Australian Government
Australian Centre for
International Agricultural Research

Pacific sandalwood

Growers' guide for sandalwood production in the Pacific region

ACIAR MONOGRAPH 218

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Page T, Bush D, Clarke B and Thomson L (eds) (2022) *Pacific sandalwood – Growers' guide for sandalwood production in the Pacific region.* ACIAR Monograph No. 218. Australian Centre for International Agricultural Research, Canberra.

ACIAR Monograph Series No. 218 (MN218)

ISSN 1031-8194 (print)

ISSN 1447-090X (pdf)

ISBN 978-1-922787-06-4 (print)

ISBN 978-1-922787-07-1 (pdf)

Technical editing by Dr Joely Taylor

Design by Griffin Graphics

Printing by CanPrint Communications

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

4 Establishing a plantation

4.1 Site selection

Suitable sites for establishing new sandalwood plantations, appropriate for rapid heartwood development:

- have a slight slope
- have volcanic soil overlying coral limestone
- receive good sunlight (not rainforest)
- have free-draining soil (i.e. that does not hold water for extended periods)
- are free from the fungus *Phellinus noxius* (see Section 8.1)
- have a distinct annual dry season, particularly in the cooler months.

Excellent growth can often be achieved on well-lit edges of existing forest (Figure 4.1) with the above attributes because the roots of diverse host species extend into the surrounding soil. As sandalwood is a high-value species, planting trees around villages or even within urban yards is feasible, though it is important to plant only as many as the surrounding hosts can support (Figure 4.2).

Figure 4.1 *S. yasi* planting in 'Eua, Tonga (left) and *S. yasi* plantation in Tutu, Taveuni, Fiji (right)

Photos: Lex Thomson

Figure 4.2 Sandalwood established in a cropping garden area in Papua New Guinea (left) and mixed kava garden in Vanuatu (right)

4.2 Site preparation

The best sandalwood growth rates occur when sandalwood is established at the same time as a new garden area. A site can be selectively cleared, leaving trees that serve as good hosts (see Chapter 6). It is important to kill stumps completely by burning to ensure that they are not a source of infection with *Phellinus* (see Section 8.1).

Sandalwood seedlings generally establish well when they are planted during the gardening season. The timing of the gardening season varies throughout the Pacific islands, but typically occurs at the start of the rainy season. This timing allows the sandalwood to establish its root system in the soil before the onset of the first dry season. Sandalwood will grow slowly during the first dry season, and in some very dry years may require supplemental watering. Rapid tree growth will occur from the second wet season.

Poor weed control in the first few years of the plantation is the main cause of tree death and plantation failure. Selecting a site with fewer weeds can help to reduce the labour inputs for controlling weeds. Sites that have many vigorous weeds need to be manually weeded every week.

Establishing sandalwood in a new garden area makes controlling the weeds less difficult because the weeds in the garden and sandalwood planting can be controlled at the same time. Better early growth of sandalwood occurs in newly established gardens than in older gardens where soil nutrients have been depleted. Sandalwood also benefits from fertiliser that is applied during the establishment years. As a guide, Nitrophoska® Special (or an equivalent organic fertiliser) may be applied at 25–50 g at 6 months; 50–100 g at 12 months; and 200 g at 24, 36 and 48 months. This fertiliser needs to be evenly distributed around the base of the tree, but **not** touching the stem.

4.3 Planting layout and tree spacing

Correct tree spacing, host ratio and management will help to maximise the growth of the sandalwood trees over their entire rotation (Figure 4.3). The plantation design will be influenced by the host species being used and their growth habits. The choice of host species (see Chapter 6) will be influenced by local availability and adaptability to the intended planting site. Different site-specific species configurations could be used in this style of grid planting, depending on local conditions (i.e. soils, climate, aspect, growing space), host species availability and grower objectives.

A 3 m × 6 m or 4 m × 5 m grid layout should provide sufficient space for all the plants (Figure 4.4). Sandalwood growth can be reduced when it is planted at high densities (i.e. spacing less than 3 m × 4 m). Although good early growth can be achieved at such densities, growth can stagnate after 3–4 years as a result of intense competition between the sandalwood trees for soil moisture, nutrients and light.

Figure 4.3 *S. album* plantation South Coast of Timor-Leste (left) and *S. lanceolatum* Quintis plantation, Queensland, Australia (right)

Photos: (left) Luis Almeida; (right) David Lee

Figure 4.4 Wide spacing in a large-scale commercial planting

At a spacing of 4 m × 5 m, the sandalwood trees are spaced at 4-m intervals along each row with a long-term host every 16 m, and a spacing of 5 m between each row (inter-row). A 5-m inter-row spacing will provide enough space for vehicle access to manage and harvest both the sandalwood trees and commercial host trees. A 5-m inter-row spacing permits the growing of crops between the rows for approximately 3–4 years (Figure 4.5). If crops need to be grown for a longer period, then a wider inter-row spacing of 6–8 m could be considered.

Figure 4.5 Garden plantings of sandalwood with a range of hosts

The 4-m spacing between each sandalwood tree provides space for the planting of intermediate host species between the sandalwood. This guide describes two distinct layouts: (1) **mixed species rows**, and (2) **alternate species rows**. The sandalwood to host ratios can vary depending upon site conditions and the hosts species used. Typically, the ratio of sandalwood to intermediate host (*Sesbania*) is 1:1. For sandalwood to long-term host, the ratio can vary between 1:1 and 2:1. A 1:1 sandalwood to long-term host ratio is recommended where the trees are growing on a site with one or more of the following: (1) infertile and shallow soil, (2) steep slope, and/or (3) long dry season. On more fertile sites with good annual rainfall and a short dry season, an up to 2:1 sandalwood to long-term host ratio may be considered.

4.3.1 Mixed species row plantings

A 'mixed species row' layout can be used to maximise the number of sandalwood trees, while still maintaining good access to host trees planted on site. This layout gives a 13% greater sandalwood stocking (375 trees) compared with an 'alternate species row' layout (333 trees) for a 4 m × 5 m grid. Long-term hosts should be planted every fourth space or 16 m, and rows should be offset so that each sandalwood tree is only 5 or 6 m from a long-term host (Figure 4.6).

4.3.2 Alternate species row plantings

The 'alternate species row' layout is a simpler arrangement, which should make management of both sandalwood and hosts more efficient. In this layout the sandalwood trees and long-term hosts are planted in individual rows, which alternate at a ratio of 2:1 sandalwood to hosts (Figure 4.7). Intermediate hosts species can be planted in every row (between the sandalwood and long-term host trees) depending on the planting objectives. A reduction in the stocking of intermediate hosts may be considered when agricultural crop production needs to be maximised. This can be achieved by either reducing the frequency of intermediate hosts within the rows or confining intermediate hosts to the sandalwood rows only.

The number of intermediate host trees will also depend on the size of the host tree. Pigeon pea (*Cajanus cajan*) has been included in every interspace between the sandalwood trees. Larger intermediate hosts such as coral tree (*Erythrina poeppigiana*), sesbania (*Sesbania grandiflora*) and cassis (*Leucaena leucocephala*) may be spaced more widely – say, every second or third sandalwood tree. In contrast, pinto peanut (*Arachis pintoi*) can be planted across the whole site and, when managed correctly, can fill the entire ground level and support all the sandalwood trees, as well as suppressing weeds.

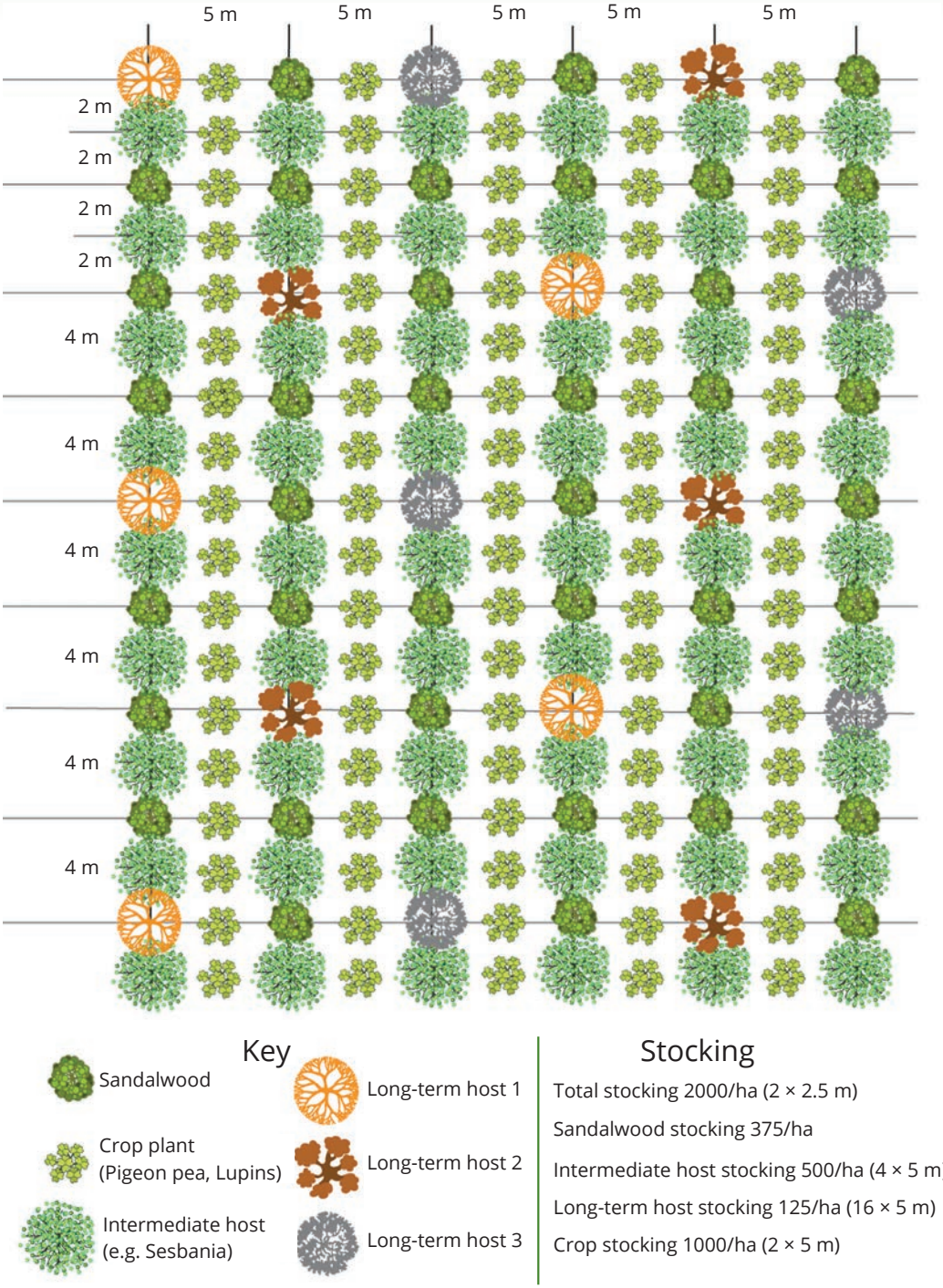
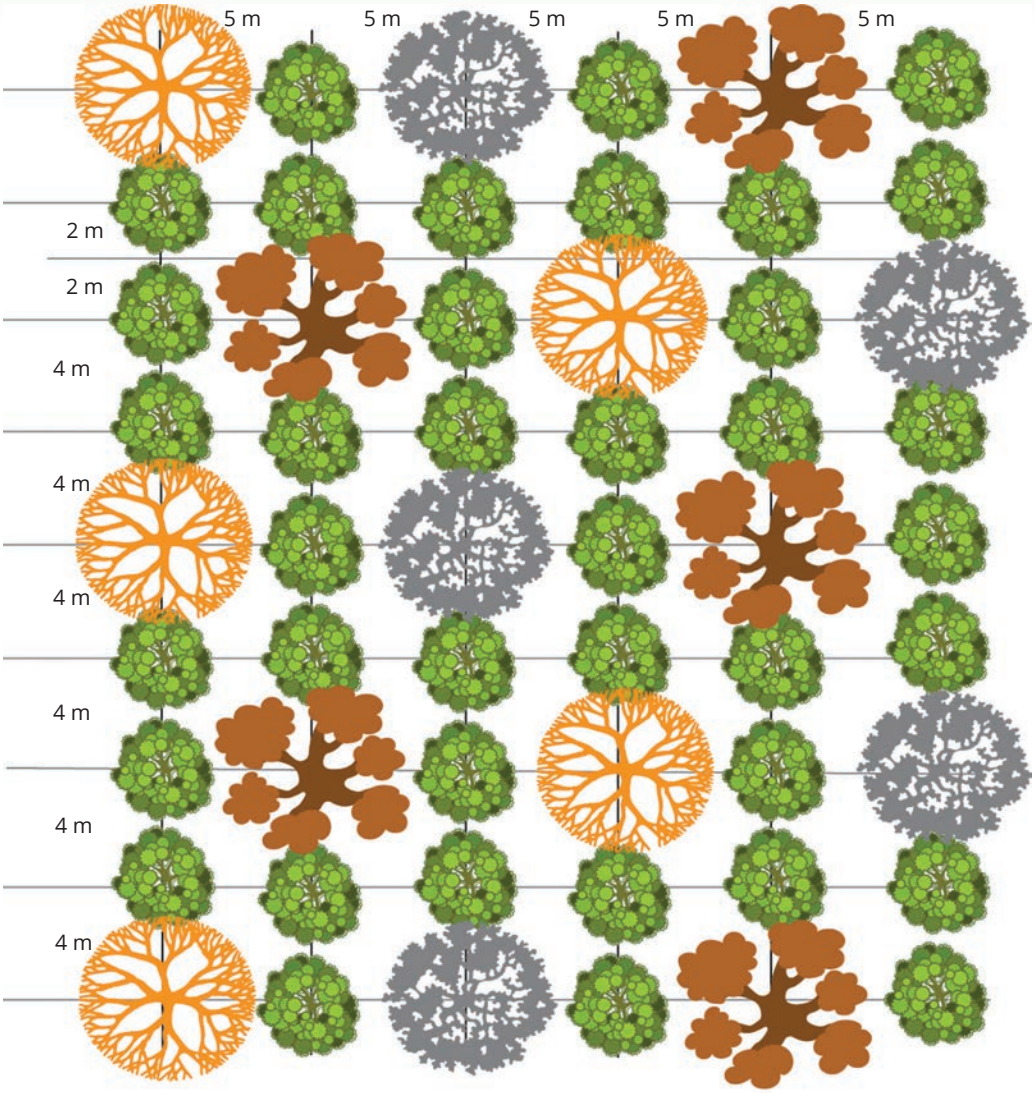


Figure 4.6 An example of a grid layout for a 'mixed species row' sandalwood planting. Representation of the first 5–10 years (left) and 10+ years (right). Persistence of crop plants is 3–4 years and intermediate hosts 5–10 years



Key

Sandalwood

Long-term host 1

Long-term host 2

Long-term host 3

Stocking

Total stocking 2000/ha (2 × 2.5 m)

Sandalwood stocking 375/ha

Long-term host stocking 125/ha (16 × 5 m)

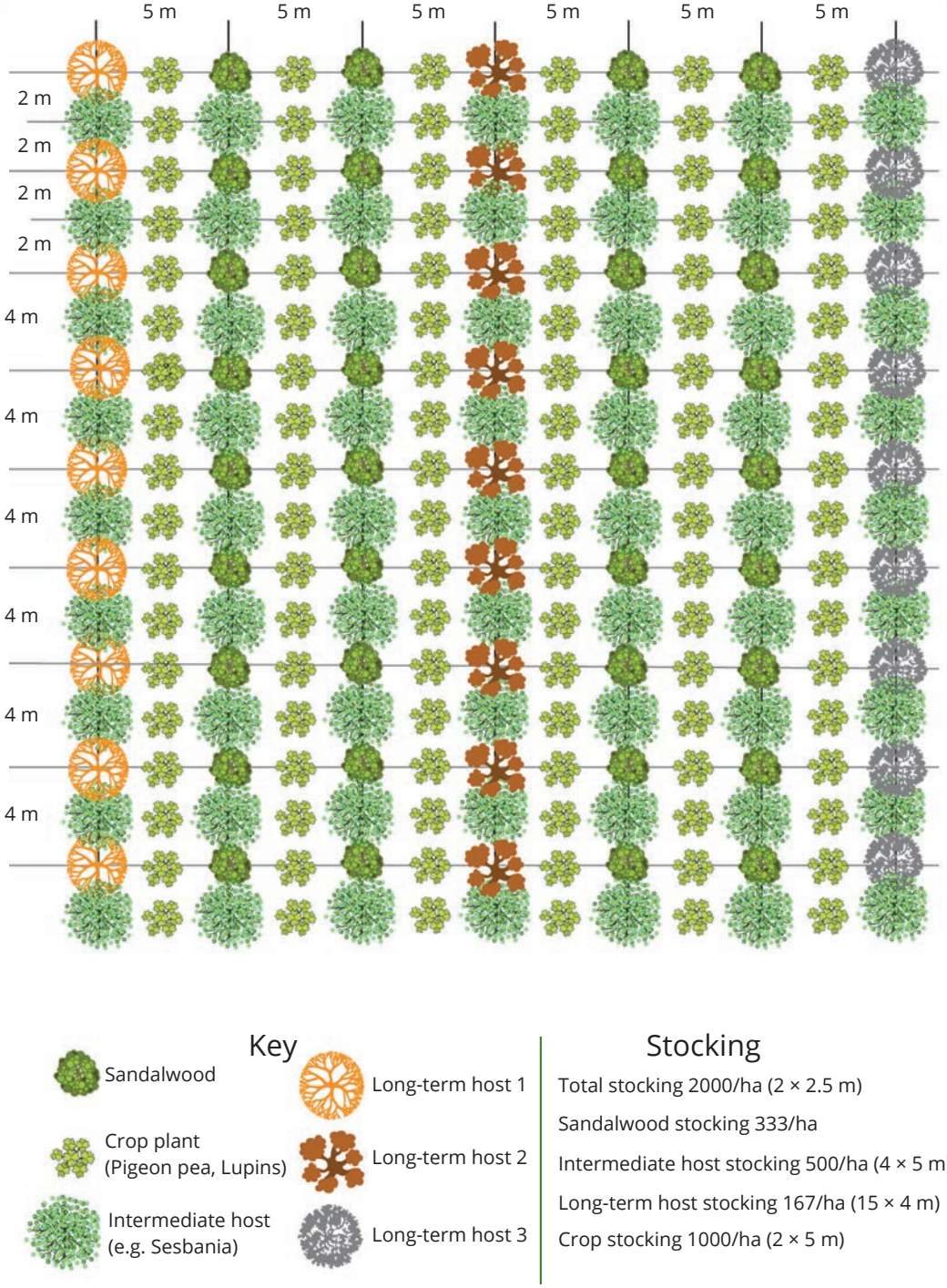
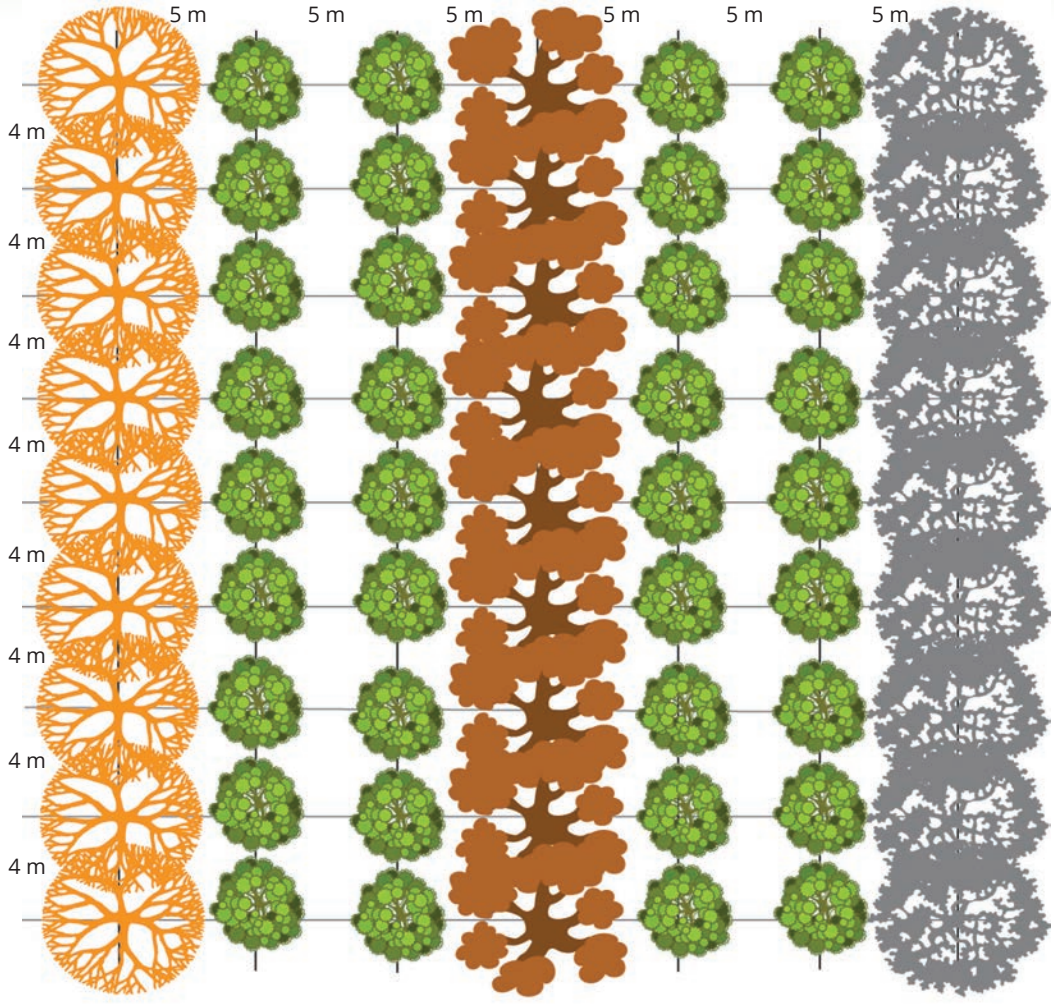


Figure 4.7 An example of a grid layout for an 'alternate species row' sandalwood planting. Representation of the first 5–10 years (left) and 10+ years (right). Persistence of crop plants is 3–4 years and intermediate hosts 5–10 years



Key

Sandalwood

Long-term host 1

Long-term host 2

Long-term host 3

Stocking

Total stocking 500/ha (4 × 5 m)

Sandalwood stocking 333/ha

Long-term host stocking 167/ha (15 × 4 m)

4.4 Direct seeding

Good results can be achieved by sowing sandalwood seeds directly in the soil at the planting site. Although a direct-seeded site requires high maintenance, seedlings managed appropriately can have greater early vigour than those transplanted from the nursery.

To achieve good survival, the area needs to be managed as intensively as a nursery:

- Keep the cultivated area free from weeds.
- Water seedlings frequently during hot, dry conditions (daily watering may be required).
- Provide the seedlings with shade, if necessary (e.g. an adjacent tree or a frame with coconut leaves).
- It may be a good idea to sow several seeds per planting location to make sure one germinates. If more than one germinates, don't be tempted to overstock the site. Dig these seedlings up and use them for another planting or raise them in polybags with growing medium, as described earlier, and sell them.

4.5 Planting seedlings

The planting technique that is used can mean the difference between vigorous early growth and seedling death. It is much better to take the time to plant seedlings properly than to rush this important step (Figure 4.8 and 4.9). Young seedlings enter a period of stress immediately after transplanting, and this stress should be minimised by good planting practices so that seedlings quickly restart leaf and root growth.

Planting seedlings to ensure the best chance of survival

Plant only in soil that has good soil moisture and when the weather is not too hot.

1. Dig hole

Dig a hole that is wider but only slightly deeper than the polybag.

2. Cut polybag

Cut the polybag carefully to minimise disturbance and breakage of the roots. *

3. Remove bag

Pick up the seedling and carefully remove the cut polybag.

4. Plant

Place the seedling in the hole without disturbing the roots.

5. Fill hole

Fill the hole and press the soil in only very slightly with hands. Never stamp the seedling in with feet, as this will break the roots of the seedling.

6. Watering

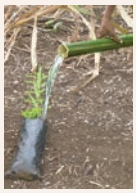
If the soil from the bag breaks apart and/or the roots are disturbed, it is important to water the seedling immediately to reduce the stress of transplanting.

* To reuse the polybag, follow the steps in Figure 4.9.

Figure 4.8 Recommended method for planting seedlings

Planting seedlings and saving the polybag for reuse

1. Wet



Wet the soil in the polybag.

2. Hold

Invert the seedling and hold the top of the soil in the palm of the hand.

3. Remove bag

Gradually remove the bag without disturbing the soil or roots.

Continue steps 4 to 6 in Figure 4.8

Figure 4.9 Method of planting seedlings to save the polybag for reuse

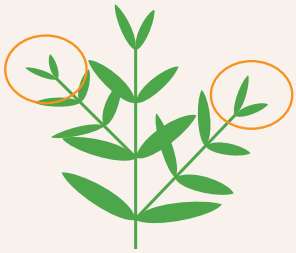
Formative pruning

1. Identify central leader

The central leader is the main, central growing point of the tree.

2. Identify competing leader

A side shoot that may compete with the central leader grows from below the central leader.



3. Remove side shoots

Break off the tips of side shoots by pinching them between fingers and thumb.

4. The pruned sapling

The growing tip of only the central leader remains.

5 Pruning saplings

The carving log, which is the most valuable sandalwood product, is formed in the heartwood of the lower trunk where there are no branches. Through formative pruning in the first 3–4 years of a tree's life, a farmer can promote a single-stemmed trunk and improve the chances of a tree forming a carving log. Heartwood development begins in the roots and butt of the tree and progresses up the main trunk. A fork in the trunk will typically slow the rate of vertical heartwood development up the main stems. Therefore, the volume of heartwood in two large branches is typically less than that in an equivalent-sized main stem.

However, it is important to note that pruning is no longer productive for poorly formed trees that are older than 3–4 years, and at this stage will do more damage than good. In these trees, pruning often stresses the trees and can severely reduce growth.

Without early pruning, growers will be unable to consider extending the rotation for some trees to meet carving log quality.

5.1 Formative pruning

Formative pruning of young saplings is the most effective pruning method because it removes only a very small amount of productive photosynthetic leaf material. This is achieved by 'pinching' off all growing tips that compete with the central leader (Figure 5.1).

Regular formative pruning means that there is little (or no) need for heavier pruning with secateurs, loppers or a bush knife (machete).

5.2 Form pruning

Often a tree is not pruned for a year or more and needs to be pruned to bring it back to being a tree with a single trunk (Figure 5.2). Form pruning is distinct from formative pruning in that it requires a sharp pruning saw or secateurs. It is important to make a clean pruning cut just above the 'shoulder/collar' of the side branch to leave the smallest possible wound and allow rapid healing of the pruning wound. Do not leave long branch stubs as they may lead to introduction of heartwood rot into the main stem. This method is effective for young saplings up to 4 years old, but less effective for older trees. Older trees should be left unpruned because pruning can introduce heartwood rot or disease.

Figure 5.1 (left) Guidelines for formative pruning

Form pruning

1. Identify forked sapling

Select saplings with a forked trunk.

2. Remove fork

Remove the fork by cutting the unwanted branch with a sharp knife or sacateurs.

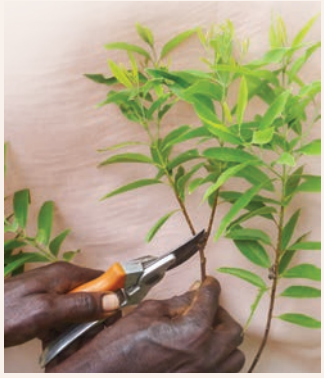
Figure 5.2 Guidelines for form pruning

3. Identify competing leader

A competing leader is a branch growing vertically towards the top of the tree.

4. Remove competing leader

Remove the competing leader with secateurs.



5. The pruned tree

5.3 Canopy reduction pruning

In areas of high intensity cyclones there can be a benefit in pruning large/heavy canopies to allow strong winds to pass through and reduce the chance of trees becoming windblown. The aim of this pruning intervention is to reduce the height and spread of the crown while also removing crossing/overlapping branches and any deadwood. This pruning is best achieved using a long-handled pole pruner and ladder, and attention must be given to safety when working at height.

Canopy reduction pruning is done at the start of cyclone season (late November), and if there is sufficient warning and a high likelihood that a high-intensity cyclone is to make a close pass, then some additional canopy reduction might be done (but this is only really possible for a smallholder with a limited number of sandalwood, i.e. fewer than 50–100 trees).

5.4 Remedial pruning

Pruning back to a single leader (singling) is often necessary when the central growing tip is damaged, possibly by wind, a bird or a falling branch. This can be done immediately after growth recommences.

Figure 5.3 demonstrates multiple competing leaders (yellow circles) growing mainly from a single branch after the original leader was damaged by a falling branch (orange circle). Competing leaders are removed by secateurs, leaving a clear leader (blue circle). Some stems may need additional pruning later if they begin to compete with the selected central leader.

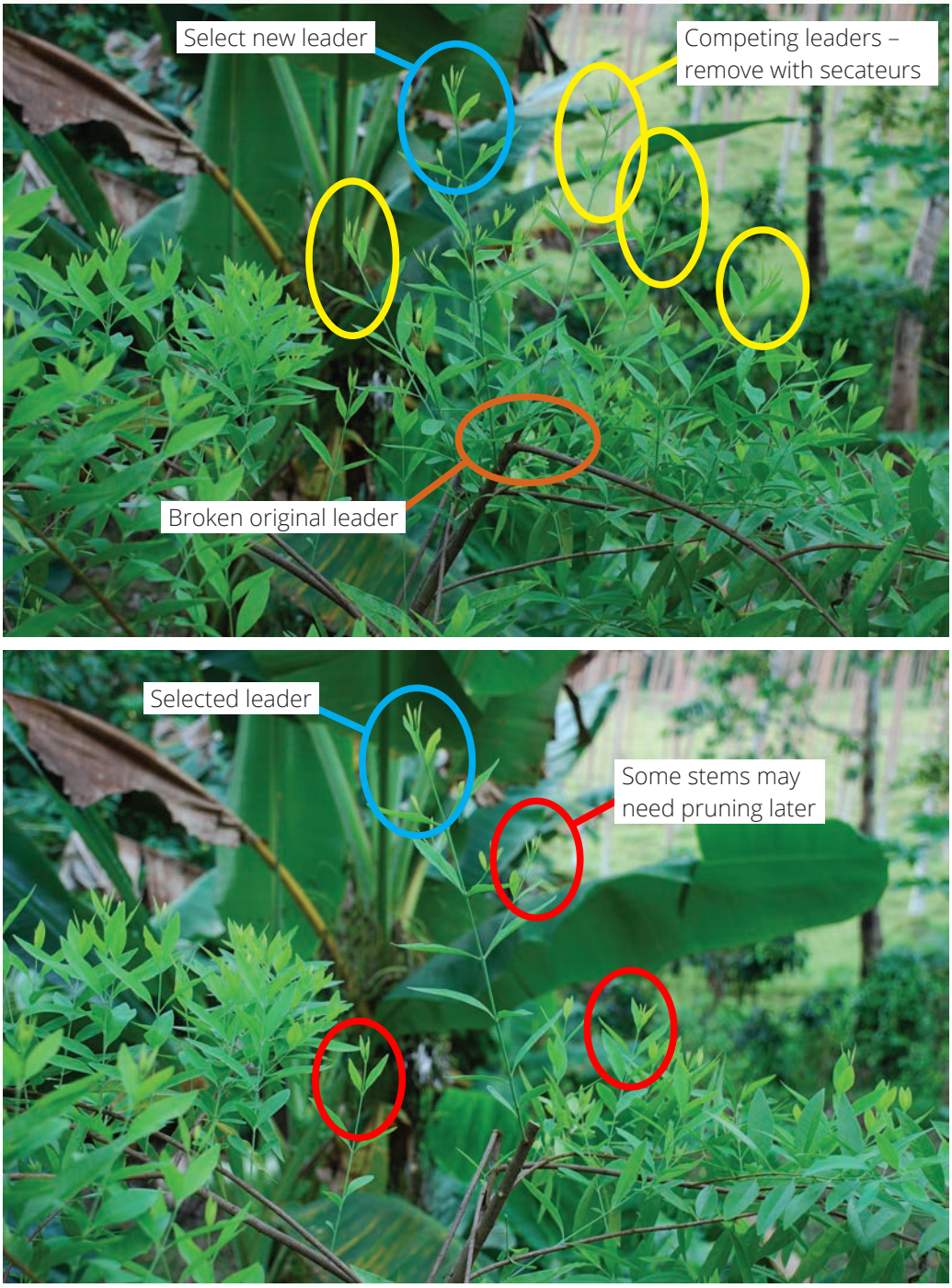


Figure 5.3 Guidelines for remedial pruning

5.5 Correctly pruned

A sandalwood tree that has been corre
pruned has (Figure 5.4 top):

- one trunk and a single leader at the t
- a canopy of leaves that extends approximately two-thirds of the height of the tree, providing a good area for photosynthesis, which will ensure a vigorous tree
- a canopy that tapers towards the top providing good balance (a low centre of gravity).

5.6 Incorrectly pruned

An example of a sandalwood tree that has been incorrectly pruned has (Figure 5.4 below):

- an inappropriate shape – in this case, a 'lollipop', because too many lower branches have been removed
- a reduced canopy – this reduces photosynthetic capacity and hence th vigour of the tree
- many branches at the top, which make the tree top heavy and unstable particularly in the wind.

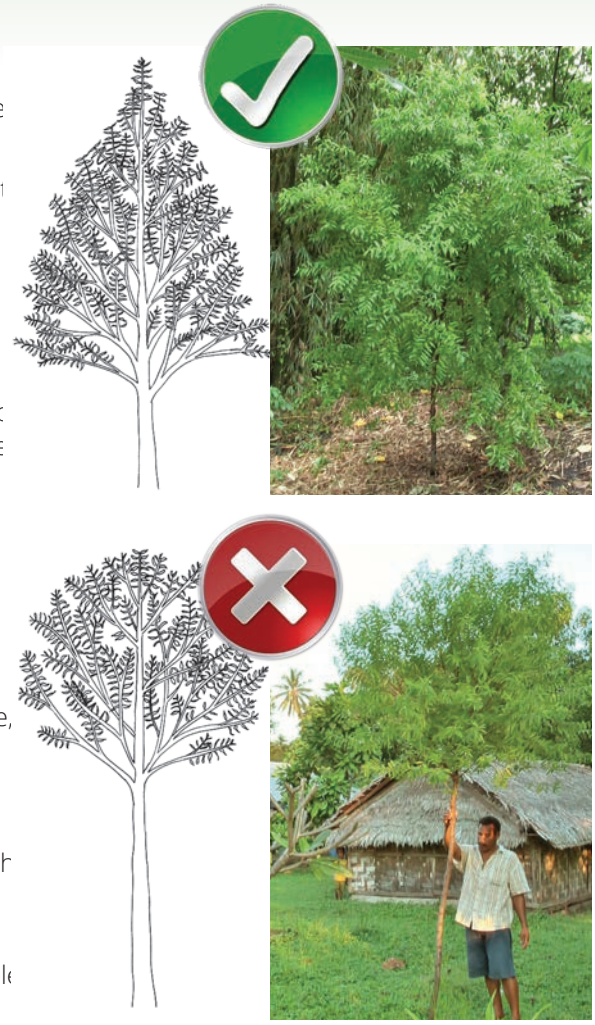


Figure 5.4 Examples of correct (top) and incorrect (below) pruning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