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Pacific sandalwood

Growers' guide for sandalwood production in the Pacific region

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Contents

Photo: (facing page) Luis Almeida

Acronyms and abbreviations

Term	Description
2CC	second cutting chips
DBH	diameter at breast height
DBHOB	diameter at breast height over bark

Units

Unit	Definition
cm	centimetre
cm AGL	centimetres above ground level
g	gram
ha	hectare
kg	kilogram
L	litre
m	metre
m^2	square metre
m AGL	metres above ground level
m ASL	metres above sea level
mm	millimetre
ppm	parts per million
t	tonne, metric tonne (1,000 kg)
°C	degree Celsius


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1 Introduction

1.1 Sandalwood products

Sandalwood trees (*Santalum* spp.) are highly valued for their fragrant heartwood oils (Figure 1.1) and are recognised as one of the most precious non-timber forest products. The oils have been used for centuries for religious and customary purposes, and are now used internationally for cosmetics, aromatherapy, scenting of soaps, perfumery and medicines.

The oil-bearing heartwood is also used for ornamental or ceremonial carvings, or powdered for the manufacture of incense joss sticks (Figure 1.2), which are valued in the international agarbatti (incense) market.

Figure 1.1 Sandalwood heartwood oil

Photo: Tony Page

1.2 Sandalwood markets

Since the 1400s, when Chinese merchants and Arab traders started visiting Timor and surrounding islands, there has been trade in sandalwood in the Pacific region. As new trade routes opened, this trade spread to other Pacific islands including Hawai'i, Fiji, French Polynesia, New Caledonia, Vanuatu and Tonga. Trade has risen and fallen with the availability of sandalwood. Tree populations recover to some extent, during times when trade has dropped off. Interest in planting and growing sandalwood for both cultural and commercial reasons has increased in the Pacific islands in recent times. In Vanuatu a modest commercial industry has been operating consistently since the 1970s, with an annual quota of about 80 t. In recent decades, the total amount of heartwood exported from Fiji and Tonga has been <100 t/year. In Timor-Leste, sandalwood exports have been prohibited since 2012 in an effort to enable wild populations to recover; however, there is still some black-market trade. Sandalwood exports from Papua New Guinea spiked between 1997 and 2002, when an average of ~36 t was exported annually. More recently (2013–2018), annual harvests ranged from <1 to 5 t, except in 2019 where 20 t was exported.

Sandalwood is used mainly in India, China, Taiwan, Hong Kong and the Middle East, with substantial markets in Europe, Japan, South Korea, North America and elsewhere. The high demand for sandalwood products and the low level of commercial production of these trees has resulted in a sharp decline in the natural supplies of many sandalwood species. International prices for sandalwood have therefore consistently risen over the past few decades. However, the price that this product attracts is dependent on its quality. Until recently, the price paid to villagers in Vanuatu for 1 kg of heartwood had risen at an annual rate of 10% since 1990. Sandalwood prices in Vanuatu are currently being affected by the lower quality of the available product. Now that recent plantings are maturing and developing substantial heartwood, the price may be expected to rise again.

Figure 1.2 Large ornamental carving from sandalwood (left page) and incense burners in a temple (above)
Photos: Tony Page


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2 Sandalwood species

2.1 Distribution and size

Sandalwood trees vary in size depending upon, among other factors, the species of sandalwood and the location where it is grown.

Santalum album

Indian sandalwood is a small tree, between 4 and 10 m tall. It occurs in the seasonally dry tropics of southern India; Sri Lanka; Indonesia (Aceh in north-west Sumatra, West Timor and Lesser Sunda Islands); Timor-Leste; and the northern coastline of the Northern Territory, Australia.

Santalum austrocaledonicum

Vanuatu and New Caledonia sandalwood is a small tree (5–10 m tall) that occurs naturally in west-coast Santo, western Malekula, north-western Efate, Erromango, Tanna, Aniwa, Futuna and Aneityum, Vanuatu; and Grande-Terre, Isle of Pines and the Loyalty Islands, New Caledonia.

Santalum lanceolatum

Northern sandalwood is a shrub or small tree growing up to 8 m high. It is a tropical species that occurs in the northern parts of Australia (latitudes north of 20°), in Queensland, the Northern Territory and Western Australia.

Santalum macgregorii

Papua New Guinea sandalwood is a medium-sized tree that is usually less than 8 m tall but which may grow up to 20 m tall and 25 cm in diameter. It occurs naturally in Papua New Guinea, occurring in the Central and Gulf provinces from near sea level to 750 mASL. Recent research has indicated that some sandalwood populations in Western Province, Papua New Guinea, thought to be *S. macgregorii* may actually be *S. lanceolatum*, or more closely related to *S. lanceolatum*.

Santalum yasi

Fiji, Tonga and Niue sandalwood is a shrub or small tree to 9 m tall with a light, spreading crown. It occurs from Niue through ‘Eua, Tongatapu, Ha’apai, Vava’u and Niuas (Tonga) and the Fiji Islands (Lau Islands, to Bua and Macuata provinces (Vanua Levu), Udu Peninsula (north-east Vanua Levu), Nausori Highlands (western Viti Levu) and Kadavu).

2.2 Biology

Sandalwood is an obligate hemiparasite, which means that although the trees can photosynthesise, they must grow with other species to survive. Their roots have specialised outgrowths (haustoria) that penetrate the roots of nearby trees and shrubs and absorb water and nutrients from them (Figure 2.1).

Figure 2.1 Haustorial connection of sandalwood root (left) and cross-section of haustoria penetrating the host root (right)

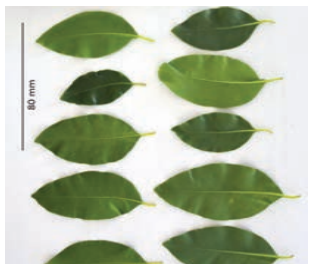
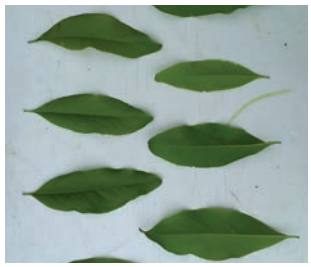
Photos: Tony Page

When growing sandalwood seedlings, a host plant needs to be planted with the sandalwood (a 'pot host'). Host plants also need to be planted among sandalwood trees in the field to promote vigorous sandalwood growth.

Sandalwood exhibits different growth habits and features across the spread of its geographic range (Table 2.1):

- **Habit** – Sandalwood growth habit is influenced by the environment in which it grows. Trees growing in open positions tend to have a short, crooked and forked trunk with a spreading crown. Trees growing in forest and sheltered positions will typically develop a longer, straighter trunk with a narrower crown and fewer heavy branches.
- **Bark** – The bark varies from smooth to rough and fissured, grey to reddish brown to almost black in some *S. album*, often with lichen on older trees.
- **Leaves** – Leaves range from near-linear in some *S. yasi* through to ovate or broadly lanceolate in *S. album*. Leaves are typically narrower in seedlings, becoming somewhat broader with age. Pacific sandalwood species leaves are mostly discolourous with a dark shiny green upper and a matte light green lower surface. *S. lanceolatum* leaves are either the same colour on either side or slightly discolorous and often slightly glaucous (greyish blue or green, or covered with a greyish waxy bloom). Planting position, soil type and amount of shade can strongly affect leaf colour. Sandalwood (especially *S. yasi*) grown in open, sunny sites with inadequate hosts, have lighter yellower leaves.
- **Flowers** – Sandalwood has small, greenish white to cream-coloured flower parts (tepals) that turn light pink through to dark red at maturity (except for *S. austrocaledonicum* and *S. lanceolatum*, whose flowers remain greenish white to cream until maturity). These flowers are borne on branched inflorescences twice each year. In *S. austrocaledonicum*, *S. lanceolatum* and *S. macgregorii*, individual flowers typically open in the morning of one day and close by the afternoon of the next. In *S. album* and *S. yasi*, flowers can stay open for several days and do not close before forming fruit or falling off.
- **Fruit** – Fruit is firm and green when young, red when ripening, and purplish black when mature. Each fruit contains a single seed covered with a juicy flesh and has a scar on the top from the tepals.
- **Seed** – Seed is covered by a hard (woody) testa and contains a white-coloured kernel that can be sticky to the touch. Seeds range from about 9 to 15 mm in diameter. The outer surface is smooth or slightly textured, and light brown.
  The seed shape of the different species is variable. While. *S. album* has a near-spherical seed, *S. yasi* has an ovate seed with a sharp point at one end. Seeds of *S. austrocaledonicum* from the southern islands are generally spherical; seeds from the northern islands are slightly elongated.
- **Wood** – The inner heartwood colour varies from yellow to red or reddish brown, and the outer sapwood is pale yellow to white. Heartwood is rich in oils that are highly aromatic and commercially valuable.

Table 2.1 Comparison of different growth habits and features of *Santalum* species

	Santalum album	*Santalum austro-caledonicum*	*Santalum lanceolatum*	*Santalum macgregorii*	*Santalum yasi*
Habit					
Bark					
Leaves					

	Santalum album	*Santalum austro-caledonicum*	*Santalum lanceolatum*	*Santalum macgregorii*	*Santalum yasi*
Flowers					
Fruit					
Seeds					

3 Nursery

3.1 Seedling production

There are various ways that growers can produce plants for establishing plantations:

1. growing seedlings in a nursery
2. transplanting seedlings from one location to another (wildings)
3. planting seeds in the ground (direct seeding)
4. taking cuttings.

Of these, growing seedlings in a nursery is probably the most common and it is our main focus in this guide. In future, this method may become preferable to transplanting wildings because programs to produce genetically improved sandalwood are underway for the main sandalwood species discussed here. Wildings may not perform as well as seedlings grown from improved seed. You should ask your local sandalwood extension officer or government agriculture / forestry staff whether improved seed or seedlings are available. Growing cuttings is challenging, particularly for inexperienced growers with a basic nursery set-up. Direct seeding can work well but has issues with achieving good germination, browsing by pests (e.g. rats), satisfying the need for intensive weeding, and achieving consistent spacing.

A very common method for establishing new sandalwood plants is to sow seeds in a germination medium and then transplant and raise seedlings in soil-filled polybags. The seedlings are typically grown with a pot host in a plant nursery (Figure 3.1) and then transplanted to the field during the wet season (preferably the early wet season).

Figure 3.1 (photo on facing page) Production nursery, Timor-Leste

Photo: Luis Almeida

3.2 Seed collection and storage

Collecting and preparing seeds

1. Pick

Pick ripe fruit from the tree and collect fruit that has recently fallen to the ground. Ripe fruit are soft, shiny and purple to black. Immature fruit are hard, dull and green. Do not collect seeds from green fruit because they will not be viable. Any fruits that show some reddish colouration are fine to collect, but are harder to process if slightly immature.

2. Soak

Soak the ripe fruit in a bucket of water overnight (about 12 hours) to loosen the flesh.

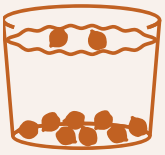
3. Clean

Rub the soaked fruit between your palms to remove the flesh from the seed. Rinse the seed in clean water to remove any impurities.

Flesh

Seed

4. Float



Place the seeds in a bucket of water. Discard seeds that float, since most of these will not be viable. Non-viable seeds break easily when pressed between the thumb and forefinger and have a small kernel that is shrunken away from the shell. Viable seeds have a kernel that fills the shell and sinks in water.

Collect the seeds that sink, because these are viable.

5. Dry

Dry the cleaned seeds on a flat surface in a warm, dry area, but not in full sun because this can overheat and kill the seeds.

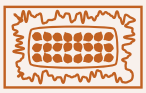
6. Store

Store dried seeds in a clean calico or paper bag, in a cool, dry place away from rats. Seeds stored like this can remain viable for up to 6 months, but should be sold or used as soon as possible.

Dried seeds stored in a sealed container in a refrigerator (2–4 °C) remain viable for more than 1 year.

Seeds stored in plastic bags will sweat and rot if not dried properly prior to storage. In Timor-Leste, growers market and store their dry seed in a plastic bottle, perforated with many holes for ventilation, for up to 3 months.

7. Transport



Keep seeds cool and dry during transport. If sending seeds as a parcel, place the calico bag in a box and pack it with scrunched paper so that the seeds do not become too hot during transit.

Figure 3.2 Method of collecting and preparing seeds for storage and transport

It is important to use good-quality seeds because they produce strong, healthy seedlings. Use the basic methods of seed preparation outlined in Figure 3.2.

Seed cleaning is an important exercise, particularly if the seeds are going to be stored for any length of time (Figure 3.3). Storage life of seed is shortened if it retains some of the flesh, because the flesh and its contained sugar provides an energy source for microorganisms such as mould and other fungi. Particular attention must also be paid to properly drying the seeds, which is also important for storage. When moisture builds up during storage this can promote unwanted germination and/or the growth of mould and fungi, which severely reduces seed viability (Figure 3.4). In Timor-Leste, dry seed is sometimes sold and stored for short periods, up to 3 months, in a plastic bottle with many holes for ventilation (Figure 3.5).

Figure 3.3 Increasingly cleaner seed from left to right

Figure 3.4 (above) Poorly stored seed creates the conditions for fungal growth, which will result in rapid loss of seed viability

Figure 3.5 (right) Dry seed stored in a plastic bottle with holes for ventilation

Photo: Luis Almeida

3.3 Germination

Seeds germinate best when they are sown in a free-draining medium such as a 2:1 mix of river sand and soil (Figure 3.6). Composted sawdust is also a very good germination medium.

Figure 3.6 Germinating seeds (top) and seedlings ready for transplanting to polybags (bottom)

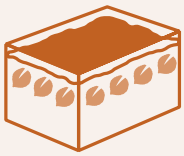
Viable sandalwood seed can typically take several months for complete germination of all the seed in a seedlot. This is caused by variable levels of seed dormancy between individual seeds. This can be an advantage where there is only one person to manage operations because there will only be small numbers of seedlings to be handled, at one time, for each task (e.g. potting, sorting, hardening). However, there are disadvantages such as the substantial variation in seedling size in the nursery, the need for close attention to seedling sorting (based on size), and variable shade management and hardening between groups of seedlings.

Germinating seeds

1. Nick

'Nick' the seed shell to expose the kernel. Nicked seed begins to germinate after 2 weeks, whereas seeds that are not nicked may take 6 weeks to germinate.

2. Sow

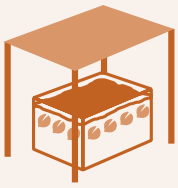


Sow seeds in a seedling tray or pot, just (5–10 mm) below the surface of the medium so that the seeds do not touch each other.

3. Water

Keep the medium moist but not wet. During the wet season, trays may need to be brought out of the rain.

4. Protect



Protect germinating seedlings from full sun and predation by rats and birds.

Figure 3.7 Method of germinating seeds

There are two main methods used to promote simultaneous germination:

1. The use of nicking the seed coat (as described in Figure 3.7) for low numbers of seed.
2. Treatment with gibberellic acid for high numbers of seed. Sandalwood seed can be soaked overnight in a solution of gibberellic acid at a rate of 0.1 to 0.25 g/L active ingredient (100 to 250 ppm). In some trials, longer periods of soaking, up to 48 hours, in a stronger solution (500 ppm) have produced better results, but longer soak times require the seed to be agitated/stirred regularly to oxygenate the solution and avoid seed damage. If available, you can also use a fish tank aerator instead of manually agitating the solution.

Variation in the capacity for seed storage has been noted in sandalwood (e.g. *S. austrocaledonicum* from the Loyalty Islands has been found to store poorly whereas other *S. austrocaledonicum* provenances can be stored as described in Figure 3.2). As a rule, *Santalum* seed is best sown fresh, as medium-term storage is risky and can result in loss of viability.

3.4 Preparing a medium

The quality of sandalwood seedlings is heavily influenced by the quality of the growing medium and the method of transferring seedlings from the germination tray to a polybag (potting up). The importance of these steps should not be underestimated and diligence in following good practice in the nursery will be evident by vigorous growth in the field for many years to come.

3.4.1 Components of a growing medium

A good potting medium needs to contain all the necessary properties for growth in a small volume. Consequently, a potting medium needs to be slightly different from a garden soil (Figure 3.8). The three main components necessary for seedling growth are:

1. good-quality loamy topsoil
   - supplies essential nutrients for seedling growth
   - influences water-holding capacity
2. drainage particles
   - comes from larger aggregates (grains), typically sand
   - allows the medium to drain after rain and watering
   - increases the air in the medium, allowing roots to breathe and not be waterlogged
3. organic matter
   - comes from **well-composted** plant material – coconut husks, rice hulls, garden refuse, cocoa pods, coffee parchment, sawdust, woodchips, etc.
   - improves water-holding capacity
   - contains healthy microorganisms (to prevent soil-borne diseases)
   - improves nutrient retention.

Soils for potting media

Heavy clay soil should be avoided for potting media.

Light clay can be used for potting media if sand and organic matter are added.

Loamy soil can be used without adding sand but with added organic matter.

Figure 3.8 Use of different soils for potting media

Sandalwood seedlings perform well in a free-draining mix composed of:

- 2 parts loamy topsoil (nutrient)
- 1 part sand (drainage particles)
- 1 part coconut husk (organic matter).

3.4.2 Sand

Sand can be sourced from clean, freshwater streams. Sand is an important component to promote drainage of the potting medium.

Sand can be classed by its grain size:

- fine (small grains)
- medium (moderate grains)
- coarse (large grains).

Sand from coastal beaches (i.e. salt water) should be avoided. If it is your only source of sand, then it can be used provided it is thoroughly 'washed' in fresh water before use.

3.4.3 Sterilising soil and sand

Topsoil and sand can contain pests and diseases, particularly when the medium is not free draining. If possible, collect from sources known to be free of disease. If unsure, the topsoil and sand need to be heat sterilised to kill pests and disease (and weed seeds). Sterilisation can take place in half steel drums over a low-intensity fire (Figure 3.9). The soil and sand need to be turned regularly for even heat distribution for a period of 1 hour. Soil can also be sandwiched in black plastic and left in the sun (solarised) to achieve sterilisation (see Section 3.8.1).

Figure 3.9 Sterilisation of soil and sand in half steel drums

Photo: David Spencer

3.4.4 Organic matter

All organic matter needs to be composted before use. Composting breaks down fresh organic matter to release its nutrients and improve its structure. Composting involves piling and turning organic material and waiting (weeks to months) for it to break down. Suitable organics include sawdust, cocoa pods, coconut husks, rice hulls, coffee parchment, peanut shells, grass clippings, plant leaves, vegetable waste, animal manure, etc. Old coconut husks can be grated and used immediately, and don't need to be composted first (Figure 3.10).

Figure 3.10 Old coconut husks can be grated and used immediately

3.4.5 Mixing and ratio

The different components of the soil medium must be well mixed prior to use. Ratios of soil, sand and organic matter should be varied to ensure a good-quality, free-draining mix, according to the properties of the soil and sand (Figure 3.11).

Mixing and ratio adjustment

Soil, sand and organic matter must be mixed well prior to use. Mixing ratios can be adjusted according to the properties of the soil and sand.

- If heavier soil is used, then add more sand.
- If the sand is coarse, then less of it may be added.
- If the soil is already sandy, then there is no need to add sand, but increase organic matter additions.

Figure 3.11 Mixing ratios of soil, sand and organic matter

In Timor-Leste, where good-quality topsoil is available, they use this rather than make a mix. When using topsoil, it is critical that it is 'good quality', has the properties described above and is sterilised.

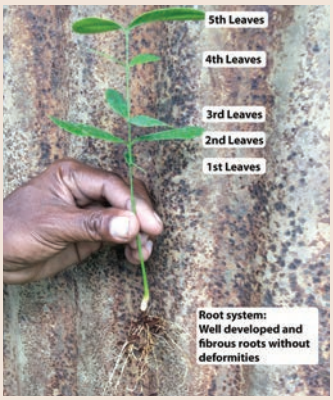
3.5 Growing seedlings

Seedlings are ready to be transplanted to polybags once they develop two true leaves (Figure 3.12).

Growing seedlings

Sandalwood seedlings are ready to transplant from germination trays into pots when they have reached the stage with 2–5 sets of leaves. In shallow germination trays (50 mm), the seedlings will need to be transplanted to polybags at or before the third leaf stage, because later than this the roots will have deformed at the bottom of the tray. In deeper germination trays (>50 mm), seedlings up to the fifth leaf stage can be readily transplanted without damage to the roots.

In some nursery operations, all seedlings within a germination tray are potted when most seedlings meet the above criteria. This means that some seedlings may have only 1–2 leaves. It is important that seedlings are sorted according to size after potting. Smaller seedlings will need a longer time under 50% shade (as described below).



Seedlings that are left in the germination tray too long will have deformed root systems (red circles) and low nutrients/vigour. These seedlings will not typically develop into strong plants and are best culled prior to potting up. For sandalwood, these seedlings will almost never produce a commercial tree and will not make the farmer any money.

Some seedlings in the germination tray will be of low vigour and these should be culled prior to potting up. The red circles in the image highlight those low-vigour seedlings that should have been discarded at the time of potting up. For sandalwood, these seedlings will almost never produce a commercial tree and will not make the farmer any money.

Lift seedlings from underneath the roots using a small stick until the roots are free from the sowing medium. Care should be taken not to break or damage the root system.

Fill polybag with growing medium until about two-thirds to three-quarters full. The remaining space at the top of the polybag will allow the seedling to be planted. Make a small indentation in the potting medium with a finger to accommodate any longer roots on the seedling.

Place the sandalwood seedling into the top part of the polybag. It is critical that the root system is not deformed in any way. The most common problem is the bending of the primary roots upward or around the stem, resulting in a seedling that becomes 'j-rooted' or 'girdled' respectively. Seedlings with these deformities will not perform well (or make money) in the nursery or after outplanting in the field.	
Fill the remaining space in the polybag with the potting medium until the sandalwood seedling roots are covered, and the surface of the medium aligns with the root collar (junction between roots and shoots).	
Centre the sandalwood seedling in the polybag and lightly press the potting medium down with the finger. Alternatively, the polybag may be picked up and its base 'tapped lightly' on the palm of the other hand to settle the potting medium. This will ensure that there are not too many air gaps in the potting medium.	
Any remaining space should be filled with the potting medium. Note this seedling only has two leaf pairs and will therefore need to be grouped with other small seedlings and allowed to grow under 50% shade for 3–5 weeks (see Section 3.5.2 on hardening seedlings).	
The potting medium is lightly pressed again with your fingers to firm in around the sandalwood seedling and eliminate any large airspaces.	
The sandalwood seedling should be well watered and set out in the nursery bed under shade (ideally under cover in humid zones). The polybags should be supported so they don't fall over. Ideally the nursery bed should have provision for drainage (such as gravel or fine rock) to allow water to move through the polybag and drain away rather than filling the polybag.	

Figure 3.12 Growing and potting seedlings

3.5.1 Planting the pot host

The pot host *Alternanthera* (see Section 6.4) should be planted as stem cuttings after the sandalwood is at the 4–6 leaf stage. Figure 3.13 shows the beneficial effect of timely planting of the pot host. If the pot host is planted too early, it will grow quickly and overtop the young seedling, leading to stunted growth and death of the sandalwood. If the pot host is planted too late, the sandalwood may grow slowly.

Figure 3.13 Sandalwood seedlings showing the effect of planting a pot host on growth rate. On the left are seedlings with no pot host, while on the right a pot host has been used

3.5.2 Hardening seedlings

Once the seedlings reach the 10–12 leaf stage, they need to be progressively moved to areas of higher light levels to 'harden' or acclimatise them to conditions in the field. They should have 50% shade in the first month, then 25% shade for another month, and then one to several months in full sun before they are planted in the field. Seedlings transplanted directly from the shade to a full-sun position in the field typically have poor survival.

A seedling is ready to plant in the field when it shows at least two of the following signs (Figure 3.14):

- The seedling is actively growing, with new shoots, and has deep green leaves.
- The bottom of the stem is slightly woody (i.e. changes from green to brown).
- The seedling is about 20–30 cm high.
- The seedling has small branches developing at the junction of the leaf and main stem.
- Some small roots are visible through the holes in the bottom of the polybag.

Figure 3.14 Seedling ready for planting in the field

3.6 Raising wildings

Seedlings germinated naturally under an existing sandalwood tree can be collected and transplanted to the nursery or another location (such seedlings are called wildings) (Figure 3.15). This is a simple method of establishing new stands of sandalwood:

- Select sandalwood trees that are fruiting or are otherwise known to fruit heavily.
- Clean all undergrowth from beneath the canopy of the selected sandalwood trees.
- Loosen the soil in the cleared area by shallow digging or cultivating only the top 5 cm of soil prior to fruit fall. Wildings begin to germinate in the cultivated area about 1–2 months after fruits have fallen to the ground.
- Water the cultivated area during dry periods, if possible, or after the first seedlings break through the soil.
- Keep the cultivated area free from weed regrowth.
- Remove seedlings when they are approximately 10 cm high by gently digging the seedling from underneath, trying not to disturb or break too many roots.
- Transplant seedlings immediately to polybags or another location, such as the sandalwood plantation.
- Water seedlings well after transplanting.

Figure 3.15 Wilding being carefully lifted from the ground (left) and wilding seedling ready for transplanting (right)

3.7 Nursery construction

A plant nursery is any place that grows seedlings for planting at another site. Nurseries can take many different forms, but good-quality sandalwood seedlings can be produced in basic nurseries, provided that it is in a sheltered position with ample natural light and accessible fresh water, and if plants are grown in a free-draining, nutrient-rich medium (Figure 3.16).

Figure 3.16 Production sandalwood nursery in Timor-Leste (left) and smallholder sandalwood nursery in Papua New Guinea (right)

The images in Figure 3.17 show examples of different sandalwood nurseries:

1. a greenhouse constructed from timber and plastic film, which is useful in cooler regions to keep the seedlings warm
2. a seedling bed with coconut leaves on a timber frame for shade
3. a seedling bed with managed *Gliricidia* trees for shade
4. a raised, sawn timber seedling bench with 50% shade cloth
5. a seedling bed with no shade, used for hardening seedlings before planting
6. a seedling bed with 20% shade cloth on a timber frame
7. seedlings in 1 kg rice bags on a raised timber bench with natural shade.


1


2


3


4


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Figure 3.17 Examples of different sandalwood nurseries

3.8 Nursery management

In addition to appropriately managing the pot host and progressively hardening the seedlings, attention to hygiene, preparation of growing medium, drainage, and appropriate watering and fertilisation regimes will provide good results.

3.8.1 Hygiene

Good hygiene in the nursery can ensure the development of healthy seedlings. The key is to keep the nursery free from plant debris (e.g. prunings, fallen leaves, dead seedlings), which will limit the potential for disease to develop. Many unexplained problems in the nursery can be attributed to diseases caused by unseen fungi and bacteria. Sterilising the growing medium can help to prevent diseases being brought in by the soil (see Section 3.4.3). The medium can be sterilised by heating it over a fire in a steel drum or sandwiching it in black plastic and leaving it in the sun for a day (Figure 3.18).

Figure 3.18 Media sterilisation using black plastic and the heat of the sun (left) and by heating over a fire in a steel drum (right)

Photo: (left) Ken Robson

3.8.2 Drainage

A poorly draining medium can lead to waterlogging, particularly during the wet season. Waterlogging is the main cause of poor seedling growth and death in the nursery. It is therefore important that the potting medium is free draining and polybags are sited on a well-drained site or in raised beds.

3.8.3 Watering

The most critical factor for the health and vitality of nursery seedlings is the quality and availability of water in the polybag (potting media).

Seedlings will require watering on a regular basis.

The frequency of watering will be influenced by:

- prevailing weather conditions (heat and rainfall)
- level of sunlight (shade provision)
- size of the seedling.

Seedlings in full sun during the dry season are best watered once or twice per day, but during the wet season shelter from the rain may be necessary.

3.8.4 Fertiliser

Improved growth can be achieved by using fertile soil. A friable, rich topsoil high in organic matter will have more available nutrients than a sandy or heavy clay soil with low organic matter. Additional nutrients can be added to the soil by applying dilute solutions of worm castings, composted organic matter, or commercial liquid and/or slow-release fertiliser.


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