Santalum spicatum (R.Br.) DC.

Santalaceae

LOCAL NAMES
English (western Australian sandalwood,spike sandal,sandalwood,fragrant sandalwood)

BOTANIC DESCRIPTION
Santalum spicatum is typically an erect small tree or shrub, 3-8 m tall and 0.1 -0.3 m diameter. The tree crown is greyish in appearance and rather umbrageous. The bark is rough, fibrous and furrowed on the lower parts of the tree but the upper limbs are grey or blue and smooth.

Cotyledon leaves linear, about 1.3 x 0.2 cm, blunt ended. In seedlings, leaves opposite to sub opposite, shortly petiolate, lanceolate, to 3 x 1 cm, with a small bulbous portion near the stem base. In the adult the leaves assume an erect position and are oppositely placed, 3-6 x 1-2 cm, dull grey- green, coriaceous. Petioles to 0.5 cm. The leaves in the crown are somewhat sparse.

Flowers, small, bisexual, green-red colored. Each flower is subtended by a small caducous bract. Perianth in four fleshy segments each bearing a tuft of hairs behind the stamens. Anthers 2-celled, filaments short and incurved. Ovary inferior with a short bilobed stigma, torus short turbinate, almost entirely adnate to the ovary. Style with 2-3 stigmas, with 4 tepals, but sometimes 5 or 6. Stamens attached near the base of each tepal.

Fruits are short peduncled drupes 2 cm in diameter, orange-red when ripe. The perianth and disc persist until the fruit is nearly ripe. The fruit exocarp leathery and endocarp smooth surfaced.

The genus Santalum contains approximately 25 species, the generic name Santalum is derived from the Greek santalon (taken from the Arabic word for sandal). The specific epithet spicatum, is from the Latin spica, in allusion to the spike-like form of the leaves or inflorescence.

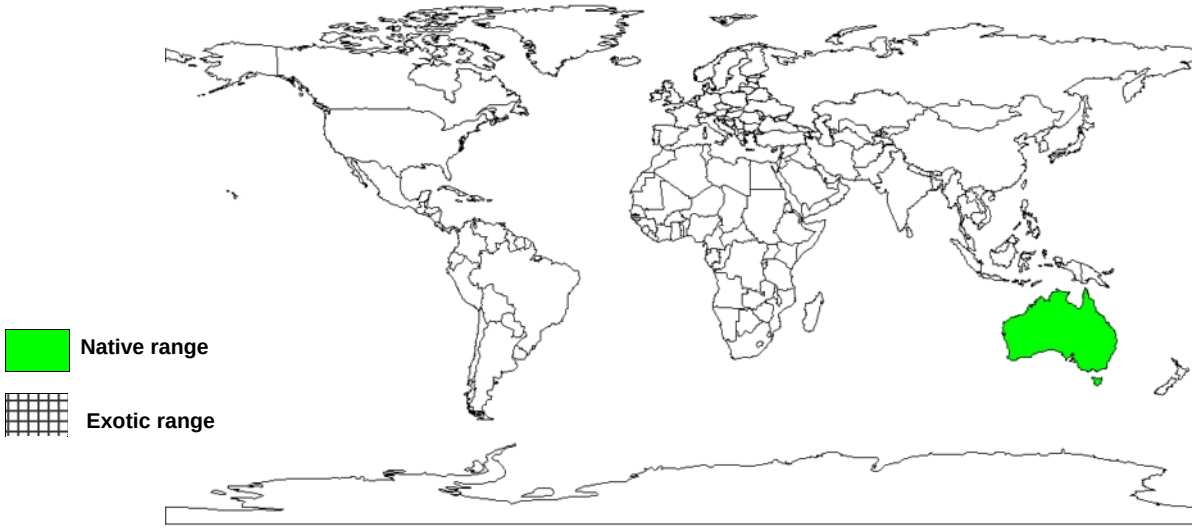
BIOLOGY
The sandalwood is a hermaphroditic species. Flowering is sporadic because of the irregular rainfall in most areas where S. spicatum grows. Flowers are carrion-scented and nectariferous, attracting a wide range of insect pollinators. Fruits ripen from June-December. Polyembryony is reported for the first time in S. spicatum (from western Australia). Results from preliminary investigations into genetic diversity within S. spicatum in western Australia indicate genetic distance between S. spicatum ecotypes increases linearly with geographic distance.

ECOLOGY
Sandalwood distribution is mainly in the warm semi-arid climatic zone having low rainfall for most of the year. The species occurs in a wide range of forest types from woodland to low open-woodlands. Sandalwood trees are a root parasite on many species. Some common recognized hosts are Eucalyptus salubris, Eucalyptus loxophleba, Casuarina cristata subsp. pauper, Acacia aneura, Atriplex vesicaria, Pittosporum phillyreoides, Acacia acuminata, Senna siamea and Pongamia pinnata.

BIOPHYSICAL LIMITS
Altitude: 0-500 m
Mean annual temperature: 18 deg C
Mean annual rainfall: 150- 500 m
Soil type: Sandalwood grows on a variety of soils from calcareous red earths to red earthy sands in Western Australia to solonized brown soils and shallow calcareous loamy soils in South Australia. These soils should however be well drained.

DOCUMENTED SPECIES DISTRIBUTION

Native: Australia
Exotic:



The map above shows countries where the species has been planted. It does neither suggest that the species can be planted in every ecological zone within that country, nor that the species can not be planted in other countries than those depicted. Since some tree species are invasive, you need to follow biosafety procedures that apply to your planting site.

PRODUCTS
Food: The fruits and pods are gathered from the wild and eaten as food. Seed kernels of sandalwood may be eaten and have formed a valuable part of the traditional Aboriginal Australian diet. The kernels are very rich in a fixed oil (ca. 45-55%) and this oil is characterized by a high percentage of unusual acetylenic fatty acids. The seed cake contains approximately 50% crude protein and is potentially a nutritionally rich food item.

Fodder: The shoots are eaten by livestock.

Fuel: The wood is an excellent fuel and has been used for firing brick kilns.

Timber: S. spicatum produces dark brown heartwood surrounded by pale coloured sapwood.
Sandalwood is used for a variety of purposes. In powdered form it is used for the manufacture of joss sticks. The wood is used for carvings and the production of napkin rings, small boxes and fans.

Lipids: Seed lipids of the western Australian sandalwood contain about 49% oleic acid and about 40% ximenynic acid. The oil consists of three major triglycerides: triximenynoyl-glycerol (triximenynin), an oleoyl-diximenynoyl-glycerol, and a dioleoyl-ximenynoyl-glycerol.

Essential oil: An aromatic oil can be distilled, mainly from the tree butts and roots, the oil is used as a fixative for perfumes and in high quality soaps. Steam distillation, yields 5 sesquiterpene alcohols, epi-alpha-bisabolol, (Z)-alpha-santalol, 2(E),6(E)-farnesol, (Z)-beta-santalol and (Z)-nuciferol. The percentage of epi-alpha-bisabolol increases with increasing height up the tree and even the volatile fraction of a dead branch contained. Two santalols,(Z)-beta-santalol and (Z)-nuciferol, were highest in the buttwood.

Other products: The oils are incorporated into high quality soaps.

SERVICES
Soil improver: The ground under the canopy of this tree is usually littered with seeds and leaves these on decay replenish soil nutrients.

Intercropping: Because of its deep rooting habit, this tree could offer shade or support services yet compete minimally with other crop. However caution should be taken on account of its parasitic attributes.

Other services: This shrub is a hemi-parasite on a number of host plants. Like other angiosperm parasites K uptake in preference to Ca is high in sandalwood.

TREE MANAGEMENT
Though a light demanding species, the tree tolerates shade and soil salinity but is susceptible to frost, fire and grazing damage. Provided that areas can be protected from grazing, successful regeneration can be enhanced. The estimated maturation time for the sandalwood in Kalgoorlie District, Australia is 50- 100 years. Establishment of S. spicatum on an operational and plantation scale can be achieved by sowing 4 seeds per spot in well drained sites, 50-70 mm below the soil and mulching in a small depression at the drip line of the south side of a suitable host plant.

Sandalwood is harvested by uprooting trees from the ground by means of horse, camel power or heavy-duty vehicle. In the past the bark and sapwood were removed by adze and discarded but at present only the bark and the sapwood is removed. The roots, stems and large branches are all utilized down to 2.5 cm diameter, dead sandalwood stems are also used.

Results show that growing seedlings rely heavily on their mineral seed reserves for about a year. Seed reserves and root intake are not sufficient to reverse a decline in mineral concentration as the seedling develops its shoots and root systems. Haustorial connections must be made not later than the time of minimum concentration. Ammonium sulphate at 779 kg/ha (especially in combination with an Acacia host), sodium phosphate at 571 kg/ha or a combination of these fertilizers appeared promising treatments for young S. spicatum. 90 days of Osmocote (hoof and horn or blood and bone meal) application at 50 kg/ha was also beneficial but superphosphate was not. Osmocote can be regarded as the most beneficial fertilizer. Increase in root dry weight was greatest with its application.
Increased Ca levels stimulate seedling growth, while lack of Ca and N is soon lethal. Uptake of Ca, N and Sodium obviously occurs via the plants' own root system, and any treatment which increases root growth may encourage early uptake of these limiting minerals.

GERMPLASM MANAGEMENT
Mechanical scarification improves germination. The seed germinates after extremes in temperature and rainfall. Field studies indicate that only 1-5% of S. spicatum seeds germinate. The rate of germination is higher in reserves and protected research and plantation areas, but is still less than 20%. S. spicatum seedlings tend to die if their roots fail to attach to suitable hosts. The deaths therefore may be due to the inability to obtain some type of element for which the host is essential or the inability to take up sufficient nutrients to maintain growth. Mixtures containing fertilizers exhibited increased height. The continued growth of the seedlings depends on attachment to a suitable host.

PESTS AND DISEASES
'Benlate' treatment, as a Benlate/water paste applied by the 'girdling' method, was successful in controlling mycoplasmal diseases of sandalwood tree. The etiology of the disease is unclear but the disease is linked with mycoplasma. A viral infection associated with the disease is likely a result of infection via the sap.

FURTHER READNG

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SUGGESTED CITATION

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