are damaged.

Cotyledons: These are the first leaves that emerge when the seed germinates; they are morphologically different from the subsequent developing leaves.

Culm: The stem of grasses, often hollow.

Cutting: A method of propagating trees by cutting pieces of stems or branches (the length required will depend on the species), which will then grow roots and shoots. Cuttings of some species may first need to be rooted in water or sterile soil under nursery conditions; others root easily by planting them directly at the intended site, usually with river sand at the bottom of the hole to reduce the risk of rot.

Cut-and-carry: Fodder or other plant products which are harvested and carried to a different location to be used or consumed.

Damping off: A fungal disease that causes rotting of tissue near the root collar so that seedlings topple over. This can occur if a nursery is overcrowded, poorly drained, too heavily shaded, or poorly ventilated.

Deciduous: Leaves (of trees) that all shed periodically; not evergreen.

Dehiscent: Splitting.

Dimba: A garden located in dambo areas or areas with enough residual dry season moisture for vegetable and green maize production.

Dispersed systematic interplanting of multi-purpose trees: Multi-purpose trees planted in crop land at a wide but regular spacing to restore soil fertility and to provide a range of tree products/uses.

Direct seeding: See 'direct sowing'.

Direct sowing: A method of raising trees by sowing the seed directly onto the soil at the site where the mature trees are required.

Dormancy: The period when seed is not active. The seed dormancy period needs to be broken to activate the germination process--by soaking in water, for example.

Dormant buds: Buds that do not normally grow into branches, but which are able to do so if the stem or branch is cut.

Drupe: A fleshy seed enclosed in a stony covering, e.g., stone fruits such as peach. Also, one-celled fruit with one or two seeds, e.g. plum.

Dry-season nursery: A nursery that is started during the dry season and that is watered regularly so that the seedlings grow to the required size before being outplanted as soon as the rains begin.

Erosion: The wearing away of the land surface by running water, wind, ice or movement due to gravity.

Evapotranspiration: Sum of the evaporation of water by the soil, and transpiration of water by plants at the same location.

Evergreen: Leaves (of trees) that fall and grow continuously throughout the year; not deciduous.

Exotic: Introduced from outside (Malawi); not indigenous.

Fallow crop: A food or tree crop that is planted or allowed to grow in farmland during a fallow period after the main crop is harvested, to help improve or recover soil fertility.

Family: A taxonomic category between order and genus. Plants or animals in the same family that share some common characteristics.

Fertilizer: Materials such as animal manure or inorganic chemicals that contain the nutrients necessary for healthy plant growth. When applied to soil they help improve fertility and crop yields.

Fodder banks: Fast growing, high yielding trees/grass of high nutritional value, grown usually in small plots for cut and carry feeding of livestock.

Fruit (botanical): The ripened ovary of a seed plant, with its contents.

Furrow: In the context of a nursery seedbed: A shallow groove opened in the surface of the soil in which seeds are sown, and which are then re-covered with soil; otherwise the depressed area between crop ridges.

Genus: A classification of plants or animals with common distinguishing characteristics.

Germination: The process of plant development in which roots and shoots emerge from seeds.

Green manure: Green leafy material applied to the soil to improve its fertility.

Green manure banks: Fast growing, high yielding leguminous trees, grown usually in small plots for cut and carry application of biomass to improve soil fertility.

Gully: A deep, narrow channel cut into the soil by erosion.

Gully erosion: The removal of soil by water concentrated in deep, narrow channels.

Hardening off: A method of toughening seedlings while still in the nursery to prepare them for normal field conditions. The aim is to gradually reduce watering and provide more to direct sunlight so that the seedlings become better adapted for survival after outplanting.

Hedgerow: A closely planted line of grass, shrubs or small trees, often in the form of a contour line for controlling runoff or erosion, or grown as boundary fence.

Herb: Any plant with soft, non-woody stems; a term also commonly applied to plants used for culinary or medicinal purposes.

Herbaceous: A plant that is not woody and does not persist above ground beyond one season.

Homestead and boundary planting: Multi-purpose trees planted around homestead or on farm boundaries for poles/fuelwood, fruits (food/cash), fodder, green manure/mulch, shade and other uses such as medicines, gums etc.

Home Garden: A complex collection of woody and herbaceous plants deliberately grown in small plots in or near home compounds; they may also be associated with the production of small domestic animals.

Hybrid: The offspring of two plants of different species or varieties.

Indigenous: Native to a specific area; not introduced. Opposite of exotic.

Infiltration: The movement of water into the soil.

Inoculant: An additive to the seed of some species that helps speed up germination. For example, the growth of leguminous species is helped by the addition of *Rhizobium* bacteria.

Intercropping: Growing two or more crops in the same field at the same time in a mixture.

Khola: Fence of living or dead branches used to enclose livestock or to direct their movements or to protect human settlements from wild animals. Also called a corral (USA) or kraal (Afrikaans).

Landcare: The concept of improving the management of land resources for sustained increases in farm productivity with reduced degradation of soil, forest and water resources.

Leaflet: A single division of a compound leaf. See compound leaf.

Litter: The uppermost layer of organic material on the soil surface, including leaves, twigs and flowers, freshly fallen or slightly decomposed.

Live fencing: Living hedge to protect or enclose people, animals, or crops.

Lop: To cut one or more branches of a standing tree.

Leaching: Nutrients moving with water below and away from the rooting zone of plants.

Leguminous plants: Plants of the family *Leguminosae* that produce seed in pods. The nutrient rich leaves of leguminous plants, when they fall and rot, help to improve soil fertility by increasing the levels of nitrogen available to plants. Many leguminous species develop root nodules that contain bacteria which fix nitrogen from the air for use by the plant.

Marker Ridge: Ridge on contour, usually made every 10 - 20 metres, to help realign the planting ridges of the whole field on contour.

Mycorrhiza: The association of a higher plant (such as a tree) and fungal mycelium (the vegetative body of a fungus) in which the fungus lives within or on the outside of roots forming a symbiotic or parasitic relationship. The fungus benefits the tree by supplying nutritional requirements in the early stages of development, and later through nitrogen fixation in root nodules.

Mulch: Grass, leaves, or other material that is laid on top of a nursery seedbed to reduce evaporation and thus retain moisture within the soil.

Multipurpose tree (MPT): A woody perennial which is grown or used to provide more than one product or service.

Naturalised (of plants): So successfully introduced (into Malawi) that they reproduce naturally.

Ndiwo: Local name referring to vegetable relish eaten with meals, often for flavoring.

Nitrogen-fixing: Relating to a plant that has the ability to convert nitrogen in the air into a form which can be used by plants. This process is performed by another organism that lives within the roots of the plant. In leguminous plants the organism is a bacterium. In other plants, such as *Casuarina* species, it is an actinomycete.

Nut: A dry seeded fruit with a hard outer covering.

Obovate: Inversely egg-shaped leaf with the narrow end at the bottom or stem end of the leaf and rounded at the top.

Outplanting: The removal of seedlings from a nursery for planting on other sites on the farm where they will grow into mature trees.

Palatable: Desirable to eat.

Perennial: A plant that grows for more than one year, in contrast to an annual, which grows for only one year (or season) before dying.

Planting out: see "Outplanting."

Planting shock: The shock experienced by a seedling when it is outplanted from a protected nursery to a field site due to exposure to direct sunlight and the absence of regular watering.

Pod: A dry fruit, usually splitting into two, typical of the leguminosae family.

Practice (noun): A technology that has been implemented in practice by a farmer.

Pre-treatment of seed: The treatment of seed by various methods prior to sowing to initiate and accelerate the process of germination. See seed treatment.

Pricking: The removal of young seedlings from seed beds or tubes for transplanting to other containers by grasping the tops of the leaves and gently pulling.

Propagation: Methods of increasing the numbers of a given plant type. Most trees propagate themselves by seed, others by root suckers; some can be propagated from cuttings or truncheons.

Provenance: A stand of trees of the same species that provides a source of high-quality seed.

Pruning: The process of regularly cutting back the shoots or roots of plants to control the structural shape of a plant, and/or to encourage the development of dense, sturdy, and well-developed rooting systems and shoots.

Raceme: A cluster of flowers with the blossoms arranged along the sides of the flower stalk, the oldest at the base.

Rhizobia: Nitrogen fixing bacteria living together with a fungus, mycorrhizae, usually on the roots of leguminous plant species.

Ridge: A long raised strip of earth prepared by hand or mechanical means, usually for cultivating crops in parallel rows.

Root block: Block of soil containing roots, cut out of a seedbed when a seedling is transplanted.

Rooting system: The mass of roots developed by a plant within the soil.

Rotation: In agriculture, changing the crops grown on a particular piece of ground from season to season. In forestry, the length of time between establishment and harvesting of a plantation or tree.

Runoff: Rainfall or other water that does not infiltrate into the soil but flows across the surface.

Scadent: Tendency to climb by means of tendrils.

Seed treatment: Nicking, soaking in water or treating seeds with substances such as insecticides or fungicides to improve germination. See pre-treatment.

Seed viability: The ability of seed to germinate and the speed at which it germinates. Normally given in germination percentages and specifying the period in which germination takes place.

Seedbed: The protected bed or soil in a nursery in which seeds are sown and seedlings are nurtured to grow until they are ready for outplanting.

Semi-arid: Climate with a substantial dry season(s) and an average annual rainfall of 150 to 900 mm. In semi-arid areas, rainfall in some years is insufficient to maintain crop cultivation.

Shrub: A woody plant branching at or near the base with no defined trunk, usually smaller than a tree.

Shoot: A stem; may also refer to new growth of a plant, usually including a stem.

Short term fallow: A fallow of fast growing plants or trees to restore soil fertility, and to provide poles/fuelwood. Crops can be grown with these plants during the first season.

Slope: The inclination or angle of the land surface, which can be measured as a percent, ratio or in degrees or grades.

Soil fertility: The relative ability of a particular soil to support crop growth, which is a function of the physical, chemical and biological properties of the soil.

Soil moisture: Water in the soil, a portion of which is available to plants.

Soil and water conservation: Measures undertaken by farmers and other resource users to conserve soil and water resources for a specified purpose or range of uses.

Species: A taxonomic category below genus. Individuals within a species can interbreed, but breeding between species does not normally occur or results in sterile offspring (hybrids).

Spine: A sharp, rigid outgrowth, deeply attached, not pulling off readily with the bark; sometimes the tip of a branch, or a specialized form of leaf.

Sp., spp.: Abbreviation for species, and the plural of species.

Ssp., subsp.: Abbreviations for subspecies.

Stover: Crop residue of maize or other cereals after grain harvest.

Subhumid climate: In the tropics, a climate with a short dry season and rainfall averaging 900 - 1200 mm a year and susceptible to occasional drought.

Superficial roots: Plant roots at or near the soil surface.

Tannin: A substance often extracted from tree bark, among other sources, and used to tan animal hides.

Tap root: A persistent, and often enlarged, main plant root that grows downward into the soil.

Technology: The development stage of a new practice to improve a desired result, or set of results. For example, a new method of intercropping leguminous shrubs to increase maize yields.

Termite resistant: Not likely to be attacked by termites or unlikely to suffer damage if attacked.

Terrace Bank: Upright slope between 2 terraces. Can be constructed from rocks or from soil covered with grass.

Tied Ridge: A narrow strip of ground between contour furrows or trenches, which joins parallel ridges on the contour at intervals. Tied ridges are meant to help hold rain water between contour ridges to improve water infiltration and to reduce runoff.

Till: Cultivate the soil; open and turn the soil surface.

Timber: Wood of a sufficient size to be used for heavy construction and/or processed into boards.

Transplanting: The removal of very young seedlings from a germination bed and pricking them into a prepared seedbed or into polythene tubes, where they can grow without competition until they are ready for outplanting. The term is also applied to the removal of wildlings to more desired planting sites.

Tree: A woody plant with one main trunk and a more-or-less distinct and elevated head or crown.

Thorn: A sharp outgrowth which is relatively superficial, often a specialized leaf.

Viability: A measure of the potential of seed to germinate. A seed with short viability will germinate well only within a short time after ripening; one with long viability will germinate readily long after it has matured, perhaps after pretreatment.

Volatilization: Nutrients changing into gas phase that are lost from the rooting zone or soil surface.

Undersowing: In the context of this manual, undersowing is a practice equivalent to interplanting one crop with another. Normally, it means doing this after the first crop is planted, but here it is recommended to interplant at the same time because it produces better results.

Truncheon: A large cutting from the branch of a tree used to propagate a new tree.

Water logging: Part of field under water for a prolonged period due to lack of good drainage or infiltration.

Wildling: A wild seedling that grows from seed dispersed by natural means.

Woodlots: Fast growing trees primarily for poles/fuelwood. Certain species may restore soil fertility. Crops can be grown during the first 1-2 seasons.

Woody: Plants, usually perennial, which consist in part of wood; not herbaceous.

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Annex 1: Guidelines for Setting Targets for each Technology

Technology	Required Targets	Target guides per HHold p.a.
Seed collection	kg by species & total no. farmers	Any amount
Nursery seedlings	no. seedlings by species & total no. farmers	Max 250 seedlings
Contour ridging	ha & no. farmers	0.20 ha
Vetiver nurseries	ha & no. farmers	0.01 ha
Contour vetiver hedges	ha & no. farmers	0.10 ha
Homestead planting	no. seedlings by species & total no. farmers	100 seedlings
Undersowing	ha & no. farmers	0.10 ha
Dispersed Systematic Interplanting	no. seedlings by species & no. farmers	0.10 ha /20 seedlings
Live fences	no. seedlings by species & total no. farmers	100 seedlings, or 50 truncheons
Live farm sheds	no. seedlings by species & total no. farmers	100 seedlings, or 50 truncheons
Fodder/Green manure banks	ha and no. seedlings by species & total no. farmers	0.02 ha

Annex 2: MAFE Partnership Forms on Targets and Results
Form 1: Multiplication of Planting Material

Instructions: 1) Source data from your own records and M&E system or from the CBM&E system. 2) Assess results and targets jointly with extension workers and the community. 3) Provide totals for each practice or species as shown. 4) Indicate total no. of participating HH and the % that are female headed for each type of planting material but not by species . 5) Set targets for next season based on participatory action plans. 6) Leave boxes blank for germplasm practices not targeted.

District/RDP/NGO:	Site/Area:	Season:
Data Collectors:		

TYPE OF PLANTING MATERIAL	TARGETS THIS SEASON				RESULTS THIS SEASON			
	No. HH	% Fem. HH	No. nurseries	Ha	No. HH	% Fem. HH	No. nurseries	Ha
Vetiver Nurseries								
Seed banks	No. HH	% Fem. HH	No. Banks	Ha	No. HH	% Fem. HH	No. Banks	Ha
Sp1:								
Sp2:								
Sp3:								
Total								
Tree Nurseries	No. HH	% Fem. HH	No. of nurseries	No. seedlings	No. HH	% Fem. HH	No. of nurseries	No. seedlings
Fruit trees								
Sp1:								
Sp2:								
Sp3:								
Sp4:								
Total fruit trees								
Other Species								
Sp1:								
Sp2:								
Sp3:								
Sp4:								
Sp5:								
Sp6:								
Sp7:								
Sp8:								
Total Other								
Total for All Trees								
Tree seed collected by species	No. HH	% Fem. HH	kg		No. HH	% Fem. HH	kg	
Sp1:								
Sp2:								
Sp3:								
Sp4:								
Total								

Note: MAFE will calculate germplasm requirements from the targeted species specified above.

Annex 2: MAFE Partnership Forms on Targets and Results

Form 2: Field Activities

Instructions: 1) Source data from your own records and M&E system or from the CBM&E system 2) Assess results and targets jointly with extension workers and the community. 3) Provide totals for each practice. 4) Indicate total no. of participating HH and the % that are female headed for each practice (no. of adopters). 5) Set targets for next season based on participatory action plans. 6) Leave boxes blank for practices not targeted.

District/RDP/NGO:	Site/Area:	Season:
Data Collectors:		

Agroforestry & Forestry Technologies	TARGETS THIS SEASON				RESULTS THIS SEASON			
	No. HH	% Fem HH	Total Area/No. Trees ha	Total Trees	No. HH	% Fem HH	Total Area/No. Trees ha	Total Trees
Nurseries (copy from Form 1)								
Homestead Tree Planting								
Streambank Planting								
Forestry Planting								
Dispersed Sys. Interplanting								
Undersowing								
Improved fallows								

Soil Conservation Practices	No. HH	% Fem HH	Total Area / No. ha	Total Area / No. No.	No. HH	% Fem HH	Total Area / No. ha	Total Area / No. No.
Gully Control								
Raised Footpaths/boundaries								
Vetiver Nurseries (from Form 1)								
Contour ridging								
Contour vetiver hedgerows								
Contour lines:trees/shrubs								

Request for MAFE Training Courses	No. Trainers	No. Ext Staff	No. Trainers	No. Ext Staff
Seed Collection & Tree Nurseries				
AF/SC Practices				
Small-scale Irrigation				
CBM&E				

Request for MAFE Extension/Training Materials	No. Requested	No. Provided
LandCare Field Manual		
Best-Bet AF/SC Booklet (English)		
Best-Bet AF/SC Booklet (Chichewa)		
Nursery/Seed Collection Booklet		
Tree Species Booklet		
SC Posters		
Tree Nursery Posters		
AF Posters		
Ext/Training Kit		
Open-Ended Poly Tubes 20 x 15 cm		
Line Levels		

Annex 3: Sample Answers to Chapter Questions

CHAPTER 1: LANDCARE ISSUES IN MALAWI

1. Identify two major problems that characterize smallholder agriculture in Malawi.
   - Declining farm productivity from widespread soil and forestry degradation
   - Low soil fertility from continuous cultivation with little or no use of organic and chemical inputs due to problems of supply and high cost
   - Acute wood shortages

2. What is the immediate effect of loss of forest cover?
   Soil erosion

3. What are the beneficial effects of forest on agriculture?
   - Some tree species help counter adverse climatic conditions by reducing damage from heavy winds and rainstorms on crops and soils
   - Some tree species help recycle nutrients from deep soil depths
   - Some species fix nitrogen
   - Trees provide abundant by-products such as oils, fruits, timber, fuelwood, etc.

4. Explain how siltation of rivers (e.g. Shire) affect the supply of electricity in Malawi.
   - Siltation is caused by sedimentation of riverbeds from surface run-off and erosion. The resulting silt deposits reduce the capacity of river channels to hold water. As the riverbed becomes silted up, water is lost through flooding, which reduces water available for hydro-electric generation.

5. Mention four poor land use practices that aggravate soil erosion in Malawi.
   - Ridges off contour
   - Little or no fallowing
   - Cultivation on steep slopes and other marginal land
   - Cultivation along stream banks
   - Deforestation
   - Overgrazing

CHAPTER 2: DEVELOPING COMMUNITY-BASED ACTION PLANS

1. Identify three criteria in selecting two sites out of five that have similarities in environmental and farming conditions.
   - Expressed commitment and willingness of the community to address the identified problems
   - Strong leadership within the community
   - Motivation, commitment and ability of the local extension staff
   - Presence of other projects and/or NGOs that could cause potential programmatic and operational conflicts

2. Name four factors in prioritizing problems/solutions identified by beneficiaries of an NRM program.
   - Does the proposed solution address the problem directly
   - Is the solution realistic in terms of management, time, labour, cost, etc
   - Is the solution short or long-term
   - Who will benefit
   - Does the solution require outside assistance
   - Is it beyond the scope of the program of landcare interventions

3. Name four activities that would catalyze community participation in an agroforestry/ soil conservation program.
   - Educational campaigns to create awareness of the issues and potential solutions
   - Strong local leadership
   - Use of committees to spearhead coordination of activities
   - Farmer to farmer visits
   - Full involvement of women and other disadvantaged groups such as female-headed households, youths and disabled people
   - Matching technologies to farmer needs

4. Identify three steps involved in developing a workplan.
   - Assist the community to set targets for each practice and species using MAFE's Partnership Forms 1 & 2 and target guidelines on what an average household can achieve in a season
   - Match targets for each practice based on expressed household interest and available resources
   - Identify tasks needed to meet the targets
   - Define staff and farmer responsibilities
   - Set a practical timeframe to carry out each task in the form of a calendar

CHAPTER 3: TREE PROPAGATION AND OUTPLANTING

1. Why is self-collection of tree seed important?

- Collect seed for species of own choice
- Ensure that seed is fresh (good quality)
- Obtain adequate quantities for own use for timely planting
- Excess seed can be sold for cash

2. What is the importance of conducting a seed germination test?
   - To ensure seed quality before planting
   - To estimate maximum number of seeds that germinate under optimum conditions

3. Identify two factors for calculating tree seed requirements.
   - Tree species desired
   - Number of seedlings needed
   - Seed germination percentage
   - Number of seeds per kilogram
   - Number of seeds to plant per plot or station
   - Expected level of losses so replanting can be done

4. Given that a farmer wishes to plant 200 *Acacia galpinii* trees along his farm boundary at a spacing of 4 meters between plants, how much seed does he/she require in grams with an allowance of 35% for losses? There are 4,800 seeds per kilogram of *A. galpinii*.
   - 112.5 grams (200 trees x 2 seeds per pot x 1.35 divided by 4800)

5. What is the recommended seed treatment for hard-coated seeds, and why is this necessary?
   - Nicking. To break seed dormancy for high and fast germination.

6. Why is air pruning recommended for *Fidherbia albida*?
   - To avoid damage to the tap root which is sensitive to root-pruning

7. When should the final root pruning be done before outplanting and why?
   - 3-4 days to allow recovery from pruning shock

8. What are the recommended dimensions for tree planting pits?
   - 60 cm diameter x 60 cm deep

9. When is the best time to plant trees and why?
   - At the beginning of the rainy season. This encourages good root establishment and development for survival over the dry season.

CHAPTER 4: SOIL & WATER CONSERVATION

1. In smoothing a pegged contour line, do you start at the beginning or end of the line and why?
   - You start from the beginning of the line to maintain any errors made in one direction.

2. What is the function of a contour marker ridge?
   - To serve as a guide to re-align planting ridges

3. How do you re-align crop ridges between 2 marker ridges, and why is it done in this way?
   - Align the top half of the area with the top marker ridge, and the bottom half with the lower marker ridge. It is done this way to minimize errors or to ensure that all planting ridges are on contour.

4. In a field with a medium slope, the interval between marker ridges is 15 meters. What should be the interval between vetiver hedgerows in the same field?
   - 10 meters

5. Where do you plant vetiver hedgerows in a field – on top of the ridge, in the furrow or on the side? Explain your answer.
   - In the furrow where there is more moisture for fast growth

6. How many vetiver slips are needed to plant 1 ha of hedgerows spaced 10 m apart.

- 10,000 slips (10 hedgerows x 100 m x 10 slips / m)

6. Identify three factors that may lead to gully formation?
   - Cultivation on steep slopes and other marginal land
   - Ridges off contour
   - Unraised footpaths and field boundaries
   - Poorly designed and constructed road drains

7. What is the best way to avoid stream bank erosion?
   - Avoid using the stream bank for cultivation or other uses that damage the stream bank environment. Maintaining a healthy stand of natural vegetation is the best protection.

CHAPTER 5: TREE PLANTING FOR SOIL FERTILITY

1. Identify two management practices to avoid negative agroforestry effects on crops.
   - Regular trimming of trees/shrubs
   - Avoid planting crops with tree species that are susceptible to root knot nematodes
   - Ensure proper spacing of trees in a crop field

2. What is the recommended method to raise *Faidherbia albida* seedlings, and what is the spacing at outplanting time under DSI?
   - Use air-pruned seedlings outplanted at 10 x 5m.

3. When should *Tephrosia vogelii* be undersown with maize and why?
   - Same time with maize so that it grows fast in the same season. *Tephrosia* does not compete with maize so planting it at the same time does not have any adverse effects on maize growth.

4. How much *Tephrosia* seed is needed to undersow 10 ha with maize? Show calculations.
   - 1 ha requires 5 kg of *Tephrosia*. Therefore 10 ha will require 10 x 5 = 50 kg.

5. What do you do with the woody stems of *Tephrosia* after cutting it down and why?
   - Remove the stems for use as firewood or other uses. Do not bury them as this tends to immobilize nitrogen which is needed by microbes for energy during the decomposition of woody material.

6. Why is natural tree regeneration an easy practice?
   - Because you do not need to raise nursery seedlings or outplant them.

7. What management steps are needed to encourage natural tree regeneration?
   a) Identify and mark the trees desired so they are not cut down,
   b) Protect them from fire and livestock,
   c) Prune side branches to encourage an upright growth form.

CHAPTER 6: TREE PLANTING FOR WOOD & OTHER PRODUCTS

1. Can a smallholder farmer with 0.4 ha land plant trees for wood/other uses? If yes explain how and if not, explain why.
   - Yes, by planting trees around the homestead where there is sufficient open space to plant trees and also along field boundaries

2. What is the spacing of trees grown for the following products?
   a) Poles: 2 x 1 m
   b) Fuelwood: 2 x 2 m
   c) Fruits: 4 x 4 m

3. Why is tree pruning important?
   - To promote straighter, healthier trees, and to reduce interference with field operations.

4. Why should you prune trees when they begin active growth?
   - To reduce dieback, fungal diseases and termite attack.

5. Identify three species suitable for establishing living farm structures (use scientific names).
   - *Gmelina arborea, Ficus natalensis, Ptecocarpus angolensis, Erythrina abyssinica, Senna siamea*