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Root-knot Nematode in Mulberry and its Management

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Mulberry (*Morus alba* L.) is a highly adaptable perennial species that thrives in diverse climatic conditions, from temperate to tropical regions, and can grow well in various soil types. As the primary food source for silkworms, mulberry foliage plays a crucial role in determining the quality of raw silk. The silkworms rely solely on mulberry leaves for their nutrients, and the quantity and quality of leaves produced per unit area directly impact cocoon production and raw silk quality. Mulberry leaf is one of the most critical factors in sericulture, accounting for approximately 38 – 40 per cent of the total factors influencing a successful cocoon crop. The quality of mulberry leaves is significantly impacted by various biotic and abiotic stress factors. Biotic stresses, including diseases caused by pathogens and infestations by insect and non-insect pests, can substantially degrade the nutritive value of the leaves. Mulberry plants, with their perennial, fast-growing and lush green characteristics, are particularly susceptible to attracting these pests and diseases, making them more vulnerable to damage.

The rhizosphere soil is a hotspot of microbial activity, characterized by a significantly higher population of microorganisms. Notably, the rhizosphere soil of mulberry plants supports a markedly higher abundance of fungi and nematodes. Among the nematodes, the root-knot nematode (RKN), *Meloidogyne incognita* (Kofoid and White) Chitwood is of high economic importance as it is known to cause 20-50 per cent loss in leaf yield apart from deteriorated quality and in India it was first reported on mulberry by Narayanan *et al.* (1966). RKNs are insidious parasites that target underground roots, making them challenging to detect. As a result, damage symptoms often go unnoticed until severe infestation has occurred. Infested plants exhibit stunted growth, marginal necrosis, and yellowing of leaves. The characteristic feature of RKN infestation is the formation of knots or galls on the roots, which impede water and nutrient uptake, leading to poor plant growth and development.

The RKN life cycle consists of three stages: egg, larva (with four juvenile stages: J1, J2, J3, and J4) and adult. The J2 larva infects host plants by entering the roots and feeding on parenchymatous cells, causing hypertrophy and hyperplasia, which induce characteristic knots. The larvae undergo four moults in the roots, developing into mature, oval or spherical, egg-laying females. Each female lays 200-300 ellipsoidal eggs, covered in a gelatinous substance, which hatch and release larvae into the soil under favourable conditions. The life cycle is completed in 30-40 days, with 2-3 cycles occurring annually. Optimal growth and development conditions for RKNs include temperatures between 15-30°C and soil moisture levels of 40-60%. As generations repeat, the size and number of galls increase, damaging parenchyma tissue and creating cracks and holes that invite secondary root infections. Consequently, RKN-infected plants exhibit nutrient deficiency symptoms and other root diseases, such as root rot. The root knots are sometimes mistaken for the root nodules of the

nitrogen-fixing bacterium, *Rhizobium*. The root knots originate from the bulging of roots from the inside and cannot be easily detached as root nodules.

Management of Root-knot Nematode in Mulberry

The RKN management can be broadly classified into four strategies: physical, cultural, biological and chemical methods, each offering distinct approaches to mitigate infestations.

1. **Physical Method:** Planting disease-free saplings is the hustle-free approach, others include deep ploughing and hot water treatment. Summer deep ploughing/digging to 30-40 cm depth in the infected gardens can reduce the nematode population. The RKN eggs and larvae are sensitive to heat and exposure to higher temperatures through soil solarisation will reduce the population. The hot water treatment of saplings (48 C for 20 minutes) before plantation.
2. **Cultural Method:** The disinfection of implements, use of trap crops and soil amendments can be considered under cultural method. The farm implements should be disinfected with 5% formalin solution or treated with boiling water before use to avoid cross-contamination and spreading of disease in healthy fields. The planting of marigold (*Tagetes patula*) as intercrop at a 30 cm distance in between mulberry plant rows and field application of neem oil cake @ 2 MT/ha/year in four split doses during the fertilizer application is recommended.
3. **Biological Method:** Biological approaches provide a targeted, safe and environmentally friendly solution, prioritizing non-target species, beneficial insects, animals and human safety while minimizing ecological impact. The utilisation of bacterial and fungal bioagents like *Pseudomonas fluorescens*, *Purpureocillium lilacinum*, *Trichoderma harzianum*, *Trichoderma viride*, *Pochonia clamydosporia* and *Trichoderma pseudokoningii* along with the FYM or seri-compost can reduce the RKN population in both soil and roots. Soil application of CSRTI, Mysore developed 'Bionema' (*Pochonia clamydosporia*: Neem oil cake: FYM :: 1:24:200) is @ 200 g/plant three times a year also reduces RKN infestation. Foliar and seed kernel extracts of plant species like *Artemisia nilagirica* and *Azadirachta indica* possess anti-nematode properties, effectively inhibiting egg hatching and inducing mortality in J2 juveniles of *M. incognita*.
4. **Chemical Method:** The soil application of Furadan (Carbofuran 3G) @ 40 kg/ha/year in four split doses during fertilizer application is recommended under severe infestation. A safety period of 40-45 days should be followed before feeding the treated plant leaves to silkworms.

In conclusion, RKN poses a significant threat to mulberry cultivation, causing substantial losses in leaf yield and quality. A holistic approach, combining physical, cultural, biological and chemical methods, can provide a comprehensive solution to mitigate RKN infestation. By adopting integrated pest management practices, we can minimize the economic and environmental impacts of RKN infestation and promote a more resilient and sustainable sericulture industry.