

Pests and diseases of sandalwood plants in nurseries and their management

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Sandalwood, the highly valued tree of global fame, grows naturally under suitable conditions in different parts of India. Relating to conservation efforts and also to promote sandalwood as a commercial species, many sandal nurseries are maintained in different states of India. Reconnaissance surveys were conducted in the sandalwood growing areas in the states of Karnataka, Tamilnadu, Kerala, Andhra Pradesh, Orissa and Madhya pradesh during 1994–1999 to study the occurrence and distribution of insect pests and diseases of sandalwood plants in the nurseries, plantations and natural forests. Defoliators and sapsuckers were the most devastating pests. An account of the more important ones and their natural enemies is given in this paper. Seedling diseases (damping off and wilt) were found to take a heavy toll (up to 100%) in the nurseries. The causal organisms were identified as *Fusarium oxysporum* and *Phytophthora* spp. and nematodes. Control measures were standardized for pest and disease management in the sandalwood nurseries.

Introduction

Sandalwood *Santalum album* L. (family *Santaleaceae*) is distributed all over India and is a tree of great economic importance because of its fragrant heartwood and oil. Large-scale plantation programs have necessitated a demand for planting stock, for which nurseries have been established in different states. Good quality seeds and grafts of superior clones are used for the production of plants. Sandal wood seedlings and grafted plants face problems from insect pests and diseases, which take a heavy toll and sometimes the whole stock is wiped off.

More than 150 insects are known to occur on *S. album*, but only a few have been recorded as serious and bearing economic importance. These include defoliators, sapsuckers, stem borers and termites. The role of sap sucking pests belonging to the family Coccidae is very deleterious to the normal health, growth and reproduction of sandalwood plants. The adult beetle, *Mylabris pustulata* Thunberg. (Coleoptera: Meloidae) was reported as a general feeder on the floral parts of sandalwood plants. (Sivaramakrishnan 1984). The weevil *Sympiezomias cretaceus* Faust belonging to a polyphagous group was recorded as defoliating several trees of forestry importance including sandalwood seedlings in nurseries (Sivaramakrishnan et al. 1987). Two species of bugs, *Saissetia nigra* Nietner and *S. coffeae* Walker were recorded damaging immature fruits of sandal, which fall off and do not germinate (Sivaramakrishnan et al. 1987). The lac insect, *Kerria lacca* Kerr. has been reported as causing mortality of the plants (Remadevi et al. 1997). *Ceroplastes ceriferus*

Anderson has been observed either singly or in groups on sandalwood trees causing leaf drop, reduction in plant vigor, leading to dieback of plants (Remadevi and Sivaramakrishnan 1997). The coccid, *Inglisia bivalvata* Green was observed to cause dieback of branches and in severe cases, death of saplings and young sandalwood trees (Remadevi and Raja Muthukrishnan 1998). Sandalwood seedling disease has been identified as a serious threat to the raising of sandal wood plants in nurseries (Nayar et al. 1980, Sivaramakrishnan et al. 1984).

A survey of the sandalwood growing areas in the different states helped to delineate the occurrence and distribution of the different insect pests and diseases of sandalwood plants. The paper gives an account of important pests and diseases of sandalwood plants in the nurseries and the methods of their management.

Materials and methods

Reconnaissance surveys were conducted during 1994–1999 under a World Bank aided FREE (Forestry Research Education and Extension) project, in the different sandalwood growing areas, plantations and nurseries in the states of Karnataka, Tamilnadu, Kerala, Andhra Pradesh, Orissa and Madhya Pradesh for recording the incidence of different insect pests and diseases. The different insects and the damaged parts of sandalwood seedlings were collected and brought to the laboratory for identification. Field and laboratory observations on the bio-ecological aspects of the pests and diseases were made. The assumed biocontrol agents of the different pests were collected, identified and preserved. Experiments on the control measures were conducted and standardized in the nurseries at Gottipura, Nallal, Yelawala and the IWSST campus.

Results and discussion

Nursery pests

An account of the important pests encountered in the nurseries in the different states in India are presented in Table 1 and 2.

Defoliators

Sandalwood seedlings in the nursery are subjected mainly to attack by defoliators and sapsuckers. *Cryptothelea cramerii* Westwood (Psychidae: Lepidoptera) cuts off the young seedlings, almost at ground level. A bag is constructed of small pieces, of the seedling stem, and these are placed side by side so as to form a cylindrical bag open at both ends. The sandalwood seedlings ultimately dry up. The weevil *Sympiezomias cretaceus* Faust (Curculionidae: Coleoptera), a polyphagous weevil feeds on the leaves from the edges towards the midrib. Sometimes the distal half of leaves gets cut off as a result of circular holes made in a line by the adult weevils. Feeding occurs at night. During the day adult beetles hide on the under surface of leaves or inside curled leaves or between webbed leaves.

The nymphs and adults of the grasshopper, *Holochlora albida* Kirby (Locustidae: Orthoptera) are green, resembling a leaf. They are well concealed among the young seedlings and they can only be detected when they move. These hoppers usually gnaw on tender shoots of sandalwood seedlings.

Table 1. Name, family and order of defoliators present in nurseries and plant part affected by these insects.

Sl. No.	Name	Family	Order	Plant part affected
1	<i>Sympiezomias cretaceus</i>	Curculionidae	Coleoptera	Leaves
2	<i>Holochlora albida</i>	Locustidae	Orthoptera	Shoots
3	<i>Teratodes monticollis</i>	Acrididae	Orthoptera	Leaves
4	<i>Letana inflata</i>	Tettigonidae	Orthoptera	Leaves
5	<i>Cryptothelea cramerii</i>	Psychidae	Lepidoptera	Shoots & leaves
6	<i>Acanthopsyche moorei</i>	Psychidae	Lepidoptera	Leaves
7	<i>Pteroma plagiophleps</i>	Psychidae	Lepidoptera	Leaves

The nymphs and adults of the grasshopper, *Letana inflata* Brunner are slender and resemble the stem of sandalwood seedlings. They feed voraciously on the foliage. The eggs are laid in longitudinal slits in succulent sandalwood seedling stems and the slit swells and cracks laterally, damaging the seedlings.

The nymphs and adults of the grasshopper, *Teratodes monticollis* Gray (Acrididae: Orthoptera) are dull green, brighter under the wings. The pronotum is produced into a sharp hood over the body, giving it a striking appearance. Its green color and appearance camouflages well with the sandalwood seedlings. They have been observed as a serious defoliator of sandalwood seedlings.

The bagworm, *Acanthopsyche moorei* Heyl (Psychidae: Lepidoptera) carries its bag upright at right angles to the stem or leaf of the seedling, but in the later instars the bag is heavy and is carried in a pendant position. The black caterpillar was seen defoliating the sandalwood seedlings giving a burnt appearance to the leaves.

The attack of bagworm, *Pteroma plagiophleps* Hampson (Psychidae: Lepidoptera) results in total defoliation and drying up of sandalwood seedlings. Defoliation by these bagworms also impart a burnt appearance to leaves.

Sapsuckers

About 50 species of sap sucking insects were recorded on *Santalum album* by Mathur and Singh (1960–61). Out of this, only a few are considered injurious to the sandalwood seedlings (Remadevi et al. 1998). New coccid species on sandalwood seedlings were also recorded during the present survey. Most of the coccids attack both sandalwood seedlings and trees. Use of sandalwood twigs for grafting purposes, when affected by coccids, has led to the failure of grafted plants. As the coccids produce honeydew, badly infested plants get completely covered by sooty molds, which reduce photosynthesis the vigor of sandalwood seedlings.

Two species of coccids, *Saissetia coffeae* and *S. nigra* were first recorded in Coimbatore on Sandal (Ayyar 1929). The adult female of *S. coffeae* Targioni-Tozzetti is elliptical in outline, convex, brown and shinny. *S. nigra* Nietner females are black and larger. The nymphs move and settle on the under part of the sandalwood plant. These scales feed on the sap of leaves and tender shoots of sandalwood seedlings, causing die back. The coccid, *Aspidiotus* sp. was observed as a minor pest causing wilting and yellowing of the leaves of nursery plants.

Table 2. Name, family and order of sapsuckers present in nurseries and plant part affected by these insects.

Sl No.	Name	Family	Order	Plant part affected
1	<i>Saissetia nigra</i>	Coccidae	Hemiptera	Shoots and leaves
2	<i>Saissetia coffeae</i>	Coccidae	Hemiptera	Shoots and leaves
3	<i>Pulvinaria psidii</i>	Coccidae	Hemiptera	Shoots and leaves
4	<i>Pulvinaria maxima</i>	Coccidae	Hemiptera	Shoots and leaves
5	<i>Ceroplastes actiniformis</i>	Coccidae	Hemiptera	Shoots and leaves
6	<i>Inglisia bivalvata</i>	Coccidae	Hemiptera	Shoots
7	<i>Tachardina lacca</i>	Coccidae	Hemiptera	Shoots
8	<i>Aspidiotus</i> sp.	Coccidae	Hemiptera	Leaves

The coccid, *Pulvinaria psidii* Mask is a common and destructive polyphagous insect in many sandalwood nurseries. The coccid, *P. maxima* Green is a new record on Sandalwood seedlings and is found very common on Neem. Sometimes it is considered to cause considerable damage to young sandalwood trees. The leathery pale brown adult females cover the tender shoots and stems in numbers and the white male scales are generally found conspicuously on the sandalwood leaves. The ovisacs are prominent and comparatively very long. The infestations leads to premature fall off of the leaves.

The coccid, *Ceroplastes actiniformis* Green has a thick pale white or pink waxy spherical test and the marginal area is divided into eight portions, which enclose a central cone area. Being sapsuckers, they cause severe sap drainage and sooty mold formation on the leaves below. The sap drainage leads to die back and ultimate death of sandalwood seedlings in nurseries. Spraying with monocrotophos (0.02–0.05%) kills this coccid.

The lac insect, *Tachardina lacca* Kerr. was observed on nursery plants and seedlings along with severe attack on trees. Quinalphos (Ekalux 20 AF) 0.5% or Dimethoate 0.2% mixed with 0.05% sticker was sprayed for effecting the control.

Feeding of sap by the coccid, *Inglisia bivalvata* Green caused browning of the leaves and withering. When the attack was severe, saplings succumb to the infestation. These scale insects are attached to twigs. Female scales look like bivalved shells. While adult males are winged, females are wingless and sedentary. Nymphs move out from underneath the scales of females and settle on tender branches to suck the sap. This insect occurs throughout the year. Parasites and predators help in the biological control of this pest. Spraying of 0.2–0.3% Chlorpyrifos or Quinalphos was effectively controlled this pest. The natural enemy complex of the different coccids was also studied. Parasitism varied from 4–10 % in the different coccids. We found the parasites in the coccids: *Ceroplastes actiniformis* Green, *I. bivalvata*, *T. lacca*, *Aspidiotus* sp. and *Saissetia* sp. (Table 3).

Table 3. Name and family of parasites found in the coccids *Ceroplastes actiniformis*, *Inglisia bivalvata*, *Tachardina lacca*, *Aspidiotus* sp. and *Saissetia* sp.

Host	Name of the parasite	Name of family
<i>Ceroplastes actiniformis</i>	<i>Signiphora</i> sp. nov.	Signiphoridae
	<i>Coccophagus cowperi</i> Girault	Aphelinidae
	<i>Coccophagus ceroplastae</i> (Howard)	Aphelinidae
	<i>Metaphycus</i> sp. nov.	Encyrtidae
	<i>Bothriophryne pulvinariae</i> Agarwal	Encyrtidae
	<i>Encyrtus aurantii</i> (Geoffroy)	Encyrtidae
	<i>Cheiloneurus basiri</i> Hayat	Encyrtidae
	<i>Cephaleta anupama</i> Narendr. & Mini	Pteromalidae
	<i>Aprostocetus</i> sp. A.	Eulophidae
	<i>Scutellista caerulea</i> (Fonscolombe)	Pteromelidae
<i>Inglisia bivalvata</i>	<i>Anicetus</i> sp. nov. <i>inglisiae</i>	Encyrtidae
	<i>Philosindia</i> sp. nov. <i>inglisiae</i>	Encyrtidae
	<i>Microterys</i> sp. nov.	Encyrtidae
	<i>Coccophagus bivittatus</i> Compere	Aphelinidae
	<i>Marietta leopardina</i> Motschulsky	Aphelinidae
	<i>Aphanogmus</i> sp.	Ceraphronidae
	<i>Aprostocetus</i> sp. B.	Eulophidae
	<i>Philosindia</i> sp.	Encyrtidae
	<i>Coccobius</i> sp.	Aphelinidae
	<i>Anagyrus mirzai</i> Agarwal & Alam	Encyrtidae
<i>Anicetus</i> sp. nov. <i>inglisiae</i>	Encyrtidae	
<i>Tachardina lacca</i>	<i>Ooencyrtus</i> sp. nov. <i>kerriae</i>	Encyrtidae
	<i>Aprostocetus</i> sp.	Eucyrtidae
<i>Aspidiotus</i> sp.	<i>Thomsonisca pakistanensis</i> (Ahmad)	Encyrtidae
	<i>Aphytis</i> sp.	Aphelinidae
<i>Saissetia</i> sp.	<i>Philosindia</i> sp. nov. <i>inglisiae</i>	Encyrtidae

Based on our studies on pests of sandal, chemical control measures have been standardized which are presented in Table 4.

Table 4. Control of different sapsuckers on sandal.

Insect pests	Prevention/control measures
<i>Ceroplastes ceriferus</i>	Spraying of Monocrotophos (0.02–0.05%)
<i>Saissetia</i> sp.	Spraying 0.5% Quinalphos
<i>Inglisia bivalvata</i>	Spraying 0.2–0.3% Chlorpyrifos or Quinalphos
<i>Tachardina lacca</i>	0.5% Quinalphos (Ekalux 20 AF) along with 0.05% sticker sprayed thoroughly on the affected parts. Initial stages can be controlled by spraying 0.1% Rogor or 0.04% Cypermethrin.

Nursery diseases

Damping off and seedling wilt were the most serious diseases recorded during the survey in different states. High incidence of disease was recorded in Karnataka and Tamilnadu destroying the entire nursery stock during damp seasons. Mortality in seedlings was recorded in all three stages during their growth- due to pre-emergence blight, post-emergence mortality, root rot and wilting of older seedlings.

The diseases are caused by a several fungi and nematodes. Species of *Fusarium*, *Rhizoctonia*, *Phytophthora* and *Pythium* were found most commonly in infected seedlings. *Fusarium oxysporum* Schlecht. was common and the most virulent fungus found in all infected sandal seedlings affected by pre-emergence blight and vascular wilt. In vascular wilt, nematodes attacked seedlings along with *Fusarium* causing serious problems to seedlings. The fungus spreads rapidly in the tissues and the seedlings either wilt completely or rot off at ground line. Fungus attack on succulent root tips in older seedlings and transplants are usually not fatal. If soil moisture is favorable, new roots develop and the seedlings continue to live though with less vigor and poorer growth. If such damage is followed by drought or by excess soil moisture, both of which discourage formation of new roots, seedling mortality may eventually occur.

Wilt is a systemic disease in sandal wood seedlings, where the entire individual or its parts exhibit wilting of the foliage in acropetal succession up to the shoot. The leaves become yellow, lose turgidity and fall off. The affected plant or the branch soon dies. Dwarfing, stunting and necrosis was also a common symptom found in seedlings. In all cases translocation of water and nutrients was adversely affected. Characteristic symptoms of vascular discoloration in the outer layers of the seedlings were evident.

F. oxysporum isolates from the infected seedlings were grown on slants of PDA and inoculated to the seedlings raised in sterile soil under controlled conditions. Wilt symptom and chlorosis developed 7–10 days after fungus inoculation. With the onset of symptoms, plants were treated with different doses of fungicide and further disease manifestation was controlled.

To formulate a package of practices for the raising healthy seedlings in nurseries, experiments were conducted with different treatments. Sandalwood seedlings were grown with well drained sterilized and non-sterilized soil; pre-treatment of seeds with copper fungicide and without treatment; controlled watering and excess of watering, soil application of nematicides and no application. Based on the different experiments, which were closely monitored, control measures were standardized and are given in Table 5.

Table 5. Control of different type fungal diseases.

Type of disease	Casual organisms	Control measures
Fungus attack on seeds	<i>Fusarium</i> , <i>Alternaria</i> , <i>Aspergillus</i>	Store the de-pulped and dried sandal seeds with organomercuric compound (Cerasan/Agallol) dressing.
Seedling disease	<i>Fusarium</i> or	Selection of seeds, which are free of fungi, seed dressing with organomercuric compound.
1. Pre-emergence rot	<i>Phytophthora</i> or	Controlled watering, good drainage in containers.
2. Damping off	<i>Rhizopus</i> spp.	
3. Fusarium wilt	<i>Fusarium</i> or <i>Phytophthora</i> species followed by nematodes	Drench the potting medium with copper fungicide and nematicide (Blitox/Bordeaux mixture and Quinalphos or Phorate). Controlled watering of plants.

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