Sandalwood Research Newsletter

July 2004 | Issue 19 | ISSN 1321-0022X

EDITOR'S NOTE

Welcome to Issue 19 of the Sandalwood Research Newsletter. In this issue, Jean François Butaud describes the distribution and ecology of Santalum insulare within Eastern Polynesia. His findings show that S. insulare grows in a variety of habitats and appears to be well suited for plantations.

Peter Jones, Owen Donovan and I discuss current growth rates and predicted yields in Western Australian sandalwood (Santalum spicatum) grown in plantations in the 400-600 mm annual rainfall zone. This Santalum species has the potential to provide high returns to farmers in relatively dry regions, without the need of irrigation. Tim Emmott also introduces a new sandalwood group (Avon Sandalwood Network) formed in Western Australia to provide information on S. spicatum to tree farmers.

Jon Brand

Santalum insulare (Bertero ex A. DC.): Distribution and Ecology

Jean-François Butaud
Ministry of Agriculture and Breeding
Territory of French Polynesia

Abstract
The Eastern polynesian sandalwood is one of the sixteen *Santalum* species of Asia and the Pacific. It is known under the name *puahi* in Marquesas Islands, *ai* in Cook Islands and *ahi* elsewhere in its geographical area. Overexploited during the beginning of the 19th century, Polynesian sandalwood is still used for carving or in powder mixed with coconut oil (*monoi ahi* or *pani puahi*) for cosmetic or medicinal purposes.

Geographical distribution and Taxonomy

Santalum insulare is the easternmost existing species of sandalwood in the Pacific (8-28°S and 128-158°W). Indeed, *Santalum fernandezianum* from Juan Fernandez Islands off Chile is declared extinct (Skottsberg 1922) and another sandalwood species which might have grown on Easter Island in prehistoric times remains only in traditional stories (Orliac & Orliac 1995).

Santalum insulare is restricted to French Polynesia, Cook Islands (Mitiaro only) and Pitcairn Islands (Henderson only). In French Polynesia, 3 archipelagoes and 10 islands are known to bear Polynesian sandalwood (see Figure 1; Map of French Polynesia from Florence 1997).

Taxonomy of *Santalum insulare* (Figure 2) has been relatively recently reviewed and nine varieties have been recognized (Fosberg & Sachet 1985). Their distributions are presented in Table 1.

The island of Ua Huka in Marquesas archipelago was known to possess sandalwood in the 19th century (Dening 1980) but after intensive field research, not a single tree was found. Thus, we can think that *Santalum insulare* is extinct on Ua Huka.

This classification, and notably both varieties from Marquesas Islands, have not been confirmed in the field with numerous material collected during our studies (Butaud J.F. & Tetuanui W. in press). Thus, *Santalum insulare* taxonomy is not definitive. Besides, extensive field research could lead to the discovery of sandalwood on two more islands: Tubuai in Austral Islands (Aitken 1930) and Makatea in Tuamotu archipelago (Florence J., pers. comm. 2001).

Pedology

The Eastern Polynesian sandalwood can grow on very different soil types:

- coral gravel or coral sand on the *motu* (small coral islets a few meters high located close to the coral reef) of Raivavae,
- *makatea* (coral limestone plateau) on uplifted island or atoll like Henderson or Mitiaro (Sykes 1980; Waldren *et. al.* 1995),
- volcanic rock outcrops on the very steep slopes of the high islands, and
- several kinds of ferralitic soils more or less evolved on all the high islands.

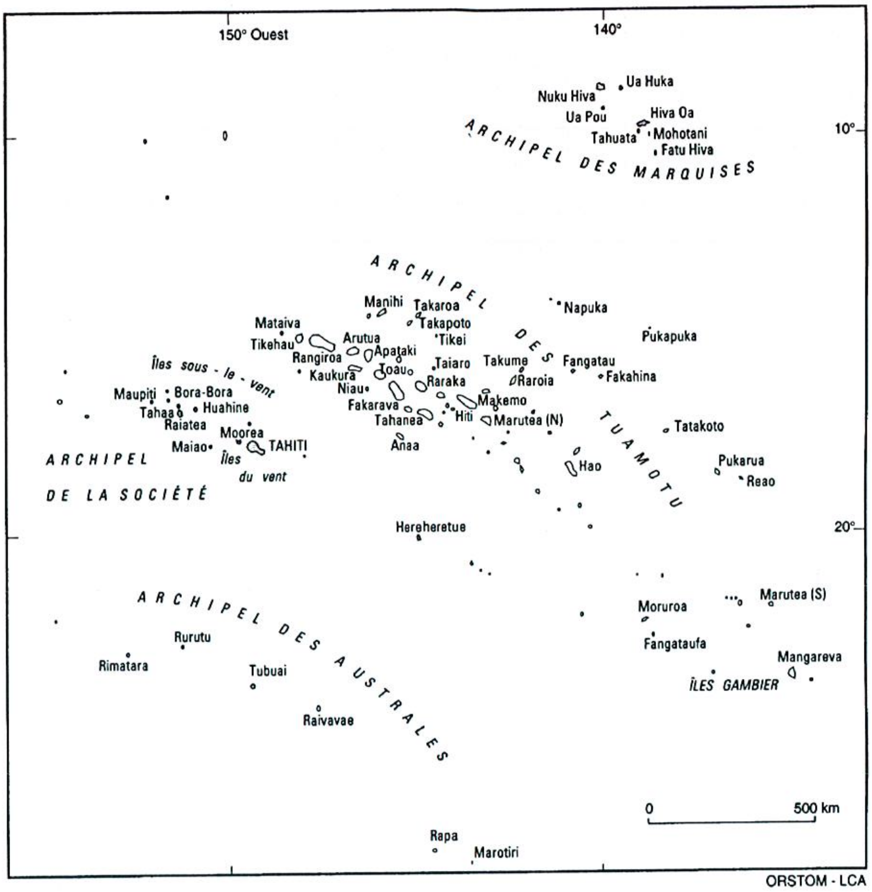

Figure 1. Map of French Polynesia

Altitude

Santalum insulare is found from sea level (1 m on Raivavae) to the summit of the highest mountains (2234 m close to Mount Orohena in Tahiti). Table 2 gathers the altitude of sandalwood populations in Polynesia.

Climatology

Rainfall

Mean annual rainfalls of the areas where sandalwood occurs range from 900 mm on the leeward slopes of Marquesas Islands to 6000 mm on the summit of Mount Orohena on Tahiti.

Temperature

Mean annual temperatures in the same areas range from less than 14°C on the summit of Mount Orohena in Tahiti to 27°C in Marquesas Islands at sea level.

Topography

All the sandalwood populations of high volcanic islands in Eastern Polynesia are located on slopes or ridges. Populations growing on limestone or coral sands (Raivavae, Mitiaro and Henderson) are located generally on flat areas (except some on cliffs on Henderson).

Santalum insulare, like the other species of *Santalum*, is not found in gulch, valley or swampy areas.

In Tahiti, the wettest is the area where sandalwood grows, the steepest is the slope under the trees.

Exposure

The exposure of sandalwood populations can be analyzed only for Marquesas Islands and Tahiti where the number of populations is enough. In Marquesas, and notably in Nuku Hiva where the sandalwood ridges are mainly E-W, exposure is N, NE, S and SE; whereas in Tahiti, exposure is essentially North (NW, N and NE) and E.

In each case, the driest exposure is preferred by sandalwood. Indeed, Eastern Polynesia being located in the southern hemisphere, slopes with a North exposure are drier than South ones. Moreover, with frequent mountain clouds in the afternoon, slopes exposed to the East (sunrise) are drier than slopes exposed to the West. Marquesan sandalwood, which is closer to the equator than the Tahitian one, is more dependent on the latter opposition (E / W).

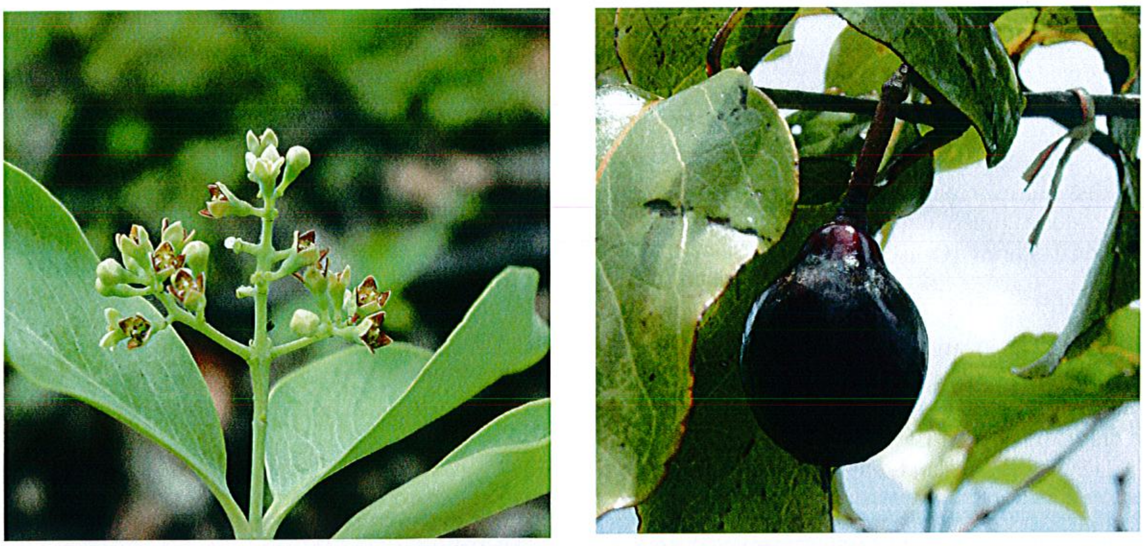

Figure 2. *Santalum insulare* flowers and fruit

Table 1. Geographical distribution of *Santalum insulare* varieties in Eastern Polynesia

Variety	Territory	Archipelago	Islands
alticola	French Polynesia	Society Islands	Tahiti
deckeri	French Polynesia	Marquesas Islands	Nuku Hiva, Hiva Oa, Tahuata, Fatu Hiva
hendersonense	Pitcairn Islands	Pitcairn Islands	Henderson
insulare	French Polynesia	Society Islands	Tahiti
marchionense	French Polynesia	Marquesas Islands	Nuku Hiva, Hiva Oa, Tahuata, Ua Pou
margaretae	French Polynesia	Austral Islands	Rapa
mitiaro	Cook Islands	Cook Islands	Mitiaro
raiateense	French Polynesia	Society Islands	Raiatea, Moorea
raivavense	French Polynesia	Austral Islands	Raivavae

Table 2. Altitude of sandalwood stands in the Polynesian islands

Island	Summit (m)	Max. sandalwood altitude (m)	Min. sandalwood altitude (m)
Tahiti	2241	2234	160
Moorea	1207	880	415
Raiatea	1017	500	300
Raivavae	439	235	1
Rapa	650	210	80
Nuku Hiva	1224	1060	350
Ua Pou	1203	575	200
Hiva Oa	1276	610	220
Tahuata	1050	900	60
Fatu Hiva	1125	450	350
Henderson	33	?	?
Mitiaro	9	?	?

Vegetation

Santalum insulare can be found in several and rather different plant communities:

- *motu* forest with *Guettarda speciosa, Pandanus tectorius, Pisonia grandis, Casuarina equisetifolia* and in understorey *Sophora tomentosa, Pemphis acidula, Suriana maritima, Scaevola sericea* and *Hedyotis romanzoffiensis* on Raivavae,
- *makatea* open forest with *Guettarda speciosa, Pandanus tectorius, Pisonia grandis, Casuarina sp.* and in understorey *Morinda citrifolia, Celtis sp., Ixora sp., Xylosma sp.* and *Geniostoma* on Mitiaro (probably close to Henderson vegetation),
- semi-xeric to mesic forest of low altitude in Marquesas Islands with *Sapindus saponaria, Xylosma sp., Wikstroemia caudata, Glochidion sp.* and *Dodonaea viscosa,*
- mesic forest of Society and Austral Islands with *Xylosma sp., Pandanus tectorius, Celtis pacifica, Dodonaea viscosa* and *Glochidion sp.*,
- ombrophilous forest of Marquesas and Society Islands with *Metrosideros collina, Weinmannia sp., Fagraea berteroana, Dodonaea viscosa, Wikstroemia sp.* and *Cyathea sp.*, and
- summital ridges and summits scrubland on Tahiti with *Metrosideros collina, Weinmannia sp., Ilex sp., Styphelia sp.* and *Vaccinium sp.*.

More details are given in Butaud J.F. *in press*.

Conclusion

Santalum insulare is distributed through a huge geographical area on 13 islands of Eastern Polynesia. Although all these islands come from oceanic hotspots, they are not all at the same geological stage. Indeed, some of them are high volcanic islands without *motu* (Marquesas islands), others are low volcanic islands with *motu* (Raivavae) and last ones are uplifted coral limestone islands (Mitiaro and Henderson). Polynesian sandalwood showed its important plasticity in taking root in nearly all the ecological conditions found on these islands.

Moreover, *Santalum insulare* is endowed with a high adaptive capacity in poor and dry soils. It is often found on cliffs or rocky outcrops in Moorea, Raivavae or Tahiti. In Tahiti, populations are concentrated in the driest parts of the island (NW / leeward slopes) which are protected from rain by high mountains.

Thus, *Santalum insulare* is a very interesting species for plantation or reforestation of particularly depleted areas (eroded, dry, poor soil)

References

Aitken R.T. 1930. Ethnology of Tubuai. *Bernice P. Bishop Museum Bulletin* **70**. Honolulu.

Butaud J.F. in press. Autécologie et Phytosociologie des Santals de Polynésie française. Proceedings of the Regional Workshop on Sandalwood Research, Development and Extension in the Pacific Islands and Asia, 7-11 October, 2002, Noumea, New Caledonia.

Butaud J.F. & Tetuanui W. in press. Le Santal en Polynésie française. Proceedings of the Regional Workshop on Sandalwood Research, Development and Extension in the Pacific Islands and Asia, 7-11 October, 2002, Noumea, New Caledonia.

Dening G. 1980. Islands and Beaches. Discourse on a silent land: Marquesas 1774-1880. University Press of Hawaii. Honolulu.

Florence J. 1997. Flore de la Polynésie française. Volume 1. Editions de l'ORSTOM. Paris.

Fosberg F.R. & Sachet M.H. 1985. Santalum in Eastern Polynesia. *Candollea* **40**: 459-470.

Orliac C. & Orliac M. 1995. Bois sculptés de l'île de Pâques. Ed. Parenthèses / Ed. Louise Leiris. Marseille. p 30-31.

Skottsberg C. 1922. The phanerogams of the Juan Fernandez Islands. p 117. In: C. Skottsberg ed. The natural history of Juan Fernandez and Easter Island. Uppsala, Almqvist & Wiksells Boktryckeri AB. Vol. **2**.

Sykes W.R. 1980. Sandalwood in the Cook Islands. *Pacific Science* **34**: 77-81.

Waldren S., Florence J. & Chepstow-Lusty A.J. 1995. Rare and endemic vascular plants of the Pitcairn Islands, South-central Pacific Ocean: a conservation appraisal. Biological conservation **74**: 83-98.

Current growth rates and predicted yields of Sandalwood (*Santalum spicatum*) grown in plantations in south-western Australia

Jon Brand, Peter Jones and Owen Donovan
Forest Products Commission, Midwest Sharefarms, Lot 1, 260 Kalamunda Road, South Guildford, Western Australia, 6055

Abstract
Aromatic timber from *S. spicatum* is a valuable commodity, and this species has the potential to provide an income to farmers in the medium annual rainfall (400-600 mm) regions of the wheatbelt. Since 1987, *S. spicatum* plantations have been successfully established in the wheatbelt, by direct seeding near 1-2 year old host seedlings, especially *Acacia acuminata*. This establishment technique has been very effective, with over 80 % survival per spot, and mean stem diameters (at 150 mm above the ground) increasing at 10-12 mm yr^{-1} near *A. acuminata*.

Allowing two years to establish both *A. acuminata* and *S. spicatum*, and then a mean stem diameter growth of only 7 mm yr^{-1} for 18 years, the *S. spicatum* are expected to reach commercial size (127 mm) at plantation age 20 years. At this age, the expected yields are approximately 4.4 tonnes ha^{-1}, with a net return of over AU $14,000 ha^{-1}. The sandalwood trees are also producing 60-170 kg ha^{-1} of seeds at age only 4-6 years. The value of the seeds may also provide a supplementary income to the sandalwood growers, while they are waiting for the trees to reach commercial size.

Introduction

Before clearing for agriculture, the highly valued sandalwood (*Santalum spicatum*) was once common in the wheatbelt of Western Australia, and currently there exists an opportunity to re-establish *S. spicatum* for commercial purposes in this region. At present, most of the remaining natural stands of *S. spicatum* occur in the central semi-arid regions of Western Australia. Approximately 2000 tonnes of *S. spicatum* is harvested annually from these natural stands, with the industry managed by the Forest Products Commission (FPC). *S. spicatum* timber is worth AU $4,000-$8,500 $tonne^{-1}$ (Jones, 2001), and most of the logs are exported raw to countries in south-east Asia, for use in the joss-stick trade. However, in recent years, more value adding has occurred in Western Australia. Joss sticks are now being manufactured locally and the valuable aromatic oils are being extracted from the timber, for use in perfumes, soaps and cosmetics.

Since 1987, the FPC and its predecessor, the Department of Conservation and Land Management (DCLM) have established *S. spicatum* plantations on farmland in the wheatbelt, with an aim of supplementing the harvest of natural stands with plantation timber. The FPC has successfully established *S. spicatum* plantations mainly in the medium annual rainfall (400-600 mm) regions, but some trials sites have also been successfully established in lower rainfall areas, such as Morawa (325 mm). This low rainfall requirement makes *S. spicatum* an ideal plantation timber for large areas of cleared land in the wheatbelt, which are too dry to support other plantation timbers. Between 1999 and 2003, the FPC has planted 50-150 ha of *S. spicatum* each year, and the aim is to increase this planting in the near future.

S. spicatum establishment is complex, due to it being a root hemiparasite (Hewson and George, 1984). To successfully establish *S. spicatum*, it needs to be planted near suitable host species, especially N_2-fixing species, such as Acacias. Direct seeding *S. spicatum* near 1-2 year old host seedlings, such as *Acacia acuminata*, has proven to be a very effective establishment technique (Shea *et al.*, 1998, Brand *et al.*, 2001). *S. spicatum* growth rates in FPC trials have been relatively fast, and the expected time for trees to reach a commercial stem diameter of 127 mm (at 150 mm above the ground) is only 20 years. To reach this size in natural stands, *S. spicatum* trees can require 32-59 years near Narrogin, and 59-115 years near Kalgoorlie (Loneragan, 1990).

This paper outlines *S. spicatum* (i) current growth rates from FPC plantation trials; and (ii) predicted growth rates and yields.

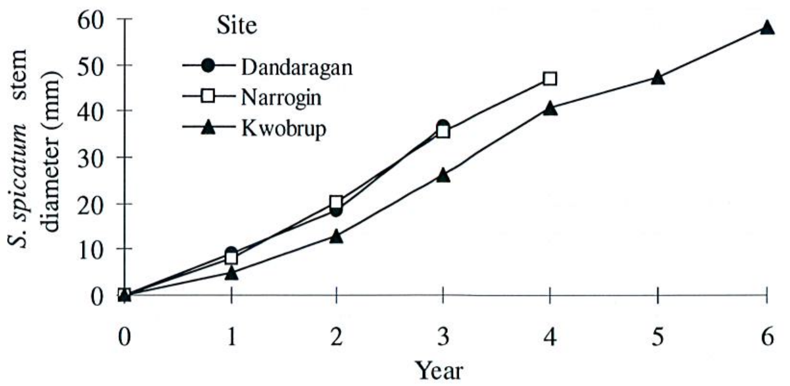

Figure 1. Mean annual stem diameter (at 150 mm) growth of *S. spicatum* direct seeded near *A. acuminata* (age 1-5 years) at three separate sites in the wheatbelt, Western Australia.

Current growth rates

In 1987, Pat Ryan established a *S. spicatum* plantation at Northampton (Brand *et al*., 1999), by planting *Acacia acuminata* seedlings in lines ripped 4.5 m apart and direct seeding 3-6 *S. spicatum* seeds near each host at age 1-2 years. The approximate stocking rate was 600 *S. spicatum* ha^{-1} and 600 hosts ha^{-1}. This establishment technique was successful, with a mean *S. spicatum* survival of 50-87 % at age 8-9 years (1997). Mean growth was also relatively good, with mean stem diameters at 150 mm above the ground increasing at 6-7 mm $year^{-1}$ between age 4.5 and 7 years. However, between 7 and 9 years growth decreased to 4-5 mm $year^{-1}$. This was thought to be due to the high host mortality. At host age 10 years (1997), only 34 % of the *A. acuminata* that had a *S. spicatum* introduced in year one (1988) were alive . At age 12 years, the mean stem diameter of *S. spicatum* was 72 mm, representing a mean annual growth of 6.0 mm.

The high parasite-to-host ratio of 1:1 at Northampton appeared to have killed the *A. acuminata* and reduced the growth rate of *S. spicatum*. To reduce stress on the hosts and to promote sandalwood growth for 15-20 years, the *S. spicatum* should be planted at low parasite-to-host ratios of 1:2 or 1:3. The FPC recommends planting 1000-1200 host seedlings ha^{-1}, and 1-2 years later planting 400-500 *S. spicatum* ha^{-1}. The FPC is mainly using *A. acuminata* as the host but there are also mixed plantings of *A. acuminata* and some other *Acacia* and *Allocasuarina* species.

Recent FPC trial plantings of *S. spicatum* near *A. acuminata* (Figure 1) in the 400-600 mm annual rainfall zone of the wheatbelt have been established at many sites, including Kwobrup (Brand *et al*., 2000), Dandaragan (Brand *et al*., 2003) and at Narrogin. At each of these sites, 4-6 *S. spicatum* seeds were direct seeded near 52-320 *A. acuminata*, aged 1-5 years. At *S. spicatum* age 3-6 years, survival at each sowing spot (4-6 seeds planted) was relatively high, with over 80 % survival. Growth was also good, with mean stem diameters (at 150 mm) growing at 9.7-12.3 mm $year^{-1}$. Mean stem diameter growth at each site appears to be linear, however the trials are only 3-6 years old and mean growth may decrease after age six years.

Oil and fruit production

In 1998, core samples were taken from twelve 10-year-old sandalwood trees planted at Northampton, to determine whether the trees were producing aromatic oils. An auger was used to core out wood samples at 15 cm and 25 cm above the ground, and supercritical fluid extraction (SFE) was used to extract the oil from the wood samples (Brand *et al*., 2001). The wood samples yielded 2.3-2.6 % total oil (Table 2), which is comparable to that from natural stands (2.4-2.9 %; Loneragan, 1990). However, the samples were taken low on the tree, and oil content decreases further up the tree (Piggott *et al*., 1997). The oil contained 16.7-21.1 % α- and β-santalol, which are the compounds that provide the distinct sandalwood fragrance (Adams *et al*., 1975). The oil also contained 17.8-20.5 % farnesol. The results provide evidence that plantation grown *S. spicatum* can produce valuable fragrant oils by age 10 years.

S. spicatum trees can flower at age two years and produce mature fruit by age three years. The fruit consists of a leathery exocarp that encloses are hard smooth nut. Within the nut is an edible kernel, similar in composition to almonds, peanuts and macadamias (Flanagan and Barrett, 1993). Although edible, at present the main value in sandalwood seeds is for use in establishing plantations. Barrett (1987) observed that six *S. spicatum* trees produced between 2 and 817 mature fruit at age six years, at Curtin University of Technology. *S. spicatum* plantations are also producing fruit at wheatbelt sites (Table 3, Figure 3). At the Kwobrup site (Brand *et al*., 1999), 179 *S. spicatum* have produced a mean of 0.34-0.62 kg seed $tree^{-1}$, at age 5-6 years. Similar results have been achieved at a site near Narrogin (0.58 kg $tree^{-1}$) at age only four years. At both sites, there were approximately 300-350 de-husked (clean) seeds kg^{-1}. *S. spicatum* seeds are currently worth up to $50 kg, but

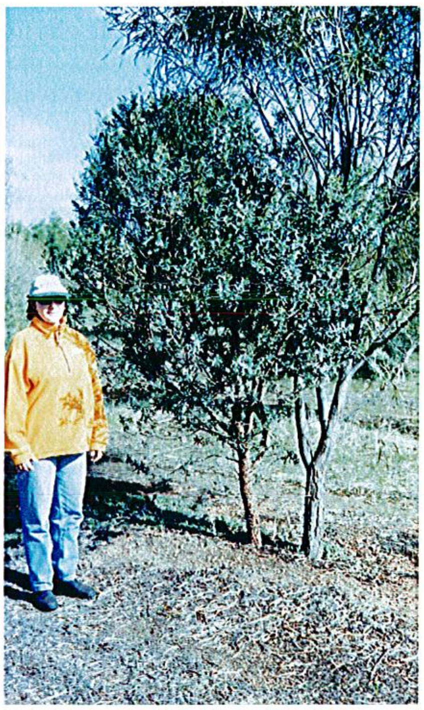

Figure 2. Four-year-old sandalwood (left), growing near a five-year-old jam (*Acacia acuminata*), near Narrogin, Western Australia. Photo: J. Brand.

Table 2. Mean proportion of compounds (± std. errors) and total extractable oil (± std. errors) from 12 *S. spicatum*, age 10 yrs, at Northampton (Source: Brand, *et al.*, 2001).

	% Compounds			
Stem height	α-santalol	β-santalol	t,t-farnesol	Total oil (%)
15 cm	15.8 ±2.7%	5.3 ±1.0%	17.8 ±2.6%	2.6 ±0.2%
25 cm	12.2 ±2.4%	4.5 ±0.9%	20.5 ±3.0%	2.3 ±0.2%

Table 3. Total seed produced and mean seed weight per tree from 4-6 year-old plantations at Kwobrup and Narrogin.

Site	Year	No. trees	Age (years)	Average seed weight/tree (kg)	Total clean seeds produced (kg ha^{-1})
Kwobrup	2001	179	5	0.34	60.9
Kwobrup	2002	179	6	0.62	110.2
Narrogin	2003	300	4	0.58	173.6

their value may drop as more seeds become available from FPC and private plantations established since 1999.

Predicted long-term growth rates and yields

At present, *S. spicatum* stem diameters are increasing at 10-12 mm yr^{-1} (age 3-6 years) near *A. acuminata* at three separate sites within the 400-600 mm annual rainfall zone of the Wheatbelt. If this growth rate was to continue at a linear rate, the *S. spicatum* will reach commercial size of 127 mm within 12 years. Although this is possible, the Northampton sandalwood trial showed that mean annual stem diameter growth dropped 2 mm after age seven years. The Northampton trees were under stress, due to a high host mortality, but it does indicate that mean *S. spicatum* stem diameter growth may not be linear over 20 years.

It appears that *S. spicatum* stem diameters (at 150 mm) may grow at approximately 10 mm yr^{-1}, between age 0-6 years, then 7 mm yr^{-1} between age 6-12 years, and then 4 mm yr^{-1} between age 12-18 years. This equates to an average stem diameter growth of 7 mm yr^{-1} over 18 years.

Therefore, allowing two years to establish both host trees and *S. spicatum* and then a mean annual stem diameter growth of only 7 mm yr^{-1} for 18 years, the mean stem diameter of the *S. spicatum* will be approximately commercial size (127 mm at 150 mm above the ground) at plantation age 20 years. This mean stem diameter (127 mm) equates to a commercial weight of 14.7 kg per tree, using the equation developed by Jones (2001):

$$\log y = 2.8045 \log x - 4.7331$$

where,
y = weight of the *S. spicatum* product
x = stem diameter of *S. spicatum* over the bark at 150 mm

If the plantation contained 300 *S. spicatum* ha^{-1}, the predicted yield would be 4.4 tonnes ha^{-1}, at plantation age 20 years. The wood from the plantations may be classed as "small green logs", which are branches 0.3-1.2 m in length, with 25-50 mm heartwood (Jones, 2001). Small green logs are currently worth AU \$4,000 a $tonne^{-1}$, but net returns would need to factor in establishment, maintenance and harvesting costs, which may be approximately AU \$3,500 ha^{-1}. Based on these predictions, the net return may be approximately AU \$14,100 ha^{-1} in the 400-600 mm annual rainfall zone.

Figure 3. Mature *Santalum spicatum* fruit. Within the brown exocarp is a hard smooth nut of approximately 20 mm in diameter. Photo: J. Brand.

Conclusion

Growing *S. spicatum* on farmland in the wheatbelt could provide an income to farmers, where the annual rainfall (400-600 mm) is too low for many other timber species. There is a proven market for *S. spicatum* both domestically and overseas, and the timber fetches AU \$4,000 - \$8,500 tonne[1]. *S. spicatum* grown within a plantation has produced valuable oils before age 10 years, and the expected value of the timber is AU \$4,000 tonne[1] at plantation age 20 years. Based on a conservative growth rate of only 7 mm $year^{-1}$, the expected net return is AU \$14,000 ha^{-1}. However, with current *S. spicatum* stem diameter growth rates near *A. acuminata* of 10-12 mm yr^{-1}, the potential yields and returns may be far greater. The seed produced within the plantation after age four years, may also provide an additional income while waiting for the trees to reach commercial size.

References

Adams, D.R., Bhatnagar, S.P. and Cookson, R.C. (1975). Sesquiterpenes of *Santalum album* and *Santalum spicatum*. *Phytochemistry* **14**: 1459-1460.

Barrett, D. R. (1987). Initial observations on flowering and fruiting in *Santalum spicatum* (R.Br.) A.DC., the Western Australian Sandalwood. *Mulga Research Centre Journal* **9**: 33-37.

Brand, J.E., Ryan, P.C. and Williams, M.R. (1999). Establishment and growth of sandalwood (*Santalum spicatum*) in south-western Australia: the Northampton pilot trial. *Australian Forestry* **62** (1): 33-37.

Brand, J.E., Crombie, D.S. and Mitchell, M.D. (2000). Establishment and growth of sandalwood

(*Santalum spicatum*) in south-western Australia: the influence of host species. *Australian Forestry* **63** (1): 60-65.
Brand, J.E., Fox, J.E.D. and Moretta, P. (2001). Review of research into sandalwood (*Santalum spicatum*) tree farm systems in south-western Australia. In Conference Proceedings: Forests in a Changing Landscape: 16th Commonwealth Forestry Conference jointly with the 19th Biennial Conference of the Institute of Foresters of Australia, Fremantle, Western Australia, 18-25 April, 2001 Promaco Conventions, Perth, pp. 527-535.
Brand J.E., Robinson N. and Archibald R. D. (2003). Establishment and growth of sandalwood (*Santalum spicatum*) in south-western Australia: *Acacia* host trials. *Australian Forestry* **66** (In print).
Flanagan, F. and Barrett, D. R. (1993). Sandalwood nuts as food. *Mulga Research Centre Journal* **11**: 21-26.
Hewson, H.J. and George, A.S. (1984). Santalaceae. In *Flora of Australia*, Volume **22**: 29-67. Bureau of Flora and Fauna, Canberra. Australian Government Publishing Service, Canberra.
Jones, P. (2001). Estimating returns on plantation grown sandalwood (*Santalum spicatum*). *Sandalwood Information Sheet* **3**. Forest Products Commission, W.A., pp1-4.
Loneragan, O.W. (1990) Historical Review of Sandalwood (*Santalum spicatum*) Research in Western Australia. *Research Bulletin* **4**. Department of Conservation and Land Management, Western Australia.
Piggott, M.J., Ghisalberti, E.L. and Trengove, R.D. (1997). Western Australian sandalwood oil: extraction by different techniques and variations of the major components in different sections of a single tree. *Flavour and Fragrance Journal* **12**: 43-46.
Shea, S.R., Radomiljac, A.M., Brand, J. and Jones, P. (1998). An overview of sandalwood and the development of sandal in farm forestry in Western Australia. In: Radomiljac, A.M., Ananthapadmanabho, H.S., Welbourn, R.M. and Satyanarayana Rao, K. (Eds.), Proceedings of an international seminar held on 18-19 December 1997, Bangalore, India. ACIAR Proceedings No. 84, pp. 9-15.

Sandalwood growers network gains momentum

Tim Emmott
Farm Forestry Coordinator, Greening Australia , (WA)

In the Avon River Basin of Western Australia, WA sandalwood (*Santalum spicatum*) has been harvested from natural stands for over 100 years. In more recent years, there has been mounting interest from landowners to establish WA sandalwood in plantations on cleared agricultural land within the Basin, mainly due to the potential to profit from the sale of plantation grown sandalwood, and the need for increased revegetation to combat environmental degradation issues, such as dryland salinity.

Research by the Forest Products Commission has demonstrated that WA sandalwood can be successfully cultivated in plantation situations in the 350 – 600 mm annual rainfall zones of southern WA.

There are an increasing number of new and existing growers establishing WA sandalwood plantations within the Avon River Basin, prompting the formation of the "Avon Sandalwood Network" (ASN). The ASN has been formed to provide a forum for new and existing WA sandalwood growers to come together to keep up to date with new developments and recent research. Sandalwood establishment and silviculture techniques are constantly evolving, and the ASN is providing growers with a means of sharing their experiences and networking with researchers and industry experts.

To date the ASN has 60 members, has held 2 successful workshops and field trips (Figure 1), and has produced 2 newsletters. The next workshop and field trip is planned for the 3rd of September 2004 in Beverley, WA, and will involve a range of guest speakers, and visits to new and established WA sandalwood plantations. For more information, or to obtain a copy of the previous ASN newsletters, contact Tim Emmott from Greening Australia (WA) on (08) 9621 2400 or temmott@gawa.org.au.

Figure 1. Sandalwood growers inspecting *S. spicatum* direct seeded near two-year-old jam (*Acacia acuminata*) host seedlings, near Beverley, Western Australia. Photo: T. Emmott.

Authors contact details:

Jean-François Butaud

Forest engineer
Forest Department
Rural Development Service
Ministry of Agriculture and Breeding
Territory of French Polynesia

Email: jean-francois.butaud@rural.gov.pf

Jon Brand

Forest Products Commission,
Midwest Sharefarms,
Lot 1, 260 Kalamunda Road,
South Guildford WA 6055
Australia

Tel: + 61 8 9279 4088
Fax: + 61 8 9279 5481
Email: jonb@fpc.wa.gov.au

Tim Emmott

Farm Forestry Coordinator
Greening Australia (WA)
PO Box 311
Northam WA 6401
Australia

Tel: + 61 8 9621 2400
Fax: + 61 8 9621 2580
Email: temmott@gawa.org.au

The Sandalwood Research Newsletter (SRN) is published by the Forest Products Commission and is distributed free of charge. It is intended as a forum for information exchange on Santalum species worldwide. Articles on a range of Santalum species research and management issues are welcomed by the Sandalwood Research Newsletter.

If you would like to contribute an article to the SRN or wish to be included on the SRN mailing list, please send details to the Editor stating: your name, title, position, organisation, postal address, telephone, fax and email address.

***Editor:** Jon Brand*
Forest Products Commission
MidWest Sharefarms
Lot 1 / 260 Kalamunda Rd
South Guildford WA 6055
Australia

***Telephone:** + 61 8 9279 4088*
***Facsimile:** + 61 8 9279 5481*
***Email:** jonb@fpc.wa.gov.au*

The Sandalwood Research Newsletter is produced by the Forest Products Commission, Western Australia.

Sandalwood