**Integrated Management of Mulberry Diseases for Diminishing Deterioration in Quality Production of Mulberry**

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**Introduction**

Silk production has a long history. Silk was discovered by Xilingji (Hsi-ling-chi), wife of China’s 3rd Emperor, Huangdi (Hoang-Ti), in 2640 B.C. Later sericulture spread throughout China, and silk became a precious commodity. [Sericulture](https://en.wikipedia.org/wiki/Sericulture), the practice of breeding silkworms for the production of raw silk, has been under way for at least 5,000 years in China, from where it spread to [Korea](https://en.wikipedia.org/wiki/Korea), Japan, [India](https://en.wikipedia.org/wiki/India) and later the West. The silkworm was domesticated from the wild silkmoth *[Bombyxmandarina](https://en.wikipedia.org/wiki/Bombyx_mandarina" \o "Bombyx mandarina)*, which has a range from northern India to northern China, Korea, Japan, and the far eastern regions of Russia. The domesticated silkworm derives from Chinese rather than Japanese or Korean stock. Demand for this exotic fabric eventually created the lucrative trade route, the historically famous Silk Road or Silk Route named after its most important commodity. Another story is that a Chinese princess married an Indian prince. She carried silkworm eggs/mulberry cocoons in her elaborate head dress. She disclosed the secret of raising silkworms thus, silk production spread in India. The technique of sericulture spread throughout the Mediterranean countries during the 7th century AD and then to Africa, Spain and Sicily. During latter part of the 19th century, modern machinery, improved techniques and intensive research helped the growth of sericulture industry in Japan. At present, Japan, China, Korea, Italy, Soviet Union, France, Brazil and India are the chief silk producing countries in the World.

Silk is Nature’s gift to mankind and a commercial fiber of animal origin other than wool. Being an eco-friendly, biodegradable and self-sustaining material; silk has assumed special relevance in present age. Promotion of sericulture can help in ecosystem development as well as high economic returns. Sericulture is practiced in India and India is the 5th largest producer of silk in the World. It has been identified as employment oriented industry. All the sections of sericulture industry, viz. mulberry cultivation, silkworm seed production, silkworm rearing, reeling and weaving of silk and collection of byproducts and its processing provide a large scale employment, thereby a source of livelihood for the rural and tribal people. Sericulture industry is rated as the second largest employer in India. Owing to this peculiar nature, the Indian planners have identified sericulture as one of the best-suited occupations for ideal growth and development of rural India. Mulberry sericulture has been traditional occupation in Karnataka, Tamil Nadu, A.P. and Kashmir. North-eastern part of India is the only region in the world where all four varieties of silk are produced.

Silkworm diseases and mulberry insect pests and diseases are the major biotic factors responsible for the decrease in silk production in general. Mulberry (Morus spp.) the sole food plant of silkworm, *Bombyxmori* L. is a perennial crop with diverse genetic base. The intensive cultivation of high yielding varieties under a wide range of agro climatic conditions has made mulberry vulnerable to various plant pathogens (Philip *et al*., 1994; Teotia and Sen, 1994 and Sukumar and Padma, 1999). It is essential that mulberry leaf should be disease free to increase the productivity and quality of cocoons. Weather situations favor disease outbreaks leading to 15 to 20% mulberry crop losses and also affect the silk cocoon production too. The diseases occurring in mulberry trees in India are:

**Fungal diseases**

**Powdery mildew - *Phyllactiniacorylea***

The fungus belongs to family Erysiphaceae order erysiphales of class Ascomycetes. The disease was first reported by Ramakrishna and Sudan in 1954. It is more prevalent in hilly areas than plains, occuring during rainy and winter season (July-March). Feeding of mildew affected leaves to siliavorm adversely affects silkworm growth and development resulting in poor cocoon yield and silk quantity (Sullia and Padma, 1987). In Kashmir valley the peak period of powdery mildew incidence has been observed from August to November (Munshi*et al*., 1994). The loss due to mildew is around 12% besides causing depletion in nutritive value (Teotia and Sen,1994;Qadri*et al.,*1998). None of the mulberry cultivars grown in the Kashmir has been observed to be completely free from the diseases, although there are differences in the degree of tolerance / susceptibility (Munshi*et al*., 1999). KNG recorded lower disease intensity reconfirming its tolerance/resistance to powdery mildew, While, the severity of powdery mildew was highest on Goshoerami.

**Symptoms**

Initially, white powdery patches on lower surface of leaves are seen which later cover the entire leaf surface. Later turn black to brown in colour. Infected leaves turn yellow and fall off. High humidity (>70%) and low temperature (24-26˚C) favour outbreak of the disease.



Source: Irfan*et al.,* 2011

**Pathogen and Disease Cycle**

The pathogen*P.corylea* is an ectoparasite which obtains nutrients by sending haustoria into the epidermal cells through the stomata (Kuno*et al*.,1980). The fungus reproduces both by asexual and sexual methods. Asexual reproduction takes place in the initial stages whereas sexual reproduction takes place in the later stages in adverse atmospheric conditions. Asexual reproduction takes place by means of conidia. The mycelium is unbranched hyaline and forms a mycelial mat and sticks to the leaf surface using globed adhesive bodies which is similar to appressorium in morphology. Conidia arehyaline, unicellular, clubshapedmeasuring20x 70p borneterminally onseptateconidiophores. The liberated conidia disperse through wind current and spread the disease.Sexual reproduction takes place by the formation of fruiting bodies, called cleistothecia by the union of antheridium and ascogonium. Cleistothecia are covered with numerous colourless needle shaped, with ball like swollen basal part appendages. Inside the cleistotheciurn, 5-50 asci are present. On maturity at favourable conditions asci liberated by splitting of cleistothecia, each ascus has 2 ascospores. The ascospores germinating produce hyphae and spread the disease by forming conidia.The fungus produces ectophytic mycelium. It gets nutrition from the host through haustoria sent into the mesophyll tissues. Conidiophores are erect, long and hyaline, which cut off oval shaped conidia at their tips. Cleistothecia are flat, sphere shaped, papillate and bear asci inside.

**Mode of spread and survival**

The fungus spreads through conidia or ascospores.

**Management**

Provide wider spacing so that there will be sufficient sun light and movement of air in the garden. Growing resistant varieties like MR1, MR2 and China White.Spraying of Karathane (0.2%) or Bavistin (0.2%) is effective for the control of disease. If disease is severe, two sprays are required with an interval of 15 days. Natural enemies like Yellow lady bird beetles,Illeiscincta Fab and I.indicaTimb have been reported as predators of *P.corylea* conidia and mycelia .The fungus *P.corylea* does not regenerate on the leaves which are predated by beetles (Kumar and Chowdary,2001).A fungal hyperparasite*Cladosporiumspp* also reported to be hyperparasitic on conodiophores and conidia of *P.corylea*(Rao and Sullia,1981).

**Leaf spot**- ***Cercospora moricola***

Leaf Spot disease caused by *Cercospora moricola* Cooke was reported by Patel *et al.* (1949) from India. The fungus belongs to the order Moniliales of the class Deuterornycetes. The disease is very common in rainy season (June-December) and prevails upto January-February (Siddaramaiah *et a1*.,1978).It reduces about 10 – 20 per cent of leaf yield depending on the season and variety(Sharma *et al*., 2009).Survey conducted by Kausar (2003) during 1999, revealed that the leaf spot disease was prevalent in Kashmir Valley with maximum incidence (66.47%) and intensity (50.03%) in district Anantnag. The minimum disease incidence (17.17%) and intensity (7.91%) was observed in district Srinagar with a mean incidence of 41% and intensity of 24% for the Kashmir Valley. Of the 34 mulberry genotypes none were immune to disease. Varieties like Obawase, KNG, Brantul and Senmestsu were categorized as resistant to the disease whereas, Botetul, Takawase and Serpentina were found highly susceptible. However, most of the commercial varities such as Goshoerami, Kokuso-20, 21 and 27 Kanva-2, Limoncinaetc were found moderately susceptible.

**Symptoms:**Brownish circular or irregular leaf spots in the initial stage, enlarge, coalesce and form shot holes in later stage. Severely affected leaves become yellowish and fall off prematurely. Source: Mulberry disease calendar for sericulture areas of India

The fungus, *C.moricola* produces a compact mass of interwoven cushion-like hyphae which produce conidia on conidiophores. Conidia are 3-7 celledhyaline,tapering and 70 x 30 µ in size. The conidia germinate and produce hyphae which enter the host cells and develop the mycelium. The disease spreads primarily with rain droplets through conidia (Sukumar and Ramalingam, 1981) and takes 10-15 days after inoculation for the development of the symptoms.

**Management**

Cultural control: Follow wider spacing of plantation (90 cm x 90 cm) or paired row planting system [(90 +150) × 60 cm].

Chemical control: Leaf spot disease can be controlled by spraying of systemic fungicide; Bavistin 50 WP @ 0.l% concentration(Siddaramaiah*et al*.,I978). For one acre of mulberry garden about 200-250 grams of bavistin is required. If the disease is very severe, two sprays are tobegivenat aninterval of 15 days. Spraying shouldbe done preferably in the cooler hours of the day. There is no residual toxicity of bavistin after one week of spray and leaves can be safely used for silkworm rearing. *Trichoderma harzianum* (Th-1) and *Trichodermapseudokoningii* (Tp) were found to be effective against Brown spot disease (Sharma and Gupta, 2000). Leaf extracts of *Eucalyptus spp.* and *Calotropisgigantia* also found to be effective (Sarvamangala*et al.,* 1993).

**Leaf spot (*Myrotheciumroridum*)**

**Symptoms**

Initially black necrotic irregular spots appear on the leaf surface. Spots enlarge, extend and join together making larger irregular holes.

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Source: Mulberry disease calendar for sericulture areas of India

**Control:** Cultural control: Follow wider spacing of plantation (90 cm x 90 cm) or paired row planting system [(90 +150) × 60 cm].

**Chemical control**: Spray 0.1% Carbendazim 50% WP (Bavistin) [2 g/lit. water]. If the disease is more a second spray may be done after 10 days.Further, it was foundthatspaying of O.2% of Foltaf80W is effective against *Myrotheciumroridum*with safe period of 10 days (Govindaiah*et al*.,1988 a).

**Resistant varieties**: The varieties having thick cuticle and epidermis are more resistant to the leaf spot disease. Varieties like KaliaKutahiand Bilidevalaya were found to be immune whereas Kanva-2, S-54, MR-2, C- 7gg, Jodhpur, Paraguay, RFS-135, RFS-175 and Almora local were resistant to this disease having less than 5%disease incidence. EB x Kosen and Mandaiaya were found susceptible (Govindaiah*et al.,* 1989b).

**Leaf spot (*Pseudocercosporamori*)**

**Symptoms**

Small or medium size velvety black spots appear on lower surface of the leaves.Spots coalesce and spread below the leaves. Severely infected leaves turn yellowish and defoliate prematurely. Source: Mulberry disease calendar for sericulture areas of India

**Control:** Spray 0.1% Carbendazim 50% WP (Bavistin) [2 g/lit. water]. If the disease is more a second spray may be done after 10 days

**Root rot-** *Fusariumoxysporum,Macrophominaphaseolina*

The disease is prevalent in all mulberry growing areas of the country with varying intensities. Insouth India the incidence of mulberry root rot, caused by *F. solani*, ranged from 3 to 55% (Philip *et al.,* 1994). In Kashmir valley the incidence of root rot disease was 16.85% during 2001-2002 (Anonymous,2002). Most of the seedlings raised for grafting the commercially important cultivars and also saplingsplanted in field in rearing zones fail because of root rot disease. Even sudden drying of older plantation, irrespective of age and system, occurs frequently.

**Symptoms**

Sudden wilting, withering of leaves and affected plants fail to sprout after pruning and dry up completely. Affected plants can be pulled out easily. Rotting of primary and secondary roots, rotten roots turn black and roots contain large number of black sclerotia. Decay of root bark.

Source: Diseases and nematodes of mulberry

**Management**

Uprooting the infected plant and the stump and root portions are burnt. Application of Neem cake @ 1 tonne/ha in four split doses. Application of antagonist *Bacillus subtilis* @ 25 g/plant.Drenching the soil with carbendazim @ 10 ml of 1% concentration per plant. Soil application of *Trichoderma harzianum*, *T. viride* and *Chaetomiumindicum*@ 2% proved highly effective in controlling the root rot disease (Munshi*et al.,* 2009).

**Stem canker- *Lasiodiplodia (Botryodiplodia) theobromae***

**Symptoms**

**Nursery**

Failure of cuttings to sprout.Sudden withering and death of sprouts.Discolouration and drying of stems and buds above the soil. Rotting and peeling of bark on stem below the soil surface. Black mycelial threads seen below infected bark and black eruptions on the bark of the infected stem portion. This disease causes around 40 -45% loss.

**Grown-up plants**

Greyish brown discoloration of the bark at the cut ends of the stem. Delayed sprouting, death of buds and sprouts, black eruptions on the bark in the infected region and death of plants. The above symptoms can be observed a few days after the plants are pruned.

**Management**

Planting in winter months should be avoided. Pre-treatment of cuttings with carbendazim@ 4g/litre for a period of 12 hrs is recommended. After pruning, the cut surfaces of the stems should be dressed with a spray/smear of carbendazim @ 4g/litre (Sengupta*et al.,* 1991).Biocontrol formulation containing *Trichodermapseudokoningii* at the rate of 2gm/m2 is recommended.

**Leaf rust**

Leaf rust disease caused by *Ceroteliumfici* (Cast.) Arth.was reported in India by Ramakrishna in 1952. The pathogen belongs to the order Uredinales and family Uredinaceae under the class basidiomycetes. It is a common disease appearing during winter (November-February) season. Matured leaves are more susceptible to this disease. In the presence of rust there will be rapid premature defoliation of leaves resulting in shortage of leaves during late age rearing.

**Symptoms**

Presence of small, irregular reddish to rusty brown spots on lower surface of older leaves. Black spots on the concomitant upper side of the leaves. Leaves become yellowish and wither off prematurely.

Source: Mulberry disease calendar for sericulture areas of India

**Disease Cycle**: The pathogen*C. fici* is obligate micro-cyclic rust fungi. It existspimarily as mycelium, uredia and uredospores. Uredospores are oval to round uninucleate produced singly on uredophores in uredia. In favourable conditions (22-24oC and high humidity), uredospores germinate and produce hyphae and enter the leaves through stomata. The hyphae grow intercellularly in the host tissue sending haustoria into the host cells to draw out the nutrients. Uredospores disperse through water droplets and wind currents and spread the disease rapidly (Sengupta*et al.,* 1991).

**Management**

Timely utilization of leaves, especially during winter months and providing wider spacing are most important to reduce the disease. Spraying carbendazim @ 500-625 g/ha. Apply 0.2% Copper Oxychloride 50WP (Blitox) [4 g/litre of water] or 0.02 Triadimefon 25WP (Bayleton) @8g/10 litres water.No variety is found to be completely resistant (immune) to this disease. However, few varieties viz., AB xPhill, K2 x Kosen, ACC-115 and Almora local were found to be moderately resistant having less than 20 per cent of disease incidence. Leaf extracts of *AdhatodaZeylanica* and *Azadirachtaindica* are found to be effective against rust diseases. *Trichodermaharzhianum* and *T. pseudokoningii* were also effective against rust (VijayaKumari, 2014).

**Red Rust**

In addition to the common leaf rust caused by *C. fici*, there is another rust called red rust of mulberry causedby *Aecidium mori* (Baracl.) Diet reported in some parts of India. This disease is widespread in subtropical countries like China,JapanUSSR, Korea etc. In India it is a minor disease seen occasionally in northern parts of the country (Sengupta*et al.,* 1991).*Aecidium mori* affects young buds, leaves, petioles and shoots. The affectedbuds become swollen and curl up in abnormal shape with many slightly protruded yellow spots on the bud.On affected leaves numerous small round, shiny yellow coloured protruded spots appear on both surfaces of the leaves. If the shoot and petiole are affected the fungus spread through theirvascularbundles. The affectedveins and mid-ribs become abnormal and curl up. The disease spreads through aeciospores by wind and water current. The disease can be controlled by spraying of suitable fungicides like Bavistin 50 WP, Foltaf 80W, Sulphur dust at 0.5%concentration.

**Twig Blight**

Twig blight disease caused by *Fusariumpallidoroseum* (Cooke) Sacc. has beenreportedbyGovindaiah*et al*.(1988b).Thepathogenbelongs totheorderMonilialesof Class Deuteromycetes. Generally, this disease was observed throughout the year but the incidence was more in rainyand postt-rainy season (June-October). Besides the above several other species of Fusariumwere alsoreported on mulberry viz.,*F. roseum*, *F. moniiliforrnis*, *F. etiseti*,*F oxysporum* and *F. accuminatum* (Saito *et a1*.,1978; Shirata*et. a1.,*1980 and Govindaiah*et al.*, 1987).

**Symptoms**

The diseased plants show bushy appearance with profuse growth ofauxillary branches, leaves show marginal browning / blackening in the beginningand completely burning in the later stages resulting in severe defoliation. Affectedbranches have black longitudinal lesions which later lead to the splitting and drying of the branches (Sengupta*et al.,* 1991).

**Control Measures**

Among the different fungicides tested Foltaf 80W and DithaneM-45 were found to be effective against the twig blight. Since the diseaseis soil as well as air borne in nature, the fungicides may be used both as foliar spray in lesser concentration (0.2%) and soil drenching in higher concentration (0.5%).

**Sooty mold-*Capnodium*, *Cladosporium*, *Aureobasidium*, *Antennariella*, *Limacinula*and *Scorias***

Sooty mold is a black, non-parasitic, superficial growth of fungi on plant surfaces. The sooty mold actually results from interaction among sap feeding insects and non – parasitic fungi. The problem of sooty mold occurs widely throughout the world’s temperate and tropical region (Nelson, 2008). Plants become blackened and are usually sticky. The fungi involved are saprophytic, *i.e*. they do not invade the plant tissues, but remain on the surface. The mold is difficult to remove and although it is not feeding on the plant, it restricts the light reaching to the leaves, thus reducing photosynthesis process. Plants / leaves become blackened and are usually sticky. The fungi involved are saprophytic, *i.e*. they do not invade the plant tissues, but remain on the surface. The mold is difficult to remove and although it is not feeding on the plant, it restricts the light reaching to the leaves, thus reducing photosynthesis process (Irfan*et al.,*2012).

**Stem rot**

Stem rot caused by *Polyporushispidus* (Bull) Fr. and *Ganodermaapplanetum*(Pers) Pat. The symptoms of the disease include drying and rotting of the twigs and branches.

**Collar rot**

It is causedby *Phomamororum*Sacc. and is common in rainy season (July-September). The symptoms are rotting of the stem near ground level resulting in wilting of the plant (Yadav and Sukumar,1987).

**Stem blight**

Stem blight caused by *Phomaexigua*Desm. is common in rainy season (July-October). The symptoms are splitting of the tender stem and wilting of the leaves.

**Bud blight**

Bud blight caused by *Fusariumlateritium*f.sp.*mori*Desm.) Maet. Sato occurs in winter (February-March) and the symptoms are rotting of the buds (Sukumarand Yadav, 1988).

**Bacterial diseases**

Bacterial diseases of mulberry wererecognised as early as 1901 by Hori in Japan. Of late, it has been reported in India by Sinha and Saxena in 1966. Subsequently, many workers have reported them from different parts of the country. Bacterial diseases commonly occur during rainy season in most of the mulberry growing areas, particularly in South India.These are more prevalent in high altitudes. The bacteria thrive within a temperature range of 10-40oC and the optimumtemperature is 20- 35oC. Bacterial diseases are more closely associated with water logged conditions and newly planted mulberry are more prone to the attack of the diseases.

**Bacterial blight**

Bacterial blight caused by *Pseudomonas mori* Bayer and Lambertbelongs to the order Pseudomonadales of the class Schizomycetes. It is a serious disease in India and cause 5-10%leaf yieldloss during rainy season (June-October).

**Symptoms**

Numerous irregular water soaked patches on the lower surface of leaf. Leaves become curled, rotten and turn brownish black in colour. Black longitudinal lesions are seen on the bark of young shoots. Yellowing and defoliation are the other symptoms.

Source: Mulberry disease calendar for sericulture areas of India

**Disease Cycle**

Soil is the primary source of bacterial inoculum. The secondary infection of the disease takes place through irrigation, cultivation activities, mechanical injuries and biological agents. The bacterium is rod-shaped measuring0.9 to 1.4 µ by 1.8 to 4.5µ Gram negative, encapsulated no endospore. Colonies on nutrient agar are white, circular, smooth, flat and translucent. The thermal inactivation point is 52oC.

**Management**

Affected plant should be uprooted and burnt.The contaminated soil shouldbe exposed for sun drying. Agricultural antibiotics like streptomycin or streptocycline can be used as foliar spray at 0.1% concentration (Krishnaprasad and Siddaramaiah, 1978). The leaves can be used for silkworm rearing after l0 days of spray.Leaf extracts of neem which is commercially available as Azhadirachtin 0.15% is effective.Bioagents like *Pseudomonas fluorescence* and *Trichoderma harzianum* are found to be effective.

**Bacterial wilt**

The disease is caused by *Pseudomonas solanacearum* Smith, commonly seen in rainy season (April- November). The symptoms are rotting of the roots and wilting of the plants. Application of formalin solution (1:100) or bleaching powder 0.2% is useful for control of the disease.

**Leaf scorch**

The leaf scorch caused by a fastidious xylem inhabiting bacteria (FXIB), commonlyoccurs in July (Kostka*et al.,*1986). The affectedleaves show marginal necrosis and desiccationof tissues.

**Shoot soft rot**

The disease caused by*Erwiniacorotovora* var. *corotovora* (Jones) Dye. isfound commonly in Japan (Takahashi and Sato, 1978). Characteristic symptoms of thedisease are the soft-rot and non-sprouting of the over wintering shoot in early spring and the soft-rot of the young shoot in middle or late spring.

**Mosaic disease**

There are few viral diseases reported on mulberry viz., mosaic and yellow net vein from India.It is caused by mosaic virus, seen only during rainy season in temperate conditions. The symptoms of the disease arc inward curling of leaves, particularly leaf margin and tip with chlorotic lesions on the leaf surface. No suitable control measures are available. Affected plants may be uprooted and burnt (Sengupta*et al.,* 1991).

**Yellow net vein**

The disease is caused by a virus and transmitted by sap of aphids (Raychaudhury*et al.,* 1965).The symptoms of thedisease includewrinkling of ventral surface of the leaves with chlorosis. Leaves become distorted and twined.

**Root knot nematode- *Meloidogyne incognita***

Root-knot nematodes are distributed world-wide and cause economic damage tomany crops under different climatic conditions (Lamberti and Taylor, 1979). Root knot disease caused by *Meloidogyne incognita* (Kofoid and White) Chitwoodwas first reported by Narayan *et al.,*(1966) on mulberry from India. It belongs to class Nematoda, order Tylenchida of family Heteroderidae. Survey conducted during recent years in South India revealed that the disease is more common in sandy type of soils under irrigatedconditions. The symptoms of fungal and bacterial diseases which usually affect the foliage can be easily identified and controlled, while the root-knot nematode which is basically parasites of underground roots is difficult to recognize and the damage very often goes unnoticed.Further, since nematodes are also known to cause disease complexes in association with other micro-organisms such as fungi, bacteria and viruses, a weak parasite can cause considerable damage in the presence of nematode.

**Symptoms**

Stunted plants, marginal necrosis and yellowing of leaves are the primary symptoms. Formation of characteristic knots or galls on the roots areunderground symptoms. Wilting of plants is also seen. The nematode damaged roots do not utilize water and fertilizers as effectively as uninjured roots. Thus, as a result ofpoor plant growth, about 10-12% leaf yield is lost in addition to affecting the leaf quality (Govindaiah, 1991).

**Disease cycle**

There are three stages in the life cycle of nematode, namely egg, larva and adult. The second stage female larvae enter into the roots through the holes made by stylet and harbour in sub epidermal layer. Soon after the entry, it starts feeding on the parenchymatous cells. Due to hypertrophy and hyperplasia induced by nematode,, characteristic knots appear on the roots. The larvae undergo four moults in the roots and develop into a mature oval/spherical egg-laying female. Each female lays 200-300 ellipsoidal eggs covered with gelatinous substance. In favourable conditions, the eggs batch and larvae are liberated in the soil. It takes30-40 days to complete the life cycle and it repeats 2-3 times in a year. Nematode damages the xylem and phloem tissues, hence disrupting the water and food conduction. Temperature from15oC to 30oC and soil moisture of 40-60% is more favourable for the growth of the nematode. In water stagnant and completely dry soils, the intensity of the nematode is very low (Vangundy,1985).

**Control Measures**

Any strategy for control of nematodes depends on the crop life cycle, total life span and cropping pattern. As mulberry is a perennial crop, the crop rotation becomes unpractical. Hence, control of the disease in the initial stage bydifferentintegratedapproacheswillbecomevery important. Thereare several means by which the disease can be controlled and kept below the damaging level.

a. Deep digging/ploughing: Deep digging or ploughing of infested garden during summer exposes the nematode eggs and larvae to direct sun. Due to high soil temperature and low moisture most of the nematodes get killed.

b.Intercropping ofnematicidal plants: Nematicidal plants like marigold (*Tagetuspatula*) and sun hemp (*Crotalaria spectabilis*) are reported to be nematicidal in property (Brodie*et al.,* 1970). When the nematodes enter into the root system of these plants, they get imprisoned because of the formation of thick coat of antinematic substances (Belcher and Hussey, 1917). Marigold and sun hemp plants at 10 per square meter can be grown in between mulberry rows. Intercropping of these plants and mulching of the same in soil after vegetative growth provides an additional organic matter to the soil which enriches soil fertility in addition to control of the disease.

c. Use of organic oil -cakes as soil amendments. The effect of different oil-cakes has been proved by many workers. These oil-cakes are used extensively in agricultural crops to control pest and diseases and to improve the soil fertility (Khan *et al*., 1974 and Alam*et a1.,*L979). Among different cakes tested, neem oil cake was found to be very effective against root-knot nematode disease. In mulberry, application of neem oil-cake at1 tonne/ ha/year in four equal split dosages is found effective (Sikdar*et al*.,1986). There is no residual toxicity of neem oil- cake on the silkworm.

d. Applicationof nematicides: Organicphosphates andcarbomates provedtobevery effective for control of root-knot nematode disease (Ahuja, 1983; Sikdar*et al.,*1986). Application of temik 10 G (Aldicarb) or Furadon (carbofuran) at 3D kg/ha/year in four equal split dosages alongwithfertilizers is recommendedforthecontrol of root-knotnematode disease. Further, application of Rugby 10G, a new nematicidemanufactured by Rallis India,Ltd., at 20 kg./ha/year found very effective. After application of nematicides, it should be well mixed in the soil while digging followed by regular irrigation.

e. Mulching of green leaves: In addition the mulching of green leaves of neem (*Azadirachtaindica)*andpongama(*Pongamiapinnata*) at 1 tonne/acre/crop is also effective in control of root-knot nematode disease (Govindaiah*et al*.,1989C).

f. Biocontrol formulation containing*Verticilliumchlamidosporium* along with neem oil cake and FYM(1:24:200) @ 200gm/plant is recommended at three split doses (Sharma *et al.,* 2009).

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