Fodder Shrubs for Dairy Farmers in East Africa

Making extension decisions and putting them into practice

Published by:

World Agroforestry Centre (ICRAF),
PO Box 30677,
Nairobi, Kenya

and

Oxford Forestry Institute,
Department of Plant Sciences,
University of Oxford,
Oxford, U.K.

ISBN: 92 9059 183 8

To be cited as:

Wambugu, C., Franzel, S., Cordero, J. & Stewart, J. (2006). *Fodder shrubs for dairy farmers in East Africa: making extension decisions and putting them into practice*. World Agroforestry Centre, Nairobi, Kenya; Oxford Forestry Institute, Oxford, U.K. 172 pp.

Photographs and illustrations:

Cover: Neil Thomas

Jan Beniest, Jesús Cordero, William Hawthorne, Heifer International, Colin Hughes, Sue Kayton, Beverley Paine, Ian Staples, Janet Stewart, Neil Thomas, Charles Wambugu, World Agroforestry Centre, www.irational.org

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Thanks to:

We would like to thank the many people have helped us in the preparation of this manual. Many of the ideas we present come from the experiences of our project staff Hellen Arimi, Bueno Dickens Sande, Jane Kugonza, Charles Lyamchai, Margaret Kingamkono, David Kagoro and the late Christophe Zaongo, and their extension partners in Kenya, Uganda, Tanzania, Rwanda, many of whom also gave us valuable input to improve the manual during a review workshop in Nairobi in June 2005. Our thanks also to Josina Kimotho for managing the workshop, to Jan Beniest and Warwick Easdown for their advice on content and design, and to Conrad Mudibo for help with production.

Forestry Research Programme

This publication is an output from a research project funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. Project R6549, Forestry Research Programme (FRP). Publication of the manual has been made possible thanks to the support of FRP and of the Programme for Cooperation with International Institutes (SII), Education and Development Division, Ministry of Foreign Affairs of the Netherlands.

Ministerie van Buitenlandse Zaken

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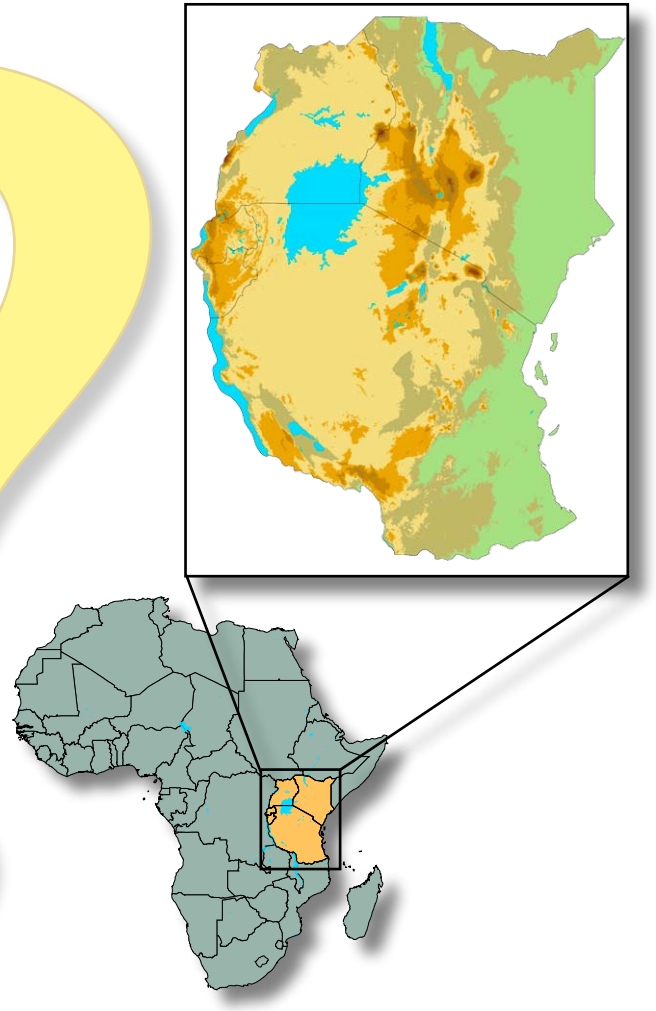
Is this book for you?

YES...

- if you are
  - » considering offering fodder shrubs to farmers
  - » already promoting fodder shrubs
- if you are an extension provider
  - » working in a
    - governmental organisation (GO)
    - non governmental organisation (NGO)
  - » in the fields of
    - agroforestry extension
    - livestock extension
- if your organisation works in the parts of East Africa, particularly Kenya, Rwanda, Tanzania or Uganda, where there are dairy farmers.



What can this book do for you?

If you are considering offering fodder shrubs to farmers...

it can help you to:

- **decide** whether your organisation should **promote fodder** shrubs.
- **choose species appropriate to your area.**
- plan for sustainable seed supply.
- develop an appropriate promotion strategy.

If you are already promoting fodder shrubs to farmers...

it can help you to:

- access **new information** available on fodder shrubs.
- **identify and solve problems** with your current extension strategy.
- make your extension approach **sustainable**.
- give farmers clear and accurate information on fodder shrub cultivation and management.

The advantages of fodder shrubs

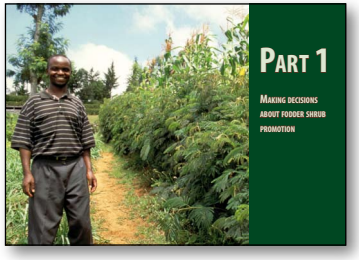
- They are **easy to grow** and take up little land.
- They can be grown **on land which would not be used for crops.**
- Farmers can save money and **increase** their **incomes.**
- Fodder shrubs are **well** researched and **tested.**
- Fodder shrubs have already **been adopted** in many parts of **the region.**
- They provide a **solution to** increasing **fodder shortages.**
- They are ideally suited to **zero grazing** systems.

But remember.....

- They require adequate rainfall and good soil to achieve their full potential.
- The system is labour-intensive.
- Farmers have to invest in planting and tending the shrubs for at least a year before getting any return.

How to use this book

This is a step-by-step guide to the promotion of fodder shrubs for smallholder dairy enterprises in East Africa. It is intended for both extension managers and field-based extensionists, in particular those who are starting to work with fodder shrubs for the first time. The book is divided into four parts:



Part 1: Making decisions about fodder shrub promotion

We introduce the idea of fodder shrubs and examine a series of key questions which can help in making decisions at the start of the dissemination process.

Part 2: Making decisions about extension approaches and methods

Wich highlight here some of the factors that are important to take into account when designing an extension strategy. We also outline the methods which we have found to be the most effective in reaching farmers.

Part 3: Putting it into practice: planting and managing fodder shrubs

Detailed technical recommendations for all stages of fodder shrub planting, management and utilisation, with further detail about the various options introduced in Part 1.

Part 4: Important fodder shrubs for East Africa

Characteristics of the most widely used fodder shrubs in the region.

We have limited the scope of the book to systems in which the plants are maintained as shrubs in hedges by repeated cutting (most of the species used in this way form small trees if left uncut). We have only included species for which there has been enough research and farmers' experience that we can recommend with confidence that they can be managed productively as shrubs. The species covered in this book are:

- *Calliandra calothyrsus* ("calliandra")
- *Chamaecytisus palmensis* (tree lucerne or "tagasaste")
- *Gliricidia sepium* ("gliricidia")
- *Leucaena diversifolia* ("diversifolia")
- *Leucaena pallida* ("pallida")
- *Leucaena trichandra* ("trichandra")
- *Morus alba* (mulberry)
- *Sesbania sesban* ("sesbania")

Our recommendations are based on

- our own research and development work on promoting these species over the last ten years across East Africa
- the collective experience of many other partners and stakeholders in the region, including farmers.

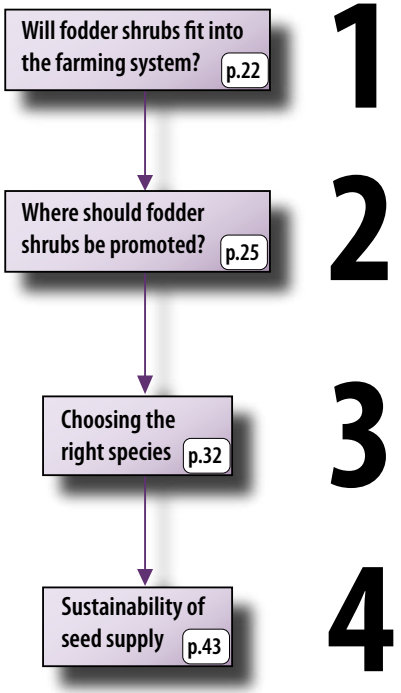
We try to show the advantages and disadvantages of different options in different situations, rather than giving fixed recommendations. We recommend experimenting with different approaches and practices to see what works best in your situation, as well as encouraging farmers to adapt and innovate.

Part 1

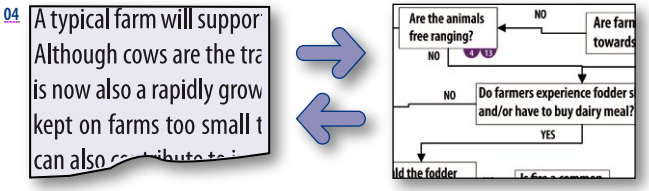
Making decisions about fodder shrub promotion

Decision Pathways

For easy reference, we have included a decision pathway at the end of each section in Part 1, summarising the choices to be made.



The boxes in the decision pathways are cross-referenced to the numbered paragraphs in the text.



Please note also:

- Look for the green arrows: they show the starting point of each decision pathway.

- Some paths will lead to a decision not to promote fodder shrubs.

- This symbol indicates potential limitations or problems.

- A call for attention to income opportunities or recommended actions.

Why promote fodder shrubs?

01 Fodder shrubs provide a valuable feed supplement for dairy cows and goats, especially during the dry season. Their clear benefits have resulted in their widespread adoption in many parts of East Africa.

02 These woody shrubs can be managed to provide nutritious fodder from their leaves, to supplement the diets of livestock, particularly dairy cows and goats. The leaves contain much more protein than the rest of the animals' normal diet of grasses and crop residues, and this makes them able to produce more milk. Other types of livestock can also benefit from the extra protein, but it has the biggest effect on milk production. The fodder plants are usually managed by repeated pruning so that they are kept in the form of multi-stemmed shrubs, usually grown in rows to form a hedge about 1 m high. This is not, of course, the only possible way of managing them, but it is a system that has been thoroughly researched and tested, and has proved to be very well suited to the mixed small-scale farming system found in many parts of East Africa (mainly Kenya, Uganda, Tanzania and Rwanda). This book focuses specifically on this system, and on the species that are commonly used in it.

Smallholder dairy farming in East Africa

03 Small-scale dairy production is an important smallholder farming system in East Africa. It is a mixed crop-livestock system, usually with small land holdings (often 1 ha or less). Maize, beans and other food crops, including a variety of vegetables and fruits, are grown in combination with fodder for livestock (usually Napier grass, *Pennisetum purpureum*) and sometimes perennial cash crops (tea, coffee, bananas). There are currently around one million smallholder dairy farmers in East Africa (the majority of them in Kenya), who are increasingly acquiring improved dairy cattle (local animals crossbred with exotic ones) and/or dairy goats, and practising zero grazing. The system works best in high potential areas with adequate rainfall (generally over 1000 mm), short dry seasons (3-4 months at most), and fertile soils, often of volcanic origin.

04 A typical farm will support one or two dairy cows and/or a few goats. Although cows are the traditional dairy animals in the region, there is now also a rapidly growing interest in dairy goats, as these can be kept on farms too small to support a cow. This means that forages can also contribute to improving the livelihoods of poorer smallholder farmers, as they can get an extra source of income through goat-keeping even if they cannot afford to keep a cow.

05 Goats have the advantage of needing much less fodder than cows; and in some areas, goat's milk also sells for a higher price than cow's milk, because it is known to be highly nutritious (with significantly higher levels of Vitamin A, Vitamin B, Riboflavin, Vitamin D, calcium and phosphorus than cow's milk),

06 More and more smallholder dairy farmers are acquiring improved animals. It is essential that they feed these animals with adequate amounts of high quality, nutritious fodder if they are to get a good return on their investment. Dairy enterprises are also increasing rapidly as the demand for milk and other livestock products increases, and as roads improve, making milk marketing easier.

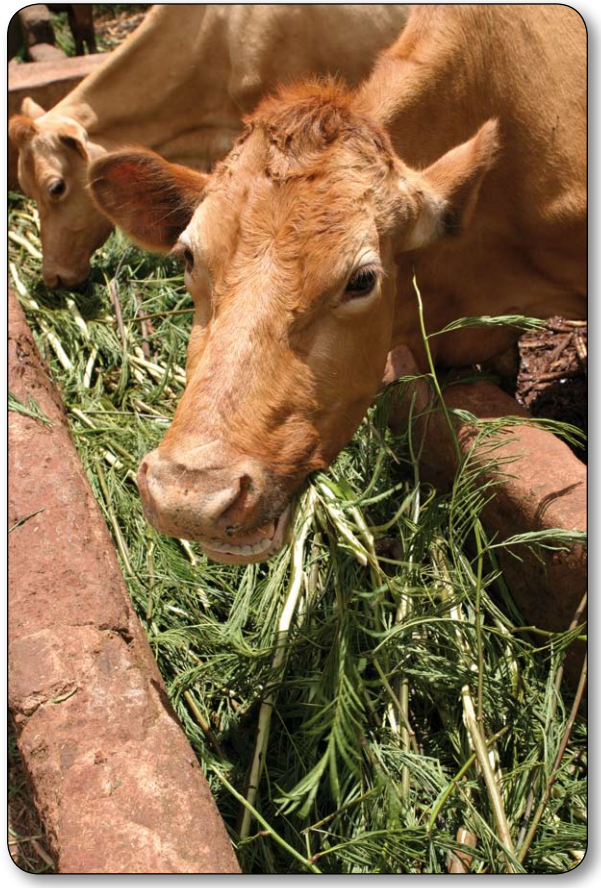
07 Dairy farming can help rural households by:

- providing income and employment (any increase in milk production beyond the family's own needs translates into a direct increase in income)
- improving soil fertility with manure
- contributing to food security, both through direct family consumption of milk, and indirectly through the income generated

Milk is an important source of income for smallholder farmers, as well as improving family nutrition

Moving towards zero grazing

08 Traditionally, smallholder dairy farmers in the region have kept their animals tethered or confined to small areas of pasture during the cropping period, and free-ranging after the crops are harvested. However, as population growth has led to smaller land holdings, it has started to become impossible to keep livestock under free-ranging grazing systems. In response to this pressure, smallholders grow high-yielding fodder crops to feed the animals from an ever decreasing land area. Once fodder crops such as Napier grass are being grown, it is no longer possible to let the animals roam freely unless they are watched constantly. There has therefore been an increasing move towards zero grazing, in which the animals are kept in a pen or shed (a zero grazing unit) at all times, and fodder is brought to them. Many farmers currently practise an intermediate system, in which the animals have some limited grazing but are also fed additional 'cut-and-carried' fodder.



The shift towards zero grazing systems has created an immediate demand for reliable, easily accessible, year-round sources of fodder. Fodder shrubs can help to meet this demand.

The problem of fodder shortage

09 Improved dairy animals (both cows and goats) have the ability to produce much more milk than local ones, because of their breeding. However they can only achieve this potential if they are given high quality feeds. Napier grass grown on the farm is traditionally supplemented, especially during the dry season, with crop residues such as maize stover, bean stalks (haulms), and banana peelings, leaves and pseudostems. These are all of poor nutritional quality and are only used when better feeds are not available.

10 Much better quality supplementation is provided by leaves collected from a variety of wild indigenous trees and shrubs, growing either as isolated individuals on the farm or in nearby bush. Some of these local trees and shrubs are highly nutritious, and many are also thought to have medicinal value for animals. However, the amounts of fodder available from local species is usually very limited, as they are not traditionally planted on the farm. Little is known about their growth rates and nutritional value, but most are thought to be fairly slow growing, and some may not tolerate frequent harvesting.

11 Overall, the low quality and/or quantity of feed resources, especially during the dry season, makes it difficult for smallholders to increase livestock production (of both milk and meat). Moreover, as dairy enterprises increase in number, fodder shortages are expected to get worse, particularly in densely-populated areas. Many farmers address the problem by buying commercial concentrates (dairy meal). However, this is expensive, and farmers sometimes find these feeds to be inconsistent in quality. They may not be an economically viable option for the farmer, especially in areas where milk prices are low.

Improving the supply of good quality fodder, particularly when linked to the provision of improved (exotic/cross-bred) dairy animals, has the potential to increase milk production, and hence family nutrition and incomes, dramatically.

12 The benefits of fodder shrubs

(see also **Box 1**)

- By growing their own high-protein fodder shrubs on the farm, farmers can increase milk production without having to buy dairy meal. This translates into extra income as well as extra milk for the family.
- Fodder shrubs take up little land; this means that they can be managed as hedges on sites where food and cash crops are not planted, such as:
  - » external and internal farm boundaries.
  - » along farm paths.
  - » across slopes as soil conservation structures.
- They can replace existing hedges which have no other productive purpose. When managed well, they do not reduce the yields of crops growing next to them.
- With more fodder shrubs growing on the farm, there is less need to collect leaves from wild trees in the bush. This reduces the time and effort spent looking for fodder, which is particularly helpful to women, as well as reducing the pressure on nearby natural forest and bush land.
- Fodder shrubs can also provide a range of other products and services, including:
  - » **soil conservation:** planted across slopes (along the contour), hedgerows provide protection against soil erosion and reduce the risk of landslides.
  - » **nitrogen to make protein:** leguminous species can take nitrogen from the air, enabling them to produce leaves rich in protein without removing nitrogen from the soil.
  - » **stakes:** in some areas (e.g. Rwanda, parts of Uganda), an important additional product is stakes to support climbing beans.
  - » **fuelwood:** if left uncut to produce more wood, fodder shrubs can also be an important source of fuelwood on the farm (though this will result in lower fodder production).
  - » **honey:** bees collect nectar from the flowers for honey production.

More information about these other uses can be found in Part 3 (p.**97**).

Fodder shrubs can be planted on land which is not used for crops. They can provide many other benefits in addition to fodder.

Adoption of fodder shrubs

13 The multiple advantages that fodder shrubs offer to farmers have led, over the last ten years, to their rapid and widespread uptake for on-farm planting in smallholder systems. Since the late 1990s fodder shrubs, primarily the Central American legume *Calliandra calothyrsus* (calliandra) have been adopted by over 50,000 farmers in East Africa, most widely in Kenya and Uganda. The process has been speeded up by the activities of development NGOs which are providing improved dairy cows and goats to farmer groups.

Box 1

14 **The benefits that fodder shrubs can offer**

- Make money from the sale of extra milk.
- Save money by reducing or eliminating the need to purchase supplements such as dairy meal.
- Use land which is not suitable for other crops (along internal or external boundaries, around homesteads or along soil conservation terraces).
- Save time and energy, as fodder is available within the farm.
- Take the pressure off native wild fodder species and thus conserve them.
- Provide the household with other non-fodder benefits such as fuelwood, bee forage, stakes, erosion control and soil fertility improvement.

Will fodder shrubs fit into the farming system?

See also Decision Pathway 1 on p. **22**

Dairy systems

15 Farmers are most likely to be highly motivated to plant fodder trees if they have, or are planning to acquire, a dairy cow or goat, and know that they will need more fodder to support it. So the first question is whether the farmers are involved in dairy enterprises, or interested in becoming involved.

Local or improved cows and goats?

16 Fodder shrubs give the best returns when they are fed to improved dairy cows or dairy goats. This is because they have a much greater potential for milk production than local breeds, but can only achieve this high production when they are well fed. Milk production from a cross-bred cow or goat, previously fed on local grasses and crop residues, will usually increase substantially if its diet is improved with high-protein fodder shrubs. Local breeds are not capable of such high milk production, however good their diet, so there is less immediate benefit in feeding them with fodder shrubs (although it will improve their overall health). Some of the fodder shrubs contain anti-nutritive factors, which may have adverse effects on the health of the animal if fed in excessive amounts. It is therefore crucial to advise farmers to feed the correct amounts, as described in Part 3.

How many shrubs does a farmer need?

17 One cow needs 6 to 10 kg fresh fodder shrub leaves per day (equivalent to 2 to 3 kg dry matter), while a goat needs about 0.5 to 1 kg fresh material. To be able to feed these amounts throughout the year, the farmer needs to plant about 500 shrubs per cow, which would occupy about 800 feet (250 metres) of a hedge if planted as a single row, or 400 feet (125 metres) if planted as a double row. One dairy goat would need about 100 shrubs for feeding throughout the year.

Socio-economic questions

18 Even when farmers are involved in dairy farming, it cannot automatically be assumed that they are interested in planting fodder shrubs. They also need to be able and willing to allocate labour and land to the enterprise. The allocation of resources to different activities on the farm, and the opportunity costs of using fodder shrubs, may in some cases lead to farmers rejecting them. For instance if the dairy enterprise is not an important activity on the farm, and/or labour is a limiting factor, fodder shrubs may not be an attractive option (see **Box 2**). It is therefore essential to give farmers a realistic view of the costs, responsibilities, as well as the benefits, associated with fodder shrubs, and, if possible, to take them to visit

farmers with fodder shrubs. They will then be in a good position to decide whether to try them themselves. A simple calculation to show farmers the profitability of using fodder shrubs is shown in **Part 3**.

19 Some aspects of the farming system can sometimes make fodder shrub establishment difficult or impossible. This can happen, for instance, when:

- land is under communal ownership, because the farmers may not be willing to invest in, or to manage, fodder shrubs to which everybody would later have access.
- there are free-ranging animals in the fields at certain times of the year (usually after crops are harvested), as they will destroy shrub seedlings.
- fire is used as a land preparation or management tool, because it also leads to destruction of fodder shrubs.

Fodder shrubs for non-ruminants (horses, pigs, chickens, rabbits)

20 Some fodder shrubs contain tannins and other anti-nutritive factors which are safe for ruminants because they can be broken down in the rumen, but which are toxic to non-ruminants if fed in large quantities. More details are given under the species descriptions in **Part 4**.

Box 2

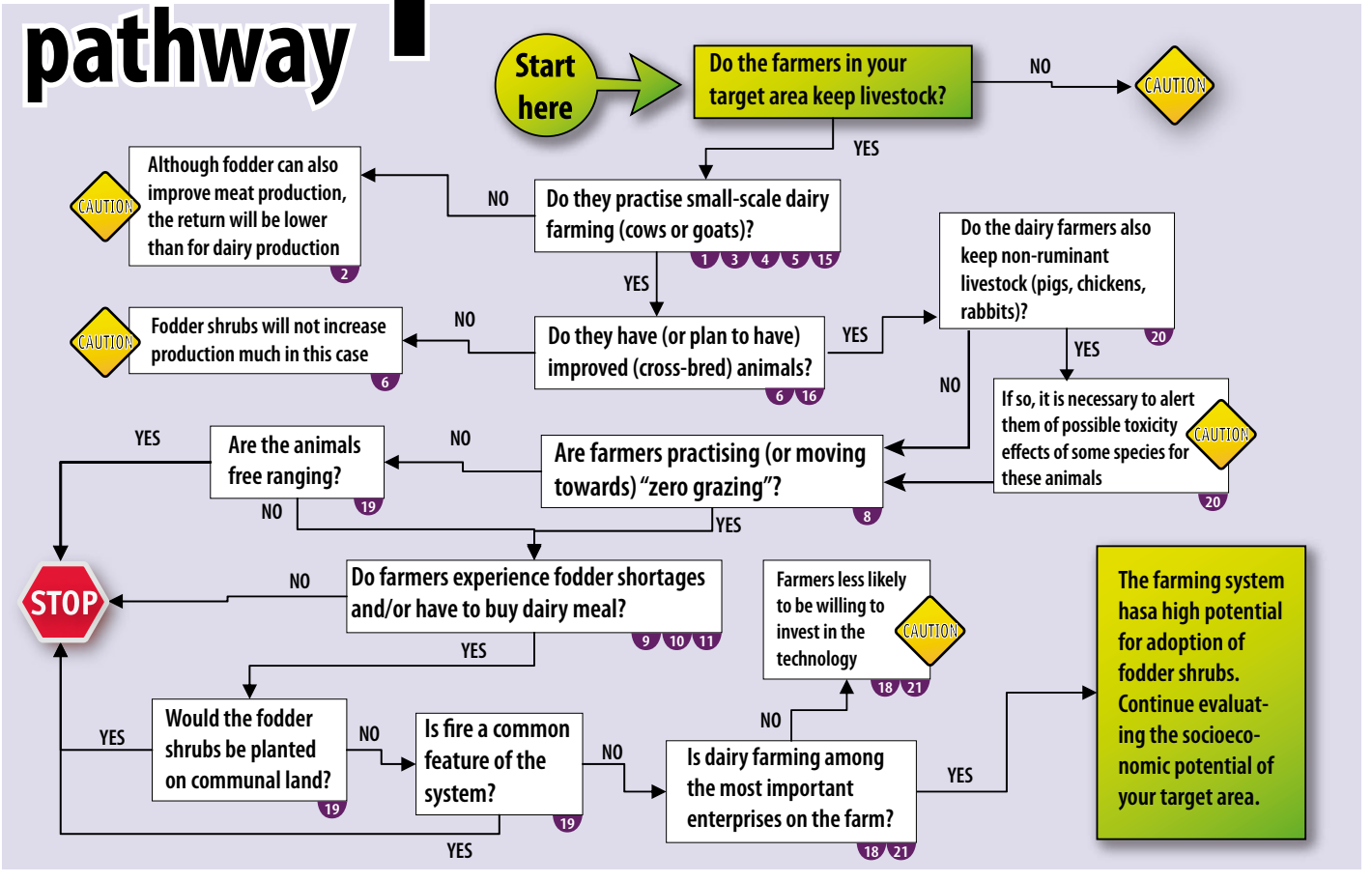
21

If dairy is not their main enterprise, farmers may not be interested in planting fodder shrubs

It is essential to find out from the farmers themselves whether a practice is of interest. An example comes from the Kibirigwi irrigation scheme in central Kenya, where the main enterprise is irrigated vegetables. This is very labour intensive, so farmers were not interested in expanding their dairy enterprises or shifting labour to plant fodder trees. They knew that returns from the vegetables were better than from dairy. This contrasted with the attitude of farmers in the neighbouring village, outside the irrigated area, where there was no major cash enterprise except dairy so the farmers were very interested in planting fodder shrubs.

Decision pathway 1

Will fodder shrubs fit into the farming system?



Where should fodder shrubs be promoted?

See also Decision Pathway 2 on p. 25

Using maps as a first step

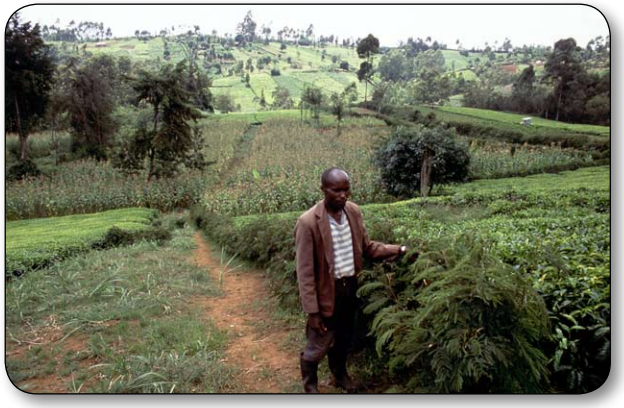
22 The maps on pages **26** and **27** combine climate and altitude data to define the areas in Kenya and Uganda where one or more of the fodder shrub species described in **Part 4** should be able to grow. We have combined the rainfall and altitude ranges of these species. Overlaid on this is the area with high dairy cow density[1]. Where the two areas overlap (i.e. in places where the shrubs can grow well, and there are many dairy cows) there is the highest likelihood that fodder shrubs will be adopted. However, it is important to be aware that high dairy density will not always indicate a high likelihood of adoption, as other social, economic and cultural factors also need to be taken into account, as described in the next section.

23 As these are very small scale maps, they are not able to provide detailed information about specific localities. They should be seen as a starting point, showing whether fodder shrubs are likely to be appropriate in an area. It is then also necessary to look in more detail at each potential location in terms of the socio-economic and cultural environment (particularly the market situation), as well as the biophysical factors (climate, soil) which will determine species choice.

[1] We were not able to obtain detailed dairy density data for Tanzania and Rwanda.

Socio-economic and cultural considerations

24 The suitability of fodder shrubs for a particular area is largely determined by the farming system (the importance of livestock, particularly for dairy) and the potential for farmers to benefit. This in turn depends critically on market access: if more milk is produced, will the farmer be able to sell it easily? If an area of high dairy density already has an excess of milk, and the market is poor (so prices are



depressed), farmers may not be interested in fodder shrubs, until their marketing problems are solved.

25 Market access could have been included on the maps, by defining it as the distance by road or track to the nearest market centre, but in practice the availability of a market for milk depends on many factors, and needs to be assessed locally (see **Box 3**). For instance it may be influenced by factors such as local preferences (is there a culture of milk-drinking in the local community?) and infrastructure (is there a milk cooling facility in the area?). The key point here is that information from maps or indicators alone cannot always predict the likelihood of adoption, because the factors affecting it are so complex. It is essential to back up this initial information with detailed knowledge of the local situation.

26 In areas where grazing land is still available, farmers will also feel less need to intensify their production by planting fodder shrubs. There are also other social and economic factors which can make some farmers more likely than others to adopt the practice. These considerations influence decisions regarding the targeting of extension: see **Part 2**.

Box 3

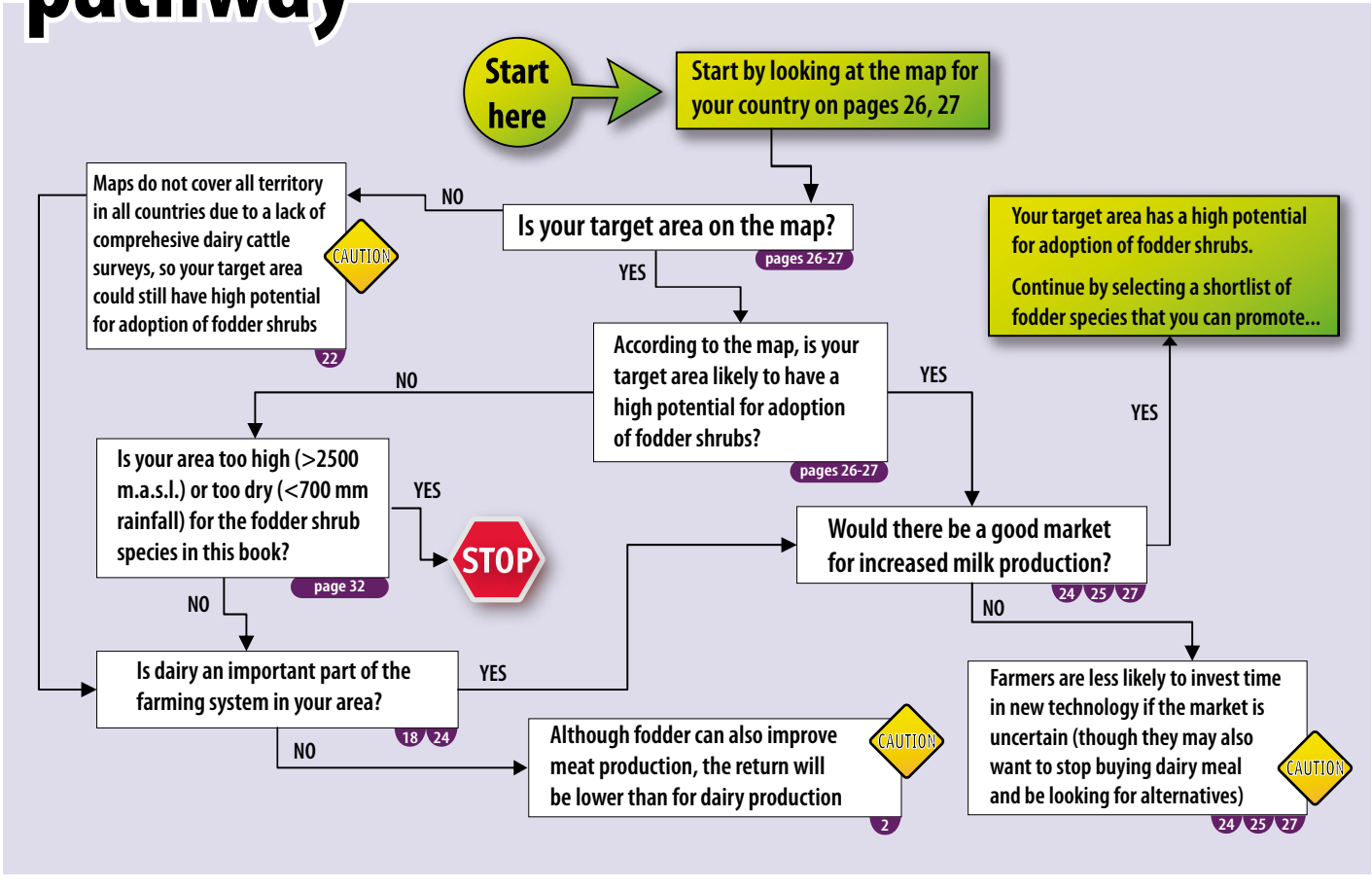
27

Understanding market access depends on local knowledge

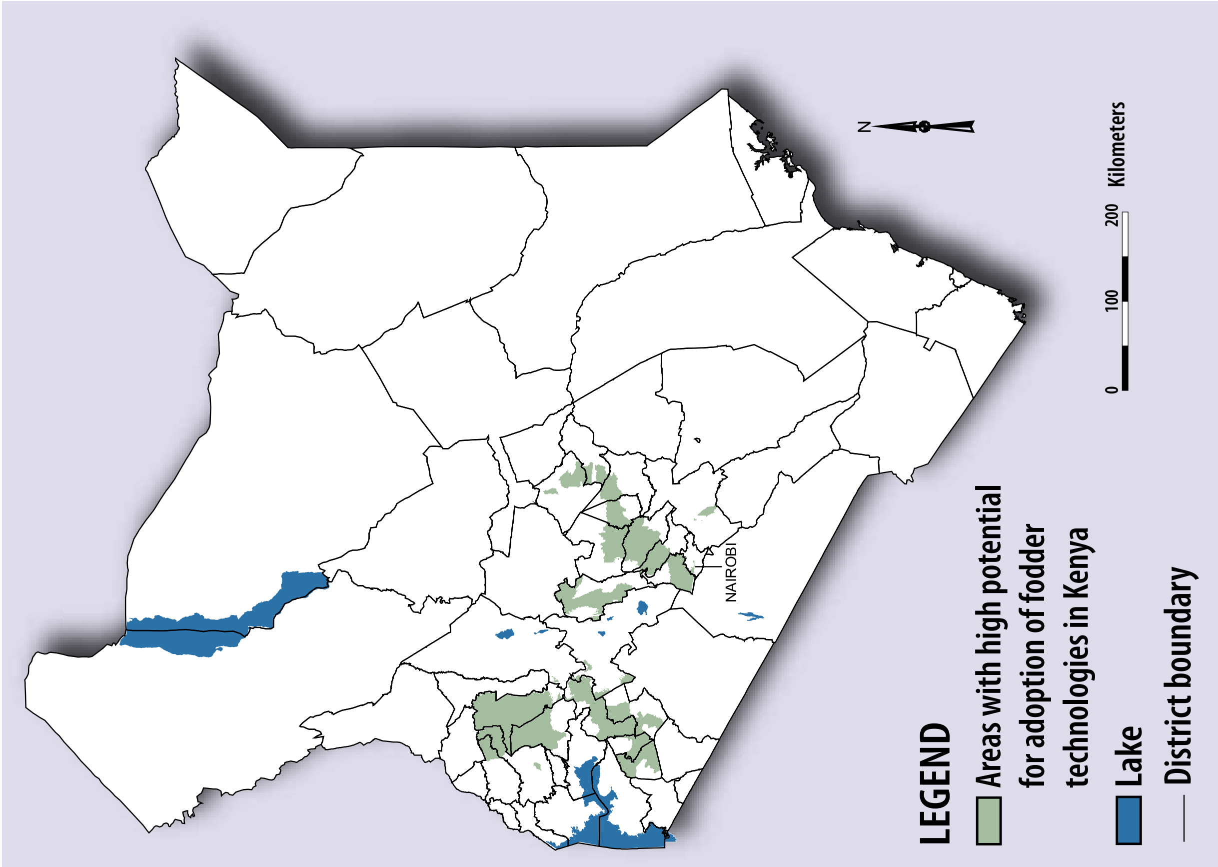
For smallholder dairy farmers on the slopes of Mt Kilimanjaro, the nearest town is Moshi, but there is little demand there for milk as the townspeople are not in the habit of drinking it. Instead, the farmers sell their milk at a collection centre set up by an entrepreneur from Dar-es-Salaam, who finds it profitable to take the milk all the way to the capital city (450 km) twice a week by truck. In this case the farmers have no market problem at present, but their situation is vulnerable as they depend to a large extent on a single buyer. There is also the risk that farmers closer to the city may initiate dairy projects and take the market from the Kilimanjaro farmers.

Decision pathway 2

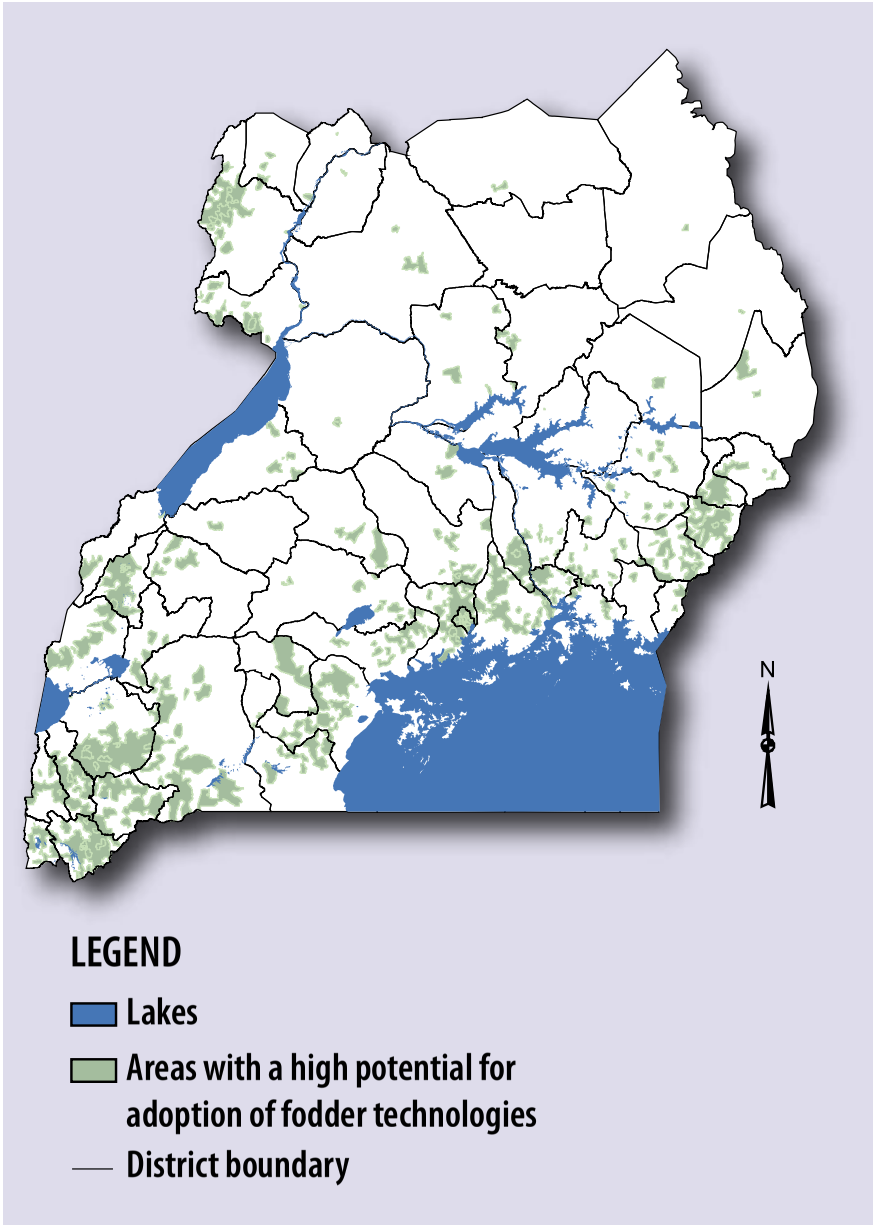
Where should fodder shrubs be promoted?



Map 1 - Areas of Kenya with a high potential for adoption of fodder technologies



Map 2 - Areas of Uganda with a high potential for adoption of fodder technologies



Choosing the right species

See also Decision Pathway 3 on p. **32-33**

Why is this book about exotic species?

28 Promoters of fodder shrubs have emphasised exotic species. The most widely promoted exotic species is calliandra (*Calliandra calothyrsus*), and farmers are also planting trichandra (*Leucaena trichandra*), mulberry (*Morus alba*), gliricidia (*Gliricidia sepium*), tree lucerne/ tagasaste (*Chamaecytisus palmensis*) and other *Leucaena* species (diversifolia, pallida). *Leucaena leucocephala*, a very fast-growing species which produces high quality fodder, should no longer be promoted because, since the late 1980s, it has been heavily attacked by an insect pest (the psyllid *Heteropsylla cubana*), which defoliates it. It is important to reassure farmers that the other three *Leucaena* species which we recommend are all much more resistant to the psyllid than *L. leucocephala.*

29 The only widely planted species native to the region is sesbania (*Sesbania sesban*). This section shows the conditions that are suitable for each of these major shrub species: the reader can then refer to **Part 4** for more detailed information about the species.

30 In addition to planted fodder, farmers also use leaves from naturally regenerated trees of a wide range of local species, particularly for goats. Examples of widely-used indigenous species include vernonia (*Vernonia amygdalina*), trema (*Trema orientalis),* sapium *(Sapium ellipticum), Bridelia micrantha, Albizia chinensis, Ehretya cymosa, Ficus* species and many of the *Acacia* species. Leaves are collected either in the bush from uncultivated (wild) trees and shrubs, or from protected natural regeneration on the farm. Many of these local species are also believed to have medicinal properties for animals.

31 Although there have been several surveys of indigenous fodder trees and shrubs, there is much less known about them than about the exotics, on which there has been much more research. None of the lesser-known local species has so far proven to be productive when managed in hedges, and for this reason we have not included them in this book. The exotic shrubs should, however, be seen as *complementing* these local species, rather than *replacing* them.

Species options

There are two types of criteria on which to base the choice of which species to plant:

32

- Environmental conditions at the site, which determine whether or not a particular species will grow there. These include:
  - » climatic factors (rainfall, temperature)
  - » altitude (which relates directly to temperature)
  - » soil characteristics.

The requirements of the major species are summarised in the table in Decision Pathway 3 (p.**32**).

33

- Attributes of the plant. These include:
  - » availability/cost of seed
  - » ease of establishment and management
  - » compatibility (or competition) with crops; nutrient demands
  - » growth rate and sustainable biomass production
  - » ability to withstand repeated cutting, and longevity (how many years can cutting be continued?)
  - » nutritive value and anti-nutritive factors: effects on animal production and health
  - » palatability
  - » resistance (or susceptibility) to pests and diseases
  - » additional products and services provided by the plant.

34 Decisions based on these criteria involve value judgements as to the relative importance of the different attributes. Some of the criteria are only important in certain situations: for instance competition effects are only important if the shrubs are being grown right next to crops. Others vary greatly according to the site, including growth rate and biomass productivity as well as nutritive value and resistance to pests and diseases. Naturally, the planting site will affect different species in different ways. For example, some species are much more tolerant than others to cold (or high altitude). At high altitude, a slow-growing but more cold-tolerant species such as tagasaste becomes a better choice than a potentially faster-growing species with less cold tolerance, such as calliandra.

35 In Part 4 we summarise the currently available information about each species. However, it is very difficult to predict the performance of a species, or the problems that might arise, in an area where it has not been grown before. We therefore recommend following the steps shown in the Decision Pathway 3 on page **32-33**, when choosing the right species for a particular site. If a species appears to be suited to the area, but has not been tried there before, it is important to test its performance in small on-farm trials before promoting it on a large scale.

36 We also recommend that farmers plant several different species rather than depending on a single one: see **Box 4**.

Box 4

37 ### Why farmers need a range of species

There are several reasons why it is better to present farmers with a range of species to choose from, rather than a single 'best' performer.

- If farmers use several species, they minimise the risks associated with one of the species succumbing to a pest or disease.
- Farmers have different needs and preferences: what is best for one farmer may not be best for another.
- Providing farmers with a range of different feeds can help improve the balance of nutrients offered to the animal and so improve its performance.

Pallida

Tagasaste

Calliandra

Trichandra

Sesbania

Diversifolia

Mulberry

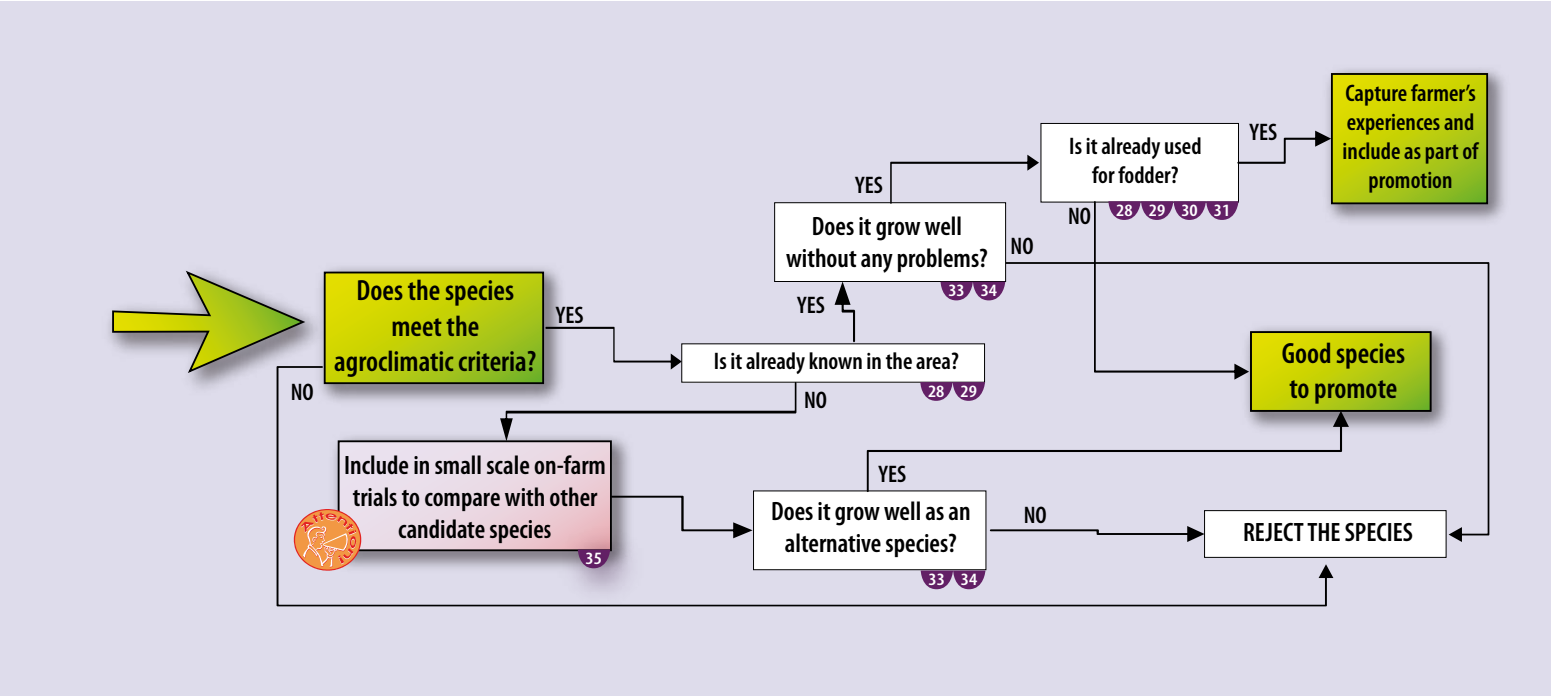
Gliricidia

Decision pathway 3 Selecting the species

Start here

Find out the agroclimatic conditions in your area. For each of the species in the table below, check their agroclimatic requirements and follow the Decision Path 3.

	Rainfall (mm)	Altitude (m.a.s.l.)	Mean annual temperature (range)	Frost (tolerance)	Soil		
					pH	Drainage	N fix
Calliandra calothyrsus ("calliandra")	> 800	0-2200	22-28 °C	no frost	acid, neutral, alkaline	well drained, no waterlogging	✔
Leucaena diversifolia ("diversifolia")	1500-3500	500-2000	18-30 °C	light frost	prefers slightly acidic	well drained	✔
Leucaena pallida ("pallida")	500-2000	1000-2000	16-21 °C	light frost	neutral, alkaline (>5)	well drained, no waterlogging	✔
Leucaena trichandra ("trichandra")	1100-1800	700-2000	17-22 °C	no frost	neutral, alkaline (>5.5)	well drained	✔
Morus alba (mulberry)	1500-2500	1000-3000	18-30 °C	frost	6.0-7.5	prefers well drained	✘
Sesbania sesban ("sesbania")	500-2000	100-2500	20-28 °C	light frost	acid, saline, alkaline	tolerates waterlogging	✔
Gliricidia sepium ("gliricidia")	600-3500	0-1600	15-30 °C	no frost	4.5-8.0	no waterlogging	✔
Chamaecytisus palmensis ("tree lucerne")	600-1600	1500-2500	20-27 °C	frost	4.0-8.5	well drained	✔


Does the species meet the agroclimatic criteria?
YES
NO
Is it already known in the area?
28 29
YES
NO
Does it grow well without any problems?
33 34
YES
NO
Is it already used for fodder?
28 29 30 31
YES
NO
Capture farmer's experiences and include as part of promotion
Good species to promote
Include in small scale on-farm trials to compare with other candidate species
35
Attention!
Does it grow well as an alternative species?
33 34
YES
NO
REJECT THE SPECIES

Getting started with planting material

See also Decision Pathway 4 on p. 43

Helping farmers to acquire starter seed

38 At the beginning of the dissemination process, you may need to assist farmers to acquire seed (or cuttings, for mulberry and gliricidia). This is particularly true in areas where the species has not previously been used, as the farmers usually have no means of accessing planting material themselves. It is also important to start off with materials that are free from pests and diseases, and project staff are more likely to be in a position to ensure that. The need to bring in seed from outside the area is likely to continue for several years, for several reasons:

- Most tree/shrub species take at least 1-2 years to start producing seed, and at first only small amounts are produced.
- Management for fodder production involves regular pruning, so the trees cannot produce seed. Seed is only produced on trees left specifically for that purpose (or grown for a different use, such as poles or firewood, which does not require frequent cutting).
- If the rate of adoption is accelerating, demand for seed will also be increasing rapidly. Shortage of planting material is a very common problem when the adoption rate is high. The shortfall may be temporary (until local seed production catches up, and/or the rate of adoption levels off), but could nonetheless be acute for several years.

Should farmers pay for the seed?

39 Most projects have tended to favour free distribution of seed initially. Farmers are often unwilling to pay for an innovation if they have no experience of it. If this approach is taken, it is important to make it clear that seed will not continue to be provided for free in the future. If farmers develop this expectation it may act as a disincentive, not only to buying seed, but also to managing trees for on-farm seed production.

40 Ways to make a gentle transition from initial free distribution to a payment-based system include:

- Selling the seed in small packets at a subsidised rate, so that the farmers attach some value to it, but it is not so expensive as to prevent them buying it. This is an effective

way to give many farmers access to the planting materials. By putting monetary value on the seeds, the strategy is also likely to attract entrepreneurs to engage in tree seed marketing and lead ultimately to a commercialised and sustainable seed distribution system. This approach has been used in central Kenya with good results (see **Box 5**).

- Giving seed for free initially, but on condition that the farmer gives back at least an equivalent amount once seed production starts (for distribution to other farmers). This approach will, of course, only work in areas where the shrub sets seed, and if the farmer has left some trees for on-farm seed production. It also depends on the capacity of the organisation to provide the necessary follow-up.

41 It is important to recognise that the two previous options both entail considerably more time, organisation and intervention by the extension staff than giving out free seed, especially if it is distributed in bulk to groups (see page **55** about *Working with groups*).

Calliandra pods

42

Box 5

Case study - Seed supply systems

An innovative approach to seed distribution was initiated by the World Agroforestry Centre (ICRAF) in July 2003 in the Central and Rift Valley regions of Kenya. The aim was to develop an effective and sustainable system of seed production and supply. With assistance from extension partners, seed was packed into 30g packets which were sold to farmers at a subsidised price of Ksh 10 (USD 0.12). The main species distributed in this way were calliandra and trichandra. The packets were clearly labelled giving information on seed pre-treatment procedures, and the benefits expected from fodder shrubs.

The seed distribution strategy of small packets targeted individual small-scale farmers (as opposed to groups). One packet contained enough seeds (average of 550 for calliandra) to establish a small on-farm nursery. The germination percentage was normally above 75% so the farmer could raise about 400 seedlings from one packet. Assuming a survival rate of 65% for the seedlings by the end of the first year, the farmer would eventually end up with about 250 shrubs. Two packets therefore have enough seed to produce 500 plants, enough to feed one cow throughout the year.

Demand for the seed has been very encouraging. For instance, during 2004 the Ministry of Agriculture in Kiambu District of central Kenya sold 30kg of calliandra and 15 kg trichandra seeds using this method. The extension workers developed links with farm input stockists who were willing to use their shops as outlets for the seed.

The process of linking up the seed producers, seed dealers and farmers who wish to plant fodder shrubs in different parts of Kenya is ongoing. The seed dealers are collecting and assembling (bulking) seed so as to meet the market demand. The best channel for retailing these seeds would be the farm inputs shops where farmers could easily access the seed. However, at the moment the success of this initiative is still uncertain due to the phytosanitary requirement that seed dealers need to be licensed to undertake this activity. In Kenya the permit costs Ksh 70,000 (US$ 875), which may inhibit seed dealers and stockists from getting involved in tree seed marketing, bearing in mind that the tree seed demand (and thus the profit) is still low. This is an issue that needs to be addressed at the policy level.

Sustainable seed supply for farmers

43 The continuing availability of good quality seed is often the greatest constraint to scaling up the adoption of fodder shrubs. Once farmers start taking them up on a substantial scale, it can be difficult for them to acquire seed (or other planting material such as cuttings) in sufficient quantities to meet the demand.

44 There are broadly two ways in which farmers can access germplasm:

- Through local, informal supply networks. Farmers may produce enough seed for their own needs (either individually or at a community level). Farmers with extra seed (or seedlings) may give or sell the surplus to friends and neighbours. Some farmers also exchange seed amongst themselves.
- Through seed marketing and distribution mechanisms (either private sector or administered by projects or non-profit organisations). Where there is not enough seed produced locally, it will have to be bought from outside the area.

45 Decision pathway 4 on page **43** is designed to help you to decide which of these options applies to your situation. You can support and encourage either or both of these approaches through a number of interventions; but it is important to understand the potential benefits and challenges associated with each of them.

Local networks

46 Where the species is already established in the area, it may be possible for farmers to acquire seed through informal local networks. Often seed is given for free in small quantities to friends, relatives and neighbours, as are wild seedlings (wildlings).

47 Advantages

- Local collection of seed by farmers, and farmer-to-farmer exchange, enables them to acquire seed cheaply or even for free.
- This option is sustainable without external inputs because the seed comes from farmers' own trees.

48 Constraints

- Development of self-sufficient local systems may inhibit market development.
- The quality of seed exchanged among farmers may not be guaranteed.
- There must be enough seed trees in the area to ensure adequate genetic diversity in the seed. If seed is collected from only one or a few trees, there may be a problem of reduced genetic diversity leading to *inbreeding depression* (reduced survival and growth). Seed should be collected and mixed from at least 30 trees to make sure that quality is not reduced by inbreeding.
- Some species do not set seed well in all areas, for example:
  - » Calliandra needs to be visited by bats to be pollinated effectively. In some areas there do not seem to be enough bats for plentiful seed production.
  - » Gliricidia needs a pronounced dry season (4-6 months with very little rain) to produce seed. In wetter areas it has to be propagated from cuttings.

Recommendations

49 When encouraging local seed exchange mechanisms, it is essential to train farmers in the need for adequate diversity and to facilitate systems such as mixing seed from several farms then re-distributing it. The seed producers need training in the management of trees for seed production, timing and methods of seed collection, and seed handling and storage.

50 In areas where there are active farmer groups, it may be possible to operate a group-owned seed stand specifically to produce seed for the group. This has the advantage that the stand will include enough trees to ensure diverse, good quality seed. However, this approach requires a plot of land and continued commitment and investment of time and labour by the group members, and is therefore very vulnerable to any problems relating to the dynamics of the group (see **Box 6**).

51 Some organisations encourage on-farm seed production by guaranteeing to buy seed from farmers. However there is a danger, where seed is being bought from farmers and at the same time given away for free (whether by the same organisation or by different organisations within an area) that the farmers may exploit the system by 'recycling' the seed.

52

Box 6

The tragedy of the commons

A project in western Kenya helped local communities to set up seed stands on public land such as schools and church compounds by providing both financial and technical support. The intention was to use these plots for seed multiplication and to provide free access to people who needed the seed. However, the initiative failed because conflicts arose over the use of the seed plots. Some people saw it as a free source of fuelwood while others used the plots for grazing. In the end the resource could not be used in a sustainable manner. It became a typical example of 'the tragedy of the commons' where no-one takes individual responsibility for a communal resource.

In a similar case in SW Uganda, the local authorities paid for the establishment of seed stands on public land, including fencing, land preparation, weeding and maintenance. Labour provided by the community was also paid for. The purpose of the seed stands was to ensure a sustainable seed supply for the local communities and for the central nurseries operated by the local authority. It was clear that the sustainability of the seed stands largely depended on continued allocation of resources by the local government. Conflicts over the use of the seed plots may arise in the future if everyone is allowed to have free access to them.

Seed marketing and distribution

53 A larger scale market, in which seed is moved from one area to another, is needed in the following circumstances:

- Where a species is being planted for the first time in a new area, so no local seed is available;
- Where demand for the species is increasing so rapidly that the local supply of seed is not sufficient to meet it;
- Where the species sets seed in some areas but not in others (and is also difficult to propagate from cuttings).

Each of these cases offers different opportunities and challenges to the extension providers.

Short-term markets

54 In the first case, the organisation promoting the new species will have to arrange for seed to be available to the farmers by buying it from outside the area (see *Getting started with planting material* on page **34**).

55 The second case applies later, during the 'scaling up' phase of the adoption process, when farmers are taking up the practice in increasing numbers. At that time there is certain to be high demand for seed, and it will probably not be possible to meet this from local sources. Again, seed will have to be acquired from outside the area, but this is also the time when there is greatest scope for a local market to develop. However the long life-span of trees and shrubs limits the market for seed and means that demand is unlikely to continue at the same level once fodder shrubs have been widely adopted in an area.

Long-term markets

56 There is great scope for tree seed markets to develop and flourish in cases where seed production varies from one area to another. For example, calliandra sets seed successfully in some areas but not in others (it depends on the presence of bats for successful pollination), and gliricidia only sets seed in areas with a long, pronounced dry season. On the other hand, for species that set seed prolifically everywhere (*Leucaena leucocephala* is the prime example), there is little possibility for a market to develop.

57 If the species you have selected do not set seed well in your area, it may continue to be necessary to buy seed from outside the area. On the other hand, if seed is more plentiful in your area than in other parts of the region, there may be real, long-term opportunities for farmers to develop seed production into a commercial enterprise (see **Box 7**). In this case it may be appropriate to establish stands specifically for seed production. It is important to be aware, however, that the market for tree seed in the East Africa region is at present fragmented, and not functioning effectively.

58 Problems with the market for fodder shrub seed in East Africa

- Even in the case of species for which seed is already produced in substantial quantities (e.g. calliandra in western Kenya), there is a current lack of linkages between producers and would-be buyers. This is partly because most of the seed is sold to projects involved in promoting fodder shrubs, rather than directly to farmers. While this system works well in the short term, it is not sustainable beyond the lifetime of the project.
- The market for tree/shrub seed is very limited compared to that for food crop seed (partly because of the longer lifespan of fodder shrubs), so large seed companies have not become involved.
- Some organisations have a policy of providing free seed even in areas where adoption and demand are high. This can undermine the development of a sustainable private sector seed marketing system because free seed is a disincentive to entrepreneurs seeking to sell seed.
- As long as the tree seed market is small and fragmented, and large companies are not involved, it is difficult to address issues of quality control and regulation. Organisations can promote seed quality by providing training to farmer groups and entrepreneurs involved in seed marketing.

Should farmers be encouraged to produce seed commercially?

59 *A word of caution.....*

Commercial seed production can be a profitable enterprise; but it is vital to look realistically at the probability of success before encouraging farmers to embark on it. Several farmer groups have reported that they were encouraged by outside organisations to produce seed, but when the seed became available they were unable to sell it. Before promoting this option, it is therefore important to make a realistic assessment of the long-term prospects for market development. In particular it is essential to assess whether the market will be sustainable, particularly if farmers in the area are able to produce seed easily for their own use.

60 *When promoting seed production for sale, it is necessary to:*

- ensure that each seed stand includes enough trees to ensure diverse, good quality seed.
- train seed producers in:
  - » management of trees for seed production
  - » timing and methods of seed collection
  - » seed quality control.
- help farmers to ensure seed quality by training them in seed handling and storage methods.
- link farmers producing seed with buyers.
- identify entrepreneurs from within the farming community to collect, assemble and market the seed.

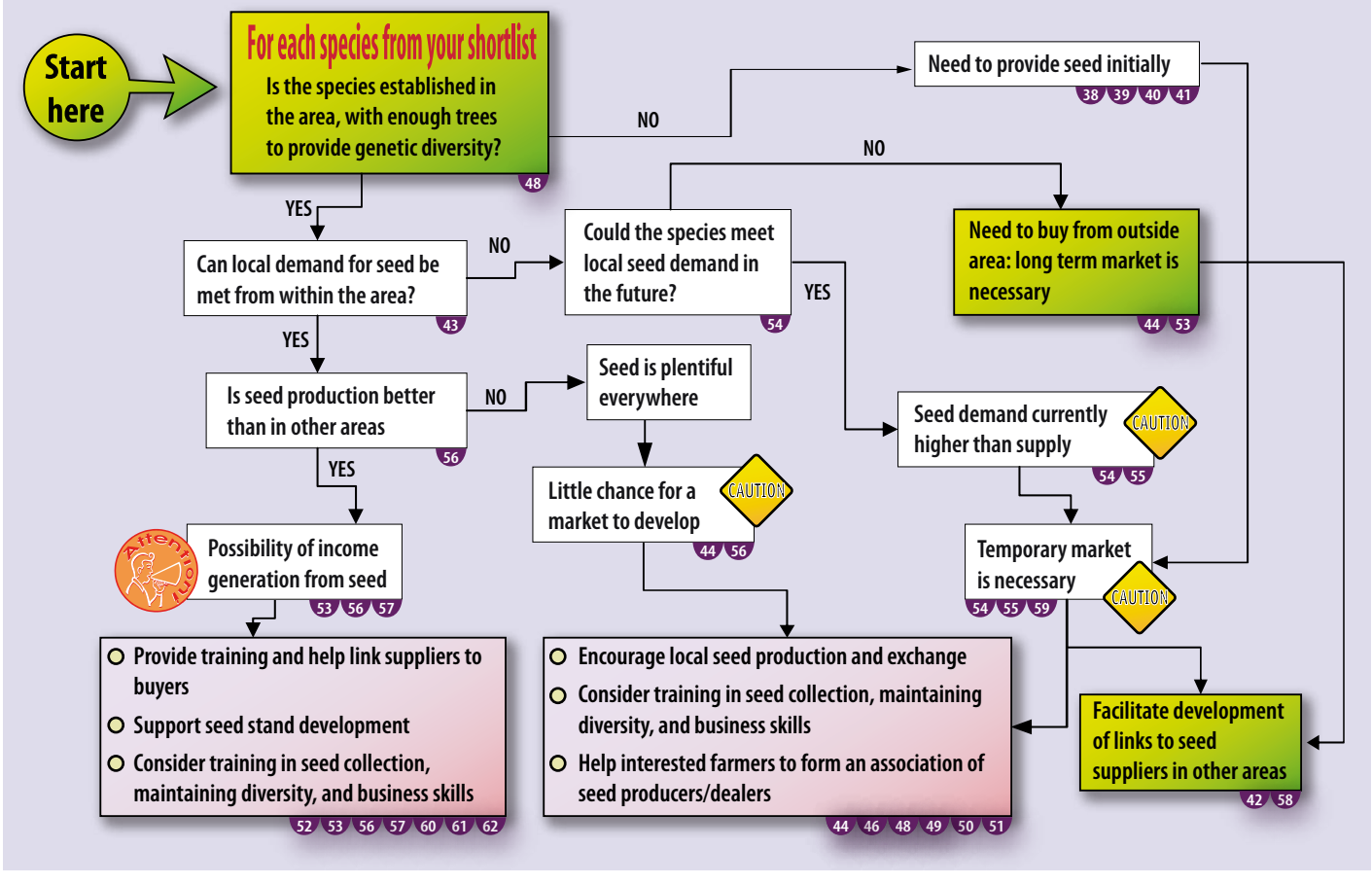
61 Commercial-scale seed producers should interact with government and/or research organisations to ensure that the seed is healthy and of high quality. It is also important to ensure that seed dealers are aware of the laws and phytosanitary requirements which regulate the movement of tree seed within and outside the country.

Box 7

62 **High demand for seed fosters market development**

In the early 1990s, a project in western Kenya encouraged farmers to grow species such as calliandra, sesbania and leucaena for fuelwood, owing to their fast growth. As demand for the species, especially calliandra, increased in subsequent years, a few of the farmers converted the fuelwood stands to seed production. There was also a market for the seed in other areas in Kenya, Uganda and Tanzania. Farmers developed linkages among themselves and with organisations involved in tree planting. They made good profits from seed sales and this was the main motivating factor for seed production. Some farmers have become seed dealers who collect and assemble seed for marketing. This makes it easier to address the issue of quality. A similar situation has developed in more recent years in the central region of Kenya and the Kilimanjaro region of Tanzania, assisted by a regional fodder shrub project which facilitated exchange of knowledge within the region.

Decision pathway 4 Sustainability of seed supply



Part 2

Making decisions about extension approaches and methods

Part 2 deals with extension issues relating to fodder shrubs. The practice is fairly 'knowledge-intensive', requiring more knowledge and skills than many other practices. It therefore requires training at several stages along the path from planting, through management, to eventual feeding. It is essential that the technical messages are suitable for the farmers, the agro-ecological zone and the farming system, and they must also be communicated in the most effective way possible.

In the first section we outline some of the key considerations which should guide the development of your extension strategy: the need to target farmers and to match fodder shrubs to farmers who are interested in using them; how extension can work with resource-poor farmers, especially women; and the importance of promoting farmer innovation.

Our experience has been that the extension approach used has a big influence on how readily farmers adopt fodder shrubs. Partnerships with other stakeholders can greatly add value to your activities: we discuss some of the issues to consider when choosing extension partners. We also look at the issue of working with groups. Next, we describe some of the extension methods which have been found to be the most effective for promoting fodder shrubs in East Africa. The final section describes how to monitor and evaluate progress in promoting fodder shrubs.

We assume that the reader is familiar with the concept of participatory approaches[1] and methods, and also has resources available to implement the chosen methods.

[1] If not, a useful reference that the reader should consult is Gonsalves *et al.*. 2005. (see p. **112**).

Targeting the right farmers

It is easy to think that all dairy farmers practising zero grazing should be interested in growing fodder shrubs but in fact some are not – and they have good reasons! There are other available protein sources and each, like fodder shrubs, has advantages and disadvantages. We have found that most dairy farmers are interested in growing fodder shrubs; but there are some cases where the practice does not fit so well into their farming system:

Constraints to adoption

- Some high-income farmers prefer to buy concentrate rather than spending time growing, maintaining, and harvesting fodder shrubs.
- One of our partners tried to introduce fodder shrubs to some farmers whose main income source was growing vegetables in an irrigation scheme. The vegetable enterprises were very labour intensive and the farmers were not interested in devoting more time and land to increasing their milk production (see **Box 2**).
- Farmers who are unable to sell their milk have no interest in new practices for increasing milk production.
- Some farmers lack access to water for a dry season nursery, and are thus unable to raise fodder shrub seedlings.

Extension providers need to examine farmers' needs and preferences carefully before deciding to promote fodder shrubs. Farmers need to be presented with the options available for providing protein to their livestock, and with information for making sound, appropriate decisions. If farmers are interested, they can be familiarised and trained using the methods described in the next section.

Attracting resource-poor farmers, especially women, to participate

Many organisations and projects try to target resource-poor farmers, and women in particular, but both these groups can be hard to reach with extension messages. Wealthier farmers, and particularly men, tend to have better access to conventional extension methods. There may be cultural or social constraints to women planting trees. In some areas, such as parts of western Kenya, it is not customary for women to plant trees, and of course this can be a major constraint to their participation. There may also be gender issues relating to control over land (since fodder shrubs are perennial crops) and the dairy enterprise.

How to reach women farmers:

- Work with women's groups. Promoters of fodder shrubs in central Kenya targeted women's groups (which, actually, often have many male members!) and as a result, 60% of beneficiaries were female.
- Consult women when arranging times and places for meetings, field days and trainings. Women have many constraints on their time.
- Find out the extension methods that women prefer and focus on these. This can be done efficiently and effectively by holding informal discussions with local women's groups, preferably organised by women facilitators.

How to reach poor farmers:

Targeting the poor may be more problematic than targeting women, for several reasons:

- They are sometimes difficult to identify. Wealth ranking is a useful technique for identifying poor farmers. Community members define poverty criteria and classify themselves and their neighbours into different wealth groups. It then becomes easy to identify the poorest farmers and to monitor the degree to which they use new practices.
- As with women, resource-poor farmers need to be consulted about the extension methods most useful to them (e.g., do they have access to radios?), and the most convenient times and places for extension events. People who consider themselves poor are less likely to attend meetings. They may also be working for another farmer and have limited time to attend events.
- They may have a fatalistic view of their situation, and not believe that it could improve.
- They may be afraid of risk or unwilling to make investments where the return is not immediate or certain.

If you do not have time or resources to do detailed surveys you can still find out from key informants who the poor are, how they may be reached, and which extension methods are most appropriate for them. It is also worth noting that there is sometimes a strong association between wealth status and type of farmer group. In western Kenya, church groups have a much higher proportion of poor members than other types of groups.

Promoting farmer innovation

Researchers developing improved practices at research stations almost never get the practices 'completely right'. Farmers often find ways to adapt the practices developed by researchers to fit better into their 'real world' conditions. With fodder shrubs, we have identified several farmer innovations which are actually improvements on the original practices recommended by researchers. In one case, feedback on a farmer innovation has even resulted in a change in extension recommendations. Farmers in Maragua District, Kenya, conducted experiments on soaking calliandra seeds before planting and found that seeds soaked for 48 to 60 hours had higher germination rates than those soaked for the recommended 24 hours. Researchers at KARI-Embu confirmed the farmers' findings and extension staff now recommend the longer soaking time.

Farmer innovators can become important partners for research and extension staff in generating and testing new innovations. Banana fibres used by farmers for potting seedlings.

Farmers have also proved to be experts at reducing the costs of producing fodder shrubs. For example farmers in some areas use local materials (e.g. banana fibres, recycled cans or milk cartons) for potting seedlings, instead of buying plastic bags.

Extension providers can facilitate the process of farmer innovation in several ways. These include:

- helping farmers prove the validity of their own experiments by encouraging others to repeat the same experiment and see if they get the same result
- bringing farmer innovators together to exchange information
- helping farmers to spread innovations to other areas
- encouraging farmers to document their innovations (and helping them to do this)
- feeding back the innovations to researchers, who may also want to test and validate them, and to include them in their research recommendations.

Working with partners

There are many benefits of working with other organisations as extension partners. Cooperation with partners can greatly increase the coverage of your activities, and organisations with complementary interests (e.g. fodder and livestock development) can work together to accelerate the uptake of both technologies simultaneously. Partners can cooperate to work efficiently by complementing each other and avoiding duplication of efforts.

Suitable partners may be government extension services, donor-funded development projects, NGOs or small community-based organisations (CBOs). Other potential partners could include churches, private extension providers, local government officials, milk companies, seed companies and stockists, farmer associations, universities, schools and nursery operators. The most useful type of partner depends on your own situation and needs, but any of the following are likely to be appropriate:

- Organisations with strong extension capability who can scale up joint initiatives e.g. government departments of agriculture and livestock.
- Resource providers: may provide information, seed/planting material, or technical backstopping (e.g. research stations, universities, farmers' training centres, ARDCs [2] (Uganda)).
- Organisations providing improved livestock. These include NGOs using the '*passing on the gift*' approach (see **Box 8**); artificial insemination services; animal breeders (e.g. farmer cooperatives and associations such as DGAK[3]).

[2] Agricultural Research & Development Centre
[3] Dairy Goat Association of Kenya

Courtesy of Heifer International

A woman gives a goat to a neighbour in Heifer International's signature "passing on the gift" ceremony. Participants who receive animals agree to pass on offspring of their goats, cows and other livestock to others.

Box 8

Passing on the gift: an effective approach for introducing dairy animals and fodder shrubs to farmers

Heifer International and several other NGOs in the region operate schemes to provide improved dairy cows or goats to communities. They work exclusively through groups, which are also ideal entry points for fodder shrub promotion. The approach is essentially a loan scheme in which a group is made the guarantor of its members. Improved animals are given to a few members of the group, who then have to pass on the first 1 or 2 female offspring to other members in the group. The process continues until all the members get animals, and is known as 'passing on the gift'. The organisation operating the scheme usually requires farmers to have planted sufficient fodder to feed the animal before they can receive it. This creates an instant demand for fodder shrubs and a strong motivation to farmers to plant and take good care of them.

What makes a useful partner?

There are many potential partners to work with. Because getting involved in partnerships has costs (especially in terms of time), it is important that you strategically select whom you work with, in order to ensure that the benefits on both sides are as great as possible.

For a useful and productive working relationship, a partner should:

- Reach many farmers and work across large areas: a small community-based organisation may require a considerable amount of your time and resources and yet may reach only a few farmers.
- Use participatory approaches: an organisation may have a very 'top down' approach in interacting with farmers and/or insist on giving free inputs to farmers.
- Have adequate staff, resources and good management: many organisations lack staff and resources and expect you to provide all the funds and resources required. The willingness to share resources may become a source of friction, and it is essential to be very clear from the beginning about what resources each party will bring to the partnership. It is best to make sure these issues are fully agreed by both parties by signing a written agreement such as a Memorandum of Understanding (MoU).
- Have shared or complementary objectives: some organisations may put greater emphasis on environmental objectives (e.g. greening the environment, enhancing biodiversity) than on increasing farmers' incomes. In other cases, organisations' objectives may differ but fit closely together and complement each other, for example livestock promotion and fodder promotion.
- Have a strong commitment to agroforestry or dairy production: some partners may have little commitment to assisting farmers with fodder shrubs, because they have so many other activities.
- Use appropriate practices: a partner may use approaches that you think are not appropriate, such as providing farmers with free seedlings.
- Be committed to monitoring and evaluation: some organisations have little interest or expertise in monitoring and evaluating their activities.
- Be accessible: some organisations are difficult to access, because their base is far from where you are working or because of poor communication facilities.
- Have the trust of farmers: it is important to know from the farmers if they trust an organisation and accept its help willingly.

Choosing partners

To help you in choosing new partners, or in assessing whether you should expand, maintain or reduce existing partnerships, it may be useful to complete the matrix in **Box 9**, using it to rate potential partners on these nine criteria. In the final two rows of the matrix, score the amount of time and resources that you devote to the partner, and the value per unit of effort that you think you get out of working with them. The criteria do not all have equal weights, so a poor score on a single criterion (e.g. trust of farmers) may outweigh positive scores on most of the other criteria. Therefore, it is not useful to sum the scores in each column to arrive at a total score for each partner.

The matrix should be seen as a tool to help with making objective judgements about the value of different partnerships. The relative importance given to the different criteria depends on your specific situation and is therefore bound to be somewhat subjective. The matrix can provide a basis for assessing whether the time and effort spent on each partner is justified by their contributions. If the value is low, you may want to reduce your involvement with them in the future. If high, perhaps you should increase. The matrix can also help identify how you can support a particular partner to become more effective, for instance in their own monitoring and evaluation procedures.

Box 9

Matrix for assessing the contribution of different partners in agroforestry dissemination

(Partners are scored high, medium, low on each criterion.)

Partner	1	2	3
Reach (areas and number of farmers)			
Participatory approaches			
Availability of staff			
Availability of resources			
Quality of management			
Shared objectives			
Commitment to agroforestry			
Openness to appropriate practices			
Commitment to monitoring and evaluation			
Accessibility (distance, ease of contacting)			
Trust of farmers			
Time/re-sources your organisation spends on the partner.			
Overall value per unit effort			

Of course, the matrix tells us nothing about the problems that other organisations perceive in developing partnerships with your organisation! It may be worthwhile for you to find out about these, for example by hiring an independent consultant (see **Box 10**). Another important task for this or a separate consultancy would be to find out which organisations and sources of information farmers have confidence in, and why; and then use this information to identify partners and strengthen partnerships

Box 10

Using a consultant to find out about problems that other organisations might have in working with your organisation

An NGO was having problems building partnerships with other organisations in scaling up agroforestry adoption. It hired a consultant to visit these organisations and find out what the problem was. The consultant found that they had difficulties participating in the national planning meetings organised by the NGO. The persons attending the meetings often did not have the authority to make commitments, and their organisations' planning period did not correspond to the NGO's planning period. Instead of attending the NGO's planning meeting, they asked that the NGO's staff participate in their own planning meetings. This information was critical in helping the NGO to improve its effectiveness and to build stronger partnerships.

Working with groups

Working with groups rather than individual farmers has many important advantages:

- It allows scarce resources to be used to reach many farmers within a shorter time and at a lower cost. It is easy and time-saving to mobilise farmers who are in groups to attend training sessions, field days, demonstrations and meetings. It is also easier to distribute seed in bulk through groups.
- Interaction (particularly 'peer pressure') and information flow among the group members enhances the dissemination and adoption process.
- Group approaches help communities to build 'social capital', the networks people form to improve their livelihoods.
- There is great variation among groups in terms of their effectiveness and cohesion, both of which are influenced by many factors. When deciding whether to use a group approach it is important to bear in mind the following points:

A » A culture of collective action in the community makes it easier to use group approaches.

B » It is generally easier to work with pre-existing groups than to form new ones. Existing groups have already proved their effectiveness (they still exist!) whereas forming a new group involves much greater effort and risk. It is easier to introduce fodder shrubs to pre-existing groups because they have experience working on other issues. These *common interest groups* (CIGs) may include a diverse range of types of groups including women's groups, church groups, youth groups, and groups focused on specific agricultural or health issues, e.g. dairy goats or HIV/AIDS.

C » Groups that have formed spontaneously are more likely to be more cohesive and sustainable than groups set up by a project or organisation.

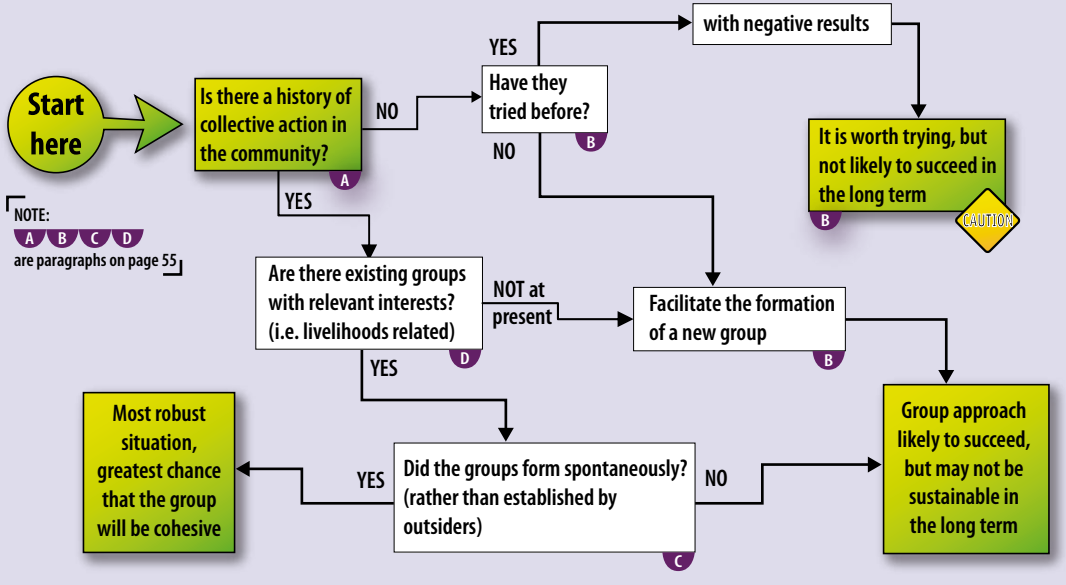
D » Wherever possible, work with groups that already have a focus on dairy cattle or goats. Milk marketing groups are another good option as they have an interest in increasing milk production.

Decision Pathway 5 on page **57** will help you to assess the feasibility of using a group approach in your area.

Working with groups rather than individual farmers has many important advantages.

Decision pathway 5

Will a group approach work in your area?



Groups vs. contact farmer approach

Some organisations, rather than working with groups, identify innovative, respected individuals within the community as 'contact farmers'. A good example is the international NGO Africa Now, which uses this approach for its agroforestry activities in Vihiga and Kisumu Districts in western Kenya. They select 8-12 contact farmers per year in each of six villages, each of whom in turn identifies and works with 3-5 follow-up farmers, who in turn work with another 3-5 farmers, and so on. They are trained in a range of interventions of which agroforestry forms part: these include dairy goats, local poultry, bee-keeping, crop diversification and soil conservation. Before a farmer can get a dairy goat (s)he must have enough fodder on the farm: this provides an ideal entry point for introducing the fodder shrubs. Farmer training, technical backstopping and provision of seed are all facilitated by the project, in partnership with Africa Now.

In our experience, working with groups is often more effective than working with contact farmers, for two reasons. First, working with groups is more efficient as many farmers are trained at the same time. Second, a contact farmer may not have both expertise in fodder shrubs and the willingness and ability to disseminate; these characteristics are more likely to be present in a group than in a single contact farmer. The effectiveness of contact farmers as extension providers, compared to professional extension staff, is another area needing further study. This relates closely to improving our understanding of the process of farmer-to-farmer dissemination (see **Box 11**).

In our experience, working with groups is often more effective than working with contact farmers to promote fodder shrubs.

Box 11

Promoting farmer-to-farmer dissemination

In 2002 a study was carried out in Nyeri, Embu, Kirinyaga, and Maragua Districts of central Kenya. Few assessments have previously been made of farmer-to-farmer dissemination, that is, who in a community disseminates new practices and how they do it. The objective of this study was to find out the degree to which farmer groups and their members in central Kenya disseminate fodder shrubs, what types of planting material they disseminate (seed, seedlings, and wildlings), and to whom.

Researchers surveyed farmer group leaders and randomly selected members from 14 groups, who had planted calliandra and other fodder species in the period 1999-2001. The survey results showed that over half (55%) of the group members had given calliandra seed or seedlings to non-group members; and that on average each group member gave planting material to six farmers outside their group. Of this total, individual members distributed material to five farmers while groups distributed to one farmer per group member. Thus, although groups play an important role in dissemination, group members, acting as individuals, do far more in distributing information and planting material than do the groups themselves. Whereas men and women are both active in disseminating, most of the planting material tends to go to men. Farmers who disseminated fodder shrubs had larger numbers of fodder shrubs, and more interaction with research and extension staff. On the other hand, most household characteristics, such as gender, wealth, education, and age did not affect whether farmers disseminated or not. Surprisingly, farmers who had had nurseries did not disseminate more than those who had never had them.

The study demonstrated the importance of farmer-to-farmer dissemination in spreading the adoption of fodder shrubs in central Kenya. This type of extension is crucial in ensuring wider dissemination of fodder shrubs in the region, especially in view of the progressive deterioration in the delivery of public extension services. The disseminating farmers need technical support from extension providers, and follow-up mechanisms are necessary to ensure that the information being disseminated is correct and that the planting materials are accessible at the right time to potential adopters.

The transition from collective to individual activities

Group approaches are particularly appropriate for activities such as nursery establishment, with a strong training component, because many people can be trained at the same time. However, there is a tendency for the groups to fragment over time. Problems may arise over the allocation of duties and responsibilities within the group, and the sharing of benefits. On the other hand, a sense of community cohesion may also be fostered by bringing farmers together for group activities, whether for training or seedling production. Even if the group nursery only functions for a single season, it will have served its training purpose. One way to improve equitable sharing of responsibilities and benefits is to encourage formation of subgroup nurseries, based on criteria such as neighbourliness, and how individuals relate. However the whole group should be trained together. Competition among the group members can greatly increase adoption levels: this can be promoted by encouraging rotational visits by the whole group to each individual farm during their routine meetings or training sessions. Often certain individuals within a group prove to be very dynamic and want to start their own nurseries, marketing, and extension efforts: in such cases it is worthwhile to provide them with support to do so.

Some farmers prefer to set up small individual nurseries on their own farms.

Choosing the right extension methods

There is a wide range of possible extension methods. Their effectiveness varies in different situations, so it is important to take careful account of the socio-economic and cultural context in which they are being used. Here we highlight those which have been found to be the most useful and effective in the context of fodder shrub promotion in East Africa.

The options are summarised in **Box 12**. They are divided into three broad topic areas:

- dissemination of information
- training
- provision of planting materials and other inputs.

It is unlikely that all the methods would be useful in any given situation, so it is important to evaluate your particular situation carefully, and also to try out different methods and see which ones appeal most to the farmers you work with. For instance in many cases your target farmers will have had no previous exposure to fodder shrubs; but if they have already tried them, some of the initial sensitisation activities may not be necessary.

Dissemination of information: the first step

Many of the farmers who could benefit from using fodder shrubs may never have heard of them before. When most of the farmers in an area have had no experience with fodder shrubs, an initial stage of sensitisation will be needed to inform the targeted farmers about the benefits that they can offer.

A good starting point is to distribute leaflets, and put up posters in public places. The aim at this first stage is to get people interested, so that they start to discuss the idea of fodder shrubs, and to ask questions. However, it is important to remember that leaflets and posters require literacy so will not reach all farmers. An open public meeting (*baraza*) can give the whole community information about the potential benefits of fodder shrubs, and start to create demand. At this stage it is essential that an extensionist, or someone else knowledgeable about fodder shrubs, is available and accessible to provide follow-up to interested farmers (see **Box 13**). It is also important to involve key opinion leaders in helping you to spread the message.

Written extension materials or non-written media?

The level of literacy in the target community will help you to decide on the type of extension and training materials to use. If the level of literacy is high, the information can be passed to farmers by

Box 12

Summary of selected extension methods

	Method	Situations where the method is suitable	Situations where the method may be unsuitable
Dissemination	Sensitisation meetings (e.g. public meetings, *barazas*)	Practice new to the area: no previous experience.	
	Written extension materials (e.g. posters, leaflets, flipcharts)	High literacy rate among farmers.	Many farmers are illiterate.
	Non-written media (e.g. pictures, video, drama, song)	Many farmers are illiterate, and/or distrustful of outsiders.	Videos need electricity supply and skills to operate the equipment.
	Farmer-to-farmer dissemination	Experienced farmers ('contact farmers') can be encouraged to disseminate to others ('follower farmers').	No previous experience of fodder shrubs in the area.
Training	Technical training (e.g. nursery establishment, planting, shrub management, feeding)	Where farmers are new to the practice. Involve farmers with previous experience, as trainers, wherever possible.	
	Demonstration plots or demonstration farmers	Farmers already using fodder shrubs in the area.	No previous experience among farmers. Demonstration plots on public land or research stations are less likely to be effective than on-farm demonstration.
	Farmer exchange visits	Where farmers are new to the practice, this can be a highly effective way of motivating them.	May be too expensive if there is no suitable site nearby to be visited.
Provision of planting materials	Distribution of planting materials	At the initial stages the extension agents can be involved and later on individuals can be assisted to be seed and seedling dealers.	
	Free starter seed or cuttings	No previous experience of fodder shrubs so farmers may be initially unwilling to invest.	Other organisations and individuals are selling seed or providing seed on credit.
	Sale of seed in small packets at subsidised rates	Should be started as early as possible to avoid attitudes of dependency.	Other organisations in the area are giving seed for free.

using written materials such as posters, leaflets and flipcharts. If the literacy level is low, the use of verbal interaction aided by pictures, real objects, audio-visual aids, drama and demonstrations is appropriate.

Previous negative exposure to outside intervention can make the community suspicious of outsiders. For instance, a previous project may have made big promises and failed to deliver on them. It is important in these cases to work with caution: it can be helpful initially to use indirect methods, such as drama and song, to foster interest.

Training and demonstration: "Seeing is believing"

Fodder shrub technologies are knowledge-intensive, so extension providers promoting them have to give special emphasis to sharing knowledge and helping farmers learn the needed skills. Even farmers who are experienced with fodder shrubs may need help with specific issues such as utilisation, nutritive value of different species, or problems with pests and diseases.

Training in stages

The scope of the first stage of farmer training should be limited to the establishment phase (seed sowing, nurseries and planting out: see **Part 3**), to avoid overloading the farmers with information and making the whole process seem too complicated. Management and utilisation should be covered in later trainings, once the farmers have reached the stage of cutting the shrubs and feeding animals. Wherever possible the training should be done at a site where practical demonstration of the techniques is possible: at an existing nursery, or for the later stages on a farm where fodder shrubs are being well managed (see **Box 14**).

Box 13

A friendly morning conversation about trying fodder shrubs

Extensionist (E): Good morning Mukulima.

Farmer (F): Good morning Mwalimu.

F I have seen that you have nice dairy cows ….. I wonder, how much milk do you get from that Friesian cow?

F I get only 5 litres a day but the former owner told me he used to get three times that amount. I wonder what went wrong….

E Let's see what the problem might be with your cow! She looks healthy, and I can see you are looking after her very well. So maybe it is the way you feed her. Generally, how do you feed milking cows?

F As you can see, I have plenty of maize stover that I stored last year, banana stems and some Napier grass for my zero grazing animals….. I think that is adequate feed for the animals.

E But you also need to provide better sources of protein for your animals if you want to increase milk production. You can buy protein-rich feeds from the shop or you can grow protein-rich fodder crops on your farm – this is a cheaper option. Which do you prefer?

F I do not have money to buy feeds. I would rather try growing the fodder crops. Which are they, and how do you grow them? Where can I get seeds?

E Do you know Juma? He grows fodder shrubs, and is also a well-established seed dealer who sells different types of fodder shrub seeds at a reasonable price. So try to get in touch with him and ask for species such as calliandra, trichandra and sesbania, which are appropriate for this area. You could also try desmodium, a herbaceous legume. For that you need cuttings, which Juma can also sell you.

F You mean everything costs money? Can't you get me some free seeds?

E No, because these plants are valuable! And if the seeds have value, you will be able to sell some yourself in the future.

F How do I manage and feed the fodder shrubs?

E You need to take care of your nursery and I will visit you to advise on how to plant the fodder species in your farm. Later we shall feed the animals and see what happens.

F Aren't these shrubs going to take up cropland and reduce the crop production?

E No, these shrubs are legumes just like beans and peas and they can add nitrogen to the soil. Better still, their roots grow very deep into the soil and so feed from the nutrients down there, while most crops feed on the nutrients that are nearer to the surface. They also have other benefits such as firewood, bees can feed on their flowers, and they can also control soil erosion. They also grow well on poor soils, or in areas not used for crops such as boundaries.

F I think now I am convinced about planting the fodder shrubs. I will look for Juma so that I can buy seeds of all types of the fodder shrubs that he can get.

E You have made a wise decision. Maybe you could also visit Juma's farm to see how he uses the shrubs.

F Please keep visiting me! The problem with you extension workers is that you rarely come back to follow up on how we are getting on with the work you start with us.

E I will definitely be back....and in the meantime you can always contact me at any time you need my advice.

Box 14

Continued assistance needed; one-stop extension does not work

Extension providers promoting fodder shrubs need to work with farmers over an extended period, covering nursery establishment, transplanting, harvesting and utilisation. They cannot expect farmers to adopt successfully if they are only present at establishment and transplanting. In one area, we found farmers who had been trained by a project during nursery establishment and transplanting, but after that the extension staff left the area. We visited the farmers one year after planting and found that they did not know how to harvest or use the fodder shrubs. In several cases, the shrubs had changed hands, and in one case a farmer did not even know that the shrubs could be fed to livestock. This experience highlights the need for continuous follow-up throughout the planting-harvesting cycle.

Demonstration plots or demonstration farmers?

The presence of farmers in or near the community with substantial previous experience of fodder shrubs and/or dairy is very helpful because they can act as demonstration farmers, participate in the training process, and/or take an active role in disseminating ideas and practices to others. Experienced farmers who are willing to take an active role in the process of dissemination and training are known as 'contact farmers'. Arranging visits of inexperienced farmers to others who are already successfully using fodder shrubs, and are willing to share their knowledge, can greatly speed up the adoption process.

An alternative method sometimes used to demonstrate a practice to farmers is for a project to set up demonstration plots, usually on public land or around the project headquarters. We have generally found this to be less effective than on-farm demonstration plots, because farmers may not believe that the practices will be feasible with their limited resources.

Exchange visits

If there are no local farmers using fodder shrubs, a very effective extension method is to take a group of farmers on a trip to another area where the practice has been more widely adopted. Details of possible ways to organise an exchange visit are given in **Box 15**. This can be a two-way process: it can be very effective for the adopters also to visit the inexperienced farmers and to participate in their training.

Box 15

Farmer-to-farmer exchange visits to promote fodder shrubs

We have found farmer-to-farmer exchange visits to be a highly effective way of motivating farmers in an area where fodder shrubs have not previously been used. Often a local visit can be very useful, and the farmers may even be willing to cost-share. For instance, in Uganda, farmers from Isingiro South (where calliandra had been recently introduced) visited farmers two hours away in Kabale (with a much longer history of usage). The farmers covered their own transport costs (USh 10,000 or US$ 5-6).

Several self-sponsored exchange visits have been conducted in central Kenya with great impact in influencing people's change of attitude and improvement in farming practices. The farmers contribute towards the transport and subsistence costs. They negotiate cheap local transport and buy or bring snacks to make the tours less expensive. The role of the extension or research staff is only to link them with sites where specific practices or innovations have been well adopted. After arrival at the site, the host farmers take over the training role and the extension staff are in the background, playing only a supporting role. The local tours have led to the exchange of planting materials and have linked farmers to markets for other farm produce such as dairy goats, rabbits and honey.

The most important aspect is that these tours lead to adoption of improved farming practices and open up communication channels among the farmers. They exchange telephone numbers and postal addresses that they later use to exchange ideas and to market produce. Most of these tours take only a day but there are cases where the host farmers accommodate the visitors at their homes, giving them adequate time to interact and learn from each other as well as saving on costs. A local visit is often the most effective, because the visiting farmers can identify closely with their hosts' situation.

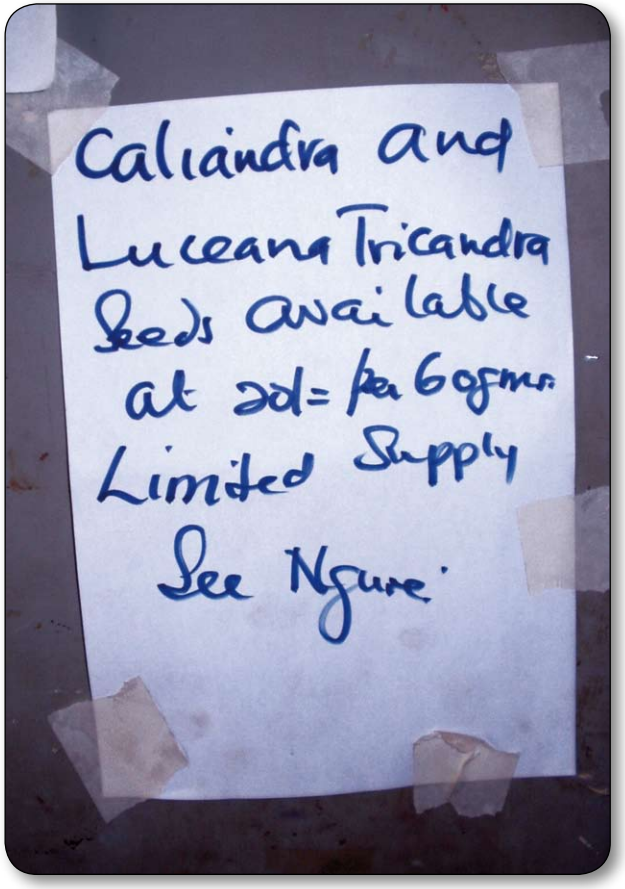
Long-distance, cross-border visits are only justified if there is no suitable local destination. Inevitably these are much more expensive. However, in the Kilimanjaro area of Tanzania, it has become very clear that a 1999 exchange visit to Embu, Kenya had a profound effect on the Kilimanjaro farmers' attitude to growing fodder shrubs. Even now, six years later, the most highly motivated and enthusiastic farmers are those who went on that visit.

In general, exchange visits are most effective if the economic and social status of the hosts is similar to those of the visitors. Special efforts often have to be made to attract women to participate, as they often cannot leave their household and childcare responsibilities. One-day visits are usually much more convenient for women than longer trips. The tours greatly enhance the adoption rates and have proved to provide worthwhile returns relative to their costs.

Planting materials and other inputs

It is important to minimise free distribution of inputs (seed, polythene tubes, seedlings, etc.) as this fosters an attitude of dependency so that farmers are unwilling to make the transition to paying for inputs. However if other organisations are providing free inputs it may be very difficult to persuade farmers to pay, so it is important to find out if this is happening in your area and develop your own strategy accordingly. It may also be useful to talk to organisations that are providing free inputs about their strategy, with a view of finding a compromise.

'Novice' farmers may be unwilling to invest in fodder shrubs until they are convinced of their value, so it is common to distribute small amounts of free seed initially ('starter packs'). As a general principle, however, it is important to introduce and strengthen the concept of putting monetary value on the inputs in order to ensure involvement of the private sector, and a sustainable future supply of inputs (see page **34** for some ideas on how to do this).



It is important to put monetary value on the planting materials and other inputs, to ensure involvement of the private sector, and a sustainable future supply.

Monitoring and evaluation

Many organisations conduct monitoring and evaluation (M&E) exercises to keep track of the progress they are making in achieving their objectives. But there are at least three other equally important reasons for conducting M&E:

- Understanding impact, that is, who is benefiting and what are the benefits?
- Getting feedback on problems and opportunities for research, extension, and policy makers
- Learning lessons: What worked and why and what needs improvement.

Understanding impact

To monitor the impact of fodder shrubs, organisations have to go beyond monitoring their activities, such as number of farmers trained or amount of seed distributed. Rather, they have to find out how the practices they are promoting affect people's livelihoods. A good starting point for defining impact indicators is to ask the farmers themselves. Once farmers have started feeding fodder shrubs to their animals, they have much to say about impact. An excellent way to find out farmer views is through workshops, during which farmers break into groups and discuss fodder shrub impacts (see **Box 16**). It is important to remember that different groups may perceive impact differently. For example, women may prefer to be in groups separate from men in order to ensure that their views are known and taken into account.

A major output of such workshops is the set of indicators needed to assess impact and a plan on how to measure them. Whereas most organisations will not be able to monitor more than a few impacts, farmers are often willing to do so. In fact, they may be interested in monitoring many of the impacts for their own purposes. For example, recent surveys in south-western Uganda and central Kenya showed that most farmers planting more than 200 fodder shrubs had conducted informal experiments to determine the quantity of milk produced by adding a specific quantity of calliandra leaves to their cow's diet. The farmers' estimates were apparently quite accurate: the amount of extra milk generated by 1 kg of calliandra in research trials was almost exactly the same as the mean of farmers' estimates.

Box 16

Farmer workshops to identify impact indicators

At a workshop in central Kenya, farmers divided into four groups with one group each discussing fodder shrubs' impact on their animals, their fields, their families, and their communities. They also defined indicators for each impact and made suggestions about how to measure them. The table shows some examples of their results.

Selected impacts of fodder shrubs identified by farmers in Embu, Kenya:

Impact	Degree of impact	Indicator of impact	How to measure
Increased quantity of milk	1 kg calliandra equals 0.5 kg dairy meal	Quantity of milk produced after feeding calliandra	Research experiment comparing effect of different feeds on milk production. Farmers can also conduct their own experiments.
Increased "thickness" of milk	Less milk needed in tea. Easier to sell the milk (but no price difference)	Measure butterfat content	Dairy companies can do this. Farmers can report on whether or not they perceive that cows fed on fodder shrubs produce thicker milk
Prolongation of lactation period	About 15 days	Length of lactation	Farmers can record this
Improved manure quality	Results in higher crop yields	Softness, degree of fibre	Lab tests
Effect on adjacent crops next to hedge	None	Crop yields, soil colour	Compare crop yields next to and away from hedge. Researchers can do this in trials and farmers can make their own appraisals.

Getting feedback

Periodic meetings with farmers are also useful for finding out farmers' problems. Extensionists may be able to solve them or feed them back to other stakeholders. For example, researchers may begin experiments to try to control or avoid a new pest or disease; policy makers may be able to change a problematic regulation.

However, feedback is not just about identifying problems. It is also about finding new opportunities for promoting livelihoods. Many farmer innovations have become research and extension recommendations (see *Promoting Farmer Innovation* on page 49): identifying farmers' innovations is critical for improving the performance and suitability of new practices. But finding them is not easy; some farmers are reluctant to discuss their innovations in meetings and some do not even recognise their innovations as such. Observational tours are probably the best way to find farmer innovations. Good innovations should be shared with other farmers as well as extensionists and researchers.

Learning lessons

The lessons an organisation learns about how to promote fodder shrubs are perhaps the most important outputs of M&E. Yet many of these lessons are learned not by collecting and analysing data but

simply by assessing experiences. For example, an organisation may find, based on observations by its staff and anecdotal information from farmers, that cutting calliandra at a different height produces more biomass than the recommended height. It is important to write up the lessons learnt, and the reasons and explanations for what works well and why. These can then be shared inside and outside the organisation so that others will not have to reinvent the wheel.

M&E can also play an important role in more rigorously confirming lessons such as the above-mentioned ones. In the case of cutting height, researchers may help farmers to organise an experiment in which farmers cut shrubs at different heights and then compare the results. Concerning farmers' preference among different fodder shrub species, the organisation can interview randomly selected farmers and get their views. Both studies would give a scientific basis to the farmers' experience, and so help to convince others of the validity of the findings.

Monitoring methods

In participatory M&E approaches, a team of project staff, farmers and other stakeholders (e.g., government extension staff) are responsible for conducting M&E to ensure that the views and interests of key stakeholder groups are represented. Three key methods used in participatory M&E are:

- farmer group meetings, in which farmers exchange views on fodder shrubs
- questionnaire surveys, in which researchers or other staff interview farmers about their experiences
- observation tours, in which members of the M&E team visit farmers' fields to view and discuss their work on fodder shrubs.

Each method has advantages and disadvantages. An advantage of group meetings is that farmers can present their views and discuss them amongst themselves. A disadvantage is that certain individuals or groups may dominate. A questionnaire survey can collect precise data which is useful for quantifying impacts. But surveys are expensive to run, questionnaires restrict responses, and the questions may miss some of the farmers' most important impacts and views. Observation tours allow the M&E team to see the problems and conditions at the farmers' homes and fields. But the homes and fields visited may not be representative of the area as a whole. Given the strengths and weaknesses of each method, a combination of all three provides the best evaluation.

Part 3

Putting it into practice: planting and managing fodder shrubs

This chapter describes in detail the methods that farmers can use at all stages of fodder production, from sowing the seeds to feeding the animals. However the descriptions of the methods should be seen as guidelines rather than fixed prescriptions. It is important to encourage farmers to try different ways of doing things: they may find new and innovative solutions (see also page **49**).

More detailed information on nursery practices are given in the publications by Jaenicke, Jaenicke and Beniest, and Wightman which are listed on page **112**.

Decisions about fodder shrub propagation

Summary of establishment methods

Depending on the species, fodder shrubs can be established in the field by:

- Raising seedlings from seed in the nursery and transplanting them to the field, either in containers (usually plastic pots or tubes), or bare-rooted
- Taking stem cuttings from mature plants (only works well with certain species, such as mulberry and gliricidia)
- Sowing seeds directly in the field; this is known as *direct seeding*. Stem cuttings may also be planted directly in the field rather than first being rooted in the nursery
- Collecting seedlings (called wildlings) from the wild or from natural regeneration on the farm, and relocating them.

Seed or cuttings?

Most species are easily propagated from seed, provided that it is available and an effective germination method is known. Many species require pre-treatment of the seed to make it germinate, and information on how to do this is included in **Part 4** for the major fodder species.

Some woody species are easy to propagate vegetatively, most commonly from stem cuttings, though there are a number of other possibilities such as root suckers. The use of cuttings is a valuable alternative to raising plants from seed, in several cases:

- If the plant does not set seed naturally in the area where it is planted
- If there is a need to maintain material of high genetic quality (e.g. a superior provenance) by avoiding crossing with inferior genetic material
- If they are very easily propagated in this way, e.g. gliricidia and mulberry
- To obtain a mature plant (e.g. for seed multiplication) more quickly.

Nursery or direct seeding?

Plants can either be raised in a nursery and then transplanted, or planted (either as seed or cuttings) directly in their final position on the farm. In general, much higher germination and seedling survival rates can be achieved if the plants are raised in a nursery, because the plants can be looked after better, particularly with regard to watering and weeding. **Direct seeding** in the field should therefore only be used if:

- Seed is plentiful
- There is no suitable site, with a reliable water supply, for a nursery
- There is a reasonable likelihood that there will be adequate rain in the weeks following planting. Drought is the main cause of mortality in direct-sown seedlings
- Farmers are willing and able to protect the seedlings in the field, and to weed the plots.

If the supply of seed or cuttings is limited (as is usually the case), it is more efficient for farmers to raise the plants initially in a **nursery**. This is the most common and reliable method of establishing fodder shrubs. Weeds and other crops on the farm can easily choke small seedlings, so they are more likely to survive in a nursery. It is also easier to protect planted seeds from insects, birds and small mammals in a nursery than out on the farm.

An afternoon visit to a farmer's fodder shrub nursery

Containers or bare-rooted plants?

In the nursery, a further decision must be made as to whether to use **containers** or raise the plants in a bed and then plant them out **bare-rooted.** Containers may be:

- commercially available polythene bags or tubes
- recycled containers made for other products, such as milk packets, old tins or plastic containers
- made from woven banana fibre.

The use of banana fibre pots is common in Uganda, and has the advantages that it is cheap and the pots are biodegradable. Seedlings potted in banana fibre pots can be planted directly into the ground (without removing the pot) as the fibre decomposes in the soil. The disadvantage of banana fibre pots is that they dry out faster than plastic containers, so they should only be used where water is not a problem. If left too long in the nursery they may also degrade before the seedlings are ready for transplanting.

The use of bare-rooted plants avoids the costs of buying, making or collecting containers, and of filling them. Bare-rooted plants are also much lighter, so are easier to transport over long distances. However, they need much more careful handling, to avoid damage or drying of the root system, and survival is therefore often considerably lower. They take longer to establish, and are more susceptible to drought in the weeks following planting, because their root systems are less robust and have suffered more disturbance.

The decision on whether to raise seedlings in containers involves several factors:

- The cost and availability of pots/tubes or recycled containers, and whether farmers can afford them
- The distance from the nursery to the planting site, and the transportation available
- The likelihood of adequate and reliable rain after planting
- The value of the plants: if seed is scarce and/or expensive, it is more important to take every possible measure to maximise survival, including the use of containers.

The relative importance of all these different factors will depend both on the specific situation and on farmers' own perceptions. Often the best approach is to encourage farmers to try different methods, and make their own choices. For instance, they might try both bare-rooted and potted seedlings, and can then decide for themselves whether the extra costs of potted seedlings are worth the extra benefits. An organisation may find that farmers in the drier parts of their area of operation prefer potted seedlings, whereas those in wetter areas prefer bare-rooted ones.

Central nursery or farmer nurseries?

Some projects establish central nurseries and supply seedlings to farmers, but we advise against this approach for two reasons. First, it is an inefficient use of project resources as seedlings can be produced and transported at much lower cost by farmers than in central nurseries, where projects need to hire labourers and guards. Survival is also likely to be higher for locally produced plants. Second, and even more important, projects contribute greatly to building farmers' and farmer groups' capacities when they train them to raise seedlings rather than delivering seedlings to them. Producing their own seedlings gives farmers a sense of ownership. They are also more likely to give or sell seedlings to other farmers, and/or to expand planting within their own farms.

There are three ways in which farmers can raise seedlings:

- **Individual nursery**: The farmer raises the seedlings to meet his/her own needs and may sell or give away the extra seedlings. Usually this type of nursery is small in size as it is aimed at meeting individual farmers' needs.
- **Group nursery**: It can be established in a member's farm. This type of nursery is normally big so as to meet the members' needs. The group can also decide to sell or distribute for free some of the seedlings.
- **Commercial nursery**: This may be managed by an individual or a group of farmers with the aim of generating income. The nursery operator(s) in this case respond to the market needs both in species and numbers raised.

"A farmer trained in nursery production can raise seedlings for a lifetime whereas a project can deliver seedlings for only a few years".

How to grow fodder shrubs

Raising seedlings in nurseries

Seedlings can be produced from nurseries either in containers or bare-rooted. Both methods are described below. For potted plants, we recommend germinating the seeds in a seedbed first, then transplanting them into pots, to avoid wastage. It is also important to dispose of the bags carefully.

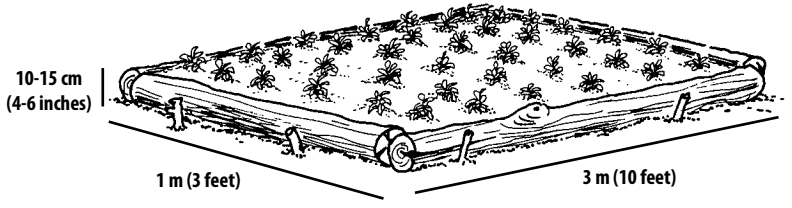
Locating and establishing a nursery

- Locate the nursery in a secure place, and near a reliable water source such as a river, deep well or piped water supply. It is essential to ensure the nursery has access to water throughout the 2-4 months that the seedlings are there.
- Clear the nursery site of weeds and fence it, to avoid destruction of seedlings by animals once they germinate. Fodder seedlings are highly palatable to wild animals such as antelopes and rodents, as well as domestic livestock, so the nursery must be well protected.

Preparing seedbeds

- Orientation: If possible, set the length of the nursery bed north to south so that the sun shines on the seedlings in the morning and in the evening when it is not too hot. The midday sunshine may scorch the seedlings if shading is not available, but complete lack of direct sunshine may result in thin, weak seedlings.
- Lay out the seedbed at a width of about 1 metre (3 feet). The length can vary with the available space. If there is more than one nursery bed, leave a path 0.6-1.0 metre (2-3 feet) wide between adjacent beds.
- To each seedbed apply one container of well-decomposed manure for every four containers of soil. This translates to about one 20-litre container of manure for every 3 metre (9-foot) length of the nursery bed. Mix the soil and the manure thoroughly. A balanced soil mixture ensures good soil aeration and drainage, and an adequate supply of plant nutrients.

- To make raised beds (also called Swaziland beds), pile up the soil and manure mixture to a height of 10-15 cm (4-6 inches), and then level it. Support the sides of the bed with locally available materials such as banana stems, timber or stones and secure them firmly with wooden pegs or stones. Use these beds in areas with adequate water.
- Levelling: It is important to have level nursery beds and fine soil texture, to improve seed germination.



Raised seedbed (Swaziland bed)

Sowing the seed

Timing

It is important to time the sowing of the seeds carefully. Ideally, the seedlings should be ready for transplanting at the onset of the rains. However, this is often the busiest time of the year on the farm, so you will have to discuss with farmers the advantages and disadvantages of planting at the onset of the rains or planting later. Most of the shrub seedlings described here are ready for transplanting after 2-4 months in the nursery.

Seed treatment

Hard-coated seeds (such as calliandra and the leucaenas) need to be treated with water to make them germinate faster. Specific treatment methods for each species are described in **Part 4**.

Inoculation

Rhizobium is a type of bacterium that lives in soil and around and inside the roots of many species of leguminous plants. It forms a close association with the roots of the plant, through which the plant can access nitrogen from the air. Sometimes the plant can use local strains of *Rhizobium*, but in most cases the *Rhizobium* population is not adequate, especially in areas where the species is being introduced for the first time. In this case the *Rhizobium* should be introduced into the soil. *Rhizobium* inoculant can be obtained

through extension and research services. It can either be applied to the seeds or to the seedlings.

To apply inoculant to the seeds, mix it with water, stir, and apply to pre-soaked seeds so that they are completely covered with *Rhizobium* mixture. Sow the pre-treated seeds immediately, avoiding too much exposure to heat and light. Alternatively, if inoculant is not available, soil can be collected from underneath mature shrubs that were previously inoculated with *Rhizobium*. This soil should be spread on the seedbed before sowing the seeds. It will contain the bacteria, but with this method there is a risk of spreading pathogens.

For seedlings, mix the inoculant with water and stir thoroughly using a stick, then apply the mixture to the seedlings by soaking leafy branches or a broom with the mixture and shaking them over the seedling bed. To ensure good spread of the *Rhizobium*, water the seedlings first before applying the *Rhizobium* mixture. Seedlings of any age can be inoculated, but it is best to do it when they are as young as possible.

Note: *Rhizobium* bacteria are destroyed by heat and light, so it is best to apply the inoculant in the late evening.

Sowing

Make a small furrow in the bed for accurate sowing. The depth of the furrow should vary according to the size of the seed: tiny seeds

Furrows should be 10 cm (4 inches) apart. Seeds should be placed 5 cm (2 inches) apart within the furrow.

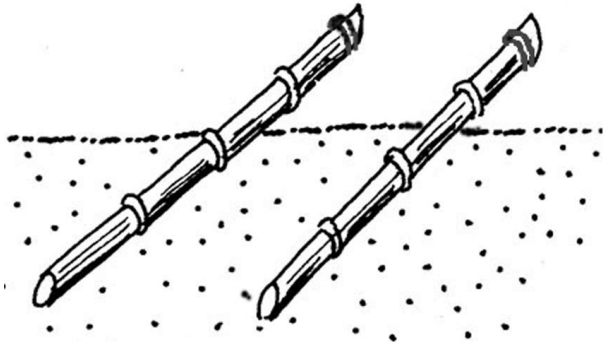
need a very shallow furrow, while for seeds such as calliandra or trichandra it should be about 2.5 cm (1 inch) deep. Furrows should be 10 cm (4 inches) apart. A seedbed of 1 x 3 metres (3 x 9 feet) produces about 600 seedlings.

Place the pre-treated seeds about 5 cm (2 inches) apart within the furrow, and cover them lightly with soil. Seeds should never be left exposed on the soil surface, but neither should they be too deep into the soil, where they are likely to rot.

A note on measuring: If there is no measuring tape or ruler available, use hands or sticks to estimate the distances. For example, the width of the palm is about 10 cm (4 inches) and the length of the first joint of the pointing finger is about 2.5 cm (1 inch). V-shaped sticks can be cut to the right measurements and used to mark where to insert the seeds. Alternatively, a piece of plywood or cardboard with holes spaced at the right distances, can be used to place the seeds on the nursery bed.

Stem cuttings

Stem cuttings can either be rooted in nurseries then planted out, or planted directly in the field. Cuttings should be taken from branches of mature trees, using only the woody parts of the branches. To improve the sprouting of cuttings, plant them slanted at an angle of about 45 degrees. Cover at least two nodes (the place on the stem where the leaves are attached) with soil, to produce roots, and leave two others above the ground to produce shoots. For most shrubs, cuttings root faster and grow more quickly than seedlings raised from seeds. One branch can produce three or four cuttings depending on its length.



Two nodes should be covered with soil and two nodes should be left above the ground

Tending the seedlings

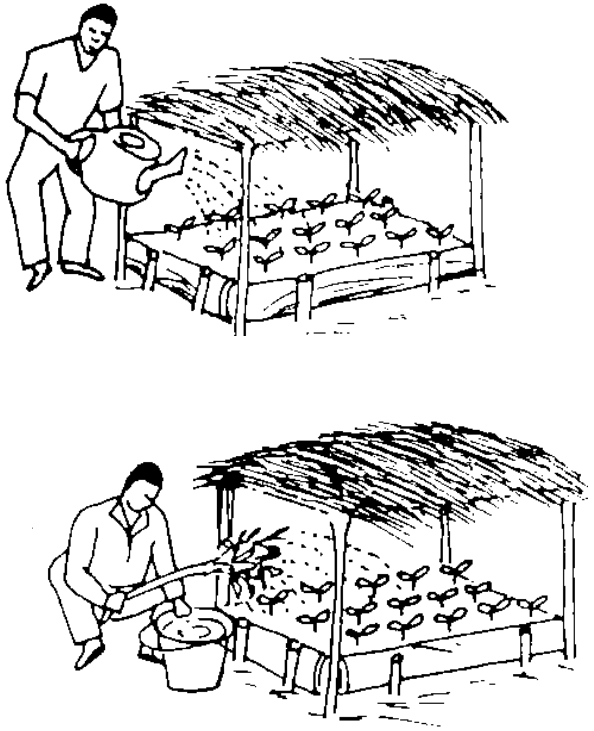
Careful work in the nursery will ensure high survival rates and healthy seedlings.

Watering during germination

Water the seedbed gently but thoroughly immediately after sowing, using a watering can or a perforated tin, or by shaking wet leafy branches or a wet broom over the bed. Proper watering during the first two weeks after sowing enhances seed germination. Carefully observe the moisture level in the bed and ensure that the young seedlings never look limp from lack of water and that the roots are not rotting because of excess water.

Shading

If the seedbed is in full sun at a hot site, it will need to be shaded. Make a shade structure 1 metre (3 feet) high and cover lightly with dry grass or tree leaves ensuring that some light passes through. It should not be any higher than this as the shade will be reduced and rain will be able to get in from the sides. Do not use branches from the eucalyptus (blue gum) tree since its fallen leaves inhibit germination of other plant species (*allelopathic effect*).



Watering of the seedbed could be done by using a watering can, a perforated tin, or shaking wet leafy branches or a wet broom over the bed.

Mulching

To increase the rate of germination, cover the seedbed lightly with dry grass until the seeds germinate. This maintains a moist, warm environment in the seedbed, but it should not be done if termites are a problem in the area (for ways to control termites, see p. **100**),

Raising bare-root plants

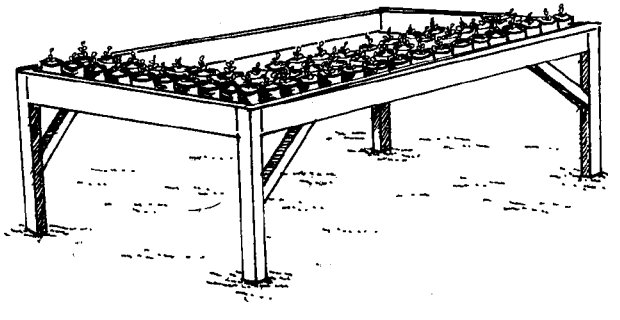
Seedlings that are being raised for planting as bare-rooted stock can be left in the same bed, but may need thinning out to 3-5 cm (1-2 inches) spacing if the germination rate has been high.

Potting

If polythene pots or tubes are being used (rather than raising bare-rooted seedlings), remove the seedlings from the seedbed after they produce a bud and two leaves, and plant one seedling per pot. If plenty of seedlings are available, two can be planted in each pot, and the weaker one removed later. The pot should be filled with soil mixed with well-decomposed manure and sand in the following proportions: one container of sand and one container of manure to three containers of soil.

The bag size depends on the desired seedling size. For large seedlings, use large bags. Large seedlings compete better and need less care after transplanting. However, small seedlings are easier and less expensive to grow and transport. Bigger bags will unnecessarily increase costs of both the soil mixture and transport. The usual size is 15-20 cm (6-8 inches) long and 6-12 cm (2.5-5 inches) diameter. Black plastic is best, to reduce the growth of algae on the inside of the pot.

Pack the potted seedlings together in a bed about 1 metre (3 feet) wide. Support the sides of the bed with stakes or stones to keep the pots upright. If only a few hundred potted seedlings are required, construct a frame for the pots, with a wire mesh base, raised a few feet above ground level. This makes weed control and root pruning easier.



Construct a raised frame for the pots a few feet above the ground to control weeds and make root pruning easier.

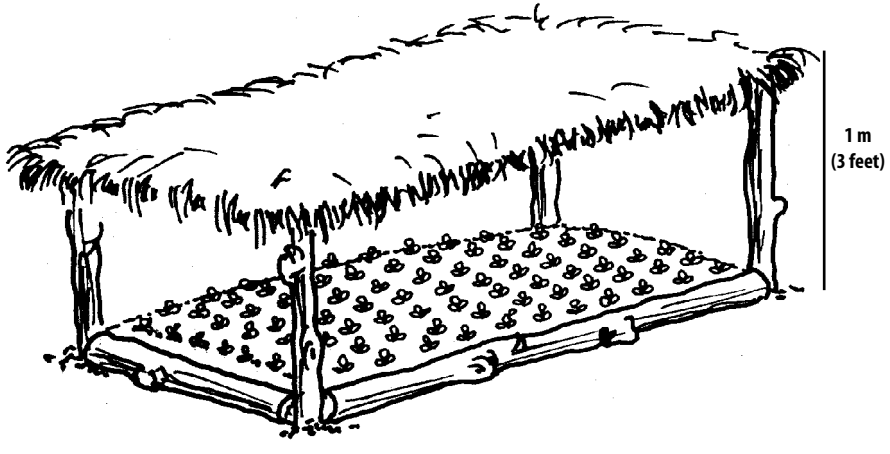
Locally available materials (banana bark above) can be used instead of commercial containers

Watering established seedlings

During the first two months after sowing, water the seedlings twice a day - early in the morning and late in the evening. After two months, when the seedlings are about 15 cm (6 inches) tall, reduce watering to once a day, preferably late in the evening. It is always important to make sure that the plants are neither too wet nor too dry.

Shading

At a hot site with direct sun, the beds will need shading as described for tending the seedlings in seedbeds on p. **83**. As the seedlings grow, the shade should be gradually reduced to get the seedlings used to full sunlight before they are planted out.



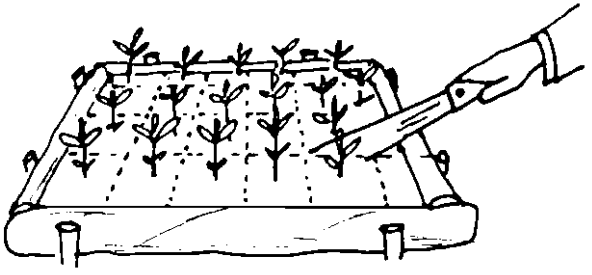
Make a shade structure 3 feet (1 metre) high covered with dry grass or tree leaves. Reduce the shading gradually as the seedlings grow.

Weeding

It is important to remove all types of weeds as soon as they appear, to ensure better growth of the seedlings. Never allow weeds to choke the seedlings. Tree lucerne is particularly sensitive to weeds, and all the seedlings can easily be lost if weeds are not controlled.

Root pruning

For seedlings raised in pots or tubes it is essential to prevent the roots from escaping from the bottom of the container and establishing themselves in the ground beneath. If this happens, a large taproot can develop which would have to be cut when the container is moved, seriously damaging the seedling. It is therefore essential to move the pots, or to run a sharp panga or other tool under them, every few days. Alternatively the roots can be 'air-pruned' by having a gap under the pots (e.g. if they are placed on a wire mesh rack), so that the root tips dry up and die as they emerge from the pot. This is also a useful labour-saving measure, but it requires initial investment. It is most suitable for high value seedlings and or those that stay longer in the nursery.



Pruning the roots of the seedlings increases their chances of survival after they are transplanted

Protecting against pests

Pests such as crickets, grasshoppers and cutworms can cause heavy losses of seedlings if left unchecked. A good and inexpensive remedy against cutworms is to sprinkle fresh wood ash around the seedlings. Another is to leave pieces of cardboard on the seedbed. The cutworms hide under them and can be collected by hand.

Some farmers apply mixtures made from plants such as tobacco or garlic to repel insect pests. Washing detergent can be used to control scales. If the pest damage is serious, apply the insecticides used in vegetable production.

Planting out fodder shrubs

Where to plant fodder shrubs

One of the most efficient ways to plant fodder shrubs on a farm is as hedges along internal or external boundaries or across slopes to conserve the soil. Often, unproductive hedges can be replaced with single or double rows of fodder shrubs. Planting shrubs in or around the crop fields also saves on the costs of weeding and protecting the shrubs, since the farmer will already be doing this for the benefit of the crops.

The fodder shrubs described in this book, with the exception of mulberry, develop deeper root systems than food crops, so they do not compete much for water and nutrients. Fodder hedges optimise the use of the available land while allowing the farmer to have easy access to high-quality fodder without affecting any other farm enterprise.

Possible planting sites:

- Along external and internal farm boundaries
- Along soil conservation terraces
- Around the homestead
- In fodder plots (also called fodder banks)
- In kitchen or home gardens
- In Napier grass plots
- On hilly areas.

Planting in rows

For medium- and high-rainfall areas (above 1,000 mm per year), a suitable spacing between shrubs planted in a row is 30 to 50 cm (12 to 18 inches). The rows can be either single or double: the spacing between double rows should be about 50 cm (18 inches) and in this case the planting should be in alternating spaces in the two lines (in a zigzag) so as to reduce soil erosion and optimise the use of land. In low rainfall areas, the spacing should be slightly increased. In Napier grass plots it is important to prevent the Napier from shading out the seedlings when they are small.

A farm of 1 hectare (2.5 acres) has over 400 metres (1,280 feet) of external boundary, plus additional sites along the internal boundaries, contours and around the homestead. Several sites are therefore available to plant fodder shrubs; and just by planting a single row of shrubs all round the boundary a farmer could establish about a thousand plants. This would be enough to feed two dairy cows or ten dairy goats throughout the year.

Planting seedlings in the field

Timing

The best time to transfer seedlings to the field is at the onset of rains when the soil has enough moisture and continuous rainfall is expected for more than two months. This ensures good establishment and growth of the seedlings and results in higher survival rates. However, competing labour demands may sometimes force farmers to delay planting of fodder shrubs until they have finished planting their food crops.

The process of planting out seedlings in the field includes the steps outlined below.

Preparing seedlings for planting out

Seedlings grown in containers are ready for transplanting when they are 25-50 cm (10-20 inches) tall: this is usually 2-4 months after sowing, for most fodder shrub species. Bare root seedlings need up to 5 months in the nursery, until they reach a height of 60-90 cm (2-3 feet). They need to be planted as quickly as possible after they have been uprooted.

About two weeks before transferring the seedlings to the field, they must be conditioned to withstand the harsh field environment. Expose them to full sunshine by removing the shading materials from the top of the nursery bed and reduce watering to only once every 2-3 days. This process is called 'hardening' the seedlings.

Preparing the site for planting seedlings

Choose a site for planting the fodder shrubs and clear all the weeds from it. Dig planting holes about 20 cm (8 inches) wide and 30 cm (12 inches) deep, or bigger than this in drier areas. The topsoil (usually the top 10-15 cm (4-6 inches)) and the subsoil (the layer below the top soil) should be kept separate.

Prepare the planting holes before removing the seedlings from the nursery. If manure is available, apply a 1-kg tin of manure to every hole and mix well with topsoil from the planting hole. Use well-decomposed animal and compost manure, mixed with fresh ash to improve its quality. Add a tinful of fresh ash to every 20 litres of manure. Besides adding to soil fertility, fresh ash also keeps off pests such as termites.

Taking the seedlings to the planting site

If the seedlings were raised for bare-root transplanting, remove them with some soil attached to their roots to help them survive in the field. Ensure that the seedbed is well watered before removing the seedlings. Use a sharp panga to cut first between the rows, then between the seedlings to form a square around each seedling, then lift the seedling with a cube of soil attached to the roots. Place a

Preparing bare-root seedlings for transplanting

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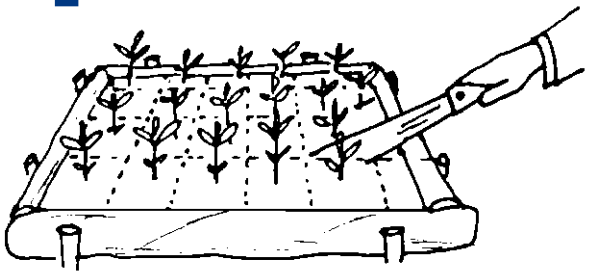

First cut vertically to form squares

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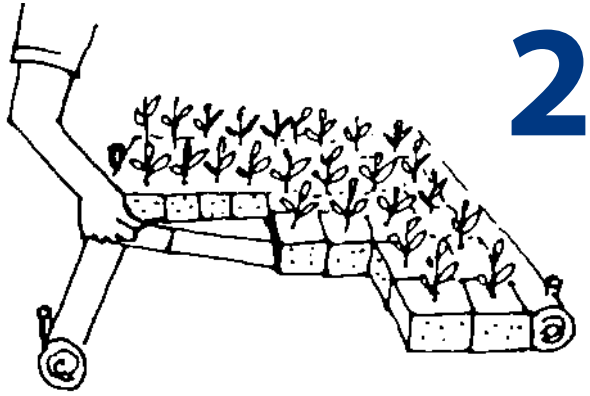


Then, cut horizontally, lift the seedling and place it in a container

3

Finally, place the seedling in a prepared hole in your chosen planting site

number of seedlings in a container, such as a bucket or a basin, for safe transportation to the field. Cover the seedlings with moist cloth or paper and take them to the planting site immediately. They should be planted within one hour.

If the seedlings were raised in polythene pots or tubes, transport them in their containers to the planting site. Water them thoroughly just before planting, to make it easier to remove the polythene bags while maintaining the soil attached to the roots. The polythene bags can be re-used.

Planting the seedlings

Position the seedling upright in the prepared hole and fill the remaining space with a mixture of topsoil and manure. If roots are encircling the soil ball, cut them on two opposite sides of the ball with a sharp knife. If the topsoil and manure is not enough to fill the hole, some of the subsoil can also be used but this should be put on top, so that the seedling can root into the topsoil/manure mixture at the bottom of the hole. When planted, the top of the soil block holding the seedling should be level with, or slightly below, the soil surface (a slight depression around the seedling will help to conserve water). Pack down the soil and manure mixture to make the seedling moderately firm. It is essential to water the newly planted seedlings well, whether potted or bare-rooted. It is also essential to keep the site well weeded after planting: see p. **93**.

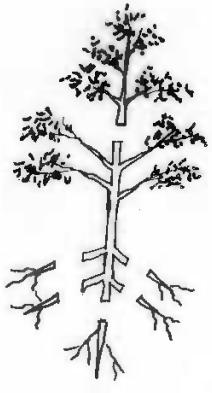
Note: Always remember to remove the polythene tubes before planting the seedlings! Also ensure that the seedlings retain some soil attached to their roots, to enhance their survival rates. Retaining soil on the roots of leguminous shrubs enables transfer of the *Rhizobium* inoculant to the field (see p. **80**).

Preparing overgrown seedlings

Sometimes seedlings become too big in the nursery, for instance if late rains delay planting. To prepare them before transporting them to the planting sites, uproot them after heavy rains when the ground is really wet. First cut the stem 15 cm (6 inches) above the ground and then cut the main root to 20 cm (8 inches) long. Finally, cut the lateral roots 5 cm (2 inches) from the main root. Pack these bare root plants in a bag, if possible containing sawdust to protect them, and transport them to the planting site. Only use this method for seedlings that grow too big in the nursery. Their survival is likely to be lower, and depends on the availability of plenty of moisture in the soil after planting.

- Uproot the seedlings after heavy rains when the ground is really wet.

- First cut the stem 15 cm (6 inches) above the ground.



- Then cut the main root to 20 cm (8 inches) long.

- Finally, cut the lateral roots 5 cm (2 inches) from the main root.

Preparing overgrown seedlings before transporting them to the planting sites

- Pack these bare root plants in a bag, if possible containing sawdust to protect them.

- Transport them to the planting sites.

Wildlings

Seed pods of some leguminous fodder species burst open when they ripen, scattering the seeds widely. These seeds later germinate into seedlings, which can be collected and planted on the farm. It may also be possible to collect seedlings of preferred fodder shrubs growing outside the farm - for example, in forests or on roadsides - and transfer them to the farm. It is important to collect wildlings from healthy-looking mother trees. For diversifolia (and leucocephala), it is best to avoid collecting either seed or wildlings from isolated trees, to avoid the risk of introducing poor quality trees to the farm. This is because these species can pollinate themselves so the seedlings may be *inbred*. This is NOT true for the other leucaena species used for fodder in East Africa, trichandra and pallida.

Wildlings are often used for indigenous species, for which there is not much information available on propagation methods. The care of wildlings is similar to that of bare-rooted plants raised in nurseries (see above).

Direct seeding

Fodder shrubs can also be established by directly sowing pre-treated seed at the planting site. This is an easy, labour-saving and cheap method, but frequently establishment is unreliable, and it requires good land preparation, preferably ploughing. Sowing should be done at the beginning of the rainy season: the seed should not be sown until the rains start. Direct seeding is successful only in areas where rainfall is reliable or where irrigation water is available. It should only be used for species which germinate easily and have plentiful, cheap seed.

Seeds should be sown 1 cm (½ inch) deep, lightly covered with soil, at a spacing of 30-50 cm. Usually two seeds are used per hole. Seeds germinate in 4-8 days. The main cause of mortality in direct sowing is animals eating seed, followed by competition from weeds. It is also important to ensure that people and animals do not trample the young seedlings. It may be necessary to remove some of the seedlings later if they become overcrowded, or to fill gaps if some spaces are empty.

For diversifolia (and leucocephala), it is best to avoid collecting either seed or wildlings from isolated trees, to avoid the risk of introducing poor quality trees to the farm. This is because these species can pollinate themselves so the seedlings may be inbred. This is NOT true for the other leucaena species used for fodder in East Africa, trichandra and pallida.

How to manage fodder shrubs

Management practices for fodder shrubs vary according to the products and services that the farmer requires: they may be grown for fodder alone, or also to provide other products such as firewood, stakes or seeds, or services such as soil erosion control, shade or beauty.

Management practices

- Fencing
- Weeding
- Thinning
- Filling in gaps
- Mulching
- Applying manure
- Coppicing (cutting back)
- Managing for seed production
- Protecting from pests and diseases
- Harvesting
- Feeding

Fencing

It is essential that livestock and wild animals are kept away from the fodder shrubs: in some cases fencing may be needed to ensure this. This is especially important when the plants are young, but trampling of mature shrubs also causes damage and can reduce their ability to regenerate after cutting.

Weeding

Young shrubs grow slowly and can easily be choked to death by weeds, which compete with them for water and nutrients and can also harbour pests. It is therefore very important to keep the area around the shrubs clear of weeds. In general, all vegetation within about 50 cm (18 inches) of the seedlings should be removed every 1-3 months. In arid conditions or shallow infertile soils, however, neighbouring vegetation may actually protect calliandra seedlings from sun and wind. Low-growing ground cover can protect the soil surface from desiccation and removing it may in fact increase seedling mortality in dry areas.

Thinning

Thinning involves removing some of the shrubs, to give the remaining ones enough room to grow strong and healthy. This management method is especially necessary when the shrubs have been established at close spacing by direct seeding. If managed for fodder, the plants should be about 30-50 cm (12-18 inches) apart. Any other plants at closer spacing than this should be removed, to allow the remaining ones to produce forage without competition. To grow shrubs to be used regularly for firewood and stakes as well as fodder, space them 1 metre (3 feet) apart to allow growth of stronger stems and branches. To conserve the soil, reduce the spacing to about 30 cm (12 inches).

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Filling in the gaps

Some seedlings (and even mature shrubs) may be lost owing to dry spells, accidental cutting and trampling, browsing by animals, damage by pests or other causes. Replace the lost shrubs during the rainy season, when there is adequate soil moisture.

Mulching

Mulching conserves soil moisture. It involves placing a thin layer of dry leafy materials around the base of each shrub to reduce loss of water through evaporation. It is useful in areas with low rainfall, especially during the dry season.

Do not place the mulch in direct contact with the shrubs, since the moist and cool environment could encourage pests and diseases. Also avoid mulching where there are termites, as this may increase damage to the shrubs by the insects. It is also important to make sure that the mulching material does not contain weed seeds.

Applying manure

Applying manure at least once every year, preferably at the onset of the rains, will enhance the growth of the shrubs and increase fodder production, particularly on acid soils. Each plant requires about 1 kg of well-decomposed manure mixed with ash.

Mix the manure with soil and spread the mixture along both sides of the hedge. Avoid spreading it just next to the base of the shrub, because the root system of the shrub (which absorbs water and nutrients) spreads away from the base of the plant.

Coppicing (cutting back close to the ground)

Coppicing is done to force new growth of multiple shoots and branches, to provide more fodder. It is best done when the shrubs are growing vigorously. Cut back the shrubs to about 15 cm (6 inches) from the ground. A clean, slanting cut, allowing water to drain off the stump, will prevent rot. The cut shoots and branches can be used as firewood or stakes, and the leaves as fodder.

Coppice for the first time when shrubs reach a height of about 2 metres (6 feet), usually 9 to 12 months after planting. The aim of coppicing at this stage is to encourage abundant branching for fodder production.

Coppicing can also be done when shrubs grow old and forage production falls, typically after about seven years. Cutting back the shrubs at this stage rejuvenates them by promoting new growth and hence production of more forage. Use a sharp panga, a garden saw or pruning shears to cut back the shrubs.

After coppicing, maintain the height of the hedges at a convenient level that allows more forage production and makes harvesting easy. Many farmers prefer to maintain their hedges at 0.6 to 1 metre (2 to 3 feet) high.

Cut back to a height of 15 cm (6 inches)

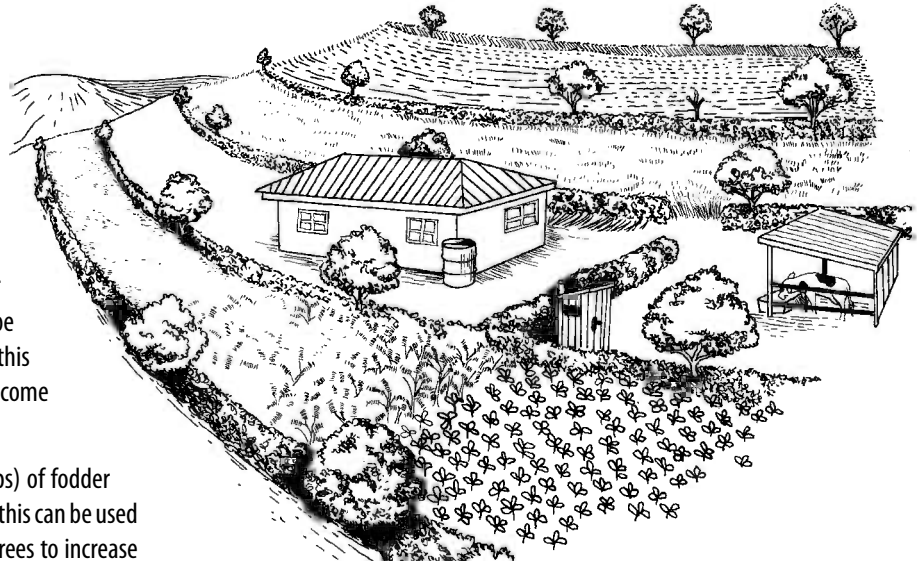
Managing fodder shrubs for other uses

As well as providing animal fodder, the shrubs can also help control soil erosion, improve the fertility of the soil, and provide bee forage, firewood, stakes and poles, fencing and shade. Some of the shrubs serve as ornamentals and windbreaks while others provide fruits. In addition, mulberry is used (mainly in Asia) for feeding silk worms, and sesbania leaves and bark were traditionally used as soap. Gliricidia is used for live fencing, because it sprouts so easily from cuttings and stakes.

Seed production

If there is local demand for fodder shrubs, some of the plants can be allowed to grow into trees which are large enough to produce seed. Some farmers also establish seed stands specifically for commercial seed production. The seed can either be sold directly, or used to raise seedlings for sale. In this way the plants can provide an additional source of income for the farmer.

For every 20 metres (60 feet, or about 20 large steps) of fodder hedge, leave one shrub uncut, to grow up into a tree: this can be used as a source of seed. Leave a total of more than 30 trees to increase the chances of cross-pollination and ensure that the seeds are of high genetic quality. If there are fewer than 30 trees on one farm, exchange seeds with neighbours, or mix seed from several farms, to ensure that the next generation of trees does not become inbred, reducing their genetic quality. If a tree is too tall to harvest the seeds, cut the upper part of the shoot to the desired height. Harvest forage for livestock from some of the branches that do not bear seeds.



Improved soil fertility

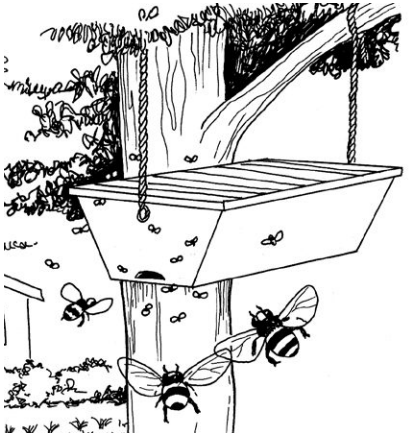
The deep root systems of fodder shrubs help collect nutrients from the soil that are too deep for many crops to reach. The roots take the nutrients to the soil surface where they are recycled into the system through feeds to the animal and then reincorporated as high quality manure. Leguminous shrubs also have the ability to take in nitrogen from the air and transfer it to the soil, making it available to plants (this is known as *nitrogen fixation*). These two processes are crucial to nutrient recycling in mixed livestock/crop farming systems. Calliandra, the leucaenas, sesbania, tree lucerne and gliricidia all contribute to improving soil fertility through nitrogen fixation.

Stabilised soil and water conservation terraces

When planted at close spacing along soil conservation terraces, the deep root system of fodder shrubs plays a significant role in holding the soil together. Soil erosion is reduced even more when the shrubs are planted alongside Napier grass on soil conservation terraces. To be effective in erosion control, the shrubs need to be planted at a close spacing of 12 to 18 inches (0.3 to 0.5 metres). It is best to plant them 18 inches (0.5 metres) above the line of Napier grass. Mulberry, calliandra, trichandra and sesbania are all used to control soil erosion. Planting Napier grass and fodder shrubs together also makes it easier to harvest and carry them together to feed the livestock.

Bee forage

Fodder shrubs that have been left to grow into trees with the objective of producing seed, firewood or stakes, can also provide forage (nectar) for bees (e.g. leucaena species, calliandra, mulberry, gliricidia). This gives the additional benefit of honey production on the farms, as well as increasing seed production in some of the species by contributing to pollination. Honey is nutritious and also fetches good prices in local markets.



Firewood

If the farmer wishes, some of the fodder shrubs can be kept for firewood production by reducing the frequency of cutting so that woody branches, large enough to use as firewood, have time to develop. Branches and stems of some fodder shrubs such as the leucaenas and calliandra dry quickly and burn well after only two days of drying. They burn steadily with little smoke and also make good quality charcoal. The shrubs produce plenty of firewood, because they grow fast and produce multiple branches when cut back to ground level (coppiced). Having readily available firewood in and around the homestead reduces the need to buy it in areas where wood is scarce. It is also a labour-saving factor for women, who often walk long distances to collect firewood for the family. However, leaving the shrubs uncut, to increase wood production, will have a cost in terms of reduced leaf fodder production.

Poles and stakes

Shrubs can be managed for stake production by cutting them back to ground level and letting them resprout. This will produce large quantities of stakes and poles within a short time. Stakes can be used to support tomatoes, peas and climbing beans. Poles are used for fencing and for construction. Mulberry produces long, straight stakes and poles. Leaf fodder can be harvested as an intermediate product from shrubs set aside for stake production (though production will be lower than if the shrubs are managed for fodder alone). Leaves can also be collected from harvested stakes and from branches that do not produce stakes. Calliandra, the leucaenas and gliricidia can all provide stakes, while several local fodder shrubs, including *Trema, Ficus* and *Sapium,* can provide poles.

Fruits (mulberry)

Mulberry provides nutritious fruits for the household. The fruits can be eaten directly, cooked or processed into juice. The shrub provides fruits even when managed for fodder production.

Ornamental value and shade

If left to grow into trees, some fodder species provide shade and beautify the home compound with the flowers that they produce. Forage can be obtained from these shrubs if harvesting is done carefully. Calliandra and gliricidia produce beautiful flowers if left uncut.

Fencing and home privacy

When fodder shrubs are planted as a hedge they form a live fence that provides some privacy to the home. These hedges can be maintained at the desired height as well as providing fodder. They also provide shelter from wind.

Protecting the shrubs from pests and diseases

Pests and diseases can attack fodder shrubs. This can lead to reduction in forage production and even to plant death. Fortunately only a few pests and diseases are known to cause serious damage to the shrubs. Some species are resistant to attack by pests such as termites.

It is important to be aware that fodder shrubs can harbour some pests and diseases which can also attack crops. Unlike annual crops, the shrubs remain on the farm throughout the year and so may act as a source of infection when new crops are planted.

Pests and diseases that attack mature shrubs include scales, black ants, termites, crickets and hoppers, and honey fungus (*Armillaria mellea*).

Scales are white, powdery insects that attack plant stems, especially calliandra. Scale attacks occur during the dry season. Control scales with washing detergents (30g of detergent dissolved in 20 litres of water). Sprinkle the detergent solution on to the affected plants using leafy branches, a broom or a knapsack sprayer.

Black ants damage the shrub by debarking the stems. To control the ants, dig out and destroy their nests. Smear wet dung or used motor vehicle oil at the base of the shrub or sprinkle some fresh ash to repel the ants.

Termites are destructive and cause serious damage by debarking the shrub and may lead to its death. Control them using the same methods as for black ants. Some farmers also use fresh urine from cows, diluted with water, to repel termites.

Nematodes live in the soil and attack the roots. *Rootknot nematodes* are a pest which particularly affects sesbania.

Crickets and hoppers are harmful to young and succulent seedlings at the nursery stage and immediately after transplanting. To control them use the pest repellents used in vegetable production (but see *Caution* next page) or a mixture of tobacco and garlic (a traditional method of pest control).

Armillaria mellea, or honey fungus, attacks the roots of plants, causing root rot and eventual death. *Armillaria* attack is common in areas where forests have recently been cleared. To control this problem, uproot the affected shrubs and burn them. Avoid planting shrubs for several years in areas affected by *Armillaria mellea*.

Caution: Avoid using chemicals to control pests and diseases on forage materials that are about to be fed to livestock. Such chemicals may affect the health of the animals and could eventually be transmitted to human beings through milk and meat. If it becomes necessary to use chemical pesticides, use products that have been approved for use in vegetable production, as these have a lower toxicity and/or persistence than other pesticides.

Scales are a typical pest of fodder shrubs in the dry season. They are frequently seen on the stems of calliandra.

How to use fodder shrubs

Harvesting forage

Frequent cutting of forage stimulates vigorous regrowth and, hence, sustained supply of fodder. It also ensures that the stems do not get lignified (woody), which would make the feed less nutritious.

When harvesting fodder, systematically cut both upright and spreading leafy branches. Maintain a uniform height for the hedges: this height will depend on the intended uses of the shrubs. For example, a hedge for the home compound can be maintained at 2 metres (6 feet) or higher, to provide privacy. Hedges on cropland should be maintained at 0.3 to 1 metre (1 to 3 feet) high to avoid shading the crops.

Forage is usually harvested using a sharp panga or knife, taking care not to split the stem. It is also possible to use secateurs (normally used for pruning coffee) or a sickle (used for pruning tea bushes and pyrethrum). Harvest from one end of the hedge to the other, so that each individual shrub is cut every 8-12 weeks, giving 4-5 harvests per year. The frequency of harvesting depends on the available rainfall, soil fertility and temperature: the higher these are, the higher the cutting frequency can be.

Feeding forage to dairy livestock

The diet of most dairy animals under zero grazing systems in eastern Africa region consists mainly of Napier and other grasses, and crop residues including maize stover, bean stalks (haulms) and banana stems, fed alone or in combination. These *basal feeds* are low in protein and thus need to be supplemented with other feeds which are richer in protein. Protein-rich feeds help the animals to produce as much milk as they are capable of (assuming the diet also contains sufficient energy and other nutrients, including minerals and vitamins). They also enable the animal to use other feeds, which are low in protein, more efficiently.

Protein-rich forages should be fed at a rate of 25% to 30% of the whole diet (i.e. about 1 part protein source to 3 parts basal feed). For best results, feed a combination of leguminous fodder species such as calliandra, leucaena species (trichandra, pallida, diversifolia) and gliricidia, and non-leguminous species such as mulberry. If more than 30% is made up of leguminous species, this wastes valuable protein and may also lead to adverse effects on the health of the animal, because many leguminous plants contain anti-nutritive factors (ANFs) which can cause health problems or give a characteristic flavour ('tainting') to milk. Further details about ANFs in the commonly used species are given in the species descriptions in **Part 4**.

Farmer harvesting calliandra fodder hedges

Leguminous shrubs contain high levels of protein (typically 20% to 28% "crude protein" – the standard measure of the amount of protein in a feed), while mulberry contains about 19% crude protein. However, mulberry is much easier to digest (digestibility up to about 80%) than calliandra (with digestibility of only 35-40%). In contrast, local grasses contain 8% to 10% protein in the wet season and less than 7% in the dry season. **Table 1** shows the nutritive value and potential yield of some of the most important fodder shrubs and other widely used feeds, as well as any important constraints to their use as fodder.

Many farmers buy commercial concentrates (dairy meal) to improve the quality of a grass-based diet. Some or all of the dairy meal can be replaced with shrub forage to save money. Owing to the high levels of energy in dairy meal, a combination of shrub forage and commercial dairy meal gives the best milk production. At very high levels of production, some supplementation with dairy meal is necessary (to provide energy and minerals), even if fodder shrubs are used as well.

The next section compares the economics of two possible scenarios: replacing dairy meal with shrub legumes ('substitution'), and adding shrub fodder to a low quality diet with no dairy meal ('supplementation').

Farmers who cannot afford dairy meal can formulate homemade rations. For example, a mixture of maize bran and dried shrub fodder at a ratio of 2:1 can greatly improve the level of nutrition of a cow. If the protein supplement is from the shrub forage alone, feed 6 to 10 kg of fresh leaves per cow per day (a dairy goat would need about 0.5 to 1 kg per day). Again, these rates and amounts are not absolutes; the farmer can experiment to determine the best substitution and supplementation rates for his/her cows.

Most species of shrub can be fed either fresh or dry. It was thought that calliandra had to be fed fresh (within a few hours of cutting) but more recent research has shown that it is an equally good feed either fresh or dry. Gliricidia, on the other hand, becomes much more palatable if it is wilted first. Excess forage produced during the rainy season can be made into leaf meal and stored for use in the dry season. Drying leads to a slight loss of nutrients, so leaf meal is made by drying the forage under shade to minimise this. If stored under good conditions, leaf meal can be kept for several months.

Table 1: Nutritive value, productivity and limitations of a range of fodder species

Species	Nutritive value	Dry matter (DM)	Potential leaf yield	Spacing	Limitations
	(% crude protein)	digestibility (in vitro)	(tons/ha/ year DM)		
Grasses					
Napier grass	7 - 14	55 - 58	17 - 30	1m x 1m	Low % CP
Maize leaves	9 - 15	50 - 61	1 – 2.7	0.75m x 0.25m	Low % CP
Herbaceous legumes					
Desmodium	16 - 24	54 - 55	4 - 7	1m inter-row drill between Napier rows	Poor persistence during dry season
Lucerne	17 - 22	68	7 - 11	30-50cm drill in pure plot	Low tolerance to low pH (acidity) and drought
Fodder shrubs					
Calliandra	22-28	35-40	6 – 16.7	30-50cm within hedgerow	High tannin level lowers digestibility
Trichandra	17-33	n/a	n/a	same	Accessions vary greatly in tannin level
Pallida	29-35	55-64	n/a	same	High tannin level lowers digestibility
Diversifolia	25-32	n/a	n/a	same	High tannin level lowers digestibility. Can become invasive.
Sesbania	15-20	75-90	Up to 20	same	Doesn't tolerate frequent harvesting (5 per year max.)
Tagasaste (tree lucerne)	20-30	77-82	Up to 10	same	
Gliricidia	18-30	60-65	Up to 20	same	Low palatability
Mulberry	15-25	75-80	5.6 – 11.2	same	May compete with crops
Others					
Sweet potato vines	11 - 18	75 - 77	15 - 18	1m x 0.5m	High moisture content. Biannual crop

Source: adapted from *Database on crop and livestock dissemination technologies for mandate districts under Regional Research Centre* – Embu, March 2001. Compiled and edited by F.M. Kihanda.

How much can a farmer save? How to show farmers the profitability of using fodder shrubs

Two options for feeding fodder shrubs

Fodder shrubs can address farmers' problems with feeding their animals in two ways:

- As a **substitute** for purchased dairy meal, to save money for the farmer
- As a **supplement** to other available feeds to improve the overall quality of the diet.

In the following analysis of profitability, we use calliandra because nearly all of the feeding trials in the region have used calliandra. Results may vary with other species. Two different scenarios can be used to show the profitability of calliandra.

Scenario 1—calliandra used as a substitute for dairy meal

Some farmers use calliandra instead of dairy meal; they thus perceive the benefits of calliandra to be the money they save from not having to buy dairy meal. In the economic analysis, the costs and benefits of feeding a cow 6 kg of fresh calliandra a day are compared with the costs and benefits of feeding 2 kg of dairy meal, which has about the same quantity of digestible protein and gives roughly the same milk output.

Assuming this substitution rate, we compare:

- the benefits of using calliandra, that is, the money saved by not purchasing and transporting the equivalent quantity of dairy meal for protein, with . . .
- the cost of using calliandra, that is, planting, cutting and feeding it.

Planting costs (including the costs of purchasing seed and raising bare-root seedlings) are modest-about $US 6 to $US 8 per 500 shrubs. Beginning in the 2nd year after planting 500 calliandra shrubs, a farmer's net income increases by between $US 101 and $US 122 a year by using calliandra as a substitute for dairy meal. The increases in income vary by site because of differences in prices (especially of milk) and in coefficients across the sites (**Tables 2-3**).

Scenario 2-calliandra used as a supplement to basal diet

Here, calliandra is fed in addition to the existing basal diet, which may or may not include dairy meal. The cow's diet thus remains the same except that calliandra is added. The farmer does not use calliandra to replace dairy meal or for any other component of the cow's diet, rather it is viewed as an additional supplement.

We compare:

- the benefits of using calliandra, that is, the value of the extra milk produced, with...
- the costs of planting, cutting and feeding calliandra

Beginning in the 2nd year after planting 500 calliandra shrubs, a farmer's net income increases by between $US 62 and $US 115 a year by using calliandra as a supplement for dairy meal (**Tables 2-3**).

Other benefits and costs

The above analysis does not take into account several other benefits of calliandra:

- It increases the butterfat content of milk (creaminess) and therefore its nutritive value. Unfortunately, milk from cows fed on calliandra does not usually fetch a higher price, but farmers say that they need to use less of it in their tea to get the desired taste and consistency.
- If used as a supplement, it can improve the cow's health and shorten the calving interval.
- It provides firewood, fencing, boundary marking, and erosion control.

The analysis also does not include the slightly negative impact that a calliandra hedge may have on crops next to it, by shading them or interfering with their roots (this is usually only a problem if the shrubs are not cut regularly).

Table 2: Selected coefficients and prices used in the economic analysis

Items	Values
Coefficients	
Calliandra quantity fed per cow per day	6 kg fresh leaves
Dairy meal quantity fed per cow per day	2 kg
Additional milk output per day from 3 kg fresh calliandra	0.6-1.4 litres
Additional milk output per day from 1 kg dairy meal	0.6-1.4 litres
Calliandra leafy biomass yield per shrub in year 1	None
Calliandra leaf biomass yield per shrub per year, years 2–5	4.5 kg (fresh weight)
Shrubs required to feed 1 cow per year	500
Labour required for planting calliandra	1 hour per 20-28 shrubs
Labour required for cutting and feeding calliandra	30-40 minutes per day
Prices ($ US)	
Dairy meal	$ 0.16-0.17/kg
Seedling cost of production (bare-rooted)	$ 0.50-0.96/100 shrubs
Labour wage rate	$ 0.51-0.79/ day
Milk price (farm gate)	$ 0.13-0.33/litre

Because coefficients and prices often vary by site, values are presented as ranges rather than specific values.

2003 Exchange rates: 1 US$ = [Shillings] 1881 Uganda / 76 Kenya / 1066 Tanzania

Table 3: Annual increases in income earned by farmers with 500 fodder shrubs at different locations, using different strategies.

Location	Increase in income ($US per year)	
	Substitution	Supplementation
Embu, Kenya, 2003	101	62
Kisumu, Kenya, 2004	122	115
Mukono, Uganda, 2003	112	93
Kabale, Uganda, 2003	102	72
Mean	109	85
Overall mean	97	

Notes:

Annual increases in income begin in the second year after planting, when farmers start feeding fodder shrubs to their dairy cows.

The substitution and supplementation strategies are defined in the text.

Data in this section are drawn from Koech (2004) and Mawanda (2004) [see *Recommended reading material* section in page **112**].

Photo: Neil Thomas

Helping farmers to assess the profitability of fodder shrubs

You can help farmers to calculate how much profit they are making from using fodder shrubs to feed their dairy animals.

Supplementation scenario: If the farmers are supplementing, you need to help them calculate how much extra milk they are producing by feeding fodder shrubs, and how much money they are earning from this. As above, you also need to help them calculate the cost of the labour they use to harvest the fodder shrubs.

The information needed is:

- Additional quantity of milk produced per day as a result of using fodder shrubs.
- Price of milk.
- Labour involved in harvesting and feeding the fodder shrubs.

Example: Before the farmer started feeding fodder shrubs, she obtained 10 litres of milk per day. After she started feeding the shrubs, the milk production increased by 1.5 litres of milk per day. Note that it does not matter whether or not she was feeding dairy meal; the important thing is that she did not reduce the quantity of dairy meal when she started feeding fodder shrubs. Assuming a milk price of $US 0.20/litre milk, the extra milk produced over a typical (300 day) lactation period amounts to about 450 litres or extra income of $US 90 per year. As above we subtract the costs of harvesting, $US 18, and 1/10 the cost of the raising and transplanting the seedlings, $US 1, to arrive at an annual increase in income of $US 71.

First determine the strategy they are using:

- **Supplementation** (using fodder shrubs in addition to the other feeds they normally feed) or
- **Substitution** (using fodder shrubs to replace dairy meal)

Substitution scenario: If the farmers are substituting, you need to help them calculate how much money they are saving compared to when they were using dairy meal. You also need to help them calculate the cost of the labour they use to harvest the fodder shrubs. A one year period is a convenient period to take for this analysis although you could use a different one if you wish.

The information needed is:

- Price and quantity of dairy meal that the farmer used to buy.
- Labour involved in harvesting and feeding fodder shrubs.

Example:

The farmer previously fed her cow 2 kg of dairy meal per day and got 12 litres milk per day. She found that she could eliminate dairy meal by feeding 6 kg fresh fodder shrubs per day and that she was still able to get the same 12 litres of milk per day.

The dairy meal price is $US 0.20/kg and over a 365 day period, the cost of feeding 2 kg per day would be $146. That represents the amount saved annually by substituting fodder shrubs for dairy meal, beginning in year 2 when the fodder shrubs are harvested for the first time.

Some farmers may want to value the labour for harvesting the shrubs and subtract this from the profit. If she spends 20 minutes (1/3 hour) per day harvesting and feeding fodder shrubs and labour is valued at $0.15 per hour then the cost of feeding fodder shrubs is $18 per year. The increase in income attributable to fodder shrubs is thus $146- $18 = $US 128 per year.

The analysis does not take into account the costs incurred in the first year for establishing the nursery and planting the fodder shrubs. Our analyses show that farmers spend roughly $US 10 in labour and materials to raise and transplant 500 bare-root seedlings. Assuming a 10-year period of depreciation, we could allocate $US 1 to each year. We would thus reduce the annual income by $US 1 to cover the cost of the nursery. The increase in income brought about by the adoption of fodder shrubs is thus $US 127, assuming 500 shrubs providing 6 kg of fresh leaves per day.

Recommended reading material

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Wanyoike, F. G. (2003). *Dissemination and adoption of improved fodder tree: The case of* Calliandra calothyrsus *in Embu district, Kenya*. Msc. Thesis, University of Nairobi. Department of Agricultural Economics, Kenya.

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List of acronyms

ARDC Agricultural Research & Development Centre

CBO Community-based organisations

CIG Common Interest Group

DFID Department for International Development, UK

DGAK Dairy Goat Association of Kenya

FRP Forestry Research Programme, UK

ICRAF International Centre for Research in Agroforestry

KES Kenyan Shillings

m.a.s.l. metres above sea level

MOA Ministry of Agriculture, Kenya

MoU Memorandum of Understanding

NGO Non Governmental Organisation

OFI Oxford Forestry Institute, UK

PRA Participatory Rural Appraisal

USD United States Dollars

Part 4

Important fodder shrubs for East Africa

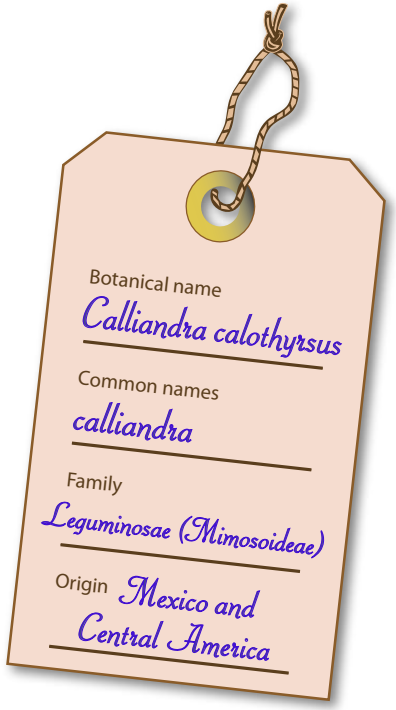
Calliandra

Calliandra calothyrsus (calliandra) is the most widely adopted exotic fodder shrub in East Africa. It use as fodder in the region started in the Central Highlands of Kenya but has now spread to the other countries in the region, including Uganda, Tanzania and Rwanda. It is a popular species for small-scale agroforestry in many parts of the tropics. Its **advantages** include:

- multiple products and services
- ease of establishment and management
- fast growth
- tolerance of acidic soils
- tolerance of repeated cutting
- ability to fix atmospheric nitrogen.

Its **disadvantages** are:

- low seed production
- only partial shade tolerance
- high levels of tannins, which make its digestibility relatively low and limit its usefulness for feeding non-ruminants.



Calliandra is native to Central America but it first started to be used for agroforestry in Indonesia, and it is from there that it was introduced to Africa, and many other parts of the tropics, during the 1980s.

Description

Calliandra is a thornless shrub or small tree, single- or multi-stemmed, and usually 4-6 metres (12-20 feet) tall (occasionally up to12 m (40 feet)). The stem diameter at the base is up to 20 cm (8 inches). It has compound (bi-pinnate) leaves, with leaflets sized 3-10 x 0.5-3 mm. The inflorescences are up to 17 cm (7 inches) long, with flowers opening sequentially from the base. Usually 4-5 flowers are open at any one time, and each flower only lasts for one day. The spectacular part of the flower is the long, red stamen filaments, which are 4-6 cm (1.5-2.5 in) long. The brown pods grow up to 14 x 2 cm (5.5 x 0.8 in), and contain about eight (sometimes up to 12) hard, dark brown, mottled seeds, 7-8 x 5-6 mm in size.

Trees may flower throughout the year (though this depends on local climatic conditions). Pollination takes place only at night, and is mainly by bats, though large hawk moths can also act as pollinators. Although bees and other small insects visit calliandra and take the nectar, the stamens are too long for them to act as pollinators. Individual flowers are receptive to pollination for only one night, though a tree may produce receptive flowers over a 4-6 week period. After the fertilisation of flowers, the fruit and seeds require 3-4 months to develop and mature.

Uses

Wood uses	Non-wood uses	Environmental services
Fuelwood	Fodder	Nitrogen fixation
Small poles	Mulch/green manure	Amenity & ornamental (trees & hedges)
Charcoal	Bee forage	Soil conservation/ erosion control
	Supports for climbing beans	Shade

Fodder

Animal fodder is the most important product of calliandra in East Africa. The leaves are a excellent source of supplementary protein in the diet of cattle, goats and sheep: in a study in Embu, Central Kenya (See Tuwei *et al*., 2003), the leaves contained about 22% protein (expressed as a proportion of the dry matter). However, calliandra also contains high levels of condensed tannins (up to 25%-30% of total dry matter), and this is probably why its dry matter digestibility is relatively low (35-40%). Despite these apparent drawbacks, calliandra has a very positive effect on animal production, particularly milk yield of improved (cross-bred) dairy cows and goats.

Wood

The main use of calliandra wood is as fuel, because it grows very quickly, coppices well and produces small diameter stems and branches. The wood is quite dense, burns well, and can also be used to produce charcoal. The stems are generally of poor form, and this limits the use of calliandra poles in light construction. However, in some parts of the region (particularly Rwanda and SW Uganda) small diameter wood is used as supports for climbing beans, and in some areas this is seen as its most important use.

Other uses

If not required for fodder, calliandra leaves can be used as mulch or green manure on other crops, to add nitrogen to the soil (because of its nitrogen-fixing ability). The nectar from the flowers is attractive to bees and they visit the flowers in the morning to collect the nectar left after nocturnal flowering. The honey is of very good quality and has a tangy flavour. Because of its showy red flowers, calliandra is also quite widely used as an ornamental tree.

Land use, environmental and service aspects

Hedgerows of calliandra have been planted across sloping land to reduce soil erosion and improve soil fertility. It can also be used to improve fallow agricultural fields and degraded land.

Climate and Soil

Climate

Calliandra is native to both the seasonally dry and humid tropics of Mexico and Central America. It can tolerate 2-4 months of drought but it grows best in higher rainfall areas with a short dry season. It is not frost tolerant, though it grows in areas of the East African highlands where night-time temperatures can be as low as 3°C.

Soil

Calliandra occurs naturally on a wide range of soils in its native range, and so does well in a variety of soils wherever it has been introduced. One of its main features of interest to agroforesters is its tolerance of acid soils (e.g. alluvial deposits, clays and sandy loams). Although it performs worse on acid than on neutral soils, it is more acid-tolerant than most other fodder shrubs. It grows in environments ranging from flat river banks to steep slopes (where it has been used in soil stabilisation projects). It does not tolerate waterlogging, soils with poor drainage, or soils which are regularly flooded.

Climate	
Altitude range	0-2200 m
Mean annual rainfall	>800 mm (unimodal or bimodal)
Dry season duration	2-4 months
Mean annual temperature	22-28°C
Mean max. temp. hottest month	19-30°C
Mean min. temp. coldest month	9-26°C
Absolute minimum temperature	3°C
Frost tolerance	No
Soil	
Texture	Light - medium
Drainage	Free, well drained
pH	Acid (pH>4.5), neutral, alkaline.
Special tolerances	Infertile soils
Soil types	Wide soil tolerance; thrives on volcanic soils

Genetic variation

A project coordinated by the Oxford Forestry Institute (UK) in the early 1990s collected provenances of calliandra across the native range in Central America, and compared them with the land races (domesticated seed sources) from Indonesia and Kenya (Embu), in a series of provenance trials. These revealed great variation in productivity amongst provenances, with the Embu land race being one of the more productive, along with the provenances Patulul (from Guatemala) and San Ramón (from Nicaragua). Further evaluation of the Patulul, San Ramón and Embu provenances in terms of fodder quality (both laboratory analyses and animal feeding trials) showed that Patulul and Embu provenances were significantly better quality than San Ramón and should be preferred for fodder use.

Measuring the leaf production of different provenances of calliandra in Embu, Kenya.

Planting and management

Seed collection

Seed production is often a problem with calliandra. It is highly variable from place to place, and calliandra is always a relatively light seed producer compared to other leguminous tree species. Production of too little seed (or none at all) may be due either to an absence of pollinators (usually bats) or to poor site conditions (inappropriate climate and poor soil fertility). If soil fertility is limiting, seed production can be improved by incorporating leaf mulch or animal manure in the soil at the base of the tree.

Calliandra produces clusters of pods. The seeds are naturally dispersed far away from the mother tree as the seed pods split from the tip to the base and burst open suddenly, sending the seeds up to 10 m (33 ft) from the mother tree. Seeds can also remain in the open pod, and drop to the foot of the mother tree at a later date. It is important that only mature pods and their ripe seeds are collected, so timing of seed collection is critical. The pods should be mature and dark brown, but not yet opening and allowing the seeds to disperse. The mature pods can be cut off using long-handled pruners, or the branches can be carefully bent down and the pods removed by hand. The sequential ripening of the pods means this has to be done every 7-10 days for each tree. Seed trees can be maintained by pruning to a height where seed collection is easy (3 m (10 ft) or less). The pods should be put in a cloth or paper bag, in a dry place, do that they open inside the bag and the seed is not lost.

Seed treatment

There are about 18,000-20,000 seeds per kilogram. Dried seed can be stored in air-tight containers at 4ºC for at least 1-2 years owing to its hard seed coat. Bulk seed should be stored in sacks in a shaded, cool, dry area, protected from insects, rats, and mice. Pretreatment of seed is not essential if the seed is fresh. However, to achieve rapid and uniform germination, calliandra seed should be pre-treated before sowing by soaking it in cool water for 24-48 hours. Soaking in hot water for 5-10 minutes before the cool water treatment may increase germination, although care is needed because if the water is too hot (boiling) it can kill the seed. Fresh or well stored seed, properly pre-treated should give germination rates of 75-90%. Inoculation of the seeds (or the nursery soil) with mycorrhiza and/or *Rhizobium* enhances tree growth and appears to be particularly important for marginal sites (see p. **80**).

Propagation & establishment

Propagation of calliandra can be by seedlings raised in a nursery, wildings collected from under a seed tree, or direct seeding. The methods described on pages **79-86** are all suitable for calliandra.

Management

Calliandra seedlings usually grow slowly initially. It is important to keep the area around the young plants free of weed competition over the first 12 months (see also p. **93**).

Calliandra can tolerate medium shade, even though it grows best in an open situation. Its shade tolerance makes it suitable for inclusion in densely planted home garden systems (e.g. the *Chagga* home gardens on the slopes of Mt. Kilimanjaro in Tanzania).

The most important attribute of calliandra, with regard to its management in agroforestry systems, is its ability to tolerate repeated cutting (and also browsing at ground level), and to regenerate rapidly.

Calliandra growing under the shade of bananas.

Harvesting

Cutting, ideally with secateurs (for a clean cut), but commonly done using a *panga*, is the preferred harvesting method. Direct browsing is possible but not recommended, because:

- The wood is fairly brittle and branches may be broken during browsing, unless the trees are cut at ground level and allowed to resprout.
- If the animals chew the bark from the trunks, the trees may die.

Harvesting can start 9-12 months after planting. The ideal cutting height is 50-100 cm (1.5-3 ft), and should not be lower than 30 cm above ground, although cutting frequency (normally 6-12 weeks) is more important than cutting height to ensure maximum productivity. Leaves can be harvested every six weeks on fertile soils, during the rainy season. In drier weather and/or on poorer sites, the harvesting interval should be increased to 12 weeks or more. Normally 4-6 harvests per year can be expected.

To optimise the fodder's nutritive value, the leaves and young succulent branches should be cut when there is about 100 cm (3 feet) of regrowth. At this stage, the edible part is about 50-60 % of the total biomass. When the fodder is lush and growing rapidly, animals will consume the soft green stems up to a diameter of about 1 cm (0.5 inches). When plant growth is slower, however, the stems become lignified at a smaller diameter, and livestock may limit their consumption to stems of about 0.4 cm (0.2 in) or less.

Fodder productivity when grown in double rows in several African countries ranges from 0.8 to 8.2 kg of dry matter/m of hedge, depending on the soil fertility and the climate. Cutting six months before the height of the dry season gives maximum yield during that season.

Although calliandra can be coppiced for up to 20 years, vigour declines with age and plants should normally be replaced after about 12 years.

Feeding

Goats readily consume calliandra, but cattle may need an adjustment period when it is first introduced to their diet. In general, ruminants (cows, goats and sheep) are more able than non-ruminants (pigs, horses, chickens, rabbits) to digest calliandra. This is because of the large amount of tannin in the leaves, which can be toxic to non-ruminants if fed in large amounts. Rabbits and chickens can eat calliandra in small quantities as part of a mixed diet (maximum 5% of the diet). It also produces a good yellow colour in egg yolks, although bigger quantities will reduce the number of eggs produced per chicken.

It used to be thought that calliandra should be fed fresh, but it has now been shown to give very similar effects whether fed fresh or dry. Because of its high protein content it should comprise no more than 30% of the feed ration, to give a balanced diet. As explained on pages **106-111**, fodder shrubs can be used either to supplement or to substitute for commercial concentrates. In the case of calliandra, it has been shown that 1 kg of concentrates can be successfully replaced by 3 kg of fresh calliandra in the diet of dairy cows.

Pests & diseases

There are few serious pest and disease problems in calliandra in most parts of the region, although there has recently been an increasing problem of sudden dieback and death, as yet unexplained, of young (2-3 year old) calliandra trees in southern Uganda. In Kenya, there was a limited outbreak of root rot at cool high altitude sites, caused by the fungal pathogen *Armillaria mellea*. In Uganda and Tanzania, scale insects attack calliandra during the dry season, but the problem becomes less serious during the rains.

There have also been infestations recorded in Kenya by the rose flower beetle (*Pachnoda ephippiata*, bruchid), probably aggravated by prolonged dry spells. These attack the flowers and hence reduce seed production.

Although calliandra has proven quite resistant to pests and diseases there is always a danger in relying too much on a single species. Thus, it is advisable that farmers plant it along with other fodder species. Farmers will also benefit from the strengths and weaknesses of different species.

Scale insects attack caliandra during the dry season, but the problem become less serious during the rains.

Further reading

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Internet links

FACTNET information sheet: http://www.winrock.org/forestry/factpub/FACTSH/C_calothyrsus.htm

FAO Grassland Species Profiles: http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000470.htm

World Agroforestry Centre Agroforestree database http://www.worldagroforestry.org/Sites/TreeDBS/aft/speciesPrinterFriendly.asp?Id=410

Tropical Forages: an interactive selection tool: http://www.tropicalforages.info/key/Forages/Media/Html/calliandra_calothyrsus.htm

Diversifolia

The strengths of diversifolia include some tolerance of low temperatures, acid soils and (for some accessions) resistance to attack by the psyllid insect. However it does not do well on hot and/or arid sites, and its nutritive value (especially digestibility) is reduced by its relatively high tannin content. It has been widely promoted worldwide as a higher altitude alternative to *Leucaena leucocephala*, and is now found throughout the tropical highlands. As it is self-fertile, it sets seed very easily. Its high seed production gives it the potential, like *L. leucocephala,* to become invasive in areas where there are no browsing animals.

Description

Diversifolia is naturally a medium-sized tree, 10-20 m in height and 10-40 cm in diameter, usually single-stemmed with an open spreading crown. The leaves are compound (*bi-pinnate*), with 14-28 pairs of pinnae and 48-58 pairs of leaflets on each pinna. The leaflets are about 1 mm wide and 4-7 mm long. The pointed apex of the leaflet is usually off-centre. Like all *Leucaena* species there is a characteristic raised gland on the leaf petiole, but this is very variable in size and shape. The flower heads are borne in clusters in the leaf axils and are 11-15 mm in diameter. Each flower head contains 45-90 flowers, and their colour ranges from bright red to light pink. Each flower head produces 1-6 pods: these are flat, dark brown or reddish-brown, sometimes shiny, with a papery texture. They are10-13 cm long x 13-16 mm wide, and contain 6-20 seeds. The seeds are small (4.3-5.5 mm wide x 2.7-3.4 mm long), and there are 60,000-80,000 seeds per kg.

Uses

Fodder

Diversifolia is high in protein (25-32%), but its digestibility is reduced by its high tannin content (6-19% of dry matter). It also contains low levels of the anti-nutritive compound mimosine (approx. 2% of dry matter). It has been found to be highly palatable (more so than most other *Leucaena* species) in short-term trials with sheep and cattle.

Wood

The wood makes good quality fuelwood and charcoal. It can also be used for poles and construction timber if managed as a tree rather than a hedge.

Other uses

The foliage can be used as a green manure, contributing nitrogen, phosphorus, potassium, calcium and magnesium to the soil.

Land use, environmental and service aspects

Hedges containing diversifolia can be planted across slopes for soil conservation. It is also used as a shade tree for perennial crops such as coffee. Like all *Leucaena* species, it fixes nitrogen and so contributes to soil fertility.

Wood uses	Non-wood uses	Environmental services
Fuelwood	Fodder	Nitrogen fixation
Poles	Green manure	Soil conservation/ erosion control
Charcoal		Shade

Climate and Soil

The native range of diversifolia in Mexico is evergreen cloud forest on mountain slopes, so it tolerates damp, cloudy conditions and frequent mist.

Climate	
Altitude range	Up to 2000 m in East Africa
Mean annual rainfall	1500-3500 mm
Dry season duration	Up to 3 months
Mean annual temperature	18°-30°C
Absolute minimum temperature	0°C
Frost tolerance	Tolerates very light frosts (though these may kill seedlings)
Soil	
Drainage	Grows best on freely-draining soils
pH	Prefers slightly acid soils (pH 5.0-6.5)
Special tolerances	Tolerates leached soils

Genetic variation

The accessions tested so far for fodder quality have shown considerable variation in insect (psyllid) resistance and in tannin content.

Hybridisation

It is important to be aware that diversifolia can hybridise easily with both pallida and leucocephala; so if it is grown near to either of these species, seeds collected from diversifolia plants may be hybrids.

Planting and management

Seed collection

Diversifolia seed is easy to collect from the tree, as the pods do not open until the seed is ripe. After extraction and drying (to 5-8% moisture content), it can be stored in sealed containers at room temperature for several years.

Seed treatment

The seed has a hard coat and must be treated before sowing. Soak seed in warm water for two days (48 hours) before sowing in the nursery.

Propagation & establishment

After treatment, diversifolia seed takes about a week to germinate. The seedlings usually need 8-12 weeks in the nursery before planting out. Alternatively, where diversifolia seed is plentiful, it can be established directly in the field by direct sowing of pre-treated seeds.

Management

Diversifolia is somewhat shade-tolerant. It also recovers well after fire, resprouting readily from burnt stumps. However, its most important attribute, with regard to its management in agroforestry systems, is its ability to tolerate repeated lopping (and also browsing at ground level), and to regenerate rapidly.

Harvesting

Like the other leucaenas, diversifolia tolerates repeated cutting so is easy to manage as a hedge, with harvests every 2-3 months (less frequently in the dry season).

Feeding

Diversifolia should not comprise more than 30% of the total diet for ruminants, because of the tannins and mimosine that it contains. This also makes it unsuitable for non-ruminants (e.g. pigs, horses, rabbits, poultry), and it should not be fed at more than 10% of the diet for these animals.

Pests & diseases

Some accessions of diversifolia are moderately resistant to the *psyllid* insect (*Heteropsylla cubana*) which as a pest of most *Leucaena* species, but others are highly susceptible, including 'K156' which was the most widely-distributed accession in the 1980s and 1990s. A range of pathogenic fungi and other insects occasionally attack diversifolia. Newly emerged nursery and field-grown seedlings are susceptible to damping-off diseases caused by the fungal species, *Pythium* or *Rhizoctonia*. A range of soil insects such as earwigs, scarab beetles, termites and cut worms can also cause serious damage to emerging seedlings.

Further reading

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Internet links

World Agroforestry Centre Agroforestree database:

http://www.worldagroforestry.org/Sites/TreeDBS/aft/speciesPrinterFriendly.asp?Id=1068

Tropical Forages: an interactive selection tool: http://www.tropicalforages.info/key/Forages/Media/Html/leucaena_diversifolia.htm

Gliricidia

Gliricidia is native to seasonally dry parts of Mexico and Central America, but it has been planted in other areas for several hundred years and is now naturalised in most parts of the tropics. It is a true multipurpose tree, with several important uses in addition to fodder. The species name *sepium* is from the Latin for hedge: it is very widely used as a live fence because of its ability to sprout easily from stakes. It fixes nitrogen and is a preferred species for improved fallows. It is also widely used as a shade tree for perennial crops.

Gliricidia is a very good quality fodder for ruminants, although there are palatability problems in some areas. The Latin name *Gliricidia* and the Spanish name *Mataratón* both mean 'mouse killer', referring to the toxic compounds (*coumarins*) found mainly in the roots and bark but also in the leaves, which can be used as rat poison. However, these compounds are only poisonous to non-ruminants.

Of the eight fodder species described in this chapter, gliricidia is the best adapted to hot, dry sites, and also has the highest potential biomass production of any of the species. It tolerates a wide range of soils and climates, though it is not at all frost-tolerant.

Description

Gliricidia is a small to medium-sized tree up to 12 m tall, heavily branched and often multi-stemmed from the base. The bark ranges from greyish-brown to whitish in colour and can be deeply fissured at the base of older stems. The branches often have white flecks (*lenticels*). Leaves are up to 30 cm long, with 7-25 leaflets arranged in two rows on either side of the midrib (*pinnate*), plus one at the leaf tip. The leaflets are 2-7 cm long x 1-3 cm wide, papery in texture and oblong in shape with a distinctive pointed tip. They increase in size towards the end of the leaf. The lower surface of the leaflet commonly has purplish patches.

The bean-like flowers are usually pink in colour, fading to a whitish-brown or faint purple with age. They are arranged in short, upward-curving flower heads, 5-15 cm long, containing 20-40 individual flowers. The pods, which contain 3-10 flat, round seeds, are 10-18 cm long x 2 cm wide. They are pale green or reddish-green when unripe, turning straw yellow-brown when fully ripe. The pods burst open (*dehisce*) explosively when ripe, scattering seeds as far as 30 m from the tree.

In its native range there is a pronounced dry season during which gliricidia sheds its leaves, and flowers whilst leafless. Where the dry season is not so pronounced (as in much of East Africa), gliricidia retains its leaves throughout the year and can also flower at any time of the year, but under these conditions it usually does not produce seeds.

Uses

Fodder

The fodder quality of gliricidia for ruminants is excellent, with a high protein content (18-30%), high digestibility (60-65% *in vitro*) and low levels of fibre and tannin. As a result it has a clear positive effect on production in ruminants. Coumarin, an anti-nutritive factor found in the roots, bark and leaves, is toxic to non-ruminants, so animals such as pigs, horses, rabbits and poultry should be given only small amounts (less than 10% of the diet).

For ruminants, the problem with gliricidia as a fodder is its palatability, which seems to vary in different parts of the world. In Colombia and Sri Lanka, there is no palatability problem and it is an important dry season feed, whereas in Indonesia, India and West Africa problems have been reported.

Wood

If gliricidia is allowed to grow into a tree, it produces useful timber which is very hard, long-lasting and resistant to termites. The wood has light brown sapwood and dark brown heartwood. It can be used for railway sleepers, construction, furniture and tools.

Gliricidia prunings are widely used for firewood and charcoal production. The wood is slow to season, but once dried it burns slowly without sparks and with little smoke.

Other uses

- Gliricidia flowers attract honey bees so it is good species for honey production.
- The leaves are a good green manure as they are high in nitrogen and break down rapidly in the soil.

Land use, environmental and service aspects

- Gliricidia is widely used in many parts of the tropics for live fences, made by rooting large stakes as the fenceposts and stringing wire between them.

- When managed as a close-spaced hedge for fodder, it can also contribute to erosion control when planted along the contour.
- It is an important component of improved fallows, owing to its fast growth and ability to fix (accumulate) nitrogen from the air.
- It provides good light shade for perennial crops such as coffee and tea.

Wood uses	Non-wood uses	Environmental services
Fuelwood	Fodder	Live fences
Poles	Mulch/green manure	Amenity & ornamental (trees & hedges)
Charcoal	Bee forage	Nitrogen fixation
	Improved fallows	Soil conservation/ erosion control
		Shade

Climate and Soil

Gliricidia does not grow well on cool sites. Mean annual temperatures below 15°C lead to leaf fall and poor growth, while temperatures close to freezing cause dieback.

Climate	
Altitude range	0-1600 m
Mean annual rainfall	600-3500 mm
Dry season duration	Up to 6 months
Mean annual temperature	15°-30°C
Absolute minimum temperature	5°C
Frost tolerance	No

Soil	
Drainage	Prefers well-drained soils and does not tolerate waterlogging.
pH	4.5-8.0
Special tolerances	Some salt tolerance. Tolerates moderate acidity but not when there are high levels of aluminium in the soil.
Soil types	Grows on a wide variety of soil types including eroded volcanic soils, pure sands, heavy clays and deep alluvial deposits.

Genetic variation

There was a programme coordinated by Oxford Forestry Institute, UK, in the 1980s to collect provenances (accessions) of gliricidia from all over the native range in Central America and Mexico, and evaluate their performance in trials throughout the tropics. The most productive provenance was found to be *Retalhuleu* (from Guatemala: also known as *Mayan Gold*). Small amounts of seed of this provenance are available from the World Agroforestry Centre. This can be planted as a multiplication plot from which cuttings can be taken for wider planting.

If superior material such as this is planted in an area where gliricidia sets seed, it is important to keep propagating it by cuttings to avoid diluting its superior quality through crossing with local material.

Planting and management

Seed collection

The seeds are scattered from the tree when the pods split open, so it is best to collect the pods before they open, but when they are mature. Mature pods are yellow-brown in colour and extremely brittle. The pods all ripen at the same time on one tree, so only one collection is needed.

After collection, the pods should be left in the sun to dry, on sheets to collect the seeds. Barriers are needed around the edge of the drying area to stop the seeds that may be thrown out of the pods as they open. It is better to let the pods open naturally than to open them by hand. After opening they can be threshed manually in a sack to separate the seeds from the pods.

It is also possible to collect seeds from the ground after they have been shed. This has the advantage that the seed is fully ripe, but there is a higher risk of insect predation.

Seed treatment

There are about 8500 seeds per kg. They maintain their viability for up to a year at room temperature, and for much longer under controlled conditions of cold storage: at 4°C and 6-10% moisture content, the viability remains over 90% for ten years.

Gliricidia seed can be sown without any pre-treatment, especially if it is fresh. Seed more than a year old may be soaked at room temperature for 24 hours, but hot water treatment is not necessary.

Propagation & establishment

Gliricidia can be very easily established from cuttings. This method is usually used in East Africa because gliricidia does not set seed well in most parts of the region. However, planting by seed gives deeper roots with greater capacity to find water and nutrients, which eventually results in higher biomass production (though production is higher for the first few harvests with cuttings). The deeper roots of seedlings can also reduce competition with nearby crops, and provide more effective erosion control when planted across slopes.

Both methods are described here.

Propagation from cuttings:

Cuttings should be taken from hard, woody branches. For best results when using the cuttings to establish a hedge, they should be at least six months old, 50 cm (18 in) long and 1-2 cm (0.5 -1 in) diameter. They should be planted as soon as possible after collection, at an angle (to stimulate root growth). Each cutting should be given a slanting cut at the sprouting (top) end to prevent rotting, and wounded at the lower end (by making several cuts with a panga) to promote rooting.

Propagation from seed:

The seeds should be sown to a depth of 1-2 cm (0.5-1 in). Germination usually starts after 3-4 days and is complete after 12-15 days. If raised initially in a nursery bed, the seedlings can be pricked out into pots when they reach about 5-6 cm (2-3 in) in height, and the first leaves appear. At this stage moderate (though not too heavy) shade is important, but this should be reduced then removed a few weeks before planting to allow the plants to harden off. The seedlings should be ready for planting out after 10-12 weeks in the nursery, when they are 30-40 cm (12-15 in) tall. If they get too large (>50 cm, or 20 in) the seedlings should be cut back to about 10 cm (4 in) before planting out.

Management

Newly-established seedlings need protection from browsing animals, weed competition and fire (though larger gliricidia plants are moderately fire-tolerant).

Gliricidia tolerates repeated pruning, and cutting between 0.3 m and 1.5 m above the ground stimulates leaf production. It can therefore be easily managed as a hedge. In dry areas, where unmanaged gliricidia trees lose their leaves in the dry season, the leaves are retained on resprouts. This means that regular cutting increases the value of gliricidia as a dry season fodder.

Harvesting

Harvesting can start 8-12 months after planting. In areas where moisture is not limiting, pruning every 6-12 weeks is recommended, to give a high proportion of leaf relative to wood. During the dry season, cutting should be less frequent. Gliricidia can produce up to 20 tons of leaf dry matter per year.

Feeding

Gliricidia is usually fed to ruminants as a high protein supplement, making up 20-40% of the total diet. There are many reports of increases in weight gain and milk production in both large and small ruminants when it is used in this way.

Animals need to become accustomed to gliricidia before they will eat it readily. The palatability is greatly increased by wilting the leaves for 12-24 hours before feeding them. Adding molasses or salt can also make the leaves more palatable.

Pests & diseases

At present gliricidia has no serious pest and disease problems in East Africa. A potentially fatal disease called little leaf disease has been recorded in Central America but has not yet been found in Africa.

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Internet links

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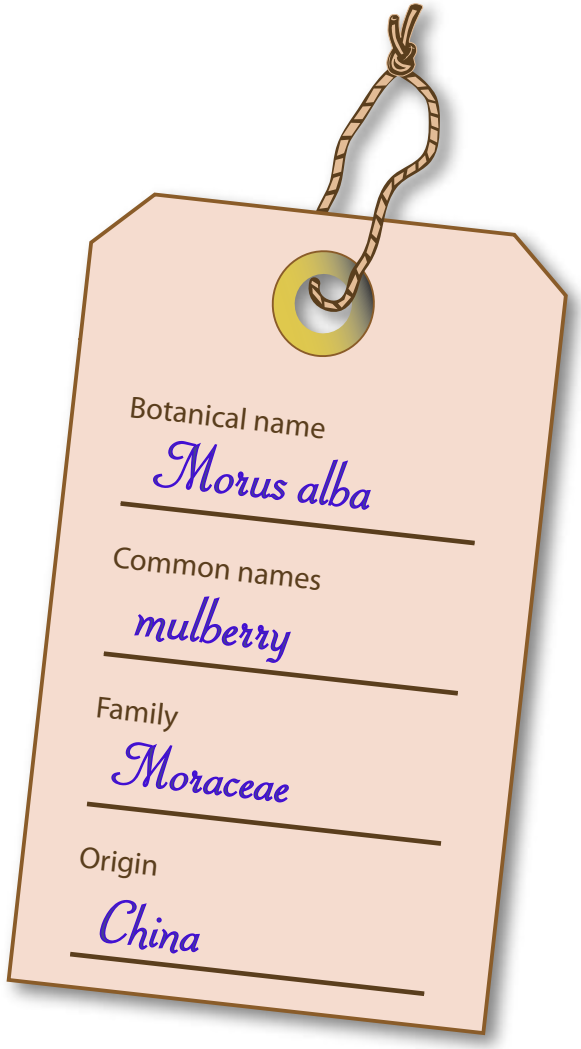
FAO Grassland Species Profiles: http://www.fao.org/ag/AGP/AGPC/doc/Gbase/DATA/Pf000156.htm

World Agroforestry Centre Agroforestree database: http://www.worldagroforestry.org/Sites/TreeDBS/aft/speciesPrinterFriendly.asp?Id=912

Tropical Forages: an interactive selection tool: http://www.tropicalforages.info/key/Forages/Media/Html/gliricidia_sepium.htm

Mulberry

Mulberry comes originally from China but is grown in most parts of the world, mainly for its edible fruits and to feed silkworms. The soft leaves are also very good livestock fodder. Although it forms a large tree if allowed to grow, mulberry can be managed as a hedgerow and withstands repeated pruning. It is usually propagated from stem cuttings. Mulberry is the only species described in this book which does not fix nitrogen from the air. There is therefore a possibility that it can deplete soil nitrogen, so fertilisation may be needed. It can also compete with crops for water and nutrients, so should not be grown right next to them.



Description

The mulberry is a fast-growing shrub or moderate-sized tree, which grows up 25 m tall if left uncut. The bark is dark greyish-brown, rough with vertical fissures, and exudes a white or yellowish-white latex. The light green leaves are cordate (heart-shaped) at the base, but are very variable in form, even on the same tree: some are un-lobed while others are 3-lobed. The leaf edges are serrated. There are separate male and female flowers, which are borne in the axils of leaves or on spurs. The male flowers are small, more or less cylindrical catkins, and the female ones form a long or short spike. The two types occur sometimes on the same tree (*monoecious*), sometimes on separate trees (*dioecious*). The fleshy fruits, containing many tiny seeds, are up to 5 cm long, and white, pinkish-white, purple or black in colour. There are about 1.1 million seeds per kg.

Photo: Sue Kayton

Uses

Fodder

The protein content of mulberry leaves is high, usually in the range 15-25% of dry matter. The leaves are relatively low in fibre and contain very little tannin (about 1% of dry matter). As a result they are highly digestible (75-80%).

One of the main features of mulberry as forage is its high palatability. Animals (both cows and goats) consume the leaves avidly. They often prefer mulberry to other forages when they are offered simultaneously, and even dig through a pile of mixed forages to look for the mulberry.

Shade-dried leaves can be fed to poultry to improve their health and increase egg production. Mulberry can also be fed to rabbits.

Wood

The wood is a medium-quality firewood. If mulberry is allowed to grow into a large tree, it produces timber which can be used for a wide variety of purposes. It is easy to saw, turn, bend and finish, and it seasons well although it has a tendency to warp. It is suitable for construction, agricultural implements, furniture and turnery.

Other uses

Worldwide, the main use of mulberry is to feed silkworms. The bark and the fruits are used traditionally in many parts of the world for a variety of medicinal purposes, and fibre from the bark and the wood can be used in paper-making.

Land use, environmental and service aspects

Mulberry can be used to provide shade and shelter. Like other fodder shrubs, it can also be planted along soil conservation structures across steep slopes, reducing erosion whilst also producing fodder.

Wood uses	Non-wood uses	Environmental services
Fuelwood	Fodder	Shade & shelter
Small poles	Mulch/green manure	Soil conservation/ erosion control
Timber	Silk worm production	

Climate and Soil

Mulberry requires adequate moisture, and does not tolerate drought. It grows best in full sun.

Climate	
Altitude range	1000-3000 m
Mean annual rainfall	1500-2500 mm
Dry season duration	Will not tolerate a long dry season
Mean annual temperature	18°-30°C
Absolute minimum temperature	-20°C
Frost tolerance	Highly frost-tolerant

Soil	
Texture	Grows on a variety of soils ranging from sandy loam to clayey loam, but prefers deep, alluvial, loamy soil.
pH	6.0-7.5

Genetic variation

If cuttings are used as the planting material, it is important to make sure that they come from at least twenty different plants, to give enough genetic diversity in the planted material. This will reduce the risk of devastating pest and disease attacks.

Planting and management

Seed collection

Fruits are picked or shaken on sheets when ripe. Mulberry seeds should be removed from the ripe fruit as soon as it is ripe, by squashing with plenty of water to separate the seed from the pulp.

Seed treatment

The seed can be dried and stored for up to three years at room temperature in sealed containers. Before sowing it should be treated by soaking in cold water for about a week.

Propagation & establishment

Mulberry is easily established from stem cuttings, and this is the usual propagation method, as cuttings are easier to collect and to work with than the tiny seeds. However, planting by seed gives deeper roots with greater capacity to find water and nutrients, which eventually results in higher biomass production. It can also reduce competition with nearby crops. Both methods are described here.

Propagation from cuttings:

Cuttings should be taken from hard, woody branches. Each cutting should be 22-30 cm (9-12 inches) long, with at least three nodes (the place on the stem where the leaves are attached). They should be planted as soon as possible after collection, at an angle of about 45 degrees. Cover at least two nodes with soil, to produce roots, and leave at least one other above the ground to produce shoots.

Propagation from seed:

Seeds should be planted in a seedbed, near the surface, with a thin layer of soil and ashes spread over them in moist soil. Seeds germinate in 9-14 days, depending on the season. When the seedlings are about 10-15 cm tall, they can be pricked out into pots. Before transplanting to the field at the beginning of the rainy season, all but a few terminal leaves are stripped (*striplings*) to minimise moisture loss.

Management

During establishment it is important to keep the young plants free of weeds. Once established the plants can be managed by coppicing or as a hedge; but every few years, the plants should be pruned down to ground level to regularise their shape and allow the growth of new shoots.

Because mulberry cannot fix nitrogen from the air, it depletes soil nitrogen, so additional fertilisation is necessary. Either mineral and organic fertilisers (animal manure or compost) should be used to replenish the nutrients removed in the leaves, to maintain sustainable production. Planting a mixture of mulberry and nitrogen-fixing (leguminous) shrubs can reduce the need for additional nitrogen, but extra fertilisation will usually be required for maximum yields. The nitrogen level in the soil has been shown to be the most important factor for mulberry growth.

It is important not to plant a mulberry hedge too close to other crops, as it may compete with them for water and nutrients.

Harvesting

Mulberry managed as a hedge should be cut at a height of 0.5-1.0 m above the ground. Both these cutting heights have been shown to give the same amount of leaf, but cutting at 0.5 m gives more wood. The usual cutting interval is about 60 days in the wet season, longer in the dry season.

Feeding

Ruminants will eat larger amounts of mulberry than of most other supplementary fodders. Because of its high digestibility and low tannin content, it is a good idea to mix it with other species such as

calliandra which are high in tannins. The total supplement should not be more than about 30% of the diet, however.

Pests & diseases

No serious problems have been reported in East Africa.

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Internet links

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FAO Grassland Species Profiles: http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/pf000542.htm

World Agroforestry Centre Agroforestree database: http://www.worldagroforestry.org/Sites/TreeDBS/aft/speciesPrinterFriendly.asp?Id=1170

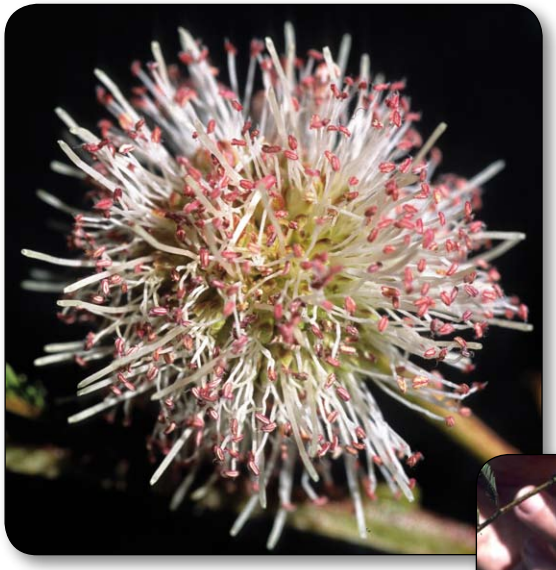
Tropical Forages: an interactive selection tool: http://www.tropicalforages.info/key/Forages/Media/Html/morus_spp.htm

Pallida

Pallida is native to Mexico and has only been used in Africa for a few years as fodder. It is highly psyllid-resistant, and tolerates cooler and more acid sites than trichandra. It is easy to establish, and is fast growing on favourable sites. However, its digestibility and palatability are reduced by its high tannin content, so it is best used in moderate amounts in a mixture with other species.

Description

Pallida forms a small to medium-sized tree with an open crown. It is often multi-stemmed. The leaves are compound (*bipinnate*) with 15-27 pairs of pinnae which are up to 35 cm long. There is a characteristic crater-shaped gland, up to 4.0 mm long x 3.2 mm wide, on the petiole. Each pinna has 39-50 pairs of leaflets, which are 6-8 mm long x 1-2 mm wide, asymmetrical at the base and pointed at the tip. The inflorescences are pale pink or dull purplish mauve in colour, 15 mm in diameter, comprising 95-110 individual flowers. They occur in groups of 3-5 in leaf axils on actively growing shoots. The pods are 12-19 cm long x 14-18 mm wide, and slightly thickened or leathery. They are glossy maroon when unripe, turning mid reddish- or orange-brown when they ripen. There are 18-22 seeds per pod: the seeds are brown, and 6-10 mm long.



Uses

Wood uses	Non-wood uses	Environmental services
Fuelwood	Fodder	Nitrogen fixation
	Green manure	Soil conservation/ erosion control

Fodder

Pallida has lower nutritive value than the other leucaenas being promoted in East Africa. Its low digestibility (55-64% *in vitro*) is probably caused by the high tannin content of the leaves. While this may be the reason for its high psyllid resistance, it also reduces its palatability. However the protein concentration in the leaves is also high (29-35%), and they contain very little mimosine (<2%). It is therefore a good option (among the *Leucaena* species) in areas where there are high levels of psyllid attack.

Wood

Pallida produces good quality fuelwood, but the wood is generally too small for other timber uses.

Land use, environmental and service aspects

The leaves of pallida can be used as green manure. As a leguminous species, it also improves soil fertility through nitrogen fixation. Like other fodder shrubs, it can also be planted along soil conservation structures across steep slopes, reducing erosion and also producing fodder.

Photo: Ian Staples

Climate and Soil

Climate	
Altitude range	1000-2000 m
Mean annual rainfall	500-1000 mm in native range, but grows well with rainfall up to 2000 mm
Dry season duration	Up to 7 months
Mean annual temperature	16°-21°C
Frost tolerance	Tolerates occasional light frosts
Soil	
Drainage	Prefers well-drained soils; intolerant of waterlogging
pH	>5.0
Special tolerances	Tolerates slightly acidic soils
Soil types	Prefers calcareous soils

Soil

Pallida does not thrive under conditions of low phosphorus, low calcium, high aluminium saturation, salinity and waterlogging.

Hybridisation

It is important to be aware that pallida can hybridise easily with both diversifolia and leucocephala, so if it is grown near to either of these species, seed collected from pallida plants may actually be hybrids.

Planting and management

Seed collection

Seed production from pallida is usually plentiful. There are 20,000-25,000 seeds/kg. Seeds can be stored for a long time at 4°C and <10 % moisture content.

Seed treatment

The seed has a hard coat and must be treated before sowing. Soak seed in warm water for two days (48 hours) before sowing in the nursery.

Propagation & establishment

Pallida is best raised in a nursery, either in pots or as bare-rooted seedlings. Seedlings can be planted out at 3-4 months old. The seedlings are vigorous and establish rapidly and easily. For best results plant on deep, well drained soils and maintain a weed-free area around the establishing plants.

Management

Pallida is somewhat shade-tolerant. It also recovers well after fire, resprouting readily from burnt stumps. However, its most important attribute, with regard to its management in agroforestry systems, is its ability to tolerate repeated cutting (and also browsing at ground level), and to regenerate rapidly.

Harvesting

Pallida grows fast with high biomass production under favourable conditions.

Feeding

The high protein content of pallida makes it a useful supplementary feed. However, because of its low digestibility and palatability, it is best to use pallida as one component of a mix of shrubs, rather than as the only supplement.

Pests & diseases

Most accessions of pallida are very resistant to the psyllid (the insect which defoliates *L. leucocephala*).

A range of pathogenic fungi and insects occasionally attack trichandra. Newly emerged seedlings are susceptible to fungal damping-off diseases. Soil insects such as earwigs, scarab beetles, termites and cut worms can also cause serious damage to emerging seedlings.

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Wheeler RA et al. (1994). Forage yield and compositional analysis of Leucaena species and hybrids adapted to cool sites. *Agroforestry Systems* 25(3): 263-274.

Internet links

World Agroforestry Centre Agroforestree database: http://www.worldagroforestry.org/Sites/TreeDBS/aft/speciesPrinterFriendly.asp?Id=1753

Tropical Forages: an interactive selection tool: http://www.tropicalforages.info/key/Forages/Media/Html/leucaena_pallida.htm

Sesbania

Sesbania sesban ('sesbania') is a fast-growing, short-lived leguminous shrub or small tree. Although its geographical origin is not certain, it is widely distributed and cultivated throughout tropical Africa and Asia, and has also been introduced into tropical America. It is found both in the humid tropics and in more arid and semi-arid regions. The greatest genetic diversity is found in Africa, so it probably originated there.

The most common use of sesbania is for fodder production. It is also often used as a short rotation tree on fallow and marginal lands, or in farming systems as a shade tree, a support tree for horticultural plants or in planted fallows. The leaves are also used as a green manure. The main disadvantage of sesbania is its short lifespan compared to other fodder shrubs. Its productivity starts to decline after about five years and the plants need replacing within ten years.

Sesbania can easily be grown from seed and nursery seedlings. There has been no formal genetic improvement of this species.

Description

Sesbania is a deciduous shrub or small tree, up to 24 feet (8 metres) tall. The bark is reddish brown, and the young shoots are hairy. The leaves are compound, up to 12 cm long, with oblong, tip-notched, narrow leaflets up to 2 cm long. The flowers are pale yellow, speckled maroon or with purple streaks, in flower heads up to 15 cm long each bearing 4-20 flowers. Sesbania seeds heavily: the thin pale brown pods occur in bunches, and are 80-200 mm long and 4 mm thick, with a round cross-section. They may be either straight or twisted, and are divided internally into separated sections, so that the seeds rattle inside. The small seeds (1.5-2.0 mm x 3.0-4.0 mm) are green-brown to red-brown, sometimes with dark mottling.

Uses

Wood uses	Non-wood uses	Environmental services
Fuelwood	Fodder	Windbreaks
Round wood	Green manure/mulch	Shelterbelts
	Bee forage	Shade
	Improved fallows	Soil conservation & erosion control
		Land reclamation

Fodder

The leaves and tender shoots are used as fodder for ruminants (cows, goats and sheep). The leaves are very palatable, and are high in protein (usually 15-20%, but sometimes as high as 25% of the dry matter), so they are an excellent supplement to protein-poor roughage (local grasses, crop residues etc) in ruminant diets. They are also very low in fibre and do not contain tannins, so they are highly digestible: the *in vitro* dry matter digestibility is 75%, and the nylon-bag (*in sacco*) dry matter digestibility of dried leaf can be over 90%. These characteristics, together with high phosphorus levels, indicate the potential of the species as a high-quality forage source.

However it should be noted that sesbania also contains a poisonous saponin which makes it fatal to young chicks, so it should not be included in poultry diets, and should only be fed in very limited amounts to other non-ruminants.

Sesbania is well suited to zero-grazing systems. When browsed, the brittle branches may snap, exposing the wood to fungal attack.

Wood

Sesbania makes good firewood and charcoal because it is fast growing and the wood, although soft, lights easily and is relatively smokeless and hot burning. The wood can be used for a range of purposes including posts, stakes and fences.

Land use, environmental and service aspects

Rapid growth, combined with high levels of nitrogen fixation, make sesbania excellent for soil conservation and fertility improvement, particularly as a component of improved fallow systems. It can be planted for soil erosion control on steep slopes at close spacing, in rows 2-6 m apart along the contour, with crops such as maize and sorghum between the rows. In Kenya it has also been used as light shade for young coffee plants.

Climate and Soil

Climate

Sesbania grows in cooler, higher elevation regions than most tropical tree legumes. It is naturalised at altitudes as high as 2500 m in East Africa, though at higher and cooler elevations growth rates and yields are reduced. It grows in both semi-arid and sub-humid regions, with annual rainfall ranging from 500 mm to 2000 mm. It prefers areas with alternating wet and dry periods to those with even rainfall distribution throughout the year. Because of its tolerance of both droughts and waterlogging, it is well adapted to seasonal fluctuations in moisture and to seasonally flooded environments: it is common along streams, swamp banks and in moist and inundated bottomlands. Flooding stimulates the production of floating, adventitious roots.

Soil

Sesbania tolerates slightly acidic soils as well as very alkaline and saline ones, although it is not well adapted to soils with high aluminium saturation and pH<4.5. It grows in marshy areas so is tolerant of waterlogging.

Climate	
Altitude range	100-2500 m
Mean annual rainfall	>500 mm (unimodal or bimodal)
Dry season duration	3-5 months
Mean annual temperature	20-28 °C
Mean max. temp. hottest month	25-30 °C
Mean min. temp. coldest month	14-19 °C
Absolute minimum temperature	>0 °C
Frost tolerance	Tolerates light frosts, but will be killed by heavy frost
Soil	
Texture	light; medium; heavy
Drainage	impeded; seasonally waterlogged
pH	acid; neutral, alkaline
Special tolerances	shallow, saline, acidic or waterlogged soils

Planting and management

Seed collection

Seed collection from sesbania is easy because the tree seeds prolifically. The pod clusters can be picked by hand or cut down from higher branches. The pods should be dried thoroughly, as this makes them open more easily as well as improving the quality of the seed. To remove the seeds from the pods, grasp a bunch of pods parallel one to another and twist them to force them open. Larger amounts of pods can be placed in a cloth bag then crushed, kneaded and twisted.

Seed storage and treatment

Sesbania seed can normally be stored for several years in air-tight containers at room temperature (15-30°C) with little loss of viability. It will last even longer if it is kept at 5 °C and at low relative humidity. It is important to collect seed when it is fully mature. Treatment with insecticide, or freezing overnight, will kill seed pests.

Viability and germination of fresh seeds is high (up to about 95%). The seeds have hard seed coats which need treatment before they can take up moisture and germinate. This is usually done by soaking the seed in either hot or cold water. One method is to put the seeds

Sesbania seed collection is easy because it seeds prolifically

in a cloth or screen bag and dip them for 30 seconds in water heated to just below boiling point. An alternative is to soak them for 24-48 hours in cold or tepid water. Successfully treated seeds will swell visibly in the water, and the root tips of viable seed will appear within two days.

Propagation & establishment

Seedlings are easily grown either bare-rooted or in containers, as described on pages **77** to **86**. The seeds germinate and grow quickly, often up to 10 cm in 20 days, 1 m in six weeks and 2 m in 12 weeks. This rapid growth helps sesbania to overcome weed competition and reduces the amount of weeding needed during establishment. Vegetative propagation has not been widely used for sesbania: it can be propagated from stem cuttings, but since it is easier to use seed, direct propagation is only useful when superior plants need to be propagated.

Sesbania can easily be established by direct seeding, as well as through wildlings or seedlings. In fact, one of the main advantages of sesbania over other fodder shrub species is its easy establishment by direct seeding. The use of nursery-grown seedlings is normally not necessary with sesbania, except when supplies of seed are limited or establishment from seed is proving difficult. In this case, transplanting seedlings into the field may help.

Sesbania may be grown in pure plots, but it is most common along fence lines, field and farm borders, paths and hedgerows.

Management

Sesbania is a very fast-growing species when young. Weeding is necessary, and it can become a weed itself if not well controlled. It may also harbour nematodes that are destructive to root and tuber crops. Sesbania responds well to soil improvement by manure or phosphate fertiliser applications. Lime applications usually improve growth on soils that are highly leached and acidic.

Under good conditions, hedgerows of sesbania can produce more than 20 tons/ha/year of dry matter. If cuttings are frequent, more than half of that yield will be leaves. Productivity is greatly influenced by cutting management. It is often highly forked. Low branches and dominant stems can be cut without risk of killing the plants.

The productivity of sesbania starts to decline after about five years, and the plants should be replaced after ten years.

Harvesting

Although sesbania does tolerate repeated cutting for fodder, harvesting should not be too frequent: it is usually only harvested 3-4 times per year. However, cutting frequency varies with growth conditions, including soil fertility and moisture availability. If growth is good, it can be cut up to five times annually. Cutting heights of 75-100 cm appear to provide maximum fodder yields. If cut below 50 cm, or too frequently, the plant mortality increases or the lifespan may decrease. It is also important not to remove all the leaves: at least 5-25% of the foliage should be left on the plant when pruning. Under favourable conditions, sesbania can produce up to 20 tons of leaf dry matter per year.

Feeding

Sesbania leaves are a good feed supplement for ruminants such as cattle, goats and sheep. The fodder can be fed fresh, wilted or dried. Dried fodder can be stored for times of shortage.

The most effective way of feeding sesbania is as a supplement of 15-30% of the total ruminant diet. Because of the high protein content sesbania should not be fed as a sole ration, but combined with low protein-high energy roughages such as dry fodder grasses. A low content in sodium, as with many other legumes, indicates a need for mineral supplements.

Pests & diseases

Pests and diseases do not usually cause large yield reductions in sesbania. Nematode infestations, however, will certainly reduce its growth. Fungal attack can also affect both seedlings and mature plants. The recommended treatment is to remove or bury the infected plants and residues.

In East Africa, larvae of the leaf-feeding beetle *Mesoplatys ochroptera* can completely defoliate and kill sesbania at altitudes up to 2000 m. Other insect pests recorded on sesbania include *Empoasca appendiculata* and a stink bug, *Nezara viridula*.

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Internet links

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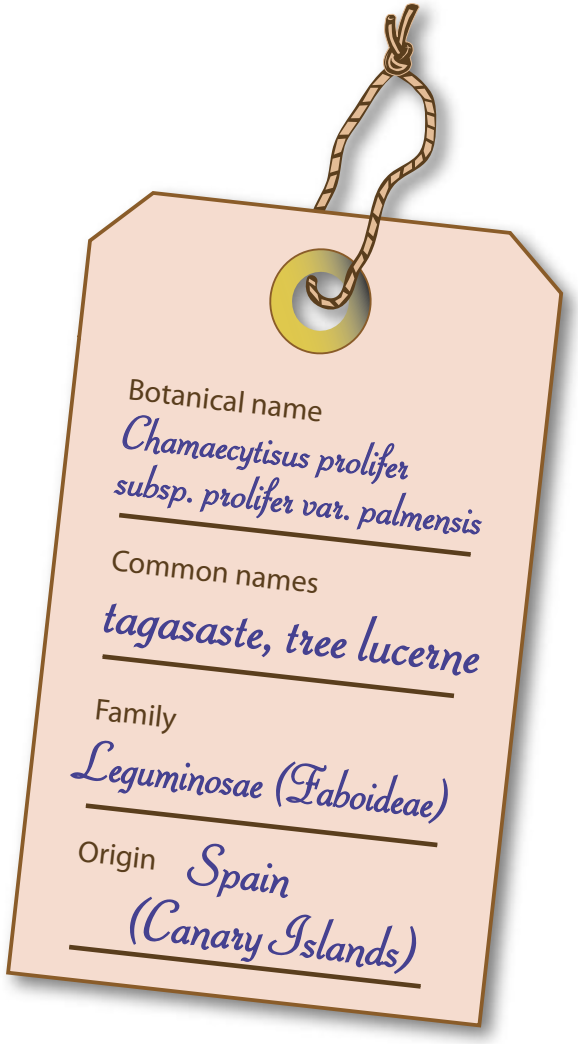
World Agroforestry Centre Agroforestree database: http://www.worldagroforestry.org/Sites/TreeDBS/aft/speciesPrinterFriendly.asp?Id=1522

Tropical Forages: an interactive selection tool: http://www.tropicalforages.info/key/Forages/Media/Html/sesbania_sesban.htm

Tagasaste

Chamaecytisus prolifer ('tagasaste') a fast-growing, palatable fodder shrub which is both frost- and drought-tolerant. It is native to volcanic slopes in the Canary Islands, where farmers have traditionally used it as dry season fodder. It is also widely used as fodder in Australia and New Zealand, and increasingly in other tropical highland and Mediterranean areas. Most experience with this species in East Africa has been in the Ethiopian Highlands. Its natural form is a small tree but it can also be managed as a hedge. It has the capacity to become invasive, especially in high rainfall areas.



Description

Tagasaste is an evergreen, frost-hardy shrub or small tree, up to 5-6 m in height. It has long, drooping, leafy branches. The leaves are dull bluish-green in colour, with three large leaflets (up to 7 cm long, with a petiole up to 2 cm long). The scented, creamy-white inflorescences are borne in clusters. The black seed pods are flat, up to 5 cm long, and covered in fine hairs (pubescent). Each pod contains about ten flattened oval brown-black seeds 3 x 5mm. There are about 45,000 seeds per kg.

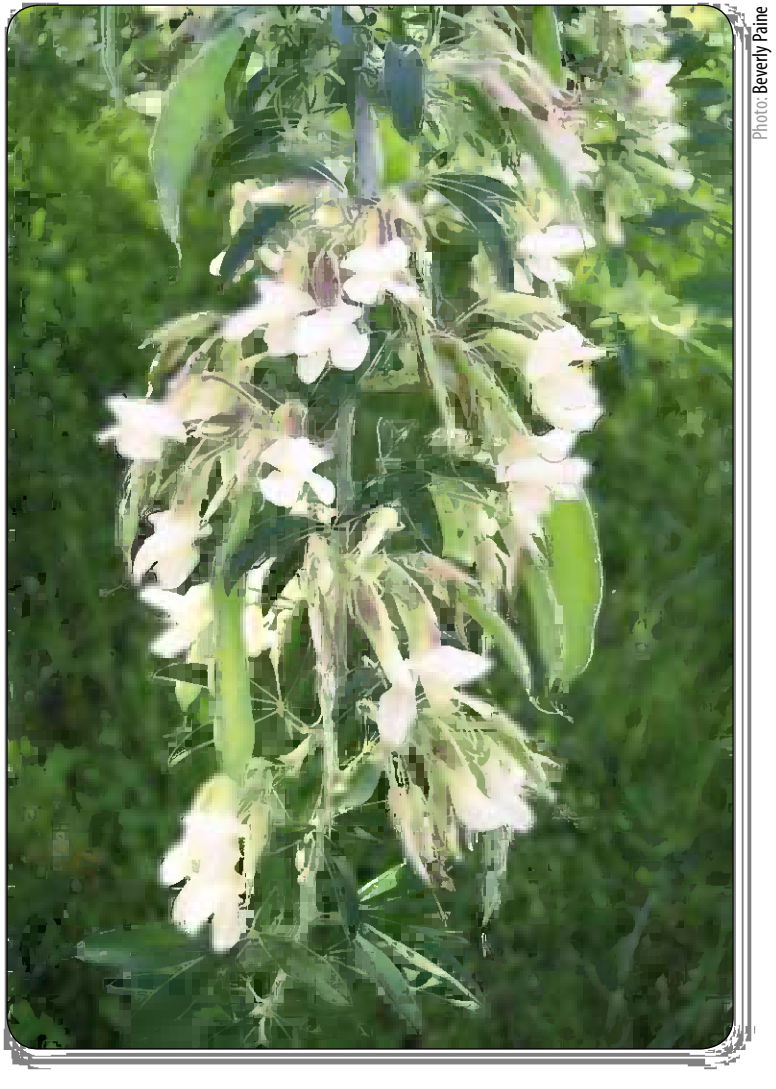


Photo: Beverly Paine

Uses

Wood uses	Non-wood uses	Environmental services
Fuelwood	Fodder	Nitrogen fixation
	Bee forage	Amenity & ornamental
		Soil conservation/ erosion control
		Windbreak

Fodder

The main use of tagasaste is fodder. It is highly palatable to ruminants, and the nutritive value of the leaves is similar to that of lucerne (*Medicago sativa*). Leaves contain 20-30% protein when young, with high digestibility (77%-82%). The tannin content is low, and there are no reports of toxicity from ant-nutritive factors in tagasaste. The leaves are high in vitamin A, and can increase the yellow colour in egg yolks when fed to poultry.

Wood

Tagasaste wood can be used for fuel, but it is not usually grown specifically for this purpose.

Other uses

The attractive, sweet-scented flowers provide nectar for honey-bees, and also make tagasaste a good ornamental species.

Land use, environmental and service aspects

Tagasaste fixes nitrogen, so it has a beneficial effect on the soil. It can also contribute to soil conservation and erosion control when planted as a hedge across slopes. It can be used as a windbreak.

Tagasaste is a fast-growing species which can spread easily by seed. As a result it has the potential to be highly **invasive**: it has quickly become naturalised wherever it has been introduced, colonising roadsides and adjacent bush land. However, the high palatability of the seedlings limits its spread wherever there are free-ranging herbivores (either wild, e.g. dik-dik, or domestic).

Climate and Soil

Climate

Because of its deep roots (to 10 m (30 feet) or more), tagasaste can tolerate long dry periods and can survive in areas with as little as 200 mm annual rainfall, though it requires at least 600 mm for good leaf production.

Climate	
Altitude range	1500-2500 m (to 3000 m in Ethiopia)
Mean annual rainfall	600-1600 mm
Absolute minimum temperature	-9°C (though small seedlings are more sensitive)
Frost tolerance	High
Soil	
Texture	Light to medium texture preferred
Drainage	Requires well-drained soils
pH	4.0-8.5
Special tolerances	Acid soils preferred
Soil types	Gravels, loams, limestones and laterites

Soil

Tagasaste prefers light well-drained sandy soils on slopes and hillsides. Slag heaps and mining dumps can also reportedly be planted with this species. It has wide adaptability to a range of soil pH, though it prefers slightly acid soils. It is not tolerant of saline soils, and is also sensitive to poor drainage: it cannot tolerate waterlogging.

Planting and management

Seed collection

Tagasaste produced large amounts of seed. The pods ripen in the dry season and open on the tree, releasing the seed. The pods should therefore be harvested before they shatter, and dried in bags, or in thin layers in the sun, to release the seeds.

Seed treatment

The seeds are hard coated and must be pre-treated before planting. Soaking the seeds in a weak solution of bleach (sodium hypochlorite), for example '*Jik*', gives good germination. Mix one capful of *Jik* with 1.5 litres of cold water for 3-4 minutes, then rinse

the seed three times in clean cold water, before soaking overnight, also in cold water. Alternatively, if bleach is not available, the seeds can be soaked in warm water for 24-48 hours. They should be sown immediately after treatment.

Propagation & establishment

Tagasaste can be established by direct seeding at a depth of 1-2.5 cm (0.5-1 inch), if plenty of seed is available. Otherwise, seedlings raised in the nursery can be transplanted to the field, ideally when they are about 45 cm tall. As it is a nitrogen-fixing species, tagasaste benefits from inoculation with *Rhizobium*: it uses the same strain of *Rhizobium* as cowpea.

Management

Shrubs should be protected from browsing by livestock for at least 2-3 years after planting, as they may kill the plant by eating the bark. However, it can be pruned back to the ground during this time, to encourage multiple stems. Once the shrubs are well established they can recover well from browsing. They are also resistant to fire because they stay green during the dry season, so they can act as a firebreak.

Leaf yields can be increased by application of superphosphate fertiliser. The shrubs can persist for up to 30 years if well managed.

Harvesting

Tagasaste responds well to frequent cutting, although regrowth is slow for the first weeks after harvest, increasing with time. Harvesting should be done during the rains: cutting in the dry season gives slower regrowth, lower biomass yields and can increase plant mortality.

In the Ethiopian Highlands, fodder yields of 5 t/ha were obtained after six months' regrowth.

Feeding

Although tagasaste is highly palatable, animals may take some time to become accustomed to it. This problem has been reported in Ethiopia, when feeding wilted tagasaste to improved dairy cows.

The leaves have a low sodium content and marginal levels of phosphorus and sulphur, so it is important to provide a mineral supplement when feeding tagasaste.

Pests & diseases

Tagasaste is very sensitive to fungal diseases including root rot and damping off. This is a major limitation to its use in humid areas or on vertisols. Slugs, cutworms and grasshoppers may eat emerging seedlings.

Further reading

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Internet links

FACTNET information sheet: http://www.winrock.org/forestry/factpub/factsh/chamacyt.htm

FAO Grassland Species Profiles: http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/Pf000473.HTM

World Agroforestry Centre Agroforestree database: http://www.worldagroforestry.org/Sites/TreeDBS/aft/speciesPrinterFriendly.asp?Id=17945

Tropical Forages: an interactive selection tool: http://www.tropicalforages.info/key/forages/media/html/chamaecytisus_prolifer_var._palmensis.htm

Trichandra

Leucaena trichandra ('trichandra') is native to Mexico and Central America. It was introduced to Africa initially as a shade tree for coffee and is now also promoted as a fodder shrub. It is well adapted to the cool tropical highlands (though it does not tolerate frost), and it is highly resistant to the sap-sucking insect (a psyllid, *Heteropsylla cubana*) which has attacked *L. leucocephala* throughout the tropics.

Description

When left uncut, trichandra forms a small to medium-sized tree (5-18 m tall) with an open, spreading crown. The form of both the leaves and the flowers is quite variable. The leaves are compound (*bipinnate*), usually with 11-22 pairs of pinnae, which may be up to 35 cm long. There are normally 30-40 pairs of leaflets per pinna: the leaflets are 4-6 mm x 1-1.4 mm. Trichandra foliage is sometimes confused with calliandra, but trichandra has a characteristic crater-shaped, round gland, up to 3.4 mm long x 1.7 mm wide, on the leaf petiole.

The flower heads are about 10 mm in diameter, each containing 70-130 individual white or pale pink flowers and occurring in groups of 3-5. The pods are 7-11 cm x 13-23 mm, glossy reddish-green or maroon when unripe, turning pale-yellow, or reddish-brown when ripe. The seeds are 4.5-6.5 mm long, and the seed weight ranges from 40,000 to 70,000 seeds/kg.

Uses

Fodder

Trichandra has a high protein content (17-33%). Some accessions also contain high levels of condensed tannin, but this varies greatly (from 1% to 23% of total dry matter). Mimosine levels are similar to *L. leucocephala.*

Wood

The wood can be used as firewood or made into charcoal. If left uncut, the stems can get large enough to use for poles.

Land use, environmental and service aspects

When planted across the slope, trichandra hedges can be used to conserve soil and reduce erosion. The leaves provide good quality mulch because trichandra fixes nitrogen from the air.

Wood uses	Non-wood uses	Environmental services
Fuelwood	Fodder	Nitrogen fixation
Small poles	Mulch/green manure	Soil conservation/ erosion control
Charcoal	Bee forage	

Climate and Soil

Climate

Trichandra is not well adapted to hot tropical environments, doing best in cool (but frost-free) highland locations.

Climate	
Altitude range	700-2000 m
Mean annual rainfall	1000-1800 mm
Mean annual temperature	17°-22°C
Frost tolerance	Not frost tolerant, but some accessions have better cold tolerance than others.
Soil	
pH	Some tolerance of acid soils, but prefers pH>5.5.
Special tolerances	Some shade tolerance.
Soil types	Found on a wide range of soil types, from calcareous to mildly acid-infertile.

Genetic variation

Trichandra is the most widely distributed *Leucaena* species in Central America, and this is reflected in its great variability, both in form and in several important traits including growth rate, fodder quality and psyllid resistance. There has so far been no systematic provenance collection and evaluation in this species.

Trichandra is not able to pollinate itself, so seed is not produced from very isolated trees. Although trichandra hybridises readily with some other *Leucaena* species, it does not do so with the species currently found in East Africa (*L. leucocephala, L. diversifolia, L. pallida*), so seeds collected from a trichandra plant will not be hybrids.

Planting and management

Seed treatment

Seed must be treated before sowing, to break the impermeable seed coat. Recommended pre-treatment methods include soaking in hot water (60-80°C) for 24 hours or in cold water for 48 hours. Do not use boiling water as this will kill the seed.

Propagation & establishment

Trichandra is usually planted using nursery-grown seedlings, either in pots or bare-rooted. Seedlings can be planted out at 3-4 months old. The seedlings are susceptible to weed competition so it is important to keep newly-established plants free of weeds.

Management

When grown for fodder, trichandra is usually managed as a hedge, either pure or mixed with other species such as calliandra.

In East Africa, seed production of trichandra is relatively light, and this combined with its high palatability means that it is unlikely to become highly invasive.

Harvesting

Trichandra resprouts well after cutting, though there is variation between provenances (accessions). Leaf production varies greatly between accessions so it is important to choose a high-yielding one which also has good nutritive value (without too much tannin).

Feeding

Like other high-protein shrubs, trichandra should not form more than about 30% of the total diet. This is particularly important

because, like *L .leucocephala,* it contains the anti-nutritive compound mimosine, which can cause poor health, including hair loss, if it is fed in large quantities. Trichandra is also much less palatable than *L. leucocephala* (though more palatable than *L. pallida*). This is another reason to limit its proportion in the diet.

Pests & diseases

Some accessions are very resistant to psyllid insects, but others are susceptible.

A range of pathogenic fungi and insects occasionally attack trichandra. Newly emerged seedlings are susceptible to fungal damping-off diseases. Soil insects such as earwigs, scarab beetles, termites and cutworms can also cause serious damage to emerging seedlings.

Further reading

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Internet links

World Agroforestry Centre Agroforestree database: http://www.worldagroforestry.org/Sites/TreeDBS/aft/speciesPrinterFriendly.asp?Id=1752

Tropical Forages: an interactive selection tool: http://www.tropicalforages.info/key/forages/media/html/leucaena_trichandra.htm