# NEMATODE MANAGEMENT IN COCONUT AND COCONUT-BASED CROPPING SYSTEM

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**ABSTRACT**

Important nematode pests in coconut and coconut-based farming systems are the burrowing *(Radopholus similis),* the root-knot *(Meloidogyne incognita)* and the lesion *(Pratylenchus coffeae)* nematodes. The burrowing nematode causes severe damage to coconut, arecanut, banana, black pepper, ginger and turmeric. Consequent on heavy root rotting, the plants exhibit loss of vigour, stunting, yellowing of leaves, delay in flowering and reduction in yield. Aerial and underground symptoms produced by other nematodes are discussed.

Measures suggested for developing an integrated nematode management in coconut and coconut-based farming system are the use of nematode-free planting material of coconut and intercrops; application of organic manure to the coconut basins, growing and incorporation of green manure crops in coconut basins, application of phorate and introduction of biocontrol agents like *Pasteuria penetrans, Paecilomyces lilacinus* and VAM to nursery potting mixture to reduce nematode population and for imparting resistance/tolerance to nematode infestation.

The coconut-based cropping systems that have been developed or evolved over many centuries on a low risk basis, are a combination of natural and farmer selections. Even though coconut cropping systems are known in various countries, very little information is available on nematode problems of coconut or of the component crops except for some exploratory surveys conducted (Orton Williams, 1980; Lamberti, 1980 and 1981) as well as investigations carried out in relation to major coconut diseases like lethal yellowing and kaincope disease (Govindankutty and Koshy, 1979). The present paper examines the nematode problems and their management in the coconut-based multispecies cropping systems on the west coast of South India.

## Nematode Problems on Coconut and Component Crops

The important nematodes recorded in coconut-based farming systems in India are the burrowing (*Radopholus similis* Cobb, 1893; Throne, 1949), the

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root-knot (*Meloidogyne incognita* Kofoid and White, 1919; Chitwood, 1949) and the lesion (*Pratylenchus coffeae* Zimmermann, 1898; Filipjev and Schuurmans Steckhoven, 1941) nematodes. The cyst nematode (*Heterodera oryzicola* Rao and Jayaprakash, 1978) was recorded on banana. Coconut as well as the component crops like arecanut, banana, black pepper, ginger, turmeric, and tuber crops are susceptible to one or more species of these nematodes. During a detailed survey in coconut based cropping systems in Kerala and Karnataka States in India, widespread occurrence of *R. similis* on coconut, arecanut, banana, black pepper, ginger, turmeric and betal vine (Koshy *et al.*, 1978; Sundararaju *et al.*, 1979a; Koshy and Bridge, 1990) was recorded. *M. incognita* was recorded on black pepper, banana, ginger, turmeric, *subabul*, cacao, cardamom, pineapple and betelvine whereas the *P. coffeae* was recorded from roots of coffee, banana, ginger and turmeric (Table 61.1).

**Table 61.1:** Susceptibility of different crops to nematode infestation

| *Crops* | *R. similis* | *M. incognita* | *P. coffeae* |
|---|---|---|---|
| INDIA | | | |
| Coconut | + + + | – | + |
| Banana | + + + | + + | + |
| Black pepper | + + + | + + + | – |
| Cacao | – | + | – |
| Nutmeg | + | + | – |
| Cinnamon | – | – | – |
| Pineapple | – | + | – |
| Clove | + | + | – |
| Coffee | + | + | + + + |
| Lemon | – | – | – |
| *Subabul* | – | + + + | – |
| Tapioca | – | + | – |
| Elephant foot yam | – | + + + | – |
| *Taro* | – | + | – |
| Papaya | – | + + + | – |
| Ginger | + + | + + + | + + |
| Turmeric | + + | + + + | + + |

| *Crops* | *R. similis* | *Meloidogyne* sp. | *P. coffeae* | *P. brachyurus* |
|---|---|---|---|---|
| FIJI | | | | |
| Banana | + | + | + | + |
| Coconut | – | + | + | + |
| Coffee | – | – | + | + |
| Ginger | + | + | + | – |
| Papaya | – | + | + | + |

*Contd.*

*Table 61.1 Contd.*

| *Crops* | *R. similis* | *Meloidogyne* sp. | *P. coffeae* | *P. brachyurus* |
|---|---|---|---|---|
| Pineapple | – | + | + | + |
| *Tannia* | – | + | + | – |
| Tapioca | – | + | – | + |
| *Taro* | + | + | + | + |
| Turmeric | + | + | – | + |
| Yam | + | + | + | + |
| KIRIBATI | | | | |
| Banana | – | + | + | – |
| Coconut | – | – | – | – |
| Papaya | – | + | + | – |
| Pineapple | – | – | – | – |
| *Tannia* | – | + | – | – |
| Yam | – | + | – | – |
| NIUE | | | | |
| Coconut | – | – | – | – |
| Papaya | – | + | + | – |
| Pineapple | – | + | + | – |
| *Taro* | – | + | – | – |
| Tapioca | – | – | + | – |
| Yam | – | + | + | – |
| WESTERN SAMOA | | | | |
| Banana | + | + | + | – |
| Cacao | – | + | – | – |
| Coconut | + | + | + | – |
| Coffee | – | + | + | – |
| Cinnamon | – | – | – | + |
| Ginger | – | + | – | – |
| Papaya | – | + | – | – |
| Pepper | – | + | – | – |
| Pineapple | + | + | – | – |
| Tapioca | + | + | – | – |
| *Taro* | + | + | – | + |
| Yam | – | + | – | – |
| TONGO | | | | |
| Cacao | – | – | – | + |
| Coconut | – | + | + | – |
| Coffee | – | – | – | – |
| Papaya | – | + | + | + |
| Pepper | – | + | + | + |
| Pineapple | – | – | – | + |
| *Tannia* | – | + | + | – |
| Tapioca | – | + | + | + |
| *Taro* | – | + | + | + |
| Yam | – | – | + | + |

+ + + = Highly susceptible.
+ + = Moderately susceptible.
+ = Less susceptible.
– = Non-host.

*Radopholus similis*

*Radopholus similis* causes pepper yellows in Indonesia (Christie, 1957), spreading decline of citrus in Florida (DuCharme, 1954) and toppling disease of banana in all banana growing regions of the world (Blake, 1972) except in Israel (Minz *et al.*, 1960) and Taiwan (Huang, 1972).

**Symptoms**

The burrowing nematode infested coconut palms exhibit general yellowing and visible reduction in growth, vigour and yield. These above-ground symptoms are non-specific and the only definite method to identify an infested palm is to look for symptoms on fresh main roots during September to November. *Radopholus similis* on infestation produces small, elongate, orange coloured lesions on the young, succulent, creamy-white to light orange tender portions of roots of coconut, banana and black pepper. These lesions coalesce and cause extensive rotting of roots. Primary lesions also show cracking of epidermis under stereo-microscopic examination. The nematode also attacks the plumules, leaf bases and haustoria of coconut seedlings (Koshy and Sosamma, 1987). Unlike in coconut, the tip of lateral and tertiary roots on infestation become black in arecanut. The primary symptoms of *R. similis* infested or slow decline affected black pepper vines are the appearance of a few, pale yellow, dropping leaves. The number of such leaves gradually increases and within a year or two the entire foliage may become yellow, and lead to shedding of leaves, cessation of growth and die back symptoms. The tender creamy-white feeder roots show typical orange to purple coloured lesions. The root system exhibits extensive rotting with the main roots devoid of feeder roots. The symptoms are well pronounced when soil moisture is depleted during November to May. Infested ginger and turmeric plants exhibit stunting, reduced vigour and tillering and dry faster than healthy plants. Tips of young leaves become chlorotic and scorched. The infested ginger rhizomes exhibit small, shallow, sunken, water-soaked lesions. Infested turmeric rhizomes tend to lose their characteristic bright yellow colour and on cross-section show brown rotting (Sosamma *et al.*, 1979; Sundararaju *et al.*, 1979b).

**Survival**

The nematode is known to survive and multiply more in deep, well drained sandy loam soils but less in shallow, poorly drained clayey soils. The coconut isolate of *R. similis* was found to survive in host-free dry sandy soil for three months and in host-free wet soil for 15 months under greenhouse conditions. Active nematode populations could also be recovered from roots of felled palms for a period of six months (Sosamma and Koshy, 1986).

**Dissemination**

Nematode is disseminated mainly through the infested planting materials, floods, irrigation water, farm implements and bulk transport of soil.

*Meloidogyne incognita*

Black pepper and betelvine infested by both burrowing and root-knot nematodes show unthrifty growth and yellowing of leaves. The prominent symptoms of root-knot nematode infestation on black pepper are a gradual decline characterised by unthrifty growth and yellowing of leaves. Leaves of vines infested with *M. incognita* exhibit dense yellowish discolouration of the interveinal areas making the leaf veins quite prominent with a deep green colour, whereas leaves of the vines infested with *R. similis* show uniform pale or whitish yellow discolouration and typical dropping. Root system becomes heavily galled. In the variety Panniyur-1 the galls are smooth and bigger in size compared to the small galls with exposed egg masses giving a pitted rough appearance to roots of cv. Karimunda.

In ginger and turmeric the root-knot nematode causes galling and rotting of roots and underground rhizomes. Infested plants show stunted growth, yellowing, marginal and tip drying of leaves and reduced tillering. In turmeric, infested rhizomes tend to lose their bright yellow colour (Sukumaran and Sundararaju, 1986; Sukumaran *et al.*, 1989).

*Pratylenchus coffeae*

The lesion nematode-infested ginger and turmeric plants exhibit stunting, reduced vigour and tillering, and dry faster than healthy plants. The youngest leaves become chlorotic with scorched tips. The infested rhizomes exhibit small, shallow, sunken, water-soaked lesions. Infested turmeric rhizomes tend to lose their characteristic bright yellow colour and show brown rotting.

**Economic Threshold Levels**

The pathogenicity of *R. similis* was studied on coconut and other component crops. The threshold inoculum density required for causing significant reduction of various growth parameters on coconut was 100 nematodes in 625 $cm^3$ or 900 g soil under field conditions over a period of five years (Koshy and Sosamma, 1987). In black pepper, reduction in the growth and productivity of the vines were more marked in the vines inoculated with 10,000 and more *M. incognita* while *R. similis* even at 100 nematodes per vine caused significant reduction in all the growth characteristics (Ramana *et al.*, 1987). An inoculum level of 10 burrowing nematodes per vine caused foliar yellowing and defoliation after two years and an inoculum level of 100 nematodes per plant caused 29 per cent reduction in yield compared to 59 per cent reduction with an initial inoculum of 10,000 nematodes per plant after two years (Mohandas and Ramana, 1991). The effect of *R. similis* was studied on turmeric and found that an initial inoculum level of 10 nematodes caused 35 per cent reduction of rhizome weight after four months and 46 per cent reduction at the end of the season (Sosamma *et al.*, 1979). A reduction of 73.6 per cent of rhizome weight was recorded at an initial inoculum level of 10,000 nematodes per plant after a period of six months and an initial inoculum level of 10 nematodes per plant caused 39.9 per cent reduction in rhizome weight (Sundararaju *et al.*, 1979b).

## INTEGRATED NEMATODE MANAGEMENT

Control of the burrowing nematode infestation on coconut with extensive root system is difficult, especially under the high density multispecies cropping system involving susceptible crops like banana, black pepper, ginger and turmeric.

Products of some crops such as banana, papaya, pineapple and betelvine are generally consumed without any processing or cooking. Application of nematicides to the root zone of one component crop can lead to deposition of residues in the produce of an adjoining crop as the roots of these crops are interwoven and the nematicides get carried through irrigation and rain water. Application of phorate at the rate of 10 g a.i./palm to coconut and 3 g a.i./vine to black pepper in June and September has been found beneficial in increasing yield. Application of phorate to banana at the rate of 3 g a.i./sucker at planting and 90 days after planting is beneficial for the control of burrowing and other nematodes besides banana aphid, root grub and rhizome weevil.

The cultural methods that are generally practised such as crop rotation, shifting of planting date, fallowing and flooding are only of limited use in coconut based farming systems, since most of the crops involved are perennial in nature. However, root-knot and burrowing nematode susceptible intercrops such as ginger, turmeric, papaya, elephant foot yam and Chinese potato may be avoided and if grown, planting sites may be changed every year. Growing nematode-resistant crops such as cacao, pineapple, cinnamon, clove, colocasia and tapioca should be preferred. Maximum care should be taken to avoid crop combinations that are susceptible to the same nematode species. Instead of root-knot susceptible *subabul (Leucaena leucocephala), Gliricidia maculata* may be grown on the borders and in the interspaces as a standard for black pepper and its leaves and tender twigs may be used for green manuring because of its known nematicidal properties. Green manure crops like *Crotalaria juncea* and *Pueraria javanica* may be grown in basins and interspaces and incorporated into the soil. Increased use of organic amendments like *neem* and *marotti (Hydnocarpus)* oil cakes, farmyard manure and mulching with weeds, grass, straw and dry leaves help in the build up of predatory nematodes and nematode parasiting fungi.

Sanitational methods such as opening planting pits, when the weather is dry and burning of trash in pits, paring of banana suckers and sun-drying them, solarising nursery beds and potting mixture are some of the easiest and less expensive methods which limit population build up of nematodes.

Host tissue environment is ideal for rapid multiplication of nematodes. Burrowing nematode infested seedlings of coconut and arecanut and rooted cuttings of black pepper do not establish easily and even if they get established initially they do not withstand the drought conditions and more than 50 per cent of them are lost in the first year itself. Seed rhizomes of ginger and turmeric should be raised in nematicide treated plots. Certified nematode free seed/planting material need to be made available as in the case of potato.

Recently biological control of plant parasitic nematodes is receiving greater attention. Some species of fungi and bacteria prevent nematode multiplication and even reduce the damage caused by nematodes. Very little work has been carried out in India on biological control of nematodes except for a few stray records of isolations of fungi. Studies were carried out at CPCRI, to find out the effect of VAM in imparting tolerance to *R. similis* and *M. incognita* infestation on plantation crops in different cropping systems. The effect of six species of VA mycorrhiza individually and in combination with root-knot nematode, *M. incognita* was studied on cardamom. The results revealed that the prior inoculation with VA mycorrhizal fungi, particularly *Glomus margarita* and *G. fasciculatum* were effective in ameliorating the deleterious effects of nematodes and in providing vigorous, healthy seedlings for transplantation in the field (Thomas *et al.*, 1989). Since the root-knot nematode is a serious problem on ginger, causing drastic reduction in rhizome yield (Charles, 1978) the individual and interactive effects of VA mycorrhiza, root-knot nematode *M. incognita* and *Pythium aphanidermatum* were studied on ginger. Inoculation with VA-mycorrhizae, particularly a mixture of *G. fasciculatum* and *G. multicauli* (100 spores) was effective in ameliorating the deleterious effects of nematode and a fungus *P. aphanidermatum* on ginger (Rohini Iyer and Sundararaju, 1990). The use of VA mycorrhiza *G. macrocarpum* as a biological control agent against root-knot nematode was also studied on *subabul* seedlings at CPCRI, Kasaragod. Prior inoculation with VA mycorrhiza *G. macrocarpum* (200 spores per 5 kg soil) was effective in ameliorating the deleterious effects of root-knot nematode on *subabul* (Sundararaju *et al.*, 1990). *Paecilomyces lilacinus* (Thom) Samson reduced the damaging effect of *R. similis* on betelvine when inoculated 25 days prior to nematode inoculation, whereas simultaneous inoculation of both the organisms or inoculation of the fungus 25 days after nematode inoculation was not effective in reducing the damage (Sosamma *et al.*, 1990). While it is not possible to achieve absolute control of plant parasitic nematodes or control to an economic level with biocontrol agents at field level, this method can be part of an integrated nematode management programme.

One of the most economical and effective ways to control nematodes is growing nematode resistant plant cultivars. In view of the importance, various crops grown in coconut based cropping systems were screened against root-knot and burrowing nematodes (Sosamma *et al.*, 1980; 1988; Sosamma, 1984; Mohandas and Ramana, 1983; Jacob and Kuriyan, 1979; Ramana and Mohandas, 1986; Mani *et al.*, 1987; Gunasekharan *et al.*, 1987; Chen *et al.*, 1986; Anonymous, 1987). A list of resistant/tolerant varieties/hybrids to the *R. similis* and *M. incognita* is given in Table 61.2. There are a number of varieties and hybrids in coconut, banana, black pepper, *subabul* and coffee that are either tolerant or resistant to the root-knot and burrowing nematodes. Based on the information available, a suitable crop combination for nematode infested areas is suggested (Table 61.3).

**Table 61.2:** Cultivars/varieties tolerant to burrowing and root-knot nematodes

| *Crops* | *Burrowing nematode* | | *Root-knot nematode* |
|---|---|---|---|
| | *Cultivars* | *Hybrids* | *Cultivars* |
| Coconut | Kenthali<br>Klappawangi<br>Java Tall | LO × Gangabondam<br>COD × WCT<br>MDY × Java Giant<br>San Ramon × Gangabondam<br>Java Giant × MDY | |
| Black pepper | – | – | CLT-P-812<br>Neyyatinkaramundi<br>Jeerakamundi<br>Karimunda<br>Kudirugunda |
| *Subabul* | – | – | K-500, K-72 |
| Banana | Palayamkodan<br>Yelakkabale<br>Njalipoovan | | |
| Coffee | – | – | Robusta |
| Turmeric | – | – | 5379-1-2, 5663-6-3, Kodur, Cheyapuspa, 5335-1-7, 5335-27, Ca-17/1, Cli-124/6 Cli-339, Armoor, Duggirala, Guntur-1 Guntur-9, Rajampet, Sugandham, Appalapadu |

**Table 61.3:** Recommended crop combinations in coconut based HDMSCS with integrated nematode management in India for rainfed conditions

| *Crop combinations* | *1* | *2* | *3* |
|---|---|---|---|
| 1. | Coconut + pepper | Cacao | – |
| 2. | Coconut + pepper | Pineapple | Banana |
| 3. | Coconut + pepper | Nutmeg/clove/cinnamon | Banana |
| 4. | Coconut + pepper | Nutmeg/clove/cinnamon | Yams/*Tannia*/cassava |
| 5. | Coconut + pepper | Hybrid napier | – |

Measures suggested for developing an integrated nematode management in coconut and coconut based farming systems are: (1) use of nematode free planting materials of coconut and intercrops, (2) use of tolerant/less susceptible cultivars or hybrids of coconut and other intercrops in infested areas, (3) application of 50 kg cowdung/farmyard manure, 2 kg *neem/marotti* oilcake and 25 kg green manure to the coconut basins, (4) growing of *C. juncea* in the basins and interspaces and its incorporation into soil at the flowering stage as

a green manure, (5) growing of *G. maculata* on the borders and in the interspaces as a standard for black pepper and use of its leaves and tender twigs for green manuring of coconut and black pepper, and (6) application of phorate at the rate of 10 g a.i./palm and 3 g a.i./vine in June and September for coconut and black pepper, respectively. For banana, phorate may be applied at the rate of 3 g a.i. per sucker at planting and 90 days after planting. In the case of ratoon crop, phorate may be applied at the same rate per hill twice a year, but care should be taken to avoid the application of phorate at and after flowering. Nematicides need not be applied separately to black pepper trailed on to coconut, if the standard is receiving nematicides already, and introduction of biocontrol agents like *P. penetrans, P. lilacinus* and VAM to nursery potting mixture and planting pits to reduce nematode population and for imparting resistance/tolerance to nematode infestation.

Developing a location specific integrated nematode management schedule depending upon the crops and nematodes involved, thereby keeping the nematode population below the threshold level to increase the income per unit area/input is the immediate need for coconut based farming system.

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## DISCUSSION

*M. de S. Liyanage*: In Sri Lanka, *Pueraria* is raised as cover crop in coconut gardens. Do you think *Pueraria* can reduce nematode population?

*P.K. Koshy*: *Pueraria* leaves have no nematicidal properties. On the other hand, they are highly susceptible to root-knot nematode which reduces nodulation by Rhizobium.

*T.P. Sreeharan*: How can the residue problem be solved in mixed cropping when nematicide application has become necessary?

*P.K. Koshy*: Nematicides should not be applied after flowering. Phorate leaves no residue after 45 days in coconut, arecanut and banana at the recommended dosages.