Management of Nematodes in fruit crops

Introduction

Nematodes constitute one of the major limiting factors in fruit crop production. They cause extensive root necrosis resulting in serious economic consequences *viz*., fertilizers are not effectively utilized, the period from planting to harvesting is extended, drastic reduction in fruit or bunch weights, the quality of fruits is impoverished and fields have to be replanted every 2 to 3 years because of drastic reduction in plant numbers. Furthermore, roots damaged by nematodes are easy prey to fungi which invade the roots and accelerate root decay. The root-knot nematode *Meloidogyne incognita*, the burrowing nematode *Radopholus similis* and citrus nematode *Tylenchulus semipentrans* are the major nematode pests that infect these fruit crops.

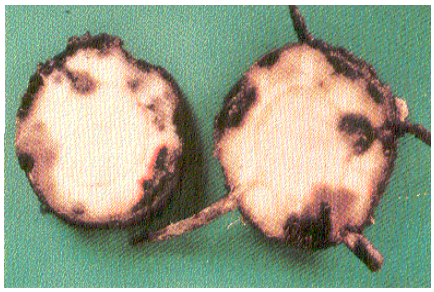
How serious are these nematodes and how does it spread? These nematodes are responsible for 30 to 40 percent yield losses in various fruit crops. The incidence of fungal pathogen would be doubled in the presence of the nematodes. These nematodes cause breakdown of resistance to fungal diseases in certain varieties of fruit crops. The nematodes spread from one area to another mainly through infested planting materials. In case of banana, paring or trimming of suckers, often done before planting is usually not sufficient to remove the infections that extend deeply into the sett. This nematode is disseminated when water that drains from infested areas gets recycled into irrigation system. Soil that adheres to implements, tyres of motor vehicles and shoes of plantation workers may also spread nematodes from one area to other area.

Where do these nematodes live? The maximum number of nematodes is present at a distance of 25 to 50 cm from the base of the plant and at a depth of 20 to 40 cm.

What are the symptoms?

Basically these nematodes are parasites of roots or underground stem. The root-knot nematode produces galls or knots on the roots. Wounding of roots by the nematodes usually induce reddish-brown cortical lesions which are diagnostic symptom of the disease in case of banana. These lesions are clearly seen when an affected root is split longitudinally and examined immediately. Root and rhizome necrosis is manifested by varying degrees of retarded growth, leaf yellowing and falling of mature plants. With the increase in nematode population, feeder roots are invaded and destroyed as fast as they are formed. The resulting setback in the uptake of plant nutrients leads to debility of the plants and production of smaller fruits. The lesions of the primary roots together with the girdling and death of these anchor roots make the plant prone to 'tip over or topple' by wind action in case of banana.

Roots affected by root-knot nematode



Rhizome necrosis in nematode infected plants

Roots affected by burrowing nematode

Life cycle of the root-knot nematode

After searching a suitable site, normally behind the root cap, the juveniles start feeding on epidermal cells, become sedentary in nature during feeding and enlarge in cross-section. They continue to feed except for 3rd and 4th stage juveniles. Third and fourth moults take place in quick succession, thereby leading to the development of pear-shaped, white adult females. The males are elongate and vermiform. The reproduction is normally by parthenogenesis or sometimes by amphimixis. Each adult female lays about 400-500 eggs in the gelatinous matrix. The total time taken for completion of one life cycle under optimum conditions (optimum temp. 27-30°C) is 3-4 weeks in most species depending upon the host and other weather conditions thus leading to completion of several generations in a year.

Life cycle of the burrowing nematode

The burrowing nematode has a migratory endoparasitic habit. Although the stages remain vermiform throughout, sexual dimorphism is apparent with adult males being somewhat degenerate and probably non-parasitic. Eggs are normally laid in infested tissue over 7-8 days at the rate of about four eggs per day. The life cycle from egg to egg extends over 20 to 25 days with eggs taking 8-10 days to hatch and the larvae 10-13 days to mature.

Life cycle of the citrus nematode

Tylenchulus semipenetrans exhibits sexual dimorphism, reproduces sexually and occasionally by facultative parthenogenesis without the need of males. From the egg, which contains the first stage juvenile (J1) , the second-stage juvenile (J2) emerges and searches for host roots. The motile and vermiform J2 female molts into the vermiform J3 and J4, and finally into the sedentary adult. The

immature female penetrates into the deep cortical layers of the root, becomes sedentary and establishes a permanent feeding site consisting of specialized cells called 'nurse cells' which are the main source of nutrients. Upon maturation, the posterior portion of its body swells and protrudes from the root surface while its elongate neck and head remains embedded into the cortex. Mature females produce eggs that are embedded in a gelatinous matrix. The length of the female life cycle from egg to egg ranges from four to eight weeks. The development of the J2 male into adult is completed in seven days and does not require feeding. Citrus nematode infected roots are thicker, darker, decayed and show a dirty appearance because of large number of females sticking on the infected roots. The infected root systems due to the nematode damage lose the ability to absorb enough water and nutrients for normal growth.

Papaya, acid lime seedlings, guava and pomegranate grafts are produced generally in substrate mixture in polythene bags. Many a times substrate mixture (sand + soil + FYM or any organic manure) harbor above mentioned nematodes and other pathogenic fungi and bacteria. Generally nursery men don't treat the soil mixture which is used for the production of fruit seedlings or grafts in their nurseries.

As such nematode infestation on the seedlings or grafts makes the way for the entry of various pathogenic fungi and bacteria. These nematodes and other pathogens multiply in the farmer's fields. As a consequence, soil in the farmers' field becomes sick and un-productive and ultimately soil becomes unfit for the cultivation over a period of time if proper measures are not taken to combat these nematodes and other pathogens.

During the process of hardening **in** banana tissue culture seedlings, owing to the quality of substrate mixture, seedling roots get infected with nematodes such as *Meloidogyne incognita, M.*

javanica (root-knot nematodes), *Rotylenchulus reniformis* (reniform nematode), *Heterodera sp.*, (cyst nematodes). Further, they are also infected with other pathogenic fungi and bacteria. Once these seedlings are infested the pathogens reach the farmers field and cause the diseases in their fields.

Healthy seedlings treated with bio-agent formulations

Nematode infested seedlings *Tissue Culture Seedlings Treated with Bio-Agent*

Need for producing the healthy seedlings or grafts of fruit crops

Securing healthy seedlings or grafts is essential to ensure optimum plant population stand, good crop growth and higher yields. Infestation by heavy populations of nematodes and other pathogens will result in very weak seedlings or grafts with poor root growth. Seedlings or grafts with stunted root system cannot establish well after transplanting. Nematode attack on the root system makes the seedlings or grafts weak and also vulnerable for the infection by secondary pathogens (soil borne fungi and bacteria). Nematode damage also results into the breakdown of the resistance against pathogenic fungi. Further, nematode infected seedlings facilitate the spread of the nematodes in the main fields making the problem more difficult to manage in a larger area. Because of all these reasons it is inevitable to produce the seedlings or grafts without infestation of nematodes or other pathogens.

The solution: The IIHR, Bengaluru has developed a bio-pesticide formulation to manage nematode problem in banana seedlings. This is an organic formulation, consists of *Pseudomonas fluorescens* and *Trichoderma harzianum*. Patents from 4 countries were granted for this innovation. United States (US) patent – No: US 7,923,005 B, Thailand patent – No: 7621, Indian patent - No.250779, Australian patent – No. AU 2007216174 B2 (Innovators: Dr. M. S. Rao, Principal Scientist, Division of Entomology & Nematology, & Dr. N. Ramachandran, Former Principal Scientist and Head, Division of Pathology, IIHR, Bengaluru).

The institute also developed mass production protocols of *Pseudomonas fluorescens* 1% W. P. (an effective bio-bactericide and also has nematicidal properties), *Trichoderma harzianum*1% W. P. & *Trichoderma viride* 1.5 % W. P. (effective bio-fungicides and also have nematicidal properties), and *Paecilomyces lilacinus*1% W. P. & *Pochonia chlamydosporia* 1 % W. P. (effective bio-nematicides). Dr. M. S. Rao is the innovator of the technologies.

Method for producing the fruit crop seedlings or grafts

One ton of soil mixture or any substrate used should be prepared by mixing two kg of each of *Pseudomonas fluorescens* 1% W. P., *Trichoderma harzianum*1% W. P. and *Paecilomyces lilacinus*1% W. P. + five kg of furadon or phorate or 25 kg of neem cake or pongamia cake / ton. After mixing with all these materials the soil mixture or any substrate can be used for hardening banana seedlings or producing grafts.

		
Untreated Seedling	*Nematode Infested Seedling*	*Healthy Seedling Treated with Bio-Agent Formulations*

Effects of substrate treatment with bio-pesticides

- ✓ It helps in producing the disease free and healthy seedlings
- ✓ It helps in promotion of growth of the seedlings
- ✓ Because of ISR (Induced Systemic Resistance) effect, it helps in the management of pathogens if any are systemic

Spraying or drenching the nursery seedlings or grafts with bio-pesticides

IIHR patented organic formulation can be sprayed on the seedlings or grafts by dissolving 5 g or 5 ml / lit of water once in 10 days. This formulation can be drenched in the substrate by dissolving 5 g or 5 ml / lit of water and this can be done once in 10 days.

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Methods of use of bio-pesticides for growing a good fruit crop (These methods are useful for plants which are to be planted or for a standing crop).

Methods of management of nematodes in the main field:

Step 1: Soil application.

Land should be thoroughly ploughed and soil should be brought to fine tilth. Add recommended doses of fertilizers. Also add carbofuran or phorate @ 20 – 25 kg + 200g neem/ pongamia/ mahua cake per acre. Maintain optimum moisture in the beds for proper decomposition of neem/ pongamia/ mahua cake.

Those who do not want to use the chemicals for the management of neamtodes, apply two tons of FYM or 500 kg of neem cake / pongamia cake or one ton of vermin-compost enriched with *Pseudomonas fluorescens* + *Trichoderma harzianum* + *Paecilomyces lilacinus* during the land preparation.

Process of Enrichment of FYM

- One ton of well decomposed FYM has to be enriched by mixing with 2 kg of each of *Pseudomonas fluorescens* + *Trichoderma harzianum* + *Paecilomyces lilacinus* formulation under shade. It has to be covered with mulch and optimum moisture of 25 - 30% has to be maintained for a period of 15 days.
- Once in a week thoroughly mix the FYM for maximum multiplication of and homogenous spread of the microorganisms in the entire lot of FYM.

Process of Enrichment of Neem cake

- 1 ton of neem cake has to be enriched by mixing with 2 kg of each of *Pseudomonas fluorescens* + *Trichoderma harzianum* + *Paecilomyces lilacinus*. It has to be covered with mulch and optimum moisture of 25 - 30% has to be maintained for a period of 15 days.

➢ Once in a week thoroughly mix the neem cake for maximum multiplication of and homogenous spread of the microorganisms in the entire lot of neem cake.

Process of Enrichment of vermicompost

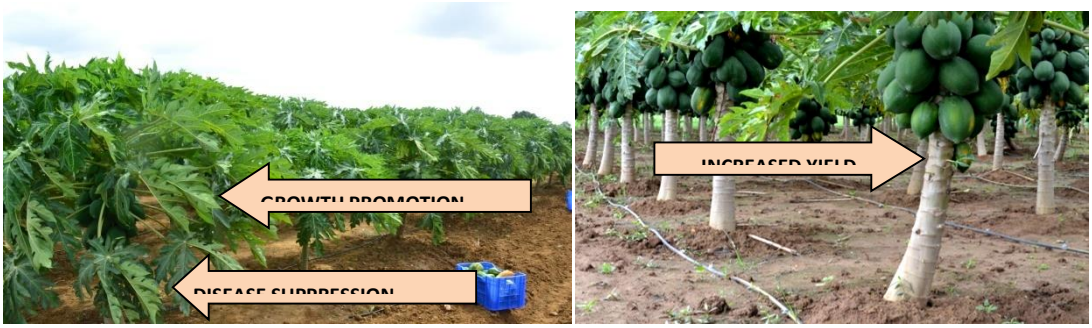
Process of Enrichment of vermicompost

➢ 1 ton of vermicompost has to be enriched by mixing with 2 kg of each of *Pseudomonas fluorescens* + *Trichoderma harzianum* + *Paecilomyces lilacinus*. It has to be covered with mulch and optimum moisture of 25 - 30% has to be maintained for a period of 15 days.

➢ Once in a week thoroughly mix the vermicompost for maximum multiplication of and homogenous spread of the microorganisms in the entire lot of vermicompost.

Step 2: Application of bio-pesticides at the time of planting:

Apply **bio-pesticide** enriched FYM@ three kg or enriched neem cake @ 250g or enriched vermicompost @500g/plant at planting and at an intervals of six months.



Papaya plants grown using bio-pesticide formulation

Step 3: Spraying:

The IIHR patented organic formulation containing *Pseudomonas fluorescens* & *Trichoderma harzianum* has to be sprayed on the plants at regular intervals of 30 days at a dosage of 5g/ lit or 5ml/ lit.

Step 3: Drenching or application through drip irrigation system:

The IIHR patented organic formulation has to be given through drip/ by drenching @ 5g/ lit or 5ml/ lit. at regular interval of 30 days.

Soil application of patented organic formulation enriched manure

Banana plants grown using organic formulation of bio-agents

- By following all these methods farmers can get 15 – 20% increase in the yield of the crops.

For products or technologies of bio-pesticides - *Pseudomonas fluorescens* 1% W. P., *Trichoderma harzianum* 1% W. P., *Trichoderma viride* 1.5% W. P. and *Paecilomyces lilacinus* 1% W. P. *Pochonia chlamydosporia* 1% W. P. and product of patented technology and patented organic formulation please contact:

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