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Root Diseases of Mulberry and Their Management

*M. Parasuramudu, K. Nandhini, and M. Venkatesh Prasad
Post Graduate, Department of Sericulture, Sri Krishna Devaraya University, Anantapur-515003, Andhra Pradesh, India
*Corresponding Author's email: parasuram723b@gmail.com

Root-related diseases pose significant challenges to mulberry cultivation, affecting both standing crops and nursery plantations. These problems arise mainly due to soil-borne pathogens that attack the root system, impairing the overall growth and vitality of the plants. Among the most damaging root diseases in mulberry are nursery diseases, root knot, root rot, and complex infections that occur in both young and established plantations.

Nursery Diseases of Mulberry

During the preparation of stem cuttings, small wounds are often created, which serve as entry points for various soil-borne pathogens. These pathogens infect the cuttings during nursery establishment, leading to several serious diseases. The most common nursery diseases in mulberry include **stem canker, cutting rot, collar rot,** and **die-back.** Among these, stem canker and cutting rot usually occur during the sprouting phase, while collar rot and die-back typically appear at the sapling stage.

Stem Canker

This disease, caused by *Botryodiplodia theobromae*, is identified by greenish-black lesions on the cuttings. The bark becomes decayed, preventing sprouting and ultimately leading to the failure of the affected cuttings.

Cutting Rot

Caused by *Fusarium solani*, this disease leads to complete rotting of the cutting and bark decay, resulting in the death of newly sprouted cuttings.

Collar Rot

Phoma sorghina and *P. mororum* are responsible for collar rot. Infected plants show brown to black discoloration and decay near the soil surface (collar region), weakening the base of the cuttings.

Die-Back

This disease, also caused by *Botryodiplodia theobromae*, is characterized by wilting that begins at the shoot apex and progresses downward, eventually causing complete death of the saplings.

Crop Loss

Nursery diseases significantly reduce cutting sprouting and sapling survival. Mortality rates can reach up to **35%**, and in high-yielding but weak-rooting varieties, losses may exceed **50%**.

Factors Responsible for Disease Spread

- The diseases spread mainly through rainwater and irrigation runoff.
- Primary infection occurs via contaminated soil, tools, and nursery implements.
- Secondary spread happens when infected stem cuttings are planted in new areas.
- Environmental conditions such as **28–30°C temperature**, **soil moisture below 40%**, and **soil pH around 5–10** are most favourable for disease development.

Management and Control

1. Cultural Methods

- Deep ploughing and exposing the soil to sunlight for about a month before planting.
- Proper land leveling to prevent waterlogging.
- Keeping nursery beds free from weeds to maintain hygiene and reduce pathogen load.

2. Chemical Method

- Soak stem cuttings in **0.1% Dithane M-45** solution for 30 minutes before planting.
- Plant the treated cuttings in nursery beds and irrigate immediately after planting.

3. Integrated Disease Management

A combined approach involving chemical and biological treatments offers the best protection. The following method is recommended:

Bioformulation Treatment:

Use "**Nursery-Guard**," a bioformulation developed by CSRTI, Mysore, containing *Trichoderma pseudokoningii*.

- Mix **1 kg Nursery-Guard** with **60 kg FYM (sufficient for 2000 cuttings)**.
- Moisten with **10–12 litres of water** and keep the mixture under shade for **one week**.
- Apply the prepared mixture to nursery beds at **2 kg per m²**, mixing it thoroughly with soil.

Cutting Treatment:

- Soak cuttings in **0.1% Dithane M-45** solution for 30 minutes.
- Plant the treated cuttings in Nursery-Guard–treated beds and irrigate.

Direct Field Application:

- For direct field planting, apply the Nursery-Guard mixture in pits at **50 g per pit** before planting the cuttings.

Root Knot Disease of Mulberry

Root knot disease, caused by the nematode *Meloidogyne incognita*, is one of the most destructive soil-borne diseases affecting mulberry. Owing to its endoparasitic behaviour and wide host range, the pathogen infects more than 2,000 plant species, including agricultural, horticultural, oilseed, ornamental, and plantation crops. Nematode infestation weakens mulberry plants and often predisposes them to secondary infections, leading to complex disease conditions.

Occurrence

The disease is caused by *Meloidogyne incognita* and is prevalent throughout the year, particularly in **sandy and sandy loam soils** under irrigated conditions.

Symptoms

- Severely affected plants exhibit **stunted growth**, **marginal chlorosis**, and **necrosis of leaves**.
- Below the ground, the disease is marked by the formation of **spherical knots or galls** on the roots. These vary in size—**young galls** are small and yellowish-white, while **older galls** become larger and pale brown.
- Nematode invasion causes disintegration of the root's vascular tissues and cortex, reducing water and nutrient absorption and resulting in overall growth retardation.
- Plant mortality is uncommon unless the infection is accompanied by other soil-borne pathogens.

Estimated crop loss: Root knot disease can cause up to **15% yield reduction** in severely affected plantations.

Differentiation between Nematode Galls and Rhizobium Nodules

- Galls induced by *M. incognita* arise from **internal swelling** of the roots and **cannot be easily detached**.
- In contrast, **Rhizobium nodules** form externally on the root surface (epiblema) and can be **easily separated** from the roots.

Factors Favouring and Spreading the Disease

- The primary sources of infection include **infested soil, irrigation or runoff water, and contaminated tools**.
- **Infected saplings**, **intercropping with susceptible species**, and the **presence of susceptible weeds** in and around mulberry plantations further enhance disease spread.
- Environmental conditions favourable for disease development include **temperatures of 20–30°C**, **soil moisture above 60%**, and a **soil pH range of 4–8**.

Control Measures for Root Knot Disease in Mulberry

Effective management of root knot disease involves a combination of **physical, cultural, chemical,** and **integrated** approaches to suppress nematode populations and prevent further spread of infection.

1. Physical Methods

- The nematode population in infested gardens can be minimized by **deep ploughing or digging the soil to a depth of 30–40 cm during summer.** Since nematode eggs and larvae are highly sensitive to heat, **solarisation of soil** through exposure to high temperatures effectively reduces their numbers.
- Always use **healthy, disease-free saplings** for new plantations. Saplings showing root-knot symptoms should be treated in **hot water at 48°C for 20 minutes** before planting.
- Avoid using **infected saplings** for new plantations or even for **gap filling** to prevent disease spread.

2. Cultural Methods

- To prevent cross-contamination between infested and healthy fields, **farm implements** should be sterilized using **5% formalin solution** or by **immersing in boiling water for 5–10 minutes** before use.
- **Marigold (*Tagetes patula*)** can be planted as an **intercrop** at a spacing of 30 cm between mulberry rows, as it acts as a trap crop for nematodes and suppresses their population.
- Apply **neem oil cake at 2 metric tonnes per hectare per year**, divided into **four split doses**, during fertilizer application or other cultural operations.

3. Chemical Methods

- Apply **Furadan (Carbofuran 3G)** at a rate of **40 kg per hectare per year**, in **four split doses**, along with fertilizer application or cultural practices.
- Maintain a **safety interval of 40–45 days** after chemical application before using the leaves for silkworm feeding.

Method of Application:

- Both **neem oil cake** and **Furadan** should be applied around the base of plants and mixed thoroughly into the soil through **light ploughing or digging**, followed by irrigation to enhance their effectiveness.

4. Integrated Management

An eco-friendly and sustainable management strategy involves the combined use of biological, organic, and cultural methods. One effective approach is the use of **"Bionema"**, a bioformulation developed by **CSRTI, Mysore**, containing *Verticillium chlamydosporium*.

Preparation and Application:

- Mix **1 kg of Bionema** with **24 kg of neem oil cake** and **200 kg of farmyard manure (FYM)** in the ratio **1:24:200**.
- Moisten the mixture with **30–32 litres of water** and keep it under shade for **about one week** to allow multiplication of beneficial organisms. (This mixture is sufficient for approximately **1,000 plants**.)
- Expose the roots of infected plants by **digging up to 15 cm depth**, remove and **destroy the knot-affected portions** by burning.
- Apply the prepared mixture **around the exposed roots at 200 g per plant**, **three times a year** at **four-month intervals**, coinciding with fertilizer application or other field operations.

- **Bionema** is completely safe and leaves **no toxic residues** on mulberry plants or silkworms.

Root Rot Disease of Mulberry

Root rot is considered one of the most destructive diseases of mulberry due to its epidemic nature and its ability to completely kill plants. It poses a major challenge in mulberry cultivation and is prevalent in most sericultural regions of the world. The disease usually begins in small, isolated patches in the field and rapidly spreads to surrounding areas through irrigation water and contaminated farm implements.

Occurrence

Root rot is caused by a complex of soil-borne fungi, occurring either individually or in combination. The major pathogens involved include *Fusarium solani*, *F. oxysporum*, *Botryodiplodia theobromae*, and *Macrophomina phaseolina*. The disease occurs throughout the year across various soil types, particularly in fields with **low soil moisture** and **poor organic matter content in soil**.

Symptoms

- **Above-ground symptoms:** Initially, affected plants show **sudden wilting** and **defoliation** that begins from the lower branches and progresses upward.
- **Below-ground symptoms:** The roots show **black discoloration and decay**, caused by fungal mycelia and spores beneath the bark. In severe cases, the entire root system decomposes, resulting in complete plant death.
- After **pruning**, diseased plants either fail to sprout or produce weak shoots with **small, pale-yellow, rough-textured leaves**. Severely affected plants lose their anchorage and can be **easily uprooted** from the soil.

Estimated crop loss: Root rot causes about **12–14% plant mortality**, but if immediate control measures are not implemented, the losses can increase drastically, leading to the death of most plants in the affected area.

Factors Responsible for Disease Spread

- The disease primarily spreads through **infected soil, irrigation water, and contaminated farm implements**.
- **Diseased saplings** and improper **irrigation or cultivation practices** act as secondary sources of infection.
- The disease is favoured by **high soil temperatures (26–35°C)**, **low soil moisture (below 40%)**, and **low organic matter content (below 0.4%)**.

Control Measures

1. Physical and Cultural Methods

- **Immediately uproot and burn** dead or severely infected plants to prevent further spread.
- **Disinfect the affected pits** by burning dry leaves or grasses to expose the soil to high temperatures.
- Apply **adequate quantities of organic manure** to improve soil fertility and microbial balance.
- **Deep plough the infested field** and expose the soil to sunlight during summer to reduce the population of soil-borne pathogens.

2. Chemical Methods

- At the first appearance of wilting or leaf withering, apply **Dithane M-45 (Mancozeb)** around the root zone at the rate of **10 g per plant**, after removing soil around the roots up to a depth of **15 cm**.
- In severe cases, **uproot and destroy infected plants**, treat the pit with **10 g of Dithane M-45**, and replant with **saplings pre-treated in 0.1% Dithane M-45 solution**.
- Apply Dithane M-45 to **surrounding healthy plants** near the infected area to prevent spread.
- Repeat the application **four times a year at intervals of three months** for effective disease control.

Integrated Management of Root Rot Disease

Integrated management provides a sustainable and eco-friendly approach for controlling root rot disease in mulberry by combining **chemical and biological control methods**. This strategy includes the use of **Dithane M-45** (a broad-spectrum fungicide) along with **biofungicides such as *Raksha* (containing *Trichoderma harzianum*)** and **Chethak**, a new formulation developed by **CSRTI, Mysore**.

Recommended Practices

- **Uproot and destroy** all infected plants by burning to eliminate the primary source of infection.
- Apply **10 g of Dithane M-45 per pit**, and replant with **healthy saplings** that have been **soaked in 0.1% Dithane M-45 solution for 30 minutes** before planting.
- Dithane M-45 should also be applied to the **neighboring healthy plants** surrounding the infected area to prevent further spread.
- After **15–20 days**, apply the **Raksha bioformulation mixture** at the rate of **500 g per plant** in the root zone, followed by irrigation.

Preparation of Raksha Mixture

- Mix **1 kg Raksha** with **50 kg farmyard manure (FYM)** (sufficient for about **100 plants**).
- Add **8–10 litres of water** and keep the mixture **under shade for one week** to allow the multiplication of beneficial fungi.
- Apply the prepared mixture around the base of plants after the chemical treatment phase.

Note:

- The Raksha formulation is completely safe and **does not leave any toxic residues** on mulberry plants or silkworms.
- When combined with cultural and chemical measures, this integrated method significantly **reduces disease incidence** and **promotes healthy root development** in mulberry plantations.

Root Disease Complex of Mulberry

In addition to individual infections such as **root knot** (*Meloidogyne incognita*) and **root rot** (*Fusarium solani*, *F. oxysporum*, *Botryodiplodia theobromae*, and *Macrophomina phaseolina*), a **root disease complex** has emerged as a major production constraint in mulberry cultivation in recent years. A disease is referred to as a *complex* when it results from the combined interaction of two or more pathogens. Although several control measures are effective against root knot and root rot individually, they often fail to provide satisfactory results when both pathogens occur together, leading to the development of this complex disease.

Occurrence

The root disease complex arises from the **combined infection** of the nematode *M. incognita* and root rot–causing fungi such as *F. solani*, *F. oxysporum*, *B. theobromae*, and *M. phaseolina*. The disease severity is particularly high when the root system bears **more than 100 galls per plant** due to nematode infestation, along with a mixed fungal infection involving *B. theobromae* and *F. solani*. Under such conditions, especially in **sandy soils with irrigation**, the mortality of plants may reach up to **88.9%**.

The nematode infestation facilitates **entry and establishment of fungal pathogens** by causing mechanical injury to the roots, thereby enhancing disease severity and often resulting in complete plant death.

Symptoms

- In the early stages, infected plants show **yellowing of leaves**, **stunted growth**, and **reduced leaf lamina size**.
- After pruning, affected plants either **fail to sprout** or produce **weak, pale yellow, wrinkled leaves**.

- As the infection progresses, **wilting, browning, and defoliation** begin from the lower branches and move upward, leading to **complete plant wilting**, often appearing in **patches across the garden**.
- The **roots turn black and decay** due to fungal colonization under the bark. In severe cases, the entire root system decomposes, and the plants **lose anchorage** and can be **easily uprooted**.
- Severely affected roots exhibit **more than 100 galls per plant** (due to nematodes) along with **rotted tissues** (due to fungal attack). The **conducting tissues** become **brown or black**, indicating internal decay.

Estimated crop loss: The disease complex can cause **15% or higher yield loss**, depending on soil type, environmental conditions, and disease intensity.

Factors Responsible for Disease Spread

- The disease primarily spreads through **contaminated soil, irrigation water, and farm implements**.
- **Infected saplings**, **intercropping with susceptible crops**, and **presence of susceptible weeds** in and around mulberry gardens serve as secondary sources of infection.
- Environmental conditions such as **temperature between 20–35°C**, **soil moisture below 40%**, and **soil pH between 4 to 8** are highly favourable for the development and spread of the disease complex.

Control Measures for Root Disease Complex in Mulberry

1. Physical and Cultural Methods

- **Deep summer ploughing:** Carrying out deep ploughing (30–40 cm depth) during the summer season helps in destroying nematode eggs, larvae, and fungal spores present in the soil.
- **Use of healthy planting material:** Only disease-free saplings should be used for new plantations. Saplings showing signs of the root disease complex should be either rejected or treated with **hot water at 48°C for 20 minutes** before planting.
- **Application of organic amendments:** Incorporating **pongamia or neem oil cake at 2 metric tonnes per hectare per year**, divided into four equal doses and applied during fertilizer or cultural operations, helps suppress soil-borne pathogens and nematodes.

2. Chemical Methods

- **Initial stage management:** At the first appearance of symptoms, apply a mixture of **1.5 g Furadan (Carbofuran 3G)** and **10 g Dithane M-45 (Mancozeb 75% WP)** per plant around the root zone after removing soil up to a depth of 15 cm.
- **For severely affected areas:** In cases of heavy infection, the **diseased or dead plants should be uprooted and destroyed by burning**. Treat the pits by applying **1.5 g Furadan + 10 g Dithane M-45 per plant**, and replant new saplings after dipping their roots in **0.1% Dithane M-45 solution for 30 minutes**. This treatment should be repeated **three times a year at four-month intervals**.
- **Protection of surrounding plants:** Apply the same dosage (1.5 g Furadan + 10 g Dithane M-45 per plant) to plants adjacent to the diseased area. **Note:** Leaves from treated plants should be used for silkworm feeding **only after 40–45 days** following pesticide application.

3. Integrated Management Approach

To achieve long-term and eco-friendly control, the **Central Sericultural Research and Training Institute (CSRTI), Mysore**, has developed a **bio-consortium named 'Bio-mix'** using native strains of *Trichoderma harzianum* and *T. viride* isolated from the mulberry rhizosphere.

Application of this **Bio-mix in combination with pongamia oil cake** has shown **75–80% disease control** and contributes to improved soil health. The Bio-mix has a **shelf life of one year** when stored at room temperature (25–30°C).

Method of Application

- Apply Bio-mix immediately after noticing **wilting or withering of leaves**.
- Mix **1 kg Bio-mix with 10 kg pongamia oil cake and 50 kg farmyard manure (FYM)**.
- Apply the mixture at the rate of **200 g per plant** — sufficient to treat about **300 plants with 1 kg Bio-mix**.
- Repeat the application **three times a year**, at four-month intervals, during cultural or fertilizer application periods (after pruning or leaf harvest), followed by irrigation.

4. Precautions

- **Uproot and destroy** plants showing wilting in more than three branches or those completely dried, along with the decayed root stumps.
- **Avoid using infected saplings** for new plantations.
- Maintain **optimum soil organic matter** through regular application of FYM or compost, which promotes beneficial microbial activity and enhances disease suppression.

Chetak: An Herbal Formulation for the Control of Major Foliar and Soil-Borne Diseases of Mulberry

Traditionally, foliar and soil-borne diseases in mulberry have been managed using **chemical fungicides** or **bioformulations**, applied either individually or in combination. However, this approach often posed difficulties for sericulturists due to the **complexity of disease-specific treatments**. To simplify plant protection and make it more farmer-friendly, the **Central Sericultural Research and Training Institute (CSRTI), Mysore** developed a new herbal formulation named **Chetak**, which combines **botanicals (65%)** with **sub-lethal doses of chemicals (35%)**.

Chetak is **eco-friendly** and effective against all major foliar and soil-borne diseases of mulberry. It is available in **powder form** at CSRTI, Mysore. Field trials have shown that Chetak can reduce the severity of **foliar diseases** (leaf spot, powdery mildew, leaf rust, and leaf blights) by **62–82%**, and **root diseases** (nursery diseases, root knot, root rot, and root disease complex) by **85–90%**.

Method of Application

1. Foliar Diseases

- Prepare a **0.5% solution** by dissolving 5 g of Chetak in 1 litre of water.
- For **one-acre gardens**, dissolve **750–900 g of Chetak** in **150–180 litres of water** to cover the entire area.
- Spray the solution **40–45 days after pruning or leaf harvesting**.
- Leaves can be fed to silkworms **5 days after spraying**.

2. Soil-Borne Diseases

Nursery Diseases:

- Soak cuttings in **0.5% Chetak solution for one hour** before planting.
- Apply the formulation to nursery beds at **10 g/m²** prior to plantation.

Root Knot, Root Rot, and Root Disease Complex:

- Mix Chetak with **lime and bleaching powder in the ratio 1:1:0.5**.
- Apply **50 g of this mixture per plant** during cultural or fertilizer application, after removing soil around the roots to a depth of 15 cm, followed by irrigation.
- Uproot and **burn severely infected plants**.
- Apply **50 g of the mixture per pit**, and plant new saplings **after dipping their roots in 0.5% Chetak solution for one hour**, followed by irrigation.
- Repeat the application **three times a year**, at **four-month intervals**.

Chetak provides a **comprehensive, eco-friendly solution** for managing major mulberry diseases while being **safe for plants and silkworms**.

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