Table 2 (continued)

Sample No.	Planted (P) Natural Regen. (NR)	Tree height (m)	Age (years)	Location	Core height (m)	Core length (cm)	% of Heart-wood core length	Oil composition % of total oil α-santalol	β-santalol
(c) *S. yasi*—Fiji[@] (continued)									
W1	P	?	C.25	Western Vitu Levu	0.5	17.4	43	47.6	24.6
W9A	P	8	16	Western Vitu Levu	0.1	16.3	45	44.9	21.4
W9B					1.0	8.7	Trace?	-	-
W10	P	8	16	Western Vitu Levu	0.1	18.8	7	50.4	21.6
W11				Western Vitu Levu	0.1	-	<2	49.1	28.8
W11A					1.3	7.2	0	-	-
B2	P	6	C.20	Bua, Western Vitu Levu	0.1	18.5	32	56.8	24.4
B6	P	6	15	Bua, Western Vitu Levu	0.2	17.4	<1	50.1	34.0
B7	P	8	15	Bua, Western Vitu Levu	0.2	12.6	19	43.5	25.9
B8	P	8	<20	Bua, Western Vitu Levu	0.2	25.1	92	35.1	14.8
(d) *S. yasi*—Tonga									
T1A	NR	8	C.20	Hafu, 'Eua	0.2	25.0	80	50.0	27.0
T5A	NR	6	C.20	Hafu, 'Eua	0.3	12.0	56	35.4	28.6
T6A	NR	10	C.20	Hafu, 'Eua	0.3	11.5	37	48.9	27.1
(e) *S. yasi*—mature trees Niue									
N1	P	x	>20	Malakava	base	x	x	43.1	26.6
N2	P	x	>20	Malakava	base	x	x	39.1	29.8

* Seven trees sampled at 0.1m (core length average of 10.2cm) and aged 10 years had no detectable heartwood. A further three trees assumed to be older from larger core lengths (average 19.1cm) also gave no oil.
[#]Two hybrids sampled at 0.1m – 0.2m (core length average of 14.8cm) and aged c.5-7 years at Nadera gave no detectable heartwood. Similarly, three, 7-year-old hybrids at Rotuma gave no heartwood oil.
[@]A further four trees sampled at 0.1m – 0.2m (core length average of 13.7cm) and aged c.10 – 21 years gave no detectable heartwood.

Indian Sandalwood: Genetic and oil diversity and biochemistry of the Australian germplasm collection

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The University of Western Australia (UWA), supported by the Forest Products Commission of Western Australia (FPC) have commenced work on the genetic diversity and oil biochemistry of *Santalum album* L. This is an ARC-Linkage project (LP 0454919) between UWA and the FPC, with molecular genetics assistance from the WA Department of Conservation and Land Management (CALM) Science division. It is being undertaken by PhD student Chris Jones, under the supervision of Dr Julie Plummer (Plant Biology, UWA), Dr Emilio Ghisalberti (Chemistry, UWA), Dr Margaret Byrne (CALM Science) and Dr Liz Barbour (FPC).

The project consists of three main components. The first component is to determine the degree of genetic diversity and species relatedness within *Santalum album*, and two other closely related species; *S. austrocaledonicum* and *S. macgregorii*. It is hoped that other researchers in the field may provide additional data which will help piece together the fascinating phylogeny of *Santalum*. At this stage, restriction enzyme digests have been performed on sandalwood DNA, and hybridisation studies using previously determined *S. spicatum* probes (Byrne *et al.* 2003) have started.

Secondly, the essential oil composition of *S. album* growing in the Ord River Irrigation Area will be examined. It has been suggested that specific 'chemotypes' of *Santalum* exist (Butaud *et al.* 2003) and may well apply to *S. album*. This will be correlated to genotypes determined in the first part of the study. Some 100 wood cores have been taken from live trees, and it is hoped that the identification of 'superior' oil producing trees is in agreement with the genetic results.

The third component of the project seeks to determine the biosynthetic pathway of essential oils in the heartwood of *S. album* and their mechanism of production. While the biosynthesis of sesquiterpenes in many plant species is well known (Cane 1990), it has only been assumed that a similar process is occurring in sandalwood (Adams *et al.* 1975; Parker *et al.* 1967). The lack of research into this aspect of sandalwood is probably due to the inherent difficulty of the location of biosynthesis; i.e. deep in the heartwood. In order to determine the pathway, a few approaches may be taken. One may take wood cores from live trees, and extract functional enzymes from the transitional zone between heartwood and sapwood (Hauch and Magel 1998). Isotopic labelling would confirm the origins of sesquiterpene metabolism. Alternatively, cell cultures of sandalwood can be used to determine metabolic pathways, or even extract and purify enzyme fractions from this tissue. This has been used in determining the biosynthetic origins of the terpenoid phytoalexin thujaplicin in the gymnosperm *Cupressus lucitanica* (Yamaguchi *et al.* 1997). Recently, much of the work on sesquiterpene biosynthesis has utilised primary structure similarity of key enzymes known as sesquiterpene synthases, or cyclases (Back and Chappell 1995; Liu *et al.* 2002; Schnee *et al.* 2002). It is anticipated that all three methods will be employed to determine both the biosynthetic pathway to the essential oils of sandalwood and to identify the key enzymes responsible. This will help in our understanding of why the sandalwoods produce essential oils, and whether it can be induced or selected for.

The research is to be published in peer-reviewed scientific journals and is expected to continue until 2007.

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