

Sandal (*Santalum album* Linn.)

Knowing the Species

Sandalwood is the fragrant heartwood of species of genus *Santalum* (family –Santalaceae). In India, the genus is represented by *Santalum album* Linn. Its wood, known commercially as “East Indian Sandalwood” and essential oil from it as “East Indian Sandalwood Oil” are among the oldest known perfumery materials.

The word sandal has been derived from Chandana (Sanskrit) and Chandan (Persian). It is called Safed Chandan in Hindi, Srigandha, Gandha in Kannada, Sandanam in Tamil, Chandanamu in Telugu. Historical review reveals that sandalwood has been referred to in Indian mythology, folklore and ancient scriptures. It is generally accepted that sandal is indigenous to peninsular India as its history of recorded occurrence dates back to at least 2500 years

Distribution and Natural Habitat

The sandal family is distributed between 30°N and 40°S from Indonesia in the West to Juan Fernandez Island in the north to New Zealand in the South.

In India *Santalum album* is found all over the country, with over 90% of the area in Karnataka and Tamil Nadu covering 8300 sq. kms. In Karnataka, it grows naturally in the southern as well as western parts over an area of 5000 sq. kms. In Tamil Nadu, it is distributed over an area of 3000 sq. kms. and dense population exists in North Arcot (Javadis and Yelagri hills) and Chitteri hills. The other states where sandal trees are found are Andhra Pradesh, Kerala, Maharashtra, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh, Bihar and Manipur.

The tree flourishes well from sea level up to 1800 m altitude in different types of soil like sandy, clayey red soils, lateritic, loamy and even in black cotton soils. Trees growing on stony or gravelly soils are known to have more highly scented wood. It grows best where there is moderate rainfall of 600 to 1600 mm. It grows well in early stages under partial shade but at the middle and later stages shows intolerance to heavy overhead shade.

Morphology and Phenology

S. album is a small evergreen tree, a partial root parasite, attaining a height of 12 to 13 meters and girth of 1 to 2.4 meters with slender drooping as well as erect branching. Leaves are opposite and decussate, and sometimes show whorled arrangement. Flowers are purplish brown, unscented and are borne in axillary or terminal cymose panicles. Flowers are tetra or pentamerous. The ovary is semi inferior and unilocular. The tree starts flowering at an early age of 2 to 3 years. Generally, trees flower twice a year from March to May, and September to December. Some times the two flushes of flower production may overlap each other so

that the same tree may show all stages of development of flower initiation to mature fruits at one time. Fruit is a drupe, purplish when fully matured and single seeded. Seeds are naked, lack testa and are dried and stored in polybags or gunny bags.

Seed and Nursery Techniques

It is desirable to obtain seed from known superior populations. Good seed sources in natural stands have been identified at Chitteri, Dharmapuri District (Tamil Nadu); and Yedehalli in Shimoga District and Royalpad of Kolar District (Karnataka), and Marayoor (Kerala).

Sandal fruits are collected fresh from the tree or as soon as they have fallen on the ground during April-May and September-October. They are soaked in water and rubbed to remove the soft pulp. The wet seeds are dried under shade and dry seeds stored in polythene or gunny bags. About 6,000 seeds weigh to a kilogram. Fresh seeds take 4 to 12 weeks to germinate after dormancy period. Eighty percent of seeds are viable upto 9 months. Germination is about 80 percent under laboratory conditions and 60 percent under field conditions. Germination can be hastened by soaking seeds in 0.05% gibberellic acid over night and then sowing, which ensures uniform germination. Soaking seeds in cowdung slurry will not improve germination.

- **Nursery Techniques**

Two types of seed beds are used to raise sandal seedlings: sunken and raised beds. Both of them perform equally well under different climatic conditions.

Seed beds are formed with only sand and red earth in the ratio 3:1 and are thoroughly mixed with nematicides (Ekalux or Thimet at 500 g per bed of 10 m x 1 m). Around 2.5 kg seed is spread uniformly over the bed, covered with straw which should be removed when the leaves start appearing on the seedlings. Sandal suffers from a very virulent disease caused by combined fungal and nematode infection. The initial symptom is that of wilting of leaves followed by suddan chlorosis and root decay. On account of this the mortality rate is very high, which can be controlled by the application of nematicide (Ekalux) and fungicide (Dithane). Seeds beds are to be sprayed with fungicide Dithane Z-78 (0.25%) once in 15 days to avoid fungal attack and 0.02% Ekalux solution once in a month to avoid nematode attack.

When seedlings have reached 4 to 6 leaf stage they are transplanted to polybags along with a seed of tur dal (*Cajanus cajan*), the primary host for better growth of sandal. Seedlings are carefully removed from beds with all roots intact; roots should not be allowed to dry. Shade can be provided for a week immediately after transplantation. Watering is to be done once a day, but excess moisture is to be avoided. Host plants are to be pruned frequently, so that they do not over grow sandal and hamper its growth. Polybags should contain soil mixture of ration 2:1:1 (Sand:Redearth:Farmyard manure). It has been found that polybags of 30 x 14 cm size are the best. To avoid nematode attack Ekalux of 2 gm/polybag or 200 gm for 1m³ of polybag mixture should be thoroughly mixed before filling the bags. Shifting may be done once in two months to avoid root penetrating soil and grading is to be done once in three months. Weeding is to be done at regular intervals.

Plantable seedlings of about 30 cm height can be raised in 6-8 month's time. A well branched seedling with a brown stem is ideal for planting in the field.

Raising Plantations

Regeneration has been obtained successfully by following methods.

- Dibbling of seeds into bushes
- Dibbling of seeds in pits or mounds
- Planting container raised seedlings in the nurseries

Dibbling of Seeds into Bushes

This method is adopted in open scrub jungles with lot of bushes. Seeds are sown during monsoon. An instrument can be made using a bamboo pole of 4 to 6 cm internal diameter and a length of 1.5 m for the purpose of sowing seeds. The septa at the nodes are removed and one end of the pole is sharpened or a hollow metal piece is attached. The pole is introduced at the base of the bush and through the hole 4 to 5 seeds are transferred to the base of the bush. Fairly good success has been achieved by this method.

Dibbling of Seeds in Pits or Mounds

The usual trench mound technique adopted in forest for other species is also adopted for sandal. But here a perennial host plant is also grown along with sandal either on the mound or in the pit.

Planting Container Raised Seedlings in the Nurseries

Pits of 50 cm³ are dug out at an espacement of 3 m x 3 m. Healthy sandal seedlings, preferably above 30 cm in height are planted in the pits. Miscellaneous secondary forest species as host plants are planted in the same pit or they may be planted in separate pits in a quincunx pattern. This method has proved successful in many forest areas. At the time of planting in the field a perennial host, if given, increases the growth of sandal, otherwise it shows stunted growth with pale yellow leaves and ultimately dies in about one year. Sandal has over 150 host plants, some of the good hosts being *Casuarina equisetifolia*, *Acacia nilotica*, *Pongamia pinnata*, *Melia dubia*, *Wrightia tinctoria* and *Cassia siamea*.

Cultural Operations

Soil working to a radius of 50 cm once in 6 months is to be done. The host plant tending to over grow sandal may be pruned, so that sandal gets maximum sun light. Adequate protection against fire and grazing is very necessary. To achieve a clean bole and maximum heartwood in the stem, side branches may be pruned periodically on the lower half of the main stem. The branches should be pruned with a sharp knife close to the stem without leaving a fork which may attract borers.

Vegetative Propagation

Vegetative propagation is done through air layering or through root suckers. Techniques of tissue culture of sandal using different types of tissues like nodal, internodal segments from young shoots, and suspension culture, using different organs have been standardized.

Growth and Yield

Growth and Yield

Though sandal is considered to be a slow growing tree under forest conditions (1 cm girth/year), it can grow at the rate of 5 cm of girth or more per year under favourable soil and moisture conditions. The heartwood formation in sandal starts around ten years of age. So far growth data is available only in respect of natural forest mainly from Javadis in Tamil Nadu and Dharwad areas of Karnataka. The table below gives an idea of growth and development.

Average Heartwood Formation

Age (Years)	Girth at breast height cm	Yield of heartwood in kg.
10	10	1
20	22	4
30	33	10
40	44	20
50	55	30

Utilisation

Heartwood of sandal is moderately hard, heavy, and strongly scented and yellow or brown in colour. Both wood and oil are used in incense, perfumes and medicine and are of great commercial importance. Sandal wood being close grained and amenable to carving, is one of the finest woods for the purpose. It is used in making idols and inlay ivory work. Such work is done on cottage industry scale. The class of people working on sandalwood carving are known as "Gudigars" (in Karnataka). The skill of carvings in this class of people is handed down from one generation to the other. There are many cooperative societies in Sagar and Sorabi in Shimoga districts. The skilled workers are also found in Thanjavoor, Tiruchirapalli and Madurai district of Tamil Nadu. It is reported that in Nagina (District Bijnor, U.P.) sandal wood carving industry was quite prominent about 15 years ago which is now nearly extinct due to non-availability and prohibitive prices of sandalwood. In Karnataka, the Government has taken lot of interest for the improvement of handicraft industries. They are supplying wood to the carvers at about 25% of the original price and the rest is borne by the Industries department so as to encourage and keep alive the skill and craft and also to earn foreign exchange for the country.

Sandal Oil

Powder of heartwood upon steam distillation yields East Indian Sandalwood oil. Light coloured wood generally contains higher percentage of oil than dark coloured. The oil content varies from 3% - 6% Sandal Oil has earned a prominent place in agarbathi (incense stick), cosmetic, fragrance and soap industries. It also finds its use in medicine as antiseptic, antipyretic etc. Its use as a base of fragrance has far outweighed its use in medicine.

Characteristics and Composition of Sandal Oil

Colourless to golden yellow viscous liquid.

Sp.Gr.0.962-0.985

Alcohol content – Santalos > 90%

Refractive index at 20°C = 1.504

Solubility in 70% alcohol 1:5 volumes

Optical rotation 19⁰-20⁰

Acid value – 1.9-2.2

Ester value – 13-16

Ester value after acetylation – 210-215

Ester content 1.6-5.4%

Diseases and Pests

Spike disease is one of the important diseases of sandal. The disease was first noticed in Frazerpet (Coorg, Karnataka) by McCarthy as early as 1899. Disease is caused by mycoplasma-like organisms (MLO). It can occur at any stage of development of the tree. As the disease progresses, the new leaves become smaller, narrower or more pointed and fewer in number with each successive year until the new shoots give an appearance of fine spike. At the advance stage of disease the inter nodal distance on twigs becomes small, haustorial connection between the host and sandal breaks and the plant dies in about 2 to 3 years.

Spread of disease is sporadic and the disease is transmitted in nature by insect vectors. It has been found that other insect vectors in addition to *Nephotettix virescens* may also be responsible for transmission of disease. So far no permanent remedial measures have been prescribed for control of spike disease.

Stem borers *Zeuzera coffeae* Nietn (red borer) *Indarbela quardinatata* Walker (bark-feeding caterpillar) and *Aristobia octofasiculata* Aurivillius (heartwood borer) are some of the pests causing considerable damage to living trees.

Tree Improvement

Genetically superior trees with good heartwood and high content of oil have been selected from southern India. Seventy nine candidate (plus) trees have been identified. These are maintained at the IWST germ plasm bank in Gottipura (Bangalore, Karnataka). Clonal seed orchards of these plus trees are maintained at Nallal and Jarakabande (Bangalore District) and at the Andhra Pradesh Forest Department Research Center, BIOTRIM, at Tirupathi (Andhra

Pradesh). First generation plants raised through these seeds showed promising results. Screening for disease resistance and breeding for high quality of sandal oil and heartwood is underway.

Management, Production and Export

Dead and dry sandal trees including roots up to 2.5 cm diameter are extracted from the forests (the root contains high oil content). After uprooting the tree top and branches which have no heartwood are chopped off and branches having heartwood are flush with the trunk so as to get as clear bole as possible. The trunk, branches and roots are roughly cleaned by chipping off the bark and portion of sapwood. Rough cleaned wood is weighed before giving for final cleaning. Final cleaned wood is separated roughly as (1) Billets (2) Roots (3) Chips and stored in sandal depot or sandal Koti. Driage of 10% is allowed during prolonged storage. The main storage depots in Tamil Nadu are at Tirupathur, Sathyamangalam and Salem, and in Karnataka, at Mysore, Kushalnagar, Hassan, Tarikere, Shimoga and Dharwar. In Andhra Pradesh the wood is stored at Chitoor. Auctions are held in Tamil Nadu generally in the month of July and December each year.

Production and Export

The annual production of sandal wood in Karnataka and Tamil Nadu during the 1989-91 was as follows.

	Karnataka (metric tonnes)	Tamil Nadu (metric tonnes)
1989	800	967
1990	760	648
1991	700	700

Export in the form of sandalwood billets is banned, but in the form of chips, dust, spent powder and carved material and sandal oil, is allowed. During 1989-90 on an average 10-11 tonnes of sandalwood oil have been exported, earning about 30 million rupees as foreign exchange.

Legal Provisions and Rules

Rules vary from state to state regarding possession and storing of sandalwood and products. According to existing legislation, a licence has to be sought to store, sell or possess sandalwood. No licence shall be required for the possession of sandal wood upto 3 kg for domestic bonafide use in Karnataka.

All owners of private land shall file a declaration with the Divisional Forest Officer or any other officer duly authorized by him in Form 12 along with a certificate from Tahsildar regarding the ownership of the land and right over the sandal tree.

The owner of private land from which the sandal trees have been extracted by the Department shall be entitled to get a bonus equivalent to 75% of the net value (gross value of wood, less cost of extraction, transport, cleaning, supervision and other incidental expenses).

For bonafide use persons can purchase sandalwood from sandal koties situated in Mysore, Kushalnagar, Hassan, Tarikere, Shimoga and Dharwar in Karnataka on retail basis. Wood can also be had in small quantity through authorized agencies

Source: Indian Council of Forestry Research and Education, Dehradun. Sandal (*Santalum album Linn.*). Dehradun, Forest Research Institute. 9p.