FORESTRY RESEARCH PROGRAMME

Improving Seed Production in *Calliandra calothyrsus*

A Field Manual for Researchers and Extension Workers

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Why is this guide needed?

Over the last ten years or so there has been substantial interest in cultivating *Calliandra calothyrsus* in the humid tropics, particularly on acid soils where other agroforestry species tend to grow poorly. As a result, the species is now cultivated for practical or research purposes in 40 countries world-wide.

With the widespread cultivation of calliandra and the identification of superior seed sources by the International Calliandra Trial Network, the need to produce local sources of good quality seed has increased. Many researchers and field workers have had, however, poor experiences with seed production from calliandra. Low seed set per tree has been a common occurrence in many seed stands planted outside the native range. This has been the driving force for recent research on the reproductive biology of calliandra and the factors that control seed production in the species.

This manual aims to present the results of this research to researchers and extension workers who are involved in the cultivation of calliandra. Guidelines are presented for the establishment and management of seed production areas. The manual does not aim to describe the seed storage, propagation and establishment techniques for calliandra which have been described in detail elsewhere.

What is ‘calliandra’?

Calliandra calothyrsus **growing in Indonesia**

When people talk about 'calliandra' they mean ***Calliandra calothyrsus***, a small, nitrogen-fixing, fast-growing tree. There are, however, over 130 different species in the genus *Calliandra*, which may be trees, shrubs or herbs.

Common names Red kalliandra, calliandra

Where does it come from?

Calliandra calothyrsus comes from Central America and Mexico. It grows in a variety of environments from seasonally **dry to humid forest**, and from **sea level to 1800m** in the mountains.

Calliandra has been introduced to, and is planted in many other tropical countries, but particularly in south-east Asia and Africa.

What is calliandra used for?

Calliandra fuelwood harvested in Indonesia

Cattle enjoying calliandra fodder in Indonesia

Fodder

Fresh calliandra leaves are a **good source of protein** in the diet of cattle, goats and sheep. The leaves are most appetizing when fed fresh, but if they are dried, the leaves should be mixed with another source of food, e.g. straw, hay, or sugar cane.

Fuelwood

Calliandra grows very quickly, coppices well and its small diameter stems and branches are a valuable source of fuelwood. The wood is quite dense, **burns well**, and can also be used to produce charcoal.

Soil improvement

Hedgerows of calliandra have been planted on sloping land to **reduce soil erosion**, **improve soil fertility** and provide a source of **green manure** for fertilising crop plants. Calliandra can also be used to improve fallow agricultural fields and recover degraded land.

Honey production

Calliandra is planted for honey production in Indonesia. Bees 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 fruit flavour.

Other uses

Calliandra is also used as **shade** for coffee, which is the only widespread use of the species in its natural range, and in Sri Lanka and Indonesia as shade for tea. It is also a suitable host for the insect *Kerria lacca,* which yields valuable **shellac**.

Where can you plant calliandra?

Fodder bank of calliandra planted in Embu, Kenya

In its natural range, calliandra grows in areas that have: between **700 and 5000 mm of rain** per year, usually with a single, short **dry season of 3-4 months**; at altitudes of between **0-1800 metres** above sea level; on a range of often **acid soils** (e.g. alluvial deposits, clays, and sandy loams). But, it is **not tolerant of frost**, preferring a mean annual temperature of 22-28ºC, and it is **not tolerant of water-logging**.

Optimal conditions for planting calliandra

Although it will grow on a large range of sites, calliandra will grow best and produce seed when it has:

- between 1000 and 4000 mm of rain per year
- a short dry season of no more than four months
- an altitude of 200-1800 m above sea level

Are there problems associated with growing calliandra?

Inflorescence of calliandra with only a few pods

One of the most serious problems with growing calliandra is being able to produce enough seed for further planting.

How much seed can we expect calliandra to produce?

In its natural range, calliandra is found in **small populations** (30-60 individual trees per population is common). Seed is produced during the tree's first year of growth, although not all trees will flower and produce seed at the same time. At least **100 g of seed per tree** (1700 seeds) can be produced each season (equivalent to **250-300 pods per tree**), however, this will vary with the age and size of the tree, and its location.

Where calliandra is planted in exotic environments, seed production can also be highly variable. In Australia, 4 year-old trees planted in an area with good site conditions produced an average of **1 kg of seed per tree**. However, **much less** than 100g of seed per tree is sometimes produced. In this case, the **absence of pollinators**, or **poor site conditions**, e.g. inappropriate climate and poor soil fertility, may adversely affect the amount of seed produced.

How does calliandra produce seed?

Inflorescence with open flowers after nocturnal flowering

Information about how calliandra produces seed, i.e. its **reproductive biology**, helps us understand what controls the amount of seed it can eventually produce.

When does calliandra flower and produce seed?

Where calliandra is planted in many African countries, a bi-modal rainfall distribution is common. This means that calliandra will often produce a small amount of flowers and seed throughout the year. In Kenya, calliandra tends to flower all year round, but with a peak flowering period during February and March. The largest amount of ripe seed is produced during April and May.

Example of flower and pod production at Embu, Kenya

Altitude: 1480 m
Latitude: 00°30' S
Longitude: 37°27' E

Month	Mean rainfall (mm)	Flowers	Pods
January	22	✓✓	✓
February	25	✓✓✓	✓✓
March	91	✓✓✓	✓✓
April	301	✓✓	✓✓✓
May	224	✓✓	✓✓✓
June	28	✓	✓✓
July	45	✓	✓
August	43	✓	✓
September	42	✓	✓
October	147	✓	✓
November	203	✓	✓
December	59	✓✓	✓

x - no flowers/pods; ✓ - few flowers/pods; ✓✓ - moderate number of flowers/pods; ✓✓✓ - largest number of flowers/pods.

Because calliandra can flower over several months, the inflorescences often contain a mixture of buds, open flowers and developing pods at various stages of maturity.

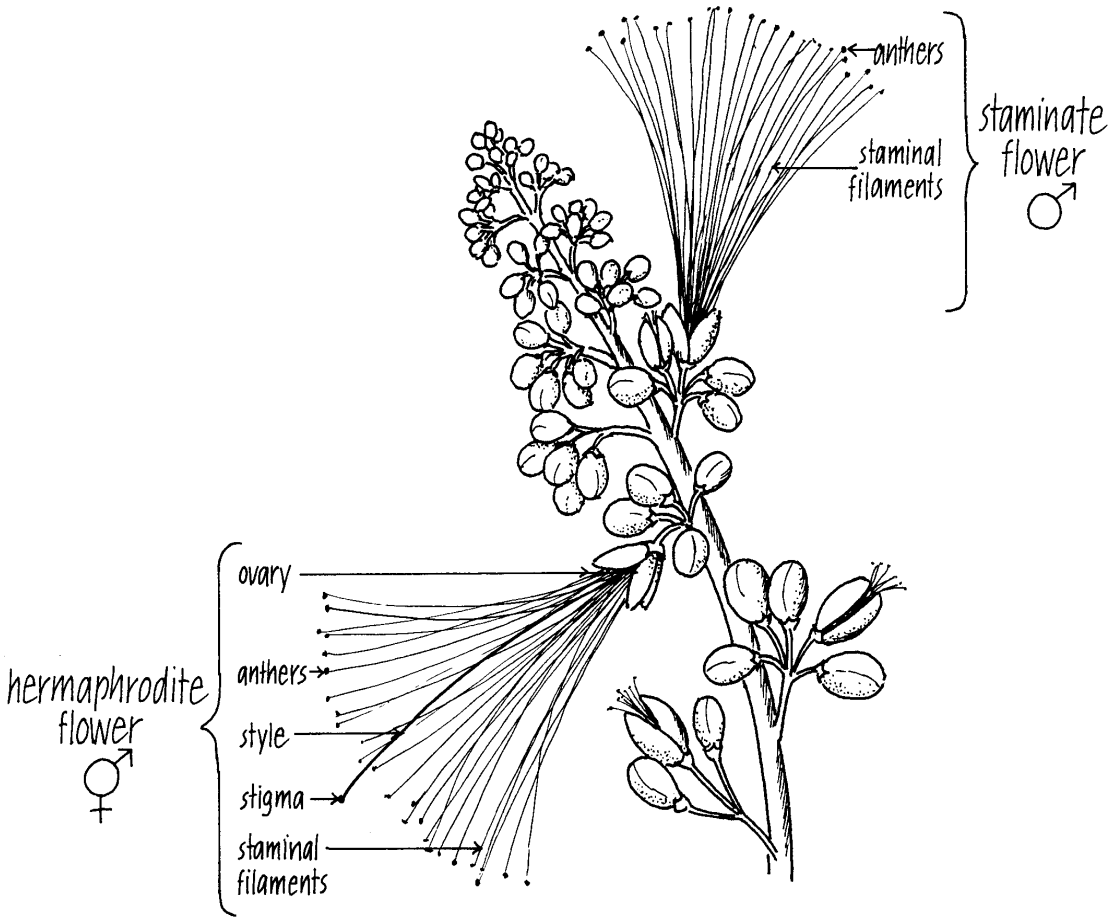
What do calliandra flowers look like?

Calliandra flowers are clustered together along the stem of a long inflorescence and open sequentially from the bottom of the inflorescence to the top. The flowers open at night and are characterised by long, delicate **red stamens** - the **male** part of the flower, which supports the small yellow **anthers** where the **pollen** is produced. The flowers open at sunset, and at sunrise the following day begin to wilt. The flowers will drop off the tree later in the day if they haven't been fertilised.

The **female** part of the flower is called the **pistil**. In calliandra, the pistil is white and it is composed of the **stigma** (where the pollen lands and is germinated), a long **style** (through which the pollen tubes travel), and the **ovary** containing the ovules, which after fertilisation by pollen becomes a pod containing the seeds. When the flower has both male and female parts, it is known as an **hermaphrodite** flower.

Sometimes calliandra flowers **do not** have a pistil, which means that the flower cannot be fertilised, become a pod and produce seed. These flowers are called **staminate** flowers. Staminate flowers are produced once the tree has begun to develop some pods (often after about 20 pods have started developing per inflorescence). When this happens, some of the tree's nutrients have been used for pod development, and the tree may not have enough to continue producing normal, hermaphrodite flowers. Hence staminate flowers are produced. Once the pods start drying and maturing, however, more nutrients become available and if the inflorescence is still flowering, the pistil can be produced again and hermaphrodite flowers are formed.

How does calliandra produce seed?



What pollinates calliandra?

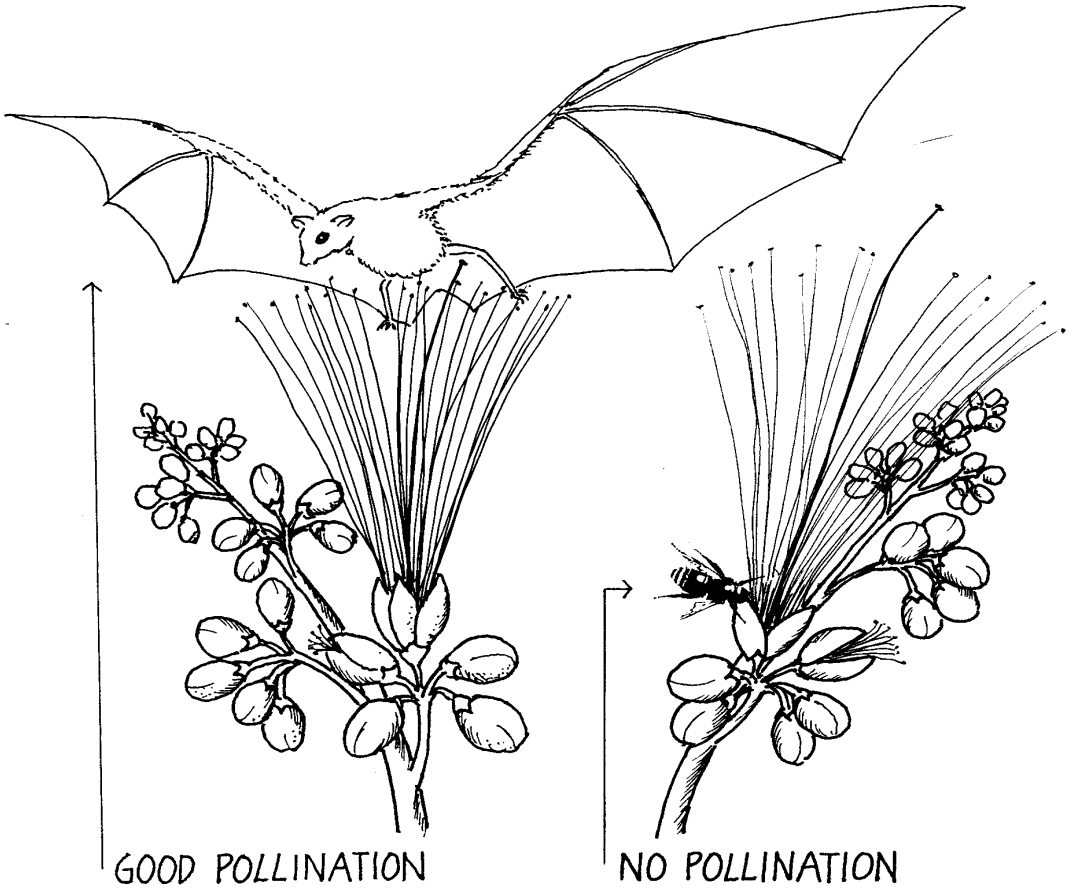
Many different insects and animals visit the flowers of calliandra, including bees, wasps, birds, butterflies, moths and bats. All of these visitors are searching for nectar or pollen that are produced by the flower. In fact, calliandra is often kept near bee hives to provide a source of nectar for honey production.

However, of all these different visitors, only **bats and moths** will actually **pollinate** the calliandra flowers. Small insects, such as bees and wasps, do not come into contact with the anthers that contain the pollen - the insects just visit the bottom of the flower and collect the nectar. This means they do not pick up the calliandra pollen, and cannot transfer pollen from one flower to another.

Larger visitors, such as hummingbirds and butterflies, may brush against the calliandra pollen, but they visit during the day when the calliandra flower is wilting and pollen cannot germinate on the stigma. Hence, these animals are not good at pollinating calliandra either.

The most efficient pollinators of calliandra are small bats, or large moths, both of which visit the open flowers at night when the stigma is receptive to pollen germination. Both hover over the flowers whilst they insert their long tongues into the nectar. Pollen is transferred onto their bodies from the anthers, and when they visit another flower, pollen will be deposited on its stigma. In Central America, a small bat called the long-tongued fruit bat (*Glossophaga sorcinia*) is a common pollinator of calliandra and in Indonesia, a similar type of bat (*Macroglossus minimus*) is also a common pollinator of calliandra.

How does calliandra produce seed?

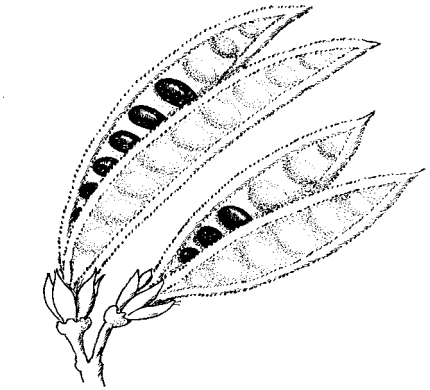


From flowers to seeds

The correct type of pollen must be deposited on the stigma by the bat or moth in order to fertilise the ovules and produce seed. Calliandra is mainly **outcrossing** which means that any given tree prefers pollen from a different tree for the fertilisation of its flowers. However, an individual tree can also fertilise its ovules with its own pollen - this is known as **selfing**. Calliandra is therefore said to have a **mixed mating system**, i.e. it is mainly outcrossing, but sometimes can produce seed on selfing.

A period of 3-4 months is needed from pollination to seed maturity.

How are calliandra seeds dispersed?



When the calliandra pods are dark-brown and mature, they split from the tip to the base of the pod and propel the seeds up to 10 m 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.

How can we maximise seed production in calliandra?

Seed orchard of calliandra planted in Australia

We can maximise seed production in calliandra by using our knowledge of its reproductive biology, and our awareness of the limitations it imposes on seed production in the species.

Commercial scale orchards

Research institutes or seed banks often need to plant large areas for the production of calliandra seed. They may be producing seed for their own research purposes and extension work with farmers, e.g. ICRAF in Kenya, or for commercial purposes, e.g. the Forest Seed Bank in Honduras.

Where should the orchard be planted?

Site

The optimum conditions for planting and producing seed from calliandra are outlined on page 6. Areas that experience **cool, persistent mists at night**, or where **rainfall is high at night** should be **avoided** when choosing a site for a seed production orchard. Such conditions are likely to interfere with the release of pollen and hence, the effective transfer of pollen by bats and moths.

Pollinators

Choose a site where **bats or moths are present**. There may be a time delay before pollinators recognise that a new stand of calliandra represents a food resource, therefore a good seed crop should not be expected in the first, or sometimes even the second year. Other flowering or fruiting plants may also attract the bats away from calliandra and may affect the success of a seed production area.

Isolation distances

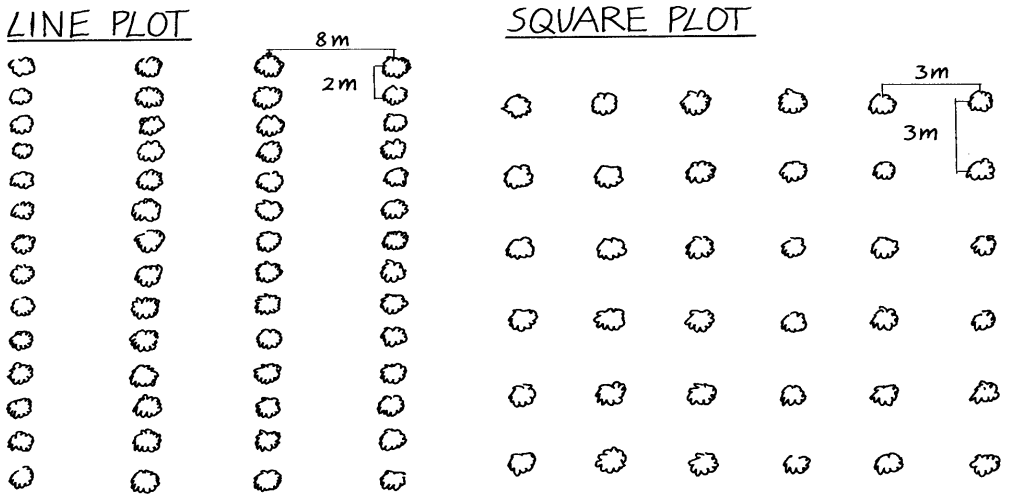
Any calliandra seed production area should be isolated from other contaminating sources of pollen in order to maintain the genetic identity of the seed produced. **Contaminating pollen** could include local, unimproved sources of calliandra, or other closely related *Calliandra* species, e.g. *Calliandra houstoniana*. The isolation distance will be dependent on the feeding ranges of the local pollinators. This could be quite variable as small, nectar-eating bats have smaller feeding ranges than larger, fruit-eating bats. As a general rule, however, a seed production area should be sited **at least 2 km** away from the nearest source of calliandra pollen.

BAD POLLINATION

GOOD POLLINATION

How should the orchard be designed?

Bats need to have free access to the inflorescences of calliandra in order to pollinate the flowers. Those inflorescences that have prominent positions at the top or sides of the tree are more likely to be pollinated than those concealed from view by other branches on the same tree or by adjacent vegetation. A planting design that maximises the number of plants per unit area, whilst allowing the **free access of pollinators** is optimal. Seed orchards where the trees are spaced in wide rows, e.g. **2 m x 8 m**, or where the trees are planted in a wide square arrangement, e.g. **3 m x 3 m**, are therefore likely to produce amongst the best seed yields.



How many trees should be planted?

In general, the larger the stand of calliandra, the more attractive the food resource may be to pollinators. Half a hectare is a good size for a seed production area, and at a spacing of 2 m x 8 m, over **300 trees** will be in the orchard. At a spacing of 3 m x 3 m, over 500 trees will be in the orchard.

How should the orchard be managed?

Pruning

Calliandra responds well to coppicing and pollarding. The growth of new stems is vigourous and new inflorescences are produced. Hence, pruning annually to a height of approximately **1 m** around 1 month prior to the main rainy season will promote the production of new shoots and inflorescences and increase seed production.

Soil fertilisation

Fertilisation of the soil around the trees can cause an increase in the number flowers of produced, and increase seed production. Studies on flower production in calliandra suggest that staminate flowers are produced when the nutrients available to the tree are reduced. Hence, soil fertilisation within seed production areas of calliandra could increase the availability of nutrients, increase the numbers of hermaphrodite flowers, and hence increase seed production. An **organic fertiliser** should be used in preference to inorganic phosphate fertilisers and applied prior to the main rainy season.

How can seed be collected?

The sequential ripening of calliandra pods often make seed collection from orchards a difficult and time-consuming activity. It is important that only dark-brown, mature pods and their ripe seeds are collected. One method of collection used in Australia that may prove useful elsewhere, is the use of **hessian sacks** placed on the ground between rows of calliandra. The pods open naturally when dry, the seed then drops onto the sacking and can be swept up at daily intervals. In this way, the majority of a tree's mature seed can be collected.

Alternatively, long-arm **pruners** have often been used to cut off inflorescences bearing mature pods, or the branches can be bent down and the **pods removed by hand**. This method may be more time-consuming and again, it is important to collect only the mature pods.

Small-scale seed production in farming communities

Seed is often produced within farming communities. In Indonesia, Sri Lanka and Kenya, farmers keep seed trees of calliandra within their farming system, e.g. several trees within a pruned hedgerow are left uncut to produce seed.

Small seed orchards have also been established within villages. In Guatemala, a small orchard of calliandra was established by a group of farmers in collaboration with the NGO, Trees, Water and People to provide seed for international sale. Alternatively, farming communities can maintain small seed orchards on communal land to provide seed for their own plantings

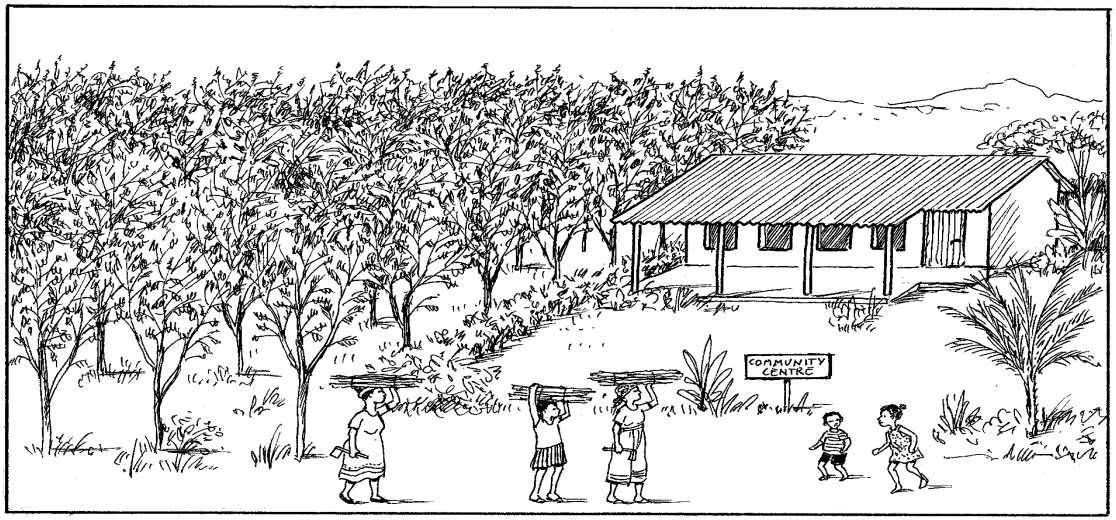
The maintenance of seed trees and the establishment of small seed orchards require different considerations. Each is described in the following sections.

Small seed orchards

When establishing small seed orchards, the **same recommendations** apply as for commercial scale orchards, i.e. site, pollinators, isolation distances, design and management regime. Only the number of plants in the orchard will differ.

Number of plants

In order to maintain genetic diversity in the seed crop, **at least 30 trees** should be planted and seed collected from all trees. Also, the larger the number of trees in the orchard, the more attractive the food resource may be to pollinators.



Recommendations for improving seed production in orchards of calliandra

- Establish a seed production area with seed from a single, genetically diverse seed source.
- Choose a site with suitable climatic conditions where bats or moths are present.
- Plant the trees at a wide spacing, e.g. 3 m x 3 m, or in wide rows, e.g. 2 m x 8 m.
- Isolate the seed production area from any other sources of calliandra pollen. Minimum isolation distance should be 2 km, but bats can forage over larger distances.
- Assess the likelihood of competition for pollinators by other plants, e.g., figs, banana.
- Make the seed production area as large as possible.
- Don't expect a good seed crop in the first flowering year.
- Prune annually to a height of 1 m to promote the production of shoots and inflorescences.
- Fertilise the soil below the trees to promote the production of hermaphrodite flowers.

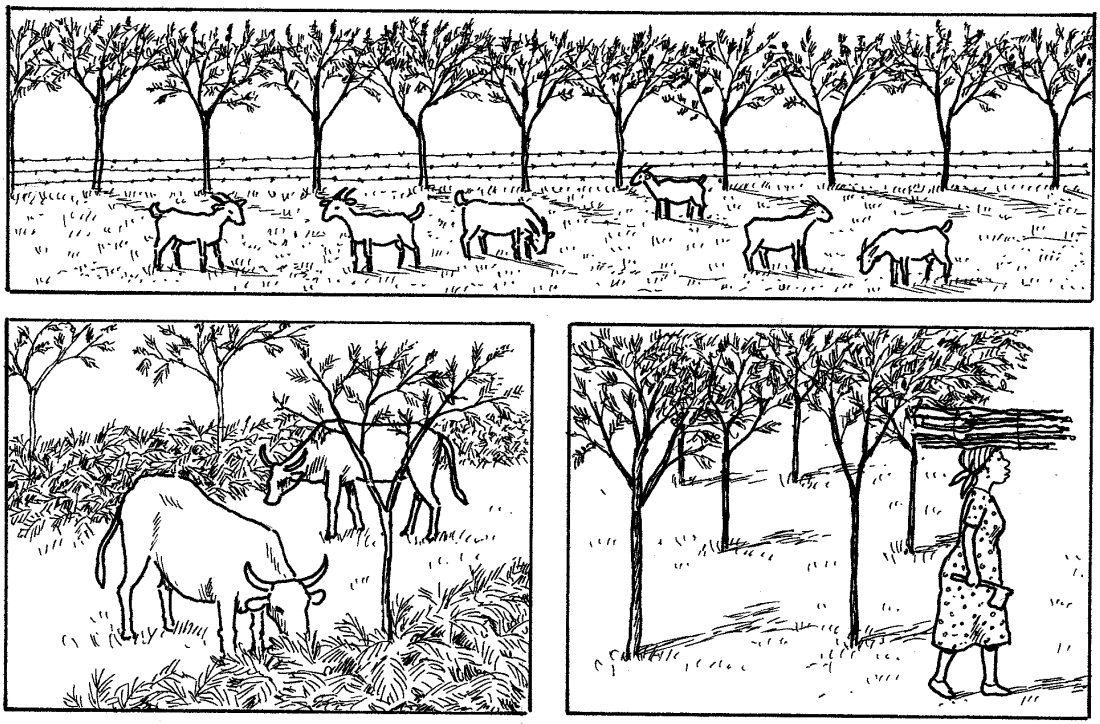
Seed trees on-farm

The problem with establishing seed trees on-farm is that often only a small number of trees are maintained for seed, e.g. perhaps less than 10. Since calliandra can produce seed on self-pollination, there is a risk that the seed crop could be **inbred** if only a small number of trees are crossing with one another. This may result in seed that produces trees with **poor growth performance,** or **susceptibility to pests and diseases**.

Where should the seed trees be planted?

When planting seed trees, choose a site with suitable climatic conditions (see page 6) where bats or moths are known to occur. If the seed used for establishing the seed trees is from a source that grows better than the local landrace, then in theory the trees should be isolated from other sources of calliandra pollen so that the genetic identity of the seed crop is maintained. In practice this may be difficult to achieve, and the farmer should be aware that the seed crop may not produce plants as productive as the mother tree. Diversity in the seed crop will be maintained, however, if crossing occurs between trees in adjacent farmer's plots.

The **planting arrangement** of the seed trees could take advantage of the **existing uses** of calliandra on the farm. For instance, several trees within a pruned hedgerow or fodder bank could be left uncut to produce seed. The seed trees could be used to form a fence around the farm, or a border around a specific plot of land. Also, calliandra could be used to provide fuelwood by coppicing a small woodlot annually after the main seed crop has been produced.



Many of these planting designs, or a combination of them, could lead to more than 10 trees being used to produce seed on the farm, and the risk of inbreeding will be reduced. In addition, if neighbouring farmers also keep seed trees of calliandra, crossing between a greater number of trees can occur, and diversity will be maintained in the seed crop.

How should the trees be managed?

Coppice or pollard the trees after the main seed crop has been produced. The **pruning height** will depend on the production system the trees have been planted in, but **1 m** would be suitable for most systems. If possible, **fertilise the soil** below the trees, either by incorporating a leaf mulch or animal manure to the soil at the base of the tree.

How can seed be collected?

If the seed trees are in a woodlot, then sacking could be spread on the ground to collect the seed. Otherwise, it will be necessary to collect seed **by hand** by carefully bending the branches down and removing only the dark-brown mature pods. The sequential ripening of the pods means this will have to be done every 7 to 10 days if the majority of a tree's seed is to be collected.

Recommendations for collecting calliandra seed from trees planted on farms

- Establish seed trees with seed from a single, genetically diverse source.
- Ensure that climatic conditions are suitable, and bats or moths are present.
- Use existing planting arrangements of calliandra to incorporate seed trees.
- If possible, isolate the seed trees from any other sources of calliandra pollen.
- The greater the number of seed trees on-farm the better. A large number of trees will represent an attractive food source and maintain genetic diversity in the seed crop.
- Don't expect a good seed crop in the first flowering year.
- Prune annually to a height of 1 m prior to the main rainy season to promote the production of new shoots and inflorescences.
- Fertilise the soil below the trees to promote the production of hermaphrodite flowers.

Useful References

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Seed producers and suppliers

Seed supplier	Address	Seed source available
Agroforester Tropical Seeds	PO Box 428 Holualoa, HI 96725 **USA** Tel: (1-808) 3244427 Fax: (1-808) 3244129 Email: agroforester@igc.org	Seed from naturalised and native populations.
Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)	Apartado Postal 137 Turrialba **Costa Rica** Tel: (506) 5561933 Fax: (506) 5567766 Email: wvasquez@catie.ac.cr	Seed from two provenances in Costa Rica, San Ramón and Piedades Sur.
Centro de Mejoramiento Genetico y Banco de Semillas Forestales	Apartado Postal 630 Leon **Nicaragua** Tel: (505-311) 5803, 6579 Fax: (505-311) 3713, 6578	Seed from San Ramón, Nicaragua.

Seed supplier	Address	Seed source available
M.L. Farrar Pty. Limited	PO Box 1046 Bomaderry, NSW 2541 **Australia** Tel: (61-44) 217966 Fax: (61-44) 210051	Naturalised seed from Asia and seed from Honduras.
Forest Seed Bank	ESNACIFOR Apartado Postal Siguatepeque **Honduras** Tel: (504-7) 730011 Fax: (504-7) 730300	Seed from La Ceiba, Honduras.
Instituto de Cienca y Tecnología Agricolas (ICTA)	Animal Production Unit Km 21.5 Carretera hacia Amatitlan Barcenas Villanueva **Guatemala** Tel: (502-9) 312008 Fax: (502-9) 312002	Seed from Fortuna, Costa Rica, produced in a seed orchard.

Seed supplier	Address	Seed source available
International Centre for Research in Agroforestry (ICRAF)	PO Box 30677 Nairobi **Kenya** Tel: (254-2) 521450 Fax: (254-2) 521001 Email: ICRAF@cgiar.com	Seed is available from a range of provenances distributed across the native range. Also seed from San Ramón, Nicaragua, Patulul, Guatemala and Embu, Kenya produced in seed orchards.
Kenya Forestry Seed Centre	PO Box 20412 Nairobi **Kenya** Tel: (254-154) 32484, 32893 Fax: (254-154) 32844 Email: kefri@arcc.or.ke	Seed from Patulul, Guatemala, Piedades Norte, Costa Rica, Migori, Kenya and Bukura, Kenya, produced in seed orchards.
National Tree Seed Programme	PO Box 373 Morogoro **Tanzania** Tel: (255-56) 3192, 3903 Fax: (255-56) 3275 Email: ntsp@twiga.com	Naturalised seed from two sites in Tanzania.

Seed supplier	Address	Seed source available
Trees, Water and People	633 South College Avenue Fort Collins, Colorado 80524 **USA** Tel: (1-970) 484-3678 Fax: (1-970) 224-1726 Email: nfpwest@aol.com	Seed from Santa María de Jesus, Guatemala produced in a seed orchard.
Tropical Seeds, S. de R.L.	3 Ave 5 Calle S.O. Apartado Postal 116 Colonia Los Angeles Siguatepeque **Honduras** Tel: (504-7) 732767 Fax: (504-7) 732767	Seed from La Ceiba, Honduras.
The Inland & Foreign Trading Co (Pte) Ltd.	Block 79A Indus Road #04-418 Singapore 169589 **Singapore** Tel: (65) 2722711 (3 lines) Fax: (65) 2716118 Email: iftco@pacific.net.sg	Naturalised seed from Indonesia, available in large quantities.