

Nematode Parasites of Coconut and Their Management

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Introduction

Coconut (*Cocos nucifera* L.) belonging to palm family Areaceae is cultivated widely throughout the tropics of the world. India is the largest producer of coconut in the world with an estimated area of 9.1 lakh hectares followed by Indonesia and Philippines. The average productivity of coconut in the country is 7777 nuts per hectare.

Coconut is considered to be "Kalpavriksha" in view of its versatile contribution to the mankind, every part of the tree and its products having an economic use. It is one of the most important sources of vegetable oil. Nearly 7 per cent of vegetable oil production in the country is accounted for by coconut oil. Coconut contributes about 15 per cent of the annual income and 35 per cent of the agricultural income of Kerala State. The foreign exchange earned by coconut through export is more than Rs.200 crores.

Coconut palm is affected by a large number of diseases and the most prevalent one in Kerala is the root (wilt) disease caused by Mycoplasma-like organisms (MLO). The annual loss due to root (wilt) disease is estimated to be about 968 million nuts. The disease was first reported in 1882 from Central parts of Kerala. The disease is non-lethal but debilitating and

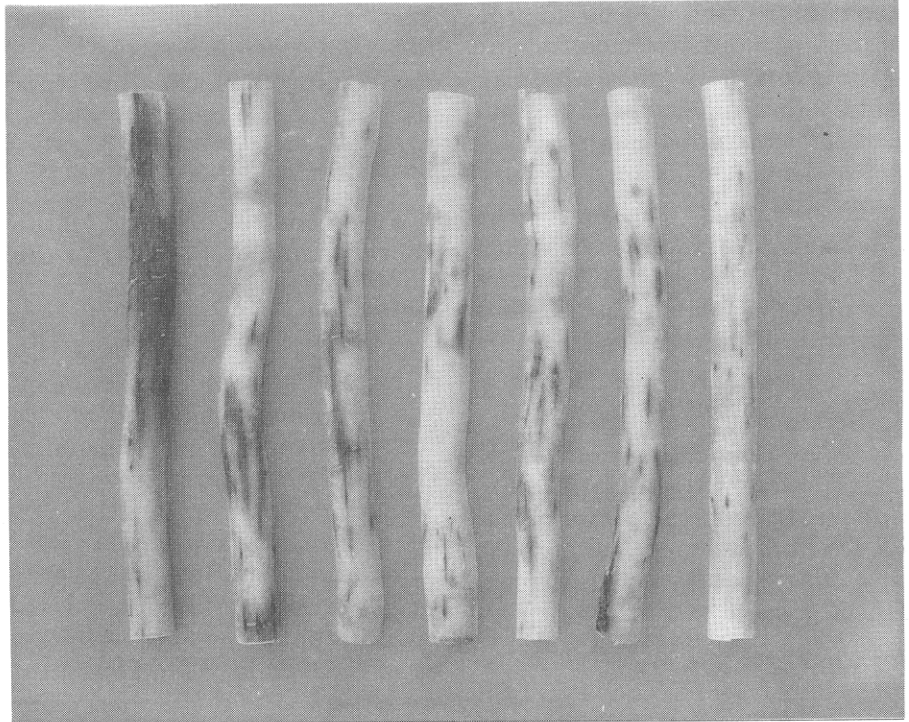


Fig.1. Shows lesions and rotting on tender creamy white main roots of coconut

palms of all groups are affected.

The coconut palms grown under the homestead and plantation situations suffer considerable damage due to the infestation by nematodes right from the seedling stage.

Of the 78 nematode species reported on coconut (Govindankutty and Koshy, 1979), the most important endoparasites are red ring nematode *Rhadinaphelenchus cocophilus* and the burrowing nematode *Radopholus similis*.

Rhadinaphelenchus cocophilus

Historical background

The "Red Ring Disease" of coconut caused by *Rhadinaphelenchus cocophilus* was first reported as occurring in Trinidad by Hart

(1905). Later it was reported in Grenada (Novel, 1918). It is a major problem faced by the coconut industry in Caribbean, Central and South America. The disease does not occur in Africa, Southeast Asia, Malaysia, the Pacific Islands, Florida or Cuba (Dean, 1979). *R. cocophilus* was first described by Cobb (1919) as *Aphelenchus cocophilus*. Goodey (1960) designated it as *R. cocophilus* Nowel (1920) and demonstrated its pathogenicity.

Diagnostic Features (Thorne 1961)

A) Female : Body very slender. Offset head, prominent cephalic framework composed of strong sclerotized arches. Spear with strong basal knob. Median bulb elongated. Vulva covered by a flap

of cuticle leading into a curved vagina.

B) Male : Body slender. Offset head, prominent cephalic framework. Spear with strong basal knobs. Elongated median bulb. Most characteristic feature is the tail, which on death curves to about four-fifths of a circle. Spicules are slightly arcuate and have prominent rostrum. Tail bears a terminal bursal flap. Four pairs of ventrosubmedian papillae are present.

C) Juveniles : Pre-audit juvenile has conical rounded head, not set off from the body. Tail shorter than that of female with a short sharp terminal bearing a mucron.

Systematic position

Nematoda, Secernentea, Tylenchida, Aphelenchina, Aphelenchoida, Aphelenchoididae, Rhadinaphelenchinae and Rhadinaphelenchus.

Distribution

At present *R. cocophilus* has been reported from the West Indian Islands of Tobago, Grenada and St. Vincent and from the Dominican Republic, Venezuela, Guyana, Surinam, French Guyana, Colombia, Ecuador, Mexico, Brazil, Panama, Costa Rica, Honduras and El Salvador. It has not been reported from India (Dean, 1979).

Hosts

Though *R. cocophilus* is primarily found on coconut and oil palm, it has also been found to occur naturally in the date palm and cabbage palm (Haglay, 1962). Successful inoculations have been reported in a number of palms (Brathwaite & Siddiqi, 1975; Dean, 1979)

Life cycle

Life history studies conducted by inoculating immature nuts of coconut palm showed that the nematodes completed one life cycle 9 to 10 days which is probably one of the shortest life

cycle reported for plant parasitic nematodes (Blair, 1966; 1970).

Survival

R. cocophilus can survive for sufficient time and move over sufficient distance in soil (Fenwick, 1969). It survived for a maximum of 15 days in soil (Blair, 1964). In fresh water films it survived for 7-8 days and in sea water for 3 days (Dean, 1979). The third stage juvenile is the most persistent form.

Dispersal

Fragments of diseased tissue from contaminated bodies of the palm weevil *Rhynchophorus palmarum* are deposited into the bases of leaf axils of healthy palms. The nematode is carried by weevil larvae, pupae and adults both internally and externally. The nematode persists without change or multiplication through the metamorphosis of the insect. On emergence of the adult insect, large numbers of nematodes located in the region of the ovipositor of the female are injected into the soft tissue of the coconut palm when the insect deposits eggs (Ashby, 1921; Haglay, 1962; Fenwick & Mohammed, 1962; Griffith; 1967; 1968).

Natural cannibalism in the larvae also affects the number of emerging weevils. The bacterium *Micrococcus roseus* Ali-Cohen in cedros wilt diseased palms produces disease in affected palm weevils. Moreover, some ground lizards also feed on the adult insects. The nematode dies in decomposing tissue of diseased palms and an unidentified fungal parasite exists for the nematode (Griffith & Koshy, 1989).

Nature of damage

Symptoms

Palms of bearing (5-7 years) are more susceptible to infestation. Primary symptoms is the appearance of yellowing of the lower

leaves starting at the tips of distal pinna which progresses towards the base of the pinnae and leaves. The yellowing is succeeded by browning and later by death of the leaf. The inner leaves are also affected and the affected trees die within 3-4 months of the appearance of the primary symptoms.

Internal symptom of a red-ring nematode infested palm is characteristic. At first, about 2.5 cm beneath the stem surface scattered reddish dots of about 1 mm diameter are seen which eventually coalesce to form an orange-red ring about 3 cm in width. Hence the name red-ring disease and red-ring nematode. The ring extends the whole length of the stem and roots and in petioles it assumes a crescent-like shape. Large number of juveniles are seen in the centre of the discoloured areas and adults in the periphery (Fenwick, 1969; Brathwaite & Siddiqi, 1975; Dean 1979). Shedding of green nuts of all sizes takes place. In advanced stages of infection putrefaction of the soft tissues takes place.

R. cocophilus causes little leaf disease of coconut and oil palm in Surinam and Guyana (Hoof & Seinhorst, 1962).

Histopathology

A thermostable phytotoxin produced due to breakdown of coconut tissue (Goberdhan, 1963). Water uptake of infested coconut palms was less due to occlusion of xylem vessels (Goberdhan, 1964; Blair, 1964; Blair & Darling, 1968). In the upper parts of the stem, the nematodes are found intercellularly (Goberdhan, 1964; Blair, 1964). In coconut roots, the nematode attacks cortical tissues.

Losses

At present, most Latin American and Caribbean countries show losses ranging from less than one per cent to more than 20 per cent of 2 to 10 year old trees. Thirty-

five per cent mortality of young coconut palms has been reported in Trinidad and 80 per cent loss in a single plantation in Tobago (Esser, 1969). Within a span of 10 years, 35 per cent of oil palms died in Venezuela (Oostenbrink, 1963).

Control

Biological

The vector weevil is found to be parasitized by several species of Rhabditidae or Heterorhabditidae throughout Latin America. Since the vector insects can be highly parasitized with the above nematodes selective pressure can be introduced against the vectors. Such measures are being employed in Trinidad with a species of Rhabditidae (Griffith & Koshy, 1989).

Chemical

The leaf axils of diseased palms should be sprayed with 0.1 per cent Lannate (Methomyl) insecticide suspension when early symptoms appear. Then the palm should be poisoned by adding one tablespoon of weedicide "100" in three holes (2 cm diameter and 10 cm deep) bored around the trunk of the tree at a level of 15 cm above the soil. In advanced stages the palms should be cut down and the piece and stumps sprayed with at least 4.5 l of 0.1 percent Lannate suspension.

Guard baskets made of 2 cm mesh wire are used to protect frequent outbreaks of the disease. These baskets are filled with fresh infected tissue and sprayed with 0.1 per cent Lannate suspension. The palm weevils are attracted to the tissues in the basket. After two weeks the tissues in the basket is burnt. One guard basket is used per 0.4 ha of palms.

Integrated

Eventhough no effective method of control is known at the moment, the following methods are being adopted:

1. Phytosanitation by using arsenic preparations in diseased tree
2. Leaf axil filling with a granular nematicide
3. Control of the palm weevil by applying insecticide.
4. Use of resistant varieties with short internodes
5. Plant quarantine measures to check its spread to newer areas.

Radopholus similis **(Cobb, 1893) Thorne, 1949** **Historical background**

The burrowing nematode, *Radopholus similis* was first described by Cobb (1893) as *Tylenchus similis* from necrotic root lesions of banana *Musa sapientum* received from Fiji in 1891. It was renamed as *Radopholus similis* by Thorne (1949) and Sher (1968), who confirmed it as the type species of the emended genus. The nematode occurs in most tropical and sub-tropical areas of the world.

Diagnostic features **(Thorne, 1961)**

Female: Vermiform, migratory, endoparasitic. Lip region rounded, strong well-developed stylet and oesophagus. Two outstretched ovaries, tail conoid to blunt, rounded terminus.

* Male: Vermiform, migratory, not parasitic. Lip region sub-spheroid, offset, slender stylet, degenerated oesophagus. Single testis, spicules paired with bursa extending two-thirds length of the tail.

Juveniles: Vermiform, migratory, parasitic. Lip region rounded, well-developed stylet and oesophagus.

Systematic position

Nematoda, Secernentea, Tylenchida, Tylenchoidea, Pratylenchidae, Radopholinae, *Radopholus*.

Distribution

R. similis has been reported from coconut palms in Florida,

U.S.A., Jamaica, Sri Lanka and India (van Weerd *et al.*, 1959a; 1959b; Latta, 1966; Weischer, 1967; Koshy *et al.*, 1978). Surveys conducted in coconut plantations in South India recorded 24 per cent incidence of *R. similis* in coconut (Sosamma, 1984; Koshy *et al.*, 1978).

3.5 Hosts

The coconut isolate of *R. similis* has a wide host range which includes many weeds, crops, fruit trees and many palms. Fortyeight species of plants belonging to fortyfive genera of seventeen families were recorded as hosts in India (Koshy & Sosamma, 1975; Sosamma & Koshy, 1977; 1981; Holdeman, 1986).

Biology

Life cycle

R. Similis is a migratory endoparasite and is capable of spending its entire life within roots. All juvenile stages and adult females including gravid females except the fourth stage and adult males are found to be infective. One life cycle was found to be completed within 25 days at a temperature range of 25-28°C (Koshy, 1986; Loss, 1962)

Survival and Dispersal

Burrowing nematode populations survive under field conditions for six months in moist soil (27 to 36°C) and one month in dry soil (29 to 39°C), whereas it survives for 15 months in moist soil (25.5 to 28.5°C) and 3 months in dry soil (27 to 31°C) under greenhouse conditions. The nematode survives in roots of stumps of felled coconut palms upto six months (Sosamma & Koshy, 1986). Studies conducted at the Central Plantation Crops Research Institute (Regional Station), Kayangulam, Kerala, India, show that adult females are the most persistent form in coconut roots and soil

during summer months and caused annual recurrence of infection.

In coconut plantations in Kerala, coconut seedlings are raised by sowing seednuts in the interspaces of coconut palms. The burrowing nematode is widely prevalent in most of the nurseries in Kerala and Tamil Nadu. One-year-old coconut seedlings raised in such infested nurseries harbour large populations of the burrowing nematode within roots both internal and external to the husk. These infested seedlings when distributed to distant places through government as well as private agencies for planting help in the dissemination of the nematode. Moreover, in the present day fast trade between countries for foliage and other ornamental plants such as *Anthurium* spp., *Calathea* spp. etc. chances of dissemination of *R. similis* through these non-conventional hosts are greater.

Biotypes/Pathotypes

Two morphologically indistinguishable races of *R. similis* are known. One is the 'banana race' which parasitizes both banana and citrus (Du Charme and Birchfield, 1956). But, the citrus race has been elevated to species rank and named *Radopholus citrophilus* because it has a haploid number of five chromosomes ($n=5$) against 4 ($n=4$) in banana race (*R. similis*) and it differed in protein patterns and pheromone mediated behaviour (Huettel *et al.*, 1984). In addition there is a report of an *R. similis* population in Puerto Rico which has a haploid number of five ($n=5$) chromosomes not infesting five species of *Citrus* (Rivas & Roman, 1985). The coconut isolate of *R. similis* from Kayangulam and Kasaragod in Kerala, India is the banana race (Koshy & Sosamma, 1977) with a haploid number of 4 ($n=4$) chromosomes.

Influence of Environmental Factors

Studies on population fluctuations of the burrowing nematode

in coconut plantations in Kerala, India showed that infested coconut roots yielded maximum number of *R. similis* during October to November and minimum during March to July. A mean soil temperature below 25°C and light rainfall coupled with availability of tender fleshy roots are favourable for nematode multiplication (Koshy & Sosamma, 1978). The burrowing nematode multiplies well on coconut in loamy sand followed by riverine alluvium and least in 'Kari' soil and causes maximum plant damage in riverine alluvium and least in laterite soil (Sosamma & Koshy, 1985).

Nature of Damage

Symptoms

Burrowing nematode infested coconut palms exhibit general decline symptoms like yellowing, button shading, reduction in leaf size, yield etc. which are non-specific. Symptoms on roots are more specific. *R. similis* on infestation produces isolated elongate orange-coloured lesions on tender and semi-hard roots. Consequent to nematode parasitization and multiplication, these lesions enlarge and coalesce to cause extensive rotting of roots (Fig.1). Tender roots on heavy infestation become spongy in texture. On semi-hard orange coloured roots surface cracks are commonly seen. Lesions are not usually seen on the old, hard, dark brown roots. As high as 4,000 nematodes were recovered from one gram (one inch length) of main roots. The nematode also attacks the plumule, leaf bases and haustoria of seedlings. The drastic reduction in the number and mass of tertiary feeder roots on parasitisation by the nematode limits plant growth (Koshy *et al.*, 1975 (Koshy & Sosamma, 1987; Koshy & Sosamma, 1996).

Histopathology

Burrowing nematode penetrates the absorbing region covered by very delicate epidermis

behind the root cap by lysis of cells. Such entry points of 1-2 cells in diameter and surrounded by sclerenchymatous cells to a depth of 10-15 cells. The cavities formed in the outer cortex are always surrounded by deeply stained and heavily suberised cells of irregular shape unlike those formed in the inner cortex. Maximum number of nematodes and cavities are seen in the outer cortex. Nematodes are not observed in the stellar region. In the early stage of infection, roots show cavities of independent origin separated by several cells. Consequent to nematode multiplication and lysis of cytoplasm and cell walls, adjacent cavities merge with each other thus destroy in the cortex to a great extent. All stages of the nematode are seen in cavities in longitudinal sections (Koshy & Sosamma, 1987).

Interaction with Other Micro-organisms

The fungi *Cylindrocarpon effusum*, *C. lucidum* and *Cylindrocladium clavatum* have been recorded in association with lesions produced by *R. similis* in coconut roots. In pathogenicity studies, *C. effusum* did not cause any appreciable damage to inoculated seedlings. But when it was inoculated simultaneously with the nematode, the rate of multiplication of the nematode and damage to coconut seedlings was reduced (Sosamma & Koshy, 1978; 1983; Koshy & Sosamma, 1987).

Nematodes viz. *Aphelenchoides aligarhiensis*, *Panagrolaimus rigidus*, *Rhabditis* sp. and *Trophurus* sp. have been found associated with leaf rot disease affected unopened leaves (spindles) of coconut in root (wilt) affected areas. Investigations are being carried out to prove the role of these nematodes, in the etiology, if any, in the incidence of leaf rot disease.

Losses

R. similis causes heavy crop loss to many fruit, spice and agri-

cultural plantation crops. It is notorious for having wiped out 22 million black pepper vines in the Banka Island of Indonesia within two decades (Christie, 1957). Similar spreading decline in citrus caused by *R. similis* first observed in Florida (1928) spread to 6000 ha within 35 years (Kaplan, 1985). It causes root rot, black-head toppling diseases and decline in banana (Blake, 1972). It causes 30 per cent yield loss in coconut. The threshold inoculum density required to cause significant reduction in various growth parameters of coconut is 100 nematodes/625 cubic cm sandy loam soil over a period of five years under field conditions (Koshy & Sosamma, 1987).

Control

Cultural

The cultural practices which exist in Kerala and Karnataka, India such as application of oil-cakes, farm yard manure and growing of sunnhemp in the basins and interspaces, and their incorporation as green manure may help in the inhibition of nematode multiplication.

Plant Resistance

Of the 29 exotic and 15 indigenous coconut cultivars and 15 hybrids screened, the dwarf cultivars, Kenthali and Klappawangi and the hybrids such as Java Giant x Kulasekharam Dwarf Yellow, Kulasekharam Dwarf Yellow x Java Giant, Java x Malayan Dwarf Yellow and San Roman x Gangabondam recorded the least nematode multiplication and lesion indices (Sosamma *et al.*, 1980, 1986; Sosamma, 1984).

Chemical

Increased incidence of *R. similis* was noticed in coconut nurseries when banana was used as a shade crop. More than 50 per cent of the seedlings raised in such nurseries failed to establish on transplantation to the main field. Treatment of nurseries with nematicides is the only way to release nematode-free seedlings.

A dip in 1000 ppm DBCP for 15

minutes was found effective in controlling nematode population and to ensure release of nematode-free coconut seedlings from *R. similis* infested coconut nurseries (Koshy & Sosamma, 1979). Soil application of phenamiphos or phorate @ 25 kg a.i./ha during September, December and May in infested coconut nurseries completely eliminated *R. similis* (Koshy & Nair, 1979; Koshy *et al.*, 1983; Sosamma *et al.*, 1986).

Application of phorate @ 10 g a.i./palm in June-July and again in October -November increased 30 per cent yield of *R. similis* infested palms.

Biological

Studies with *Paecilomyces lilacinus*, *Pasteuria penetrans* and VAM have shown that these micro-organisms can suppress nematode population and may become useful control agents.

The effect of the biocontrol agents *Paecilomyces lilacinus*, *Trichoderma viridae*, *T. harzianum*, *Verticillium Chalmydosporium*, *Pasteruia penetrans* and VAM on the burrowing nematode was studied in the green house. *P. lilacinus* is found to infect the eggs of the burrowing nematode. A virulent strain of *P. penetrans* which is highly pathogenic to *R. similis* was found to infect all stages of *R. similis* experiments conducted in the green house proved that prior colonization of VA mycorrhizae could promote plant growth characters viz. height, leaf area, shoot weight, root weight and ameliorate the ill-effects of *R. similis* infestation on coconut seedlings. Application of mycorrhizal inoculum in nursery beds enhanced the growth of the seedlings compared to untreated beds.

Integrated

The following measures are suggested for an integrated management schedule for *R. similis* infestation on coconut palms:

1. Application of cowdung farm-yard manure, oil cakes and

green manure to the basins. *Crotolaria juncea* may be cultivated in the basin and interspaces and used as a green manure.

2. Application of phorate @ 10g a.i./palm in June-July and October-November.
3. Avoid banana as a shade crop in coconut nurseries.
4. Use of nematode-free planting material of coconut and other intercrops.
5. Use of less susceptible / tolerant cultivars or their hybrids in infested areas.

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