

# NEMATODE DISEASES OF COCONUT

P.K. Koshy and Rachel Samuel

Nematology Laboratory

Central Plantation Crops Research Institute

Regional Station, Kayangulam,

Krishnapuram-690533, Kerala

The term 'Nematodes' which means 'threadworms' comes from the Greek word 'Nematoda' (Nema = thread and eidos = form). Nematodes are also known as 'eel worms' (because of their eel like body shape) or 'round worms' as their body appear round in a cross section.

Nematodes are soft bodies, multicellular triploblastic, unsegmented, pseudocoelomate, bilaterally symmetrical worm like animal belonging to the Phylum Nematoda. Nematode parasites of man and other animals are grouped under Helminthology while plant parasitic nematodes and other free living forms in soil are grouped under Nematology.

The first references about nematodes are of animal parasitic forms. The Guinea worm, *Dracunculus medinensis* considered as a dreadful nematode causing intense pain and inflammation in human body is mentioned in Egyptian writings even as early as 1553 B.C. Some historians are of the opinion that the 'fiery serpents' that attacked the Israelites (Numbers 21:69 in Bible) were the same Guinea worms. References about animal parasitic nematodes are cited in Aristotle's writings (384-322 B.C.) and also in early Indian scriptures (4000-6000 B.C.).

It might not be surprising if we believe that the nematode, *Anguina*

*tritici* was the reason for William Shakespeare's mention about 'Sowed Cockle, reap'd no corn' in his article 'Love's Labour's Lost' in 1594. The first discovery of a plant parasitic nematode was made by John Needham in 1743. The root-knot nematodes infesting greenhouse cucumbers were the next plant parasitic nematodes to be reported. Later years recorded more and more new nematode species attacking various crops in different parts of the world.

The first report of a plant parasitic nematode in India was of root-knot nematode infesting seedlings of tea in Munnar, Kerala by Barber in 1901. The next report was in 1906 when Butler recorded root-knot nematode on black pepper in Kerala. Since then a number of crops and weeds were reported susceptible to root-knot, cyst, ear cockle and other nematodes but organised research in Nematology was started only in 1960. Weischer (1967) during his survey of nematodes associated with the root (wilt) disease of coconut, was the first to observe *Radopholus similis* infestation of coconut in Kerala.

Plant parasitic nematodes are mostly microscopic and invisible to the naked eye. The plant and soil nematodes have a body size ranging from 0.3 - 1.0 mm, which in a few cases extend upto 5.0 mm. *Paralongidorus maximus* of a length

of over 1 cm is the largest known species of plant parasitic nematode. *Paratylenchus* spp. are among the smallest plant parasitic nematode. *None of the Paratylenchus* spp. is known to exceed 0.5mm and mostly are less than 0.3 mm in length. Animal parasites are easily visible to the naked eyes because of their large size (even upto 1m). The nematode parasitising the placenta of sperm whale was reported to be 27 feet long. The identifying character of a plant parasitic nematode is the presence of a small needle like protrusible structure at its oral end called spear or the stylet. This is totally absent in animal parasites and other free living forms.

## NEMATODES OF COCONUT

Though many nematode species have been found associated with coconut palms, the nematodes that are considered to be economically important are only two - the Red-ring nematode (*Rhadinaphelenchus cocophilus*) and the borrowing nematode, *Radopholus similis*. The red-ring disease has so far never been reported from India as well as from south east Asia. The only important nematode found associated with the coconut palms in India is the *Radopholus similis*. Nematodes that are of common occurrence in the rhizosphere of coconut palms in India are *Aphelenchoides* sp, *Criconemoides* sp,

*Dolichodoros pulvinius*, *Helicotylenchus abunaamai*, *Hemicycliophora* sp., *Hemicriconemoides* sp., *Hoplolaimus seinhorsti*, *Longidorus saginus*, *Meloidogyne* larvae, *Pratylenchus* sp., *Pratylenchus zaeae*, *Radopholus similis*, *Rotylenchulus reniformis*, *Tylenchorhynchus* sp., *Tylenchus* sp and *Xiphinema* sp. Many of the weeds and intercrops growing in the coconut basins and inter spaces serve as good hosts for the multiplication of these nematodes.

### 1. *RADOPHOLUS SIMILIS* (Cobb, 1893) Thorne, 1949

In India, the burrowing nematode, *Rodopholus similis* is the only important nematode pest that significantly affects the growth and yield of the palm. The population has been identified as the banana race (Koshy & Sosamma, 1977) having a haploid number (n=4) of chromosomes. A wide variety of crops viz. banana, black pepper, ginger, turmeric, sweet potato, ground nut, sugarcane, betel vine, arecanut and many of the ornamental plants are known hosts of this nematode. *R. similis* occurs in most tropical and sub-tropical areas of the world and has been reported from coconut palms in Florida (Van Weerd et al., 1959a, 1959b), Jamaica (Latta 1966), Sri Lanka (Ekanayake, 1964) and India (Weischer, 1967; Koshy et al., 1978).

*Diagnostic Features of Radopholus similis* (Cobb, 1893) Thorne, 1949

**Systematic Position:** Nematoda, Secernentea, Tylenchida, Tylenchoidea, Pratylenchidae, Radopholinae, Radopholus.

**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.

### Symptoms

Burrowing nematode infested coconut palms exhibit general decline symptoms like stunting, yellowing, reduction in the number and size of leaves and leaflets, delay in flowering, button shedding and reduced yield. As the above ground symptoms are non-specific, the definite method to identify the nematode damage is to look for the characteristic lesions on the young creamy white roots in October-November and ascertain the presence of nematodes by staining the roots. *R. similis*, on infestation produces small elongate, orange-

coloured lesions on the tender creamy-white roots. As a result of nematode multiplication and parasitisation, these lesions enlarge and coalesce to cause extensive rotting of roots. The tender portions of the root on heavy infestation become spongy in texture. Surface cracks develop on the semi-hard orange coloured roots. Lesions are generally rare on the old, hard dark brown roots. Symptoms are better seen on pencil thick tender main roots compared to secondary and tertiary roots as they rot quickly (Fig.1). One gram of the infested root can yield as many as 4000 nematodes (Koshy et al., 1975). Plumule, leaf bases and haustoria of seedlings are also susceptible to *R. similis* infestation.

*R. similis* is a migratory endoparasite capable of spending its entire life cycle within roots. The nematode completes its life cycle (J<sub>2</sub>-J<sub>2</sub>) within 25 days at a temperature range of 25-28°C (Koshy, 1986). Except the fourth stage male juveniles and adult males, all other juvenile stages and adult females

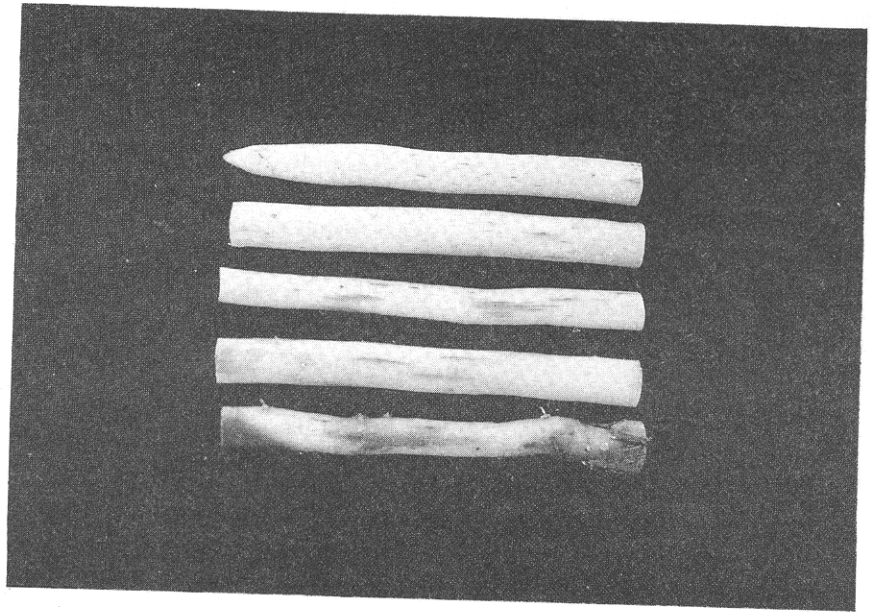


Fig. 1. Shows lesions and rotting on tender, white main roots of coconut

are found to be infective. The burrowing nematodes penetrate the absorbing region of the root behind the root cap, by the lysis of the cells. Such entry points are 1-2 cells in diameter and surrounded by sclerenchymatous cells to a depth of 10-15 cells. In the early stages of infestation, the roots contain independent cavities separated by several cells. Consequent to nematode multiplication and lysis of cell walls and cytoplasm, the adjacent cavities merge with each other leading to almost complete destruction of the cortex. Longitudinal section of the roots showed nematodes in all stages of development (Koshy & Sosamma, 1987).

Thirty per cent increase in yield was recorded by application of *Hydnocarpus wightiana* Bl. oil cake (Marotti oil cake) at 8 kg/palm/year or Phorate or Aldicarb @ 10g a.i./palm in June-July and October-November to the burrowing nematode infested coconut palms (Koshy, 1986). The threshold inoculum density causing significant reduction in various growth parameters was 100 nematodes/seedling or one nematode in 576cm<sup>3</sup> or 800 g sandy loam soil over a period of five years (Koshy & Sosamma, 1987).

The pathogenic effect of *R. similis* on growth, flowering and yield of coconut (WCT) was established under field conditions by conducting an experiment for a period of 12 years in 1.8 x 1.8 x 1.2 M tanks filled with methyl bromide fumigated sandy loam soil. Burrowing nematodes were inoculated in logarithmic series viz. 100, 1000, 10,000, 1 lakh and 10 lakhs to individual seedlings with five replications for each inoculum level and 5 plants were retained as control. All the uninoculated palms came

to flowering during 65-83 months after planting whereas four out of five palms that received an initial inoculum level of 100 nematodes flowered during 67-130 months. Two palms each that received an initial inoculum level of 1000 and 10,000 nematodes came to flowering after 108 months and one out of five palms which received an initial inoculum level of one lakh nematodes came to flowering after 132 months. None of the palms that received 10 lakh nematodes came to flowering. However, the palms that received an initial inoculum of 1000 nematodes and above did not yield any nuts even after 12 years of planting. The control palms produced a total of 624 nuts compared to 186 nuts by palms that were inoculated initially with 100 nematodes. The economic threshold level of *R. similis* on coconut (WCT) is 100 nematodes per seedling or one nematode in 3.5 kg loamy sand under the experimental conditions (Koshy & Sosamma, 1994 unpublished).

#### Survival and dispersal

Under field conditions, the burrowing nematode survives for six months in moist soil (27-36°C) and one month in dry soil (29-39°C). Under greenhouse conditions it survives for fifteen months in moist soil (25.5-28.5°C) and three months in dry soil (27-31°C). The nematode survives for upto six months in the roots of stumps of felled coconut palms (Sosamma, 1984). A mean soil temperature below 25°C and light rainfall coupled with availability of tender fleshy roots are the favourable factors for burrowing nematode multiplication (Koshy & Sosamma, 1978). Studies on the seasonal fluctuation of the burrowing nematode population in coconut plantation in Kerala,

showed that infested coconut roots yielded maximum number of *R. similis* during October to November and minimum during March to July.

The nematode is generally disseminated through rooted planting materials such as banana suckers, rooted pepper cuttings, infested seed rhizomes of ginger, turmeric, infested coconut seedlings, farm implements, irrigation and through rain water, soil dispersal and also through man and other animals.

Many of the government coconut nurseries in Kerala and Tamil Nadu are heavily infested with *R. similis*. Such infested nurseries serve as distribution centres of *R. similis*. The seedlings raised in infested nurseries, on transplantation into other fields spread the nematodes. Cutting of all roots close to the husk before transplantation helps in reducing the inoculum carried by the seedlings. But the roots inside the husk are also infested and carries large inoculum. New roots put out, on transplantation, get infested quickly from the nematodes carried by the seedlings as well as from the nematodes present in the planting pit. Heavily infested seedlings thus suffer from lack of nutrition and water because of rotten roots and fail to put out new leaves and easily succumb to drought during the ensuing summer. Such seedlings should be treated with 30 gms of phorate at transplantation and again after 3 months. The nematicide application should be carried out atleast twice a year which will also keep the seedlings reasonably free of insect pest attack, as phorate is primarily a systemic insecticide.

Coconut cultivars Kenthali, Klappawangi, Java Tall and hybrids viz. LO x Gangabondam, COD x WCT, MDY x Java Giant, San Ramon x Gangabondam and Java Giant x MDY are found tolerant to burrowing nematodes (Sosamma, 1984).

#### Control

1. Use nematode free coconut seedlings and planting materials of other intercrops.

2. Apply phorate @ 10 kg a.i. / ha in heavily infested nurseries during September, December and May. Remove all roots external to the husk before planting to reduce the inoculum carried to the planting pit.

3. Use less susceptible/tolerant cultivars or hybrids of coconut and intercrops in infested areas.

4. Avoid use of banana as a shade crop in nurseries.

5. Sanitational methods such as exposing planting pits to summer heat, burning of trash in pits and solarising nursery beds will help in reducing nematode multiplication.

6. Apply phorate @ 10g a.i./ palm in June/July and in September/October to infested palms in the field.

7. Grow green manure crops viz. *Crotalaria juncea* or *Peuraria javanica* in coconut basins and interspaces or *Glyricidia maculata* on the borders and incorporate the leaves and tender stem into the soil in September/October.

8. Incorporate effective biocontrol agents viz. bacteria, fungi and the beneficial symbiotic Vesicular arbuscular mycorrhizal fungi into the nursery beds and planting pits for reducing nematode multiplication, for improving

plant growth and imparting tolerance/resistance to nematodes. Prior inoculation of VA mycorrhizal fungi 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.

9. Effect of vermicompost on the multiplication of nematodes is yet an area to be studied.

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

#### 2. RHADINAPHELENCHUS COCOPHILUS (Cobb, 1919; Goodey, 1960)

The most important nematode disease of coconut Red-ring disease caused by the nematode, *Rhadinaphelenchus cocophilus*. This disease is transmitted by the black palm weevil, *Rhynchophorus palmarum* L. The gru-gru palm, cohune nut palm, oil palm, date palm, cabbage palm, royal palm and sabal palm are also susceptible to the red-ring nematode. The life cycle of the nematode is 9-10 days.

The disease, first reported in Trinidad by Hart (1905) is now reported to occur in twenty countries seriously affecting their economy. The countries are West Indies (Trinidad, Tobago, Grenada and St. Vincent) and from Latin America - Dominican Republic, Venezuela, Guyana, Surinam, French Guyana, Colombia,

Ecuador, Peru, Mexico, Brazil, Panama, Nicaragua, Costa Rica, Honduras, Belize, El-salvador and Guatemala.

#### Symptoms

Chlorosis that first appears at the tips of the oldest leaves gradually spreads towards the leaf-bases. The yellowed leaves later dry up and turn brown. The brown lower leaves may break across the petiole and may hang down. Premature shedding of the nuts is another symptom. About four to six weeks after the appearance of the first symptom, the crown often topples as a result of severe internal damage caused by the palm weevil. The trunk then remains standing in the field for several months and finally it decays (Griffith & Koshy, 1990). Full development of internal symptoms in the stem, roots and petioles takes place even prior to the expression of the first external symptoms. The most characteristic symptom of the red-ring disease is the internal lesions and the characteristic orange-red ring (2-4 cms wide) extending the whole length of the stem from top to bottom. In the beginning, scattered reddish dots of about 1 mm diameter first appears about 3-5 cms below the stem surface. Roots and petioles also show discolouration. Root cortex become orange to faint red, dry and become flaky. In the petioles, it assumes a crescent shape. In dwarf coconut varieties, the red colour gives way to shades of brown. Large number of nematodes are encountered in the infested parenchymatous cells of the stem, petioles and roots. Nematodes have never been encountered in the xylem vessels, but the xylem vessels often get occluded by tyloses. Infested trees invariably die. Young

coconut trees of 3-10 years old are most commonly affected by the disease.

The female palm weevil makes punctures in the softer tissue of stem of the coconut palm (generally in the soft axils) and the eggs are deposited. The eggs are placed normally deep in the puncture. Larvae of the palm weevil while feeding in diseased trees get infested with nematodes and the adult beetles that emerge, act as carriers. Diseased tree acts as the breeding ground for insects and red-ring nematodes and attracts all palm weevils including potential vectors. All stages of the insect are able to carry the nematode infestation, either internally or externally for transmission. Weevils trapped from an infested area, showed that about 35-45% of them act as carriers of living nematodes with an average of 71 nematodes.

### Control

Griffith (1971) recommended spraying of the leaf axils of the diseased trees with 0.1 per cent Lannate (Methomyl) insecticide solution. Immediately then, the trees should be killed with herbicides (Weedicide "100" or Silvisar '510'). Trees in the advanced stages of the disease should be cut down and the pieces and remaining stumps sprayed thoroughly with atleast 4.5 litres of 0.1 per cent Lannate solution. Burn off the dried remains after 14 days. Traps or guard baskets for attracting and killing the palm weevils can also be used. Biocontrol measures involving the parasitization of vector weevils using several nematode species of Rhabditidae or Heterorhabditidae are being tried in Latin America (Griffith & Koshy, 1990). Trapping and killing of vec-

tor weevils with the use of the male produced aggregation pheromone 'Rhyncholure' (2-methyl-5(E)-hypten-4-01) will be an ideal method (Chinchilla *et al.*, 1993). Leaf axil treatment of young non-bearing palms (3-10 year old) quarterly with Phorate @ 3 g a.i./palm or any other granular nematicide is yet another method which could be thought of.

Red-ring disease originally found in coconut is known to cause red-ring and little leaf disease in oil palm. (Van Hoff & Seinhorst, 1962; Webster & Gonzales, 1959). Even though the disease has so far not been reported from India or from South East Asia, the risk involved in importing the planting materials of oil palm from countries known to have red-ring disease on coconut eg. Costa Rica should be taken into consideration and strict plant quarantine measures need to be adopted at the ports of export and import and periodical observations need to be carried out for symptoms after planting in the field.

### REFERENCES

- Chinchilla, C.M., Oehlschlager, A.C., and Gonzalez, L.M. 1993. *Management of Red ring disease in oil palm through pheromone-based trapping of Rhynchophorus palmarum* (L). Proceedings of PORIM oil palm congress, Kuala Lumpur, Malaysia, Sept. 1993.
- Ekanayake, U.B.M. 1964. Annual Report of the Crop Protection Officer, Coconut Research Institute for 1963. *Ceylone Coconut Quarterly*. 15 : 50-57.
- Griffith, R. 1971. Red ring disease : the mechanism of spread and recommendations for control. *Nematopica*. 1 : 2.
- Griffith, R. and Koshy, P.K. 1990. Nematode parasites of coconut and other palms. In *Plant parasitic nematodes of Sub-tropical and Tropical Agriculture* (Eds) Luc.M., Sikora, R.A. and Bridge, J. CAB England pp. 363-386.
- Hart, J.H. 1905. Coconut disease. *Bulletin of Miscellaneous information*, Royal Botanic Gardens, Trinidad, 6:241-243.
- Koshy, P.K. 1986. The burrowing nematode, *Radopholus similis* (Cobb, 1893) Thorne, 1949. In *Plant parasitic Nematodes of India - Problems and Progress* (Eds) Swarup, G. and Dasgupta, D.R., IARI, New Delhi, India. pp. 223-248.
- Koshy, P.K. and Sosamma, V.K. 1977. Identification of physiological race of *Radopholus similis* populations infesting coconut, arecanut and banana in Kerala, South India. *Indian Phytopath.* 30:415-416.
- Koshy, P.K. and Sosamma, V.K. 1978. Studies on the population fluctuations of *Radopholus similis* in coconut and areca roots. *Indian Phytopath.* 31 : 180-183.
- Koshy, P.K. and Sosamma, V.K. 1979. Control of the burrowing nematode *Radopholus similis* on coconut seedlings with DBCP. *Indian J. Nematol.* 7 : 32-33.
- Koshy, P.K. and Sosamma, V.K. 1987. Pathogenicity of *Radopholus similis* on coconut (*Cocos nucifera* L.) seedlings under greenhouse and field conditions. *Indian J. Nematol.* 17 : 108-118.
- Koshy, P.K., Sosamma, V.K. and Nair, C.P.R., 1975. Preliminary studies on *Radopholus similis*

- (Cobb, 1893) Thorne, 1949 infesting coconut and arecanut palms in South India. *Indian J. Nematol.* 5 : 26-35.
- Koshy, P.K., Sundararaju, P. and Sosamma, V.K. 1978. Occurrence and distribution of *Radopholus similis* (Cobb, 1893) Thorne, 1949 in South India. *Indian. J. Nematol.* 8 : 49-58.
- Koshy, P.K., Sundararaju, P., Sosamma, V.K. and Ravi Kumar, K. 1985. Efficacy of four systemic nematicides against *Radopholus similis* in coconut nursery. *Indian J. Nematol.* 15 : 148-151.
- Latta, R. 1966. Attempts to relate nematodes to lethal yellowing disease of coconut palms in Jamaica. *Tropical Agriculture Trinidad.* 43: 59-68.
- Sosamma, V.K. 1984. *Studies on the burrowing nematode of coconut.* Ph.D. Thesis. Kerala University, Trivandrum, Kerala, India. 195 pp.
- Sosamma, V.K. and Koshy, P.K. 1986. Survival of *Radopholus similis*. National Conference - Plant parasitic nematodes of India - Problems and Progress, 17-20 December, 1986, IARI, New Delhi, India : 107.
- Van Hoff, H.A. and Seinhorst, W. 1962. *Rhadinaphelenchus cocophilus* associated with little leaf of coconut and oil palm. *Neth. J. Pl. Path.* 68 : 251.
- Van Weerd, L.G., Birchfield, W.R. and Esser, R.P. 1959a. Observations on some subtropical plant parasitic nematodes in Florida. *Proceedings of the soil crop Science Society of Florida,* 19 : 443-451.
- Van Weerd, L.G., Martinez, A.P. and Esser, R.P. 1959b. Results of a survey designed to determine the etiology of lethal yellowing of *Cocos nucifera*. *Proceedings of the Florida State Horticultural Society.* 72 : 421-430.
- Webster, B.N. & Gonzalez, J. 1959. *Investigaciones sobre la enfermedad canillo rojo en cocas y palma de aceite.* 9th Convencion de la Association Venezolana el Advance de la Ciencia, Servicio Shell para el Agricultor, Estado Arajua, Venezuela.
- Weischer, B. 1967. *Report to the Government of India on plant parasitic nematodes.* PL 24/52 Report No. TA 2332, FAO, Rome, 15p.

## ROBBER CRAB - COCONUT PEST

*Robber Crab is a pest of coconuts found around the coastal areas of the islands in the Indian and Pacific oceans. As the name implies, the pest 'robs' by eating into the vitals of the nuts. The robber crab is more than a foot long and can tear away the husk of the nut, fibre by fibre, with a powerful pincer legs and hammer the nut with its heavy claws. It then extracts the soft kernel, with its posterior pringers, to eat.*

*Early references of the coconut crab or Birgus latro was made by Charles Clusius, a French botanist in 1605, though not by its name. He observed the giant land crab in large numbers prevalent at Ternate Island of Indonesia. The detailed descriptions of the giant crab confirmed that Clusius was reporting on Birgus latro. Approximately about 200 publications on coconut crab have appeared in print as contributors by travellers, explorers and biologists. In spite of these investigations, still knowledge on the behavioural and sensory physiology of the crab is limited. Reason for this is that the crab lives in remote places and is active only during the night. Although a number of investigators described the robber crab as a pest of coconut palm there are still who claim that it is not a pest of any significance. While the crab enjoys coconut kernel as a vegetable food, this is not an essential diet since the crab also lives in areas where coconuts do not grow at all.*