

Experiences with sandalwood in plantations in the South Pacific and north Queensland

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Abstract

Sandalwood is an important commercial industry in the south western Pacific. A number of sandalwood species occur across the south western Pacific, *Santalum austrocaledonicum* in New Caledonia and Vanuatu, and *Santalum yasi* in the Fiji Islands and Tonga. Communities do the majority of sandalwood plantings, manage and harvest existing stands. There is a growing interest among villagers, other small-scale growers and Governments to expand the scale of planting in both countries. The most common type of planting is garden plantings of sandalwood by villagers. However, large investors and Governments now starting to invest in plantations across the south western Pacific.

Introduction

Sandalwood has been, and still is, an important commercial industry in the south western Pacific. Individual farmers or communities do the majority of sandalwood plantings, manage and harvest existing stands. Although, the sandalwood industry has played a large part in the history of the Pacific, only recently has there been a push to start a replanting program. There are many cultural, political and historical hindrances that have inhibited any large scale plantings in the islands.

A number of Sandalwood species occur across the south western Pacific, the most important being *Santalum macgregorii* F. v. Mueller in PNG, *Santalum austrocaledonicum* Vieill. in New Caledonia and Vanuatu, *Santalum yasi* Seem. in the Fiji Islands and Tonga. *Santalum album* Linn. is also planted and growing well in most tropical, Pacific countries from New Caledonia to French Polynesia and the Cook Islands.

Santalum austrocaledonicum

Santalum austrocaledonicum is found in the island archipelagos of New Caledonia and Vanuatu. The species was heavily exploited over about three decades in the middle of last century, and has been utilized periodically since then. Carvings, incense production and sandalwood oil are the three major wood uses of *S. austrocaledonicum*. The species has a number of traditional uses in Vanuatu (Siwatibau *et al*, 1998).

In Vanuatu sandalwood is mainly found in low open *Acacia* forest, in regrowth forests and agricultural fallows. Associated plant species in Vanuatu include *Cocos nucifera*, grasses, bamboos, *Cryptocarya turbinata*, *Hibiscus tiliaceus*, *Dracontomelon vitiensis*, *Garuga floribunda*, *Leucaena leucocephala* (introduced) and *Pterocarpus indicus* (Daruhi 1993).

In New Caledonia, it chiefly occurs in regrowth formations within sclerophyll forest on the west coast of the main island, and regrowth within closed forests (vine thickets) growing on limestone in the Loyalty Islands and on the Isle of Pines. These secondary formations are mainly the result of human activity, usually former gardens and burnt areas. Associated plant species include grasses such as *Panicum maximum*, on plains; *Acacia spirobis*, *Casuarina sp*, *Dodonaea viscosa*, *L. leucocephala* (introduced) and *Croton sp.* in forest regrowth/bush fallows and in secondary thickets (Veillon and Jaffré 1995).

The species can produce heartwood on a rotation of about 25-40 years (Tacconi 1995), and has good commercial potential to generate future cash revenue for rural communities in remote areas.

There is a growing interest among villagers, other small-scale growers and Governments to expand the scale of planting in both countries.

Vanuatu

In Vanuatu, Sandalwood has long been an important forest industry. Royalty payments for sandalwood, in 2000 were about AUD\$700 000 for 70 tons of wood (Berry, 2002). This is almost equivalent to that paid for all other timber species. The income from sandalwood royalty payments, plus wages for harvesting and transporting the wood is particularly important for small farmers in remote areas where there are few other income earning opportunities.

There was a change in Government policy in 1977, which recognized the importance of good management of sandalwood, restricted the export of sandalwood logs, and called for efforts to encourage replanting and local sandalwood processing. Since this change in policy direction, two sandalwood oil distilleries have been established in Port Vila. The oil is extracted by simple pressure steam distillation of the heartwood.

There is increasing interest from local communities in replanting sandalwood, with a number of smallholders planting blocks of sandalwood on the islands of Santo, Erromango, Tanna and Efate, in association with *Casuarina sp.* and crops such as papaya, citrus and kava. On Tanna, good establishment and early growth has been achieved in garden border plantings. Wildlings are transplanted around garden plots made in bush areas. The planted wildlings are well-protected by their proximity to gardens, receive a suitable light regime (partially shaded by bush, but good light from inside of garden), and with a diverse set of hosts available in the adjacent bush.

Case 1

An example of private sandalwood plantation in Vanuatu is the farm of Des Parks.

Des has a leased farm on which he produces vegetables for the local markets. He is also a partner with one of the sandalwood processors. He has established several hectares of sandalwood in plantation on his farm on Efate, the main island in Vanuatu (18^o latitude, similar to Innisfail /Tully). He buys seed from local landowners and has a small nursery where he raises several hundred seedlings each year.

Being involved with the processing side he knows that the best sandalwood grows on Erromango. Erromango is south of Efate, (19^o latitude, similar to Ingham) and has the highest density of natural sandalwood in Vanuatu. Bringing seed from Erromango, he raises seedling in long plastic tubes, using forest soil as potting mix. Normally no pot host is used and he plants out when seedlings are about 6 months old.

Des has trialed several plantation systems and has used a “trial and error” method to develop a successful system. He started by under planting sandalwood in an area of regrowth forest. He removed understorey and vines, planted sandalwood seedlings and gradually removed overstorey.

His oldest planting is now about 8 years old and has developed well. As well as management of the overstorey he has found that some *S. austrocaledonicum* requires pruning to ensure the tree develops an apical shape. Without removal of lateral branches the tree will tend to multi-stem and develop a shrub shape.

Des encountered a few problems with this under planting system. Controlling grasses and weeds was difficult; many of the over story trees were not the most effective hosts and the sandalwood was not growing well; and it was difficult to work out how much of the overstorey to remove for optimal shade. After some reading and discussion with various experts he decided to try a new system.

He moved on to establishing a variety of hosts in rows and inter planting sandalwood. He investigated planting sandalwood as seedlings, and by direct sowing. The direct sowing method was promising with good initial germination but dry periods and grass competition resulted in high mortality. Des now plants out young sandalwood seedlings grown in 20 cm deep plastic tubes. He uses a tube of shade cloth around each seedling when it is first planted. This provides adequate shade, pest and weed control for the seedling.

He now has a sandalwood plantation where *Casuarina equisetifolia* is the main host. The *C. equisetifolia* seedlings are now planted in rows 12 metres apart, with trees spaced 3 metres along the row. The sandalwood is planted in double rows, 4 metres apart between the host trees. His oldest plantings using this system are about 6 years old and sandalwood plants are between 4 to 6 m tall, with ground diameters averaging more than 10 cm.

Case 2

Mr Malaki is developing a less structured system of sandalwood plantation in Vanuatu. He is a tribal chief and controls several hundred hectares of tropical forest on the north island of Espiritu Santo. Several years ago he realised the benefits of replanting trees into used gardens. One of the species he is planting is *S. austrocaledonicum*. He purchases local sandalwood seed, raises them in plastic pots for 12 months. He uses *Alternanthera sp* as a pot host.

He plants the sandalwood in areas that have been used for gardens for several years. These areas generally have dappled shade from overstorey trees. The gardens also are used to produce papaya and kava.

Mr Malaki encourages the *Alternanthera sp.* by continually controlling grasses and maintaining the garden area. He also has found form pruning is needed to ensure apically formed sandalwood trees.

New Caledonia

In New Caledonia there are three distinct varieties of *S. austrocaledonicum* based on morphological characteristics and different ecological preferences (Veillon and Jaffré, 1995).

Like the rest of the Pacific, exploitation of the sandalwood resource in New Caledonia dates back to the early 1800's. Today a sustainable harvest limit of 40 tonnes / year has been set by the provincial Government. Negotiation between the chiefs, and Government determines where the sandalwood is harvested from. Trained forest officers mark mature trees greater than 12 cm diameter before each tree can be harvested.

Landowners sell the unprocessed wood to the distillers for \$4AUD / kg. Approx 10 litres of oil can be extracted from 350 kg of heartwood chip. New Caledonia sandalwood oil sells for \$350AUD / litre to European buyers.

On the Isle of Pines, one of the main sandalwood regions, farmers have been using direct sowing to re-establish sandalwood (Azais, 1995). Using a slash and burn technique, they clear the existing bush and then burn it when it dries. The farmers use the site to grow crops and sow sandalwood seeds, which germinate and grow amongst other crops planted by the farmer.

New Caledonian agricultural department policy provides free sandalwood seedlings to landowners who are harvesting trees. For every tree removed 3 to 4 seedlings are supplied. Seedlings are grown in agricultural department nurseries and sandalwood seed is sown into plastic bags with *Alternanthera sp.* as a pot host. When seedlings are several months old they are made available to farmers.

Other than these rehabilitation plantings a small amount of planting is undertaken in cleared land and in cleared rows within existing bush. Before planting, rows are opened at 4 m spacing between lines and seedlings are planted at 2-2.5 m within lines, with sandalwood and host plant (usually *Casuarina sp.* or *Acacia sp.*) alternated in lines, giving a planting density of about 500-625 sandalwood plants per ha.

Santalum yasi

Santalum yasi naturally occurs in the Fiji and Tongan islands. It is found mainly in open forest types, including secondary forests that have developed from old garden sites (Jiko, 1993). A large number of associated species, including *Acacia sp.*, *Casuarina sp.*, *Calophyllum sp.*, *Cocos nucifera*, *Hibiscus tiliaceus*, *Inocarpus fagiferus*, *Pometia pinnata* and *Citrus sp.* are used as hosts.

In Fiji the species is usually found on stony soil, ridge slopes, shallow degraded soils with rock outcrops and also on sandy soil, coastal areas and the edges of swamps.

In Tonga, the species has a broad edaphic range and is found growing in coralline soils on raised coral or sand, saline soil near the coast, it has also been found on limestone terrace at sea level and mountain ridges with volcanic soil (Yuncker, 1959).

Santalum yasi was heavily exploited in the early 1800's and quickly became rare. Commercial utilization has only recently started again. The markets in South East Asia took over 100 tonnes of sandalwood a year from Fiji. Between 1984 and 1993, the prices fluctuated over that 10 year period, from \$2 780AUD/tonne in 1984, to \$11 000AUD/tonne in 1991, and down to \$2200AUD/tonne in 1992 (Bulai, 1995).

Overexploitation of sandalwood in Tonga in the 1960 and 1970's severely reduced the resource. A total ban on harvesting existed until the late 1990's. A small harvest in 1996-97 netted timber owners \$3000AUD / tonne (Kaufusi *et al.* 1999).

Due to the historic over exploitation, trade in *S .yasi* from Fiji and Tonga is practically nonexistent. Nearly all populations are depleted of large merchantable trees except in remote and inaccessible locations. In most areas there is good natural regeneration around large trees, and protection of these stands from fire and premature harvesting is require to ensure that they develop into a future economic resource.

Another important factor influencing sandalwood in this region was the introduction of *S. album*. *S. album* grows as well as the native species and importantly will spontaneously hybridise with *S. yasi* (Bulai and Nataniela, 2002)

Fiji

Individual farmers or community groups do the majority of sandalwood field plantings. As with the types of plantings in Vanuatu and New Caledonia, much of the sandalwood is planted in old gardens. A number of urban families also plant sandalwood trees in their back yards. The urban sprawl around the capital city of Suva may have sandalwood stocking of up to 150 stems per hectare (Robson, pers. obs.).

The Fiji Department of Forestry (FDoF) is the only Pacific government organisation presently doing research into the silviculture and tree breeding of sandalwood.

Focus of research has been in:

- seed and nursery production;
- silviculture;
- vegetative propagation;
- tree Improvement; and
- extension and awareness.

Seed production

The poor availability of seed has been one of the biggest hindrances to development of a sandalwood planting program. The research group within FDoF, based at Suva, has conducted detailed flowering studies and germination trials to determine when to collect seed and how to obtain the best results from sowing.

When the fruit is fully mature it is collected from the tree or very recently fallen fruits are collected from the ground. Seed is soaked in water for a day, de-pulped and then air-dried at room temperature. A pre-treatment, by nicking or cutting the pointed end of the seed, has been found to give best results. Pre-treated seeds will germinate two weeks after sowing, with germination being completed after about four weeks (Jiko, 1993; Bulai, 1995). Seedlings are pricked out of sowing trays when they have 2-4 leaves and dibbled into pots containing a previously planted pot host, usually *Alternanthera* species (Bulai, 1995).

Silviculture

Jiko (1993) reported on trials demonstrating a number of planting systems and investigating possible hosts. Several permanent host plants have been investigated in Fiji. Results from these trials have led to the recommendation of *Calliandra calothyrsus* as an intermediate host and *Citrus limon*, *Glyricidia sepium* and *Morinda citrifolia* as final hosts (Bulai and Nataniela, 2002). Periodic cutting back of vigorous secondary hosts is necessary to prevent *S. yasi* plants from being over shaded by hosts.

Based on research recommendations, community plantings are done using lines cut through regrowth forest at 3 metre intervals and sandalwood planted with host alternatively also at 3 meters spacing. These plantings have produced a lot of natural regeneration on the ground. The landowners regularly pot these natural germinants up to sell on to the community or use for further plantings.

Like the Vanuatu species, *S. yasi* also requires frequent (annual), light pruning from a young age, focusing on removing competing leaders.

Vegetative propagation

Trials have shown that vegetative cuttings taken from young seedlings at the 2-4-leaf stage root well, with success rate of 90% (Bulai, 1995). Shoot cuttings taken from 18 month old plants produced a 41% strike rate under mist conditions (Bulai and Nataniela, 2002). Other studies conducted by Collins *et al.* (2000) have shown that *S. yasi* is the easiest of the sandalwood species to root.

Tree Improvement

The FDoF research group have begun a program that includes development of seedling seed orchards (SSO), clonal seed orchards (CSO) and provenance resource stands (PRS). They also have recently begun a utilisation program by core drilling selected trees and testing for oil quality. Trees shown to be high in oil are then grafted into a CSO. This will provide seed material of high genetic quality which will be available to the public.

Hybrids

The native Fijian species, *S. yasi* is able to naturally hybridise with *S. album* in mixed plantings. This natural hybridisation predominantly occurs with the maternal *S. yasi*. Seed collected from *S. yasi* trees in mixed planting with *S. album* will give up to 20% hybrid seed. Seed collected from *S. album* within the same planting produce much lower hybrid progeny. Germination trials from *S. yasi* seed parents that are located close to *S. album* trees, have up to 25% F1 hybrid germinates (Bulai and Nataniela, 2002). Detection of putative hybrid seedlings is easily spotted after seedlings have germinated and developed 2-4 leaves. *S. yasi* seedlings have long thin leaves, *S. yasi* x *S. album* hybrid seedlings have wider larger leaves and the seedling tends to be bigger. These putative hybrid seedlings have shown exceptional growth rates when compared with parents. Hybrid sandalwood seedlings planted at the FDoF research station, near Suva, have grown at almost twice the rate of pure *S. yasi*, achieving over 2.5 m in height in 2 years (Robson, pers. obs.). The hybrid offers an opportunity to Fiji that currently does not exist elsewhere. However, care must be taken to ensure that the genetic integrity of the pure *S. yasi* is protected.

Extension and awareness.

The extension service is offered to communities. This is in the form of demonstration plantings, manuals on the best methods to plant, and good quality seedlings for sale.

Tonga

Tonga has one of the highest population densities in the Pacific. Good quality arable land available for plantation forestry is scarce. All of the land on the main island of Tongatapu not within the towns and villages is cultivated for growing coconuts, squash and vanilla. Each Tongan family owns a small parcel of land on which they grow crops for sale and for their own use. Many families have boundary planting of fruit trees, within which many also plant *S. yasi*. As sandalwood is now quite rare in Tonga it is costly to collect seed. Seedlings are raised by the Government nursery and sold to farmers. The sale price helps to cover the cost of seed collection and raising the plants.

The small island of 'Eua has a forest plantation reserve of approx 400 hectares in which they grow *Pinus caribaea*, *Toona ciliata*, *Agathis robusta* and *S. yasi*. The *S. yasi* seed is collected from large mother trees on the island and seedlings are raised in plastic pots with a pot host. When seedlings are about 12 months old they are planted under established pine plantations. The pine is usually 2 to 3 years old when the sandalwood is planted.

The oldest planting of this type is 10 years old with the sandalwood aged 8 years. The sandalwood stocking is quite high with about 200 stem / hectare surviving. The sandalwood understorey has

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developed healthy crowns and bole development has tended to be apical, although most trees are multi-stemmed. No form pruning has been done. It is anticipated that the pine rotation period will be between 20 to 25 years. It is anticipated that this will give the sandalwood sufficient time to develop a commercial quantity of heartwood so both species can be harvested at the same time.

Sandalwood research in Queensland

In Queensland there has been a growing interest in the development of sandalwood plantations since early the 1990's. Unfortunately the research required to support any large scale investment in plantation development has been intermittent due to non-secure funding.

Department of Primary Industries and Fisheries has been involved in a number of small research projects since the mid 1990's. Much of the early work looked at nursery and germination techniques with Queensland sandalwood, *S. lanceolatum*. It was found that *S. lanceolatum* would germinate using similar pre-treatment methods to most of the other sandalwood species (scarifying and Gibberellic acid) (Robson, pers.obs).

Using similar nursery methods to those used for other species, i.e. standard size pots and time periods, continually led to high fatality rates in the field. The practice now, for all sandalwood species, is to have well developed plants grown in large pots, with well developed *Alternanthera sp.* as a pot host.

The first phase of the South Pacific Regional Initiative on Forest Genetic Resources (SPRIG 1) project conducted comprehensive trials in Queensland in late 1998 comparing/contrasting the rooting performance of five different sandalwood species, *S. album*, *S. austrocaledonicum*, *S. yasi*, *S. macgregorii* and *S. lanceolatum* set under a mist propagation environment in both sand and sand-peat potting media. Substantial differences in survival and rooting success were observed between the species, with an average rooting success of 63.5% for *S. austrocaledonicum*, *S. yasi* (46.1%), compared to only 9.5% for *S. album* (Collins *et al.*, 2000).

Host Interactions

In recent years the testing of various hosts across a range of sites has been on the main focus for research in Queensland. The aim is to find a tree that can host sandalwood but also be grown for its own value. Species currently under test include citrus, *Khaya senegalensis*, *Casuarina sp.* and *Acacia sp.*

Planting systems

Like the Pacific countries, it is not always possible to develop large scale plantation systems. A number of trials have been established to evaluate the possibility of under planting existing forest, and /or enrichment planting with sandalwood and preferred hosts. Using *S. album*, several plantings have been established on the Cape York Peninsula to investigate this system

Seed orchards

The shortage of available seed has been a large hindrance to the establishment of research. A number of small provenance seedling seed orchards of *S. album* have been established and are producing several kilos of seed per year. Currently these orchards are producing only enough seed to sustain research plantings.

Discussion

The historical significance of sandalwood to the people of the Pacific is well known and valued. Traditional farmers in the Pacific Islands are growing and cultivating sandalwood as a means of earning income in the future. In our terms, many see it as money in the bank. Leaving the gardens fallow enabling sandalwood to mature until the land is needed again enhances subsistence farming practices.

There are real economic, environmental and cultural benefit to planting sandalwood for the landowners in the sandalwood countries of the Pacific. Some larger investors are now realising this and establishing structured plantations of high quality seed material.

Queensland lags behind the rest of the Pacific in this regard. There is a huge potential for growing many of the sandalwood species in the tropical regions of Queensland. The success of small research planting in Queensland has shown that sandalwood can be successfully established and the next step now needs to be taken. There is opportunity for small holder plantings and community groups, as well as larger commercial planting to take advantage the early developmental work that has been done.

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