Sandalwood Research Newsletter

May 2000 Issue 10 ISSN 1321-0022X

Editor's Note

This edition of the Sandalwood Research Newsletter looks at the status of sandalwood in Fiji and Timor with a research note on four Santalum species trialed in south Queensland, Australia.

A common undercurrent in the Fiji and Timor articles is the need for revised statutory regulations in each country to conserve sandalwood and ensure its long term economic viability. The Queensland experience also encourages strategies such as plantation establishment for conservation and also to ensure increasing market potential can be realised.

In Timor it appears that the regulations established to conserve sandalwood are so stringent and unprofitable to the local landholders that they are in fact causing its decline. At the other extreme, the absence of any regulations on harvesting or selling of sandalwood in Fiji has still resulted in an over exploitation and subsequent loss of the resource. Somewhere between these extremes, lies the potential for a policy to reflect the demands of the local and national community, whilst not compromising its sustainable supply.

In Fiji, Timor and Australia sandalwood contributes significantly to each national economy. The price of sandalwood per tonne has risen dramatically in the last decade, whilst the naturally occuring resource continues to decline.

Globally, there are similar reasons cited for the decline such as illegal cutting, uncontrolled burning or grazing and the removal of seedlings to avoid the obligation of maintenance. However as Rohadi et al notes in this issue, these are often a corollary to ineffective local government policies and incentives. Increasing returns to the landholder is required to ensure greater protection of the seedlings. Local people must be empowered to manage the resource which can be achieved through involvement in policy and project development from the earliest planning phase. Plantation establishment, regeneration strategies and a long term research program can be included in participatory approaches to ensure conservation and maintain economic sustainability.

One example of such a program is the trial in Queensland (page 6) with local landholders. This will assist in determining the appropriate species for plantation establishment to maximise economic returns as well as including other benefits such as in situ conservation of S. lanceolatum and ex situ conservation of other Santalum species.

I hope you enjoy these articles. Authors are encouraged to send articles for the September edition by 31 July 2000. Feedback, queries and comments are also welcome.

Tanya Vernes

Status and Current Interest in Sandalwood in Fiji

L.R.Jiko

ting Conservator of Forests, Ministry of Agriculture, Fisheries & Forests, Department of Forestry, Fiji

Santalum yasi, the only sandalwood species in Fiji, earned F$4.74 million in foreign exchange over the period 1987 –90. This recent resurgence in the utilisation of sandalwood has created an interest among landowners in planting and restocking new areas with the species. This paper presents information on early history, traditional uses, growing conditions, silviculture and marketing of yasi, together with some notes on current research directions.

The small tree, *Santalum yasi*, with aromatic wood grew abundantly along the Bua coast and in grassland areas of Fiji. Although it also occurs in Vanua Levu, northern Lau, Kadavu and Viti Levu, the species is believed to be native to Bua.

Well before the advent of European traders to Fiji, sandalwood was traded between the Fijians and the neighbouring Polynesian island states. Tongan canoes made long voyages to Fiji to barter sandalwood for bark cloth and sting of ray, which the Fijians used for pointing their spears.

Sandalwood was used by Fijians themselves to scent coconut oil and during marriage ceremonies. It was also used as an insect fumigant, and as a medicinal to clear dandruff and head lice.

Following the publication of Captain Bligh's chart of the Fiji Islands in London, navigators and treasure hunters flocked to the Fiji Islands to search for, and trade in, sandalwood, whale products and beche-demer.

High prices for sandalwood in the ports of China at the beginning of the nineteenth century sent adventurers in search of the timber all over the South Pacific. In Fiji, exploitation of yasi began between 1800 and 1805, and lasted only for about 10 years. This boom resulted in the species becoming rare, and commercial exploitation lapsed until recently.

inside...

Growing Conditions

Fiji has a land area of 18,300 km^2 on some 300 islands. The largest islands are Viti Levu and Vanua Levu, which comprise 87 per cent of the land area. The islands lie between 178°E and 179°W longitude and between 16 and 22°S latitude. They are largely volcanic in origin, with reasonably fertile soils and often with steep dissected topography.

The mean annual rainfall varies from 1,650 mm in the low leeward coasts of Vanua Levu and Viti Levu to over 3,800 mm in large parts of the island interiors. Natural hardwood forest areas generally have more than 250 mm per month with only a short dry period. Mean monthly temperatures for the period January to March, during greatest rainfall, are around 29°C, dropping to 24°C during July to August. Cyclones are frequent from December to April, and cause much damage to settlements, crops, plantations and forests.

Distribution

The principal areas of occurrence of yasi are in parts of Bua province of Vanua Levu, on the open hills behind Bua Bay and around the southwestern corner of Galoa Island. In earlier days, the wood was also obtainable in lesser quantities along the western and northern coast of Vanua Levu as far as Naduri. As a result of heavy cutting and uncontrolled fire, sandalwood has now disappeared along the Naduri coast.

In Viti Levu, sandalwood was found only on steep banks along the Colo West Range from Tubainasolo to Nasaucoko. During the recent period of harvesting, some supplies were also observed at Nakelo in the Central Division and parts of the Eastern Division including Yawe, Tavuki, Naceva and Ono-i-Lau.

Silviculture

In Fiji, sandalwood grows to a maximum height of 10 m, with a diameter overbark at breast height of up to 40 cm. The bark is grey with brown fissures, and the leaves are opposite, light green and shiny, forming a light crown. The flowers are small and purplish, and the fruit is a small dark purple drupe. The sapwood is white and scentless while the heartwood is yellowish brown, hard, oily and strongly scented.

The sandalwood grows mainly in open forestland with grass and patches of trees. It is usually found on rather stony soil, and under these conditions appears to produce the most scented wood. It has been observed that trees growing in rich soil do not have as much scented wood as trees, which are slower growing on stony soils.

In the outlying islands of the Western Division, natural regeneration of yasi is found in old gardens and on wasteland. It is commonly found on ridge slopes, shallow degraded soils with rock outcrops, sandy soil in coastal areas and the edges of swamps.

Examples of species usually found growing together with the sandalwood in its natural habitat include:
Casuarina equisitifolia, Cocos nucifera, Albizzia lebbek, Acacia rishii, Alphitonia spp., Podocarpus nerifolius, Ficus theophrastiodes, Hibiscus tiliaceus, Litsea spp., Inocarpus fagerus, Erythrina spp., Citrus spp., Pongamia glabra, Dodonea viscosa, Zingiber zerumbet.

Figure 1: *S. yasi*, Tamavua Research Station

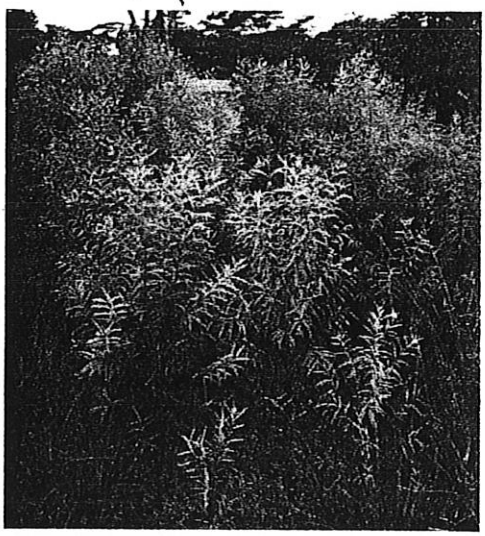

Photo: T Vernes

Sandalwood may attach itself to the roots of almost any plant. However, it seems to grow best in the company of the plants listed above.

In Fiji, the sandalwood tree is a prolific seed bearer and fruiting begins as early as 3-4 years, although the fertility is poor at that age. However, a high percentage of sound seed is available from about 8 years onward, and there is an annual seed crop. Seed collection is carried out from November to March.

Natural regeneration is found mainly under shrubs and not as a rule in the open. This is believed to be partly because birds which have eaten the fruits settle in the shrubs and drop the seeds there, and partly due to better seedling survival in the shelter of other vegetation.

Sandalwood in Fiji has a tendency to fork early, often when only a few months old. It is not known whether this tendency is inherited, or whether some environmental factor is responsible. An average of two leaders have been observed on seven-month-old seedlings in the nursery, whilst 45 per cent of the 20 saplings sampled at Galoa forked within one metre of the ground, with multiple leaders ranging from two to seven per tree. Root suckers have been observed on recently felled sandalwood trees.

Harvesting and Marketing

Harvesting of sandalwood beg again in 1984 at Bua, and subsequently at all other areas where sandalwood occurs naturally.

A resource survey was carried out at Bua (Usumaki 1981) and on Ono-i-Lau (Tabunakawai & Chang 1984) to determine the quantity available for export.

The standing volume was estimated to be 2,623 m^3 in Bua and only 11.5 m^3 in Ono-i-Lau, which is equivalent to about 1,000 t of heartwood. The latter was calculated from limited sampling, which indicated the average proportion of heartwood to total volume was 35 per cent.

The price received for yasi rose from F$300 to F$1,000 per tonne in 1985 to F$16,000 to F$20,000 p tonne in 1990 (F$1 = U$0.71 in Ma 1991).

The markets for the produce were Singapore, Hong Kong, Taiwan, Korea and Japan. Despite the exhaustion of the resource in 1990, there were still enquiries for sandalwood.

At the beginning of the exploitation of yasi, the government introduced a regeneration levy in addition to the existing royalty and fees. Of the total amount in sales 17.5 per cent is deducted from the price of the sandalwood, 10 per cent for the regeneration levy, 5 per cent royalty to the government and 2.5 per cent government fees. The remainder of the income is paid to the landowners.

The regeneration levy is paid to

the Native Lands Trust Board, an organisation that is the trustee of all Fijian-owned land. The funds generated are administered jointly by the Trust and the Ministry of Forests for regeneration work, which is supervised and certified by the Forestry Extension staff.

Current Research

Research on sandalwood in Fiji has been on an ad-hoc basis over the years.

Germination

Obtaining seed is a major problem, partly because it comes from outer islands where communication is poor, and partly because there are relatively few seed trees available. Hurricanes are also a frequent cause of loss of a seed crop.

With fresh seeds, germination of sandalwood is rapid. A germination test of 250 seeds pretreated according to the technique of Barrett (1987) showed that germination begins after 14 days and is complete after 31 days.

Host Species

The sandalwood is sown direct into a plant pot into which a host plant has already been planted.

Several hosts have been tested with no species yet being adopted as standard. Currently, *Acacia richii, A.mangium, Citrus lomon* and *Calliandra spp.* are being established for a new field trial. In the field trial at Wainunu, the growth and survival of *S. yasi* with no host, and with three different hosts were compared and differences in both growth and survival rate were observed.

Conclusions

As a result of the financial benefits realised from the recent exploitation, there is now a far greater interest in the cultivation of the species. The challenge for the Forestry Department now is to provide the technical support to keep this impetus going. It is essential that simple and successful established techniques are developed and implemented. A great deal of research is required to provide the information needed. Provided research is continued and the regeneration work is carried out to a good standard, the supplies of yasi should increase in the future.

The main area of concern at the present time is the continuing inadequate supply of good quality seed for the regeneration program. As there are few yasi mother trees remaining it may be necessary to establish special seed production areas for this purpose. It may also be necessary to place a ban on the sale of yasi except for traditional purposes to conserve the species.

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Can Sandalwood in East Nusa Tenggara Survive? Lessons from the policy impact on resource sustainability.

Dede Rohadi[1 2], Rento Maryani[1] Brian Belcher[2] Manual Ruiz Perez[2 3], and Made Widnyana[1]

[1] Forest and Estate Crops Research and Development Agency (FERDA)
[2] Centre for International Forestry Research (CIFOR)
[3] Departmento de Ecologia Facultad de Ciencias-Edificio Biologia Universidad Autonoma de Madrid, Madrid

This paper discusses the policy aspects of sandalwood in East Nusa Tenggara province, focusing primarily on the impacts of regional government regulations on the resource sustainability. The paper is based on a field survey that was conducted during July-August 1999, as well as from various publications and official reports from the region.

Introduction.

Research being carried out on sandalwood (*Santalum album* Linn.) production and utilisation in Indonesia, as part of a larger comparison of cases of non-timber forest products development, has highlighted an interesting policy phenomenon. The study shows that sandalwood production has been severely hindered by regulations that were intended to maintain resource sustainability. The important historical and contemporary role of sandalwood resources as a significant contributor to the regional income has triggered the regional government to regulate each step of activities related to sandalwood production and utilisation. However, the current condition of the resource shows that the results of the policy have been the opposite of what was intended. Wood supply has declined at an alarming rate, threatening its role as a significant source of regional income as well as raw material source to the local sandalwood industries.

The history and nature of sandalwood in East Nusa Tenggara province.

The history of Sandalwood (called Cendana in Bahasa Indonesia) in East Nusa Tenggara province closely parallels the history of the province itself. The wood has been commercially traded by Chinese traders to Malaya and India since the 10th century. During the 15th century, sandalwood from this area attracted western traders and may have been one of the stimuli for colonialization in Indonesia (Husain 1983). Traders distributed the wood to other parts of the world, including to the southern part of India (Sumarna 1985).

In the region, sandalwood grows as an evergreen tree, 12 to 20 meters in height, with a diameter between 25 to 40 cm (although some individuals may reach 55 cm) and usually with many irregular branches (Sumarna 1985; Sipayung 1985). They are rarely found as singly, usually being distributed in small groups of 4 to 5 trees (Sipayung 1985). The tree grows well in a dry climate region with a wide range of annual rainfall (625 to 1,625 mm) and temperature (10 °C to 35 °C). It grows at altitudes from 50 to 1,200 m, although it grows much better in higher elevations. It grows well on well-drained soil and adapts to rocky or stony soil with low fertility (Sinaga & Surata 1997; Sumarna 1985).

The tree regenerates either by seedlings or coppices (root or stump) (Sumarna 1985). The current sandalwood production in East Nusa Tenggara province is based on natural regenera-

tion, although efforts to plant the trees were initiated in the early part of this century (Sipayung 1985; Husain 1983). Intensive efforts in sandalwood plantation were carried out by the East Nusa Tenggara Regional Forestry Office during 1987-1991 with about 2,000 ha planted. Perum Perhutani established 417 ha of plantation during 1988-1994. However, the efforts were not successful due to limited knowledge of silviculture techniques, poor management system and limited plantation facilities (Surata et al 1995).

Sandalwood is used for several purposes. Sandalwood oil is extracted from the heartwood and exported to USA, Singapore and European countries (mainly Switzerland, UK, France and Holland) for use in the perfume and cosmetics industries (BPEN 1993). The wood is used locally and on neighbouring islands such as Bali, for woodcarving and various forms of handicrafts such as fans, pens, beads, rosaries, accessories and handbags. The wood is also used to make joss (incense) sticks for ritual purposes that are marketed domestically or exported, mainly to Taiwan. Currently there are 4 sandalwood oil factories, 24 handicraft and 14 joss stick companies with the total wood intake capacity of around 4,000 tons. All of the factories are mainly located in Kupang, Timor island, the capital city of the province.

Sandalwood plays an important role as one of the main sources of regional government revenues. From 1986/1987 to 1991/1992, sandalwood contributed about 2.5 billion rupiah annually or about 40% of the total regional income (Suara Pembaruan, 1994). Since that time, this contribution has declined to only 16.5% in 1997/1998. However, sandalwood is still considered an important resource by the regional government.

Policies and impacts.

Historically, sandalwood was appropriated by the ruling class, under traditional law. All sandalwood trees no matter on whose land they grew were owned by the king (Radja). The king appointed a Fetor or Uis Pah to control sandalwood in their region. The Fetor then appointed Adat[2] chief to administer the rules governing sandalwood, as well as to conduct ritual ceremonies at harvest time. The sharing of benefits from harvested sandalwood was as follows: the root belonged to the *radja*, the stem to the *fetor*, and the branches to the landowner (Ormeling, 1955).

Similar rules were maintained after Indonesia gained independence in 1945. The wood was controlled by the regional government through a series of regulations covering all aspects of its management. These regulations deal with property rights, resource maintenance, harvesting, marketing and wood allocation. The main points of these regulations are as follows:

1. All naturally regenerated sandalwood (live trees, dead trees and wood) belong to the regional government. Any parties could plant sandalwood trees on their own land, but their income share from the harvested wood was only 15%[3] (Regional Government Regulation or "Perda" No. 16/1986 and the Ministry of Home Affairs Decree No. 522.63-433/1988). Landowners need to prove their land certificate to claim their income from their cultivated sandalwood (Governor decree No. 7/1993).
2. The Regional Forestry Office conducts resource inventory every 5 years and determines the annual allowable cutting (AAC) for the following five years[4] (Perda No. 16/1986 and Governor decree No. 7/1993, Governor letter No. 112/SKEP/HK/1995).
3. The local government conducts the harvesting activities, determines the harvesting cost[5] and provide/prepare the documents required for harvesting and transporting the wood (Governor decree No. 7 and No. 8/1993, Governor letter No. 113/SKEP/HK/1995).
4. The local government determines the wood price[6] and allocates the wood to the selected companies[7] (Governor decree No. 7/1993, Governor letter No. 260/SKEP/HK/1995, Governor letter No. 5/SKEP/HK/1996).
5. All communities should care for and maintain the sustainability of the resource. Illegal cutting, stockpiling or transporting sandalwood, as well as intentional acts to damage the trees will be prosecuted. Co-ordinating boards, comprised of several government institutions including the head of the regency or *bupati*, head of sub district office or *camat*, head of village or *lurah*, the armed forces or *ABRI* as well as some local community leaders were established by the Governor (Governor decree No. 53/1992).

"In 1997, the law totally banned sandalwood cutting for the next five years..."

In 1997, the Governor totally banned sandalwood cutting for 5 years (to 2002) due to an alarming rate of resource depletion. One year prior to the ban, the Governor launched a sweeping operation[8] ostensibly to collect illegally cut wood being stored by the local people. Almost 2000 tones of "illegal" wood was collected during the operation and was earmarked for allocation to local industries to maintain their operation up to the year 2003. However, local reports indicate that the wood collected also included an amount of freshly cut wood.

The regulations, designed to sustain the resource, as well as to maintain local government income, in reality had the opposite effect. Local people are not interested to maintain naturally regenerated trees. They are even more unlikely to cultivate sandalwood trees because the benefits are so low, and the risk of losing it all to another sweeping operation. Husain (1983) and Surata et al (1995) reported that some of the main causes of the low rate of survival for young sandalwood in the regions were fire (from the traditional shifting cultivation activities) and wild grazing. There is also anecdotal evidence that local people tend to kill the young trees to avoid any obligation to maintain the trees once they have been inventoried (Leki 1996; field notes).

The impact on resource availability is illustrated in Figure 1. The figure shows the annual wood production, the industrial capacity and the estimated sandalwood standing stock in the region during the last three decades. Wood production fluctuated within the range of 87 tones to 995 tones per year (Surata et al 1995; Leki 1996) during 1969/1970 up to 1996/1997. The production in 1997/1998 reached a high of about 2,000 tones, which was derived from the sweeping operation and then dropped to zero due to the harvest ban. In the mean time, industrial capacity increased significantly from only 800 tonnes in 1974 to 1600 tonnes in 1985 to over 4000 tones in 1998. Significant increase was mainly for handicraft industries, due to a former government policy to encourage and promote traditional industries (e.g. carving and handicrafts).

The big gap between the industrial capacity and the official wood production has been filled, at least in part, by illegal cutting. It is likely that a black

market was prevalent to feed the industry. There was also anecdotal evidence during the field survey, that inter-islands smuggling of sandalwood material had been practised significantly. These are to be expected for reasons, such as: the formal procedure does not give sufficient incentive to the local people to market wood through legal channels; the local industries, as well as the industries located at the neighbour islands, need raw material, and there is an opportunity to obtain the wood at a lower price from illegal cutters/ traders. There have been several newspaper reports about illegally cut wood caught by officials (Suara Pembaruan 1991; Suara Pembaruan 1994). The sweeping operation also collected a great deal, though it is not clear how much of it had in fact been cut already.

The estimated wood standing stock can be calculated based on the inventory results, by multiplying the total number of mother trees with the conversion values of heartwood content per tree. Two conversion values were used in the Figure 1, i.e. 22 and 45 kg heartwood/tree (green basis). The low estimation was based on an experimental finding on heartwood content of *Santalum album* in South Amanuban Sub District, South Central Timor (Susila 1994). The high estimate was based on excavation study of *Santalum spicatum* in Kalgoorlie, Western Australia (Brand *et al*, 1999). It was shown that the standing stock has been decreasing sharply since 1994. The current standing stock is about a quarter (low estimate) or half (high estimate) of the industrial capacity. The sharp decline of this standing stock could be the result of complex factors, involving high rates of illegal cutting and failure of the natural regeneration due to frequent uncontrolled burning and wild grazing, or even accuracy of inventory data.

The decline also affected the sandalwood contribution to the regional income. During 1986/1987 to 1991/1992, sandalwood contributed up to about 40% of the total regional income (Suara Pembaruan, 1994). The income contribution has dropped to only 16.5% in 1997/1998 and will drop to zero in the period following the logging ban.

Future direction.

The current figures on sandalwood production and consumption show a high level of threat to the sustainability of the resource. The future of the resource depends on how much effort will be invested to increase sandalwood production in the region. The efforts will require local participation in maintaining the natural regeneration of sandalwood trees as well as government or private companies' investments in new plantation developments to meet the increasing demand. The local government has taken one positive step by issuing a new regulation (Perda no. 2/1999 that abolishes the earlier regulation) that will allow people to capture more or even all revenue from trees planted on their own. In the spirit of decentralisation, the authority for sandalwood management has been transferred from the provincial government to the District government. Debate is ongoing on whether to change the previous arrangement of benefit sharing from 60%: 40% between the government and community to a new proportion of 20 %: 80% respectively, to encourage people's participation on sustaining sandalwood.

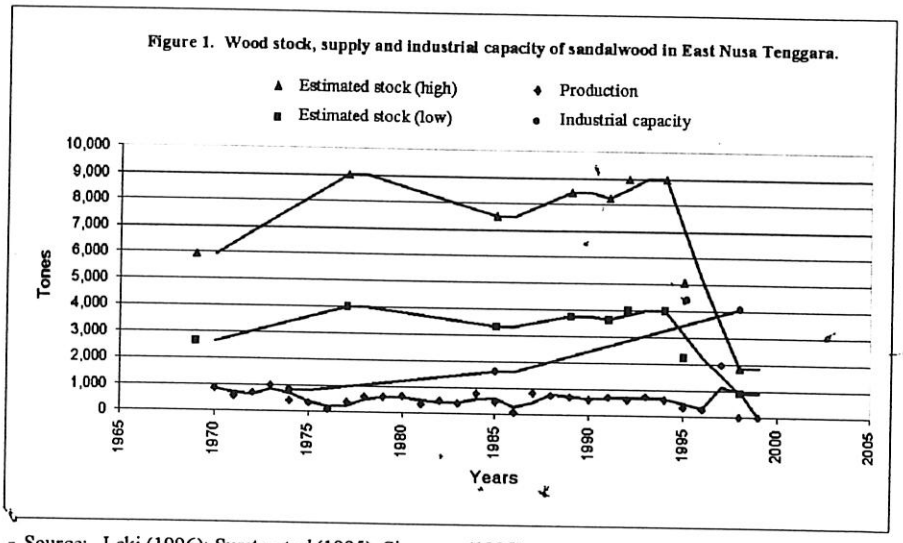

Figure 1. Wood stock, supply and industrial capacity of sandalwood in East Nusa Tenggara.

Source: Leki (1996); Surata *et al* (1995); Sipayung (1995).

There is another question regarding the established sandalwood industries. By banning harvest the industries can no longer find raw materials from the region. To prevent from collapse, they have to find wood materials from outside (by, for example, importing from India or Australia), or they have to modify the products. At the same time, it is necessary to encourage them to invest in sandalwood plantation for their own future materials.

Conclusions and recommendations.

Sandalwood is one of the precious resources from East Nusa Tenggara province. This important asset had contributed significantly to the regional income. However, current development shows that sandalwood population in the region is decreasing in an alarming rate. Various factors including illegal cutting, uncontrolled burning and wild grazing have been proposed as the detrimental factors causing the current resource scarcity. This paper, however, shows that the root of these factors is ineffective local government policies that is too focused on regulations to control these resources. The regulations tend to neglect community rights and thus discourage them from participating in the maintenance of sandalwood natural regeneration. The condition is getting worse by the imbalance between industrial capacity and sandalwood supply as well as limited efforts in developing sandalwood plantations.

The paper recommends the local government to encourage people to maintain naturally regenerating sandalwood in the region by offering more rational benefits to the community. Instead of regulations to control the resource, government efforts should be more focused on investment to establish and maintain new plantations. Participation by the local industries should also be encouraged on plantation development to sustain their production in the future.

Acknowledgements

The authors would like to thank to Forest Research Institute Kupang for the supports during the field survey. Special thanks also directed to Ida Ayu N. Pradnja Resosudarmo and Grahame Applegate for their help on reviewing the manuscript.

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[1] Fetor was the person who rules the region (similar with the land lord).
[2] Adat chief is usually a local community leader dealing with cultural affairs.
[3] The income share was increased to 40% since the issue of Perda No. 2/1996.
[4] The Governor letter No. 112/SKEP/HK/1995, for example stated that the AAC for the year 1995/1996 was 300 tones.
[5] The Governor letter No. 113/SKEP/HK/1995, for example determined the exploitation cost of Rp 1,300/kg heartwood, consists of the cost for felling, bucking and skidding (which was the total wage delivered to the local community) of Rp 800/kg and the cost for transportation, storage, monitoring, equipment, administration and levies of Rp 500/ kg.
[6] The Governor letter No. 260/SKEP/ HK/1995, for example stated that the price for Class A (the best quality) was Rp 18,000/ kg, Class B was Rp 15,300/kg, Class Mix was Rp 9,000/kg, Sapwood was Rp 1,000/kg and small branches was Rp 500/kg.
[7] The Governor letter No. 5/SKEP/HK/1996 selected 20 local companies to receive sandalwood allocation from the respective harvesting year.
[8] An operation consisting of intergovernment institutions to collect illegally cut wood from the community. Literally this means a friendly operation, because instead of collecting the wood and punishing the illegal cutter, the Regional Government compensates the harvesting cost for any collected wood. However, it could also be said that the Operasi Bersahabat, in fact was a pre-emptive coup by the provincial government against the proposed new regulations that requested people getting up to 80% of the sandalwood value. The provincial government subsequently declared a ban on sandalwood cutting, once they had taken all the stock available from people.
[9] With the increasing attention on sandalwood handicrafts by the tourist visiting the province, the Governor encourages to develop local handicraft industries by allocating wood raw material to the industries (Governor Decree No. 7/1993) and discouraging raw material supply to outside the province. Other example support was given by supporting 30 local craftsmen to improve their skill on handicraft making in Bali (Suara Pembaruan, 1994).

Testing Growth and Survival of Four Sandalwood Species in Queensland

D. Taylor[1], S. Swift[1] and S. Collins [2]

[1] *Queensland Forestry Research Institute, Gympie*
[2] *Formerly of Queensland Forestry Research Institute, now Integrated Tree Cropping, Albany WA.*

Sandalwood production in Queensland has been based on harvesting from naturally occurring Santalum lanceolatum, principally from relatively remote areas in northern Queensland between Hughenden and Normanton. Santalum lanceolatum has a relatively low oil yield in comparison to other sandalwood species and a consequent lower market value. With declining amounts of natural sandalwood available for harvest and an increasing market the potential exists for sandalwood production from plantations. To date, little work has been done in Queensland on production of Sandalwood in plantations. This report details an experiment established in late 1999 to investigate the growth and survival of four sandalwood species, viz; Santalum album, S. austrocaledonicum, S. yasi and S. macgregorii on two sites in Queensland.

Introduction

Sanatalum lanceolatum occurs throughout Queensland in a wide range of climates and habitats (Keenan 1996). Past and present industry has been based on harvesting the natural resource, principally from the northern parts of Queensland. However *S. lanceolatum* has a relatively low oil content of variable quality in comparison to other sandalwood species and in its natural habitat relatively slow growth rates. To date, little work has been conducted on the establishment of plantation sandalwood in Queensland (Applegate *et al* 1990). Given the greater oil content and higher market value of other sandalwood species, assessment and selection of a range of these species for plantation rather than *S. lanceolatum* is a logical choice. However survival, growth rates, host species compatibility and site suitability have not been previously tested in Queensland. Results reported from other work in Western Australia (Radomiljac 1993) indicate the potential for production of sandalwood in plantations.

This experiment seeks to

investigate the suitability of a number of seedlots within four sandalwood species for plantation in Queensland on two very different sites. Site one is near Mareeba on the Atherton Tablelands of tropical north Queensland and site two is near Dalby on the Darling Downs in subtropical southern Queensland. Both sites are in agricultural areas where irrigation is available. At site one, the sandalwood seedlings were planted simultaneously with host trees, predominantly *Acacia spp*, while at site two seedlings were planted adjacent to a remnant *Acacia harpophylla* (Brigalow) / Belah (*Casuarina cristata*) remnant forest strip or 'shadeline'. At site two, abundant natural sandalwood is present within the shadelines. This report outlines the species planted and discusses the potential attributes in terms of sandalwood growth on site two.

Materials and Methods

Site

Site two is located approximately 50 km north west of Dalby on freehold land (AMG 2932 70247). MAR for Dalby Post Office is 676mm predominantly falling in summer. Climate is subhumid, subtropical. The land was cleared in the early to mid 1900s with the exception of strips ('shadelines') and clumps for shade and shelter. Remnant vegetation in the shadelines is Brigalow / Belah. *S. lanceolatum* and *Geijera parviflora* (Wilga) are common within the remnants. Soil type is a 'cracking clay' or Brown Vertisol (Isbell 1996), ie, a light – medium clay overlying a heavy clay. The profile is well structured throughout. The principal land use is cropping, with both summer and winter cereals and cotton grown.

Design

The experiment comprises a randomised block of 12 single row line plots comprising 30 seedlings within each plot.

Treatments are comprised of 27 seedlots within four species. A variable number of seedlings were planted within each treatment and plot due to limited seedling numbers. Treatments are given in table 1 below:

Table 1. Sandalwood species by number of treatments within species.

Species	No. of Treatments (seedlots) Tested
S. austrocaledonicum	15 seedlots
S. mcgregorii	1 seedlot
S. yasi	8 seedlots
S. album	3 seedlots

Seedlings for this experiment were grown from seed collected as part of the AusAID funded SPRIG (South Pacific Regional Initiative on Forest Genetic Resources) project. The material used in this trial was remnant stock from other SPRIG research work and had been in the nursery for considerable time and thus was not ideal. Seed had been germinated in mid 1998 and grown in 'Vic' pots up to planting. Vic pots are a planting tube 200ml in volume. All seedlings had been established with a pot host (*Alternanthera* spp.) however not all had survived and in many cases nursery weeds had established. Potting media consisted of a standard peat moss – vermiculite mix with slow release fertiliser incorporated. Seedling health could generally be described as poor at planting out.

Establishment of the plots was carried out in rip-lines created by a single tyne ripper approximately 30 cm deep. Rip-lines run parallel and adjacent to the Brigalow / Belah shadeline and are offset 3 and 6 m respectively. Tree roots were in great abundance in the rip lines. Seedlings were planted by hand at three metre intervals along the riplines using a mattock. In some cases the shadeline was not continuous and a mix of Brigalow and Belah seedlings were planted between the sandalwood seedlings. Drip irrigation was laid out immediately following planting and seedlings were watered in. Fertiliser, in the form of Di-Ammonium Phosphate, was applied to individual seedlings at the rate of 45-50-5 kg of elemental Nitrogen, Phosphorus and Sulfur per hectare respectively.

Management

Weed control with herbicide around the seedlings will not be carried out until six months after planting when it is expected that seedlings will be established. Some hand weeding is being carried out to remove overtopping weeds. It is thought that weeds may act as an intermediate host until hosting off the Brigalow is established and control other than for severe competition may slow establishment. Irrigation is to be carried out twice a week delivering approximately 16 litre per seedling each time. Following establishment, weed control and irrigation scheduling will be reviewed as seedling growth requires.

Discussion

The Darling Downs occurs in the easterly part of the Southern Brigalow Bioregion of Queensland (Sattler 1999). It is an area of intensive agricultural production, producing both summer and winter cereal crops and cotton. A combination of fertile soils, climate and ideal topography provides an excellent environment for high yields from farming. Many of the farms around the Dalby area have been cleared and farmed for some time. In much of this area, retained remnant strips or clumps of Brigalow / Belah are a feature between paddocks or along boundaries. Brigalow / Belah forests usually occur as very dense stands (Boland *et al* 1984) with a very extensive root system extending well beyond the projected crown cover. Both species are capable of nitrogen fixation. Many of these remnants are relatively narrow in width and particularly in the cropping regions where fertilisers are applied, relatively vigorous. Where cattle or sheep grazing is absent, this remnant vegetation provides an opportunity for the establishment of sandalwood on the

Photo 1. Example of area planted adjacent to Brigalow shadeline, Warra.

Photo: S Swift

Brigalow / Belah remnants.

Selection of this site was based on the abundance of natural sandalwood occurring in the remnant Brigalow / Belah shadelines, lack of grazing and the obvious vigour of the remnant forest. Observations by the property owner of some natural *S. lanceolatum* regrowth suggest that growth within the shadelines is relatively rapid. Some larger regrowth sandalwood occurs as isolated individuals near this site however their age is unknown. Both Brigalow and Belah are nitrogen fixing tree species and are thus potentially able to offer better nutrition to a parasitic plant. Much of the sandalwood occurring within the remnant shadelines appears to be hosting off the more abundant Brigalow.

Given the combination of factors including soil fertility, nitrogen fixing host species and irrigation availability, the potential for hosting sandalwood off the remnant vegetation type on this site is high. However, the performance of these sandalwood species on this site remains to be tested. All four species are naturally found and planted in tropical climates rather than subtropical and the incidence of frost may prove a problem. Poor seedling health at planting may also prove a barrier to successful establishment. If successful however, the potential for use of remnant vegetation on farms as hosts, such as the Brigalow / Belah shadelines, in combination with high quality sandalwood seedlots may prove a viable alternative income source for farmers.

Photo 2. Example of sandalwood stock planted, Warra, November, 1999.

Photo: S Swift

Acknowledgments

Acknowledgment and thanks go to Jeff Bidstrup and family of Warra for providing the site for this trial as well as assistance and enthusiasm for the establishment and ongoing maintenance.

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Articles on a range of Santalum species research and management issues are welcomed by the Sandalwood Research Newsletter (SRN). If you wish to contribute an article to the SRN or wish to be included on the SRN mailing list, please write to the Editor stating your name, organisation and postal address.

Editor: *Ms Tanya Vernes*
Department of Conservation and Land Management
Post Office Box 942
KUNUNURRA WA 6743

Telephone: *+ 61 8 9168 4200*
Facsimile: *+ 61 8 9168 2179*
Email: *tarnyav@calm.wa.gov.au*

The Sandalwood Research Newsletter is produced by the Department of Conservation and Land Management, Western Australia.

Editor: Tanya Vernes *Typesetting and Publishing: Shani Owens*