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Sandal spike disease (SSD)

A major threat to Indian sandalwood

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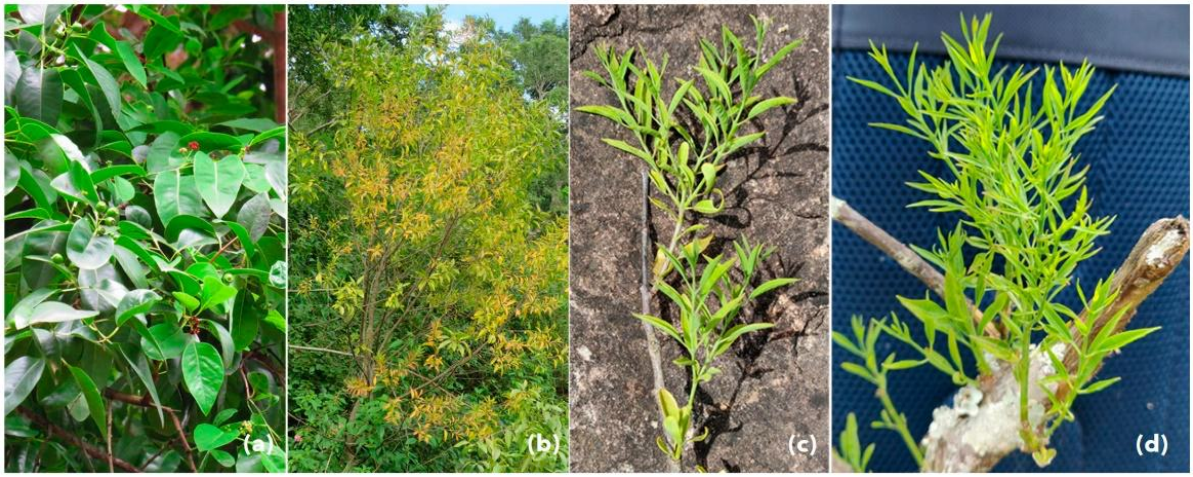
Introduction

Indian sandalwood (*Santalum album. L*) a highly valuable hardwood species of the santalacae is popular for its fragrant wood and essential oil and has importance in traditional a pharmaceutical medicine, as well as in the cosmetics and perfumery industries. Therefore, sustainable cultivation methods are required for the large scale propagation and production of disease free *s.album* plants. This disease was first reported from Coorg district of Karnataka state in 1899 (Mc Carthy 1900 & Barber, 1903). It has now spread to the entire southern part of Karnataka as well as to the border areas of the neighbouring states. This disease has become very serious and is threatening the sandal industry. It was earlier thought to be caused by grafting transmission (Coleman ,1917) and an insect –borne virus. The tree is a semi-root parasite, grows in the forests of southern Karnataka and northern Tamil Nadu. A recurring annual loss of Rs.194 million has been reported.

Symptoms

The major symptoms of SSD are chlorosis of leaves, a reduction in leaf lamina size, the stems become stiffy and shortened internodes in stem which leads to “bushy” appearance and finally they acquire a spike-like appearance (Barber 1903; Hole 1917).

The trees of all ages get infected. Sandal spike is of two types, rosette and pendular type. Rosette is more common and commonly referred to as spike or spike disease. The disease is characterized by an extensive reduction in the size and the internodes the whole shoot look likes spike bearing four rows of spiked bristles. Spiked plants do not bear flowers or fruits (Balasundaran & Muralidharan, 2004). Only occasionally phylloid or abortive flower are produced. Diseased tree display virescence. Disease also affects fine roots and cause their disconnection from the roots of the host plants causing death of trees. Pendulous spike is less common. Due to elongation of infected shoots disproportionate to their thickness they droop. Rosette symptoms are absent in these branches. In this case, the roots ends and haustoria do not die. Due to SSD, *S. album* populations in Kerala and Karnataka forests of India became considerably decreased (Arunkumar *et al.*, 2016).



*Healthy sandalwood tree bearing levees, inflorescence, and fruits (**a**) and phytoplasma infected sandalwood (Santalum album L.) tree showing typical symptoms of shoot spike, little leaf, and discoloration of leaves (**b**); sandalwood branches and twigs showing typical symptoms of SSD (**c**,**d**) (Arunkumar et al., 2016).*

Aetiology

In earlier years spike disease was suspected to be physiological disorder caused by unbranched circulation brought about by adverse factors such as forest fires, a fungal disease and also caused by some ultramicroscopic bacteria. In 1969 the viral theory of sandal spike was disproved by three group of workers who demonstrated mycoplasma – like bodies or organisms (MLBs or MLOs) in the phloem tissues of the diseased plants. These bodies are mostly 40 to 750nm in diameter, ovoid to ellipsoidal in shape. Typically, they are devoid cell walls and the cytoplasm is bound by unit membranes 10-12nm thick. The organism contains a fibrillar network of DNA and ribosomal bodies. Dijkstra and Ie (1969) observed the presence of mycoplasma in the phloem sap of infected *S. album* trees, with Hull *et al*. (1969) and Verma *et al*. (1969) independently confirming the causal agent to be a mycoplasma. Mycoplasmas are now referred as phytoplasmas, i.e., prokaryotes lacking cell walls, infecting a wide range of plant taxa (Marcone 2015).

Physiological changes in SSD infected trees

In diseased plants there is accumulation of starch in branches and leaves. Coleman (1923) further showed that spiked plants contain lower amounts of calcium and have a higher total ash content and nitrogen content in contrast to healthy plants. The ratio of calcium to nitrogen can be used as a diagnostic character to see if the plants are infected or not. spiked plants show lower iron content.

Disease transmission

The disease is transmitted through root contact and insects (leaf hoppers –*Nephotettix virescens*). The MLOs infect a large number collateral host such as *Eucalyptus grandis*, vinca *rosea, zizyphus oenoplea, and Dodonia viscosa.* The diseases can be transferred from *vinca rosea* to sandal and vice versa through dodder. *Lantana camara* renders the trees susceptible to the disease and may be acting as a pathogen reservoir.

SSD management

There is no effective method of controlling the SSD is known. Nayar (1980) reviewed various methods such as the use of heat therapy and chemical treatment using arsenic, benlate, or tetracyclines to control SSD, the latter having the most positive effect on SSD control. In the past attempts have been made to cure the trees by raising the temperatures above 38 ^{O}C by

building fires in trenches around affected trees but it was neither successful nor practicable.

Different host plants of sandal impart resistance or susceptibility to the disease in sandal. Among the host plants through which sandal acquires resistance are Neem, Bamboo, *Cassia*, *casuarina*, fig, curry tree etc. and susceptible to the species of *Acacia*, Red gram, *Lantana camara* etc.

Spraying of Tetracycline is slightly effective but application for larger area is practically impossible and uneconomic. The systemic fungicides Benlate has been reported to bring about temporary remission of symptoms. Application of antibiotics such as terramycin alone or combine with Benlate and another method is Ledermycin alone or combine with Benlate.

Conclusion

Indian sandalwood is used for producing high quality furniture and perfume industries. SSD may cause serious threat to our production quality and quantity. Research on the SSD in future may help us to identify the disease-free seedlings and produce good quality woods.

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