

Ganoderma /Thanjavur Wilt/Basal Stem Rot Disease of Coconut

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Abstract

Ganoderma wilt disease of coconut was first reported from Thanjavur district of Tamil Nadu, India in 1952. The disease is lethal and is widespread in Tamil Nadu. Information available on the occurrence, geographic distribution, symptoms, host range, etiology, epidemiology, physiology of diseased palms, methods for early detection and management of the disease are reviewed hereunder.

Introduction

Coconut palm is affected by a number of lethal and debilitating diseases in India. *Ganoderma* wilt disease is the most destructive one in Tamil Nadu. It was first noticed among 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 *ganoderma* wilt in symptomatology and etiology is prevalent in Andhra Pradesh, Karnataka, Maharashtra and Gujarat states. This disease is also referred to as *ganoderma* root rot or basal stem rot or *ganoderma* wilt or *ganoderma* disease or anabe (Nambiar and Rethinam, 1986). The occurrence of a basal stem rot disease in coconut in Kerala caused by *G. lucidum* was reported by Wilson *et al.* (1987). 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 at Aliyarnagar.

Occurrence and Distribution

In 1978 the *ganoderma* disease was first noticed in all over the districts of Tamil Nadu and incidence ranged from 0.6 to 4.9 per cent (Bhaskaran and Ramanathan, 1984). Maximum

incidence was recorded in Thanjavur district with a mean of 4.9 per cent followed by Changalpattu district with 4.5 per cent incidence. In Pollachi tract, (Coimbatore) the incidence was high in Thenchittur (8.0%) Arthanaripalayam (5.45%) Cheticalypalayam (3.5%) and Nadupuni (3.33%).

Symptomatology

Stem

The first visible symptom is the exudation of reddish brown viscous fluid from the basal portion of the stem of affected palms. The bleeding begins at the base of the stem and extends up to three meters upwards as the disease progresses. By destructive sampling of affected palms, it was found that the internal tissues were brown in colour and this discoloration was confined to the height upto which active bleeding occurred. In advanced stages, basal portion of the stem decays completely. In certain cases some of the infected palms do not show bleeding symptoms. In some, the bark from the base of the stem peels off. Sporophores of *G. lucidum* appears at the base of the trunk in certain palms just above the soil level prior to wilting or just after the death of the palm (Vijayan *et al.*, 1973; Bhaskaran *et al.*, 1982; Rethinam, 1984 and Bhaskaran, 1986).

Leaves

The outer whorl of the leaves turn yellow initially, Later they exhibit light to moderate browning followed by drooping. In the crown, the leaflets wilt. As the disease advances, the remaining leaves droop down in quick succession and the spindle alone

remains. Under prolonged infection, the outer leaves fall off and subsequent leaves are reduced in size with a short spindle that does not unfold properly. In certain cases soft rot sets in the bud resulting in loss of turgidity and death of the cells due to breakdown of conducting elements. In advanced stages the crown is blown off leaving the decapitated stem (Vijayan and Nambiar, 1972; Bhaskaran *et al.*, 1982 and Bhaskaran, 1986).

Flowers

Normal development of flowers and bunches are arrested. Aggravation of the disease leads to button shedding. In mild cases, this may not occur. 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 and Bhaskaran *et al.*, 1989).

Roots

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

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Five distinct stages can be recognized in the development of ganoderma wilt.

Stage I

Wilting of leaflets, yellowing of lowest leaf whorl, decay and death of the 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 extent in the stem, drooping of lower leaf whorl, heavy button shedding and nuts barren.

Stage IV

Stem decay extends upward, lowest leaf whorl dry and droop 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 between II stage and V (Initial appearance of bleeding patches and death of the palms) is from 6 to 54 months, the average being 24 months. In the stages III, IV & V the scolytid beetle *Xyleborus perforans* and *Diocalandra stigmaticollis* are found boring into the stem at the bleeding patches. These insects accelerate the death of the palm (Bhaskaran et al., 1987, Anonymous, 1976; Bhaskaran et al., 1982; Rethinam, 1984 and Bhaskaran, 1986).

Etiology

From the 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 (Bhaskaran et al., 1989). The root samples examined were free from parasitic nematodes while the soil sample yield nematodes belongs to several genera viz., *Tylenchorhynchulus*, *Dorylaimus*, *Ecpfyadophora*, *Hoplolaimus*, *Longidorus*, *Rhabditis* and *Mononchus*. However, the population of these nematodes were very low (Anonymous, 1981a). Sivagami et al, (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 (Bhaskaran et al., 1989).

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 (Bhaskaran et al., 1989) and not from above ground parts of the palms (Anonymous, 1987) The pathogen was isolated from affected palms of roots only, (Aliyarnagar).

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 colonized on the surface of the root to a distance of 8-10 cm on either side of 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 (Bhaskaran et al., 1989). *G. applanatum* was isolated in the roots and the fungus colonized on the surface of the point of inoculation and was reisolated from the bark of the roots at Aliyarnagar, Pollachi tract (Coimbatore District).

Host range

G. lucidum infecting both monocots and dicots. It has been recorded on *Acacia catechu* Willd., *A. aurichulaeformis*, *A. cunn.*, *A. melanoxylon* R.Br., *Anilotica* (L.) Willd. ex Del., *Acrocarpus fraxinifolius* Wt., *Albizia chinensis* (Osbeck) Merr., *A. lebbek*, Benth, *A. procera* Benth., *Aquillaria agallocha* Roxb., *Areca catechu* L., *Boswellia serrata* Roxb., *Cassia fistula* L., *C. javanica* L., *C. nodosa* Ham., *C. sianea* Lam., *Casuarina equisetifolia* Forst., *Dalbergia latifolia* Roxb., *D. sissoo* Roxb., *Daltonia regia* (Boj. ex Hook.) Raf, *Eucalyptus citriodora* Hook, *Ficus* spp. *Hevea* spp., *Jacaranda acutifolia*, Hamb and 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 semecarpitolia* Smith., *Shorea robusta* Gaerth., *Sterculia villosa* Roxb., *Terminalia tomentosa* W. & A. and *Tbona cibiata* Roem (Bakshi et al., 1967-1972 and 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 gardens and neglect of cultural operations were found to be conducive to the spread of the disease. Hard subsoil observed in some parts of Thanjavur and in Pollachi tract also impedes root penetration, which in turn predisposes the coconut palms to infection (Bhaskaran et al., 1989; Anonymous, 1976; Ramasami et al., 1977 and Bhaskaran et al., 1989).



Age of the palm

Generally trees in the age group of 10-30 years are more susceptible to the disease (43 per cent) than young trees (17 per cent) (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 (Bhaskaran et al., 1989). Trees (Tall variety) in the age group of 16 to 30 years are more susceptible to the disease while hybrid become susceptible at 6 years at Pollachi tract.

Weather factors

Observations recorded during 1971-76 revealed that the disease incidence was more between March and August. It was positively correlated with the mean maximum soil temperature and the number of bleeding patches and not correlated with minimum temperature, rainfall and relative humidity (Ramasami et al., 1977; Lewis et al., 1983 and Bhaskaran et al., 1988). Observations recorded during 1991 to 1995 revealed the disease incidence was positively correlated with mean maximum temperature and bleeding patches at Aliyar Nagar.

Physiology of the diseased palms

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

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 production was only 8 litres/palm/month in the case of diseased palm as compared to 28 litres in a healthy palm. The sugar content of neera was only 9 per cent in the affected palm as against 13 per cent in the healthy palms (Vijayaraghavan et al., 1986 and Anbalagan et al., 1987).

Activity of the enzymes viz., peroxidase, polyphenol oxidase and nitrate reductase were more in the diseased tissues than the healthy ones. The enzymes peroxidase and polyphenol oxidase were high in leaf tissues as compared to the root tissues while nitrate reductase activity was more in root than leaf tissues (Karthikeyan and Bhaskaran 1992). The auxin secreted by the pathogen increased the plasticity of the cell wall, thus allowing pectic enzymes to weaken the cell walls and enabling the protoplast to bulge into the lumen of the vessel, suggesting the modus operandi of the auxin in the formation of tyloses and the mechanism of wilt induction (Sequeira, 1963). *G. lucidum* produced Indole-3-Acetic Acid (IAA) in tryptophan supplemented malt extract medium (Bhaskaran and Ramadass, 1993).

The first report of enzymes secreted by *G. lucidum* viz., diastase, lactase, invertase, protease, coagulase, rennetase and oxidase but not maltase, lipase and catalase was by Venkatarayan (1936). *G. lucidum* secreted endopolygalacturonase in culture indicating the macerative character of the fungus reported by Lalithakumari and Sirsi (1971). Production of extracellular amylase in the culture filtrate of *G. lucidum* and a partially purification of a cellulose degrading enzyme by ammonium sulphate precipitation was reported by Do and Kim (1985). Factors affecting the

productivity of cellulolytic enzymes by *G. lucidum* were reported by Hong et al., (1986). The *in vitro* production of cellulolytic and pectinolytic enzymes and extracellular toxin by the fungus *G. lucidum* was reported by Anbalagan (1979).

Early detection of the disease

Ganoderma wilt disease can be contained by management practices, when 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 et al., 1986 and Vijayaraghavan et al., 1987). In the calorimetric method, 10 ml of saturated potassium hydroxide was added to 5 g of root or stem tissues and autoclaved for 30 min. at 1.0-5 kg/cm². The solution was decanted and the tissues were treated with 5 ml of 95 per cent ethanol. One ml of ethanol extract was made upto 10 ml with the same solution 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 0.3 M EDTA solution. The optical density 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 extract was more in diseased tissues in both EDTA and orthophenanthroline tests (Anonymous, 1989) Orthophenanthroline test was more reliable than EDTA test for easy diagnosis of *ganoderma* wilt.

Transpiration rate was 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 parable roots for early diagnosis (Vijayaraghavan *et al.*, 1987).

Management of *ganoderma* wilt disease

Field experiments were conducted on the cultural and chemical control of the disease at Veppankulam and Nagargoil centres of Tamil Nadu Agricultural University. These experiments have given certain definite indications on the management practices.

Management of soil moisture regime

Basin irrigation coupled with fertilizer application 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 intensity (Bhaskaran *et al.*, 1978a). Burying 500 coconut husks in circular trench around the diseased palms contained the disease (Vijayan and Natarajan, 1975).

Effect of fertilizers

Field trials were conducted from 1977 to 1982 and it was found that the treatment with 350, 250 and 450 g N, P_2O_5 and K_2O /palm/year respectively supported low disease index and high nut yield while higher doses of fertilizers increased the disease intensity (Bhaskaran *et al.*, 1978b; Bhaskaran and Rethinam, 1983 and Bhaskaran *et al.*, 1989).

Effect of micronutrients

Application of 227 g of manganese sulphate / palm / year reduced the disease intensity (2.8 DI 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 no direct effect on the disease by application of micronutrients was observed in Kanyakumari district, Tamil Nadu (Sindha Mathar *et al.*, 1983).

Effect of organic manure

Annual application of 50 kg farm yard manure or green leaves or 300 kg tanks 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 of 1 per cent bordeaux mixture thrice at quarterly intervals was most effective in reducing the intensity of the disease giving 12.30 and 11.42 disease index respectively compared to 117.72 in control plots (Bhaskaran *et al.*, 1989). Tank silt 100 kg + 50 kg green leaves + 1 per cent Bordeaux mixture soil drenching recorded low disease index (15.0) as compared to control (75.2) (Anonymous, 1981b).

Effect of fungicides and chemicals

Studies conducted from 1965 to 1969 revealed that drenching with 40 litre of bordeaux mixture was effective when compared to copper oxy chloride + BHC + Tar application. Trials 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, 1978b; 1978c). The field trial conducted with systemic fungicides and antibiotics from 1972 to 1976 indicated that aureofungin sol (0.2 per cent) was very effective in reducing the intensity of the disease (Anonymous, 1978a; 1978b). Drenching of 10 litre of 0.1 per cent benomyl/palm after exposing the roots also gave good control (Kolandaisami and Arjunan, 1972). Soil drenching with 40 litres of one per cent bordeaux mixture and stem injection of aureofungin sol 2 g +

1 g of copper sulphate in 100 ml of water thrice at quarterly intervals reduced the disease intensity and increased the yield of nuts (Bhaskaran and Ramanathan, 1982 and Bhaskaran *et al.*, 1985). However the treatment should be repeated once in three years (Ramadass and Bhaskaran, 1987). Sindha Mathar and Balasubramaniam (1987) reported that soil drenching with 0.1 per cent IBP or carboxin or tridemorph 0.05 per cent carbendazim in combination with neem cake at 5 kg/palm reduced the disease intensity significantly.

Field trial conducted at Palghat (Kerala) by CPCRI, Kasaragod showed that in tridemorph and aureofungin Sol treated palms, the disease was less (Anonymous, 1988). Soil application of neem cake 5 kg/palm/year and root feeding of calixin 2 per cent or kitazin 0.3 per cent is effective in reducing basal stem rot at Aliyar Nagar (Anonymous, 2000).

Since the association of the *Scotyild* beetle *Xyleborus perforans* was noticed in some affected palms, a field trial using dieldrex, heptachlor and sulphate 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 100ml of water showed variable results regarding disease intensity, through the treatment marginally increased nut yield (Anonymous, 1983). Benomyl, thirum and captafol were most effective as soil drenches when the soil moisture was 100 per cent. (Koti Reddy and Saraswathi, 1976). Field trials indicated that drenching the base of the palm with captan / carbendazim at 0.3 per cent concentration was effective in preventing the spread of the disease to the neighbouring palms (Sampath Kumar and Nambiar, 1990).

Management by tapping for neera

To findout the effect of neera



tapping on disease intensity, tapping was done from May to October and 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 and Anonymous, 1989).

Biological control of *Ganoderma* wilt

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 control of *Ganoderma* wilt (Gunasekaran et al., 1986 and Bhaskaran, et al., 1988).

Plant extracts were tested on the growth of *G. lucidum*. Neem cake extract completely inhibited its growth. Banana rhizome extracts and *Teprosia purpuria* root extracts gave 86 per cent and 45 per cent inhibition respectively (Bhaskaran et al., 1987). As banana is an intercrop in coconut gardens where the disease is endemic, it may offer scope for reducing the intensity of the disease. *Trichoderma harzianum* with 15 kg green manure or FYM 50 kg with 1 per cent bordeaux mixture or 5 kg neem cake applied to palms, reduced the disease incidence (Anonymous, 2000).

Integrated management

On-farm trials conducted at Coconut Research Station, Veppankulam, Tamil Nadu by integrated approach with cultural, chemical and biological methods recorded the disease index of 1.66 as compared to 71.00 in control.

On-farm trials conducted by Coconut Research Station, Aliyarnagar, adopting an integrated approach with cultural, chemical and biological methods involving the following steps

was very effective for control of the basal stem rot.

1. Removal of dead palms with roots and destroying
2. Irrigation of diseased palms separately. 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)
3. Regular basin irrigation during summer months once in 10 days
4. Avoid flood irrigation and ploughing to prevent the spread of the disease
5. Addition of 50 kg FYM or green leaves/palm/year
6. Application of 5 kg neem cake/palm/year
7. Soil application with 1 per cent Bordeaux mixture @ 40 litre / palm for thrice at quarterly intervals along with root feeding of calixin (2 per cent).
8. Soil application of *Trichoderma harzianum* 250 g/palm/year or *Azotobacter* 500 g/palm/year or *Pseudomonas fluorescences*.
9. If *Xyleborus* attack is found in the stem of basal stem rot disease affected palms, root feeding with 5 ml of monocrotophos is effective.

By adopting the above management practices the disease index in the management plot was reduced to 0.5 as compared to 33 in control in New management trial I. In New management trial II, the disease index was reduced to 3.2 by calixin (2 per cent) root feeding and neem cake 5 kg/palm/year soil application as compared 24.0 in control treatment. In comprehensive management trial the disease index was reduced to 1.28 in Kitazin (0.3 per cent) treated palms as compared to 2.0 in control.

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