

Combating Root-Knot Nematodes: Boosting Guava Health and Productivity

Guava (*Psidium guajava* L.) is the 4th most commercially important fruit crop in India and is indigenous to tropical America. India leads in global guava production, but the area of expansion is declining due to biotic stresses. Among the major constraints in its commercial cultivation is the root-knot nematodes (*Meloidogyne* spp.), which significantly hampers productivity. Recently, *Meloidogyne enterolobii* was reported from Tamil Nadu, which is considered a serious threat to guava cultivation. This nematode causes substantial yield loss across various crops, resulting in considerable economic damage to growers. RKNs can cause yield loss of 60 to 80% in guava. *M. enterolobii* possesses a wide host range, enabling its survival and spread across cropping systems. Effective management strategies include the use of bio-agents, bio-pesticides and chemical nematicides such as Carbofuran.

Keyword: Bio-pesticides, Guava, Management, Root-knot nematode

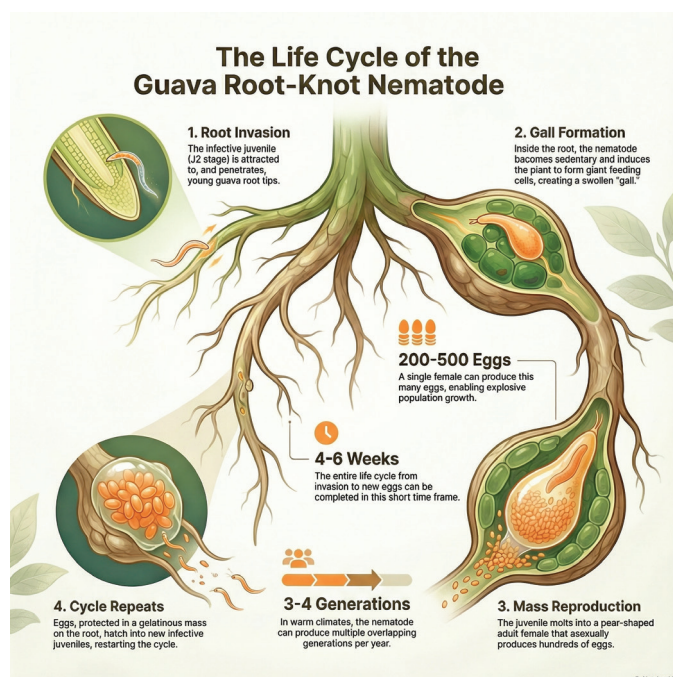
GUAVA (*P. guajava* L.) is the 4th most important fruit crop of India, which is globally spread from tropical to subtropical regions. Southern Mexico or Central America is the native place of the guava. It is popularly referred to as the 'apple of the tropics'. Guava can be cultivated across a wide range of soils and climatic conditions and is relatively tolerant to extremes of temperature, hot winds, scanty rainfall, saline soils and waterlogging. India is the largest producer of guava, with an area of 287 thousand hectares and a production volume of 4,304 thousand metric tonnes, followed by China, Thailand, Indonesia, Mexico and Brazil. Within India, Uttar Pradesh leads in guava production with 983.59 thousand metric tonnes, followed by Madhya Pradesh (776.75 thousand MT) and Bihar (434.41 thousand MT).

Guava roots were primarily affected by root knot nematodes and once infected, the roots are more vulnerable to the wilt fungus, a common pathogen that causes wilt disease in guava. The severity of the disease was increased because of this synergetic interaction

between RKNs and wilt pathogen. *Fusarium oxysporum* and *Meloidogyne* spp. together cause more damage to guava than the nematode alone. In India, *M. enterolobii* was found to be associated with wilted guava orchards. The root-knot nematodes, *Meloidogyne* spp., have been reported on some species of tropical fruit trees grown in the region over the last two decades. The RKN, *M. enterolobii*, was isolated in China for the first time. Later, it was isolated from guava

orchards in different parts of China. The first report of *M. enterolobii* on guava came in 2016 from the Ayakudi region of Tamil Nadu. It has been added to the EPPO A2 list due to the risk of introduction and spread throughout the country. *M. enterolobii* is a serious threat to guava cultivation due to its rapid spread, and it makes guava cultivation impossible in highly infested areas. *M. enterolobii* is found in poly-specific communities and interacts dynamically with the host plant, the environment and other organisms in the rhizosphere.

Distribution: The root-knot nematodes (*Meloidogyne* spp.) of guava have become



Infographic illustration of the life cycle and mode of infestation of root-knot nematodes (RKNs) in guava plants.

one of the world's most dangerous pathogenic nematodes due to their widespread geographical distribution and wide host range. The RKNs occur in tropical to subtropical parts of the world, including Asian countries, African countries and Central and South America. Recently, *M. enterolobii* has emerged as the most prevalent pathogenic nematode species that infests various crop species such as fruit crops, vegetables and ornamentals as well as weeds. It has previously been reported from Florida, North Carolina and most recently from South Carolina and India. Currently, this species is considered the most destructive and aggressive among the *Meloidogyne* genus due to its high rate of reproduction and the difficulty in controlling it.

In India, *M. enterolobii* was first reported from Tamil Nadu during 2016 and later reported from different parts of the country such as Uttar Pradesh, Uttarakhand, Madhya Pradesh, Rajasthan, Haryana and other parts of country; and it can cause a yield loss of 60–80%.

Mode of infestation: A single female nematode can lay up to 400–600 eggs in warm weather conditions (27°C), and the life cycle can be completed within one month. Many creamy or whitish egg masses can be observed on

Table 1. The reactions of host plants to the root-knot nematode (*Meloidogyne* spp.) of guava

Susceptible plants			Resistant plants		
Cotton	Bell pepper	Brinjal	Millet	Rye	Cabbage
Peanut	Broccoli	Okra	Corn	Sorghum	(S-R)
Peanut	(S-MR)	Squash	Oats	Wheat	Cauliflower
Sugarcane	Celery	Tomato	Radishes	Carrot	Garlic
(S-R)	Cabbage	Cucumber	Rice	Broccoli	Lettuce
Sun Hemp	(S-R)	Beetroot		(S-MR)	Parsley
(S-R)	Chilli				
Sweet	Cowpea				
potato	(S-R)				
Tobacco	Common				
	bean				

Note: S= Susceptible, R= Resistant, MR= Moderately resistant

the roots of the plant. However, the nematode is unable to move quite far in the soil and it can spread easily through any form of soil movement viz., farm implements, irrigation and heavy rainfall.

The guava root-knot nematode behaves similarly to other species of root-knot nematodes in that it produces young juveniles that migrate towards the root tips of susceptible plants after hatching from eggs in the soil. These juveniles (J2) penetrate roots, establishing a permanent

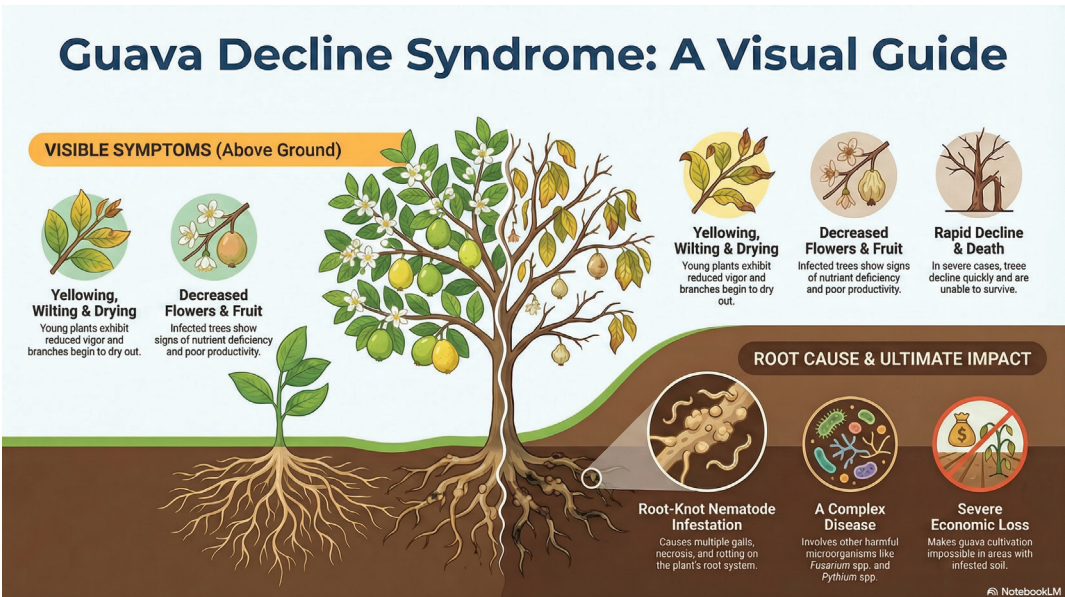
Table 2. Losses in other fruit crops due to nematodes in India

Fruit crops	Nematode species	Annual Loss (%)
Banana	<i>Radopholus similis</i> & <i>Meloidogyne</i> spp.	19–40, can up to 100%
Strawberry	<i>Meloidogyne</i> spp., <i>Pratylenchus</i> spp. & <i>Aphelenchoides</i> spp.	10–41
Grape	<i>Meloidogyne incognita</i>	30
Citrus	<i>Tylenchulus semipenetrans</i>	10–30
Papaya	<i>Meloidogyne incognita</i> & <i>Rotylenchulus reniformis</i>	30–40
Pomegranate	<i>Meloidogyne</i> spp.	40

feeding site and begins to mature into females. The formation of large galls or swellings of root tissues may happen in association with the developing females during this process.

Symptoms: The symptoms caused by the guava root-knot nematodes (RKNs) are similar to those caused by other species of RKNs; however, the symptoms of guava root-knot nematode infection are generally more severe. Young plants exhibit yellowing, wilting, branch drying, reduced vigour and decreased productivity.

Trees that are severely infected decline rapidly, eventually dying. Moderately infested plants show symptoms of general chlorosis and deficiency of nutrients, and they have decreased flowering and fruiting. Infected tree roots have multiple galls and root necrosis, resulting in a significant reduction of fine roots. The RKNs affect the entire root system of the plant, which may show distorted and swollen symptoms and heavily infested roots may rot. The death and decline of guava plants infested by *M. enterolobii* is a complex disease that involves other microorganisms such as *Fusarium* spp., *Trichoderma* spp., *Verticillium* spp. and *Pythium aphanidermatum*. This syndrome makes guava cultivation in infested areas



Infographic illustrating characteristic symptoms of root-knot nematodes (RKNs) infestation in guava plants.



Infested guava plant with RKN in field

Infested guava saplings showing chlorosis and stunting symptoms

Root distortion, rotting and decaying symptoms

Overview of infested guava saplings

Many galls and egg masses are showing on the infested guava root

impossible, causing serious economic problems for growers.

Management

Nematode management in nursery: Soil mixture treatment is a good method which is used to raise guava rootstocks to produce nematode-free planting material. A tonne of soil mixture needs to be blended using 50–100 kg of neem cake or pongamia cake that has been supplemented with some bio-pesticides like '*Paecilomyces lilacinus*', '*Pseudomonas fluorescens*' and '*Trichoderma harzianum*'. Additionally, 5 kg of carbofuran or phorate may be incorporated into 1 tonne of the soil mixture for more effective results.

Nematode management in orchards

Before planting

A) Prevention: The soil for establishing a new orchard should be free of nematodes and the planting material used for new planting should not be infected with nematodes. The saplings that will be used for rootstock or transplanting purposes should be grown in sterilised soil. All farm implements should be sterilised before use.

B) Deep summer ploughing: Deep ploughing of the soil is recommended during the hot summer months before planting new guava plants. At intervals of 15 days, it should be done twice or three times.

C) Soil application: The soil needs to be thoroughly ploughed and well pulverised before the planting of guava saplings. Afterwards, the recommended fertiliser dose needs to be incorporated for better growth and development of the plants, as vigorous plants may avoid the attack of nematodes. Add 20–25 kg carbofuran or phorate + 200 g of neem or pongamia or mahua cake per acre for the reduction of the initial population of nematodes. The beds must be kept at the optimal moisture level for better decomposition of organic matter.

Two tonnes of FYM/500 kg of neem or pongamia cake or one tonne of vermicompost enhanced with three bio-pesticides like *P. fluorescens*, *Trichoderma harzianum* and *Paecilomyces lilacinus* should be applied during the land preparation phase in organic farming.

After planting

A) Biological control: Several bacterial and fungal bio-agents are employed in the management. *P. lilacinus* and

Verticillium clamydosporium have been identified to be the most potent fungal parasites for controlling the root-knot nematodes on several crop species. Another fungal bio-agent i.e., *Trichoderma harzianum* also effectively reduce the RKNs in both soil as well as roots.

a) Preparation of Bio-pesticide: Apply 3–4 kg of compost or FYM or vermicompost enhanced with bio-pesticide per plant every three to four months. A mixture of 20 kg of neem/pongamia cake that is enriched with bio-pesticides should be soaked in 200 L of water for 2 days. This suspension can be used for drenching purposes @2–3 L/plant, or it can be thoroughly filtered and used for drip irrigation once every 15–20 days. This filtered suspension can also be used to spray the crop or as a spray fluid for spraying micronutrient mixtures.

b) Procedure for enrichment of different cakes with bio-pesticides: Mix 3–4 kg of each of '*Paecilomyces lilacinus*' or '*Pochonia chlamydosporia*', '*Pseudomonas fluorescens*' and '*Trichoderma harzianum*' or '*T. viride*' in 1 tonne of neem/pongamia cake and leave it in shade for 20 days at 25–30% moisture for multiplication of beneficial microbes.

B) Use of non-host and antagonistic crops: Sunn hemp, sorghum and mungbean were reported to be poor or non-hosts for RKNs. However, onion, garlic and marigold were found to be antagonistic crops to *M. enterolobii* and these crops can be grown as intercrops with guava. Brassicas and certain green manures also offer resistance. Avoid susceptible crops like sunflower, cowpea and pulses.

C) Chemical control: Carbofuran is a pesticide that belongs to the carbamate family and is commonly used for nematode control in many crops. The application of Carbofuran 3G @60 g/plant is recommended when symptoms such as yellowing, bronzing and stunting are observed. In India, two novel chemical compounds, namely fluensulfone and fluopyram, were registered as nematicides in 2018. These new compounds differ in chemistry and mode of action from commonly used chemicals and they are relatively safe for the environment.

Way forward: Due to the hazardous nature of chemical nematicides, we should encourage the application of such efficient bio-control combinations in the management of plant-parasitic nematodes in guava orchards. Bio-pesticides don't harm the soil environment and are less expensive to formulate than chemical substances. It effectively controls a variety of other soil-borne pathogens and has been shown to induce disease resistance and encourage more adventitious root growth in plants. Research should be

emphasised to develop resistant rootstock and/or cultivars with wide adaptability.

SUMMARY

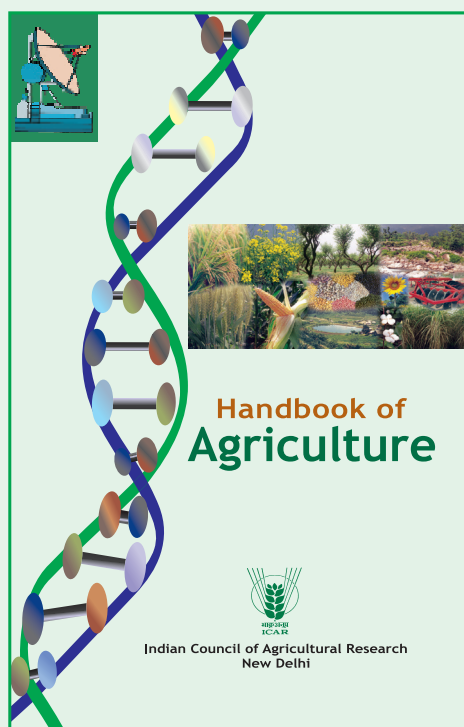
Meloidogyne enterolobii, a highly aggressive root-knot nematode (RKN), poses a severe threat to guava production in India, causing 60% to 80% yield loss through severe root galling. These parasites facilitate the guava wilt complex alongside *Fusarium oxysporum*, leading to rapid orchard decline. Effective management necessitates an integrated approach, utilising nursery sanitation, non-host

crop rotation, bio-agents and the application of chemical nematicides.

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TECHNICAL SPECIFICATIONS

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