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A FIELD MANUAL FOR AGROFORESTRY 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

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TABLE OF CONTENTS

ACKNOWLEDGMENTS iii

FORWARD iv

CHAPTER ONE BASIC CONCEPTS
- INTRODUCTION AND BACKGROUND ON MALAWI 1
- ROLE OF AGROFORESTRY 8

CHAPTER TWO NURSERY CONSTRUCTION AND MANAGEMENT
- INTRODUCTION 13
- NEED FOR TREE PLANTING 13
- NURSERY DESIGN AND CONSTRUCTION 13
- NURSERY PRODUCTION AND MANAGEMENT 21
- GENERAL NURSERY CARE 28
- OUTPLANTING 36
- OTHER METHODS OF TREE PROPAGATION 38
- SEED COLLECTION, PROCESSING AND STORAGE 40

CHAPTER THREE AGROFORESTRY TECHNOLOGIES
- INTRODUCTION 43
- CONTOUR RIDGING 45
- ALLEY CROPPING 51
- SHORT-TERM FALLOWS 60
- CONTOUR VEGETATION STRIPS 64
- FODDER AND GREEN MANURE BANKS 71
- SYSTEMATIC TREE INTERCROPPING 76
- HOMESTEAD, BOUNDARY AND WOODLOT PLANTING 82
- LIVING FENCES 87
- REFERENCE TABLES ON AGROFORESTRY TECHNOLOGIES 91
- NEW OR MODIFIED TECHNOLOGIES UNDER TEST 102

CHAPTER FOUR COMMON AGROFORESTRY SPECIES 107

INDEX OF SPECIES 151

GLOSSARY **152**

REFERENCES **165**

LIST OF TABLES

Table 1 Bare-Rooted Stock vs Containers 19

Table 2 Recommended Species with Characteristics, Uses and Management 59

Table 3 Thinning Regime After Initial Establishment of 100 Trees/Ha 79

Table 4 Generalised Characteristics of Recommended Agroforestry Technologies 92

Table 5 Plant Spacing and Density for Each Technology 94

Table 6 Agroforestry Species Uses, Size, and Altitude Range 95

Table 7 Agroforestry Species Wood, Medicinal, and Other Uses 96

Table 8 Agroforestry Species Seed Requirements Per Technology 98

Table 9 Index of Species 151

ACRONYMS

ADD	Agricultural Development Division
Bunda	Bunda College of Agriculture
CURE	Coordination Unit for Rehabilitation of the Environment
DAR	Department of Agricultural Research
FRIM	Forestry Research Institute of Malawi
GAP	Guide to Agricultural Production
GDP	Gross Domestic Product
GOM	Government of Malawi
ICRAF	International Centre for Research on Agroforestry
MAFE	Malawi Agroforestry Extension Project
MNR	Ministry of Natural Resources
MOALD	Ministry of Agriculture and Livestock Development
SFFRFM	Smallholder Farmers Fertiliser Revolving Fund of Malawi
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development

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FORWARD

Malawi's farmers face population problems today that are eroding the productivity of agriculture and natural resources This has serious implications for the economy and the ability of the country to feed itself With shrinking land holdings and access to credit, animal and crop yields are declining 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 little or no inputs or opportunities to diversify Households lack basic needs of food, water, wood, shelter, health, and education Dropping income levels limit options to reverse this situation By 2015, demands for food and other resources will almost double as the population increases to 18 million In their struggle to survive, ***people are unable to make the critical trade-off between sustained resource use and immediate short-term needs*** Agroforestry offers the potential to alleviate many of these concerns by integrating trees and conservation practices with farming to improve productivity, diversification and natural resource management

This manual reflects Malawi's current state of the art in agroforestry It marks over 10 years of collaborative research, extension and on-farm testing by numerous professionals, organisations and farmers The support of the Ministry of Agriculture and Livestock Development and Forestry Department in partnership with USAID, Washington State University and the Rockefeller Foundation has been particularly instrumental in the development of agroforestry for Malawi farmers

The production of this manual is one step in developing innovative agroforestry technologies to meet the different needs of Malawi's farmers and the natural resource base It is intended to serve as a practical reference guide with a menu of options to support nursery and agroforestry activities by farmers As such, it represents an evolutionary process that illustrates only the current state of our knowledge Additional information is available on forestry practices and extension methods from the Forestry Extension Kit soon to be published by the Forestry Department Not all technologies are suited to all locations and with all farmers Farmers must be active partners in identifying, evaluating and adapting technologies to address their specific needs and resources Clearly, there is much room for

improvement through iterative on-farm testing and collaborative research As we learn more about the interaction of existing and new technologies under different farm and environmental conditions revisions of the manual will be made to reflect changing needs and priorities We strongly urge practitioners to be experimental and creative in using the information presented Only in this way can we improve and diversify options to develop sustainable farming practices into the future Ideas, experiences and suggestions to improve this manual are welcome and should be addressed to the coordinators of the MAFE Project

Dr Mapopa Chipeta
Minister of Agriculture and Livestock Development

INTRODUCTION AND BACKGROUND ON MALAWI

Geography, Climate and Vegetation

Malawi is a small country in Southern Africa located between latitudes 9° to 18° S and longitudes 33° to 36°E It occupies an area of 11 8 million hectares, of which 9 4 million is land, with the balance comprising Lake Malawi and other smaller lakes The country has three distinct topographical areas (1) the High-Altitude Plateaux from 1400 m to 2300 m a s l with peaks reaching 3,000 m, (2) the Medium-Altitude Plateaux between 800 m and 1,400 m and (3) the Rift Valley Plains 50 m to 800 m a s l along the lakes and Shire River

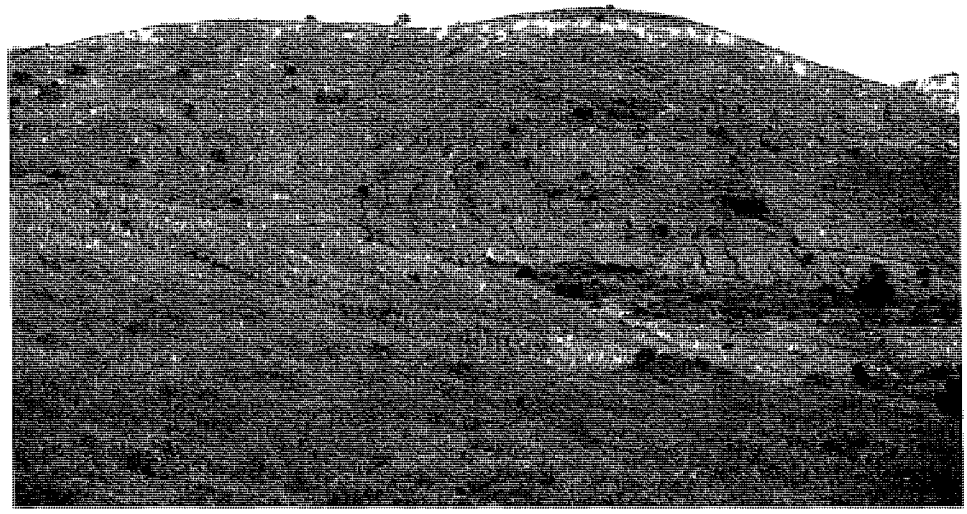
Malawi's climate is tropical, warm and semi-arid to sub-humid Most of the country receives adequate moisture for rainfed agriculture, although droughts have been common in recent years Rainfall occurs during a single season between November and April, and generally increases with altitude Annual amounts average under 800 mm in the Rift Valley area, 800 to 1,000 mm in the Medium-Altitude Plateaux, and 1,000 to 1,500 mm in the High-Altitude Plateaux Temperatures are mostly warm but influenced by season and altitude The coolest period is June and July, while the hottest is October and November before the rains Much of the natural vegetation of Malawi is *Brachystegia* miombo woodland, interspersed with *Acacia-Combretum* wooded savanna Montane grasslands mixed with evergreen forests are common in the higher elevations, while dry bush savanna characterises the lowlands

Population and Economic Characteristics

Malawi is one of the world's poorest countries The human population today is estimated at 10 4 million with a density averaging 110 / km^2, although this varies by region The North averages 44 / km^2, the Centre 113 / km^2, and the South 162 / km^2 In 1987, 88% of the population was rural, but this proportion is declining due to rapid urbanisation (estimated at more than 6 5% per annum) By the year 2015, the population will almost double, even with a decline in the rate of growth over the next 20 years from 3 3% to 2 3%

Land-locked with no significant mineral resources Malawi's principal assets have been a hard-working people, relatively fertile land, extensive indigenous forests and

Deforestation of hillside with early signs of erosion



Severe gullying can occur on gentle slopes from poor cultivation practices

Fuelwood demands contribute to deforestation

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

The Agricultural Sector

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 Livestock are relatively insignificant numbering about 800,000 cattle, 850,000 goats, 100,000 sheep, 2,000 donkeys, and 12 million poultry

About 71 475 km^2 (76% of the total land mass) falls within the customary/private sector Of this area the estate sector lays claim to 12 000 km^2, with 59,281 km^2 falling under customary tenure Although data on the ratio of cultivated to arable land are contradictory (World Bank, 1995), land available for agricultural expansion is limited The scarcity of arable land is compounded by the variation in population density between regions

Characteristics of the Smallholder Sector

This sector involves about 1 8 million smallholder farm families Women play a vital role in farming and comprise 70% of the total full-time farmers in Malawi (World Bank, 1995, UNICEF, 1993) An estimated 30% of smallholder households are headed by women, but this percentage increases among the smaller and poorer category of farms High population densities and growth limit available land for farming 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 55 ha, 1 40 ha and 2 91 ha respectively, with an average of 1 11 ha Land pressures are forcing smallholders to undertake continuous cropping, often in cereal monocultures Despite increases in the sale of fertilisers to smallholders, soil fertility continues to decline with falling crop yields

Crop production is dominated by maize which is the staple food crop, accounting for 75% of the total cultivated area (UNICEF, 1993) 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 and cotton

Until recently, tobacco growing by smallholders was limited to dark-fired, air-cured and oriental varieties, and farmers had no direct access to the auction floors As of 1990, burley production was permitted under a limited quota system The following year, licensed smallholders could sell burley on the auction floors Each year, the smallholder quota for burley is increased at pre-set levels Ultimately, Malawi's quota system is likely to be removed, allowing open competition among all producers

Smallholders have been subject to other crop restrictions in the recent past For example, intermittent bans were imposed on

Horticultural produce from beneath* Faidherbia albida *trees

Faidherbia albida *soils remain productive even without fertiliser. Notice the greener maize beneath the canopy*

private trading in groundnuts which severely reduced production in the late 1980s Smallholder access to inputs has also been limited Until 1993/94, the sole supplier of fertiliser was the Smallholder Farmers Fertiliser Revolving Fund of Malawi (SFFRFM) This credit system is undergoing major reforms after collapsing in 1994, and its future is questionable

Emerging Problems

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 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 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

Despite enormous efforts to promote production-increasing technologies among smallholder households nearly 60% currently live below the poverty line Another 20% are only marginally better Households lack basic needs such as adequate food, water, fuel, health, shelter, and education In urban areas, wage earnings are frequently insufficient to purchase food The graveness of Malawi s food crisis is evident from the high level of child malnutrition and mortality (GOM 1987) Restrictive policies aggravate the situation by suppressing true market forces and incentives for sound resource management One result is that real incomes and foreign exchange earnings are declining This is eroding the ability to satisfy essential needs Although Malawi's new democratic government is responding to policy and market distortions, obstacles remain that preclude active participation by farmers in the market place

Outlooks for reversing this predicament are bleak Most households lack the resources and support to undertake sound agronomic and animal husbandry practices The gap in the distribution of income continues

to widen as policies favour the privileged few Family labour, so vital to smallholders in Malawi, is decreasing from the necessity to engage in off-farm employment (ganyu) This often coincides with peak periods of labour demand forcing households into a vicious cycle of increasing poverty and food deficits Particularly vulnerable are female-headed households burdened by the added tasks of collecting water and fuelwood, cooking, child rearing and other domestic chores

Environmental Degradation

Land degradation in Malawi has become acute Soil erosion currently averages 20 tons / ha per annum (World Bank 1992), with rates more than 50 tons / ha in many areas This problem is exacerbated by poor agronomic practices, particularly in marginal lands and steep slopes Soil erosion is characterised by deteriorating soil structure, reduced moisture retention capacity, depletion of nutrients and organic matter, and decreased micro-fauna and flora All reduce the rooting depth of crops which decrease yields, especially in drought years Loss of topsoil has enormous costs to the economy, agriculture and environment, representing an estimated 1 to 5% of GDP from current production alone (World Bank 1992)

Land clearing for agricultural expansion, coupled with high wood demands have led to increased deforestation Between 1972 and 1990, total forest cover declined by an appalling 41%, averaging a loss of 2 3% annually (Bunderson and Hayes, 1995) Since present policies do little to promote alternative fuels, reliance on wood energy is threatened by unsustained exploitation of forest resources

The rising scarcity of trees has direct impacts on agriculture Loss of tree cover causes organic matter to mineralise and leach more quickly from the topsoil, with long-term effects on fertility It also forces households to replace wood energy with crop residues and animal manure, which are better reserved for soil improvement Farm households (mostly women and children) must walk greater distances and spend more time gathering fuelwood This detracts from more productive activities for farming, child care, education nutrition and health Fuelwood scarcity also limits opportunities to generate income from wood sales, beer brewing, fish smoking, brick making, pottery, etc These non-farm activities are among the few options available for resource-poor households to earn cash for food and other basic needs

Most deforestation in Malawi has occurred on customary and private land due to the protected status of parks and reserves 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 threatened Combined with the added risks of flooding, these problems have far-reaching effects on agriculture, fisheries, 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 was estimated at nearly 1 million m^3 of wood in the 1994/95 season 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 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 and along major roads from ineffective policies to curb urban growth and wood use

ROLE OF AGROFORESTRY

As a nation whose livelihood depends on agriculture Malawi recognizes the urgency of developing production-increasing technologies that preserve the integrity of the natural resource base Trees play a vital role in maintaining crop and animal yields by improving the soil water and vegetative base, and by mitigating harmful environmental pest and disease problems They also provide a broad range of uses and products essential to industry, trade health and nutrition As such, agroforestry has high potential to alleviate many farm and environmental problems

Agroforestry is 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 components

More simply put agroforestry is any use or planting of trees by farmers within the farm or homestead for a variety of purposes wood fodder fruits, medicine shade, soil improvement, water conservation, etc Agroforestry is more than intercropping trees with food crops, it combines crop and livestock production with forestry activities to improve or prevent further degradation of ecosystems (Wilson Kang and Mulongoy, 1986) Because of the organic matter added with nutrient recycling, agroforestry can help sustain and improve farmland productivity with a greater range of outputs from the same area of land Potential contributions of agroforestry are outlined below

Fuelwood

Globally, more than 2000 million people depend on fuelwood for cooking Within 5 years, 3000 million people will face acute fuelwood shortages worldwide Fuelwood is estimated to account for 93% of the total energy consumed in Malawi (Anon , 1981) Energy is the most important use of wood in volumetric terms As wood supplies decline, efforts to find and collect fuelwood, a responsibility falling mostly on women and children reduce the time and energy available for other important activities Wood shortages force people to use alternative sources of fuel In parts of the south, maize, stover and animal manure are used for cooking This deprives livestock of valuable feed, and soils of needed organic matter

Soil Improvement

Trees and shrubs have beneficial effects on soils Some trees increase soil nutrients by fixing nitrogen All trees increase soil organic matter, which helps improve the availability of water and nutrients Tree cover also helps to reduce soil temperature, which decreases evapotranspiration making more water available for crops

Nitrogen fixing trees and shrubs have organisms in or around their roots that fix nitrogen from the air, making it available to the tree Most leguminous trees fix nitrogen using existing organisms in the soil Seeds from other nitrogen fixing trees need to be inoculated with appropriate bacteria when planted When the foliage of these trees are added to the soil, nitrogen and other nutrients are released and made available to crops Leaves and pods of nitrogen-fixing trees usually make excellent fodder because of their high protein content The resulting manure can then be returned to the soil

Useful agroforestry trees to grow with crops are those with deep root systems Once well established, they are less vulnerable to drought Trees help to recycle nutrients from deep soil depths to the topsoil, thereby improving soil fertility

Fodder

The productivity of smallholder livestock is low This is reflected in slow rates of growth and maturation, extended parturition intervals, limited quantity and duration of milk production and high mortalities The primary constraint to improved productivity is nutrition and disease Livestock commonly exhibit pronounced deficiencies in energy, protein and sometimes phosphorous Available forage supplies are further affected by expanding cultivation, widespread burning, tree-cutting, and shortened fallows In general, the supply of dry-season forage, mostly grass, is below animal maintenance requirements This is especially true among pregnant and lactating females, as well as young stock Agroforestry practices can address nutritional constraints through planting suitable fodder trees and shrubs Leaves and pods from these plants can provide increased energy and protein levels to livestock during limiting times of the year

Conservation of Natural Resources

Many agroforestry technologies assist in the conservation of natural resources These technologies reduce deforestation by decreasing the dependence on cutting wood from natural forests Farmers will produce more fodder to improve livestock nutrition during the dry season when fodder is scarce and of low nutritional value This will help reduce overgrazing around villages Increasing the ability of farmers to grow much of their wood and fodder needs will help preserve the biodiversity of natural woodlands and forests In many steep areas farmers are cultivating highly erodable soils Using agroforestry techniques for erosion control, farmers will help conserve soil and water that would otherwise be lost, while maintaining the productivity of their farms

Other Products and Services

In addition to fuelwood fodder and improved soil fertility agroforestry practices yield other important products and services of value to the farmer These include food from leaves, seeds, nuts fruits roots and gums a wide variety of medicines and insecticides derived from different parts of certain species, honey, fibres for string and ropes, resins,

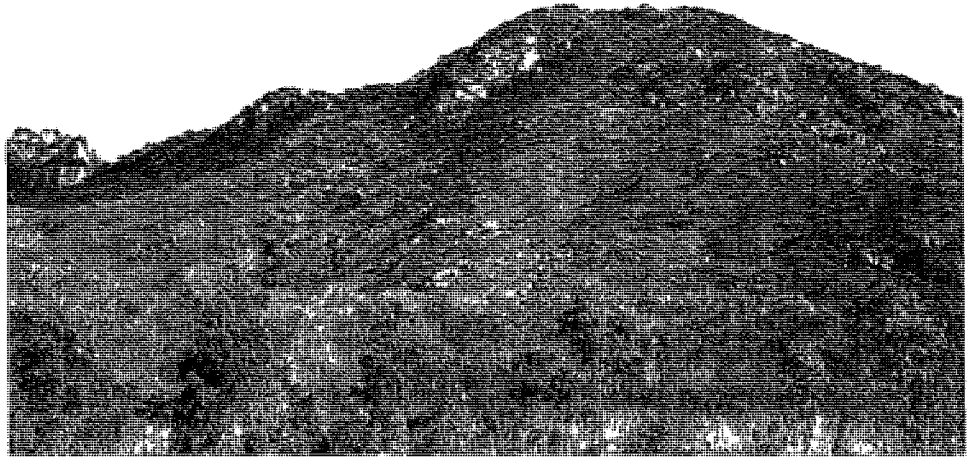
dyes, and tannins for a range of uses Many trees also have cultural uses and values All of these products can generate important sources of cash to meet different farm and domestic needs

Summary

Agroforestry practices can provide a valuable source of food and income-earning products, as well as ingredients for many traditional and modern medicines In addition, trees act as a carbon sink, helping to reduce global warming and as natural genebanks to help conserve biodiversity Trees stabilise hillside soil and reduce erosion from water run-off, they also 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 Trees help to counter adverse climatic conditions by reducing the damaging effects of heavy winds and rainstorms on soils and crops, while improving water infiltration and its availability to plants Many trees provide shade to people and livestock and supply valuable fodder from their foliage and pods Wood from trees is essential for fuel and construction in the absence of cost-effective alternatives Certain species are cultivated commercially for fruits, oil, timber, fuelwood, latex and gums, providing income and contributing to the local economy and export earnings As the major user of land, water and living resources, farmers inevitably play a vital role in the conservation of natural resources Helping them adopt sustainable agroforestry practices will bring significant economic benefits while alleviating environmental degradation

Forest cover of Nsanjika Mountain in Ntcheu, 1987

Same hillside in 1995 showing effects of deforestation



CHAPTER TWO: NURSERY CONSTRUCTION AND MANAGEMENT

INTRODUCTION

This chapter discusses the construction and management of on-farm nurseries to increase tree planting on farms The focus is to demonstrate how tree nurseries can be owned and operated by groups or individuals using simple techniques of propagation with local materials that require less labour and management The size and practicality of such nurseries make them better adapted to smallholder conditions For these reasons, they are becoming increasingly important, especially where access to government nurseries is limited or absent

NEED FOR TREE PLANTING

Tree planting in rural Malawi is becoming increasingly urgent in order 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 material Tree propagation to meet these needs has 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 necessitates 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 raising their own seed and seedlings This will reduce problems of centralised production and distribution of seedlings the use of polythene pots and the costs to farmers With widespread adoption germination and survival rates of nursery and planted seedlings will greatly improve This will increase the stocks of trees on farms throughout rural areas

NURSERY DESIGN AND CONSTRUCTION

General Considerations

The purpose of establishing tree nurseries is to provide a protected site for young seedlings so that they are strong and healthy when outplanted in the field Nurseries also protect seedlings from theft, and from

damage by animals, people wind and rain A major objective of this chapter is to show how the survival and vigour of outplanted seedlings can improve by promoting nursery techniques that encourage good root development The type of nursery recommended is inexpensive flexible and sustainable by farmers

Key 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 the planned agroforestry activities in the community determine the type and size of nursery required The nursery envisioned here is small and permanent for ease of management Nursery owners may involve one or more families organised groups of farmers or special interest groups such as burley tobacco clubs, women's groups, schools or cooperatives Key points in establishing nurseries include

- ***Practicality*** Nursery design and layout are critical for ease of management cost, and labour efficiency Nursery size and location should reflect the number and type of trees required with proximity to water and the household(s) involved Use local materials to minimise costs of external inputs Nurseries are established during the dry season to reduce conflicts with farming

- ***Fertile 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

- ***Sound 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 germinating 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 for most species Shorter roots reduce damage when uplifting or moving seedlings which make field outplanting easier with better seedling establishment

- ***Alternatives to Root Pruning*** Some tree species such as *Faidherbia albida* are easily damaged by root pruning These species can be planted out when young, before their roots penetrate through the pot into the ground, avoiding the need to root prune They can also be raised in open tubes on elevated wire-mesh platforms Contact with air prevents roots from penetrating through the tubes

- ***Quality Seed*** Collecting and storing good quality seed from local sources is important for sustainability and cost efficiency Guidelines are offered for collecting local seed Seed pre-treatments which ensure uniform and rapid germination are described for different types of seed, with instructions for sowing and spacing

Site Selection and Layout

Choose a site that is convenient for ease of management, protection, shade, and watering (i e near a reliable water source) Avoid hilly sites as they require considerable levelling and make water carrying difficult Nursery size depends on the number of seedlings needed A rough guide is to plan about 10 m x 10 m for every 5,000 plants

The nursery site should be easy to reach by foot Select sites close to the planting areas in the field Remove grass and other unwanted material, and level the ground with a hoe Compress loose soil by stamping on it Remember that this soil will not be used for growing the seedlings A slight slope will help to drain off excess surface water Protection from prevailing winds is also desirable 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 young seedlings is discussed more fully later Nurseries with prepared seedbeds for bare-rooted stock need well drained, fertile soil The best soil is loamy in texture, with a loose crumbly structure Nurseries that use only containerised seedlings need not be as selective, since suitable soil or mixtures can be brought in from outside

A sketch of the nursery layout is often useful, particularly for larger communal or group nurseries The sketch should show the size and location of germinating seedbeds, potted seedlings, compost piles pathways storage space, and water sources An example is shown in Fig 1 Fire lines 1 - 3 m wide may also be needed around the fence perimetre

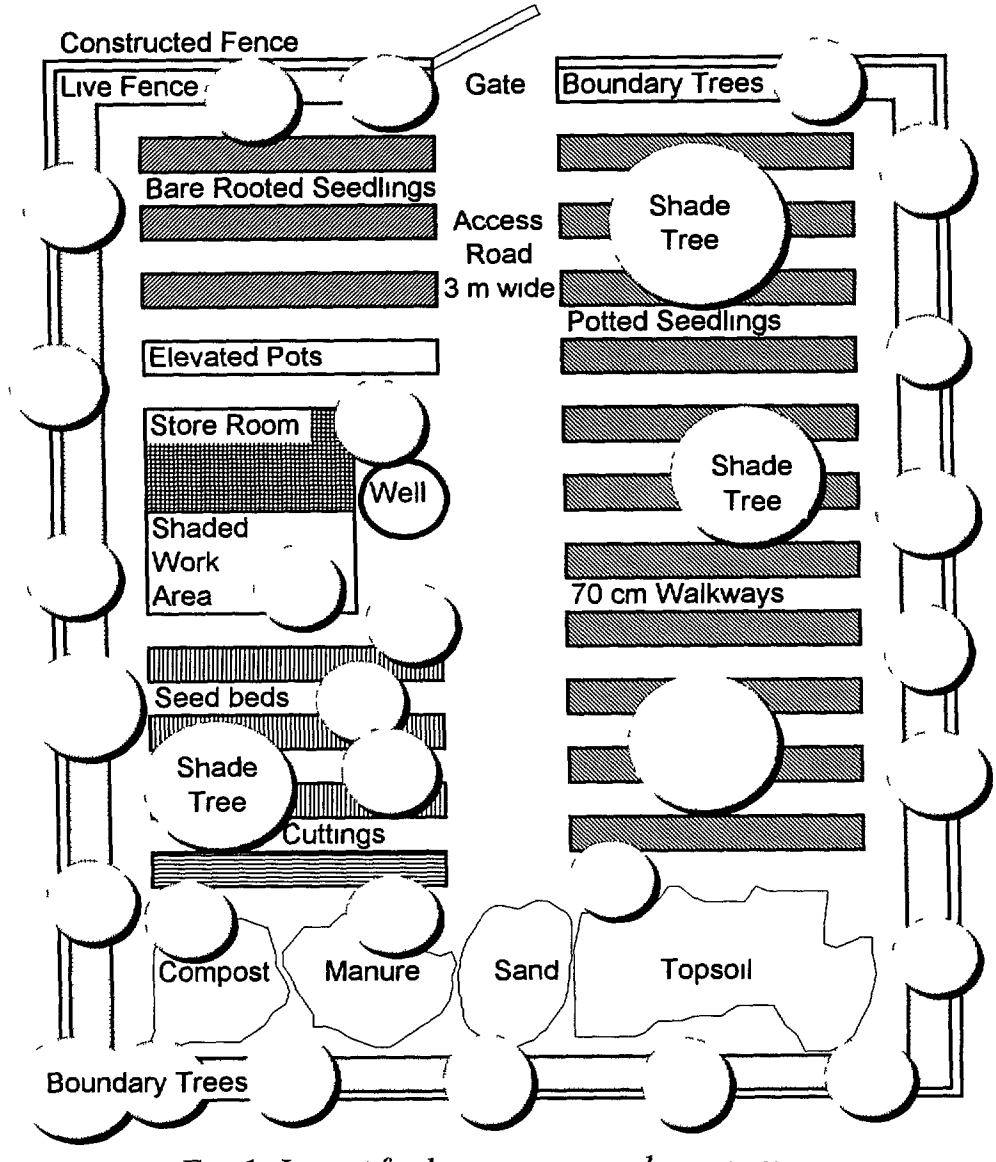
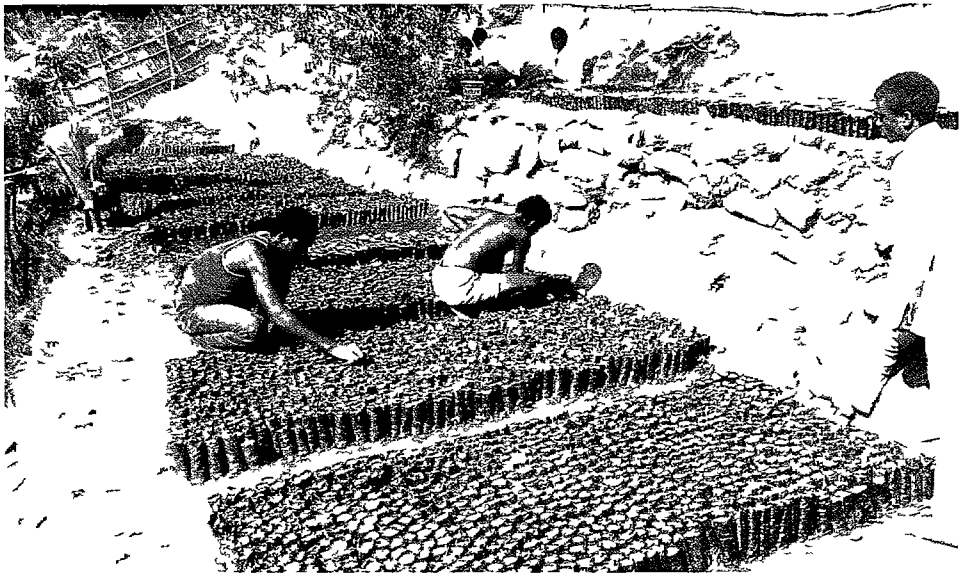
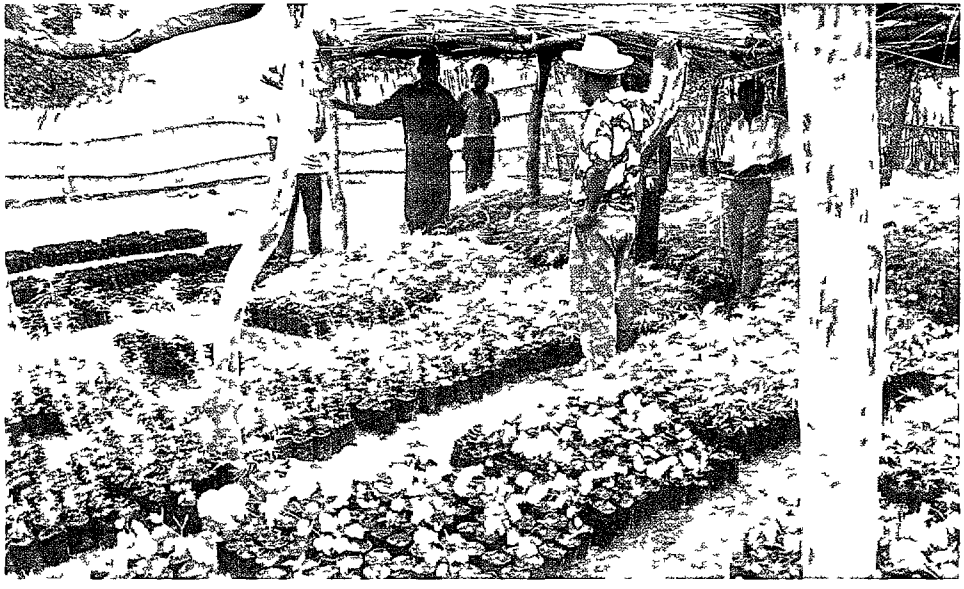


Fig 1 *Layout for larger communal nurseries*



Communal village nursery with filled planting tubes



Communal village nursery with indigenous and exotic tree species

Construction

Levelling and Terracing

After determining the size of the nursery, the first task is to terrace the slope if it is more than 10 degrees Make terraces at least 5 m wide to allow space for 2 or more beds, including access paths After levelling the site, remove all large stones and compress the soil prior to constructing the nursery beds Thereafter, plant suitable binding grasses, such as vetiver or napier, on the banks to help stabilise the terraces Terrace banks may serve a dual role for multiplying these grasses

Nursery Beds and Land Area

The area needed for the nursery depends on the total number of trees required In general, a bed of 5 m^2 is needed for 1000 seedlings regardless of whether seedlings are raised in pots or as bare-rooted stock Double this area to allow space for work, walkways, sheds, etc Make the width of individual beds about 80-100 cm to allow easy access to all seedlings Make walkways between beds at least 60 cm wide Thus, for 5,000 seedlings, the area needed is 10 m^2 x 5 (50 m^2) Increase this to 20 m^2 x 5 (100 m^2) if the pots used are large, or if bare-rooted plants are widely spaced in seedbeds Arrange beds in blocks of 500 or 1000 to make stock taking easy Do this by making beds 10 or 20 pots wide by 50 or 100 pots long If possible orient the long dimension of the beds east-west to give trees more uniform exposure to the sun by reducing edge effects

Bare-Rooted vs Potted Stock

Seedlings may be grown without containers for practicality Bare-root seedlings involve sowing seed directly into a specially prepared seedbed from which seedlings are extracted for outplanting in the field Use of bare-root 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 The pros and cons of using bare-root vs containers are shown in Table 1 Management differences are discussed later

Nursery containers facilitate transporting seedlings over long distances Containers also minimise the risk of drying out and disturbance to the roots For this reason containers are recommended in areas with dry climates and long travelling distances

TABLE 1 ADVANTAGES AND DISADVANTAGES OF BARE-ROOTED STOCK VS CONTAINERS

Bare-Rooted Stock	Containers
Advantages	*Advantages*
• They are easier to transport due to less weight	• Seedlings can be spaced closer, to save space, while time in the nursery is usually shorter
• Transplanting takes less time	• Pots can be moved to the planting site well before outplanting if watering can be continued
• Less care is required in the nursery	• Root growth is contained in a package that is easier to transport, minimising exposure or drying out
• Container costs are absent	• Potted plants may survive better, and root diseases are less common
• Seedlings are usually larger and require less protection after outplanting	
Disadvantages	*Disadvantages*
• Seedlings need more space, and more time in the nursery	• Pots are expensive and labour demanding
• Nursery conditions and soil must be of good quality	• Pots are more difficult to transport because of their size and weight
• Risk of damage to plant is higher since the roots are exposed to air after extraction from the seedbed for outplanting	• Seedlings often require frequent root pruning, which is labour intensive with risks of root damage
	• Seedlings are usually smaller when planted out, requiring more care and protection until well established

Nursery Soil

Fertile soil for the seedbed is desirable to grow healthy seedlings Prepare the soil or mixture close to the nursery site The soil mixture should maintain a balance of good drainage and nutrient content A suitable mixture consists of 2 parts fine, fertile topsoil to 1 part farm-yard or compost manure If the latter is not available use fertile fine-grained sandy-loam soil from the garden, or from beneath acacias or other soil-improving trees If necessary, mix the soil with 1-2 parts sand for better drainage, especially with clay soil The key point is to avoid extreme materials Pure sand retains little moisture and has few nutrients, while pure clay fluctuates from water-logging when wet to hard and cracking when dry A sandy loam is ideal because it is intermediate in texture and is well-drained These are important for root development

Avoid soils infested with root worms or other pests Too much organic matter may also lead to diseases In permanent or long-term nurseries, change the soil of the seedbed, or treat it with fungicide before each planting to reduce diseases

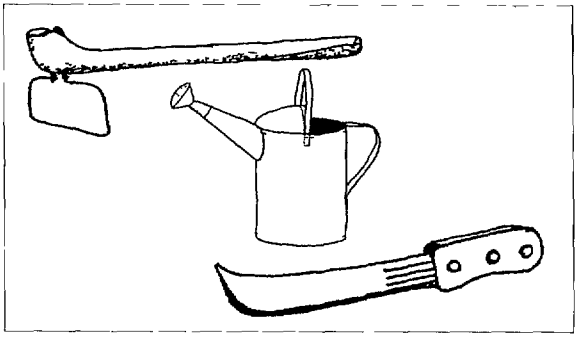
Seed

An adequate supply of quality seed is needed for the required species of trees Details of seed collection storage, and treatment are discussed later in the chapter

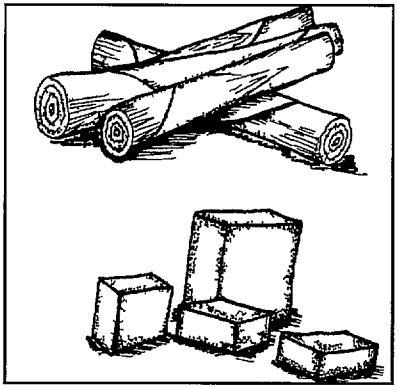
Tools and Construction Materials

Pangas, hoes and watering cans are the main tools needed These tools are used to prepare the nursery site and seedbeds, to extract seedlings and their root mass from seedbeds, to prune roots, and to water the seedlings Watering

Important nursery tools



Materials for nursery construction



cans are convenient but buckets or large tin cans with holes in the bottom will work fine

Wooden boxes plastic washbasins and other containers at least 15-20 cm deep may also be used as seedbeds Containers should be free draining Shallow containers (less than 15 cm) should be used only to grow seedlings for transplanting to individual containers They should not be used to raise seedlings to planting-out size because root development is likely to be inadequate This will result in poor survival and growth in the field

NURSERY PRODUCTION AND MANAGEMENT

Sound nursery techniques are essential for producing strong, healthy seedlings This section discusses nursery techniques for raising and managing bare-rooted and potted seedlings, focusing on procedures that are simple practical and efficient 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 minimise the need for remedial controls

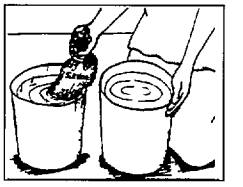
Treatments for Seed Germination

Seed pre-treatment is needed before planting some tree species These are briefly discussed below Table 8 on page 98 presents a list of recommended agroforestry species, indicating the seed treatment necessary for each The basic types of pre-treatments are as follows

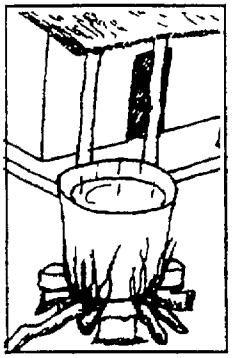
0 Some seed requires no treatment, generally plant fresh seed due to short viability

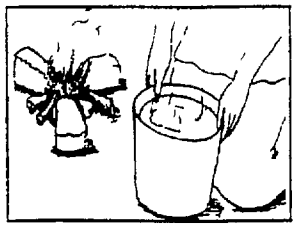
1 Soak in water at room temperature for 48 hours Use ordinary tap or stream water Plant the same day

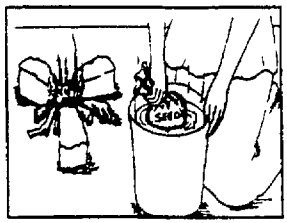
Soaking seed for 48 hours in ordinary water after hot water treatment



2 Soak in hot water at 65°C for 10 - 15 minutes Do this by boiling a pot of water which is removed from the fire and left to sit for 15 - 20 minutes Then place the seed in a cloth bag or sock and immerse it fully in the water for 10 - 15 minutes Remove the seed from bag and sun-dry for 15 - 20 minutes Plant the same day







Steps in hot water treatment

3 Remove the fleshy pulp and plant the same day

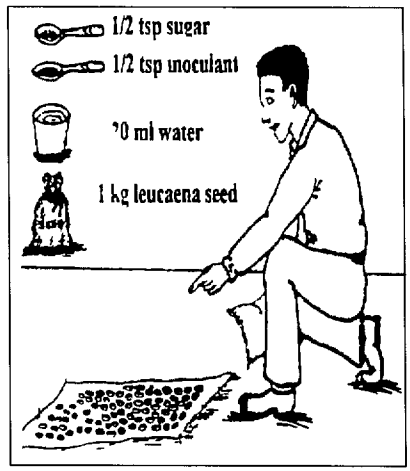
4 Crack the shell and extract the seed, plant the same day

5 Crack the shell and plant the seed with the cracked shell on the same day This is for seeds that are difficult to extract without damaging the seed

6 Nick off end of seed with nail clippers or knife to allow entry of water This is extremely effective for certain species, but is labour intensive (1,000 seeds per person hour) Do not apply hot water treatment after opening the seed coat

Inoculation of Leucaena *Seed*

Leucaena seed needs inoculation with rhizobia to enable the plants to fix air nitrogen with their roots Use proper rhizobia for the inoculant, available in 50 g air-tight packets from Soil Microbiology at Chitedze The inoculant can be mixed into a slurry so that it



Sun-drying of Leucaena *seed and inoculation recipe*

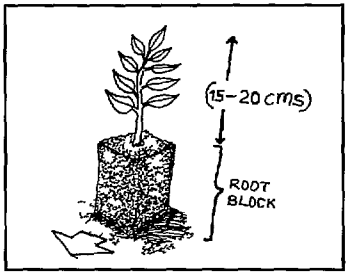
will stick to the seed Soil from around existing *Leucaena* plants can also be used as it should contain the necessary rhizobia

Procedure Using a pot, mix a solution comprising 1/2 teaspoon of inoculant, 1/2 teaspoon of sugar, and 20 ml of water for every 1 kg of *Leucaena* seed First, pre-treat the *Leucaena* seed in hot water as described above under treatment 2 Take the seed out of the hot water and stir with the inoculant until the seed is covered with inoculant Sun-dry for a few minutes and plant the same day

Bare-Rooted Stock

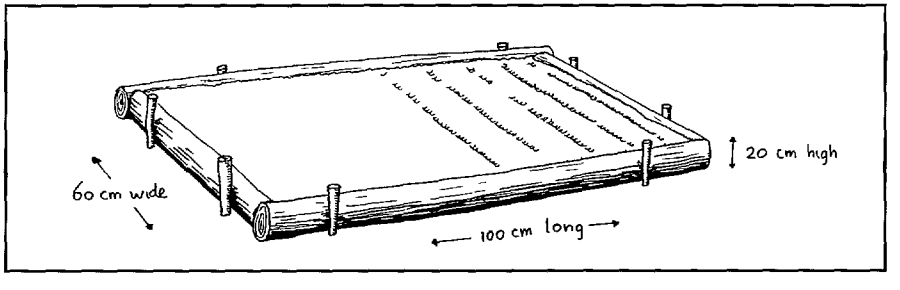
Seedbed Preparation

The type of seedbed recommended is modeled after the Swaziland Bed, which is a raised seedbed for growing open, bare-rooted seedlings When large enough, outplant the seedlings directly in the field with a ball of soil around their roots



Bare-rooted seedling with cube of soil after extraction from seedbed

Lay the seedbed out on levelled ground, enclosed by a frame of wooden boards or planks, tree branches, palm fronds, sisal poles, or sections of banana stems with a diametre of 20 cm The frame prevents crumbling and erosion of the seedbed sides Construct the seedbed 60-90 cm wide by 1 m or more in length If the seedbed is to be used for several years, 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



Seedbed for bare-rooted stock

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

Sowing the Seed

Use a small stick or finger to make furrows about 10 cm apart along the length of the seedbed Leave a space of 5 cm 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 should be roughly 2-3 times the smallest diametre of the seed For example, make furrows about 1 cm deep for medium-sized seed such as *Senna siamea Leucaena* and *Faidherbia albida* For larger seed such as *Gliricidia sepium, Acacia galpinii* and *Acacia nigrescens,* make furrows 1 5 cm deep Furrows for small seed such as *Sesbania sesban* and *Toona ciliata* should be about 0 5 cm If the furrows are too shallow the seed may become exposed to the sun and dry out If too deep, newly germinating plants may choke and die

Starting at one end of the seedbed sow seeds about 5 cm apart For seeds of low viability, sow 2-5 seeds together in case some seeds fail to germinate Cover the seed with soil and compress the surface lightly Tiny seed can be mixed with sand and sprinkled evenly along the furrow After germination thin out the seedlings so that there are 5 cm between plants This reduces competition and crowding A seedbed 1 m x 0 6 m wide will produce about 100 seedlings

Other management practices are discussed later under general nursery care which applies equally to bare-rooted and potted stock

Containers for Individual Seedlings

Preparation of the Site

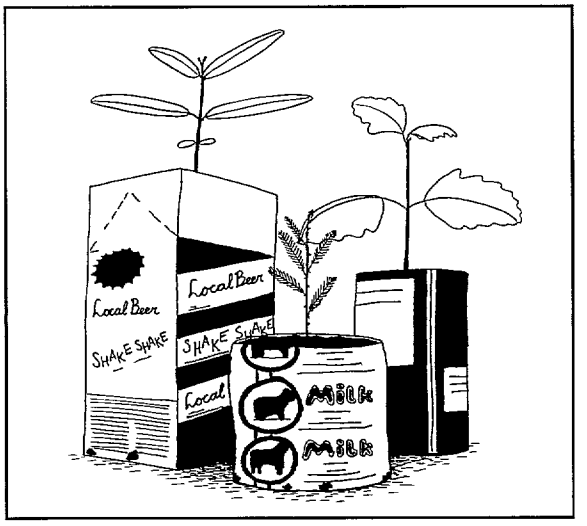
Pots are commonly used for raising seedlings in Malawi For greater efficiency, seed is often sown into pots to avoid the need to pick out and transplant the seedlings from seedbeds Small seedbeds are recommended for seed that germinates erratically, or which has questionable viability Use sandy soil for easier transplanting Direct sowing such seed into pots can be costly and inefficient because of low germination

The site needed is firm, level ground A cambered slope will encourage drainage of excess water to avoid fungal attack or damping off Set up the pots in blocks about 1 m wide to

accommodate 500 or 1000 pots each This makes work easier, and facilitates germination assessments and stock taking Block length will vary with the size of the pots Stand pots upright in straight, even rows for uniform watering and good growth Protect outside rows from the sun (to avoid stunting) by piling a wedge of soil against these rows

Pot Filling

Polythene pots or tubes are the most common nursery containers, but tin cans and used *chibuku* packets may also be used Other types of containers include pots made of ceramic, wood, or banana leaves and stems



Possible containers for seedlings

Nursery containers should be at least 15 cm deep, and from 8 cm to 12 cm wide when flat In general, containers must be tough enough to last 2 to 3 months, or as long as it takes for the seedlings to be ready for outplanting in the field The bottoms may be open (e g , polythene tubes) or closed Tubes are preferred over pots with closed bottoms because they allow better drainage and help reduce the risk of root deformities If closed, perforate the bottom area so that water does not stagnate and cause rot and fungal problems Fill the pots to the top with prepared nursery soil (see page 20), lightly packing it while filling The soil will settle about 0 5 cm from the top after watering Below this level, the sides of the pot may collapse towards the inside, which prevents adequate watering As the seedling emerges and grows, add more soil if the root collar drops 1 5 cm or more below the container's top

Sowing

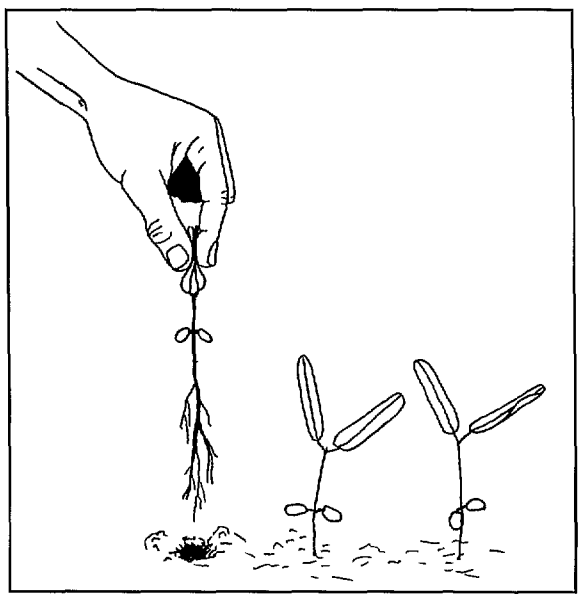
Water the pots about two weeks before sowing so that germinating weeds can be removed to reduce competition Lay the seeds flat (except seed of *Anacardium occidentale* which is planted upright) Plant one or two seeds in the middle of each pot Add extra seeds if germination is expected to be low Push seeds into the soil with a thumb or stick to the required depth based on seed size (as

discussed above undei bare-rooted stock) If seeds rise to the soil surface after watering push them back down to the proper depth

Transplanting from seedbeds to pots

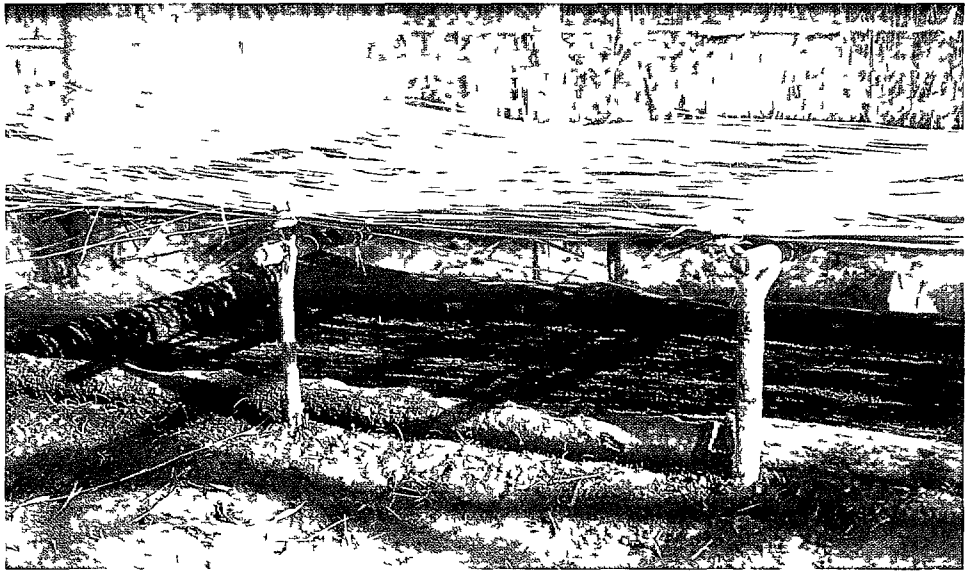
This section refers to seed that has been sown in germination beds due to low viability or small size

Transplant seedlings in the shade on a wet windless day after the seedbed and containers have been thoroughly watered and softened While holding the top leaves lift the seedlings after loosening the soil below the roots with a knife or trowel Seedlings are pricked-out in this way when they have one set of leaves above the cotyledons (the fat 'seed leaves) By then most seedlings are 3-8 cm tall, and about 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 competition from growing under crowded conditions in the seedbed If the seedlings already have a tap root prune it with a sharp knife, or it may bend on transplanting this may later interfere with growth Transplant the pricked-out seedlings right away into 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



Pricking out seedlings from a seedbed

Hot water treatment of seed (see page 22)



Shade for a seed bed (see page 29)

GENERAL NURSERY CARE

Timing of Operations

Set up tree nurseries about 2-3 months before the onset of the rains This allows outplanting in the field to start soon afterwards (i e , November to December) Remember that most bare-rooted stock requires more time in the nursery

Early outplanting is critical in order to give the seedlings sufficient moisture and time to become well-established before the onset of the dry season During this period, conflicts with farming are lower, allowing more time to set up the nursery properly There are also fewer pests at this time Most tree seedlings should be planted in the nursery during August or September although this will vary for different species Some species like *Sesbania sesban* need only 4-5 weeks in the nursery Plant such species later so that they do not overgrow before outplanting in the field Other species like *Azadirachta indica, Khaya nyasica,* and *Trichilia emetica* are planted earlier due to slow initial growth The main point is to have nursery seedlings ready for outplanting when the rains begin

Mulching

After sowing, mulch seedbed or potted soil with leaves or grass to maintain good soil texture, and to reduce temperatures, evapotranspiration 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

Watering

A ready, cheap supply of water to the nursery is crucial for reliability Permanent village streams are ideal, but these are not always available where needed Wells are sometimes necessary costs of which are reasonable where ground water is shallow Pumps may facilitate 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

The rule for watering is simple adequate amounts of water are needed at regular intervals Seeds must be watered as soon as they are planted Take care that they are not left exposed to the sun, or washed to the side of the pot For at least the first month,

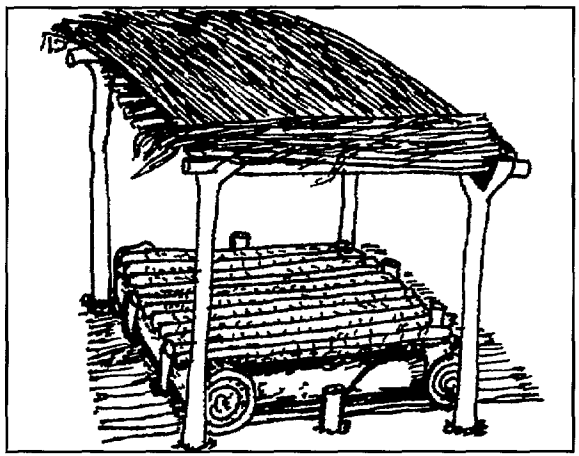
water twice daily making allowances for soil type location and climate which influence the amount of watering needed Water in the early morning and late afternoon Plants need an average of 3 - 4 watering cans per 1000 pots each time Check seedbeds and pots regularly for adequate moisture to a depth of 20 cm Never allow moisture levels to drop near the wilting point Underwatering leads to poor root development and growth while overwatering may encourage damping-off diseases (see **Protection** below)

When watering seedlings, take care that they are not damaged or washed out of the soil Add water slowly so it does not form puddles or run off before it has a chance to soak in To reduce the impact of watering, place a bundle of grass or leafy branch over the pots when watering

Protection

Shade

Shade may be required to protect seedlings from sun scorch and excessive water loss (evapotranspiration) during the first weeks This is critical after transplanting from seedbeds to pots Shading also reduces damage from heavy rainstorms Shade is more important for the lower hotter altitudes of the



Shading of a seed bed

country (e g , the Lakeshore plains, and Shire Valley) This is necessary for only a short time, since most species adapt early and well to full sunlight Shading for seedbeds and seedlings should be about 75 cm high and may be fashioned out of banana or palm leaves, straw, grass or split bamboo Avoid heavy shade and opaque materials as deep shade interferes with plant growth, which cause seedlings to be weak and spindly

Browsing animals

A rough fence of sticks or thorn branches can 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 Chapter 3 for species recommended as living fences) Living fences are more permanent, reduce maintenance costs, and offer multiple uses, such as fodder, wood, fruits and thorny material

Insect pests and diseases

A variety of pests and diseases may attack nursery tree seedlings In small-scale nurseries, serious losses of trees to 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 threaten beneficial organisms The best method to minimise pests and disease is to maintain high standards of hygiene and management Specific recommendations follow

Ants and termites Some species 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 locale Reduce this risk by keeping pots and seedbeds 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 clumps of 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 area with mulch to prevent the woodash from washing away Tree seedlings may also be protected after outplanting by placing woodash into the planting hole

Cutworms, caterpillars, and sucking insects Good nursery hygiene with frequent inspection will reduce these problems Seedlings with cut stems may indicate cutworms which should be dug up and destroyed Caterpillars should also be removed and killed Aphids and other sucking insects cause wilting Infected seedlings must be removed and destroyed

Diseases Damping-off is the most common nursery disease which is 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 centres The

cause is usually poor nursery hygiene and management Problems and remedies are as follows

- *Soil too rich in organic matter, which encourages fungi growth* Remedy is to reduce the ratio of manure to soil to 1 4

- *Overwatering* Remedy is to water well but do not cause water-logging conditions

- *Seed sown too densely with overcrowding of seedlings* Remedy is to space seeds wider, and thin out soon after seedlings emerge

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

Thinning

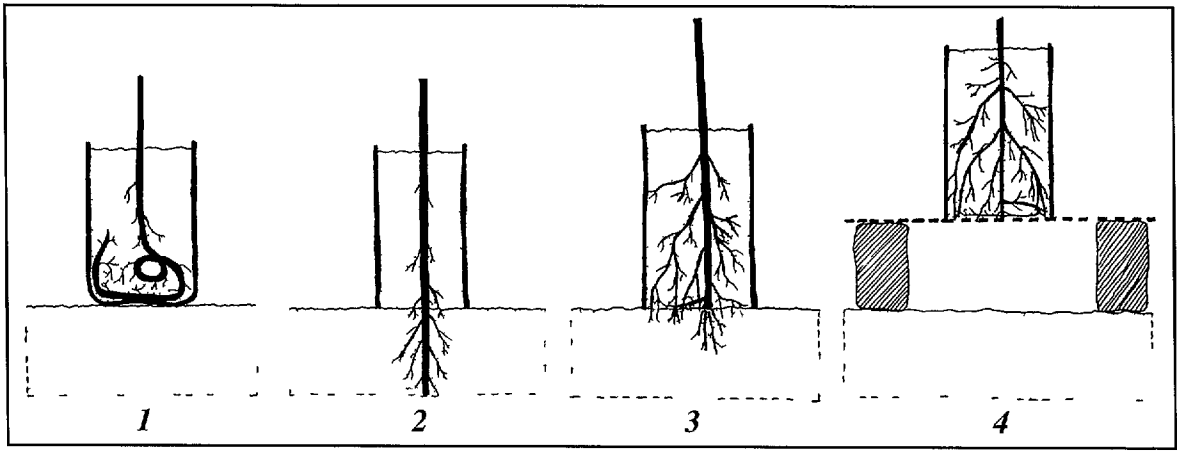
Good germination from densely sown seed may cause overcrowding and competition which makes plants vulnerable to damping off While still small, thin seedlings to the standard density 5 cm between plants per row for bare-rooted stock, and 1 plant per container for potted seedlings Done at an early stage thinned plants may be used to fill gaps in the seedbed, of pots where germination has failed

Weeding

Weeds compete with seedlings for nutrients, water, and light Aggressive weeds may dominate, weaken and even kill tree seedlings Weed potted stock and seedbeds at regular intervals, about once a week Failure to weed regularly may result in deep-rooted weeds which are hard to extract without damaging the tree seedlings Weeding also reduces the incidence of animal and insect pests that may be attracted by the weeds

Root pruning

Root pruning involves regular trimming of tap and side-roots while the seedlings are growing 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, improving seedling survival when outplanted The shorter dense roots also make outplanting easier and minimise root deformities caused by bending or breaking longer roots Left unpruned, taproots of many species grow into the compacted ground beneath the nursery bed This makes it difficult to remove



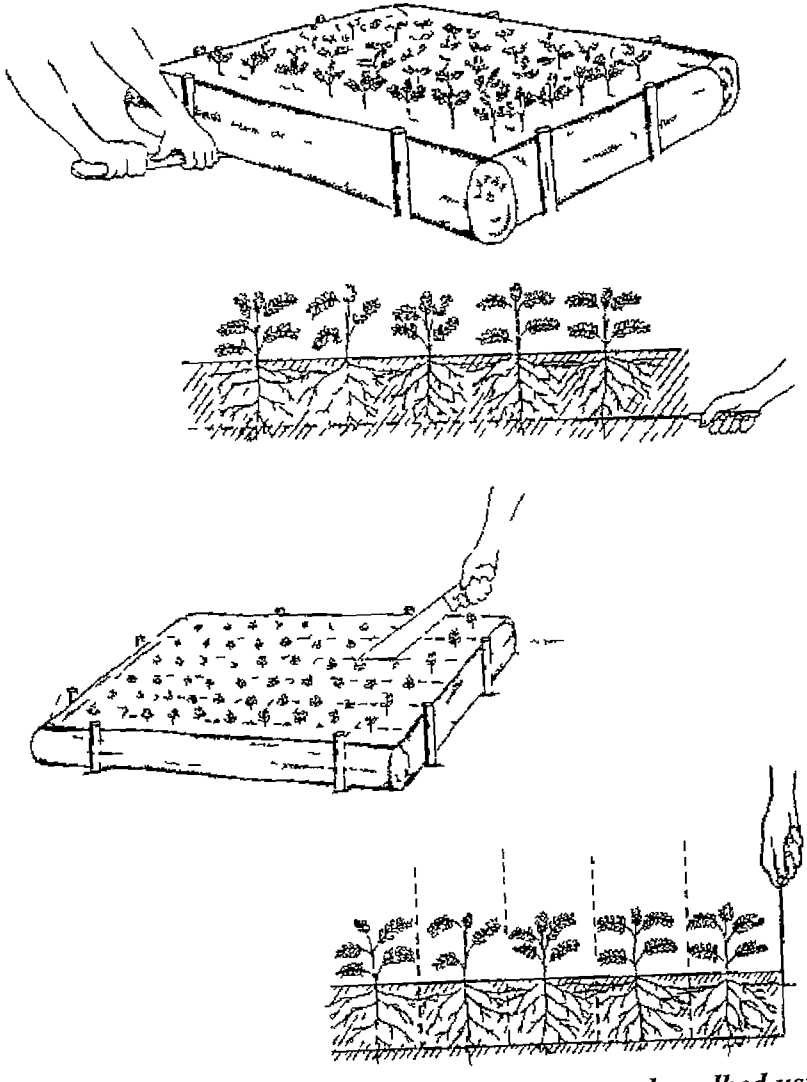
Root problems 1) closed pot with bent root, 2) open tube, no root pruning, 3) frequent rootpruning, 4) elevated tube, air pruning

seedlings which cause roots to be damaged or broken Such seedlings are unlikely to grow or survive well, even if they appear healthy in the nursery

Root pruning will shock the seedlings, especially if it is delayed, or if the roots have grown long before their first cut Removing the growing tips of roots temporarily reduces the uptake of water Seedlings need about 2 days in the shade to recover from this longer in direct sun Root prune every 2-3 weeks and a few days before outplanting, but never on the same day Always soften the soil by watering to make cutting easier To minimise stress prune early in the morning or in the evening when evapotranspiration is lowest to minimise the risk of wilting

Potted Seedlings Eliminate small roots protruding from the pots by simply lifting the pots and breaking the rootlets Roots may also be pruned with a sharp knife or panga This is necessary for bigger roots

Bare-rooted seedlings Root prune seedlings by running a thin wire or panga under the seedbed at ground level Remove pegs or stones that interfere with the operation Use of a wire requires 2 people holding it taut while moving it down the length of the seedbed A panga, held with both hands, needs only one person to firmly cut tap roots along each side of the bed Prune side roots by slicing the soil vertically with a knife or panga along and



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

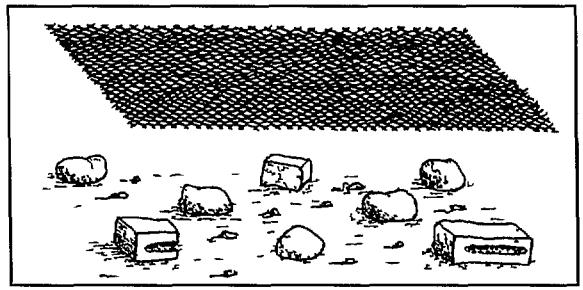
across the rows of seedlings This forms a "cube" around each plant usually 6-8 cm wide and 12-15 cm deep (see page 23)

Alternatives to Root Pruning

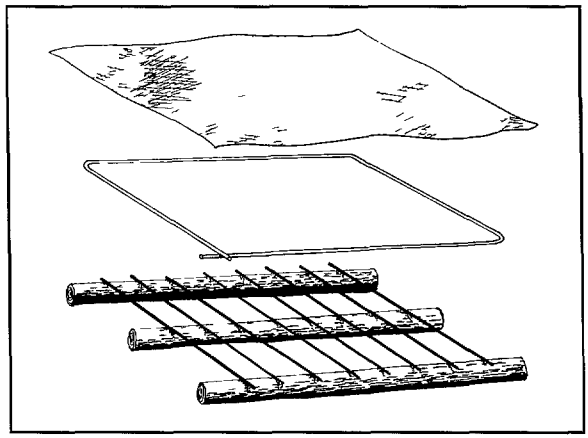
Some species do not respond well to root pruning due to a fast growing root system that is sensitive to disturbance One such species is *Faidherbia albida* Two methods are recommended to minimise interference with the root system for good growth and establishment

Early Outplanting Outplant seedlings within 4 weeks of germination, before the roots grow through the bottom of the tube or pot into the ground below

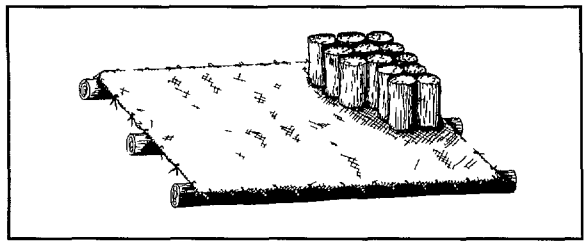
Air Pruning Raise seedlings in open tubes or sleeves on a wire-mesh platform elevated above the ground As soon as the roots reach the bottom of the tube and make air contact, they cease growing The root system is not harmed and fine lateral roots will develop in the tubes A platform may be re-used in the same season by planting seedlings in 2 lots of 150 about 3 weeks apart This means that the second lot of seedlings can be left on the ground for up to 3 weeks before transferring them to the elevated platform



Platform made out of expanded metal



Construction of wire-mesh platform



***Wire-mesh platform for elevating pots of* F albida**

The disadvantages of using a wire-mesh platform are that the materials needed are expensive and not always available However, since seedlings of tree species like *Faidherbia albida* are often needed in only small quantities, costs are low A frame of 100 x 60 cm will support 150 seedlings using small tubes (15 cm x 10 cm) Two examples of elevated wire-mesh platforms are illustrated on page 34 The first platform is made of expanded metal with holes smaller than the diametre of a pencil A platform with larger holes (e g , chicken wire) will result in loss of soil from the tube The second platform is made of mosquito wire spread and tightened over a frame of reinforcing bar with supporting bars This is more difficult to construct and not as strong A platform 100 x 60 cm in size needs one bar of 330 cm, 8 bars of 70 cm, one piece of mosquito wire of 120 x 80 cm and some string Elevate the platform with stones or poles

Hardening Off

Hardening off is the gradual reduction of watering and shade to seedlings, with increased root pruning during the last weeks in the nursery This helps to prepare trees for the sunnier, hotter, and dryer conditions they are likely to face at the planting site Without hardening, seedlings will experience shock when moved suddenly to a harsher environment

Watering Reduce watering from twice to once a day 4-6 weeks before planting out After a week, water every other day until time for outplanting **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 If the seedlings begin to wilt, they need watering immediately to avoid damage Do not water at midday when evaporation is at its highest because the seedlings may be shocked, especially if cold water is used Also remember that over watering may cause fungal disease

Shading After 3-4 weeks in the nursery cut the shade by half After another 2-3 weeks, remove it completely During the last weeks in the nursery, expose seedlings fully to the conditions they will face after outplanting

Root pruning Gradually increase the frequency of root pruning to once a week This will reduce root deformities

OUTPLANTING

Preparation

Outplant with care and foresight to minimise damage to young delicate seedlings, and to ensure 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 It is important to outplant at the start of the rains choosing a wet day if possible with soil that is moist to a depth of at least 20 to 30 cm Outplant early in the morning or evening to avoid heat and high evapotranspiration, which may cause seedlings to wilt Before outplanting water the seedlings well and make sure they have recovered from any root-pruning

Most species are ready for outplanting when shoot development is roughly in balance with the roots For example with proper pruning, seedlings with shoots 20 cm long should have a root system 15-20 cm long Seedlings 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 **A word of caution** Overgrown seedlings with damaged or deformed roots have a lower chance of survival than smaller seedlings with normal root systems Thus, avoid seedlings that have not been root-pruned, or whose shoots are taller than 20 cm This may indicate that the tap roots have grown too deep, risking damage when lifted, and reducing survival after outplanting

Bare-rooted stock 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, which may be done in buckets, boxes or other suitable containers to minimise disturbance to the soil/root mass To reduce damage and wilting, remove only enough seedlings at a time to outplant in one-two hours If the seedlings cannot be planted right away, keep them shaded and covered with wet straw or grass The message for transport is clear any method will do, as long as water loss and disruption of the root/soil mass are minimised

Potted seedlings Do not allow seedlings to overgrow in their containers, especially plastic ones, which may lead to root deformities such

as J-shaped or spiraling roots This increases the susceptibility of seedlings to root diseases, causing slow growth and poor development form A general 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 *Faidherbia albida* is an exception due to its fast growing and sensitive tap root (See Alternatives to Root Pruning) There may also be other species that respond in a manner similar to *Faidherbia albida* At the planting site, remove the container carefully to minimise damage to the roots and loss of soil If the bottom is closed, cut the bottom off with a sharp knife, then cut the pot lengthwise Remove the container only after placing the pot correctly in the prepared hole (see below)

Planting

With both potted or bare-rooted seedlings, dig holes 30 cm deep by 30 cm in diametre In areas of low rainfall, enlarge the holes just before the rains to allow thorough soaking of the hole and surrounding soil This will improve soil-moisture conditions for better growth and establishment Loosen the soil at the base of the hole to enhance root development and to reduce waterlogging after storms

Place the seedling in the centre of the hole, keeping the root collar level with the ground surface With the heel of the foot, pack down the loose soil firmly If possible, water the seedlings well and add mulch Mix in farmyard manure to infertile soils to get the trees off to a better start As with other crops, keep young seedlings free of weeds and browsing animals until tall enough to minimise these dangers (see photo on page 85)

OTHER METHODS OF TREE PROPAGATION

Direct Sowing of Seed

In agroforestry, an ideal form of planting trees is to sow the seeds directly in the field, as done with maize and other crops If done well this method permits larger numbers of trees to be grown This eliminates costly labourious and time consuming operations such as running nurseries and outplanting seedlings The disadvantage is lower survival rates and the need for greater quantities of seed This is due to the greater vulnerability of small plants to sun exposure dry spells, heavy rainfall, pests, disease, and browsing animals Poor visibility of small germinating plants may also lead to accidental trampling or weeding

The best species for direct sowing are those yielding high quantities of seed that germinate easily, and whose initial growth rates are fast Examples include *Caesalpinia decapetala Gliricidia sepium Leucaena leucocephala, Sesbania sesban* and *Tephrosia vogelii Tephrosia* is one of the few species that appears to perform better from direct sowing than from nursery seedlings Other species showing reasonable results with direct sowing include *Acacia galpinii, A nigrescens, A polyacantha Faidherbia albida Senna siamea, Ziziphus* spp and some exotic fruit trees such as avocado *(Persea americana)*, and mango *(Mangifera indica)*

Direct sowing is best suited for alley cropping, short-term fallows, fodder banks, living fences and contour vegetation strips Clear the land and open a shallow furrow, 2-3 times the smallest diametre of the seed Cover the seed lightly with soil, pressing it down gently Mix very small seed with sand before sowing Keep the area free of weeds during the early growth stage

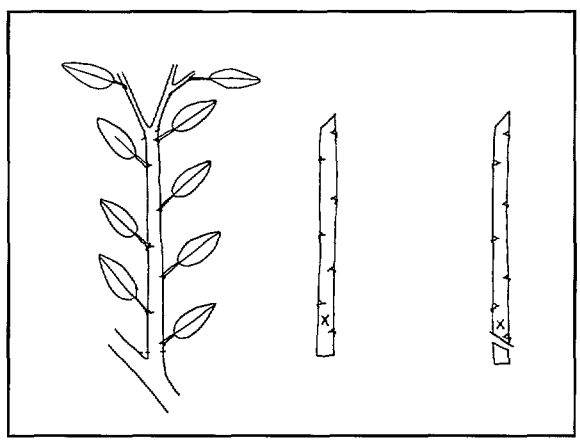
For interventions using a wider tree spacing, (e g woodlots, systematic interplanting, and boundary/homestead planting), weed and loosen the topsoil of the planting sites Sow 2-5 seeds at each planting station to the proper depth, covering lightly but firmly with soil Clearly mark the tree rows and/or boundaries to minimise disturbance trampling, and accidental weeding of the trees For systematic intercropping and boundary/homestead planting, mark each planting station with a stake or other visible marker until the trees are well established Protective fences may also be needed

Propagation from Cuttings

Some tree and shrub species can reproduce from sections of stems which strike roots when placed in the soil Advantages of cuttings are that seedlings develop rapidly and their genetic make-up is identical to the mother plant Not all species can be propagated this way With some species, cuttings may be planted directly in the field, which is practical and convenient for farmers Others need initial nursery care in pots or cutting beds with regular watering in good, well-drained soil

Take cuttings from deciduous trees late in the dry season when the tree is dormant, i e before the sap has started to rise and before the new leaves appear For evergreen trees, take cuttings early in the rainy season Do not take cuttings when trees are in fruit or flower Select mature healthy trees, cutting young vigorously growing branches that have had one full year's growth Roots cannot develop from new stem growth Most cuttings are 1 to 2 cm in diametre Larger ones, called truncheons of 5 to 10 cm diametre, may also be used with some species Separate the cutting section from the lower and upper stem with two clean angled cuts Mark the rooting end The cutting may vary from 40 to 200 cm long Each cutting should have several nodal points from which new branches and roots will sprout Remove leaf and flower buds as they tend to inhibit vegetative resprouting

Plant cuttings as soon as possible, within 24 hours Just before planting, cut 1-2 cm off the base with a sharp knife, since ends that have been exposed to air are less likely to regenerate 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 development of shoots and roots Large truncheons may be planted to a depth 40 - 75 cm Replace and firm down the soil Ideally,



Propagation cuttings 1) take one year old branch, 1 -2 cm in diametre, 40 -80 cm long, 2) mark bottom end, remove leaves, 3) just before planting, cut off 1 - 2 cm of bottom

keep cuttings well watered until the roots have formed In nurseries, stem cuttings are commonly rooted in sand to reduce risk of waterlogging Fungal decay is also less likely in sand Species that are capable of reproducing from cuttings are specified in Chapter 3 under specific agroforestry technologies

SEED COLLECTION, PROCESSING AND STORAGE

High-quality viable seed is essential in raising vigorous tree seedlings This requires identifying robust mother trees that are good seed producers Collect seed from healthy stands of the same species to improve offspring vigor and to increase genetic variability Avoid trees that are young, diseased, isolated, poorly shaped, or low seed producers Locate collecting sites similar to those where the trees will be grown to help ensure environmental adaptability Keep records on seed location, altitude, soil and climate for future reference

Timing of Seed Collection

The optimum time for seed collection is as soon as the seed is mature and ready for harvest Whatever 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 To check for ripeness extract and cut open a few seeds They should be white and firm inside, and should fill the seed coat Some types of seed will not germinate if they remain on the tree too long Timing is critical for species with dehiscent fruits, since the seeds are light and easily blown away by the wind

Methods of Seed Collection

Natural or Induced Seed Fall

This is the simplest method since no special skills are needed Only a rake, sieve and seed container are required Large plastic sheets or blankets may also be spread under the tree for collecting seeds Alternatively, keep the ground clean of leaves, branches and undergrowth to facilitate seed collection Collect seeds daily to minimise insect attack and fungal infection Do not use this method with dehiscent species as the seeds may be blown away before they can be collected

Trees with Fruits Intact

Fruits may be picked directly off the tree by hand Seed-bearing branches may also be cut with a saw or panga, taking care not to damage the tree Fruits may be reached from the ground if the trees are small Poles attached with hooks may also be used to shake branches to dislodge the fruits Try to collect seed from the entire crown as lower branches may contain seed of poor quality Tree climbing or use of long-handled pruning shears may be required for higher branches

Seed Drying and Storage

Dry the fruits or pods so that they open up more quickly, then cover at night to prevent reabsorption of moisture Dried fruits of many species may be shaken or beaten to remove the seed For the latter, place the fruits in a sack or bag and beat it with a heavy stick Be careful not to damage or break the seed, which may increase susceptibility to disease and rot

There are many methods to dry seed The most common is to spread the seed out in a well ventilated site, and sun-dry gradually over a few days Never expose seed directly to fire which may damage or kill it

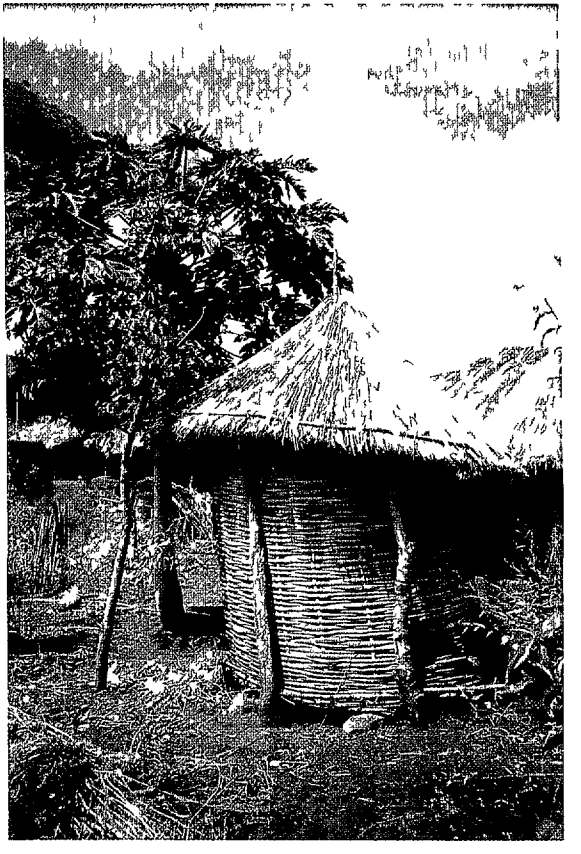
Always aim to sow or dispatch seed soon after acquiring it However, in some cases, seed needs to be stored for future use The longer the seed is stored, the greater the probability that it will lose its viability For many species, empty or damaged seed can be separated by immersing it in water The good seed sinks, the bad floats If seed needs to be stored for some time, find out what conditions are best for this, and how long it will stay viable A general rule is to store seed in a cool, dry and dark place, as heat, light and moisture may activate seed germination Proper storage of dried seed will also minimise attack by fungi or insects Seed may be mixed with ash to reduce these problems since treatment with chemical insecticides or fungicides is too expensive

After drying and winnowing to remove chaff and dirt, place the seed in an airtight tin, plastic bag, or other suitable container

Important points to remember when using sealed containers include

- Never seal in moist seed
- Use clean, airtight containers
- Avoid opening seed containers unless absolutely necessary
- Label the container, showing date, species, and place of collection
- Specify the length of viability, and if possible, the viable seed per kg

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



CHAPTER THREE: AGROFORESTRY TECHNOLOGIES

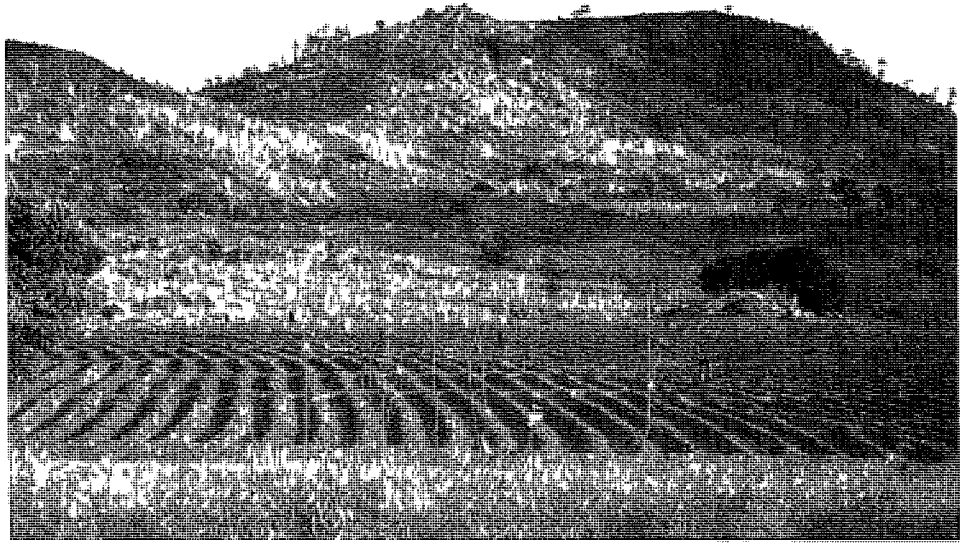
INTRODUCTION

Agroforestry shows high potential as a complementary, low-cost approach for sustainable agriculture (Hayes 1991, Simler 1992, Leach 1994, Bunderson and Hayes 1995) Its universal appeal lies in the multi-purpose functions of trees to alleviate environmental degradation, while benefiting farmers directly with improved farm yields and secondary products Farmers must be active partners in identifying what technologies are most suitable for their needs

Research on improved fallows, intercropping with *Faidherbia albida* and alley cropping shows that maize yields can improve by 50-200% (Bunderson et al , 1991, 1994, Jones et al , 1993, Saka et al , 1994, Kwesiga et al 1994) More recent work on mixed tree intercropping (a modified system of alley cropping) and relay intercropping shows similar results (J Maghembe personal communications) Contour strips of vetiver or napier grass reduce soil erosion and runoff on steep slopes These strips may be combined with fruit or other multi-purpose trees (MPTs) to increase outputs and services Planting MPTs on boundaries and homesteads, as well as along rivers and roads, generates important sources of food, fuelwood, fodder, shelter, and income Fodder and green manure banks of nutrient-rich tree legumes provide abundant supplies of high-quality feed to livestock, or green manure to crops

Most agroforestry practices provide secondary products such as fuelwood, high quality fodder, and shade Certain agroforestry species are also reputed to decrease infestation by *Striga*, a common parasitic pest of cereal and legume crops in Africa In many cases, supplemental chemical fertilisers can boost crop yields by 50-100% This has been achieved with 30-60 kg N / ha during the initial years of alley cropping, and with 20-30 kg P / ha every other year in phosphorous deficient soils (Bunderson et al , 1991, 1993, Jones et al , 1993) Many agroforestry practices also supply essential organic matter and other nutrients such as Mg, K, Ca, and S (Jones et al , in prep) Without inputs, these nutrients can be limiting under continuous monocropping, which is commonly practiced in Malawi This has serious implications for the current policy of importing high-analysis N and P fertilisers

Contour ridging to reduce soil erosion Note the tied ridges



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

This chapter describes various soil conservation and agroforesty practices for addressing specific problems at the farm level A summary of these practices with planting instructions begins on page 92 (Tables 4 through 8)

CONTOUR RIDGING

Many agroforestry technologies are best planted on the contour to improve their function and effectiveness This helps to reduce soil loss and runoff while improving water infiltration The nature of these concerns demands a catchment-area approach by the entire community, otherwise the efforts may be compromised For cultivated land the first task is to delineate and build contour marker ridges throughout the catchment Crop ridges are then aligned to the contour lines

Traditionally, marker ridges have been delineated by Government land husbandry staff Lacking numbers and support, their impact nationwide has been low A change is clearly needed to transfer the required tools and skills to farmers, with the rationale for community participation This can be achieved through awareness campaigns, on-farm training, and the formation of village conservation committees Contour ridging is done during the dry season to minimise labour conflicts with farming activities Other conservation measures can then be promoted such as tied ridges, check dams, storm drains, and various agroforestry practices

Common Errors in Contour Ridging

A prevalent problem in marking contour lines is that the interval between measurements is too far apart to accommodate terrain irregularities As a result, contours often follow the slope into depressions This encourages runoff and erosion, leading to gully formation The problem is encouraged by using hand and dumpy levels, rather than the A-frame or line level The latter instruments avoid common errors because the intervals between measurements are short They are also cheap, fast and simple to use (see details below) This makes them appropriate for farmers to increase the area covered Box and tied ridges can reinforce contour ridging by reducing runoff, especially next to paths and drainage ways

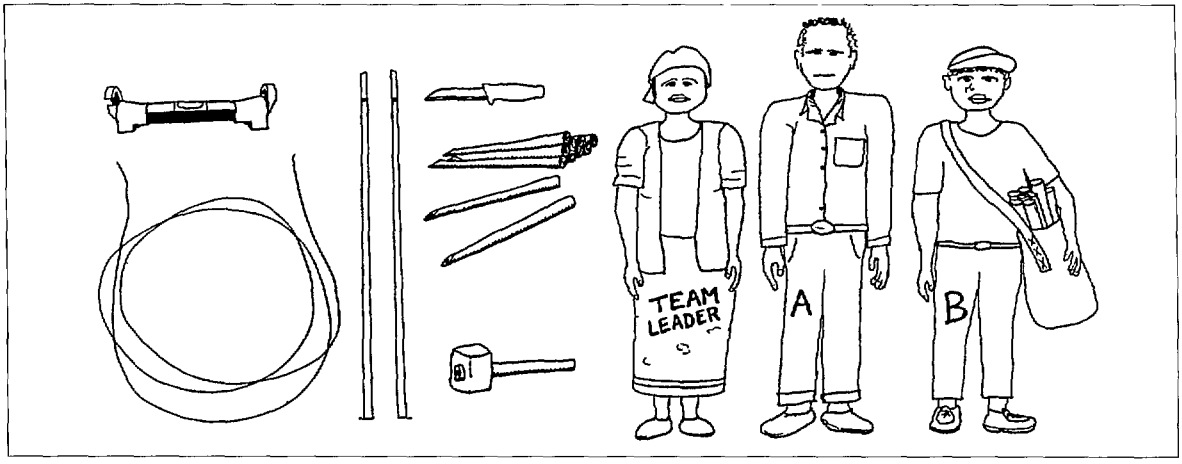
After the contour lines are marked a common error is to align the area between two marker ridges to the upper ridge This means that the lower half may not be on contour The correct procedure is to align the upper half of the area to the top marker ridge, and the bottom half to the lower one, meeting in the middle

The Line Level and its Use

The line level is a simple instrument used in marking contour lines It is cheap, quick and accurate It consists of a miniature spirit level that hangs by hooks from a taut line Details of its use follow

Equipment and People Needed (see figure below)

- 1 line level
- 5 m of string
- 2 sturdy sticks, 1 6 to 2 0 m in length with flat ends
- 1 knife
- Pegs to mark coutour 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, stone, or large stake for driving pegs into the ground
- 3 people comprising a leader who will also read the line level, and 2 assistants, referred to as A and B **Note** At least one adult must be present



Equipment and people needed line level, string, 2 sticks, knife, pegs, hammer, 3 people

Equipment Setup

1 Stand both sticks upright on firm level ground Holding them together, use the knife to mark a groove around each stick at **exactly** the same height above the ground The grooves can be anywhere from 1 3 to 1 6 m high, as long as **both** are **identical** in height

2 Tie a knot in the centre of the 5 m string Then attach the ends of the string securely in the groove of each stick

3 Assign a grooved stick to each assistant, A and B Suspend the line level from the string with the centre knot between the hooks This prevents the level from sliding along the string

Testing the Equipment

Test the equipment before going into the field as follows

- Use a flat level surface like the floor of a house
- Instruct A and B to hold their sticks about 5 m apart with the string taut
- Mark the exact positions of the two sticks, then read the line level
- A and B then switch places, and the level is read again
- If the bubble in the level is not **perfectly centred** both times, check that the ground is level, and that the groove heights of both sticks are identical

Using the Level in the Field (see illustrations on following page)

1 Share out the pegs and hammer among the team and move to a point 10-20 m below the upper corner of the field

2 Insert a peg at the starting point, and instruct A to stand his/her stick next to it Avoid placing the stick in holes and depressions, or on stones, ridges humps, or anthills

3 Instruct B to move 5 m along the estimated contour line B then stands his/her stick upright on level ground, keeping the string taut Shorten or lengthen the string to avoid irregular terrain

4 The team leader then reads the position of the bubble relative to the centre point of the level He/she instructs B to move up or down the slope until the **bubble is precisely centred** Then insert a peg at the **precise location** of B's stick

The bubble points to Mr A The team leader says "Up" to Mr B

After Mr B has moved up, the bubble points to Mr B Now, the team leader says "Down" to Mr B

Mr B moves down slowly until the team leader says "OK " The bubble is now perfectly centred

(Drawings adapted by F Bodnar from Agroforestry Today, Vol 4, No 1)

5 Leaving B in place, A moves past B to locate the next peg This time, the team leader instructs A to move up or down the slope When the bubble in the line level is **perfectly centred**, drive another peg into the **exact** position of A's stick

6 Repeat steps 3-5 to locate the next peg This continues until the opposite side of the field is reached

7 The team then moves downslope to the estimated position of the next contour line, where steps 2 to 6 are repeated Note that the steeper the land, the closer the contour lines A rough guide is to locate contour lines 20 m apart on flat to gentle slopes and 10-15 m apart on medium to steep slopes

Note A and B alternate positions to even out errors if the line level is not perfectly calibrated However, such errors can be avoided with proper testing

THE A-FRAME

The A-frame is made of poles shaped like the letter A Details of its use follow

Equipment and People Needed (see illustration on page 50)

- 2 m of strong string
- 1 stone
- 3 wooden poles with flat ends, two that are 3 m long, and one about 2 m long
- 1 knife
- 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)
- 1 hammer, rock, or large stake for driving pegs into the ground
- a team of 2 people, one of who must be an adult

Equipment Setup

1 Take the two 3 m poles and tie their tops together Tie the 2 m pole across the other two poles about 1 m from the bottom to form an A shape

2 Hang a string, with a stone at its end, from the top of the two vertical poles The stone

should hang 5-10 cm below the horizontal pole

3 Calibrate the A-frame by standing it on a level floor Then mark the **exact** spot where the string crosses the horizontal pole The A-frame is **perfectly level** when the string hangs **precisely over** this centre point Mark the two spots on the floor Then reverse the position of the two A-frame legs If the calibration is correct, the string will still hang precisely over the centre point

Two people mark out a contour line using an A-frame From T Hirst, in Kiepe 1992

Using the A-Frame in the Field

Use the A-frame only on calm days since wind may disturb the string

1 Share out the pegs and hammer to carry, and move to a point about 10-20 m below the upper corner of the field

2 Insert a peg at the starting point of the field, and position one of the legs of the A-frame next to it Avoid placing the legs in holes and depressions, or on stones, ridges humps, or anthills

3 Holding this leg in place, move the other one around 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 around until the string hangs **exactly** over the mark again Drive another peg into the soil at this point 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

6 The team then moves downslope to the estimated position of the next contour line where steps 2 to 5 are repeated

ALLEY CROPPING

Alley cropping or hedgerow intercropping is the cultivation of annual crops such as maize between hedgerows of woody plants The major aim of alley cropping is to improve soil fertility and crop yields It also improves the efficiency of chemical fertilisers so that rates can be reduced Hedges are pruned two or three times during the year to prevent shading of the crop, and to provide leaf biomass for organic manure and mulch Mulching this

Alley cropping with hedgerows

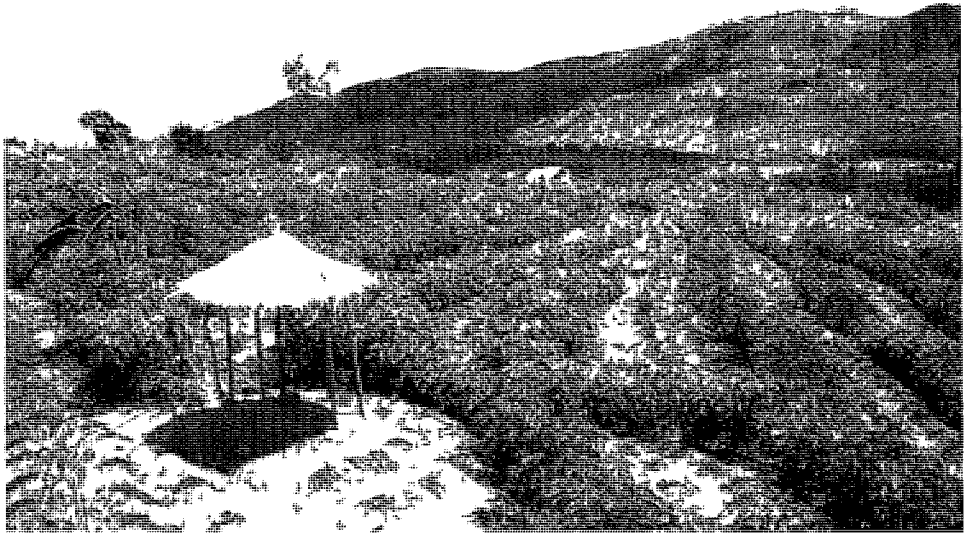
material into the crop alleys adds nutrients and organic matter to the topsoil suppresses weeds, and decreases erosion and runoff Pruned branches can also be used for fuelwood or racks for hanging tobacco The foliage of some species makes excellent fodder

Hedges in alley cropping are generally fast-growing, high yielding leguminous shrubs and trees with nutrient-rich foliage Species recommended are *Gliricidia sepium Leucaena leucocephala Senna spectabilis, Sesbania sesban,* and *Tephrosia vogelii* Choice of species depends on the environment and products desired (see Table 2, page 59) *Sesbania* and *Tephrosia* are shorter-lived than the other three species, but they are faster growing Some species like *Tephrosia* and *Gliricidia* are easy to direct sow

Establishment and Maintenance

Direct sowing is recommended due to the high number of plants required Nursery stock is best reserved for filling gaps due to the high costs involved in raising and transplanting nursery seedlings Direct sow on the sides or tops of ridges 20 cm apart, and thin to one plant per station Since establishment is expected to be only 40-60%, this will help insure that we have one surviving plant every 40-60 cm If nursery stock is used, space seedlings 40 cm apart for all species, except *Senna spectabilis,* which may be planted at 0 9 to 1 8 m due to its larger size Seed or nursery seedlings may be planted on separate ridges or interplanted on the same ridge between crop stations Competitive effects on the crop will be low the first year Thereafter, intercropping within the hedge may have to be abandoned if the hedge becomes too dense or competitive

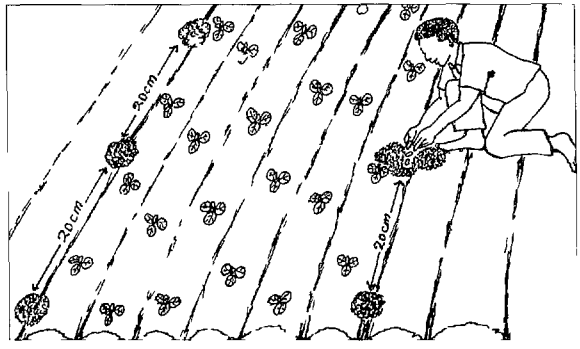
Small holder alley cropping of maize with **Leucaena leucocephala** *hedges (to improve soil fertility)*



Hedges of **Senna spectabilis** *in the dry season*

Alley cropping with pruned hedge at mid-season

Pruning and application of biomass with crop residues after maize harvest

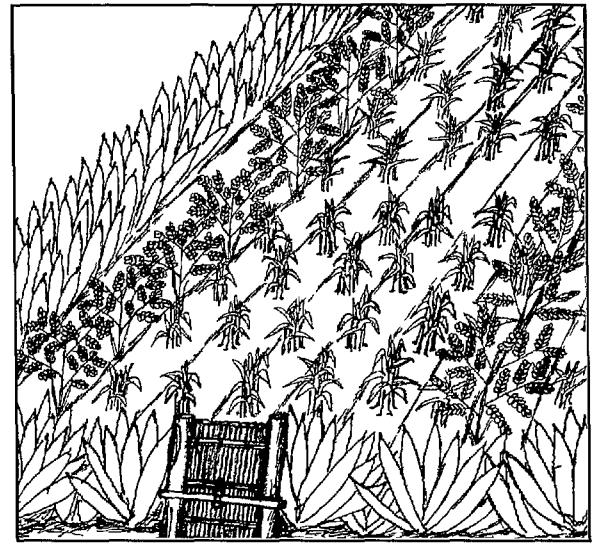


Planting seeds of hedgerow trees 20 cm apart in a groundnut field

On flat terrain or gentle slopes space hedgerows 5 4 m apart (6 ridges between hedgerows) For steep or erodible land, space hedgerows 4 5 m apart on the contour (5 ridges between hedgerows)

Do not count marker ridges falling in the alleys between the hedgerows when determining where to plant hedgerows This means that the spacing between hedgerows will be greater than 4 5 m on steep slopes, and greater than 5 4 m in flat areas when the alleys contain marker ridges Additional hedges may be planted on marker ridges to help stabilise them

Young trees benefit from normal crop weeding and organic manures or fertilisers



Protecting young hedgerows and maize field from animal damage using a sisal fence

applied to the crops Initial hedge establishment and growth may be retarded by shade and competition from the taller and faster growing crops like maize This may be serious if the hedges are planted late Intercrops may also smother the small hedge plants

To facilitate better establishment and growth hedges may be planted with shorter-growing or late planted crops such as beans, groundnuts, soyabeans cassava, sweet potatoes and even tobacco Alternatively, one or both ridges next to the hedgerow may be planted with beans or groundnuts These practices have

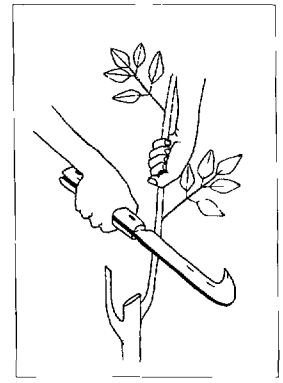
Above Pruning **Gliricidia** *hedges and leaving the branches in the alleys Below Shaking off the leaves, collecting firewood, re-ridging and incorporating the leaves in the soil*

other advantages the young hedge plants are more visible, so they are less likely to be mistaken for weeds and removed There is also less conflict with labour demands if the hedges are planted later with crops that are less competitive Finally, because the establishment of hedgerows is fairly labour-intensive, it encourages farmers to start on smaller plots making the practice more manageable Since these plots are commonly rotated with maize, the farmer should have all his or her farm under alley cropping within a few years

During establishment hedgerows need weeding and may require protection from browsing animals and trampling Since the hedges are sown along with crops, the farmer should protect the field as a whole This can be done through controlled animal herding by the community, or by establishing dead or living fences around the plots (*see Living Fences, page 87*)

Pruning and Management of Pruned Material

Begin pruning during the second growing season if the hedges are greater than one metre in height This size will allow the woody plants sufficient root development and resilience Prune branches with a clean, upward slanting cut within 2 weeks of crop planting The most useful tool for pruning hedges is the tea pruning knife Prune again after 6 to 8 weeks if shading or competition become apparent Distribute the fresh prunings in the furrows and along the maize ridges When the leaves fall off the woody branches may be collected for fuelwood or tobacco ties

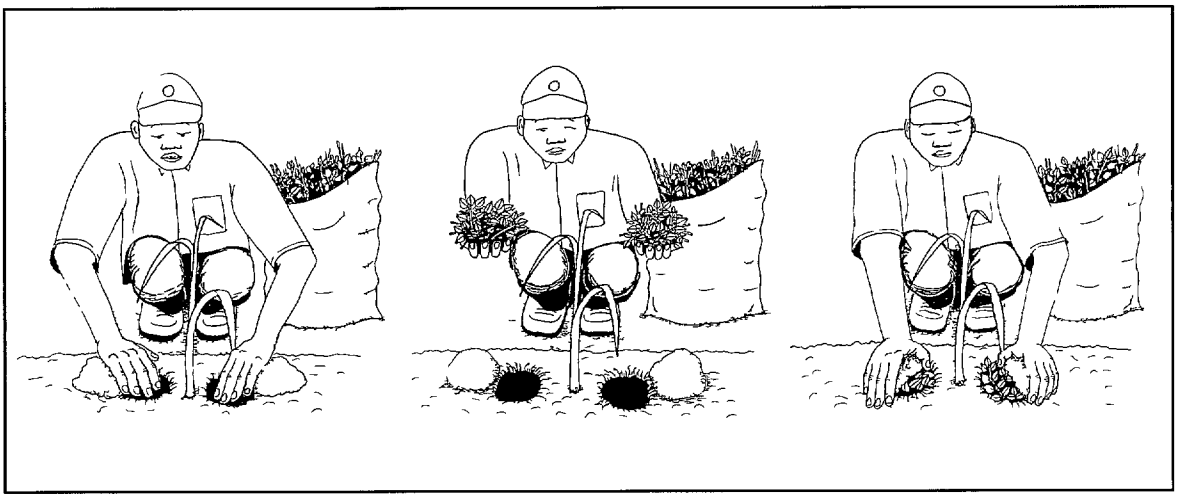


The most useful tool for pruning hedges is the tea pruning knife

Prune again just after crop harvest This supplies most of the biomass during the year, and is therefore the most important pruning There are two methods to apply leaves The first is similar to that described above but cover the leaves and non-woody stems with soil, or bury in the ridges with the crop residues Do this immediately after pruning to avoid nutrient losses from leaching and exposure to the sun, rain and wind

The second method involves storing the dry leaves for next season, and concentrating them around the germinating crop **Note** this method is practical only for very small plots After pruning, transport the branches to the household where they can be spread out on clean ground to dry in the sun for one or two days Then, shake off the leaves and store them away from the sun and rain The stems may again be collected for fuel or other purposes Next season, apply the stored leaves in dollops around the crop one to two weeks after planting A general guide is to apply a double handful of leaves around each planting station (minimum of 120 g/station or 1 5 tons/ha) The dollops may be buried in the soil or applied on the surface

Note Whatever method is used, if the biomass harvested is low, concentrate the pruned material on only part of the area under alley cropping (e g , half the area) Otherwise the biomass may be spread too thinly to have the desired impact



Application of two handfuls of leaves at each planting station

Fertiliser Supplements

Alley hedges contribute considerable amounts of organic matter, nitrogen potassium, calcium, magnesium, and sulphur If resources permit, supplemental chemical fertilisers may greatly boost crop yields During the initial years of alley cropping, N fertiliser at a third or half the full rate is recommended until the accumulated biomass meets the nitrogen demands of the crop Modest use of phosphate at 20-30 kg P/ha every other year is also recommended in phosphorous deficient soils, since trees contribute only small quantities of P

Re-Ridging

If the ridges are broken and rebuilt in the traditional manner, the farmer will lose one ridge in each alley every other year (alleys have 5 or 6 ridges depending on slope) This is equivalent to 17% to 20% of the cultivated area Yield reductions, if any, will be much lower than this for crops like maize because they are not sensitive to fairly wide variations in plant population The farmer may also wish to rebuild the same ridges each year so no ridges are lost, but this requires more labour

Availability of Seed

See Chapter 2 or contact your local agricultural extension agent

TABLE 2 RECOMMENDED HEDGE SPECIES WITH CHARACTERISTICS, USES AND MANAGEMENT

Characteristics	*Leucaena leucocephala*	*Senna spectabilis*	*Gliricidia sepium*	*Tephrosia vogelii*	*Sesbania sesban*
Ecology & Altitude Range	500 1500 mm rainfall basic or neutral fertile soils 0 1500 m a s l	600 2000 mm rainfall most types of neutral to basic soils 0 2000 m a s l	500 1200 mm rainfall basic or neutral fertile soils 0 1200 m a s l	800 2000 mm rainfall most soil types 800 2000 m a s l	500 2000 mm rainfall most soils including acid saline and water logged soils 0 2000 m a s l
Growth Rate	Medium	Medium to fast	Medium	Fast	Fast
Biomass Yield	Medium	High	Medium to high	Medium High	Medium
Nutrient Content	Medium to High	High	High	Medium to high	Medium to high
Forage Value	High	None	Good for ruminants only use dry or wilted leaves other parts poisonous	Poor	Medium to high
Wood & Other Values	Good fuelwood and small poles	Good fuelwood and small poles	Fair fuelwood and small poles	Poor wood foliage used as fish poison and insecticide	Fair fuelwood and small poles
Life Span	> 10 years	> 10 years	> 6 years	3 to 6 years	1 to 4 years
Soil/Pest & Disease Problems	Psyllid and termite damage intolerant of acid and nutrient deficient soils	Appears affected by acidic soils and certain nutrient deficiencies	Appears affected by acidic and nutrient deficient soils some leaf damage from beetles and aphids that may harm legume crops	Prone to root nematodes which could harm current or subsequent crops such as tobacco	Prone to root nemotode and leaf eaters which could harm current or subsequent crops such as tobacco
Seed Treatement	2 a Innoculation with correct rhizobia	2 b	None	None	None or 2 a
Establishment by Direct Sowing	Good	Poor to Fair	Good	Excellent	Fair
Pruning Management					
Height	<	30 to 40 cm	>	60 to 75 cm Leave 2 to 3 upper lateral branches intact to improve regrowth	
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	Within 2 weeks of planting the crop and again after crop harvest Prune at mid season only when the hedge begins to dominate or shade the crop The first pruning is done when the plants are at least 1 metre tall (usually 12 to 18 months of age)				

SHORT-TERM FALLOWS

Short-term fallows incorporate fast-growing trees and shrubs to speed up soil restoration with secondary wood products The best species are those that enhance soil fertility by fixing nitrogen, and by establishing ground cover quickly The main advantage of this technology is the lower labour and management required, but small land holdings may limit its application Two types of tree fallows may be used

Fallows with Short-lived Shrubs

Grow short-lived shrubs such as *Cajanus cajan Sesbania sesban* or *Tephrosia vogelii* for 2-3 years Direct sow *Cajanus* and *Tephrosia* at 90 x 45 cm with 1-3 seeds per station *Sesbania* is best grown from bare-root seedlings at 90 x 90 cm, but seed may be direct sown at 90 x 45 cm with 5 seeds per station Short or late planted crops like groundnuts, soyabeans sweet potatoes and cassava, may be grown with the shrubs for the first year while the trees are still small Cultivation is then abandoned, allowing the trees to continue growing After 2-3 years, cut the shrubs down at ground level before the onset of the next season Their root system and foliage will improve soil fertility Woody material may be used for firewood or tobacco ties Cultivation is then resumed with restored soil fertility

Fallows with Long-lived Trees

Larger and longer-lived trees may also be used in fallows to improve soil fertility This may take longer, because the trees are not as fast growing but they will provide a greater range of products Crops may also be grown with the trees for the first 2-3 years because of slower tree development and wider spacing Thereafter the trees continue growing until fertility is restored, or until they reach a size suitable for harvesting the desired wood products Cultivation may then resume after removing the trees, or while allowing them to coppice Some trees may need to be thinned out With trees such as *Gliricidia Leucaena* and *Senna spectabilis* several rows may be removed to simulate alley cropping Prune the remaining trees in the same manner to reduce shading and to provide green manure and wood

Recommended species include *Acacia galpinii A nigrescens A polyacantha, Albizia lebbeck Bauhinia thonningii Erythrina abyssinica Faidherbia albida Gliricidia sepium Leucaena leucocephala*

Prosopis juliflora and *Senna spectabilis* If wood is a higher priority than fertility, *Azadirachta indica, Senna siamea* and *Toona ciliata* may be used Space small trees like *Gliricidia* and *Leucaena* at 0 9 m x 0 9 m, medium trees like *Azadirachta Bauhinia, Prosopis* and *Senna* at 1 8 x 1 8 m and large trees like the *Acacias, Erythrina, Faidherbia* and *Toona* at 3 6 x 3 6 m For more information, see Tables 5-8 and Chapter 4

Short-term fallows may be combined with other agroforestry technologies on the same land e g living fences, boundary planting and vetiver grass strips

Availability of Planting Material

See information contained in Chapter 2, or contact your local extension agent

Young fallow of Tephrosia vogelii

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

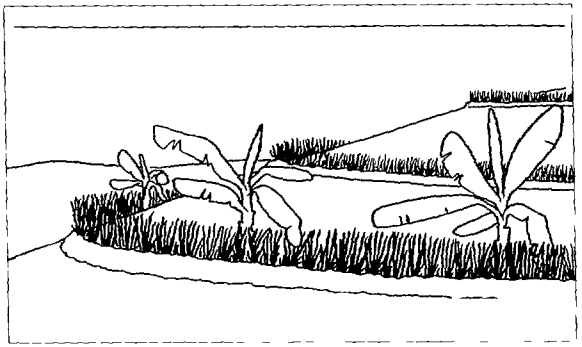
Two-year tree fallow of **Gliricidia sepium** *for wood and soil fertility restoration*

Sesbania sesban *fallow after 2 seasons of growth*

***A* Senna spectabilis** *fallow that has been pruned and thinned to allow re-cultivation with maize*

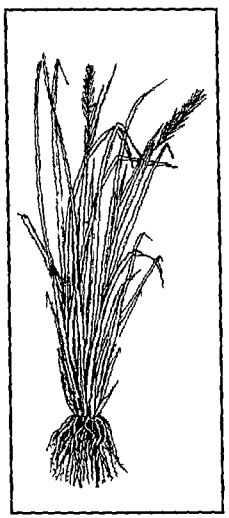
CONTOUR VEGETATION STRIPS

Erosion, runoff, deforestation and overgrazing are becoming serious problems on cultivated hillsides Strips of deep-rooted, perennial bunch grasses planted along the contours of farmers' fields produce an effective barrier against erosion and runoff With proper spacing and management, natural terraces will form between the contour strips as soil is moved from the upper side to the lower end behind the grass strip Grass strips may be strengthened with multi-purpose fruit trees or hedgerows of leguminous shrubs These grass strips are planted at 5-20 m intervals across the slope on the upper side of marker and planting ridges



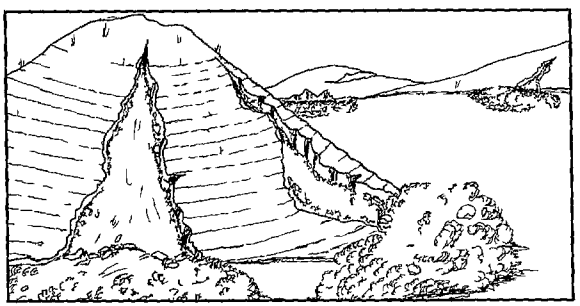
Hillside with newly planted contour vegetation strips and trees The grass will soon form a continuous unbroken barrier

Recommended Species



Vetiveria zizanioides

The two grasses most commonly used are *Vetiveria zizanioides* (vetiver grass) and *Pennisetum purpureum* (napier grass) Vetiver is a widely adaptable, fast growing, deep-rooted perennial that is unpalatable to livestock It is not competitive with adjacent crops and is not known to serve as a host to pests and diseases of concern to agriculture Vetiver is



Erosion on cultivated hillside without

propagated by vegetative means since the seed has low viability Hence, there is little danger of it becoming a weed Vetiver is easy to establish and maintain, and it makes good thatching material

Napier grass is a tall, thick-stemmed bunch-type 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 and is not as effective for soil moisture conservation Napier tends to spread and compete more with crops, so it requires more trimming

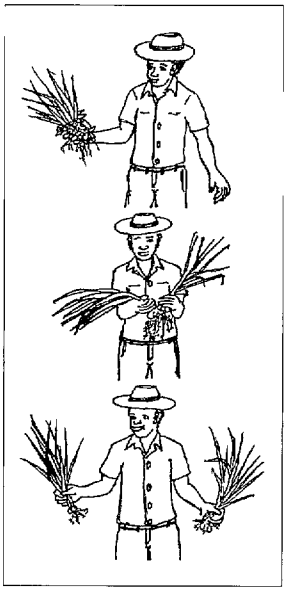
Planting Vetiver Grass

1 Mark the contour lines with a level or A-frame (see Contour Ridging earlier in this chapter on page 45)

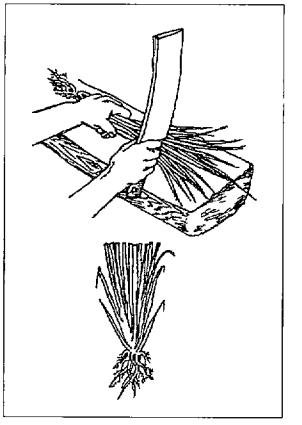
2 Dig out healthy clumps of grass with roots after the start of the rains Transport the clumps to the field, keeping the grass moist and out of the drying sun and wind until it can be planted

3 Divide the clumps into slips about the size of a handful (several tillers with their roots)

4 Cut the leaves with a panga or hoe 20 cm from the base, and trim the roots to about 10 cm



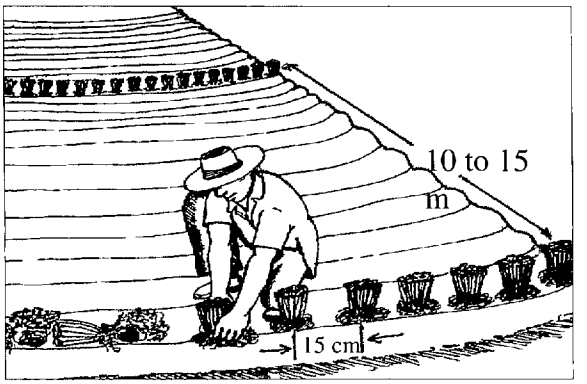
Dividing clumps of grass into slips for planting



Cut leaves to 20 cm, cut roots to 10 cm

5 Plant within 48 hours of collecting the grass Plant vetiver slips 15 cm apart in single rows along the contour at 10-15 m intervals On steeper slopes, double rows spaced 25 cm apart may be used, with 5-10 m intervals between double rows

Vetiver nurseries Collect enough clumps to establish a nursery for future expansion Plant at 45 x 45 cm spacing The best nursery sites are in dambos Fast establishment allows slips to be taken from the nursery after one season A nursery of 0 1 ha is sufficient to plant 10 km of strips Replant depleted areas of the nursery to maintain propagation material Nurseries and their maintenance are vital for multiplication and expansion



Planting vetiver grass 15 cm apart with 10 to 15 m between strips

If land for nurseries is limited, farmers may plant several closely spaced rows on the lower ends of their farms where the soils are deeper and less prone to drying out Grass from these sites may be used to plant other areas of the farm

Planting Napier Grass

Napier produces little viable seed so it is always established from stem cuttings (setts) or rooted cuttings (splits) The main varieties are Gold Coast, Cameroon, and Congo All are established as follows

1 Collect fresh material from healthy plants as done for vetiver grass

2 Push setts into the soil at a 45 degree angle so that at least 2 nodes are buried Space setts 20 cm apart in contour lines similar to vetiver

3 Plant splits to a depth of 8 - 10 cm and compact the soil around the roots Plant spacing is the same as for setts

Management

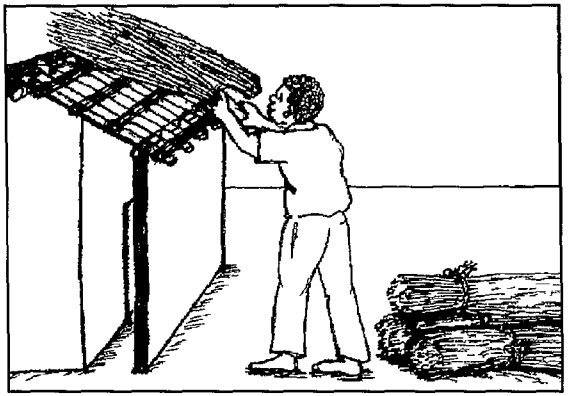
After the grass strips are well established, trim the grass to a height of 40 cm to encourage tillering If the plants are not well established, wait to trim them until the onset of the next rainy season Napier grass needs to be trimmed more frequently to avoid shading and competition The trimmed material may be used as fodder (using napier) or thatching (using vetiver)

Contour Strips with Fruit Trees and Shrubs

Farmers may choose whether trees or shrubs are preferable for their contour strips Fruit trees provide valuable nutrition or income to the household Leguminous shrubs provide fuelwood, green manure and/or fodder For fruit trees, plant varieties that are resistant to common diseases (consult ADD or research staff in horticulture on available planting material) Bananas can be planted about 90 cm above and parallel to the grass strip with plants 1 m to 1 5 m apart Other fruit trees may be planted at 4 m intervals along the upper side of the contour ridge This may be done along each strip or along alternate strips

Hedge species used in this practice include *Senna spectabilis, Leucaena leucocephala* and *Gliricidia sepium*, depending on the environment and local needs *Cajanus cajan Tephrosia vogelii* and *Sesbania sesban* may also be used, but these are short-lived species which need replanting after 2 to 5 years Where livestock damage is a problem *S spectabilis* is recommended since it is not grazed by livestock This species also produces greater quantities of fuelwood Where livestock fodder is desired, plant *Leucaena Sesbania,* or *Gliricidia Gliricidia* leaves should be fed wilted or dried only to ruminant livestock Plant these species 50 cm above and parallel to the grass strips For direct sowing, plant seeds 20 cm apart, space nursery seedlings 40 cm apart, except for *Senna spectabilis,* which can be 90-180 cm apart because of its larger size

Hedges are pruned to reduce competition with crops, and to provide green manure, fuelwood or fodder Prune at the start of the second growing season if hedge height is greater than 1 metre This size will allow the woody plants sufficient root development and resilience Prune branches with a clean, upward slanting cut at a height of 30-40 cm for *Senna Leucaena,* and *Gliricidia* and 60-75 cm for *Cajanus, Sesbania,* and *Tephrosia* (See Table 2 under Alley Cropping on page 59) During



Using trimmed grass as thatching

the growing season, prune trees whenever shading or competition become a risk Distribute these prunings along the crop ridges to help reduce weeds and to increase available nutrients for the crops Once the leaves fall off the branches may be collected for fuelwood

At crop harvest, prune the trees again for green manure, wood or fodder Fresh prunings can be laid along the crop ridges When the leaves are dry enough to shake off, cover them with soil, or store them for use as manure next season The branches may again be collected for fuelwood

Availability of Planting Material

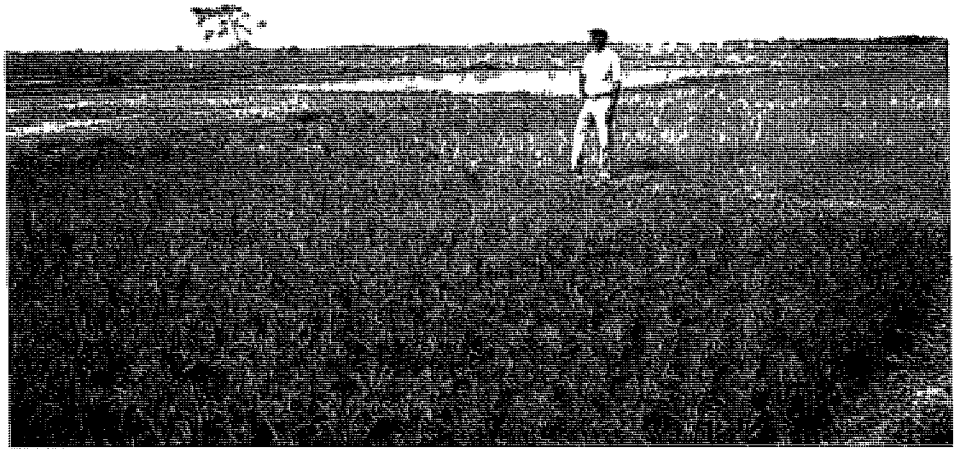
For tree planting material, see Chapter 2 or contact your local agricultural extension agent

Several varieties of Vetiver grass are found in Malawi in the Shire Valley around farmers fields, on a limited scale in the Ekwendeni and Central Mzimba areas of Mzuzu Agricultural Development Division (ADD) and in the Namwera/Kawinga areas of Machinga ADD A network of nurseries for vetiver grass is currently being established in the ADDs The most suitable variety appears to be the Central Mzimba one due to its vigorous growth later flowering, and apparent better resistance to termites Napier grass is generally available locally Consult your ADD staff for assistance

Contour Vegetation Strips to reduce erosion and runoff

Contour Vegetation Strips of vetiver grass and young banana trees

A newly planted communal vetiver nursery in a dambo area (note the 45 x 45 cm spacing)



A small vetiver nursery in a farmer's dimba garden

FODDER AND GREEN MANURE BANKS

Fodder Banks

Fodder banks are ideal for farmers with intensive livestock production Fodder banks are small plots of high yielding plants with nutrient-rich foliage and pods A considerable amount of fuelwood, stakes/ poles and fodder can be produced from a fairly small area The fodder is especially useful in the dry season as a feed supplement

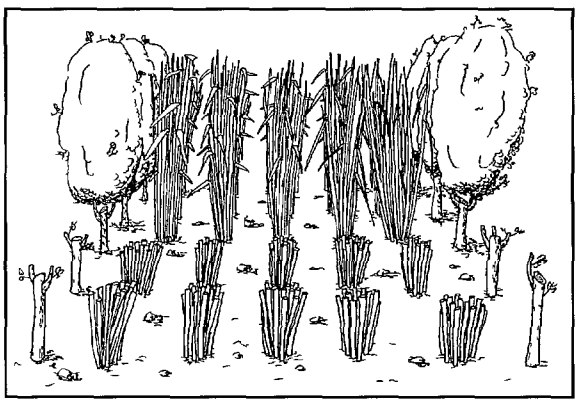
Recommended species are *Leucaena leucocephala* (cunningham variety), *Gliricidia sepium* and *Sesbania sesban* to be planted in pure stands or interplanted with alleys of napier grass *Note* Feed *Gliricidia* wilted or dried, and only to ruminant animals

Establishment and Maintenance

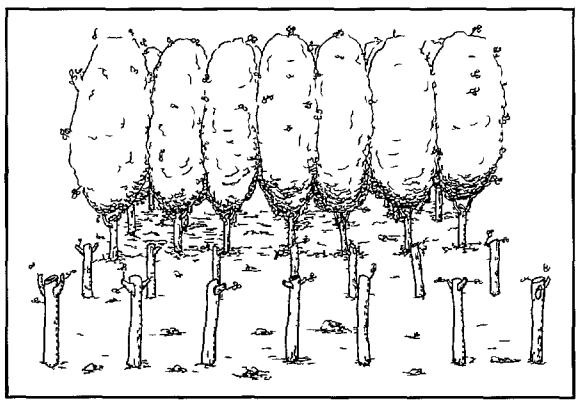
In pure stands plant trees at 0 9 m x 0 9 m When trees are mixed with napier grass space trees at 0 9 m apart in alleys 4 5 m wide Plant napier at 90 x 45 cm in alleys During establishment, the plants may require protection from animals

Pruning Management

Begin pruning at the start of the second growing season when the hedges are greater than one metre in height This size will allow the woody plants sufficient root development



A fodder bank tree alleys with napier grass, half of it has been pruned recently



A fodder bank pure stand of fodder trees, half of the trees have been pruned recently

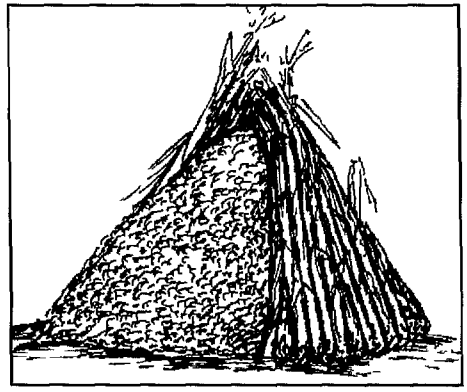
and resilience Prune *Sesbania* at 75 cm Prune branches of *Leucaena* and *Gliricidia* to 30-40 cm with a clean upward slanting cut 1 to 2 weeks after crop planting Prune hedges again shortly after the crop harvest Trees may also be pruned during the rainy season for additional fodder Pruned material may be dried and fed to livestock with the branches

Feeding of pruned napier and dried leucaena leaves to livestock

used as fuelwood or poles For optimal forage quantity and quality three prunings are recommended early December, early February and early June If fuelwood is also a priority, prune twice in early December and early June If poles are a priority, prune once in June Fodder can also be cut and fed as needed on a daily basis

Green Manure Banks

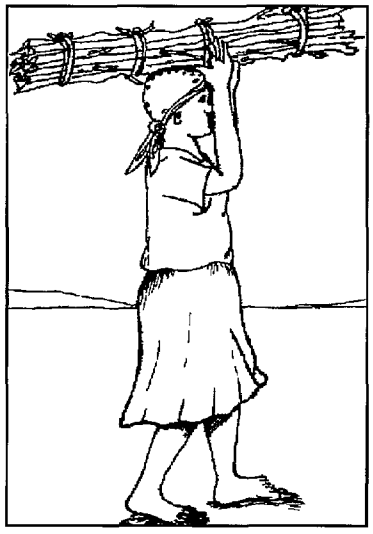
Tree banks may also be established for green manure The pruned leaves are used as fertiliser for other crop areas by applying the leaf matter to the soil Green manure banks may be established with *Leucaena, Sesbania, Cajanus cajan Tephrosia, Gliricidia and Senna spectabilis* Space *Leucaena* and *Sesbania* at 0 9 x 0 9 m *Gliricidia* and *Senna* may be spaced wider apart at 1 8 x 1 8 m because of their larger size *Cajanus* and



Protecting leaf matter with dried maize stocks

Tephrosia are best spaced at 0 9 x 0 45 m During the growing season distribute the pruned material in the furrows and along the sides of the maize ridges Application of the pruned material helps to decrease weeds and

to increase the available nutrients for the crop When the leaves fall off, the woody branches may be collected for fuelwood or tobacco ties Pruning at the end of the rainy season provides the bulk of the biomass produced during the year and is therefore the most important After sun-drying the branches for a few days shake off the leaves and store for use next



A woman carrying fuelwood collected from her fodder bank

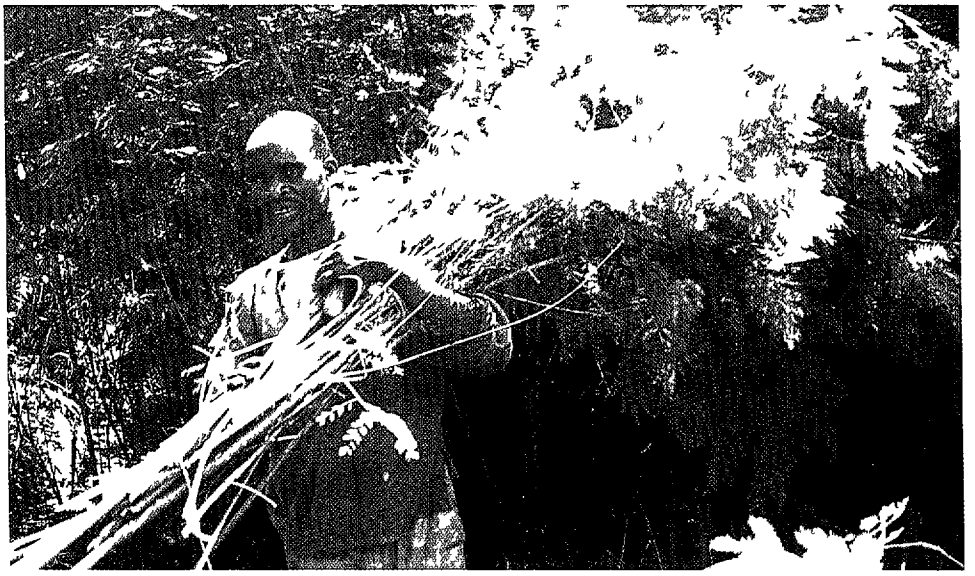
season The stems may again be collected for fuelwood or other purposes Then bury or apply the dry leaves on the surface around the planting stations within 15 days of crop emergence A general guide is to apply leaves at a minimum rate of 1 5 tons/ha or roughly a double handful per station (120g/station) Storage of dried leaves for later use should be necessary only when the hedges are young and producing low levels of biomass

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

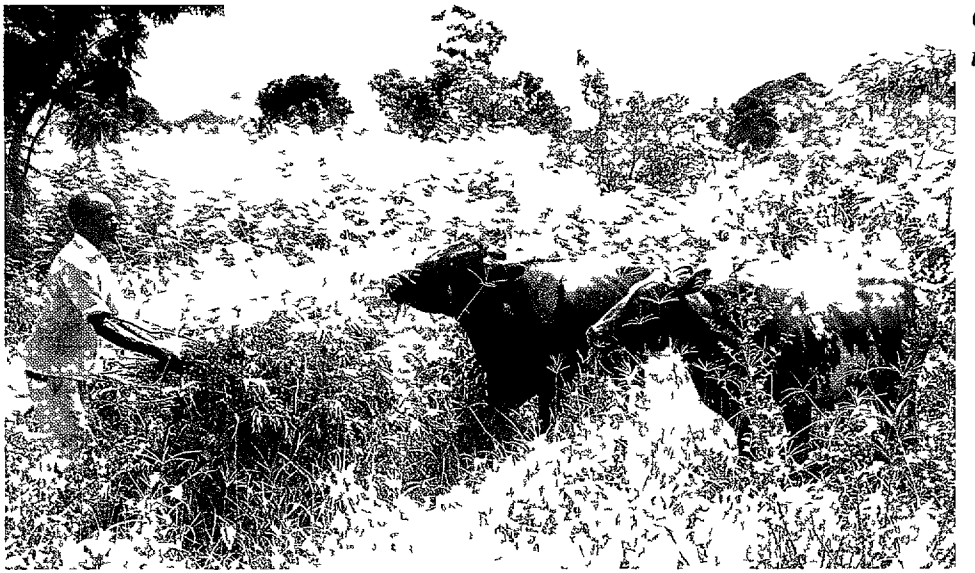
Availability of Planting Material

See information contained in Chapter 2 or contact your local extension agent

Fodder harvested from lukina (Leucaena leucocephala) *fodder banks*



Harvested fuelwood from fodder bank

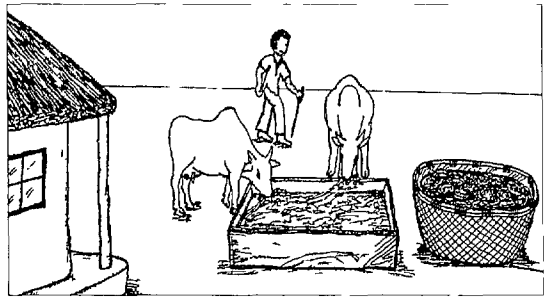


Cattle grazing in fodder bank

Cattle eating fodder cut from Leucaena *fodder banks*

SYSTEMATIC TREE INTERCROPPING

Most farmers in Malawi retain or sometimes plant trees in their cultivated fields for a variety of reasons - fuelwood, poles, fruits, fodder, material for building or making tools soil improvement, medicines, and various cultural uses Indigenous species that are commonly left in fields or allowed to regenerate naturally include *Acacia galpinii, A nigrescens, A polyacantha, Albizia harveyi, Azanza garkeana, Bauhinia thonningii, Brachystegia spiciformis Combretum species, Erythrina abyssinica, Faidherbia albida, Ficus natalensis, Kigelia africana Lonchocarpus capassa, Pterocarpus angolensis, Sclerocarya birrea,* and *Ziziphus mauritiana* Planted exotic species include *Azadirachta indica Melia azaderach Toona ciliata* and various fruit trees, notably mango and bananas but also papaya, avocado, guava, and peaches Because of population pressures these trees are steadily declining in abundance and diversity and their value to farmers is being lost Farmers are encouraged to protect naturally regenerating trees in their fields to help reverse these degrading trends This is perhaps one of the easiest agroforestry systems to adopt since no tree planting is required and the trees are already adapted to the area

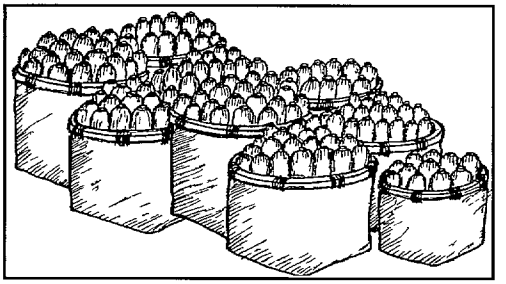


Using products from trees as fodder for livestock

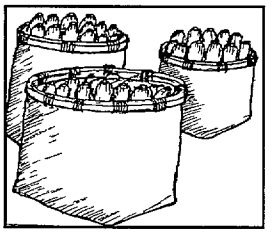
The technology decribed here builds upon traditional agroforestry practices by planting trees more systematically to reduce problems of deforestation and continuous monocropping Virtually any type of tree can be used depending on the needs and priorities of the farmer For example, mangos have become a dominant tree in many farms of the central region despite detrimental shading effects on crops The fruit and wood value of the mango tree make its integration acceptable to the farmer

Certain trees can be systematically intercropped with crops in farmers' fields to

- improve soil fertility and crop production
- extend the period of productive cultivation



Relative maize yield with a Msangu tree



And without a Msangu tree

Farmers appreciate the value of this tree, and have long cultivated crops beneath its canopy without fertiliser inputs or declines in yields

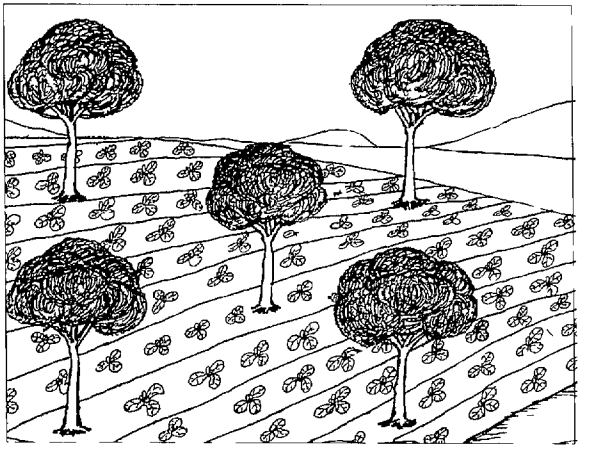
- diversify farm products and uses from the tree including firewood, building material, fodder, medicines, honey and shade

Trees are spaced regularly for uniform coverage and to facilitate crop operations and use of ox-drawn implements

The tree most commonly recommended for this practice is *Faidherbia albida* (Msangu) Yields of cereal crops like maize and sorghum are generally 50% to 250% higher under the tree's canopy than areas outside *Faidherbia albida* is a large, fast-growing leguminous tree indigenous to much of Africa and fairly widespread in Malawi It is found in a broad range of soils and terrain from 50 m to 1500 m above sea level Its distinctive feature is leaf growth in the dry season and leaf fall at the start of the rains The fall of leaves at this time enriches the soil, improves the micro-environment and minimises shading effects

Faidherbia trees have other uses They produce abundant, quality fodder during the dry season, mainly in the form of pods which may average over 100 kg per tree Msangu trees also provide good fuelwood and building material Since it is one of the few trees in leaf during the dry season, it also provides valuable shade to people and livestock

Protection of young seedlings



Systematic tree intercropping of Erythrina ***(Muwale) with a shade tolerant crop***

Recommended Species

In addition to *Faidherbia albida*, several other fast-growing species are recommended These include *Acacia galpinii*, *A goetzei*, *A nigrescens A nilotica*, *A polyacantha A tortilis Albizia lebbeck Annona senegalensis Azadirachta indica Azanza garckeana, Bauhinia thonningii*, *Senna spectabilis Erythrina abyssinica*, *Ficus spp Gliricidia sepium Leucaena leucocephala*, *Melia azaderach Prosopis juliflora Sclerocarya birrea Senna siamea Terminalia sericea Toona ciliata Trichelia emetica Uapaca kirkiana* and *Ziziphus spp* Although the impact on crop yields may be lower than with *Faidherbia*, many of these species, especially the N-fixing ones are soil improving trees with other valued products and uses

Establishment and Maintenance

Direct sowing with 3 or more seeds per station is recommended for most species except *Azadirachta Toona* and *Melia* Sow seed at 10 m x 5 m or plant nursery stock at 10 m x 10 m In most cases nursery seedlings are preferred over direct sowing *Erythrina Ficus* and *Sclerocarya* are best established from cuttings or truncheons *Faidherbia albida* seedlings deserve a special note outplant when seedlings are less than 4 weeks old before roots penetrate the ground through the tube or pot Alternatively, raise seedlings in tubes elevated on a wire-mesh platform above the ground (see page 34) This prevents roots from growing through the tube Do not use pots with closed bottoms Make sure the tap root has not been damaged from root pruning, or bending when outplanting Because of *Faidherbia albida's* sensitive tap root system, direct sowing may be a better option to avoid root damage To improve and speed up germination, nick off one end of the seed and soak seed in unheated water overnight just before direct sowing Sow 5 seeds per station in moist soil, thinning to one plant later Plant maize no nearer than 90 cm from seedlings to reduce competition and encourage good growth Young seedlings need to be clearly

marked so that they are not mistaken for weeds Protect young seedlings from animals in the dry season by placing simple fences or thorn branches over each plant (see page 77)

Thinning and Pruning of Intercropped Trees

Trees are planted initially at a high density to ensure adequate survival and to provide a faster impact while still young Trees should be thinned as they grow in size as shown in Table 3 below Thinned trees and pruned branches can provide valuable fuelwood, fodder or building material Except for *Faidherbia albida*, which is leafless during the cropping season, thin the canopy of other tree species to reduce shade effects if these are significant Do this at the start of the rainy season by selectively pruning certain branches, but not the main stem This is necessary only after the trees are several years old and well established Some trees will require more pruning due to their denser canopies Use a saw to make clean, angled cuts to minimise damage to the trees Spread the cut foliage on the ground to act as green manure It may also be used as animal feed if the tree is a good fodder species Collect the wood for fuel or other uses

TABLE 3 THINNING REGIME AFTER INITIAL ESTABLISHMENT OF 100 TREES/HA

Tree canopy radius	Recommended spacing	Recommended density
5 meter	10 x 20 m	50 trees / ha
8 meter	20 x 20 m	25 trees / ha
> 10 meter	selectively thin or prune lower branches	15 - 20 trees / ha

Time of Planting

Plant trees at the start of the rainy season when the soil is moist down to 30 cm or more This is essential for good survival and growth before the dry season begins If nursery stock is used, ensure that seedlings are raised in sufficient time to allow early outplanting

Compatibility of Trees with Local Crops

Most crops may be grown with the recommended leguminous trees with noticeable improvements on harvest and plant nutrition Favoured crops include maize, sorghum, millet, pumpkins, tobacco, sweet potatoes, cotton, tomatoes and cassava Leguminous crops such as groundnuts and beans perform well relative to unfertilized plots without the trees, but less well than plots with properly applied inorganic fertilisers

Availability of Planting Material

See Chapter 2, or contact your local agricultural extension agent

One-year old **Faidherbia albida** *tree grown from a seedling with a healthy root system*

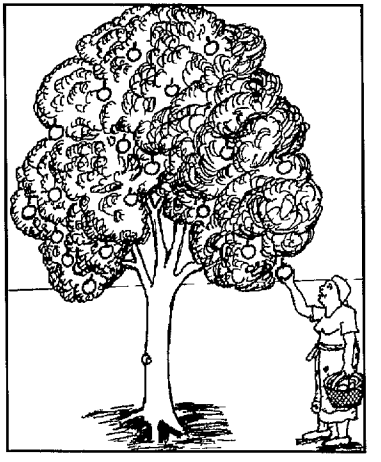
Six-year old **Faidherbia albida** *tree*

Systematic Tree Intercropping of Faidherbia albida *(12 year-old stand)*

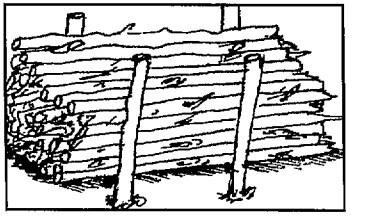
Faidherbia albida *with green vigorous mature*

HOMESTEAD, BOUNDARY AND WOODLOT PLANTING

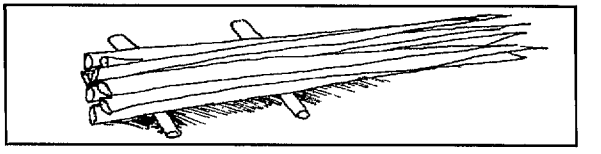
Fruit and other multi-purpose tree (MPT) species may be planted along boundaries of farms, roads homesteads or simply scattered around the household Trees may also be planted in small woodlots or orchards, depending on available land or integrated in dimbas and home gardens Many farmers already grow various trees around their homestead for different purposes 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 Farmers who plant higher densities of trees in or around their farms and homesteads are able to produce a variety of useful products

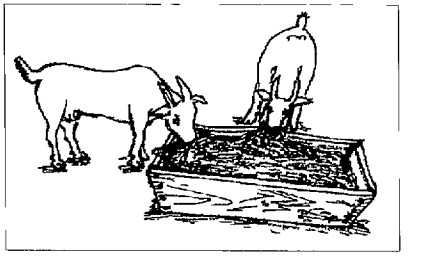


Woman picking fruit from a mango tree

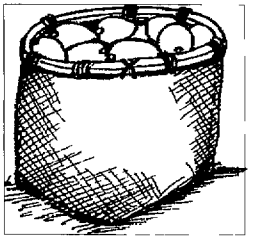


Fuelwood from homestead trees

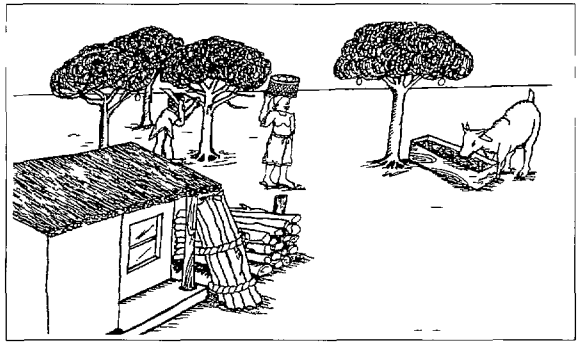




Poles and fodder from homestead trees



Fruit gathered from homestead trees



A homestead with multi-purpose trees, fodder, poles, fuelwood, and fruit

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 higher, cooler areas, especially apples, peaches, and plums Other MPT species include many fast growing trees that are adapted to a wide range of environments including *Faidherbia albida*, *Acacia polyacantha* *Bauhinia thonningii*, *Senna spectabilis*, *Erythrina abyssinica*, *Ficus natalensis*, *Ficus capensis*, *Gliricidia sepium*, *Khaya nyasica*, *Melia azaderach*, *Azanza garkeana* *Terminalia sericea*, *Toona ciliata*, *Cajanus cajan*, *Flacourtia indica*, *Sesbania sesban*, *Trichilia emetica* and *Ziziphus* species

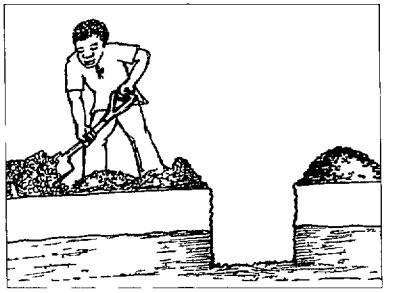
Species well suited to low elevations include *Acacia nigrescens* *Acacia tortilis* *Albizia lebbeck* *Azadirachta indica*, *Senna siamea*, *Prosopis juliflora* *Ziziphus mauritiana*, and *Z spina-christi*

Trees best adapted to medium and higher elevations include *Acrocarpus fraxinofolius*, *Tephrosia vogelii*, *Ziziphus abyssinica*, and *Uapaca kirkiana* As more research is conducted, other species will likely be added to this list

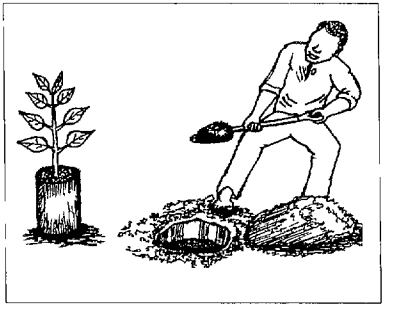
Species suitable for boundary and homestead planting and for woodlots are indicated in Table 6, page 95

Establishment and Maintenance

Consult the latest Guide to Agricultural Production (GAP) for planting fruit trees Prepare planting holes before the rains that measure 0 6 m deep by 0 6 m in diametre for bananas and 0 9 m deep by 0 9 m in diametre for other fruit trees Pile the topsoil separately from the subsoil Mix the topsoil with manure at 1 pail (approx 3 kg) per plant or fertiliser (1 handful) and return mixture to the hole, then add the subsoil

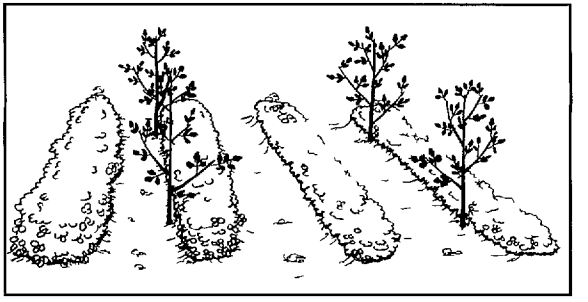


Dig a hole 0 9 x 0 9 m separating the topsoil from the subsoil



Mixing the topsoil with manure and filling the hole back in Now the seedling is ready for planting

In dimba and home gardens, space fruit trees 4 x 4 m and bananas at 2 x 2 m Vegetables may be planted between the fruit trees

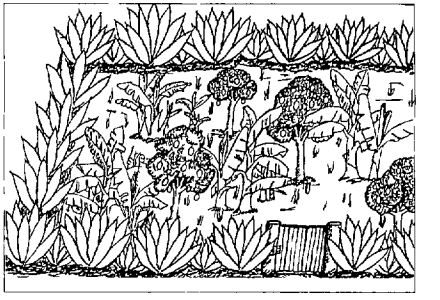


A young woodlot in its second year with short crop such as groundnuts

Around homesteads or farm boundaries, space the fruit trees and bananas at 4 m and 2 m intervals respectively These and other MPT species may also be scattered around the homestead or along desired boundaries at 2 to 6 m intervals For woodlots plant trees at a spacing of 1 8 x 1 8 m for poles, or 3 6 x 1 8 m or 3 6m for firewood or other products

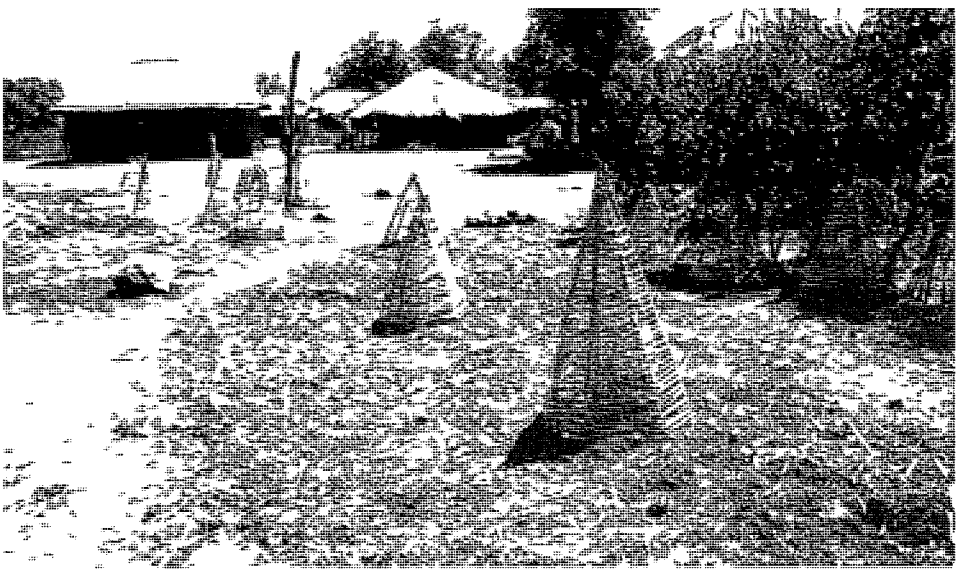
Protection and Moisture Conservation Measures

Protect trees from livestock damage, especially during the dry season Living fences or protective structures may be used Watering may be necessary in the homegardens during the dry season Mulch or thatching grass placed around the base of the tree will help keep the soil moist around the tree In some cases a cover crop may be used for this purpose



Sisal protecting a home fruit garden

Homestead planting of multi-purpose trees



Protecting seedlings around a homestead

Home garden with various fruit trees

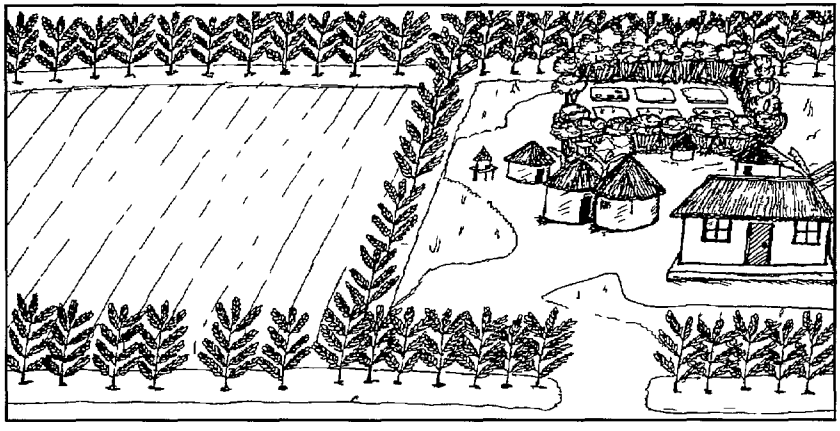
Household woodlot of 3 year old Senna siamea

LIVING FENCES

Living fences serve a variety of purposes Their main function is to eliminate the need to construct and replace dead fences every year or the cost of purchasing and maintaining wire fences Most often, living fences are planted to keep out domestic or wild animals where they are not well controlled The living hedge is also used to mark boundaries of farm plots, gardens or homesteads Some living fences are used to enclose animals in the form of a **khola** Depending on the species used the living fence provides multi-purpose uses such as fodder, green manure, fruits wood for fuel and farm tools, as well as privacy

Establishment and Maintenance

Living fences are considered permanent or semi-permanent structures Seeds of trees or shrubs are sown 20 cm apart in rows along the intended fence line If nursery seedlings are used, space the plants 40 cm apart Thorny species recommended as a dense barrier to animal movements in the mid-altitude plateau include *Ziziphus abyssinica*, *Z mauritiana*, *Z mucronata* *Agave sisalana*, *Caesalpinia decapetala*, *Acacia nilotica* *A polyacantha*, *A galpinii* *A goetzei*, and *Pyracantha coccinea* Thorny species recommended for the Lakeshore/Shire Valley include *Acacia nigrescens*, *A polyacantha*, *Caesalpinia decapetala*, *Prosopis juliflora*, *Ziziphus mauritiana* and *Z mucronata* Plants that are palatable to



Living fences around a homestead, field, and home garden

livestock are the *Acacia* and *Ziziphus* species, which need protection during the first year of growth Species that do not need protection from livestock are sisal, *Prosopis* and *Caesalpinia* Pods from *Prosopis* however are good fodder In addition several species make good live fence posts These include *Erythrina spp Ficus spp Moringa oleifera, Commiphora spp Lannea spp* and *Sclerocarya birrea* Truncheons from these species should be planted 1 metre apart about one month before the rains and 30 to 50 cm deep If desired, other thorny species can be planted to fill in gaps between the truncheons or cuttings Details of planting cuttings are provided in Chapter 2

Trimming

At the onset of the second or third season trim hedges to 50-75 cm to encourage low and dense lateral branching One plant may be left untrimmed every 5-10 m for production of 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 dangers of becoming a weed from prolific seed production

Farmer trimming hedges to encourage low and dense lateral branching

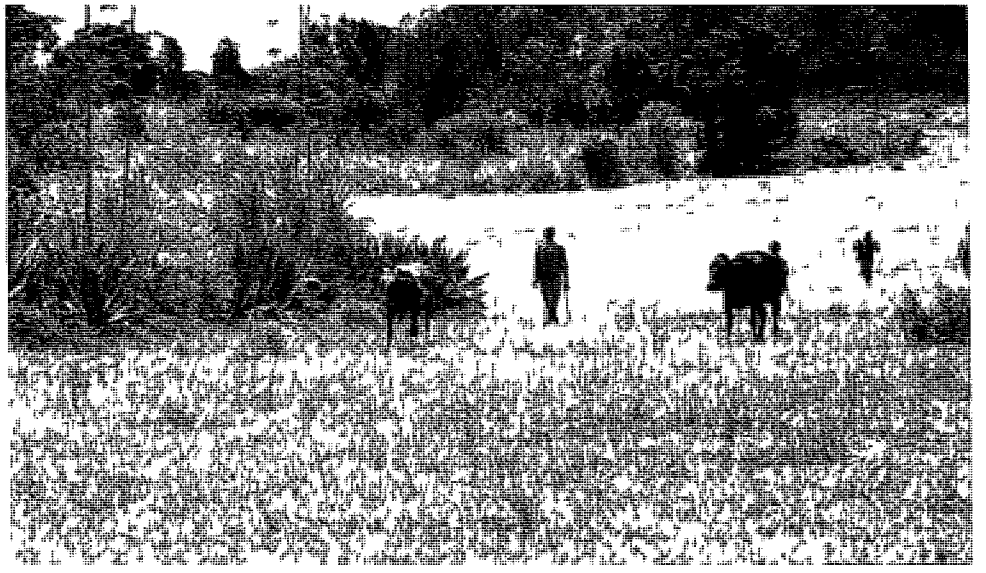
Availability of Planting Material

See information contained in Chapter 2, or contact your local extension agent

Mixed living fence of **Ziziphus mauritiana** *and* **Acacia** nigrescens

Live fence enclosure of vetiver nursery from truncheons of Commiphora *trees*

Sisal protecting dimba garden from livestock



Tobacco drying shed using living trees for upright poles (see text on page 104)

REFERENCE TABLES ON AGROFORESTRY TECHNOLOGIES AND SPECIES

Introduction

For planning purposes this section summarises information on agroforestry species and technologies Using these tables one should be able to convert a plan like

"a number of farmers want to plant a certain area with these agroforestry technologies using these species "

to a plan like

"this number of polythene tubes is needed for these species with this quantity of seed pretreated as indicated "

This section also summarises information on different species and their uses to facilitate species choice

The Tables are as follows

Table 4 summarises key characteristics of recommended agroforestry technologies

Table 5 specifies plant spacing and density for different technologies from either direct sowing or nursery seedlings **Note** ***Spacing distances do not require exact measurement or the need for tape measures*** Farmers must be able to do this on their own Estimate distances of one or more metres by pacing or counting ridges 40 cm is about half the maize spacing, 20 cm is about the length of a farmer's foot, and 15 cm is the width of a stretched hand

Table 6 provides botanical, Chichewa and English names for different agroforestry species, along with information on plant size altitude range and uses in agroforestry

Table 7 indicates products and uses of different agroforestry species (e g , medicinal values, fodder quality, wood value for different purposes, etc)

Table 8 gives detailed planting instructions with seed quantities and pre-treatment for different agroforestry species and practices using either direct sowing or nursery seedlings

TABLE 4 GENERALISED CHARACTERISTICS OF AGROFORESTRY TECHNOLOGIES

Agroforestry Technology	Uses
Tree Nurseries	Seed seedlings cash income
Establishment Locate near to participating households farms & water supply At start up provide training seed and nursery inputs for communal nursery Thereafter transfer responsibilities to individuals/groups as appropriate *Management* Construct & prepare nursery early with timely provision of inputs/tools Use raised seedbeds (swazi beds) for small nurseries to reduce pot & labor costs Restrict nursery to species that cannot be direct sown or that require few seedlings/ha Root prune seedlings every 2 weeks avoid outplanting old or overgrown seedlings For *Faidherbia albida* raise tubes on elevated platforms or outplant at 3-4 weeks	
Alley Cropping or Hedgerow Intercropping (AC)	Soil fertility soil erosion & runoff fodder fuelwood weed suppression tobacco ties windbreaks
Contouring Transfer skills & tools to farmers to peg fields on contour in dry season *Establishment* Direct sow trees early half way up ridge since waterlogged furrows may kill seedlings & underlying hard pans impede root growth interplant short or late planted crops (e g soyabeans groundnuts cassava sweet potato) to reduce competition *Management* Make big ridges & deep furrows next to hedges to minimise competition Time pruning and leaf application to meet crop demands and to reduce competition - Minimise labor by applying fresh surface prunings after crop planting or 1st weeding - Prune again after harvest and cover prunings immediately with soil or bury in ridges In nutrient poor soils or to boost yields supplement with chemical fertilisers as needed Integrate with syst tree interplanting contour veg strips or tree fallows as desired	
Short Term Fallows (STF)	Soil fertility soil erosion & runoff fodder fuelwood tobacco ties poles weed suppression appropriate on exhausted land
Establishment Clear land of weeds and plough with animal draft power if possible Direct sow with planting rains on sides or tops of ridges *Management* Option to intercrop legume or tuber/root crops for first 1 2 seasons Keep weed free during first season to assist establishment After year 3 remove shrubs and resume cultivation or coppice shrubs in a manner similar to alley cropping the latter may require thinning of hedgerows If larger tree species are integrated with the shrubs coppice these for wood when large enough or if competing with the crop integrate with AC CVS or SI as desired	
Fodder/Green Manure Banks (FB)	Green manure fodder soil fertility fuel wood soil erosion & runoff tobacco ties poles appropriate on non arable land
Establishment Direct sow with planting rains on sides or tops of ridges Grow legume or tuber/root crops with trees for first 1 2 seasons *Management* Keep weed free during first season to assist establishment with protection from browsing for 1 3 years apply green prunings to crops as in alley cropping Use fodder as a dry season supplement to female breeding or lactating stock	

TABLE 4 CONT GENERALISED CHARACTERISTICS OF AGROFORESTRY TECHNOLOGIES

Agroforestry Technology	Uses
Contour Vegetation Strips (CVS)	Soil erosion & runoff fodder / thatching weed suppression, tobacco ties windbreaks
Contouring Transfer skills & tools to farmers to peg fields on the contour in dry season *Nurseries* Establish individual/group grass nurseries in dambos for fast multiplication *Establishment* Plant slips or cuttings as needed starting on upper slopes fill gaps - Plant early with slips closely spaced on upper half of marker & crop ridges *Management* Trim at start, mid and end of growing season to encourage tillering Integrate with alley cropping syst tree intercropping or improved fallows as desired	
Systematic Tree Intercropping (SI)	Soil fertility fodder fuelwood tobacco ties poles soil erosion & runoff
Establishment Plant healthy seedlings with good root systems or direct sow Plant with the first rains mark each tree to avoid trampling and weeding Plant 100 seedlings/ha to ensure good establishment and selection of healthy trees as well as for faster payoffs *Management* Protect trees from browsing for first 1 3 years As planted trees grow in size thin out weakest individuals or prune large branches for wood/fodder/poles if tree canopies are too large or dense - Coppice or selectively prune trees with dense canopies at start of season to minimise competition and to provide green manure - Integrate with alley cropping contour veg strips or improved fallows as desired	
Homestead/Boundary Planting (H/B) & Woodlots (WL)	Fruit, cash fodder fuelwood poles tobacco ties windbreaks demarcation appropriate on non arable land
Establishment Match desired species with environment selecting tree species with multiple uses that are not competitive for water/nutrients and that coppice readily Use healthy nursery seedlings with good root systems Plant with first rains on boundaries woodlots or homesteads marking each tree or plot *Management* Protect from browsing for 1 3 years water and mulch if possible to speed up growth and establishment	
Living Fences (LF)	Live fence fruits fuelwood, fodder green manure
Establishment Use healthy seedlings with good root systems or direct sow seed depending on the species certain trees may be established from live truncheons Select thorny species that are fast growing with good coppicing ability Plant with first rains on the inside of a dead fence which the live fence will replace *Management* Some trees need protection from browsing the first year Trim to 50 to 75 cm at the onset of the second or third season to encourage low and dense lateral branching thereafter maintain hedge at 1 to 1 5 m to prvent overgrowing One tree every 5 to 10 m may be left untrimmed for fruit fuelwood poles or fodder	

TABLE 5 PLANT SPACING AND DENSITY FOR EACH TECHNOLOGY

AGROFORESTRY TECHNOLOGY		DIRECT SOWN SEEDS		NURSERY SEEDLINGS	
		Field Spacing	Plants/ha or /km	Field Spacing	Plants/ha or /km
Alley Cropping *	Flat/gentle slopes	5 4 x 0 2 m	9,259 /ha	5 4 x 0 4 m	4 630 /ha
	Steep slopes	4 5 x 0 2 m	11 111 /ha	4 5 x 0 4 m	5 556 /ha
Short Term Fallows	Large trees	3 6 x 1 8 m	1 543 /ha	3 6 x 3 6 m	772 /ha
	Medium trees	1 8 x 0 9 m	6 173 /ha	1 8 x 1 8 m	3 086 /ha
	Small trees	0 9 x 0 45 m	24 691 /ha	0 9 x 0 9 m	12 346 /ha
	Shrubs *T vogelii C cajan*	0 9 x 0 45 m	24 691 /ha	NA	NA
Contour Strips **	Vetiver Slips / Napier Cuttings	NA	NA	0 15 m	6667 /km
	Optional tree hedgerows	0 2 m	5 000 /km	0 4 m	2 500 /km
Fodder / Green Manure Banks	Pure Stand of Trees	0 9 x 0 45 m	24 691 /ha	0 9 x 0 9 m	12 346 /ha
	Intercropped Trees with Napier	4 5 x 0 2 m	11 111 /ha	4 5 x 0 4 m	5 556 /ha
	Intercropped Napier with trees	NA	NA	0 9 x 0 45 m	24 691 /ha
Systematic Interplanting	(Trees may need to be thinned after establishment/growth)	10 x 5 m	200 /ha	10 x 10 m	100 /ha
Homestead / Boundaries	Small and medium trees	2 m	500 /km	4 m	250 /km
	Large trees	3 m	334 /km	6 m	167 /km
Woodlots	Poles	1 8 x 0 9 m	6 173 /ha	1 8 x 1 8 m	3 086 /ha
	Firewood/other				
	Small med trees	1 8 x 1 8 m	3 086 /ha	3 6 x 1 8 m	1 543 /ha
	Large trees	3 6 x 1 8 m	1 543 /ha	3 6 x 3 6 m	772 /ha
Live Fencing	Trees	0 2 m	5 000 /km	0 4 m	2 500 /km
	Sisal	NA	NA	1 0 m	1 000 /km
Tree Seed Orchards		1 8 x 0 9 m	6 173 /ha	1 8 x 1 8 m	3 086 /ha
Vetiver Grass Nurseries		NA	NA	0 45 x 0 45 m	49 383 /ha

After establishment thin out trees so that there is only one seedling per station
carefully done at an early stage thinned plants can be used to fill gaps
Anticipating lower germination and initial survival double the density when direct sowing
Numbers of seeds to sow per station depend on the species used (see Table 8 for more information)

* For Senna spectabilis double the spacing to 1 8 x 1 8 m in Green Manure Banks
and increase the spacing within hedgerows of Alley Cropping to 0 9 1 8 m

** Distance between grass strips varies from 20 m on gentle slopes to 5 m on very steep slopes

TABLE 6 AGROFORESTRY SPECIES AF-USES, SIZE AND ALTITUDE RANGE

Botanical Name	Chichewa	English	Agroforestry Technology [1]	Size [2]	Altitude [3]
Acacia galpinii	NKUNGU	Monkey Thorn	BH, SI, FA, WL LF	L	L-M
Acacia goetzei	NKUNGU	Purple Pod Acacia	BH, SI, FA, WL LF	M-L	L-M
Acacia nigrescens	MKUNGU	Knob Thorn	BH, SI, FA, WL LF	M	L
Acacia nilotica	MPAMPA	Scented thorn	BH, SI, FA, WL LF	S-M	L-M
Acacia polyacantha	MTHETE	White thorn	BH, SI, FA, WL, LF	M	W
Acacia tortilis	NCHONGWE	Umbrella Thorn	BH SI, WL LF	S-M	L
Acrocarpus fraxinifolius		Indian Ash	BH, WL	L	M H
*Agava sisalana**	KHONJE	Sisal	LF BH		L-M
Albizia lebbeck	MTANGMTANGA	Woman s Tongue	BH, SI, FA, WL	M	L
Annona senegalensis	MPOSA	Wild Custard Apple	BH,SI	S	L-M
Azadirachta indica	NIMU	Neem	BH, SI, FA, WL	M	L
Azanza garkeana	MTOWO	Snot Apple	BH, SI	S	W
Bauhinia thonningii	CHITIMBE	Monkey Bread	BH, SI, FA	S-M	W
Caesalpinia decapetala	MLUNGUZI	Mauritius Thorn	LF	S	W
Cajanus cajan	NANDOLO	Pigeon Pea	AC FA, CS	SS	W
Erythrina abyssinica	MUWALE	Red Hot Poker Tree	BH, SI, FA, LF	M	W
Eucalyptus species	BLUE GUM	Gum	BH, WL	L	W
Faidherbia albida	MSANGU	Winter Thorn	BH, SI, FA, WL	L	W
Ficus capensis	MKUYU	Cape Fig	BH, SI, LF	M L	W
Ficus natalensis	KACHERE	Common Wild Fig	BH, SI, LF	L	W
Flacourtia indica	NTHUDZA	Indian Plum	BH, SI	S	W
Gliricidia sepium		Mexican Lilac	AC BH, SI, FB FA, CS WL	S M	W
Khaya nyasica	MBAWA	Red Mahogany	BH, WL	L	W
Leucaena leucocephala	LUKINA	Leucaena	AC BH, SI, FB FA, CS WL	S	L-M
Melia azaderach	NDYA	China Berry	BH, SI, WL	S M	W
Moringa oleifera	KANGALUNI	Horse-Raddish Tree	BH, LF	S	L-M
Pennisetum purpureum	NSENJERE	Napier grass	CS FB		W
Prosopis juliflora		Mesquite	BH, SI, LF FA, WL	S	L
Pyracantha coccinea	MCHENDE	Fire Thorn	LF	SS	M H
*Sclerocarya birrea***	MFULA	Marula	BH, SI, LF	M L	L-M
Senna siamea	KESHYA	Cassia	BH, SI, WL FA	M	L-M
Senna spectabilis	KESHYA	Cassia	AC BH, SI, FA, CS WL	S M	W
Sesbania sesban	JELEJELE BINU	River Bean	AC BH, SI, FA, CS FB	SS	W
Tephrosia vogelii	MTHUTHU	Fish Bean	AC BH, SI FA, CS	SS	M H
Terminalia sericea	NAPINI	Silver Terminalia	BH, SI WL	M L	L-M
Toona ciliata	SENDRELLA	Toon Tree	BH SI, FA, WL	L	W
Trichilia emetica	MSIKITSI	Natal Mahogany	BH WL	M L	L-M
Uapaca kirkiana	MASUKU	Wild Loquat	BH SI	S	M H
Vetiveria zizanioides	THEDZI	Vetiver grass	CS		W
*Ziziphus abyssinica**	KANKHANDE	Jujube	BH SI, WL LF	S	M H
*Ziziphus mauritiana**	MASAWO	Jujube	BH, SI, WL LF	S	L-M
*Ziziphus mucronata**	KANKHANDE	Buffalo Thorn	BH, SI, WL LF	S	W
*Ziziphus spina christi**		Christ Thorn	BH SI WL LF	S	L-M

[1] Agroforestry technologies AC=Alley Cropping BH=Boundary Homestead SI=Systematic Interplanting WL=Woodlots LF=Live Fencing FB=Fodder / Green Manure Banks FA=Short Term Fallow CS=Contour Vegetation Strips

[2] Tree size SS small shrub S=small M=medium L=large [3] Altitude W=Wide range L=Low M=Medium H=High

TABLE 7 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 goetzei	I	++	o	o			+		
Acacia nigrescens	I	++	+	++			+		
Acacia nilotica	I	+	++	++			++	Gum	DY,IM RP
Acacia polyacantha	I	++	++	+	++		++	Gum	VD SN TR
Acacia tortilis	I	++				+	+		
Acrocarpus fraxinifolius	E	o	o						
*Agava sisalana**	E						+		
Albizia lebbeck	E	++	+++	++	++		++		TN
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
Caesalpinia decapetala	I								
Cajanus cajan	E	o					++	Pods	
Erythrina abyssinica	I				o				PO
Eucalyptus species	E	+	++						
Faidherbia albida	I	++	+	+	+		+++	Seeds	TN ST
Ficus capensis	I	o	o			++	++		SK
Ficus natalensis	I	o	o			++	++	Fruit	RP GP
Flacourtia indica	I							Fruit	BP GP RP RU ST

Origin I = Indigenous E = Exotic

Use Ratings +++ Excellent; ++ Very Good; + Good; o Fair; Blanks Poor or unknown

Medicinal and other uses

AB Abortcide
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 7 CONT AGROFORESTRY SPECIES WOOD MEDICINAL AND OTHER USES

Species	Origin	Fuelwood	Timber/building	Furniture	Tools/Carvings	Rope/Textiles	Animal Fodder	Edible Parts	Medicine/Other
Khaya nyasica	I	++	+++	+++	++				RP
Leucaena leucocephala	E	+	o				++	Leaves	
Melia azaderach	E	++	o	o					PO,IN
Moringa oleifera	E					+	+	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					+++		
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
*Ziziphus spina christi**	E	+++	++	++	++		++	Fruit	

Origin I = Indigenous E = Exotic

Use Ratings +++ Excellent; ++ Very Good; + Good; o Fair; Blanks Poor or unknown

Medicinal and other uses

AB Abortcide
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 8 AGROFORESTRY SPECIES SEED REQUIREMENTS PER TECHNOLOGY

SPECIES	Planting Method [1]	Treat-ment [2]	Seed /hole	Seeds per Kg	Alley Cropping [3] g/ha DS	Alley Cropping [3] g/ha NS	Short Term Fallows g/ha DS	Short Term Fallows g/ha NS	Contour Strips g/km DS	Contour Strips g/km NS	Fodder / Green Man. g/ha DS	Fodder / Green Man. g/ha NS
Acacia galpinii	DS NS	2	2	4 800			**1,286**	643				
Acacia goetzei	DS NS	2	3	9 900			**1,870**	935				
Acacia nigrescens	DS NS	2	2	4 800			**2,572**	1 286				
Acacia nilotica	DS NS	2 or 6	2	6 329			**1,951**	975				
Acacia polyacantha	DS NS	2	3	9 900			**1,871**	935				
Acacia tortilis	NS	2 or 6	3	13 330				**695**				
Acrocarpus fraxinifolius	NS SB	2	3	41 650								
*Agava sisalana**	SU BU	NA	NA	NA								
Albizia lebbeck	DS NS	2 or 6	3	9 000			**2,057**	1 029				
Annona senegalensis	NS	0 F	3	12 500								
Azadirachta indica	NS	3 F	2	11 000				**561**				
Azanza garkeana	NS	3 F	2	4 000								
Bauhinia thonningii	DS NS	2	3	6 100			**3,036**	1 518				
Caesalpinia decapetala	DS NS	2	2	3 380								
Cajanus cajan	DS	0	3	12 000	**2,315**		**6,173**		**1,250**			
Erythrina abyssinica	CT NS	2 or 6	2	6 800				**908**				
Eucalyptus species	NS SB	0	5	500 000								
Faidherbia albida	DS NS	2 or 6	3	6 900			**672**	336				
Ficus capensis	CT	NA	NA	NA								
Ficus natalensis	CT	NA	NA	NA								
Flacourtia indica	NS	3+1 F	5	22 000								

[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=soak 48 hr cold water 2=soak 15 min 65° C water
3=remove fleshy pulp 4=crack shell and extract seed 5=crack nut 6=nick off end of seed
with nail clipper or knife 7=wash wax off in cold water F=plant fresh I=inoculate with rhizobia

[3] Alley Cropping based on an alley width of 5 4 m for gentle slopes
For steep slopes with an alley width of 4 5 m use 20 % more seed

* No of slips or cuttings

Recommended planting method in bold and shaded

Vegetative propagation material underlined

TABLE 8 CONT AGROFORESTRY SPECIES SEED REQUIREMENTS PER TECHNOLOGY

					Systematic Interplant. g/ha		Boundary Homestead g/km		Woodlots g/ha		Living Fences g/km	
SPECIES	Planting Method [1]	Treat-ment [2]	Seed /hole	Seeds per Kg	DS	NS	DS	NS	DS	NS	DS	NS
Acacia galpinii	DS NS	2	2	4 800	83	**42**	139	**70**	643	**322**	**2,083**	1 042
Acacia goetzei	DS NS	2	3	9 900	61	**30**	152	**76**	935	**468**	**1,515**	0 758
Acacia nigrescens	DS NS	2	2	4 800	83	**42**	208	**104**	1 286	**643**	**2,083**	1 042
Acacia nilotica	DS NS	2 or 6	2	6 329	63	**32**	158	**79**	975	**488**	**1,580**	790
Acacia polyacantha	DS NS	2	3	9 900	61	**30**	101	**51**	468	**234**	**1,515**	758
Acacia tortilis	NS	2 or 6	3	13 330		**23**		**56**		**347**		**563**
Acrocarpus fraxinifolius	NS SB	2	3	41 650				**18**		**56**		
*Agava sisalana**	SU BU	NA	NA	NA				**250**				**1,000**
Albizia lebbeck	DS NS	2 or 6	3	9 000	67	**33**	167	**83**	1 029	**514**		
Annona senegalensis	NS	0 F	3	12,500		**24**		**60**				
Azadirachta indica	NS	3 F	2	11 000		**18**		**45**		**281**		
Azanza garkeana	NS	3 F	2	4 000		**50**		**125**				
Bauhinia thonningii	DS NS	2	3	6 100	98	**49**	246	**123**	1 518	**759**		
Caesalpinia decapetala	DS NS	2	2	3 380			296	**148**			**2,960**	1 480
Cajanus cajan	DS	0	3	12 000								
Erythrina abyssinica	CT NS	2 or 6	2	6 800		**29**		**74**				
Eucalyptus species	NS SB	0	5	500 000				**4**		**15**		
Faidherbia albida	DS NS	2 or 6	3	6 900	87	**43**	146	**73**	671	**336**		
Ficus capensis	CT	NA	NA	NA		**100**		**167**				
Ficus natalensis	CT	NA	NA	NA		**100**		**167**				
Flacourtia indica	NS	3+1 F	5	22 000		**23**		**57**				

[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=soak 48 hr cold water 2=soak 15 min 65° C water
3=remove fleshy pulp 4=crack shell and extract seed 5=crack nut 6=nick off end of seed
with nail clipper or knife 7=wash wax off in cold water F=plant fresh I=inoculate with rhizobia

* No of slips or cuttings

Recommended planting method in bold and shaded

Vegetative propagation material underlined

TABLE 8 CONT AGROFORESTRY SPECIES SEED REQUIREMENTS PER TECHNOLOGY

SPECIES	Planting Method [1]	Treat-ment [2]	Seed /hole	Seeds per Kg	Alley Cropping [3] g/ha DS	Alley Cropping [3] g/ha NS	Short Term Fallows g/ha DS	Short Term Fallows g/ha NS	Contour Strips g/km DS	Contour Strips g/km NS	Fodder / Green Man. g/ha DS	Fodder / Green Man. g/ha NS
Gliricidia sepium	CT DS NS	0 F	1	7 000	1 323	**661**	**3,527**	1 764	714	**357**	3 527	**1,764**
Khaya nyasica	NS	0 F	2	2 980								
Leucaena leucocephala	DS NS	2 or 6 +I	3	18 850	1 474	**737**	**3,930**	1 965	796	**398**	3 930	**1,965**
Melia azaderach	NS	3 F	3	1 750								
Moringa oleifera	CT NS	0 F	3	4 500								
*Pennisetum purpureum**	CT	NA	NA	NA						**5,000**		**24,691**
Prosopis juliflora	DS NS	2	3	10 900			**1,699**	849				
Pyracantha coccinea	NS SB	7	10	370 400								
*Sclerocarya birrea****	CT NS	3 F	1**	100								
Senna siamea	DS NS	2	3	33 000			**561**	281				
Senna spectabilis	DS NS	2+1	3	32 000	868	**193**	**578**	289	234	**117**	579	**289**
Sesbania sesban	DS NS	2	5	82 305	562	**281**	**1,500**	750	304	**152**	1 500	**750**
Tephrosia vogelii	DS	0	1	17 500	**529**		**1,412**		**286**			
Terminalia sericea	NS	3+1 F	3	3 906								
Toona ciliata	NS SB	0 F	5	300 000				515				
Trichilia emetica	NS	0 F	2	1 200								
Uapaca kirkiana	NS	3 F	2	2 860								
*Vetiveria zizanioides**	SL	NA	NA	NA						**6,667**		
*Ziziphus abyssinica***	DS NS	3+4+1 F	2	250								
*Ziziphus mauritiana***	DS NS	3+5+1 F	2	1 500								
*Ziziphus mucronata***	DS NS	3+4+1 F	2	1 100								
*Ziziphus spina christi***	DS NS	3+5+1 F	2	1 100								

[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=soak 48 hr cold water 2=soak 15 min 65° C water
3=remove fleshy pulp 4=crack shell and extract seed 5=crack nut 6=nick off end of seed
with nail clipper or knife 7=wash wax off in cold water F=plant fresh I=inoculate with rhizobia

[3] Alley Cropping based on alley width of 5 4 m for gentle slopes steep slopes with 4 5m alleys use 20% more seed

* No of slips or cuttings ** Weight based on dried nuts without the fleshy pulp

*** *Sclerocarya birrea* 2 stones containing 3 seeds each

Recommended planting method in bold and shaded

Vegegative propagation material underlined

TABLE 8 CONT AGROFORESTRY SPECIES SEED REQUIREMENTS PER TECHNOLOGY

					Systematic Interplant. g/ha		Boundary Homestead g/km		Woodlots g/ha		Living Fences g/km	
SPECIES	Planting Method [1]	Treat-ment [2]	Seed /hole	Seeds per Kg	DS	NS	DS	NS	DS	NS	DS	NS
Gliricidia sepium	CT DS NS	0 F	1	7 000	29	**14**	71	**36**	441	**220**		
Khaya nyasica	NS	0 F	2	2,980				**112**		**518**		
Leucaena leucocephala	DS NS	2 or 6 +I	3	18 850	32	**16**	80	**40**	982	**491**		
Melia azaderach	NS	3 F	3	1 750		**171**		**429**		**2,645**		
Moringa oleifera	CT NS	0 F	3	4 500			333	**167**	4 114	**2,057**		
Pennisetum purpureum	CT	NA	NA	NA								
Prosopis juliflora	DS NS	2	3	10 900	55	**28**	138	**69**	849	**425**	**1,376**	688
Pyracantha coccinea	NS SB	7	10	370 400								**68**
*Sclerocarya birrea***	CT NS	3 F	1**	100		**1,000**		**2,500**				**25,000**
Senna siamea	DS NS	2	3	33 000	18	**9**	46	**23**	281	**140**		
Senna spectabilis	DS NS	2+1	3	32 000	19	**9**	46	**23**	289	**145**		
Sesbania sesban	DS NS	2	5	82 305	12	**6**	30	**15**				
Tephrosia vogelii	DS	0	1	17 500	**11**		30					
Terminalia sericea	NS	3+1 F	3	3 906		77		**128**		**593**		
Toona ciliata	NS SB	0 F	5	300 000		**19**		**32**		**155**		
Trichilia emetica	NS	0 F	2	1 200				**278**		**1,287**		
Uapaca kirkiana	NS	3 F	2	2 860		**70**		**175**				
Vetiveria zizanioides	SL	NA	NA	NA								
*Ziziphus abyssinica**	DS NS	3+4+1 F	2	250	1 600	**800**	4 000	**2,000**	49 376	**24,689**	40 000	20 000
*Ziziphus mauritiana**	DS NS	3+5+1 F	2	1 500	267	**133**	666	**333**	8 223	**4,115**	6 667	3 333
*Ziziphus mucronata**	DS NS	3+4+1 F	2	1 100	364	**182**	909	**455**	11 222	**5,611**	9 091	4 546
*Ziziphus spina-christi**	DS NS	3+5+1 F	2	1 100	364	**182**	909	**455**	11 222	**5,611**	9 091	4 546

[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=soak 48 hr cold water 2=soak 15 min 65° C water
3=remove fleshy pulp 4=crack shell and extract seed 5=crack nut; 6=nick off end of seed
with nail clipper or knife 7=wash wax off in cold water F=plant fresh I=inoculate with rhizobia

* Weight based on dried nuts without the fleshy pulp

** *Sclerocarya birrea* 2 stones containing 3 seeds each

Recommended planting method in bold and shaded

Vegegative propagation material underlined

NEW OR MODIFIED AGROFORESTRY TECHNOLOGIES UNDER TEST

Germplasm Screening and Propagation

A major limitation of current agroforestry technologies is the narrow availability of suitable species and varieties of trees Several institutions in Malawi (e g Bunda, ICRAF, DAR FRIM) are investigating the potential of other species, provenances and varieties of trees that may prove better suited to Malawi farm conditions 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

Mixed Tree Intercropping

This technology is being researched mainly by ICRAF at Makoka Research Station under the direction of Dr J Maghembe (personal communications) The practice is essentially a modified system of hedgerow intercropping The main distinction is the hedge spacing, and lower management for pruning and leaf application Hedges are commonly grown in every other furrow (1 8 m apart) with plants 90 cm apart and crops on the ridges Depending on the species the hedges may be retained for one or more seasons They are then replanted For example, *Cajanus cajan*, *Tephrosia* or *Sesbania* may be grown for only one season and replanted The shrubs are cut down at ground level after the harvest or just before the next rains The foliage and roots remain to decompose Retained hedges, such as *Gliricidia sepium*, are allowed to regenerate naturally or are coppiced and managed in a manner similar to hedgerow intercropping

Relay Cropping

A common definition of relay cropping is to plant a second (different) crop after the first crop has reached maturity This reduces competition and enables two crops to be grown on the same land Relay cropping, as defined here involves undersowing a fast-growing legume shrub or tree to improve soil fertility This crop is incorporated as green manure before the next season when a dense leafy cover is established Two main planting systems are under test

1 Broadcast tree seed along every ridge at a high density just before the second weeding to obtain a green carpet of plants (Stephen Carr personal communications) This practice is designed to minimise labour by combining it with normal weeding and banking, which covers the seed with soil

2 Interplant trees on every other ridge between maize stations (Jumanne Maghembe personal communications) Recent findings suggest planting certain tree species at the same time as the crop This means it no longer functions as a relay crop, but more as mixed intercropping

A clear advantage of this technology is the lower labour and management costs Yield benefits and farmer responses have not been documented Research is needed on the time and method of undersowing, the optimum species and population density of the shrubs, and the time of incorporating the green manure The MAFE Project plans to test this technology with volunteer farmers during the 1995/96 season Suitable shrubs for this practice include pigeon peas, *Tephrosia vogelii,* and *Sesbania* species Use of pigeon peas may be affected by farmers interest in harvesting the peas for food or sale Common grain and forage legumes may also be used in this practice, but such species do not contribute as much foliage and root biomass to the soil

Strip Cropping

Research on this technology is being done by ICRAF and the Chitedze Agroforestry Research Team Hedges of short-lived species such as *Cajanus cajan Tephrosia*, or *Sesbania* are grown in alternate strips with crops The hedges are retained for only one or two seasons, and replanted but in different locations Hedge strips usually comprise 2-4 ridges, while crop strips may be wider This system facilitates management of the hedges and crop, and may also reduce competition between them However, it appears to require more land due to the area occupied by the trees

Integrating Agroforestry with Smallholder Burley Tobacco

A recent amendment to the MAFE Project is to identify and disseminate ecologically sound and cost-effective methods to integrate agroforestry techniques with smallholder burley tobacco production Specific objectives are

1 To maintain or improve soil fertility with reduced use of chemical fertilisers by interplanting soil-improving trees and hedges

2 To reduce erosion and water runoff by establishing contour strips of vetiver grass

3 To decrease deforestation problems from cutting wood for tobacco curing by establishing woodlots and living barns

Except for living barns these technologies are identical to those under test with other farmers

Although the concept of living barns is new to smallholders, some tenant farmers on tobacco estates are using this technology with *Gmelina arborea* The MAFE Project plans to evaluate other species, and to compare farmer interests for different species These are presently dominated by *Eucalyptus, Gmelina* and *Senna siamea* Proposed species for living barns and woodlots are shown on page 106

Establishment and Management of Living Barns for Tobacco Curing

A living barn for drying burley tobacco is a shed made of living trees in place of upright poles (see bottom photo on page 90) 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 tobacco ties or other purposes Since a typical "dead" shed lasts only 3 years, living barns reduce labour and maintenance as well as deforestation A shed 30m long with 45 upright poles is sufficient to cure 300 kg of tobacco So far *Gmelina arborea* is the major tree used successfully by farmers It is established from both seedlings and cuttings *Eucalyptus* species are used with mixed results, apparently due to poor coppicing Few other species have been tested Guidelines for establishing and managing living barns 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 tobacco nurseries

- If cuttings or truncheons are used, identify species and sources of this 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 2 on nursery management for details on preparing cuttings

- Provide stake supports and prune branches to encourage a straight-growing trunk

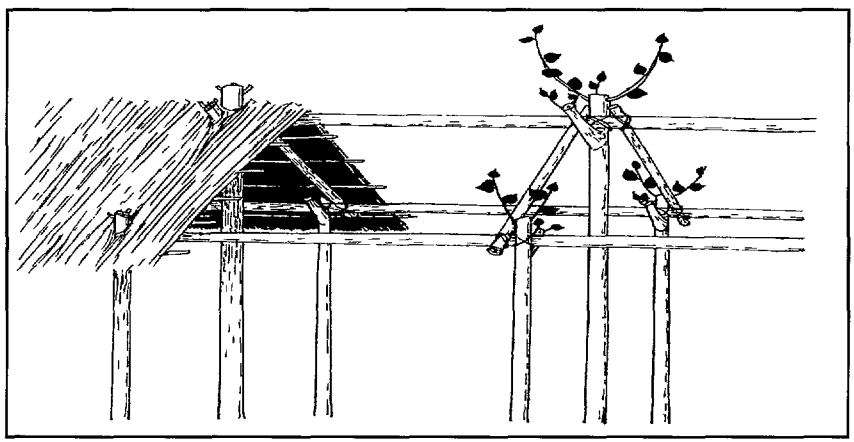
- Locate the shed near the house or farm, preferably not on good farm land Establish seedlings or truncheons in the configuration of a typical shed 2 x 2 m in 3 lines (see page 105) The centre line poles are 2 5 to 3 m tall, while the outside poles are 1 5 to 2 m tall

- Protect young trees from browsing/other damage to avoid uneven or mis-shapen poles Fill in gaps where seedlings have died, or where truncheons have failed to grow With truncheons allow 1-2 years for roots and foliage to develop before building the roof

- Construct the shed only when the living trees are large and strong enough to support the roof Ensure coppicing is done evenly so that the roof is uniform, sloping from the centre down each side

- Coppice/pollard trees when well established, timed to provide tobacco ties and to minimise 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

Living barn Construction of roof on live poles



Configuration of a Living Barn 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
```

TREE SPECIES FOR ON-FARM TESTING IN WOODLOTS AND LIVING BARNS

Note Not all species listed here are contained in the description of trees in Chapter 4

Species	Local Name	Technology	Altitude Preference	Method of Establishment
Acacia galpinii	Nkungu	WL LB	Wide range	seedlings
Albizia lebbeck	Mtangatanga	WL LB	Low to medium	seedlings
Albizia versicolor	Nsenjere	LB	Low to medium	seedlings
Albizia zimmermannii	Mtangatanga	LB	Low to medium	seedlings
Azadirachta indica	Nimu	WL LB	Low to medium	seedlings or wildlings
Bridelia micrantha	Mpasa	WL LB	Low to medium	seedlings
Burttdavya nyasica	Mbvule	WL LB	Low to medium	seedlings
Commiphora spp *	Khobo	LB	Depends on species	cuttings
Dombeya rotundifolia	Nchiu	WL LB	Wide range	seedlings
Erythrina abyssinica *	Muwale	LB	Low to medium	seedlings cuttings
Ficus natalensis *	Kachere	LB	Wide range	seedlings cuttings
Ficus capensis *	Mkuyu	LB	Low to medium	seedlings cuttings
Gmelina arborea	Malaina	WL LB	Wide range	seedlings cuttings
Eucalyptus spp	Blue gum	WL LB	Depends on species	seedlings
Khaya nyasica	Mbawa	WL LB	Wide range	seedlings
Lannea discolor *	Chiumbu	WL LB	Wide range	truncheons
*Pterocarpus angolensis**	Mlombwa	LB	Low to medium	truncheons
Sclerocarya birrea	Mfula	LB	Low to medium	seedlings cuttings
Senna siamea	Keshya	WL LB	Low to medium	seedlings
Toona ciliata	Sendrella	WL LB	Wide range	seedlings or wildlings

* Tree species traditionally used for live fence posts in *kholas* and home bathing sites
Legend WL = Woodlots LB = Living Barns

CHAPTER FOUR: COMMON AGROFORESTRY SPECIES

INTRODUCTION

This chapter is intended to serve as a practical field guide to some common fast-growing agroforestry species used in Malawi It is by no means a comprehensive list of plants suitable for agroforestry since research is continually identifying other species The plants listed are organised alphabetically by family For each species the botanical name is provided along with the common English and Chichewa names, a brief, illustrated description of the species, common uses and products, and any special notes Table 9 at the end of this chapter gives an index of species by botanical, Chichewa and English names Specific agroforestry uses are not specified in the text since they are included in Table 6 Details on uses and planting instructions are given for each technology and species in Tables 6, 7, and 8 beginning on page 95 Consult references at the back of this manual for more detailed information

Trees may be interplanted with crops for multi-purpose uses as shown here with coppiced **Toona ciliata** *just before the growing season*

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**

Sclerocarya birrea

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 diametre

Uses/Products Edible fruits high in vitamin C, richly scented and can be made into jams, juices, and an alcoholic drink, the stone inside the fruits contain 2-3 edible kernels containing a protein-rich oil which burns like a candle Wood used for carvings, furniture, flooring, and match-making, bark for rope/string, cut truncheons grown as live fence posts, makes good browse for all stock The tree has many medicinal and cultural uses, and is highly valued in many parts of Africa

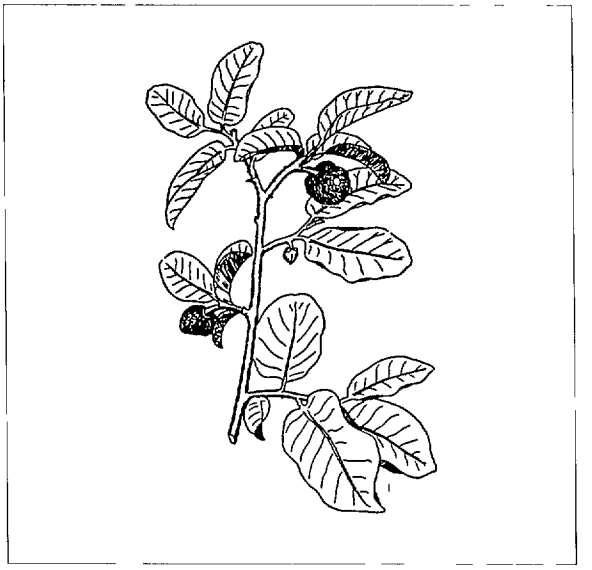
Special Notes Best propagated from cuttings/ truncheons Food value of fruits is high, but not eaten much in Malawi Fruits have commercial value for jams, juices and liqueurs in S Africa, Botswana and Zimbabwe

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

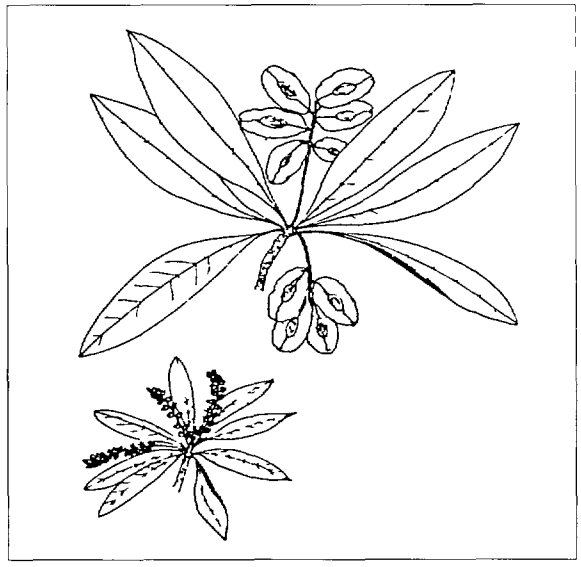
from Useful plants of Malawi, 1975
J Williamson

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

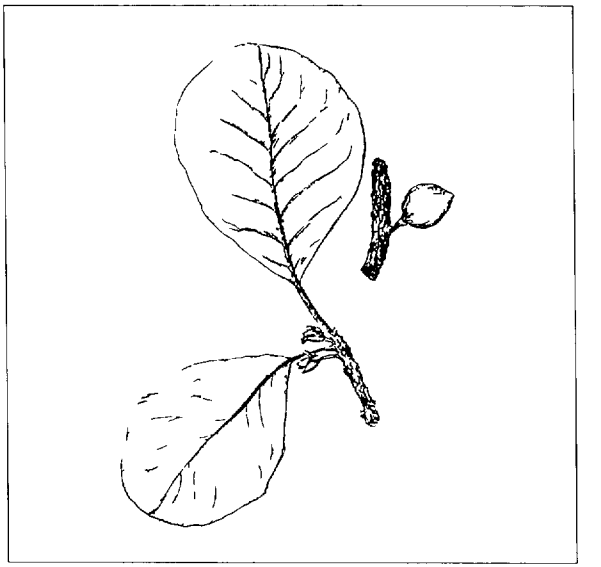
FAMILY EUPHORBIACEAE

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 diametre

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

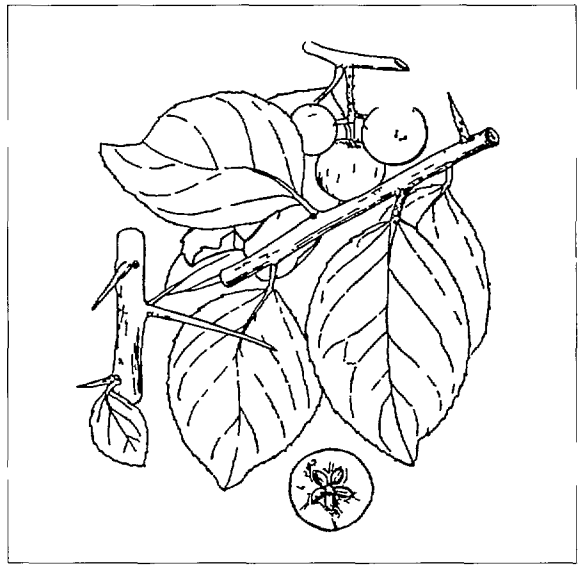
FAMILY FLACOURTIACEAE

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

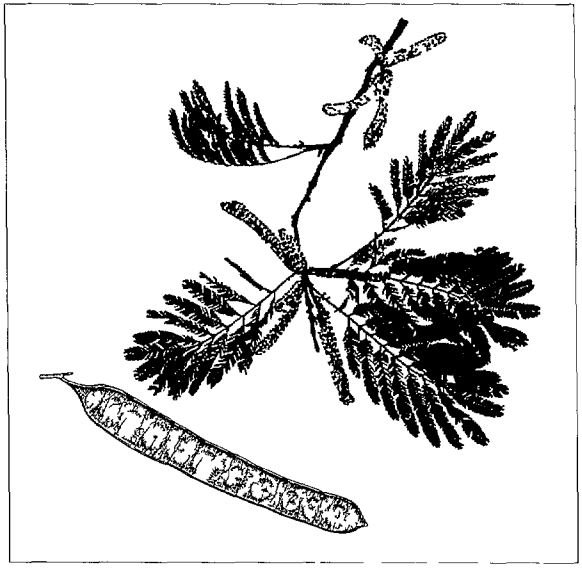
from Useful Plants of Malawi
J Williamson ill G Jackson

FAMILY LEGUMINOSAE
Sub-Family Mimosoideae

Acacia galpinii
Monkey Thorn **Nkungu**

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 goetzei
Purple-Pod Acacia **Nkungu**

Description Indigenous A medium to large deciduous tree 15-20 m tall **Bark** brown-grey and rough paired prickles are dark strong and hooked downwards, **leaves** 3-10 pairs of pinnae, 5-23 pairs of leaflets each, **flowers** creamy-white in spikes, **fruits** a reddish-purple straight pod

Uses/Products Good fuelwood and fodder

Acacia goetzei

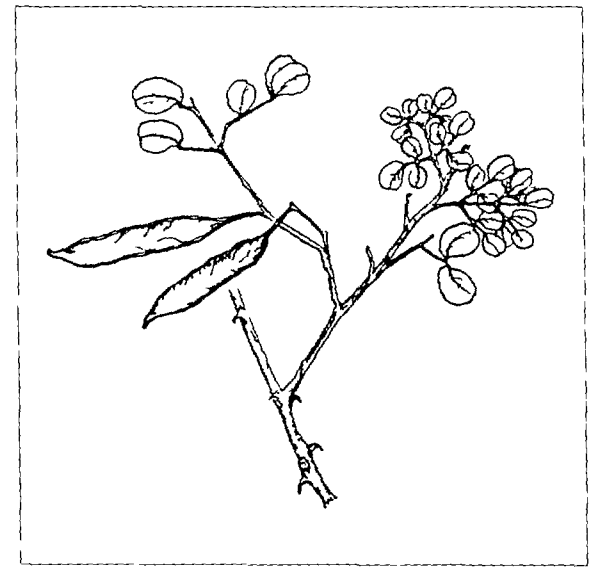
ill F Bodnar

FAMILY LEGUMINOSAE
Sub-Family Mimosoideae

Acacia nigrescens
Knobthorn **Mkungu**

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

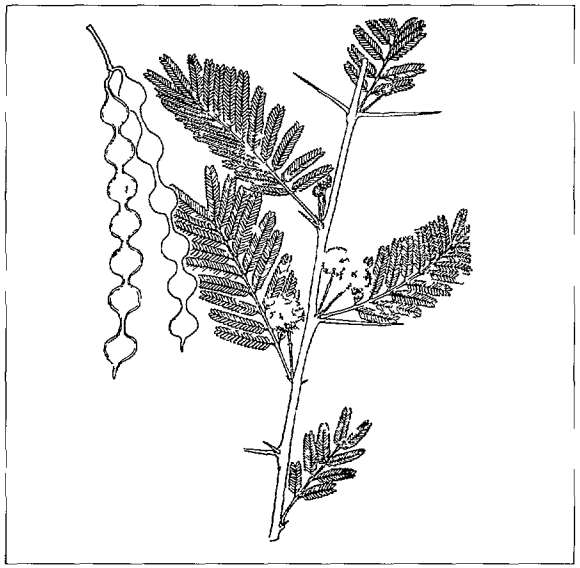
from Useful Plants of Malawi, 1975
J Williamson

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

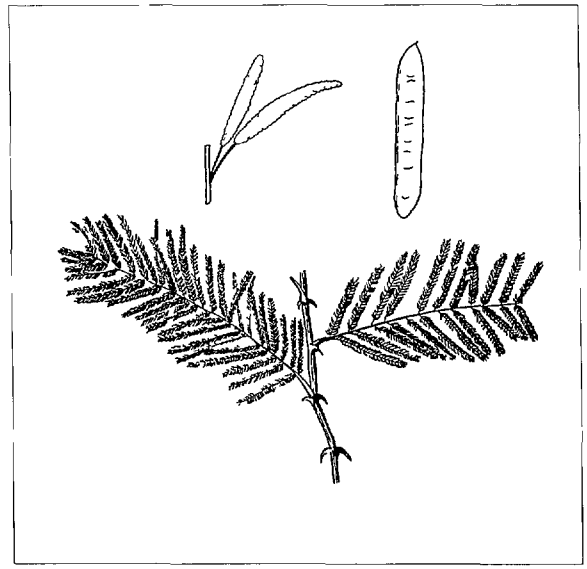
from Common Fuelwood Crops
Elbert L Little, Jr ill Sahni

FAMILY LEGUMINOSAE
Sub-Family Mimosoideae

Acacia polyacantha
White Thorn **Mthete**

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

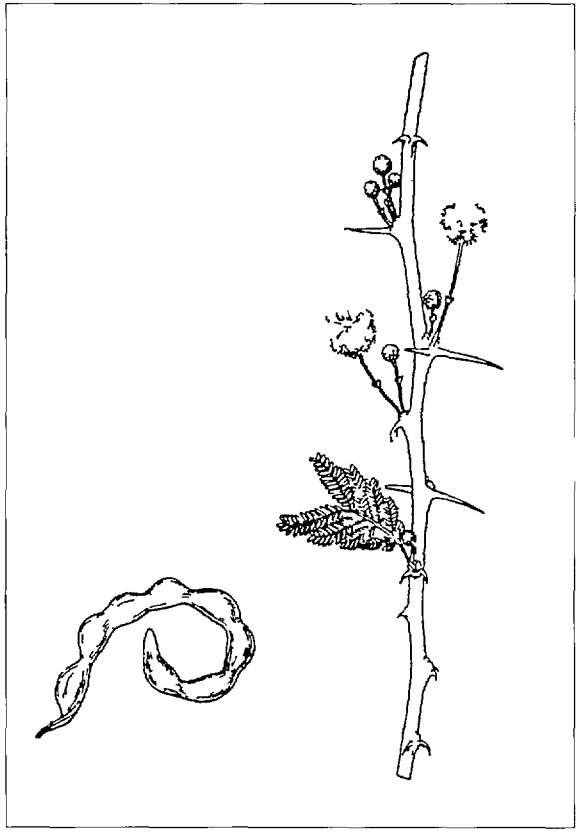
from A Field Guide to Lengwe National Park, 1984 B Y Sherry and A J Ridgeway

FAMILY LEGUMINOSAE
Sub-Family Mimosoideae

Acacia 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

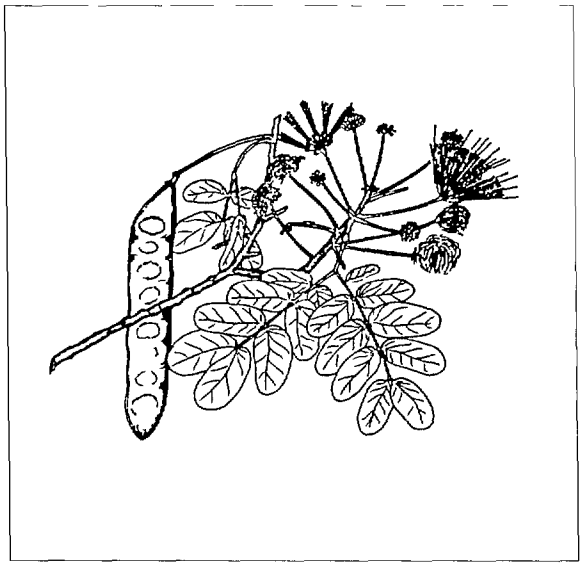
from Common Fuelwood Crops
Elbert L Little, Jr

FAMILY LEGUMINOSAE
Sub-Family Mimosoideae

Albizia lebbeck
Woman's Tongue Mtangamtanga

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

Faidherbia albida
Winter Thorn **Msangu**

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

Faidherbia albida

from ICRAF 1992 A Selection of Useful Trees and Shrubs for Kenya

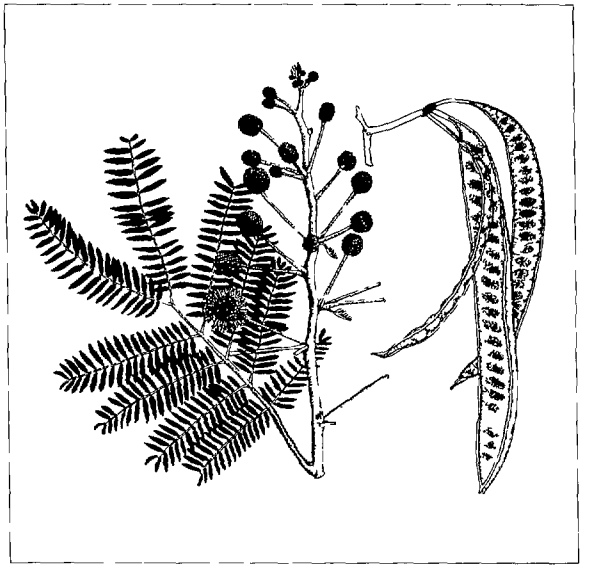
Special Notes Ideal agroforestry tree and widely appreciated by farmers, but return on investment may be fairly long-term (over 7-10 years) due to variable growth rate Fast growing tap-root can be deformed in nursery or when out-planting due to mismanagement Young seedlings need protection from browsing 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

Leucaena leucocephala
Leucaena **Lukina**

Description Native to Mexico now widely naturalised throughout the tropics Tree size depends on variety, but generally a rounded, very branched shrub 5-8 m high Taller varieties are 10-20 m, with an irregular crown **Bark** grey or grey-brown and smooth, **leaves** dark green and compound, **flowers** creamy-white in clustered balls, **fruit** a narrow, long, and flat pod in clusters, green when young, turning brown at maturity

Uses/Products Nutritious fodder but can be poisonous especially to monogastric animals such as horses, hogs, poultry and rabbits if eaten solely for long periods, due to mimosine in the leaves and seeds, causing illness and hair loss, makes good fuelwood, taller varieties used for construction, lumber, and pulpwood



Leucaena leucocephala

from Common Fuelwood Crops
Elbert L Little, Jr

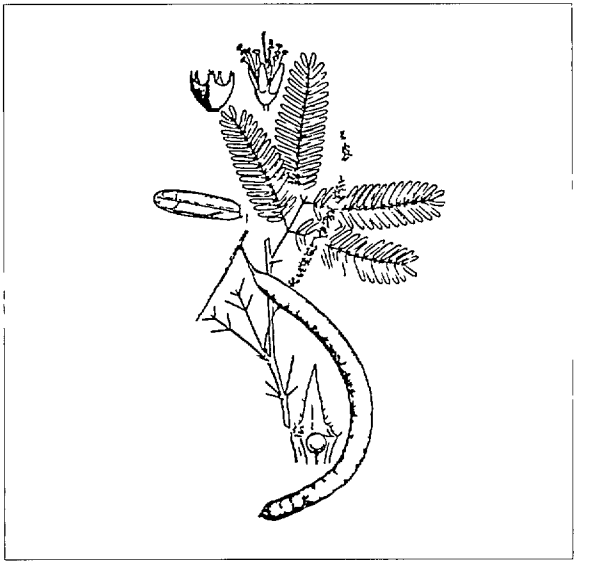
Special Notes Very fast-growing drought-resistant, nitrogen-fixing tree that coppices readily used extensively for green manure, soil conservation and livestock feed Limitations in Malawi include susceptibility to termite attack and browsing by animals, damage from psyllids, need for special rhizobia for nodulation, and poor performance in acidic and nutrient-deficient soils

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



Prosopis juliflora

from Common Fuelwood Crops
Elbert L Little, Jr

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

FAMILY LEGUMINOSAE
Sub-Family Caesalpinioideae

Acrocarpus fraxinifolius
Indian Ash

Description Native of India and Southeast Asia A very tall, fast-growing deciduous tree up to 60 m high with a clean straight trunk **Bark** pale grey, smooth with horizontal markings **leaves** compound up to 1 m long, leaflets broadly elliptic, shiny green but bright red when young, **flowers** with green petals and orange stamens, short-lived in dense stalked clusters 12 cm long at terminal branches, **fruit** a thin dark brown pod up to 12 cm long in persistent terminal bunches splitting to release numerous dark brown seeds

Uses/Products Timber for light construction, good for making bee-hives, widely used as a shade tree for tea and coffee plantations, and popular as an avenue and park tree

Special Notes Extremely fast growing, reaching over 3 m in its first year, quick to regenerate after pruning, but somewhat susceptible to termite attack

Acrocarpus fraxinifolius

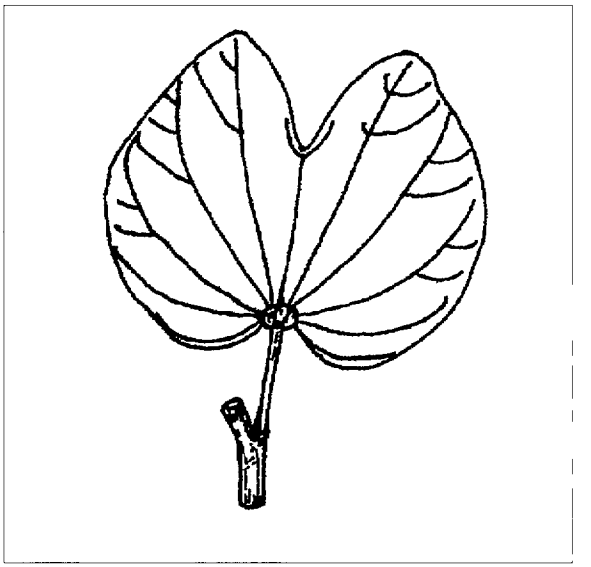
from Trees of Kenya, 1989
T Noad and A Birnie ill A Birnie

FAMILY LEGUMINOSAE
Sub-Family Caesalpinioideae

Bauhinia thonningii
Monkey Bread **Chitimbe**

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

ill L Chikadza

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

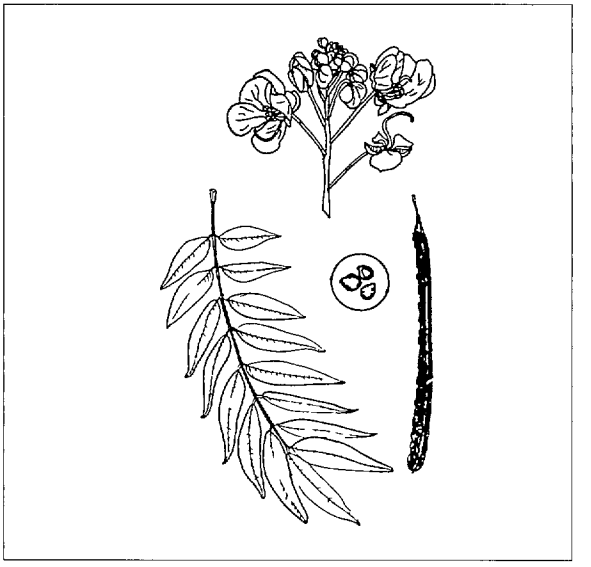
FAMILY LEGUMINOSAE
Sub-Family Caesalpinioideae

Senna spectabilis

Cassia **Keshya**

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



Senna spectabilis

Trees of Kenya, 1989
T Noad and A Birnie ill A Birnie

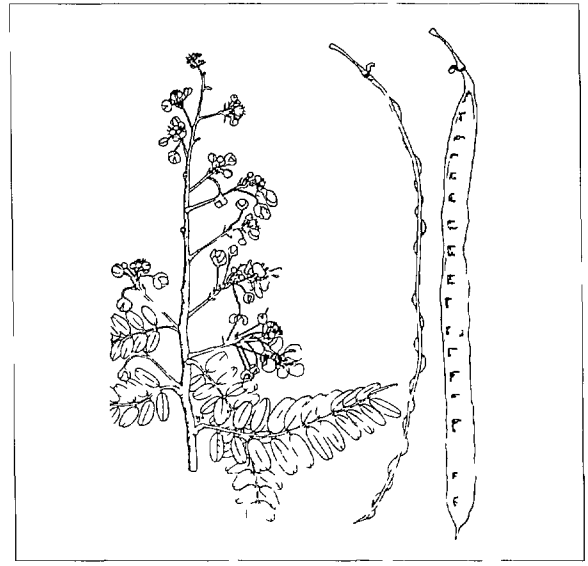
FAMILY LEGUMINOSAE
Sub-Family Caesalpinioideae

Senna siamea

Cassia **Keshya**

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

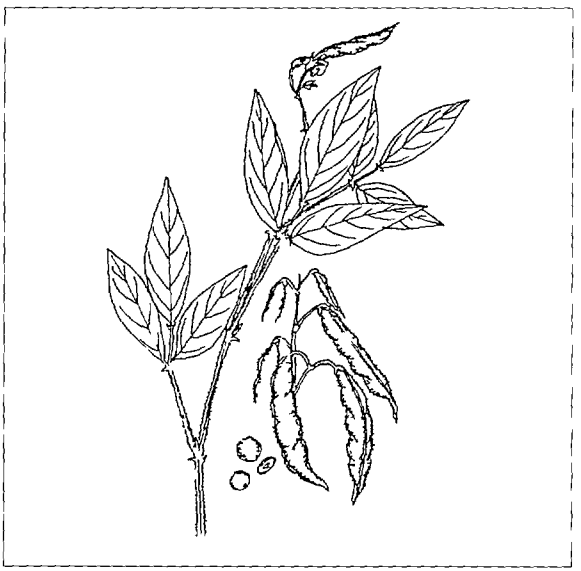
FAMILY LEGUMINOSAE
Sub-Family Papilionoideae

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 deeproot 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

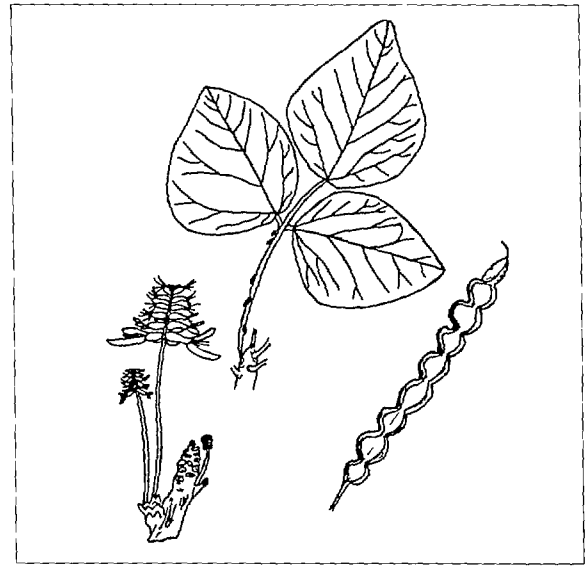
FAMILY LEGUMINOSAE
Sub-Family Papilionoideae

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 Colourful 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

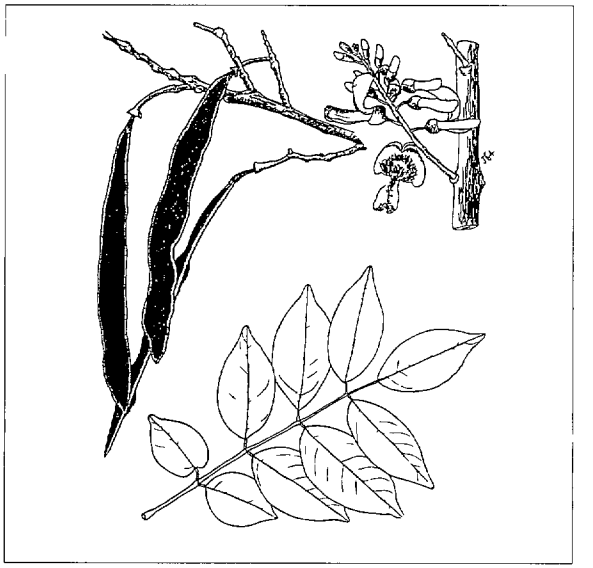
from Useful Plants of Malawi, 1975
J Williamson

FAMILY LEGUMINOSAE
Sub-Family Papilionoideae

Gliricidia sepium
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



Gliricidia sepium

from NFT Highlights
Little and Wadsworth, 1964

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

FAMILY LEGUMINOSAE
Sub-Family Papilionoideae

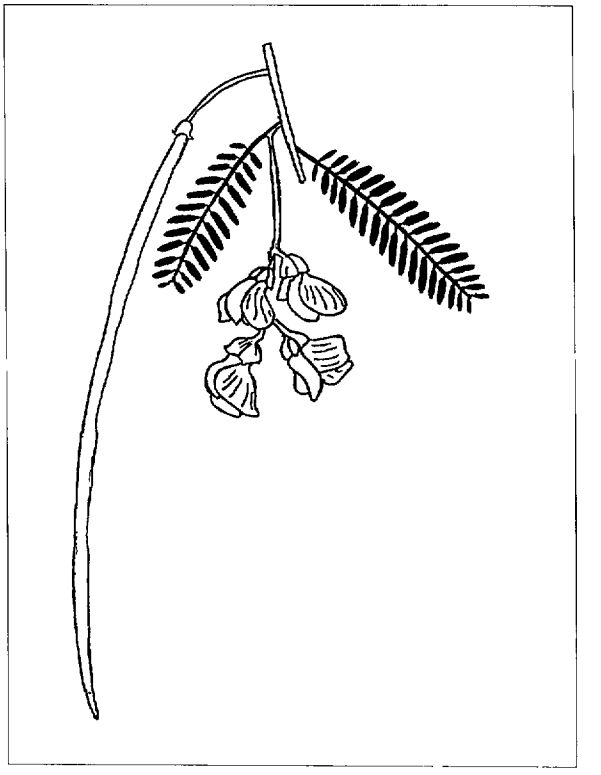
Sesbania sesban

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

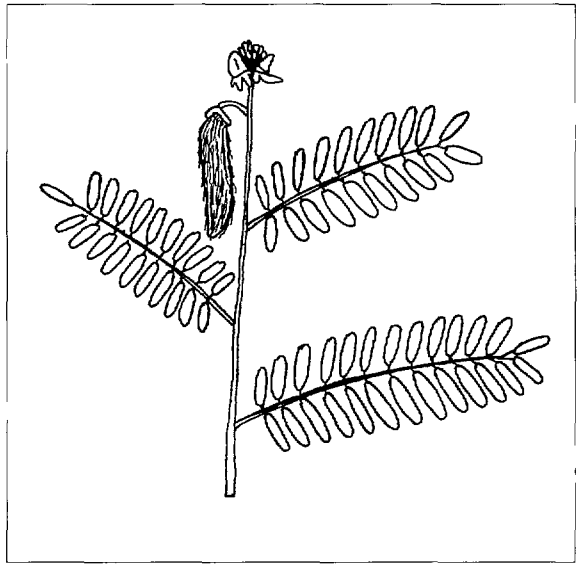


Sesbania sesban

from Trees of Kenya, 1989
T Noad and A Birnie

FAMILY LEGUMINOSAE
Sub-Family Papilionoideae

Tephrosia vogelii
Fish Bean **Mthuthu, Mtetezga**



Tephrosia vogelii

ill F Bodnar

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

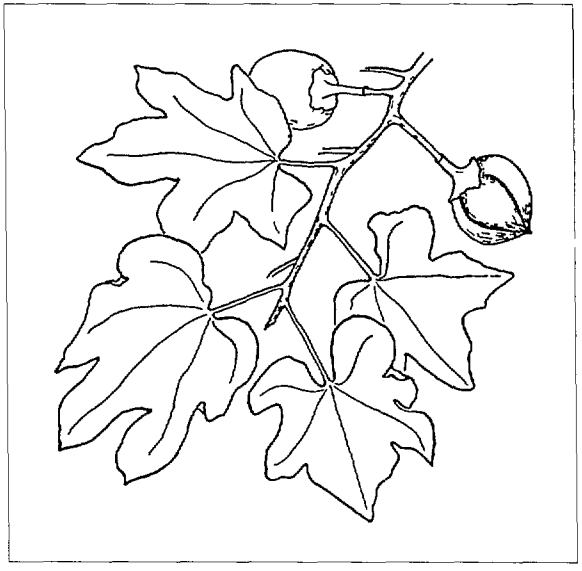
FAMILY MALVACEAE

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

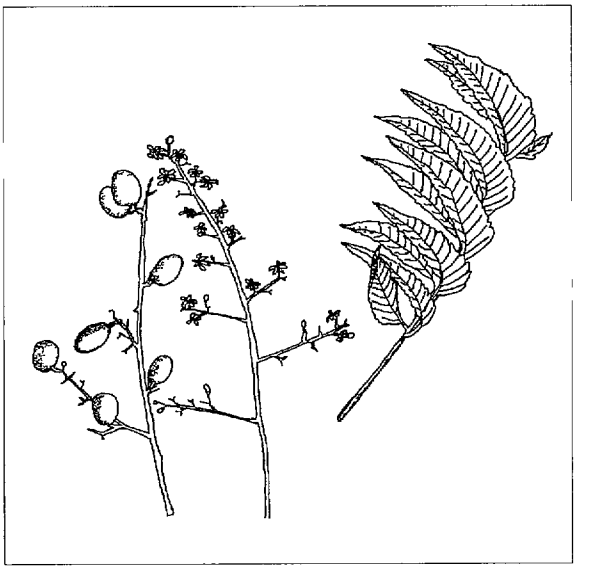
FAMILY MELIACEAE

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

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



Azadirachta indica

from Trees of Kenya, 1989
T Noad and A Birnie

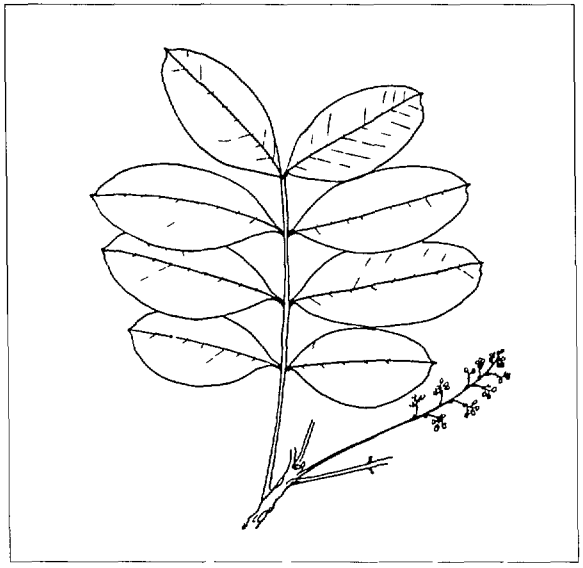
Special Notes Neem is a fast growing tree that coppices readily Azadirachtin from the seed and leaves is a promising insect repellant Dried leaves are used to protect stored crops, cloth and books from insect attack Leaves and twigs have been used as mulch and green manure Without proper storage, seed has short viability, so needs to be planted quickly in pots or as bare-root stock

FAMILY MELIACEAE

Khaya nyasica
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 azaderach
Persian Lilac, Chinaberry **Ndya**

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

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

Melia azaderach

Common Fuelwood Crops
Elbert L Little, Jr

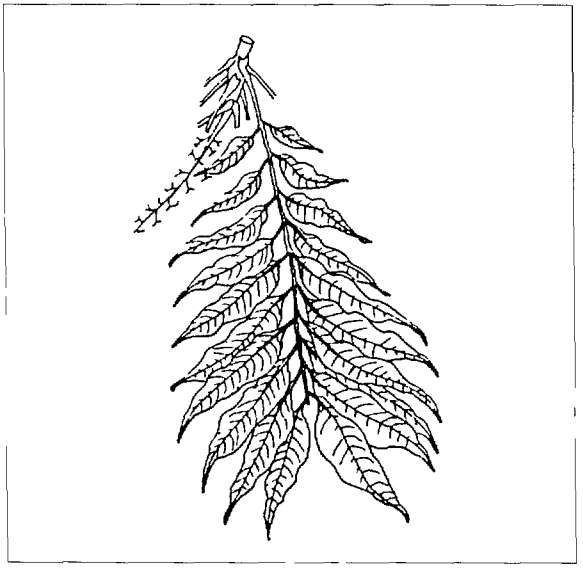
FAMILY MELIACEAE

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

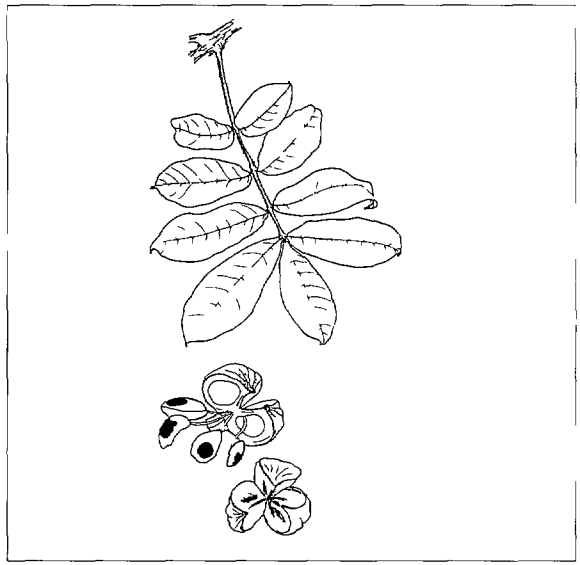
FAMILY MELIACEAE

Trichilia emetica

Natal Mahogany **Msikitsi**

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 diam , 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

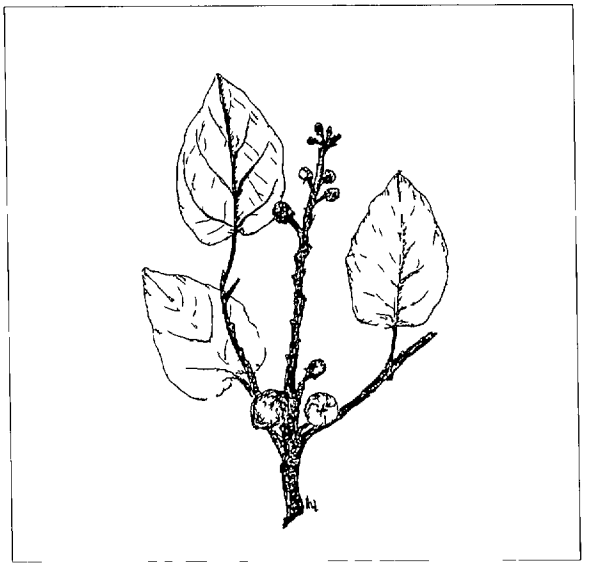
FAMILY MORACEAE

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 diametre

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

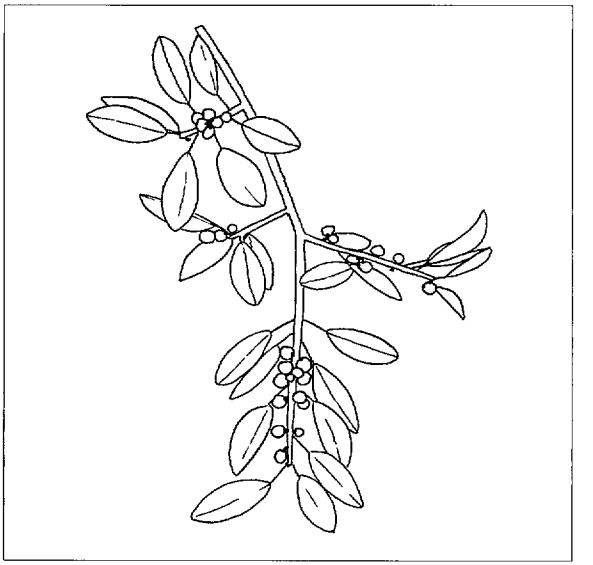
Ficus natalensis

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 diametre, 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

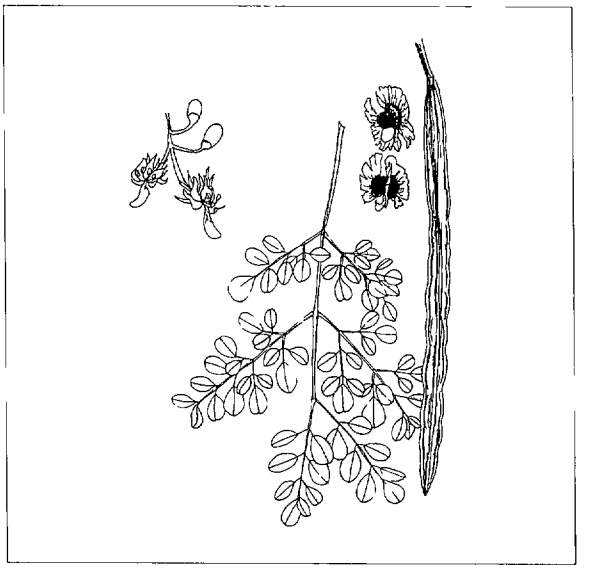


Ficus natalensis

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 as **ndiwo** in a solution of potashes, 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 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
Gum **Blue 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

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

Eucalyptus camaldulensis

from Common Fuelwood Crops
Elbert L Little, Jr ill Mueller, 1879

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 of rotation with crops

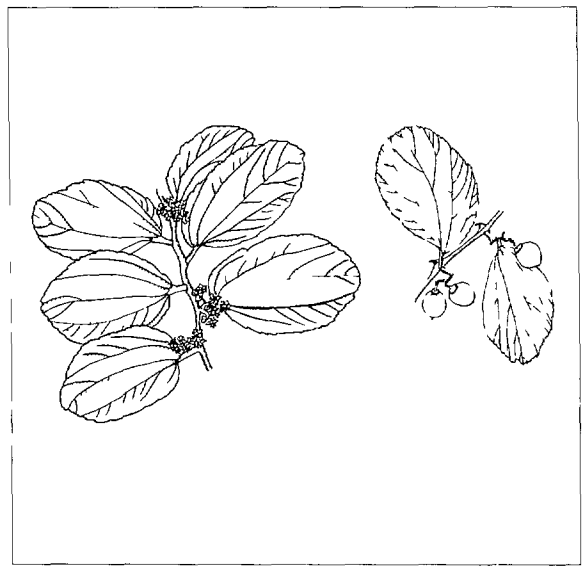
FAMILY RHAMNACEAE

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 diametre

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

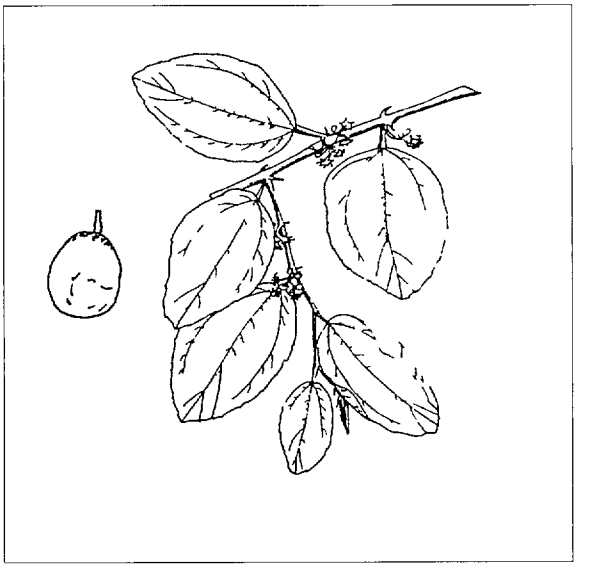
FAMILY RHAMNACEAE

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

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



Ziziphus mauritiana

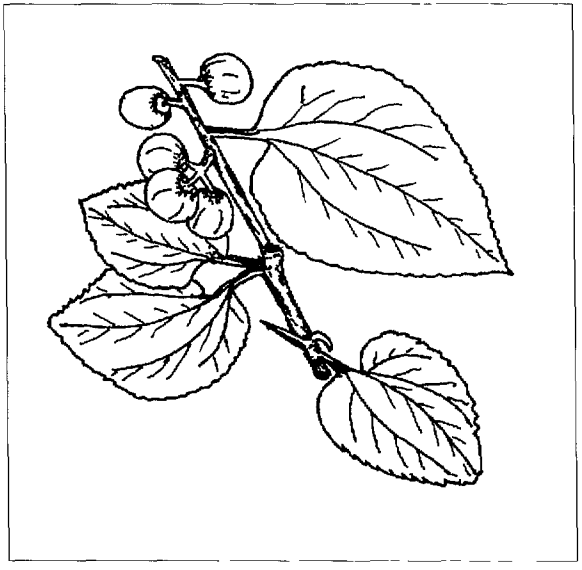
from Trees of Kenya, 1989
T Noad and A Birnie

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 diametre

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



Ziziphus mucronata

from Trees of Kenya, 1989
T Noad and A Birnie

FAMILY RHAMNACEAE

Ziziphus spina-christi
Christ-Thorn

Description Native to the Sudan-Sahelian zone and the Middle East A spiny, mostly evergreen shrub or small tree 3-10 m tall with a spreading crown of slender branches, and a deep taproot **Bark** is grey-brown, smooth and becoming fissured, spines in pairs, one long and one recurved **leaves** elliptic-oval, margin finely toothed, shiny green, paler below, **flowers** small, greenish-yellow, **fruit** round yellow-brown to red

Uses/Products Fruit edible, juicy and marketed in Sudan and West Africa, foliage and fruits valued fodder/browse, wood durable, hard, and heavy, excellent fuelwood, used for light construction, making tool handles, farm implements, posts, beds, spear shafts, household utensils, flower nectar a good source of honey, leaves fruit, and roots have various medicinal uses

Special Notes Highly drought-resistant species used for erosion control and sand-dune stabilisation because of deep-root system It is also planted for fruit, windbreaks, shelterbelts, and stock-proof living fences

Ziziphus spina-christi

From Common Fuelwood Crops
Elbert L Little, Jr Ill Sahni, 1968

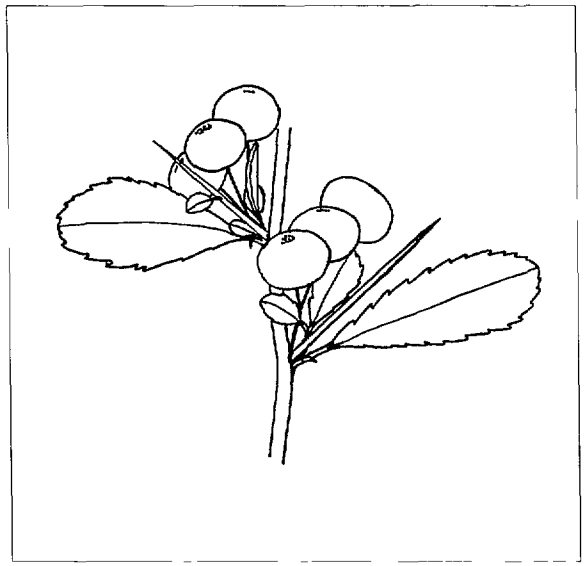
FAMILY ROSACEAE

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 diametre

Uses / Products Planted as a live fence and ornamental hedge



Pyracantha coccinea

ill F Bodnar

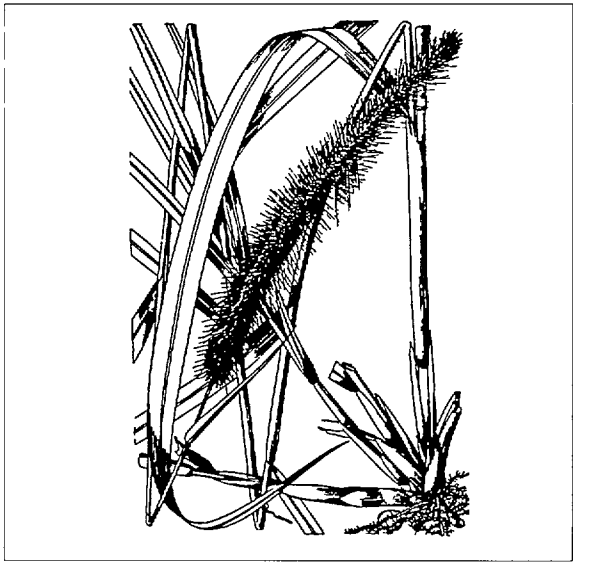
FAMILY GRAMINACEAE

Pennisetum purpureum
Napier Grass **Nsenjere**

Description Indigenous A perennial grass with reed-like stems 2 5 cm in diametre, 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 9 INDEX OF SPECIES

Botanical names in italics
CHICHEWA NAMES in CAPITALS
English in bold and not capitalised

Species	page	*Species*	page	*Species*	page
Acacia galpinii	114	KANKHANDE	144/6	NGAGAGA	117
Acacia goetzei	115	KAPITAGWILERE	126	NIMU	135
Acacia nigrescens	116	KESHYA	127/8	NKUNGU	116/7
Acacia nilotica	117	*Khaya nyasica*	136	NSENJERE	149
Acacia polyacantha	118	KHONJE	108	NTHUDJA NTHUDZA	113
Acacia tortilis	119	**Knob Thorn**	116	*Pennisetum purpureum*	149
Acrocarpus fraxinifolius	124	**Leucaena**	122	**Persian Lilac**	137
Agava sisalana	108	*Leucaena leucocephal*	122	**Pigeon Pea**	129
Albizia lebbeck	120	LUKINA	122	*Prosopis juliflora*	123
Annona senegalensis	110	**Marula**	109	**Purple Pod Acacia**	115
Azadirachta indica	135	MASAWO	145	*Pyracantha coccinea*	148
Azanza garkeana	134	MASUKU	112	**Red Mahogany**	136
Bauhinia thonningii	125	**Mauritius Thorn**	126	**Red-Hot Poker Tree**	130
BINU	132	MBAWA	136	**River Bean**	132
BLUE GUM	143	MCHENDE	148	**Scented thorn**	117
Buffalo Thorn	146	*Melia azaderach*	137	*Sclerocarya birrea*	109
Caesalpinia decapetala	126	**Mesquite**	123	SENDRELLA	138
Cajanus cajan	129	**Mexican Lilac**	131	*Senna siamea*	128
Cape Fig	140	MFULA	109	*Senna spectabilis*	127
Cassia	127/28	MKUNGU	116	*Sesbania sesban*	132
CHAMWAMBA	142	MKUYU	140	**Silver Terminalia**	111
China Berry	137	MLUNGUZI	126	**Sisal**	108
CHITIMBE	125	**Monkey Bread**	125	**Snot Apple**	134
Christ-Thorn	147	**Monkey Thorn**	114	*Tephrosia vogelii*	133
Common Wild Fig	141	*Moringa oleifera*	142	*Terminalia sericea*	111
Erythrina abyssinica	130	MPAMPA	117	THEDZI	150
Eucalyptus species	143	MPOSA	110	**Toon Tree**	138
Faidherbia albida	121	MSANGU	121	*Toona ciliata*	138
Ficus capensis	140	MSIKITSI	139	*Trichilia emetica*	139
Ficus natalensis	141	MTANGAMTANGA	120	*Uapaca kirkiana*	112
Fire Thorn	148	MTETEZGA	133	**Umbrella Thorn**	119
Fish Bean	133	MTHETE	118	**Vetiver grass**	150
Flacourtia indica	113	MTHUTHU	133	*Vetiveria zizanioides*	150
Gliricidia sepium	131	MTOWO	134	**White thorn**	118
Gum	143	MUWALE	130	**Wild Custard Apple**	110
Horse-Raddish Tree	142	NANDOLO	129	**Wild Loquat**	112
Indian Ash	124	**Napier grass**	149	**Winter Thorn**	121
Indian Plum	113	NAPINI	111	**Woman's Tongue**	120
JELEJELE	132	**Natal Mahogany**	139	*Ziziphus abyssinica*	144
Jujube	144/5	NCHONGWE	119	*Ziziphus mauritiana*	145
KACHERE	141	NDYA	137	*Ziziphus mucronata*	146
KANGALUNI	142	**Neem**	135	*Ziziphus spina-christi*	147

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

Afforestation Planting forest

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

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 envelopping 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 The buds, shoots, leaves and flowers of woody plants which are eaten by livestock or wild animals

Bund A ridge of earth placed in a line along the contour of a 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 (of leaves) a whole leaf made up of similar leaflets, not simple

Containerised seedlings A central nursery production system in which seedlings are raised in individual polythene tubes or containers The seedlings are easy to handle but are heavy and difficult to distribute

Contour linking points in a field at the same altitude, forming 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 First leaves when seed germinates, morphologically different from the subsequent developing leaves

Culm The stem of grasses, often hollow

Cutting A method of regenerating trees by cutting pieces of stems or branches (the length required will depend on the species) which will then form roots and shoots Cuttings of some species may first need to be rooted in water or sterile soil, others root easily in wet soil

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 (of leaves) Shedding all leaves periodically, not evergreen

Dehiscent Splitting

Direct seeding See direct sowing

Direct sowing A method of raising trees by sowing or scattering the seed broadcast directly onto 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 Stone fruit such as peach 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, plus the transpiration of water by the crop, on the same field

Evergreen (of trees) with leaves falling and growing 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 share some common characteristics

Fertiliser 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 the shock of normal field conditions If gradually given less water and exposed to more direct sunlight, the seedlings are more likely to survive after outplanting

Hedgerow A closely planted line of shrubs or small trees, often forming a boundary or 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 They can also be grown along stream banks to control erosion and to stabilise water flow

Home Garden A complex collection of woody and herbaceous plants deliberately grown in small plots in or near home compounds, may 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 zeriba (west Africa) or corral (USA)

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 the rooting zone of plants

Leguminous plants Plants of the family *Leguminosae* that produce seed in pods Most leguminous plants develop root nodules that contain nitrogen-fixing bacteria The leaves of leguminous plants, when they fall and rot help to improve soil fertility by increasing the levels of nitrogen that are available to plants

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 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 a seedling experiences when it is outplanted from a protected nursery to a normal site on the farm The loss of regular watering and exposure to direct sunlight make the seedling very vulnerable at this time

Pod A dry fruit, usually splitting into two typical of the leguminosae family

Pretreatment 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 trowel loosened seed beds 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

Provenance A stand or group of trees of the same species that provides a source of high-quality, viable seed

Pruning The process of regularly cutting back the shoots or roots of plants 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, 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 pretreatment

Seed viability The ability of seed to germinate and the speed at which it germinates Normally given in germination percentage and period in which germination takes place

Seedbed The protected bed or soil in a nursery in which the seed are sown and seedlings are enabled 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 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 moisture Water in the soil, a portion of which is available to plants

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

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 near the soil surface

Systematic interplanting of multi-purpose trees Multi-purpose trees planted at a regular spacing on a field to provide various tree products and to restore soil fertility

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

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 at intervals, parallel ridges on the contour Tied ridges are meant to contain runoff water from the ridges on the contour

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 Swaziland bed or into polythene tubes, where they can grow without competition until they are ready for outplanting onto the farm The term is also applied to the removal of wildlings to more permanent sites on the farm

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

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 perhaps after pretreatment, long after it has matured

Volatisation Nutrients changing into gas phase that are lost from the rooting zone or soil surface

Truncheon A large cutting from the branch of a tree used to propagate a new tree

Water logging Part of field under water due to lack of drainage or infiltration

Wildling A wild seedling that grows from seed that has been 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 2 seasons

Woody Plants which consist in part of wood, not herbaceous

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