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Impact of plant parasitic nematodes & its management in Mulberry (Morus sp.) cultivation in India— A Review

Tanvi Rahman[1,*], Sahil Rahman[2], Kishan Kumar R[3], Jashwanth S[4]

[1&3] Department of Studies in Sericulture Science, University of Mysore, Manasagangotri, Mysuru, Karnataka, India
[2]Department of Nematology, Assam Agricultural University, Jorhat, Assam, India
[4]Department of Botany, Yuvaraja College, Mysuru, Karnataka, India
*Corresponding author - Tanvi Rahman
Email: trahman234@rediffmail.com

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Abstract— *Mulberry (Morus sp.), a vital crop for India's silk industry, faces significant yield reductions (10-30%) due to plant parasitic nematodes. Root-knot nematodes (Meloidogyne incognita) are primary pests, compromising plant health and leaf quality. This review provides a comprehensive analysis of nematode diversity, damage, and management strategies in Indian mulberry cultivation. The review elucidates the impact of nematode infestations on mulberry growth, yield, and quality, highlighting the need for effective management. Chemical, biological, and cultural methods are evaluated for their efficacy and sustainability. Chemical treatments, while effective, pose environmental and health risks, emphasizing the need for alternative approaches. Biological control agents, such as Trichoderma viride and Pseudomonas fluorescens, show promise in managing nematode populations. Cultural practices like crop rotation, soil solarization, and resistant cultivars are also discussed. Integrated management strategies, combining multiple approaches, are recommended for optimal results.*

Keywords— ***Plant parasitic nematodes, mulberry, silk production, sustainable nematode management, ecological sustainability.***

I. INTRODUCTION

Mulberry (*Morus alba*) is a deciduous woody perennial plant which has a deep rooting system along with simple, stipulate, petiolate leaves arranged alternately. It is cultivated in many different types of soil ranging from loamy to clayey, deep fertile to flat, with high drainage and exceptional water retention capacity. It thrives under varied climatic conditions ranging from tropical to temperate. Most of the species of the genus *Morus* and its cultivated varieties are diploid, however, triploids are also extensively used for their vigorous growth and quality of leaves. The main commercial part of mulberry is the foliage which is used as a primary food source of silkworm (*Bombyx mori*) in the silk industry.

India is the second major silk producing country after China. The mulberry is cultivated in most of the silk producing states of the country including Andhra Pradesh, Karnataka, Assam, Kerala and many more(Table 1). The total area of cultivation in the country is around 2,82,244 ha (Source: Central Silk Board). The majorly cultivated species of mulberry are *Morus alba, M. indica, M. serrata* and *M. laevigata.* Although this plant is grown in a variety of climates, the tropical zone is where it is most commonly found covering Karnataka, Andhra Pradesh and Tamil Nadu. The cultivation of mulberry and leaf production are impeded by many pests and diseases, such as plant parasitic nematodes.(1) It is estimated that 10–30% of the leaf yield in mulberry is lost due to various diseases.(2) The rhizosphere soil of mulberry was observed with a significantly greater number of nematodes.(3) The nematodes spread easily and result in wilting, yellowing of the leaves, stunted growth, or a general decline in growth. Plant-parasitic nematodes, particularly root-knot nematode (RKN), *Meloidogyne incognita* (Kofoid and White), pose a major risk to mulberry productivity that shortens plant lifespan and significantly reduces herbage yield and leaf quality.(4) The incidence of nematode disease was found

to be greater in irrigated mulberry gardens and lower in rainfed gardens.(5)

II. DIVERSITY OF NEMATODES IN MULBERRY SOIL ECOSYSTEM

The soil ecosystem of mulberry is inhabited by a wide range of microorganisms including nematodes. These includes plant parasitic nematodes and free-living nematodes which accounts about 42 species belonging to 24 genera(6). Of these 24, the nematodes belonging to five genera viz. , *Meloidogyne* , *Rotylenchulus* , *Helicotylenchus* , *Hoplolaimus* and *Xiphinema* were reported from India.(4) About 89 species of nematodes under 34 genera, 21 subfamilies, 17 families, 12 superfamilies and 6 suborders belonging to 4 orders, were described and reported so far from India(7). The plant parasitic nematodes which are most frequently associated with mulberry are *Meloidogyne incognita* (Swamy and Govindu, 1965), *M. javanica* (Mathur *et al.*, 1969), *M. arenaria* (Wang and Chen,1989), *Xiphinema index* (Martelli and Raski, 1963), *Helicotylenchus digitiformis* (Kiryanova and Shangalina, 1976) *Rotylenchulus reniformis* (Swarup *et al.* 1964), *Hoplolaimus seinhorsti* (Keereewan and Leeprasert, 1975), *Longidorus marini* (Ohishima *et al.*, 1971) and *Pratylenchus* sp. (Edward *et al.*, 1963). In India, Narayanan (1966) for the first time reported about the association of root knot nematode with mulberry(8). In a survey conducted by Bina Chanu in the some mulberry cultivations of Manipur, about four species of Aphelenchoides were found out of which two species namely *Aphelenchoides dhanachandi* sp. n. and *A. neoechinocaudatus* sp.n. were newly discovered from there(16).

III. ECONOMIC DAMAGE CAUSED BY SOME MAJOR NEMATODES

Root Knot Nematode (*Meloidogyne* spp.)

It is estimated that the nutritional value of mulberry leaves is reduced by up to 10% as a result of the root-knot nematode infestation.(9 & 10) The specific symptoms in mulberry caused by root knot nematode are sick with thrifty look as if due to water and nutrient deficiency, since the vascular tissue and cortex in the roots are highly disorganized. Therefore, the water and nutrient absorption in infected roots is highly affected resulting in disruption of the plant physiology. Symptoms like stunted growth, leaf chlorosis and necrosis along leaf margins can be seen in infected plants. In the root systems, extensive root gall formations are seen as separate beads unlike merged galls and flattened root seen in other crops.(6) In some studies, it has been observed that *M. incognita* provides a good site for easy entry of developing hyphae of some soil-borne fungal pathogens like *Botryodiplodia theobromae* and *Fusarium solani*.(11)

In Karnataka, studies were carried out to check the predominance of *M. incognita* in different farming systems and soil types and it showed that red sandy soil had the highest disease incidence (66.3%), with 31 to more than 100 galls containing egg masses per root system followed by red loamy soil (42.55%) with moderate to severe intensity having more than 11 to less than 100 galls with egg mass. Very poor incidence was noticed in black cotton soil (6.06%) with mild intensity having less than 10 galls and egg mass. Under irrigation gardens, there was a greater occurrence and seriousness as compared to other different cropping methods. The disease incidence was not at all noticed under rainfed conditions (5) .

Spiral Nematode (*Helicotylenchus indicus*)

In mulberry habitats, spiral nematodes are typically observed with their heads entrenched and feeding on roots. They are also known to spread secondary infections in the general vicinity of their feeding sites. The distinctive symptoms are reduced length and weight of shoot, lower number of leaves and leaf weight as well as reduced number of leaf buds (12).

Dagger Nematode (*Xiphinema basiri*)

The dagger nematode is dominant in 10-15 cm depth of soil (13) and feeds with long stylet deeply at near the root tips even up to vascular elements of young roots, but up to cortical parenchyma in older roots. Duration of feeding is long. Reduced growth and stunting are frequent. Common signs include reduced root system, lesion formation, discoloration, disintegration, and degradation of cortical tissue, terminal and sub-terminal swelling, and the formation of a fishhook or curling tip. The root tips exhibit profuse root development and significant forking.(14)

IV. FACTORS RESPONSIBLE FOR PATHOGENICITY

The nematode populations fluctuate in response to pressure and obstacles from external factors. As a result, they acquire a structure and exhibit growth characteristics in response to variables like temperature, rainfall, host plant type, and soil type, demonstrating the precise ways in which each of these variables influence biological processes. Factors like soil temperature and pH are inversely proportional to nematode population. Soil moisture is directly proportional to the population of nematodes belonging to different genera. In some studies, populations of all orders of nematodes were observed to be highest during rainy season(June-October)

but remained comparatively lower in summer and winter seasons.(15)

V. PROSPECTS OF NEMATODE MANAGEMENT IN MULBERRY

Mulberries were treated with a variety of management techniques, including chemical, biological, physical, and cultural treatments(18), in order to reduce the infestation of root-knot nematodes. Among them, it was found that chemical techniques using nematicides applied in the field were more effective.(20 & 22) However, it has been noted that the nematicides and soil fumigants used to control plant-parasitic nematodes may be hazardous to silkworms and have an adverse effect on human health, groundwater contamination, and soil health.(19 and 21) Therefore, due to the serious risks associated with nematicides and pesticides, there has been a surge in interest in biological management in its widest sense as a means of reducing nematode damage in an eco-friendly manner. Hence, some studies has been done in this aspect with a view towards sustainable management strategies.

a. Cultural Approaches

Crop rotation is a sustainable method of using inadequate hosts, resistant or tolerant cultivars, plants hostile to nematodes, trap crops, or cover crops in conjunction with seasonal main crop rotation has produced noteworthy outcomes.(25) A technique known as soil solarization which involves the covering of soil with a plastic film during the summer season. This technique effectively increases soil temperature which causes destruction of nematode egg masses and their populations.(26) Trap crop is a way to develop susceptible plants that parasitic nematodes quickly infect, then destroy the plants at the right moment to prevent nematode reproduction. A crop that supports nematode hatching and heavy invasion but not support reproduction is the perfect trap crop. Some studies have revealed that crops such as sunhemp (*Crotalaria juncea*) can be used because of its dual benefits. In addition to eliminating soil nematodes, it also causes nitrogen fixation, which raises the amount of nitrogen in the soil.(18) Kafle (2013) conducted a pot experiment at Tsukuba, Japan on marigold, crotolaria and oat in rotation with tomato to determine their antagonistic effect on southern root knot nematode. It was observed that marigold and crotalaria followed by oat were proved to be the best antagonist plants to control southern root knot nematode.(27) Mulching with neem leaves have been found to reduce root-knot disease and prevent leaf yield loss. (28)

b. Host Resistance

Natural resistance (R) genes have been demonstrated as good alternative in effectively limiting nematode damage in crops under field conditions. Even though root-knot and cyst nematodes have been resisted by some cultivars for decades, recent evidence suggests that growing populations of resistance breaking nematode pathotypes are starting to appear. (31) Host Plant Resistance (HPR) against nematodes have been discovered in many major crops as well as their related wild relatives. This is because nematicides application are increasing with times. Thus, molecular biological methods will facilitate more straightforward ways of selecting and transferring resistance genes. Hence, the status of HPR for nematode control will improve in the near future. (29)

Kumari and Sujathamma (2016) studied the different degrees of tolerance by mulberry varieties toward nematode from which we can select the appropriate variety for cultivation depending on the climatic conditions and available inputs. The varieties Tr10, V1 can be selected for the regions with good irrigation or rainfall conditions. Also, the variety RFS175 can be used for rainfed cultivation. (2)

RNA interference (RNAi) has become one of the most promising strategies for nematode management in recent times. The most promising method for developing nematode resistance in plants is the host-mediated RNA interference (RNAi) strategy, which targets nematode genes and incorporates both plants and nematode RNA interference machinery. As of right now, the greatest rate of nematode infection decrease has been observed through the suppression of effector or secretory class of proteins. Hence, these genes represent the most promising targets for an RNA interference (RNAi) method.(30)

c. Biological Approaches

Using bio-pesticides on a sustainable farm for parasite and infection management is certainly a sustainable practice. The effectiveness of these products is usually affected by external factors such as rains, temperature variations, soil chemistry or it may be that they selectively disintegrate in either chemical or physical terms. Nevertheless, despite this sometimes they perform equally as synthetic pesticides; even in those instances agricultural products containing these bio-pesticides are anticipated to be highly sought after for ecological as well as health reasons.(32)

Under field conditions, the effectiveness of commercial formulations of the antagonistic fungus *Trichoderma viride* and the plant growth-promoting rhizobacterium *Pseudomonas fluorescens* on the root-knot nematode *Meloidogyne incognita* that infecting mulberry was assessed. When mixed together in a ratio of six grams per plot (6 g/plot), it was observed that both *P. fluorescens* and

T. viride were effective against *M. incognita* in soil as well as roots and inhibited the occurrence of root-galling on mulberry.(33)

In some field experiments, the bio-control agents *Pseudomonas fluorescens* and *Trichoderma viride*, were evaluated against *Meloidogyne incognita* in mulberry (V1 variety). The results showed that application of *P. fluorescens* and *T. viride* to the soil, either separately or in combination, was able to control the nematode population and enhance mulberry leaf yield and nutritional standards. (24)

VI. CONCLUSION

With the concerning issues regarding nematodes impact on the production of mulberry, there have been utmost attempts made by researchers for finding more and more effective as well sustainable management strategies for lessening the intensity of economic damage of plant parasitic nematodes. The lesser-known nematodes associated with mulberry plants might have been uncovered by exhaustive studies undertaken in the past, and their potential effects on the productivity of these plants may be analyzed. Most of the biocontrol studies on nematodes have been concentrated on sedentary endoparasitic nematodes. There are significant reductions in root knot and cyst nematodes of the genera *Meloidogyne* and *Heterodera* respectively. On the other hand, little is known about migratory parasitic nematodes that feed outside roots as well as those present in aerial part of plants. Therefore, more research and experimental assessment is required in order to support the biological methods for the management of these type of nematodes.

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