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Review Article

THANJAVUR WILT OF COCONUT

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ABSTRACT

Thanjavur wilt of coconut was first reported from Thanjavur district of Tamil Nadu, India in 1952. The disease has now spread throughout Tamil Nadu. Information available on the occurrence and spread of the disease in Tamil Nadu, symptoms, etiology and epidemiology of the disease, physiology of diseased palms, methods for early detection and management of the disease are reviewed.

INTRODUCTION

Coconut palm is affected by a number of lethal and debilitating diseases in India. Thanjavur wilt is the most destructive one in Tamil Nadu. This disease was first noticed in coconut palms in Thanjavur district of Tamil Nadu after the cyclone of 1952 and hence the name Thanjavur wilt (Vijayan and Natarajan, 1972). A disease of coconut almost similar to Thanjavur wilt in symptomatology and caused by fungus associated with Thanjavur wilt is prevalent in Andhra Pradesh, Karnataka, Maharashtra and Gujarat states. The disease is also referred to as *Ganoderma* root rot or *Ganoderma* wilt or *Ganoderma* disease or 'Anabe' (Nambiar and Rethinam, 1986). Wilson et al. (1987) reported the occurrence of a basal stem rot disease in coconut in Kerala caused by *G. lucidum*. In Sri Lanka, a basal stem rot disease of coconut caused by *G. boninense* was reported by Peries (1974). This paper reviews the research work carried out on Thanjavur wilt.

Occurrence and distribution

A survey conducted in Tamil Nadu during 1965–'66 revealed that the disease was confined to the coastal areas in the state. In 1978 the disease was noticed in all the districts of Tamil Nadu and the incidence ranged from 0.6 to 4.9% (Bhaskaran and Ramanathan, 1984). Maximum incidence of the disease was in Thanjavur district with a mean of 4.9% followed by Chengalpattu district with 4.5% incidence. In Thanjavur district, the incidence was very high in

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Muthupet block with a mean of 8.4% while in some severely infected gardens, the incidence was as high as 31.4% (Bhaskaran, Ramanathan and Ramaiah, 1984 a).

Symptomatology

Stem

The symptom first appears as exudation of reddish brown viscous fluid from the basal portions of the stem. The bleeding patches begin from the base and extend to three metres upwards as the disease progresses. In the destructive sampling of affected palm, it was found that the internal tissues were brown in colour and this discolouration was confined to the height upto which active bleeding occurred. In advanced stages, basal portion of the stem decays completely. Occasionally, some infected palms do not show bleeding symptom. In some palms, the bark from the base of the stem peels off. Sporophore of *G. lucidum* appears at the base of the trunk in some palms just above the soil level prior to wilting or just after the death of the palm (Bhaskaran, Ramanathan and Ramaiah, 1982; Vijayan, Natarajan and Krishnamoorthy, 1973; Rethinam, 1984; Bhaskaran, 1986).

Leaves

In the crown, leaflets wilt and outer one or two whorls of leaves turn yellow. Later, they exhibit light to moderate browning followed by drooping. As the disease advances, the remaining leaves also droop down in quick succession and the spindle alone remains. Under prolonged infection, the outer leaves fall off and subsequent ones are reduced in size with a shortened spindle that does not unfold properly. In some cases leaves break off near the base along the midrib. In certain cases soft rot sets in in the bud resulting in loss of turgidity and death of the cells due to breakdown of conducting elements. The affected bud emits a bad smell and in advanced stages the crown is blown off leaving the decapitated stem (Vijayan and Natarajan, 1972; Bhaskaran et al., 1982; Bhaskaran, 1986).

Flowers

Normal development of flowers and bunches is arrested with the progress of disease leading to button shedding. In mild cases there is no button shedding. As the leaves droop down, the subtended bunches also hang down. The nuts become barren. Where disease progress is slow, a few normal nuts are produced. Most of the palms bear profusely, just prior to and at the time of initiation of symptoms (Vijayan and Natarajan, 1972; Anonymous, 1976; Bhaskaran, 1986).

Roots

Extensive rotting and discolouration of root system is a characteristic symptom of the disease. Cortical tissues disintegrate and the stele turns brown. The roots are watery with a distinct alcoholic smell, red below the hypodermis and brownish towards stele. New roots are rarely produced after the initiation of symptoms. The number of new roots produced is progressively reduced (Anonymous, 1976; Rethinam, 1984; Bhaskaran, 1986).

Five distinct stages can be recognised in the development of Thanjavur wilt.

Stage I.

Wilting of leaflets (which sometimes may not be very prominent), yellowing of lowest leaf whorl, decay and death of fine roots.

Stage II.

Appearance of bleeding patches at the base of the stem near the ground level which gradually extend upwards, extensive root decay and production of new bunches stops.

Stage III.

Bleeding patches extend in the stem, drooping of lower leaf whorl, heavy button shedding and nuts barren.

Stage IV.

Stem decay extends upwards, lowest leaf whorl dry and drop off; other leaves also droop except the spindle leaf along with two or three young leaves which remain erect.

Stage V.

All the leaves droop and fall off leaving the decapitated stem, stem shrivels and dries up.

The time taken from the initial appearance of bleeding patches on the stem (Stage II) to death of the palms (Stage V) is from 6 to 54 months, the average being 24 months. In stage III, IV and V, the scolytid beetle *Xyleborus perforans* and the weevil *Diocalandra stigmaticollis* are found boring into the stem at the bleeding patches. These insects accelerate the death of the palm (Anonymous, 1976; Bhaskaran et al., 1982; Rethinam, 1984; Bhaskaran 1986).

Etiology

The exact cause of the disease still remains uncertain. From diseased palms *Ganoderma applanatum* (Pers.) Pat., *G. lucidum* (Leys.) Karst., *Ceratostomella* sp., *Schizophyllum commune* and *Trichoderma* sp. were isolated. But none of these fungi could produce symptoms of the disease on artificial inoculation.

The root samples examined were free from parasitic nematodes while the soil samples yielded nematodes belonging to several genera *viz., Tylenchorhynchus, Dorylaimus, Ecphyadophora, Hoplolaimus, Longidorus, Rhabditis* and *Mononchus*. However, the population of these nematodes was very low (Anonymous, 1981 a). Sivagami, Sivakumar and Jayaraj (1987) reported the occurrence of *Meloidogyne* sp., *Rotylenchulus reniformis* and *Pratylenchus* sp. in coconut rhizosphere in Kanyakumari and Tirunelveli districts of Tamil Nadu. The involvement of nematodes in Thanjavur wilt is doubtful.

Recently, isolation of pathogen(s) from diseased palms with or without bleeding symptoms and *Ganoderma* sporophore was attempted from different tissues. Irrespective of the extent of bleeding symptom, *G. applanatum,* and *G. lucidum* were isolated only from roots (Table I) and not from above ground parts of the palm (Anonymous, 1987).

Six months after inoculation with *G. lucidum* root rotting upto 21 per cent was noticed. However in the roots inoculated with *G. applanatum*, there was no root rotting, but the fungus colonised on the surface of the root to a distance of 8–10 cm on either side of

Table I. Ganoderma *spp. isolated from coconut roots*

Sporophore in the palm	Bleeding in stem	Species isolated
G. applanatum	Less	*G. applanatum*
G. applanatum	Profuse	*G. applanatum*
G. lucidum	Profuse	*G. lucidum*
Nil	Profuse	*G. lucidum*

the point of inoculation. From inoculated roots, *G. lucidum* was reisolated both from cortical tissues and bark of the roots, while *G. applanatum* was reisolated only from the bark of the roots.

Host range

G. lucidum has got a very wide host range infecting both monocots and dicots. Besides coconut, it has been recorded on *Acacia catechu* willd., *A. auriculaeformis* A. Cunn., *A. melanoxylon* R. Br., *A. nilotica* (L.) Willd. ex Del., *Acrocarpus fraxinifolius* Wt., *Albizia chinensis* (Osbeck) Merr., *A. lebbeck* Benth; *A. procera* Benth., *Aquillaria agallocha* Roxb., *Areca catechu* L. *Bosweilia serrata* Roxb., *Cassia fistula* L., *C. javanica* L., *C. nodosa* Ham., *C. siamea* Lam., *Casuarina equisetifolia* Forst., *Dalbergia latifolia* Roxb., *D. sissoo* Roxb., *Delonix regia* (Boj. ex Hook.) Raf, *Eucalyptus citriodora* Hook, *Ficus* spp., *Hevea* spp., *Jacaranda acutifolia* Humb. & Bonpl., *Lannea grandis* Engl., *Mangifera indica* L., *Melia azadiracta* L., *Morus alba* L., *Pinus roxburghii* Sarg., *Pleiogynium cerasiferum* (F. V. M.) Parker, *Pongamia pinnata* (L) Merr., *Populus euramericana* (Dode) Guinier, *Pterocarpus marsupium* Roxb., *Quercus semecarpifolia* Smith; *Shorea robusta* Gaertn., *Sterculia villosa* Roxb., *Terminallia tomentosa* W. & A. and *Toona cibiata* Roem. (Bakshi et al., 1967–1972; Rajan, 1987).

Epidemiology

Soil conditions

Generally the disease is prevalent in sandy or sandy loam soils in coastal areas where coconut is grown under rainfed conditions and also in neglected plantations. Lack of soil moisture during summer months, water logging in rainy seasons, presence of old infections in the garden and neglect of cultural operations were found to be conducive to the spread of the disease. Hard subsoil, observed in some parts of Thanjavur district, impedes root penetration which in turn predisposes the coconut palms to infection (Anonymous, 1976; Ramasami, Bhaskaran and Jaganathan, 1977).

Age of the palm

Generally trees in the age group of 10 to 30 years are more susceptible to the disease (43%) than younger trees (17%) (Vijayan and Natarajan, 1979). The hybrid VHC–1 was found to be affected even at the age of 5 to 6 years in endemic areas.

Weather factors

Observations recorded during 1971 to 1976 revealed that the disease incidence was more between March and August. It was positively correlated with mean maximum soil temperature

and the number of bleeding palms. It was not correlated with minimum temperature, rainfall and relative humidity (Ramasami et al., 1977; Lewin, Sindhu Mathar and Sethuraman, 1983; Bhaskaran, Chandrasekar and Shanmugam, 1988)

Physiology of the diseased palms

Anbalagan (1979) and Anbalagan et al., (1987) found that nitrogen, phosphorus, potassium, calcium and magnesium decreased in the diseased leaf, stem, bole and root tissues when compared to the corresponding healthy tissues. There was a maximum decrease in total nitrogen in the bole to an extent of 52% while decrease in phosphorus was pronounced in diseased root tissue (41%). Potassium content decreased by 39% and calcium by 26% in diseased stem tissue. Total phenol increased from 20 to 35% in diseased tissue and the increase in ortho dihydroxy phenol content was much more pronounced (40 to 48%) than the total phenol itself. Total and reducing sugars increased in diseased tissue.

Tapping of diseased palms for 'neera' production reduced the sugar content in the leaves and increased the level of total phenols. The quantity of 'neera' produced was only 8 l/palm/month in the case of diseased palm as compared to 28 in healthy palm. The sugar content of neera was only 9% in affected palm as against 13% in healthy palms (Vijayaraghavan et al., 1986; Anbalagan et al., 1987).

Early detection of the disease

Thanjavur wilt disease can be contained by management practices, if the disease is detected in the early stages. A few methods have been reported to be useful for early diagnosis of the disease, though the methods need further refinement (Natarajan, Bhaskaran and Shanmugam, 1986; Vijayaraghavan, Ramadas and Bhaskaran, 1987). In the colorimetric method, 10 ml of saturated potassium hydroxide was added to 5g of the root or stem tissues and autoclaved for 30 minutes at 1.05 kg/cm^2. The solution was decanted and the tissues were treated with 5 ml of 95% ethanol. One ml of ethanol extract was made up to 10 ml with the same solvent and read in a spectrophotometer at 425 nm. The optical density of stem tissues increased with increase in disease intensity from 0.445 in healthy to 1.002 in severely diseased palms (Natarajan et al., 1986).

In the EDTA test leaf or root tissues were extracted with 0.3M EDTA solution. The optical density at 400 nm increased with increase in disease severity (Natarajan et al., 1986).

In the orthophenanthroline reagent test, O.D. values at 570 nm in root samples increased with increase in disease intensity. The iron content of the extracts was more in diseased tissues in both EDTA and orthophenanthroline tests than apparently healthy roots. However, within the different disease categories, the iron content decreased with increase in disease severity in EDTA test while in orthophenanthroline test, the iron content of the extract increased with increase in disease severity (Anonymous, 1989). Orthophenanthroline test was more reliable than EDTA test for early diagnosis of Thanjavur wilt.

However, further studies are warranted to fix the critical limit of iron content in infected palms for diagnosing the disease.

Transpiration rate was significantly low in the diseased palms while the stomatal diffusive resistance was slightly higher than healthy palms. These parameters can also be examined for use as probable tools for early diagnosis (Vijayaraghavan et al, 1987).

Management

A series of field experiments were conducted on the cultural and chemical control of the disease for the management of Thanjavur wilt at Veppankulam and Nagercoil centres of Tamil Nadu Agricultural University. These experiments have given certain definite indications on the management practices to be followed for containing the disease.

i) *Management of soil moisture regime*

Irrigation alone was not very effective in containing the disease. Basin irrigation coupled with application of fertilizers increased the disease intensity. Irrigation combined with Bordeaux mixture drenching checked the disease intensity considerably. Organic manure with irrigation also ameliorated the disease symptoms to certain extent. Irrigation along with farm yard manure + burying coconut husks in circular trench around the palm + Bordeaux mixture drenching was most effective in reducing the disease intensity (Bhaskaran, Chandrasekar and Jaganathan, 1978 a). Burying 500 coconut husk in circular trench around the diseased palms contained the disease (Vijayan and Natarajan, 1975).

ii) *Effect of fertilizers*

In trials conducted from 1977 to 1982, it was found that the treatment with 350, 250 and 450g N, P_2O_5 and K_2O/palm/year respectively had low disease index and high nut yield while higher doses of fertilizers increased the disease intensity (Bhaskaran, Chandrasekar and Jaganathan, 1978 b; Bhaskaran and Ramanathan, 1983).

iii) *Effect of micronutrients*

Application of 227 g of manganese sulphate/palm/year reduced the intensity of the disease (Disease index 2.8 in treated palms as against 33.0 in control). The disease intensity was maximum (50.4) in palms that received molybdenum. (Jaganathan and Ramasami, 1975; Anonymous, 1978 a; Bhaskaran et al., 1985). However, Sindha Mathar, Lewin and Sethuraman (1983) could not observe any direct effect on the disease by application of micronutrients in Kanyakumari district, Tamil Nadu.

iv) *Effect of organic manures*

Annual application of 50 kg farm yard manure or green leaves or 300 kg tank silt or 5 kg neem cake was found to be useful in containing the disease (Vijayan and Natarajan, 1975). Application of neem cake alone and in combination with drenching 1% Bordeaux mixture thrice at quarterly intervals was most effective in reducing the intensity of disease giving 12.30 and 11.42 disease index respectively as compared to 117.72 in control palms

(Bhaskaran and Ramanathan, 1983). The study on the effect of 100 kg tank silt + 50 kg green leaves + 1% Bordeaux mixture soil drenching conducted for five years revealed that the disease index was considerably low in these plots (15.0) as compared to control (75.2) (Anonymous, 1981 b).

v) *Effect of fungicides and chemicals*

The fungicidal trials conducted between 1965 and 1969 revealed that drenching with 40 l of 1% Bordeaux mixture was effective when compared to copper oxychloride + BHC and tar application. Studies conducted from 1969 to 1973 indicated that the application of Bordeaux mixture during October – January was effective in reducing the intensity of the disease (Anonymous, 1978 b; 1978 c). The field trial conducted with systemic fungicides and antibiotics from 1972 to 1976 indicated that Aureofungin-sol (0.2%) was very effective in reducing the intensity of the disease (Anonymous, 1978 a; 1978 b). Drenching with 10 l of 0.1% benomyl / palm after exposing the roots also gave good control (Kolandaisami and Arjunan, 1977). Soil drenching with 40 litres of 1% Bordeaux mixture and stem injection of Aureofungin–sol 2g + 1g of copper sulphate in 100 ml of water thrice at quarterly intervals significantly reduced the disease intensity and increased the yield of nuts (Bhaskaran and Ramanathan, 1982; Bhaskaran, Ramanathan and Ramaiah, 1984 b). However, the treatment should be repeated once in three years (Ramadoss and Bhaskaran, 1987). Anbalagan and Shanmugam (1984) reported that tridemorph at 500 ppm inhibited the growth of *G. lucidum in vitro*. Sindha Mathar and Balasubramaniam (1987) reported that soil drenching with 0.1% IBP, carboxin, tridemorph or 0.05% carbendazim in combination with neem cake at 5 kg/ palm reduced the disease intensity significantly. Field trial conducted at Palghat (Kerala) by Central Plantation Crops Research Institute, Kasaragod showed that in tridemorph and Aureofungin–sol treated palms, the disease was less (Anonymous, 1988).

Since the association of the scolytid beetle *Xyleborus perforans* was also noticed in some wilt affected palms, a field trial using dieldrex, heptachlor, chlordane and sulphur dust was conducted from 1966 to 1969. The palms treated with heptachlor showed minimum disease intensity (Anonymous, 1981 b). Stem injection of 2.5 ml monocrotophos in 100 ml of water showed variable results regarding disease intensity, though the treatment marginally increased nut yield (Anonymous, 1983).

vi) *Management by tapping for 'neera'*

To find out the effect of tapping 'neera' on disease intensity, tapping was done from May to October or from September to February in palms with different disease intensities and in apparently healthy palms. In both the experiments, tapping in mildly and moderately diseased palms reduced the disease index and the effect persisted even one year after completion of tapping (Vijayaraghavan et al., 1986; Anonymous, 1989).

vii) *Biological control*

Trichoderma harzianum and *T. viride* were found to be antagonistic to *G. lucidum*. Neem cake application to diseased palms encouraged the saprophytic soil microflora especially *Trichoderma* in coconut basins and was effective in the control of Thanjavur wilt (Gunasekaran et al., 1986; Bhaskaran, 1988).

A number of plant extracts were tested for their effect on the growth of *G. lucidum*. Neem cake extract completely inhibited its growth. Banana rhizome extract and *Tephrosia purpurea* root extract gave 86% and 54% inhibition respectively (Bhaskaran, Ramadoss and Ramachandran, 1987; Bhaskaran, et al., 1988; Bhaskaran, Ramadoss and Suria-Chandrasekaran, 1988) As banana is one of the profitable intercrops in coconut gardens and *Tephrosia* is a green manure crop for coconut, growing banana and applying *Tephrosia* in coconut basins where the disease is endemic may offer scope for reducing the intensity of the disease.

viii) *Integrated management*

On-farm trials conducted by Coconut Research Station, Veppankulam, Tamil Nadu showed that an integrated approach with cultural, chemical and biological methods involving the following steps was very effective for containing the disease.

1. Removal of dead palms and palms in advanced stages of the disease with bole and root bits and destroying.

2. Isolation of diseased palms from healthy palms by digging isolation trenches of 1m deep and 30cm wide.

3. Regular basin irrigation during summer months or moisture conservation by coconut husk burial.

4. Avoiding flood irrigation and cultural practices like ploughing to prevent spread of the inoculum.

5. Addition of 50 kg farm yard manure or green leaves or 200 kg tank silt/palm/year.

6. Application of 5kg neem cake/ palm/ year.

7. Soil drenching with 40 l of 1% Bordeaux mixture thrice a year for one year along with root feeding of 2g of Aureofungin-sol + 1g of copper sulphate in 100 ml of water. Tridemorph also can be used for root feeding. These treatments will be effective only for palms in early stages of the disease (Stages I & II).

8. Raising banana as intercrop in coconut gardens in wilt endemic areas.

9. If *Xyleborus* attack is found in the stem, smearing with BHC wettable powder or heptachlor and/or root feeding with 5 ml of monocrotophos may be done.

By adopting the above management practices, the disease index in the managed plot was reduced to 1.66 as compared to 71 in control (Anonymous, 1989).

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