Growing East African Sandalwood

Guidelines for Tree Growers

Kamondo Bernard, Giathi Gitehi, Osore Chahilu, Machua Joseph, Kagunyu Lucy, Wafula Allan, Bala Pauline, Njuguna Jane Wakori Samuel, Maingi Froza and Nyingi Kamau.

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Cover photographs (Clockwise)

- Harvested mature Sandalwood fruits
- Sandalwood seedlings ready for transplanting
- 2–year old Sandalwood plantation

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Foreword

Sandalwood has captured the limelight due to its overexploitation to meet international demand for its perfumery and medicinal products. The nature of exploitation of Sandalwood in Kenya raises concern on its survival in the wild as it involves uprooting of the whole tree. The mode and scale of harvesting has made the tree to be locally endangered which threatens not only the survival of the species, but also the sustainability of the trade in the species products. Unfortunately, while the resource base is declining, the markets of sandalwood oil have been rising.

Growing of Sandalwood has the potential of meeting demand for sandalwood oil sustainably and changing the focus from exploiting what is available in nature to cultivation of the species as an economic enterprise. However, growing Sandalwood is curtailed by lack of guidelines on its cultivation. Kenya Forestry Research Institute has undertaken research to generate information on Sandalwood growing. The information has been packaged as guidelines presented in this booklet. The booklet is intended for a wide range of tree growers and therefore presented as easy to follow guidelines. It is expected that the guidelines will go a long way in mainstreaming growing of Sandalwood by both private and public actors.

Ben N. Chikamai (PhD)
Director, Kenya Forestry Research Institute

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1.0 Introduction

East African Sandalwood (Sandalwood) is a tree indigenous to eastern Africa. Its scientific name is *Osyris lanceolata* while the common names in different ethnic groups in Kenya include; Munyungamai, Kithawa (Kamba), Mutero (Mbeere), Olosesiyet (MAA), Kijulu (Taita), Kepurwet (Kipsigis), Jemokabyl (Marakwet) and Mũthĩthĩi (Kikuyu).

Sandalwoods are also indigenous to India, Nepal, Bangladesh, Sri Lanka, Australia, Indonesia, Hawaii, and other Indo-pacific Islands. Sandalwoods have essential oils in the wood and roots that produce a distinctive fragrance that is highly valued. The most priced sandalwood is *Santallum alba*, the Indian Sandalwood.

Sandalwoods have been exploited for over 5000 years and many of the natural populations of these species are now classified as vulnerable to extinction. This situation made the Indo-pacific countries ban exploitation of the species which triggered a search for substitutes to satisfy demand. Traders discovered the East African Sandalwood and set trading bases in Tanzania in the late 1990s. Tanzania offered a ready market to Sandalwood from Kenya and by the year 2004, the exploitation of the species in Kenya was a matter of concern. Apart from the vast Sandalwood quantities that were being harvested from the wild, the nature of exploitation raised concern on the species survival as it involved uprooting the whole tree. The species was consequently protected under a Presidential ban for a period of five (5) years, with effect from 2007.

Despite the ban, illegal harvesting of Sandalwood continues to date. As a safeguard, populations of the species occurring in eastern Africa have been protected under Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II. This means that international trade in Sandalwood from these countries is subject to strict regulation in order to avoid utilization incompatible with the survival of the species in the wild. Protection of natural populations will be achieved by setting up a domestication programme where cultivation and harvesting of the species will ease pressure on natural populations while providing income to growers.

Kenya Forestry Research Institute embarked on research to domesticate Sandalwood. As the species had previously not been cultivated, there was limited information about its propagation and management. However, through research efforts, techniques for propagating Sandalwood through seeds and air-layering have been developed. Planting and establishment of Sandalwood into the field has been successful in Kitui and Kiambu and useful insights on growing of Sandalwood have been gained. This information booklet provides a technical guide on how to raise seedlings, establish and manage Sandalwood in the field.

2.0 Sandalwood tree characteristics

The East African Sandalwood is a shrub or small tree growing to a height of up to 6 m. The species is dioecious with a given tree being either male or female. It is multi-stemmed with dark-brown to blackish bark. The species is evergreen with many drooping small branches with bluish to yellow-green, sharply pointed leaves. The flowers are yellow-green, not readily noticeable as they are small round heads. Flowers are the main features that distinguish between male and female trees (Figure 1). The fruits are round, about 1 cm in diameter, green when unripe turning orange or deep red when ripe. The fruit contains a single whitish seed covered by fleshy pulp when ripe. Sandalwood is a hemi-parasite with its roots attaching to roots of host plants from which they absorb nutrients.

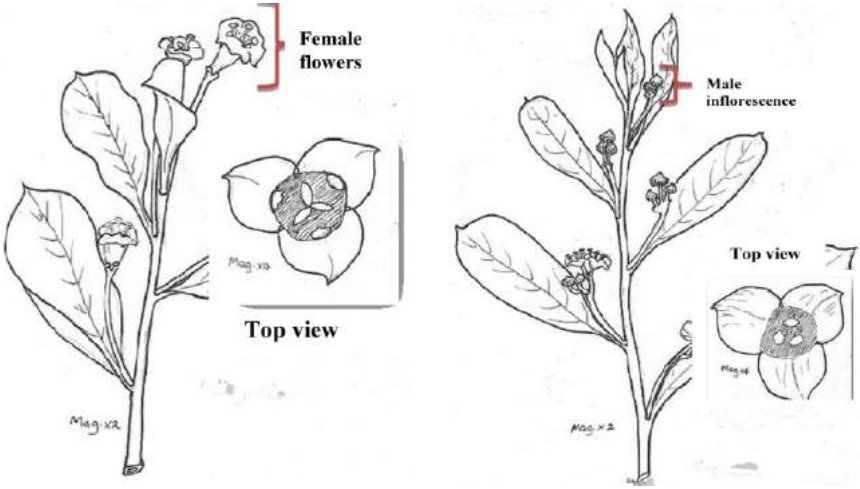


Figure 1. *Features of female (left) and male (right) Sandalwood flowers*

3.0 Ecology and distribution

Sandalwood grows at an altitude of 900 to 2250 m above sea level in areas with mean annual rainfall of 600 to 1600 mm. The species can grow in areas whose natural typical vegetation is dry woodland and bushland in ecological zone IV, dry forest and moist woodland in ecological zone III and moist to dry forest in ecological zone II. The species requires well drained soil. Sandalwood does not tolerate areas prone to frost.

4.0 How to propagate Sandalwood

Sandalwood seedlings can be raised through seeds, air-layering and cuttings. The most effective method of raising a large quantity of seedlings at the moment is through seeds and air-layering. Raising seedlings through cuttings for the moment is only feasible in specialized nurseries that have the capacity to control fungal attack prevalent on cuttings.

4.1 Propagating Sandalwood from seed

4.1.1 Seed source and seed trees selection

Seed source selection involves surveying areas with Sandalwood plants to identify potential populations for seed collection. Sandalwood in Kenya is associated with other plant species such as; *Harrisonia abbysinica*, *Euclea divinorum*, *Lantana camara*, *Rhus natalensis, Rhus vulgaris, Maytenus acuminata, Grewia similis* and *Dondonea viscosa* whose presence can be used as an indicator of occurrence of Sandalwood. A good seed source should have as many individual Sandalwood plants as possible from which to collect seeds. Sandalwood occurs in groups and therefore adjacent groups in one locality should be considered as one source.

In the selected seed source(s), select seed trees from which to collect seeds. In selecting seed trees, choose healthy and vigorously growing individuals. Avoid deformed, unhealthy, infected and young or over-mature trees. A seed source should ideally have more than 20 seed trees. However, over-exploitation of Sandalwood populations makes it almost impossible to attain this number and in such cases, seeds may be collected from all seeding trees with exception of unhealthy and infected ones.

4.1.2 Flower and seed survey

Sandalwood flowers throughout the year but exhibits two peak flowering seasons just before the onset of the two rainy seasons. Flower survey should commence a month before the onset of the rains i.e. mid-September and mid-March. Flower survey will give you an indication of amount of seed to expect. During flower survey, confirm that there is adequate flowering and occurrence of both female and male flowers within the seed source. Sandalwood generally is not a prolific seeder but it will periodically exhibit a contrary behavior and flower and seed prolifically.

Seed survey should be done to monitor development and maturation of fruits so as to enable accurate scheduling of seed collection. Seed survey should commence about a month after confirmation of adequate flowering. Sandalwood fruit maturation is indicated by change of fruit colour. As the fruits mature, they turn from green to orange and then to deep orange/red. The condition of the seeds should also be ascertained by performing a cutting test.

A cutting test involves picking 5 to 10 fruits at random in a given tree and slicing them to crosscheck the seed maturity and health status. A mature Sandalwood seed has a white firm endosperm while an immature one has milky content. This test should be repeated on seed from a number of trees within the seed source.

a

b

*Sandalwood fruits **(a)** partially ripe (**b**) ripe*

Sandalwood seeds with firm endosperm upon performing a cutting test

4.1.3 Seed collection, extraction, processing and storage

Ripe fruits are hand-picked and dropped into a cloth or khaki bag. Where the tree is tall, a ladder should be used to reach the fruits. Never attempt to lower the high branches by pulling as Sandalwood stems and branches are brittle and break easily. Avoid collecting fruits already fallen on the ground to minimize chances of fungal infestation. Collected fruits should be handled with care, as the seed coat of freshly collected seeds is fragile and easily crushed.

Collected Sandalwood fruits should be extracted within 48 hours after harvesting. Seed extraction and processing involves: cleaning and sorting of fruits; depulping, floatation and drying; treatment to prevent fungal infection; and packaging and storage of the seeds.

Sandalwood seeds are rinsed in clean water and then immersed in water (floatation) to isolate empty seeds from filled seeds. Most empty fruits float and should be discarded while fruits with good seeds sink. The fruits that sink should be subjected to further extraction process that involves depulping, floatation and drying.

Without delay, extract Sandalwood seed by removing pulp surrounding the seed by gently squeezing or rubbing the fruits with hands to separate the seeds from the fleshy pulp while avoiding crushing the tender seed coat. Any pulp remaining on the seeds should be removed by spreading the seeds on a wire mesh (4 mm) and rinsing with water. The clean seeds are then immersed in water. The seeds that sink give the best grade while any floating seeds can be retained as lower grade seed. The floating seeds are scooped out and the water drained to retain the sinkers. The seeds are subsequently handled as different seedlots although subjected to similar treatment.

Cleaning Sandalwood seed by rinsing over a wire mesh

The seedlots are spread on wire mesh layered with wire gauze for air-drying for a period of about 24 hours. In hot sunny weather, the seeds should be dried under shade. If drying is done in the open, ensure the seeds are not rained on. Frequent turning of the seeds is recommended especially on cloudy days for uniform drying.

Dried seed are dusted with fungicide such as Benlate or Murtano powder to control fungal infection during seed storage or after seed sowing. Appropriate packaging and storage maintains the quality and protects Sandalwood seeds until the time of sowing. Seed is packed in moisture tight polythene envelopes or in closed plastic containers. Packed seeds should be stored in cool dry cabinets or cupboards at room temperature. Sandalwood seeds can be stored in airtight containers in a cool dry place for up to a year without significant loss of viability.

4.1.4 Pre-treatment and sowing of Sandalwood seed

To achieve good germination, seeds of Sandalwood should be sown in a mixture of sand and fertile soil at temperatures of between 25 and 40°C, and high humidity. These temperatures and humidity can be achieved by using a simple greenhouse. Preparation and management of a greenhouse, as well as procedures for sowing Sandalwood seeds involve the following:

- Constructing a simple germination chamber measuring 2 m long, 1 m wide and 1 m high using timber/poles and polythene sheeting under partial shade
- Availing clean rivers and and fertile soil
- Sieving both sand and soil using a wire mesh
- Preparing a seed germination media by mixing sand and soil at a ratio of 1:1
- Filling a germination container (e.g.tray, plastic basin)with the germination media to half depth
- Fully wetting the germination media with water
- Removing a small piece of the seed coat with a razor blade or nail clipper (nicking) and spreading the seeds uniformly and sparingly on the surface of the germination media

- Spraying the seeds with 1% benlate/murtano fungicide solution (1 teaspoonful of fungicide powder dissolved in 10 litres of water)
- Covering the sown seed uniformly with the germination media to a depth equivalent to twice the diameter of the seed
- Watering the sown seeds sparingly
- Labeling with following details: Date of sowing, place where seed was collected, date of expected germination
- Placing the germination containers with sown seeds into the green house
- Always ensuring high humidity in the germination chamber by spraying inside the chamber with water and keeping it closed
- Monitoring germination

High quality Sandalwood seeds will start germinating in about 21 days after sowing. However, germination period may extend to 60 days. With proper seed handling, careful sowing and maintenance of ideal conditions in the greenhouse, a germination percentage of between 60 to 80% is achievable.

4.1.5 Raising of host seedlings

Raising of hosts should be done early in order to have them ready for pricking out together with Sandalwood germinants. Appropriate hosts include: *Calliandra calothyrsus, Croton megalocarpus, Cajanus cajan* (Pigeon pea), *Sesbania sesban* and indigenous Acacia species.

4.1.6 Pricking out and hosting

Suitable potting media in which to prick the young Sandalwood seedlings is a mixture of top soil, sand and manure in a ratio of 5:2:1. Sandalwood seedlings are ready for pricking out 4 months after germination when they have 6 to 8 leaves and about 6 to 10 cm tall. Sandalwood and a host seedling are pricked out into plastic polyethylene pots of size 6 x 10 x 10 inches gauge 300. Immediately after pricking out the young seedlings are thoroughly watered and placed in the greenhouse where they stay for one year. The glass house should be shaded with 50% shade net for the first 6 months.

Sandalwood seedlings planted together with Calliandra as host plants

4.1.7 Ensuring adequate number of seedlings are produced from seeds

The amount of seeds to sow in the nursery is determined by the target number of Sandalwood trees to raise. On average 70% of seeds germinate. However, about 50% of resultant seedlings do not transit to seedlings due to mortality and inability to attach to a host. About another 20% mortality occurs in the field. A kilogram of Sandalwood seed has an average of 11,600 seeds. With a germination rate of 70%, a kilogram of seeds will yield about 8,100 germinants. Hence, the amount of seeds (kilograms) required to raise a number of Sandalwood trees (N) is calculated as follows:

kilogram of seeds to sow = (N x 3.57)/8100

For example, with a target to raise 1600 Sandalwood trees, a nursery should aim to sow (1600 x 3.57)/8100 equal 0.7 kilogram of seeds.

4.1.8 Sandalwood seedling duration in the nursery

In order to get a seedling ready for transplanting and robust survival and establishment in the field, Sandalwood takes about 15 months in the nursery.

4.2 Propagating Sandalwood through marcots

Currently the only viable vegetative propagation method of Sandalwood in Kenya is marcotting (air-layering). Other methods such as rooted cuttings, tissue culture and grafting are at research stage. It is important that planting stock produced through vegetative propagation be a mixture of both female and male plants. It is therefore essential to be able to distinguish between female and male Sandalwood plants. Distinguishing features (Figure 1) are only found in flowers and can be seen using either a magnifying glass or naked eyes.

Marcotting is a process in which roots are induced to develop on a branch (stem) while it remains attached to and nutritionally supported by the parent plant. Once the roots are developed, the branch is detached and becomes a new individual growing on its own roots and is referred to as a marcot or a layer. Rooting in marcotting is initiated by girdling (removing away a section of bark about 3 cm wide around the circumference of the branch) the branch thus interrupting the downward flow of photosynthates through the phloem from the branch tip.

Girdling causes the accumulation of auxins, carbohydrates and other growth factors at the upper point of the girdled section. When a moist rooting medium is applied to the girdled section, rooting occurs. External root inducing hormones are often applied to hasten and enhance the rooting. Such hormones include IBA and IAA. When the marcot has developed enough roots, it is severed from the mother tree and potted as an independent self-sustaining seedling.

An air-layered branch with roots

4.2.1 Tools and materials for marcotting

All the necessary materials and tools are assembled prior to initiating marcotting. These include:

- Surgical blades/grafting knife/razor blade:
  For girdling and should be sharp, clean and free from contamination.
- A pair of clean secateurs:
  For removal of side branches around the point of girdling for ease of working.
- Ethanol/methylated spirit:
  For cleaning and sterilizing blades/knives and other containers prior to use.
- Rooting medium:
  To provide medium for root formation. The rooting medium of choice should be sterilized to get rid of all disease-causing agents. Examples of rooting media include, coconut husks/peat, sand, decomposing saw dust and subsoil.
- Transparent/clear plastic/polyethylene tubes or sheets:
  For holding rooting medium in place around the girdled section and to keep off any foreign material.
- Parafilm:
  For sealing the plastic wrap around the girdled section of the branch to keep out any unwanted foreign materials and water. Thin polyethylene straps and/or strings/coated wire can also be used as alternative.
- Rooting hormone (Preferably Indole-3-Butyric Acid (IBA)): (Seradix, Rhizopon):
  To promote root formation. It is applied around the girdled section directly if in powder form using a small brush, or injected into the rooting medium if in solution form.
- Distilled water or boiled water (that has been left to cool):
  This is used to moisten the rooting medium. It is injected once the rooting medium has been securely placed around the girdled section. Distilled water will give more desirable results than boiled water.

- Fungicide (such as Ridomil, Bavistin):
  To prevent/minimize incidences of fungal attack. This is also injected once the rooting medium has been securely placed around the girdled section. (Use the manufacturers recommended rate).
- Hypodermic syringes and needles:
  These are used to inject fungicides, water and the rooting hormone into the rooting medium around the wound.

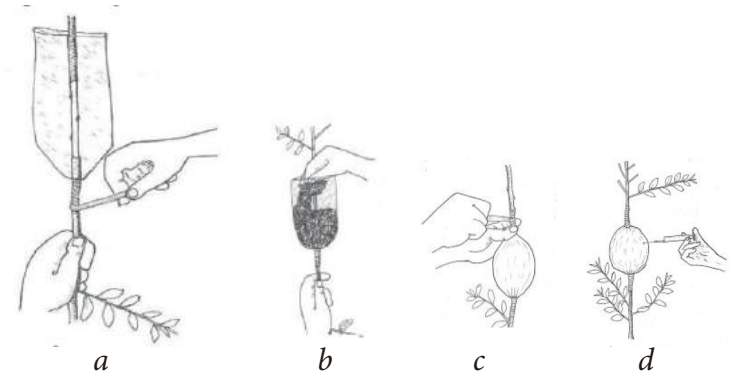
4.2.2 Setting marcots in the field

The Sandalwood trees to be multiplied through marcotting should have vigorously vegetative growth, be free from diseases and pests, and be shaded from direct sun radiation. They should be accessible but at the same time relatively removed away from heavy human traffic, livestock or other potential agents of damage.

On the selected trees, branches with diameter between 5-10 mm and at least 60 cm long are chosen. If the Sandalwood tree is not fully shaded but has met all the other selection criteria, the branches that are away from direct sunlight are selected for marcotting. The point of girdling is chosen at approximately 40-45 cm from the tip of the branch in the cool highland climate and at 60 cm in semi-arid climate. All the side branches on either side of the chosen point of girdling are removed using secateurs to create a clear section of about 20 cm long. A ring of about 3 cm wide is made at the marked point using a clean sterilized knife. The ring should not be smaller than 3 cm and debarking should be complete, otherwise there will be a risk of the wound healing instead of forming roots.

A girdled stem

After debarking, fungicide is applied all-round the girdled section with a hand sprayer. At this point, if the rooting hormone in use is in form of a powder, it is carefully applied all around the upper side of the girdled section using a small sterile brush. Rooting medium is applied around the wound in form of a ball and tied firmly using a clear plastic wrap that may be in form of a sheet or a tube. Parafilm is used to fasten the plastic wrapper holding the rooting medium on to the branch. Other materials that may be used instead of parafilm are plastic straps, strings and coated wire.



Process of setting marcots in the field: **a.** fastening the plastic tube around the girdle: **b.** filling the tube with rooting medium: **c.** tying the rooting medium in place: **d.** injecting rooting hormone

After the rooting medium is in place, 20 ml of 60 mg/l of IBA rooting hormone is injected into the rooting medium using a hypodermic syringe. Alternatively, the hormone solution is mixed with fungicide (1.5 g/l) and applied together. However, when the rooting hormone is used in powder form, water is applied 24 hours later to avoid washing hormone away before the hormones has ample time to act. Marcots made on weak branches are provided with support. They may be tied to adjacent strong branches or can

Injecting the marcot with fungicide and hormone

4.2.3 Management of set marcots in the field

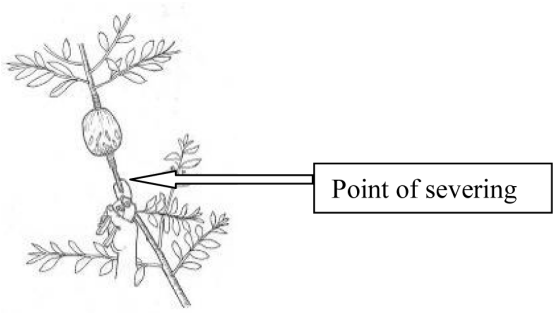
The rooting medium is kept moist throughout the rooting period and when sign of drying is noted watering is done by injection using hypodermic syringe. Great care is taken not to waterlog the rooting medium. Water logging would promote rotting. Watering may start as early as 4 days after air-layering, depending on the prevailing weather conditions. Frequency of watering is also dependent on the prevailing weather conditions. However, no watering should be done a week to the harvesting date.

In the semi-arid climate rooting may begin from 6^{th} to 8^{th} week. The roots formed eventually become visible through the plastic wrap. In the highlands, rooting begins from 10^{th} to 12^{th} week. Once the roots are visible, it is advisable to allow the marcots two more weeks before harvesting. This will allow the roots to grow stronger and be able to withstand stress on potting. Marcots are harvested when about 40% of surviving marcots have formed visible roots through the plastic wrapper.

Roots on a marcot

4.2.4 Harvesting of marcots

Marcots are severed from the mother tree at about 15 cm below the girdling point and trimmed at 40-45 cm above the upper point for ease of transportation. They are then transported to the nursery in buckets; however, if they are to be transported over long distances, a small amount of water is added into the buckets to cover the base/proximal end to 5 cm to minimize dehydration. During transportation, marcots are kept away from wind to further minimize chances of desiccation. Water leakage into the harvested marcots is avoided as far as possible for it promotes dispersion of the rooting medium away from the roots thus making them more susceptible to damage. On arrival at the nursery, the marcots are kept under shade.



Harvesting marcot: showing the point of severing

4.2.5 Potting and hosting of marcots

Potting of media is done before harvesting of the marcots. The composition of the potting medium may vary from nursery to nursery but the main ingredients are usually forest soil, sand and manure mixed at a ratio of 5:2:1. The size of the pot used is 6 x 10 x 10 inch gauge 300.

The plastic wrappers are carefully peeled-off the rooting medium to avoid injuring the roots. The marcot is then potted intact, that is, without removing any rooting medium clinging to the roots. During potting irrespective of the intensities of roots the basal end (proximal end) of marcot is cut slightly below the end of the longest root.

Rooted marcot showing the lower point of cutting the stem

When the marcot is finally inserted into the half-filled polyethylene pots, it is the proximal end of the marcot that always touches the potting mixture first and not the roots. The pot is filled slowly and carefully with the potting medium to the top. No pressure should be applied to firm the rooting medium around the marcot in order to minimize root breakage.

After potting, the potting medium is drenched with a fungicide suspension (at 0.15 g/litre). Then at least 2 seeds of the host plant are sown. The marcots are finally trimmed to 35- 40 cm long and the number of branches reduced to about 5 and leaves stripped to reduce loss of moisture through evapo-transpiration. The potted marcots (now seedlings) are then placed inside a greenhouse.

Potted marcots stripped of branches and leaves

4.2.6 Ensuring adequate number of seedlings are produced from marcots

The average success rate of rooting marcots is about 90%. Approximately 30% of marcots do not transit to seedlings in the nursery due to mortality and inability to attach to a host. About another 20% mortality occurs in the field. Hence with a target to have N number of established Sandalwood trees, the following formula applies to guide the number of marcots to be set (MS).

MS = N x 1.98

For example, with a target to raise 1,600 Sandalwood trees, the marcots to set (MS) are:

MS = 1600 x 1.98 i.e. 3174 marcots

4.2.7 Duration for Sandalwood marcot seedlings

It takes about 15 months to produce marcot Sandalwood seedling ready for transplanting and robust survival and establishment in the field.

5.0 Management and care of Sandalwood seedlings raised from both seeds and marcots

In the greenhouse, Sandalwood seedlings should be watered in the evening, twice a week with 0.5 litres of water per seedling per watering.

Weeding should be done only during the first 2 weeks. Thereafter, the weeds should only be trimmed not to overgrow the Sandalwood plant and its host.

Root pruning is not encouraged because Sandalwood has a poor root system. However, the pots should be moved carefully once every 3 months to avoid the host's roots penetrating to the ground.

Pruning of fast growing hosts such as Calliandra, Croton, and Pigeon pea should be done once every 3 months by reducing the crown to 50% to avoid the host from overshadowing the Sandalwood. The Sandalwood plant should be left intact when pruning the host.

Sandalwood seedlings should be removed from the greenhouse to the open nursery after 1 year for field acclimatisation. Acclimatisation is done over a period of 3 months. During this period, watering should be done 3 times a week. Two weeks before transplanting in the field, watering should be reduced to once a week and the seedlings spread out for hardening.

Before transplanting in the field, culling should be done to ensure only strong healthy seedlings are taken to the field. Healthy seedlings should measure on average between 60 and 90 cm in height.

All nursery records should be maintained.

Sandalwood seedlings ready for hardening up

6.0 Transplanting Sandalwood in the field

6.1 Planning

It is important to plan for budgetary implication for all activities including labour in order to grow Sandalwood cost-effectively. As a guide to planning for labour one person can stake, pit, place and plant about 50 Sandalwood trees in the highlands and 25 in the drylands in a day.

All records should be kept including the following: source of planting materials; date of planting; number of seedlings planted; and costs incurred.

6.2 Selection of suitable sites

Sandalwood tolerates a wide range of soils so long as they are well drained but does not tolerate areas prone to water logging. Sandalwood should not be planted in areas prone to frost.

6.3 Land preparation

Complete ploughing or 1 m strip ploughing should be done before the onset of the rainy season. In case of bushy areas, complete slashing should be done before ploughing. Slashed material can be used as fuelwood and the remaining brush spread uniformly along the rows.

6.4 Staking

When Sandalwood is established as a plantation crop, stakes should be prepared in advance, at least a week before the onset of the rainy season. The stakes are used to mark the planting spots for pitting. During staking, a spacing of 2.5 m x 2.5 m should be adopted in the highlands while a spacing of 3.5 m x 3.5 m should be used in the semi arid areas.

Sandalwood can also be planted as hedge and ornamental. For a hedge, 2 rows should be interlocked with stakes placed at a spacing of 1 m. For ornamental planting, staking should be as appropriate.

6.5 Pitting

Pitting should be done at least 2 weeks before the onset of the rainy season. In the highlands, Sandalwood should be planted in round pits of 30 cm deep and 30 cm diameter. In the semi arid areas, it should be planted in square pits of 45 cm x 45 cm x 45 cm.

6.6 Planting

Planting is done after the onset of the rainy season. Seedlings should be planted in the morning before the sun becomes too hot. Maximum care should be taken during loading, ferrying, off-loading and placement of seedlings to ensure that there is no damage whatsoever. It is recommended that seedlings should be handled by holding the pot and not seedlings. During actual planting, seedlings should be gently eased out of the pot with care not to separate the host and the sandalwood plant. The seedling and its host should be placed in the pit and the pit refilled completely to avoid collection of water around the planted seedling.

7.0 Tending and management

Sandalwood seedlings and most of the hosts are palatable to both domestic and wild herbivores. Sandalwood plantations should therefore be fenced all round to avoid damage by animals. In case of planting Sandalwood in hedges and as ornamentals, care on individual seedlings should be taken to avoid similar damage.

Replacement of dead Sandalwood or host seedlings should be done the following rainy season after establishment/planting.

Sandalwood plantation should be kept clean by complete slashing. The host should be maintained through pruning to ensure that it does not over shadow Sandalwood plant. A 50% crown of the host is recommended.

8.0 Harvesting

Sandalwood growing in Kenya is in its initial stages and the average rotation period is not fully understood. However, experiences of growing other Sandalwoods in the world indicate that the tree can be harvested for oil production at age 15 to 20 years.

9.0 Sustainable Sandalwood production

Sandalwood coppices profusely after cutting. It is therefore feasible to easily regenerate Sandalwood plantations after harvesting without incurring establishment costs.

Glossary

Cool box: A container that is used to keep items placed inside it cool. Ice cubes are mostly used to maintain a low temperature inside the cool box.

Coppice: Ability of certain species of plants to re-sprout when felled. The sprout is also called a coppice and can be tended to re-establish the tree crop after harvesting.

Depulping: Removal of the outer fleshy covering of the fruit.

Dioecious: Plant population of the same species having separate male and female plants (e.g. papaws).

Endosperm: The tissue within seeds of flowering plants on which a young emerging seedling feeds on in the early stage of seed germination.

Essential oil: Oil from a plant that easily turns into vapour on heating usually having the characteristic smell or taste of the plant from which it is obtained. Essential oils are used to make perfumes, flavourings and medicinal products.

Fungicide: Chemical compounds used to kill or slow down growth of fungi and their seeds. Some fungi species cause rotting in seeds.

Germinating media: The physical material on which seed is germinated. The most commonly used materials include sand and soil or a mixture of both.

Girdling: Complete removal of a strip of bark from around the entire circumference of either a branch or trunk of a woody plant. It is also referred to as ring-barking.

Hemi-parasite: Characteristics of being partially dependant on host plant as opposed to being fully dependant.

Host plant: A host plant is one that aids another plant to produce, survive, grow and mature. Host plants supply food resources to its dependant plant.

Hypodermic syringe: A normal syringe fitted with a hollow needle to help direct flow of liquid or gas into and out of the barrel. They are commonly used to administer injections in medicine.

Inflorescence: Flowering part of a plant or several flowers on one stem or branch.

Meristematic tip: The tip of the plant that keeps the plant growing. It contains undifferentiated cells (meristematic cells) that with time give rise to various organs of the plant.

Phloem: A living tissue that transports food in plant from leaves to the other parts of plant. It is located in the bark of the plant.

Pricking out: Removing the young germinated seedlings from the container the seeds were germinated in to give them more growing room by replanting each individual seedling into a seedling container (mostly polyethylene tube) or into a seedling raising bed.

Proximal end: The point of attachment.

Seed coat: The outer protective covering of a seed.

Seed viability: The capacity of seed to germinate.

Sparingly: Supplied in limited quantity.

Sterilize: Make free from harmful living micro-organisms. This is achieved through heating or application of chemical.