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Sandal Spike Disease — A Vector-Transmitted Tree Disease

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Sandal (*Santalum album* Linn.) is a medium-sized tree growing wild in the States of Karnataka, Tamil Nadu and some parts of Andhra Pradesh and Kerala. Sandal wood is primarily valued for the highly priced sandal oil derived from its heartwood. However, extensive areas bearing sandal are affected by spike disease, caused by MLOs. Symptoms of the disease and the causal organism have been briefly discussed. Like other plant diseases of mycoplasmal etiology, spike disease was proved to be vector transmitted as early as 1934. Insect vectors incriminated so far are *Moonia albimaculata*, *Coelidia indica* and *Nephotettix virescens*. Biology, host-plants and transmission studies of these three insect vectors, have been presented. The population of *N. viresens* is the highest in October–November. It primarily breeds on rice and gramineous weeds. *N. virescens* also causes rice yellow dwarf disease which is a MLO disease.

Key Words: **Sandal, Spike disease, Insect vectors, Biology**

Introduction

Santalum album L. (Sandal) belongs to the family Santalaceae which comprises of thirty genera, the chief ones being *Santalum*, *Osyris*, *Thesium*, *Exocarpus*, *Leptomeria*, *Dendrotrophe*, *Cladomyza* and *Quinchamalium*. Like all Santalaceae plants, sandal tree is a root hemiparasite and derives its sustenance partly from the plants which it haustorises. However, during the first two years of its growth it can survive by taking up mineral nutrients directly from the soil (Iyenger 1972, Ramaiah et al. 1962, Parthasarathi et al. 1971).

Sandal is a medium-sized tree growing wild in the States of Karnataka, Tamil Nadu and some parts of Andhra Pradesh and Kerala. However, the heartwood formation is rather poor in the areas of introduction. Sandal wood is primarily valued for its oil which is extensively used in perfumery industry throughout the world. Though synthetic oil has been developed it did not find favour with the industry. The supply of sandal trees which hold great export potential is progressively decreasing from the natural forests primarily due to spike-disease which is an "yellows type" of disease. Between one-quarter and one-half of sandal trees in Karnataka are killed by spike-disease before they reach the productive age (15–20 years) and that many of the remaining trees are killed before they attain full-size (Krishnamoorty quoted by

Hull 1969). Large areas where once sandal flourished have been laid barren due to the disease.

Symptoms of the Disease

The disease causes diminution of leaf-lamina which results in greater decrease in width than length. The affected leaves stand out stiffly from the branch acquiring a spike-like appearance. Due to shortening of internodes, diseased leaves become crowded. The disease also results in phyllody of flowers with leaf-like enlargement of the pistil accompanied by marked reduction of perianth and stamens. Initially, only a few branches exhibit the disease-symptoms which gradually spread to the entire tree. The affected tree is killed within two or three years after the manifestation of external symptoms.

Causal Organism

The symptoms include chlorosis, growth stimulation of dormant buds, phyllody of flowers, witches broom-like effect of leaves, etc. Causal organisms of this were formerly considered to be viruses. However, electron microscopy of diseased plant parts and chemotherapy of the diseased plants have conclusively proved that the causal organisms are not viruses but may be mycoplasma-like organism (MLO) or rickettsia-like organism (RLO) or "Spiroplasma" with helical forms. These MLOs are present in the sieve-tubes of spike-infected sandal leaves and twigs (Djikstra & Ie 1969, Hull et al. 1969 and Varma et al. 1969). These organisms are absent in the healthy leaves but are also present in graft-transmitted diseased leaves (Plavsic-Benjac et al. 1973(. Since no remission of the disease symptoms could be brought about by penicillin treatment, the possibility of association of RLO with the disease is excluded.

Vector Transmission

Most of the "yellows type" of plant diseases are transmitted by homopterous insects (Whitcomb & Davi 1970). In carefully designed experiments, Rangaswami and Griffith (1940), conclusively proved that spike disease of sandal is primarily transmitted by insect vectors in nature (in 6–7% cases disease transmission can take place through haustorial connections). Earlier Rangaswami and Sreenivasaya (1935) indicated insect transmission of spike-disease of sandal. Insects that produced spike-like symptoms in transmission tests belong exclusively to Cicadellidae. They are *Moonia albimaculata* (Dover & Appanna 1934), *Coelidia indica* (=*Jassus indicus**) (Rangaswami & Griffith 1940) and *Nephotettix virescens* (Shivaramakrishnan & Sen-Sarma 1978). Transmission by *Moonia* and the so-called *Coelidia* needs further investigation.

Transmission with Moonia albimaculata

The transmission studies were carried out by mass release of adults of *M. albimaculata* using 7 test plants. Only one plant developed typical symptoms of spike which was, however, not confirmed by retransmission to healthy plants by grafting. (Dover & Appanna 1934). Results of subsequent experiments carried out by Rangaswami and Griffith (1940) are, however, suggestive of the fact that manifestation of spike-like symptoms might be due to mass feeding.

Transmission with Coelidia indica

Only 29 adults were released in batches of two or three to feed on a disease-masking plant in a wire-mesh cage. The infective

*According to Nielson (in litt.), this species does not occur in South India. Examination of specimens used in transmission tests revealed that they belong to a new genus and a new species.

plant was kept raised on a bamboo platform so as to keep the top of the plant near the roof of the cage, because the test insects showed preference to feeding at the top. After the aquisition feeding for about 20 days, they were released to healthy plants for inoculation access. After about 60–90 days, four plants exhibited external manifestation of disease symptoms which was also successfully transmitted to other healthy plants by means of leaf and bud grafting. All the insect-transmitted diseased plants died within 2–4 months. (Rangaswami & Griffith 1941). *Acacia farnesiana* was used as the host plant.

Transmission with Nephotettix virescens

For transmission tests with *N. virescens*, a minimum of 60 adults are required for successful infection of a potted 3–5 years old healthy sandal plant grown along with *Pongamia pinnata* (Syn. *P. glabra*) as the host-plant. Two hundred adults bred under laboratory condition on 'Madhu' variety of paddy were divided into two equal groups (100 adults in each group). One group was subjected to aquisition feeding on diseased leaves for 24 or 48 hr, after which they were transferred to test plant of sandal in a transmission cage (size 75×75×110 cm with 45 mesh wire gauze on all sides and with a plywood base). The insects were allowed inoculation access for 7 days after which the test plant was transferred to insect-proof green house for further observation. After 30 days, the plants were heavily prunned to force out symptoms. The other group (control) was released on healthy sandal leaves for aquisition feeding for 24 or 48 hr after which they were released in the transmission cage with a healthy potted plant with the same period of inoculation access. The experiments were repeated several times, and in majority of the cases insect-transmitted plants developed typical symptoms of the disease which were absent in control plants fed with non-infective leafhoppers. The disease from insect-transmitted plants was also successfully retransmitted to healthy plants by leaf and bud grafting, a technique successfully used earlier for transmission of the disease from diseased plants to healthy plants. None of the insect-transmitted plants recovered and all died within 4–5 months after the manifestation of disease symptoms.

Plants fed with non-infective leafhoppers (control) did not induce any disease symptom and these developed in the normal way. Adults of *N. virescens* were also successfully used in transmitting the MLOs of diseased *Catharanthus roseus* (=*Vinca rosea*) which is one of the collateral hosts of spike pathogen (Djikstra & Lee 1972) to healthy sandal seedlings and *vice versa* (Shivaramakrishnan, unpublished). Further, spike MLOs cultured in synthetic medium were transmitted to the healthy sandal seedlings *via* adults of *N. virescens* (Nayar & Ananthapadmahabha, unpublished). The discovery of *N. virescens* as vector of sandal spike disease is important as this species also transmits an MLO disease of rice (rice yellow dwarf) which is cultivated in plenty in Karnataka and Tamil Nadu. Earlier Sreenivasaya and Rangaswami (1931) reported constant association of agricultural operations with the primary site of disease outbreak.

Bioecological Notes on Vectors

Moonia albimaculata

M. albimaculata is a common species found on sandal. Though it was collected from many localities, it is specially abundant at Fraserpet in Coorg where it is most common from May to July and again in December and January. The species is, however, rather rare in October. Other host plants from

which the species was collected are *Dodonaea viscosa*, *Terena asiatica* (=*Webera corymbosa*) and *Pterocarpus indicus*. It has probably three overlapping generations in a year. Eggs are inserted on the edges of the leaves of host plants by making slits in plants tissues.

Coelidia indica (=*Jassus indicus*)

This species is very common in Jawalagiri though it was collected from other localities such as Fraserpet, Aiyur, Kottur etc. It is most abundant in Jawalagiri in the months of June–July. Records of its seasonal incidence show three other peaks—in February–March, October and in December. The species has been collected on several plants besides sandal, e.g., *Canthium dicoccum* (=*C. didymum*), *Dodonaea viscosa*, *Lantana camara*, *Scutiamyrtina indicus* (=*S. indica*) and *Ziziphus oenoplea*. Eggs are laid in small slits on tender leaves of host plants. Life-cycle is completed by 12–14 weeks. It seems to have three overlapping generations in a year. Longevity of adults is about three months.

Nephotettix virescens

This species is very common in all parts of India. It is attracted to light in extremely large numbers but in the day time, collection is rather difficult and one does not get many specimens even with thorough sweeping of bushes and grass in the forest.

This species seems to breed in succulent green grasses near tanks, rivers, canals, etc. Until the beginning of June, they do not move to tender rice seedlings. The eggs are laid in the lacerated tissues of sheathing of leaves. Often eggs are laid on edges and midribs of leaves. The population of the insect in the sandal ecosystem starts declining progressively by the middle of February until the minimum is reached in May. The population build-up commences after the first rain in June and reaches its maximum by October–November.

Discussion

From the account given above, it seems likely that more than one species of leafhoppers is involved in spreading the disease in nature, as it is common for several MLO diseases to have a broad spectrum of vectors (Severin 1940, Jensen 1969). At present leafhopper species occurring in sandal ecosystem are being screened for their ability to transmit the disease.

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