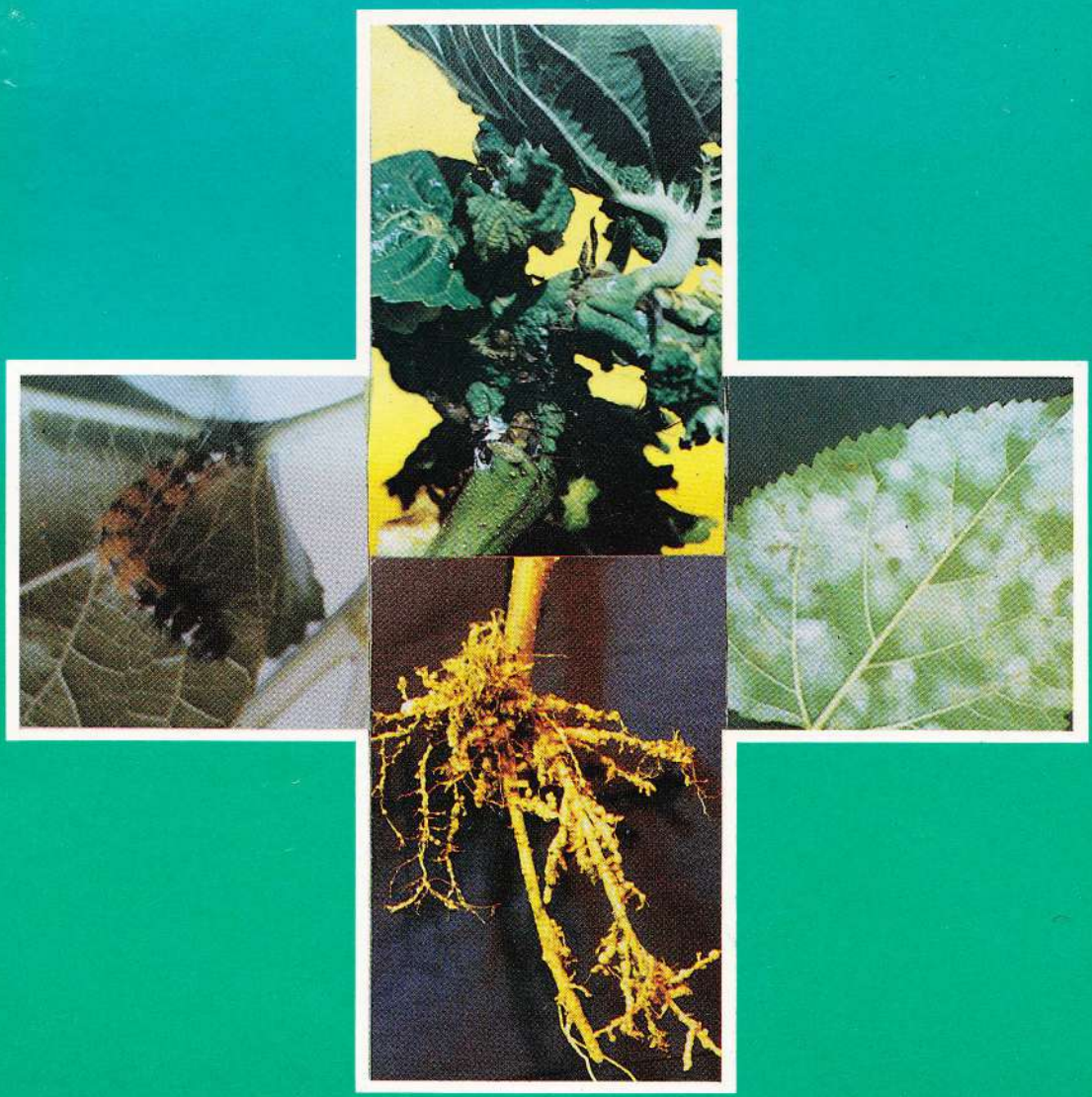
DISEASES AND PESTS OF MULBERRY AND THEIR CONTROL



CENTRAL SERICULTURAL RESEARCH & TRAINING INSTITUTE MYSORE

DISEASES AND PESTS OF MULBERRY AND THEIR CONTROL

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FOREWORD

Mulberry (*Morus sp*) - the food plant of silkworm (*Bombyx mori* L.) is cultivated in both tropical and temperate countries of the world. Mulberry is grown under a wide range of climatic conditions and is affected by a large number of diseases and pests and many of them are of greater economic importance.

The diseases, in addition to the reduction in leaf yield, also affect the quality of the leaf. Bio-chemical studies have revealed that the diseased leaves are poor in nutritive values and moisture content. Feeding such leaves, not only affects the growth and development of silkworms, but also the cocoon yield and silk quality. Similarly, pests also affect the quality and quantity of the mulberry leaves. Though frequent leaf picking and pruning of the shoot restrict the attack of pests, many insects still find enough time and place on mulberry for their feeding and breeding.

Recently, sericulture is being extended in new areas and countries including low temperature and high rainfall areas which may throw new challenges, since many of the plant pathogens are known to multiply quicker in such conditions. Protection of mulberry from diseases and pests has become more important today than ever before.

This booklet will serve as a manual to provide up-to-date information on the diseases and pests of mulberry and their control and would help to create awareness among the sericulturists and there by to prevent the economic loss. I acknowledge thankfully the efforts of the authors in preparing this booklet and also the help extended by Dr. D.D. Sharma, Dr. Tomy Philip, Dr. V. Gunashekar and Dr. Ramkishore of Central Sericultural Research and Training Institute, Mysore in compiling the information.

Mysore,
1.12.1991

(Dr. R.K. DATTA)
DIRECTOR

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Fungal Diseases

MAJOR

LEAF SPOT 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 Deuteromycetes. The disease is very common in rainy season (June-December) and prevails upto January-February (Siddaramaiah *et al., 1978).* It reduces about 10 - 20 per cent of leaf yield depending on the season and variety.

Symptoms: The symptoms of the disease are the appearence of small brownish, irregular spots on the leaves in the initial stages. As the disease become severe, the spots enlarge, coalesce and shot-holes are formed. Severely affected leaves become yellowish and fall off prematurely (Fig. 1 A and B).

Disease Cycle: The fungus, *C moricola* produces a compact mass of interwoven cushion-like hyphae which produce conidia on conidiophores. Conidia are 3-7 celled,hyaline,tapering and 70 x 30 μ in size (Fig.2). 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 (Fig.3).

In addition to *Cercospora moricola*, there are many other pathogens causing leaf spot in mulberry viz., *Septogloem mori* Briosi et Cavara (Stewart,1948); *Alternaria tenussima* (Ness ex Fr.) Wiltshire (Pandotra,1966); *Drechslera yamadi* (Nisik) Subram and Jain (Sharma,1974); *Phloeospora maculans* (Berng) Allesch (Munshi *et al.*, 1985); *Fusarium solani* (Mart.) Sacc. (Chaudhury and Raj,1986) and *Myrothecium roridum* Tode ex Fr. (Govindaiah *et al.*; 1989 a). The symptoms of the disease caused by the said pathogens are slightly different from that of *Cercospora moricola* i.e., appearence of circular/irregular brownish black spots of varying sizes on the leaves.

Control Measures: Leaf spot disease can be controlled by spraying of systemic fungicide; Bavistin 50 WP at 0.1% concentration (1 gm Bavistin dissolved in one

litre of water)(Siddaramaiah *et al.*,1978). For one acre of mulberry garden about 200-250 grams of Bavistin is required. If the disease is very severe, two sprays are to be given at an interval of 15 days. Spraying should be done preferably in the cooler hours of the day (Appendix-III)). There is no residual toxicity of Bavistin after one week of spray and leaves can be safely used for silkworm rearing. Further, it was found that spraying of 0.2% Foltaf 80W is effective against *Myrothecium roridum* with safe period of 10 days (Govindaiah *et al.*,1988 a).

Varietal Resistance: The disease resistance of mulberry varieties depends upon many factors. Generally, it was observed that the varieties having thick cuticle and epidermis are more resistant to the leaf spot disease. Varieties like Kalia Kutahi and Bilidevalaya were found to be immune whereas Kanva-2, S-54, MR-2, C- 799, Jodhpur, Paraguay, RFS-135, RFS-175 and Almora local were resistant to this disease having less than 5% disease incidence. EB x Kosen and Mandalaya were found susceptible (Govindaiah *et al.*, 1989b).

POWDERY MILDEW

Powdery mildew caused by *Phyllactinia corylea* (Pers.) Karst. is the most common and widespread disease. 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 silkworm adversely affects silkworm growth and development resulting in poor cocoon yield and silk quality (Nomani *et al.*,1970 and Sullia and Padma,1987).

Symptoms: This disease can be easily identified by the appearence of white powdery patches on the lower surface of the leaves (Fig. 4). As the disease advances the patches spreads to entire leaf surface and turn to blackish colour.

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 (Fig. 6). 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 (Fig. 6.B. and C). Conidia are hyaline, unicellular, club shaped measuring 20 x 70μ borne terminally on septate conidiophores (Fig. 5). The liberated conidia disperse through wind current and spread the disease.

Fig.1A. Mulberry affected by leaf spot in field condition

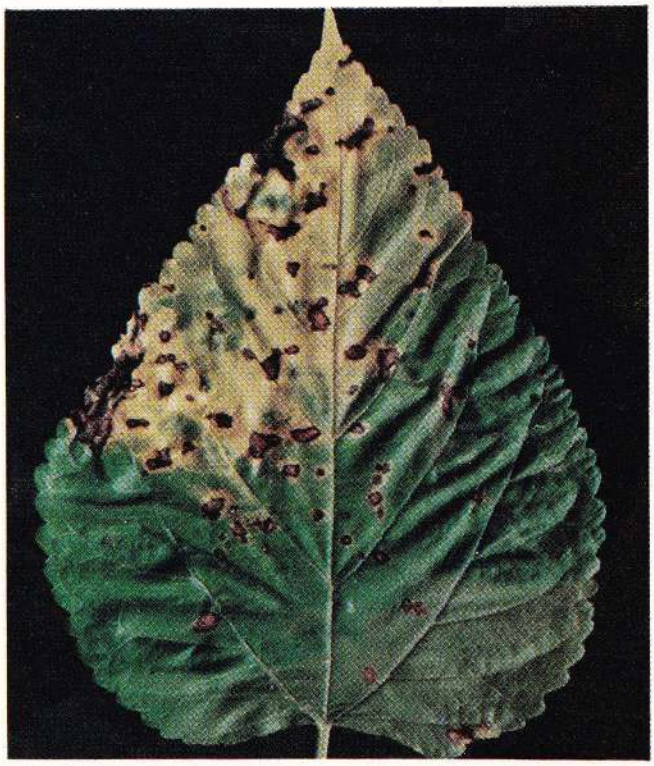


Fig.1B. Mulberry leaf affected by leaf spot

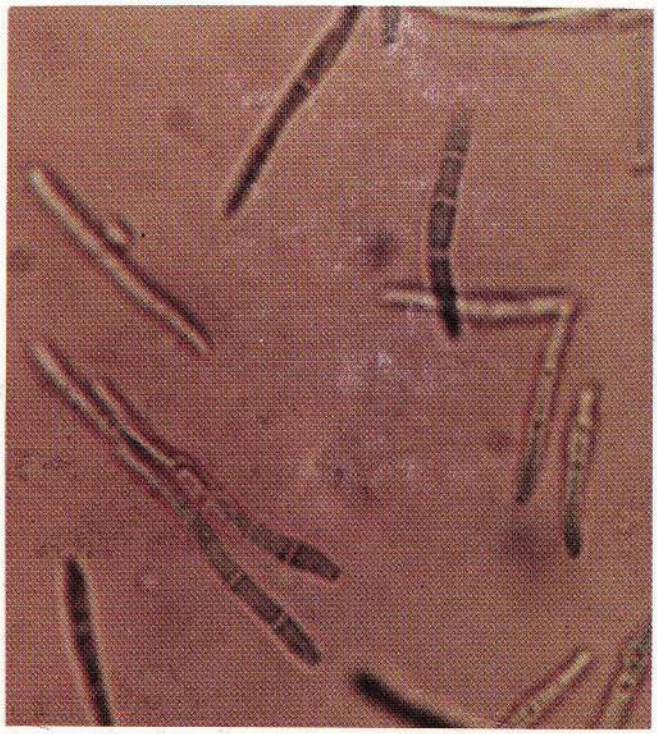
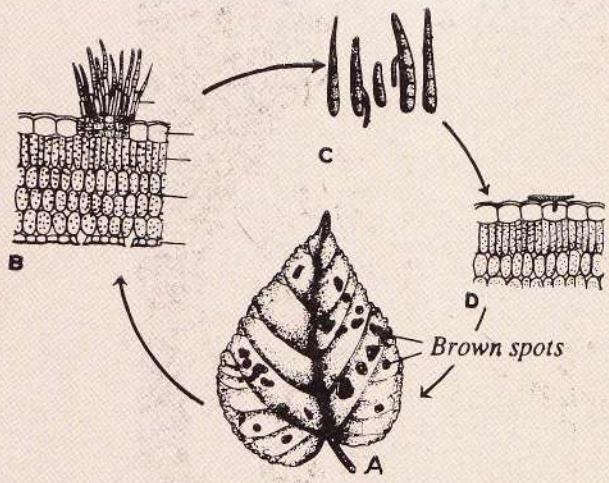


Fig.2. Conidia of Cercospora moricola



A. Mulberry leaf affected by leaf spot

B. T.S. of infected leaf

1. Conidiophores with conidia

2. Upper epidermis

3. Palisade tissue

4. Spongy Tissue

5. Lower epidermis

C. Conidia with germ tube/germinating conidia

D. Germinating conidia on the leaf surface

Fig.3. Disease cycle of leaf spot of mulberry caused by C. moricola

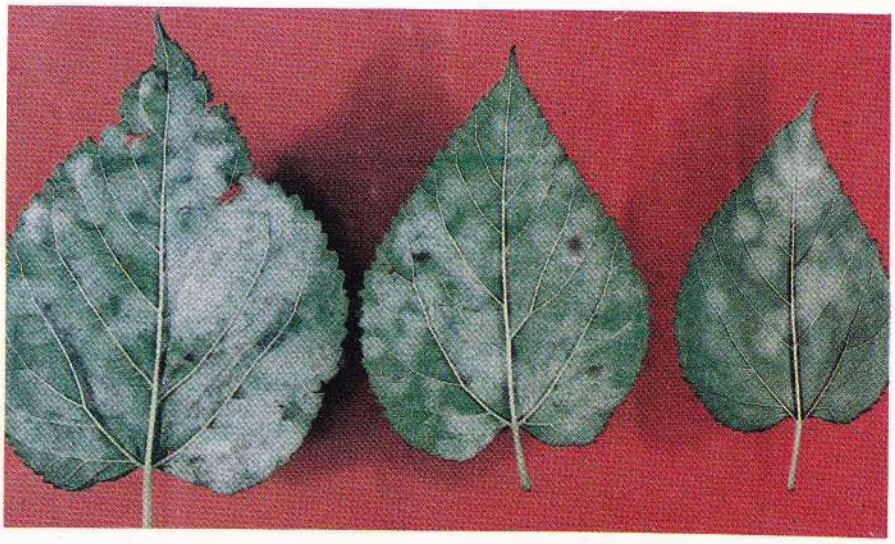


Fig.4. Mulberry leaves affected by powdery mildew (white patches)

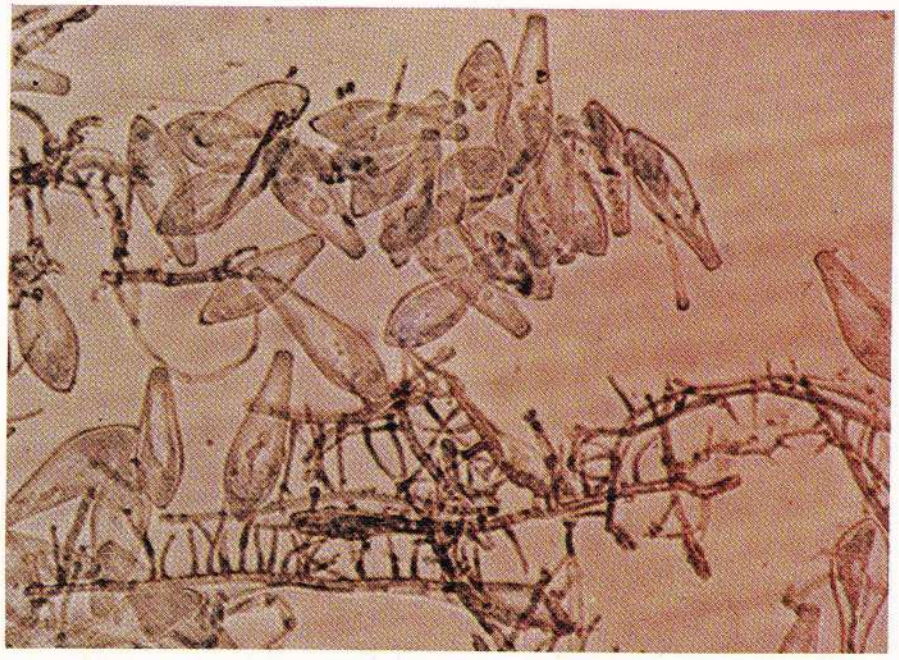
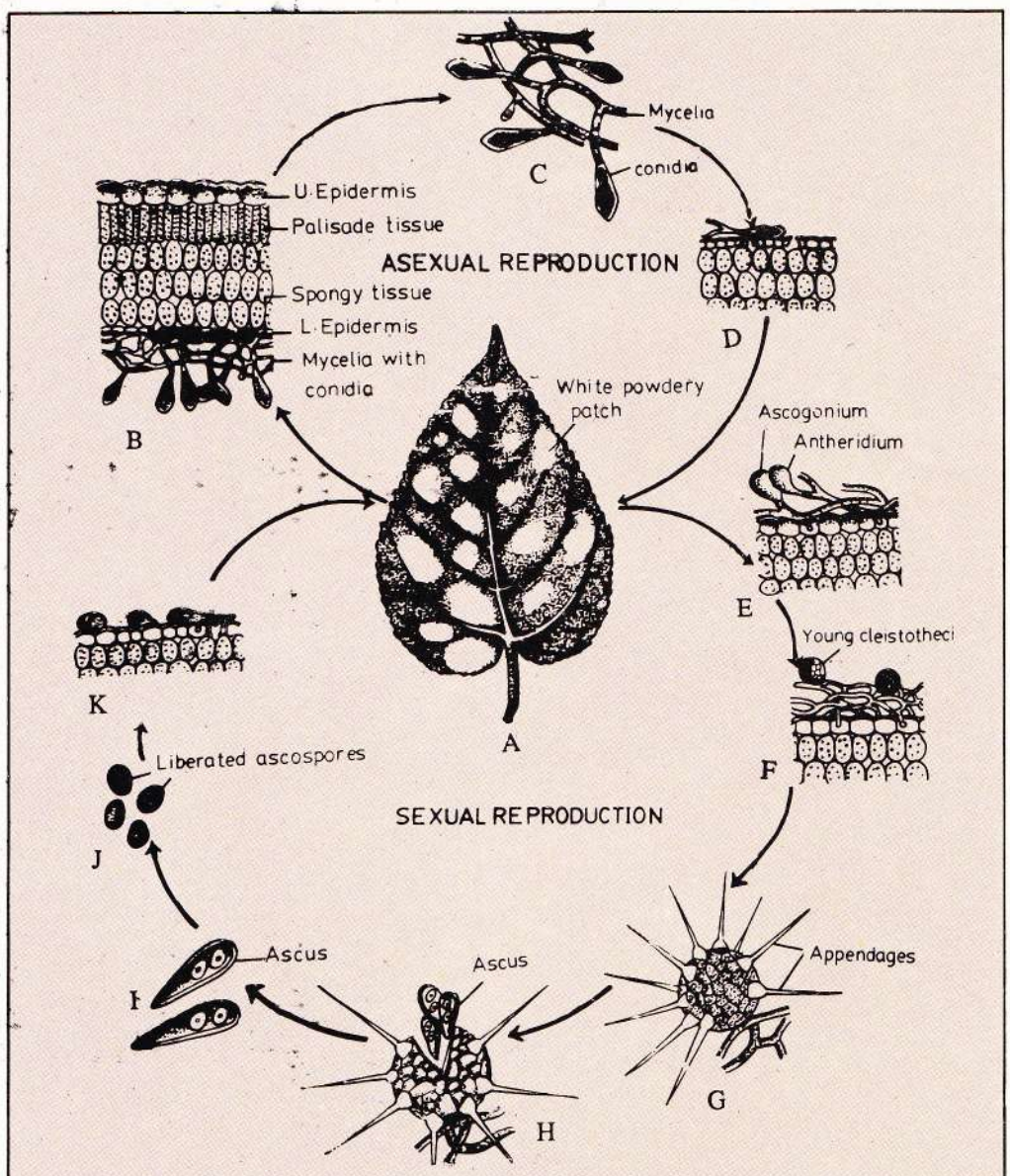


Fig.5. Conidia of phyllactinia corylea causing powdering mildew



A. Mulberry leaf affected by powdery mildew
B. T.S. of infected leaf
C. Myselia with conidia
D. Germinating conidia
E. Ascogonium & antheridium
F. Young cleistohecium
G. Matured cleistohecium
H. Liberation of asci
I. Ascus
J. Ascospores
K. Germinating ascospore

Fig.6. Disease cycle of P. corylea on mulberry

Sexual reproduction takes place by the formation of fruiting bodies, called cleistothecia, by the union of antheridium and ascogonium (Fig.6 E and F). Cleistothecia are covered with numerous colourless needle shaped, with ball like swollen basal part appendages (Fig. 6 G). Inside the cleistothecium, 5-50 asci are present. On maturity at favourable conditions asci liberated by splitting of cleistothecia, each ascus has 2 ascospores (Fig. 6 I). The ascospores germinate, produce hyphae and spread the disease by forming conidia.(Fig. 6 K).

Control Measures:

1. Selection of mildew resistant varieties.
2. Provide wider spacing, so that there will be sufficient sun light and movement of air in the garden.
3. Spraying of Karathane EC (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. While spraying the fungicides, the lower surface of the leaves should thoroughly be drenched. The leaves can be fed to silkworm after 10 days of spraying.

Varietal Resistance: Resistance to powdery mildew disease among the different mulberry varieties are variable. Kalia Kutahi is found immune to the disease. Some varieties like Mandalaya, Katania, China-White, Jodhpur, Punjab local, MR-2, Almora local, Himachal local and S-523 were found to be resistant, with below 5% disease incidence, while ACC-125,S-130,K_2 x BC and EB x Kosen were found susceptible.

LEAF RUST Leaf rust disease caused by *Cerotelium fici* (Cast.) Arth. was reported in India by Ramakrishna in 1952. The pathogen belongs to the order Uredinales and family Uredinaceae under the class Imperfect fungi. 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: The pathogen produces numerous pin-head sized circular to oval, brownish to black erruptive lesions/spots on the surface of the leaves. The affected leaves become yellowish and as the disease becomes severe, the leaves wither off prematurely (Fig. 7).

Disease Cycle: The pathogen, *C. fici* is an obligate, micro-cyclic rust fungi. It exists primarily as mycelium,uredia and uredospores. Uredospores are oval to round uninucleate produced singly on uredophores in uredia (Fig. 8). In favourable conditions (22-24 ^{o}C 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 (Fig. 9).

Control Measures:

1. Timely utilization of leaves, especially during winter months and providing wider spacing are most important to reduce the disease.

2. Spraying suitable fungicides like Kavach 75 WP or Foltaf 80W at 0.2% concentration helps in controlling the disease. Leaves can be used after 10-12 days of spraying safely to silkworms.

Varietal Resistance: No variety is found to be completely resistant (immune) to this disease. However, few varieties viz., AB x Phill, K_2 x Kosen, ACC-115 and Almora local were found to be moderately resistant having less than 20 per cent of disease incidence.

RED RUST In addition to the common leaf rust caused by *C. fici*, there is another rust called red rust of mulberry caused by *Aecidium mori* (Baracl.) Diet. reported in some parts of India. This disease is widespread in sub-tropical countries like China, Japan, USSR, Korea etc. In India it is a minor disease seen occassionally in northern parts of the country.

A. mori affects young buds, leaves, petioles and shoots. The affected buds 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 spreads through their vascular bundles. The affected veins 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, Sulpher dust at 0.5% concentration.

TWIG BLIGHT

Twig blight disease caused by *Fusarium pallidoroseum* (Cooke) Sacc. has been reported by Govindaiah *et al.*(1988 b). The pathogen belongs to the order Moniliales of Class Deuteromycetes. Generally, this disease was observed throughout the year but the incidence was more in rainy and post-rainy season (June-October). Besides the above, several other species of *Fusarium* were also reported on mulberry viz., *F. roseum, F. moniliformis, F. equiseti,F oxysporum* and *F accuminatum* (Saito *et al.*, 1978; Shirata et. al.,1980 and Govindaiah *et al.*,1987).

Symptoms: The diseased plants show bushy appearence with profuse growth of auxillary branches, leaves show marginal browning / blackening in the beginning and completely burning in the later stages resulting in severe defoliation. Affected branches have black longitudinal lesions which later leads to the splitting and drying of the branches.

Control Measures: Among the different fungicides tested Foltaf 80W and Dithane M-45 were found to be effective against the twig blight. Since the disease is 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%).

MINOR

Besides the major diseases discussed above, there are some minor and economically less important diseases in mulberry. They are

WHITE ROOT ROT

It is caused by *Rosellinia necatrix* (hartig) Brelesse. The attack of the fungus results in rotting of the roots with white mycelium mat on the root surface. For controlling the disease soil is to be disinfected with chloropicrin or calcium cynamide at 1 pound per 108 sq.ft. or 75 gram per 36 sq.ft., respectively

VIOLET ROOT ROT

It is caused by *Helicobasidium mompa* N.Tanaka. The symptoms of the disease are rotting of the roots with violet mycelial mat. The control measures are similar to that of white root-rot.

STEM CANKER

This disease is caused by *Botryodiplodia theobromae Pat*. The symptoms of the disease appear as greenish black lesions on the stem surface. Usually this disease affects the sprouting of the cuttings in the nursery bed and new plantations. For

For controlling the disease, mulberry cuttings are to be soaked in 10 ppm solution of Bavistin 50 WP for 12 hours. Treated cuttings should be thoroughly washed before planting.

STEM ROT Stem rot caused by *Polyporus hispidus* (Bull) Fr. and *Ganoderma applanetum* (Pers.) Pat. The symptoms of the disease include drying and rotting of the twigs and branches.

COLLAR ROT It is caused by *Phoma mororum* 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 *Phoma exigua* 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 *Fusarium lateritium* f. sp. *mori* (Desm.) Ma et. Sato occurs in winter (February-March) and the symptoms are rotting of the buds (Sukumar and Yadav,1988).

BACTERIAL DISEASES

MAJOR

Bacterial diseases of mulberry were recognised 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 10-40 ^{O}C and the optimum temperature is 20- 35 ^{O}C. 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 Lambert, belongs to the order Pseudomonadales of the class Schizomycetes. It is a serious disease in India and cause 5-10% leaf yield loss during rainy season (June-October).

Symptoms: Numerous irregular water-soaked patches appear on the lower surface of leaves. In severe condition, the leaves become curled, rotten and turn brownish black in colour (Fig.12).

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 measuring 0.9 to 1.4 μ by 1.8 to 4.5 μ, Gram negative, encapsulated, no endospore. Colonies on nutrient agar are white, circular, smooth, flat and translucent. The thermal inactivation point is 52 ^{o}C.

Control Measures: Affected plant should be uprooted and burnt, the contaminated soil should be explosed for sun drying.

Agricultural antibiotics like streptomycin or streptocycline can be used as foliar spray at 0.1% concentration (Krishnaprasada and Siddaramaiah,1978). The leaves can be used for silkworm rearing after 10 days of spray.

MINOR

Some minor bacterial diseases have also been reported on mulberry.

BACTERIAL ROT/ TWIG BLIGHT It is caused by *Bacterium moricolum* Yendo et Higuchi. The disease occurs in rainy season. It erodes the base of the twigs and the branches. The disease can be controlled by treating the soil with calcium cynamide (lime nitrogen).

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 concentration) or bleaching powder (0.2%) is useful for control of the disease.

LEAF SCROCH The leaf scroch caused by a Fastidious xylem inhabiting Bacteria (FXIB), commonly occurs in July (Kostka *et al*.,1986). The affected leaves show marginal necrosis and dessication of tissues.

SHOOT SOFT -ROT The disease caused by *Erwinia çarotovora* var. *carotovora* (Jones) Dye. is found commonly in Japan (Takahashi and Sato,1978). Characteristic symptoms of the disease 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.

VIRAL DISEASES

There are few viral diseases reported on mulberry viz., mosaic and yellow net vein from India.

MOSAIC DISEASE

It is caused by mosaic virus, seen only during rainy season in temperate condi-tions. The symptoms of the disease are inward curling of leaves, particularly leaf margin and tip with chlorotic lesions on the leaf surface (Fig. 13). No suitable control measures are available. Affected plants may be uprooted and burnt.

YELLOW NET VEIN

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

NEMATODE DISEASE

ROOT-KNOT DISEASE

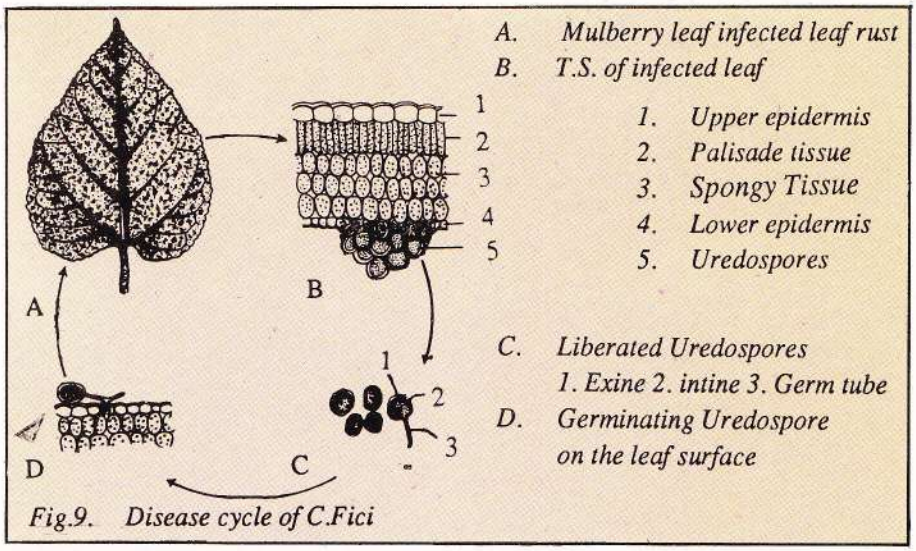
Root-knot nematodes are distributed world-wide and cause economic damage to many crops under different climatic conditions (Lamberti and Taylor,1979). Root-knot disease caused by *Meloidogyne incognita* (Kofoid and White) Chitwood was first reported by Narayan *et al.*,(1966) on mulberry from India. 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 irrigated conditions. The symptoms of fungal and bacterial diseases which usually affect the foliage, can be easily identified and controlled, while the root-knot nematodes which are basically parasites of underground roots is difficult to recognise 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: The affected plants showed stunted growth, marginal necrosis and yellowing of leaves. The underground symptoms include the formation of characteristic knots/galls on the root (Fig. 14, and 15). The nematode damaged roots do not utilize water and fertilizers as effectively as uninjured roots. Thus, as a result of poor 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 (Fig. 17). The second stage female larvae enter into the roots through the holes made by stylet and harbour in subepidermal layer. Soon after the entry, it starts feeding on the parenchymatous cells. Due to hypertrophy and hyperplasia induced

Fig.7. Mulberry leaf affected by leaf rust disease

Fig.8. Uredospores of C.Fici causing leaf rust



A. Mulberry leaf infected leaf rust
B. T.S. of infected leaf

1. *Upper epidermis*
2. *Palisade tissue*
3. *Spongy Tissue*
4. *Lower epidermis*
5. *Uredospores*

C. Liberated Uredospores
1. Exine 2. intine 3. Germ tube
D. Germinating Uredospore on the leaf surface

Fig.9. Disease cycle of C.Fici

Fig.10. Twig blight showing marginal burning of leaves.

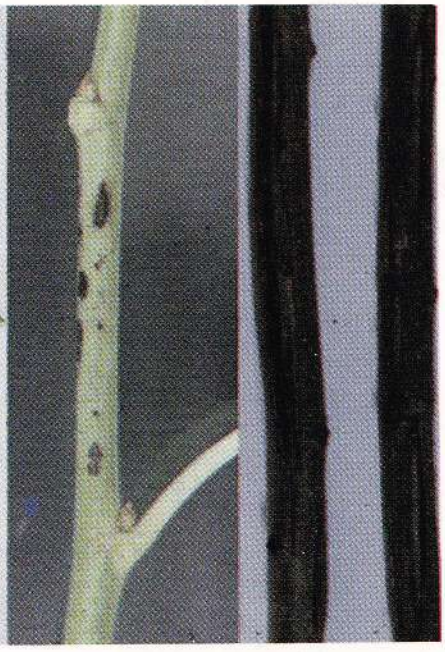


Fig.11. Twig blight showing stem blackening and splitting

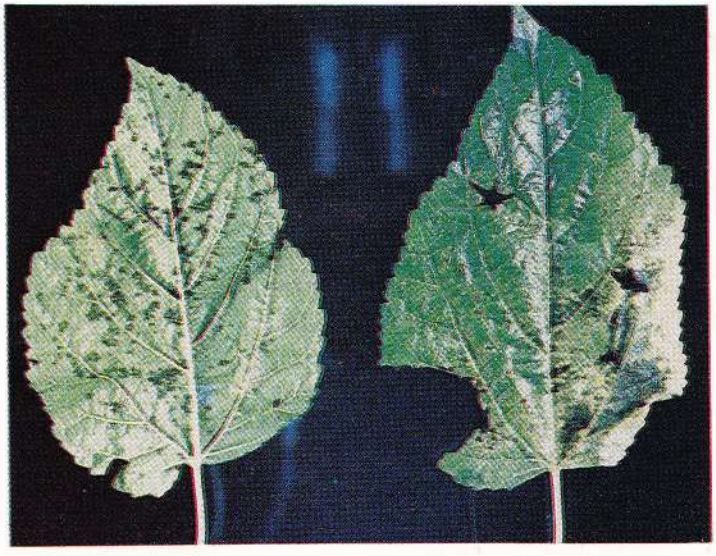


Fig.12. Mulberry leaves affected by bacterial blight

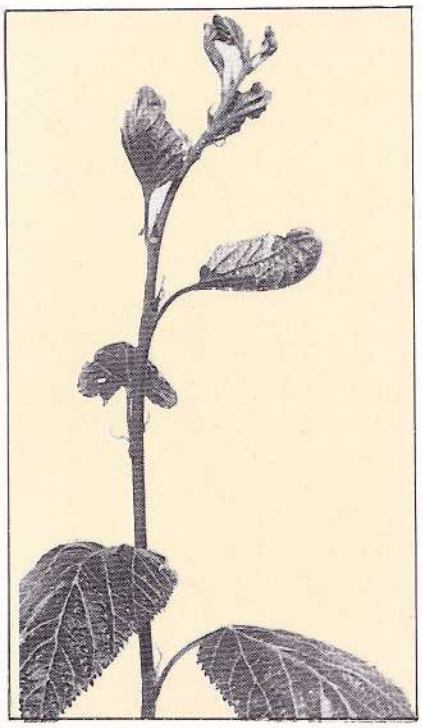


Fig.13. Curling of mulberry leaves due to mosaic virus

Fig.14. Mulberry affected by root-knot nematode (M.incognita)

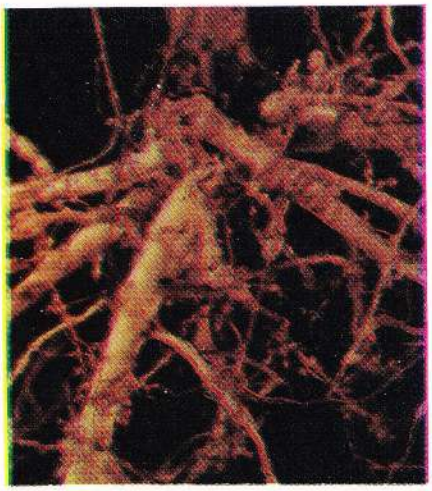


Fig.15. Mulberry roots showing the galls/knots

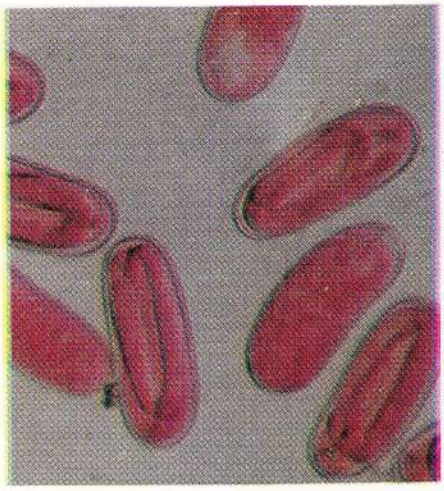


Fig.16. M.incognita eggs

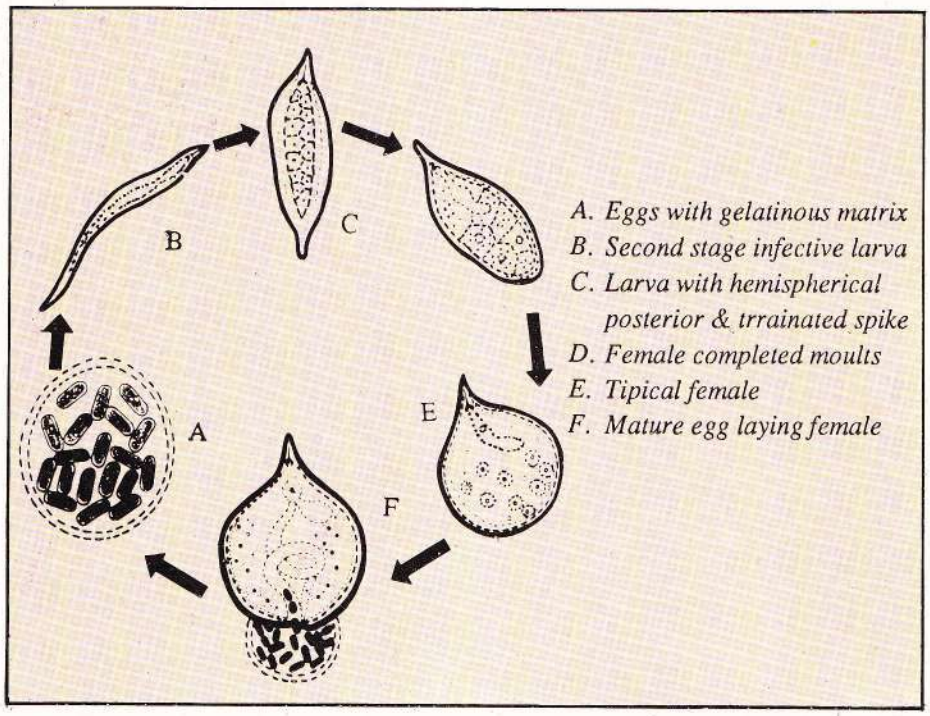


Fig.17. Development stage of female nematode (M. incognita)

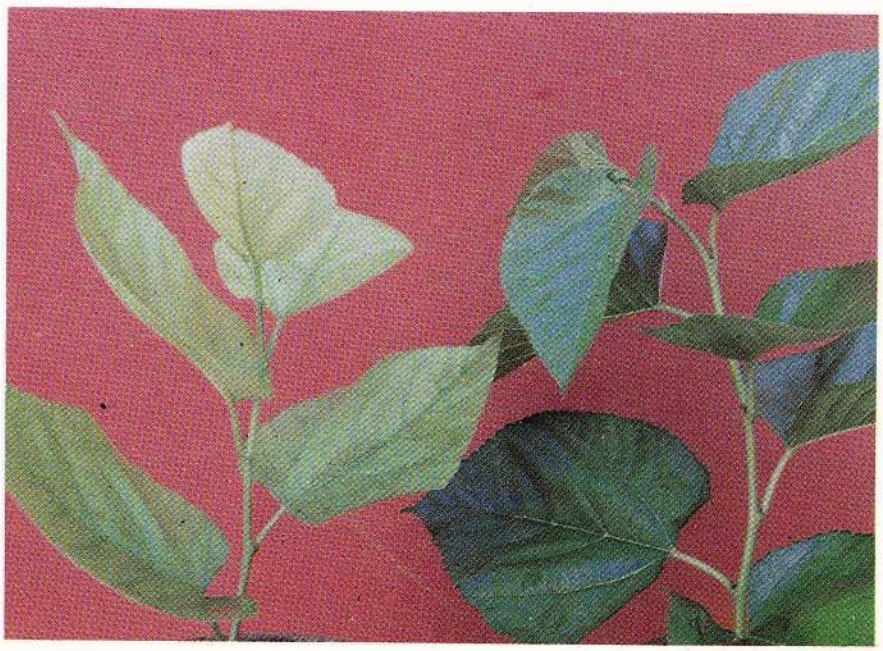


Fig.18. Mulberry leaf showing nitrogen deficiency vis-a-vis healthy leaf

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 (Fig. 16) covered with gelatinous substance. In favourable conditions, the eggs hatch and larvae are liberated in the soil. It takes 30-40 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 from 15 ^{o}C to 30 ^{o}C and soil moisture of 40-60% are 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 by different integrated approaches will become very important. There are several means by which the disease can be controlled and kept below thedamaging 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 temperaturte and low moisture, most of the nematodes get killed.

b. *Intercropping of nematicidal plants*: Nematicidal plants like marigold (*Tagetus patula)* 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, 1977). Marrigold 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 (Lear,1959; Mankau 1963; Khan *et al*., 1974 and Alam *et al*.,1979). 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 at 1 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 *Application of nematicides*: Organic phosphates and carbomates proved to be very effective for control of root-knot nematode disease (Reddy and Sheshadri,1971; Disanzo,1981; Ahuja,1983; Sikdar *et al*., 1986). Application of temik 10 G (Aldicarb) or Furadon (Carbofuran) at 30kg/ha/year in four equal split dosages alongwith fertilizers is recommended for the control of root-knot nematode disease. Further, application of Rugby 10G, a new nematicide manufactured 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 *(Azadirachta indica)* and pongamia (*Pongamia pinnata*) at 1 tonne/acre/crop is also effective in control of root-knot nematode disease (Govindaiah et. al.,1989C).

Mineral Deficiency Diseases

Besides the various diseases caused by micro-oraganisms, like any other crops mulberry also suffers due to the deficiency of available minerals in the soil. Deficiency symptoms mainly occur due to the non-availability of minerals like nitrogen, phosphorus, calcium, sulphur, zinc and magnesium in the soil. Disorders caused by the mineral deficiencies can overcome by the application of suitable fertilizers/chemicals to the soil. They are as follows:

NITROGEN DEFICIENCY Slow and week growth of plant with less branching/vigour. Young green leaves show chlorosis, stem is slender and yellowish green and stunted root growth (Fig. 18). Apply nitrogenous fertilizers like urea, ammonium nitrate and calcium nitrate for correction.

POTASSIUM DEFICIENCY Marginal scorching of leaves in younger stage and later become coarse, non-juicy and necrotic. Stem and root systems become weaker. Apply potassium fertilizers for correction.

PHOSPHORUS DEFICIENCY Intra-veinal chlorosis of older leaves. The chlorosis spreads throughout the leaf followed by marginal necrosis and defoliation. Stem is slender, without fresh growth and stunted growth of roots. By adding of phosphorus and NPK fertilizers, the deficiency can be controlled.

MAGNESIUM DEFICIENCY Chlorosis and necrotic spots on leaves. The leaf tip and margin become dry and scroched. Apply magnesium sulphate or magnesium oxide for correction.

CALCIUM DEFICIENCY Defoliation of young leaves with necrosis along the veins. The stems become woody and short with yellowish tips. Roots are stubby and dry. Apply calcium ammonium nitrate or single superphosphate for correction.

SULPHUR DEFICIENCY Slight chlorosis of leaves, lack of plant growth with slender stem. Apply Gypsum or ammonium sulphate for correction.

ZINC DEFICIENCY Young leaves show interveinal chlorosis and yellowish white spots on leaves. Apply zinc sulphate for correction.

PART II

Pests of Mulberry and Their Control

A number of insects belonging to different orders attack mulberry plants. Life history, type of damage, symptoms of attack, period of occurrence and management of important pests are detailed below :

Hemiptera

MAJOR

MEALY BUG *Maconellicoccus hirsutus* (Green) (Pseudococcidae) : This is commonly known as mealy bug and is associated with mulberry plants showing symptoms popularly known as Tukra disease.

Life Cycle : On an average about 250 eggs are laid by a single adult female. Eggs are elongated in shape and orange in colour. They are laid in white powdery egg sac (Fig.20). Hatching takes place in about 5-6 days. Nymphs (Fig.19a) are covered with mealy substances and undergo moult for 2-3 times. Adults (Fig.19b, c) reproduce parthenogenetically. They mate but do not feed and die in 2-3 days after oviposition.

Type of damage : The leaf yield is tremendously reduced and are depleted in nutritive value.

Symptom : The affected apical shoot shows retarded growth. Flattening of the apical shoot and wrinkling of the affected leaves are also associated. The leaves become dark green in colour.

Period of occurrence : Tukra disease is mostly recorded during summer months.

Management : (i) Cutting affected shoot and burning, (ii) Spraying 0.2% DDVP (Nuvan) prepared in 0.5% detergent solution or preferably withfish oil rosin soap (25g/l)twice at the interval of 7 days. Safe period is 17 days after last application and (iii) Release of *Cryptolaemus montrouzieri* (coccinellidae), a natural enemy of mealy bug may also be helpful in the control of Tukra disease.

JASSID ***Empoasca flavescens*** (F.) (Cicadellidae) : This species of Jassid is commonly called as Leaf hopper or Plant hopper.

Life Cycle : Adults (Fig.21) are pale green in colour. They measure 2.5 to 4 mm in body length. Adult and nymphs move sideways. Eggs, which are pale

yellow in colour, elongated in shape are laid on the lower surface of the leaf below the epidermis. Eggs hatch in 4-9 days. Nymphs moult four times and are pale green in colour. Pupation takes place on leaf itself.

Type of damage : The adults and nymphs attack the mulberry leaves from lower side of the margin of the veins. The affected leaves are depleted in nutritive value.

Symptom : The characteristic symptom of Jassid attack is known as hopper burn. In this, a triangular spot dark brown in colour appears at the tip followed by such patches along the margin of veins. It starts from periphery (Fig.22) and extends towards the midrib of the leaf. In the final stage of attack the leaf becomes cup shaped and withers easily from the plant.

Period of occurrence : Usually during summer months.

Management : (i) Setting light traps for attracting and trapping adults (ii) Spraying 0.1% Dimethoate (Rogor) or 0.05% DDVP (Nuvan) is effective. Treated leaves can be used for silkworm rearing only after 11 days.

MINOR

SCALE INSECT

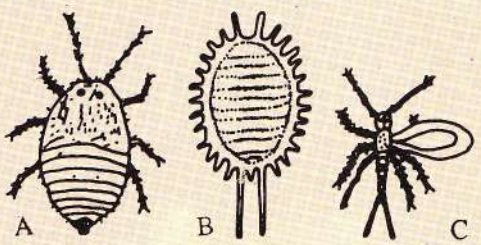
Saissetia nigra (Nietm.) (Coccidae) : This insect is commonly called as Black scale insect.

Life Cycle : Adult female lays 300-600 eggs which are minute, white and elongated. The colour of eggs become reddish brown with the advancement in age. The female shields the eggs and in about 6 days, they hatch. Within a few hours the nymphs crawl and select the place of feeding on the stem. It secretes a fibrous waxy material which hardens to form the scale. Female moults three times and male twice. In the process of moulting, they loose the appendages. This make them sedentary in nature. Reproduction takes place parthenogenetically.

Type of damage : They suck the sap of the plants and affected shoots start dying from the distal end.

Symptom : The affected shoot is studded with thousands of dark brown or black scales (Fig.23). Yellowish or mottled appearance of the leaf blade can also be noticed.

Period of occurrence : Generally during summer months.



a. Nymph;
b. Adult female;
c. Adult male

Fig.19. Mealy bug

Fig.20. Characteristic symptoms of Tukra.

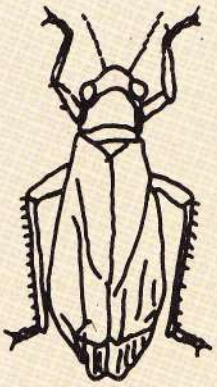
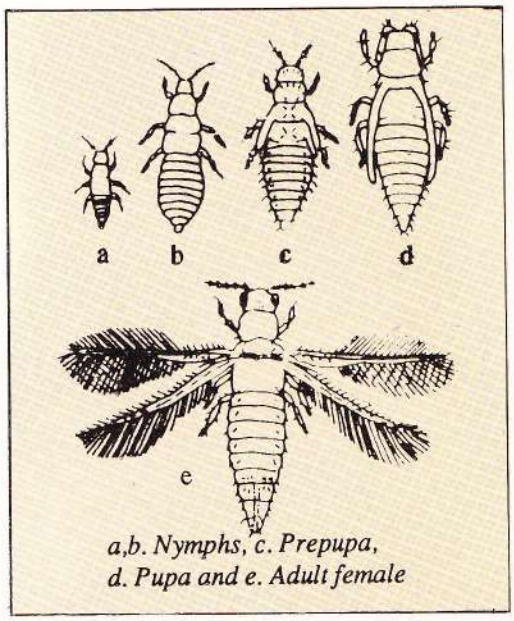


Fig.21. Adult jassid

Fig.22. Characteristic symptoms of hopper burn

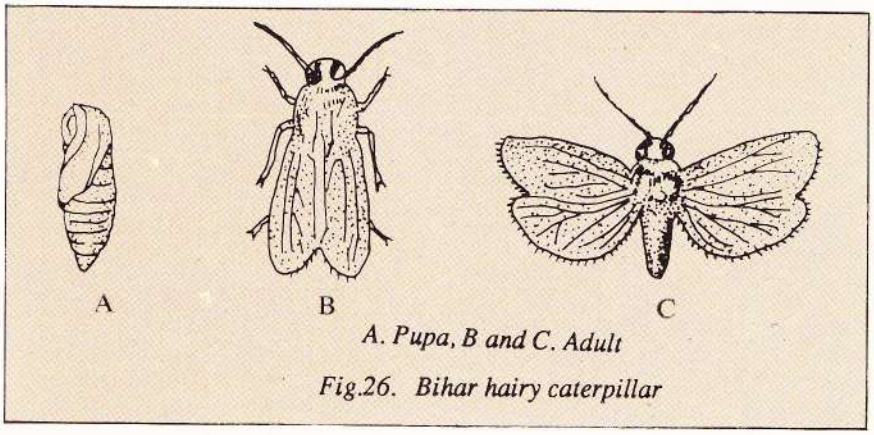
Fig.23. Mulberry affected by black scale



a,b. Nymphs, c. Prepupa, d. Pupa and e. Adult female

Fig.24. Developmental stages of Thrips

Fig.25. Symptoms of thrips attack on Mulberry



A. Pupa, B and C. Adult

Fig.26. Bihar hairy caterpillar

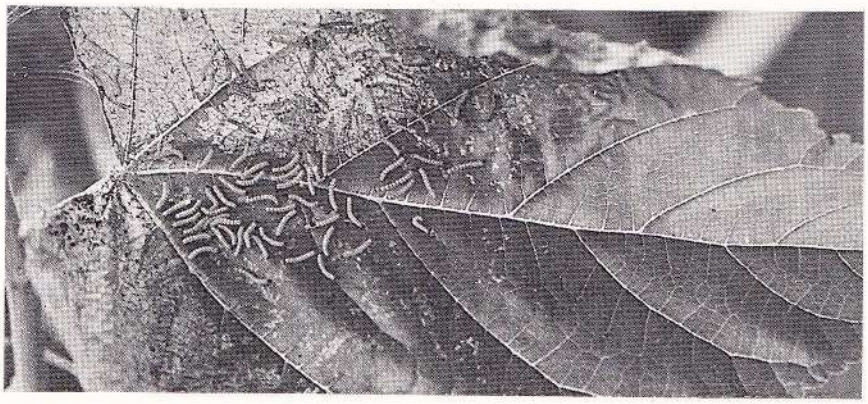


Fig.27. Chlorophyll tissues of Mulberry leaf eaten away by young caterpillars of S.obliqua

Fig.28. Late age caterpillar of S.obliqua

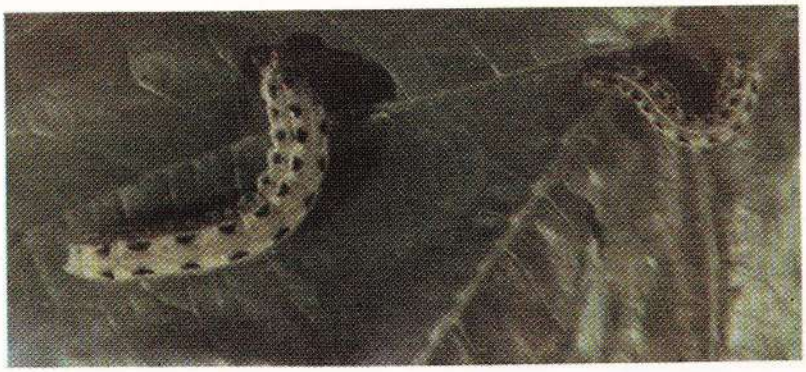


Fig.29. Cutworm feeding on mulberry

Fig.30. Pupae of cutworm

Fig.31. Adult of Cutworm

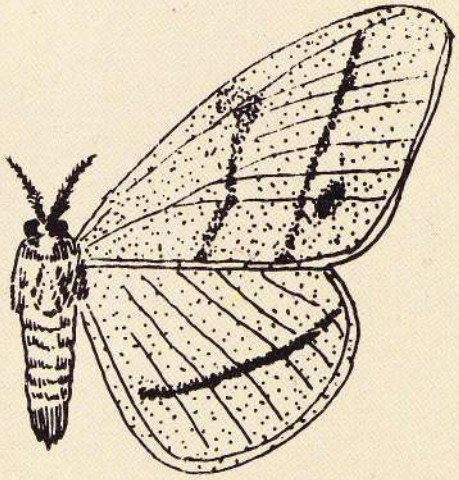


Fig.32. Adult Moringa hairy caterpillar

Management : (i) Diesel oil and soap emulsion (1:3 ratio), swabbing on the stem to dislodge the scale insects (ii) Scrapping with a blunt edge wooden plate also dislodges these insects (iii) Lime-Sulphur swabbing on stems is effective (iv) Spraying 0.05% Malathion controls the insect attack. The safe period is 10 days.

Thysanoptera

MAJOR

THRIPS

Pseudodendrothrips mori Niwa (Thripiidae) : This species of thrips is generally reported to cause damage to mulberry in South India. It is commonly known as mulberry thrips.

Life Cycle : Adult male is brownish yellow and female is dark brown in colour. Females are longer than males. Average adult measures 0.9 mm in body length. 30-50 bean shaped yellow coloured eggs are laid by adult females on the ventral side of the leaf. Eggs hatch in 6-8 days. The nymphs (Fig. 24a, b) are pale yellow coloured. They moult four times in 15-18 days. Adults are with fringed wings (Fig. 24c).

Type of damage : Thrips affect the leaves of the mulberry shoot. They injure the epidermal tissue and suck the sap. Early maturity, depletion of moisture, reduction in crude protein and total sugars are met with the affected leaves. Leaves become unsuitable for silkworm rearing.

Symptom : Affected leaves show white streaks (Fig. 25) or blotches which become yellowish brown on maturity.

Period of occurrence : Although the incidence is recorded throughout the year, the damage is very high during summer months.

Management : (i) Sprinkler irrigation disburses the nymphs and adults (ii) Spraying 0.02% DDVP (Nuvan) twice at weekly intervals. Leaves from treated plots can be used for silkworm rearing seven days after spray.

Lepidoptera

MAJOR

BIHAR HAIRY CATER-PILLAR

Spilosomaobliqua* Walker *(=Diacrisia obliqua) (Arctidae) : This polyphagous insect species is commonly known as Bihar hairy caterpillar.

Life Cycle : Adults are light brown with brick red abdomen, peppered with

dark row of spots laterally and dorsally (Fig. 26b, c). 1000-1200 eggs are laid in batches on the lower surface of the leaf. Eggs hatch in 5-7 days. Caterpillars moult six times. Fully grown caterpillar measures 4.5 to 5 cm. Anterior and posterior regions are black in colour and the rest of the body is reddish brown (Fig. 28). Pupation takes place in loose soil or below the dried leaves. The pupa (Fig. 26a) is dark brown in colour and measures about 2 cm in length. Pupal period lasts for 12-14 days. The life cycle is completed in about 48 days.

Type of damage : Gregarious young instar larvae (Fig. 27) feed upon the chlorophyll layer of the leaf exposing the veins. Late instars larvae are voracious eaters of mulberry leaves.

Symptom : The affected leaves look like dead dried leaves and easily fall off. Clear branches without leaf alone can also be noticed after a severe attack.

Period of occurrence : Incidence is frequent from August to February.

Management : i) Installation of light traps to attract adults ii) Collection and destruction of egg masses and gregarious young instarts caterpillar iii) Deep ploughing and flood irrigation for exposing and killing the pupae and iv) 0.2% Dimethoate (Rogor) or DDVP (Nuvan) can be sprayed on mulberry plants to kill the caterpillars and sprayed leaves can be used for silkworm rearing after 13 days and 17 days respectively.

MINOR

CUTWORM

Spodoptera litura (F.) ***(=Prodenia litura)*** (Noctuidae) : This polyphagous insect is commonly called as Cutworm or Tobacco caterpillar. Occasionally serious damage to mulberry is caused by this pest.

Life Cycle : The adult moths are stout, dark with wavy white markings on the forewings and white hindwings, margins having a brown colour (Fig. 31). Eggs are laid in clusters of 200-300 underneath the leaves covered with brown hairs. The incubation period is 4-5 days. The full grown larva is stout, cylindrical and pale greenish brown in colour with dark markings (Fig. 29). They have transverse and longitudinal grey and yellow bands. The caterpillars are nocturnal in habit. It measures 35 to 40 mm in length. It pupates in the soil (Fig. 30) in an earthen cocoon. The larval period lasts for 2-3 weeks. Adult emerges from pupa (Fig. 30) in about two weeks. Life cycle occupies 30 to 40 days

Type of damage : The caterpillars attack the shoot of young plants and cut

them. The cut portion of the shoot dries up and falls down. They also feed upon the leaves.

Symptom : Newly sprouted mulberry garden or the garden having young plants are found with cut branches with dried leaves.

Period of occurrence : Generally during August to February.

Management : i) Deep ploughing of mulberry garden exposes the different stages of pest which can be picked up and killed and ii) After pruning, deep digging around the mulberry plants and dusting of BHC 5-10% kills the caterpillars. Leaves can be utilised 45 days after the dust. iii) Spray of 0.025% Parathion (Folidol) on mulberry plants also kills the caterpillars. Safe period is 8 days.

MORINGA HAIRY CATER PILLAR

***Eupterote mollifera* W.** (Eupterotidae) : This is commonly known as Moringa hairy caterpillar

Life Cycle : Freshly laid eggs are sulphur-yellow in colour and later changes to brownish yellow. Eggs laid in closely attached mass around the tender twigs or on the petiole of leaves hatch in 9-13 days. Larval stage has generally four moults and it takes about 68 days to pass through the five instars. Final stage caterpillars are dark in colour with thick growth of the hairy tufts and each measures 48-50 mm in length (Fig. 33). Pupation takes place in a soft thin cocoon made up of silk secreted along the hairs of the caterpillars. Pupa is dark brown in colour. It measures 18-20 mm in length. Pupal stage lasts 35-60 days. Male moths (Fig. 32) are smaller in size and light yellow in colour. Females are larger and dark brown in colour.

Type of damage : Feeds on mulberry leaves thereby the leaf yield is reduced.

Symptom : Branches of plant without mulberry leaves are noticed in the garden.

Period of occurrence : Generally during August to February.

Management : As in S. Obliqua

TUSSOCK CATERPILLAR

Euproctis fraterna (Moore) (Lymantridae) : This minor pest of mulberry is commonly known as Tussock caterpillar.

Life Cycle : About 100-120 pale yellow coloured eggs are laid in masses covered with yellow hairs (Fig. 35) on the underside of mulberry leaves. They hatch in about 15-18 days. The hatched larvae are yellow in colour with dark tufts of hairs on the second and third abdominal segments. They feed on

mulberry leaves gregariously. The final instar caterpillars are dark brown in colour and measuring 20-25 mm in length (Fig. 34a). Larval duration is 60 days with four moults. Pupa is dirty brown in colour. Pupal stage lasts for about 13-15 days. The moths (Fig. 34b) are yellow in colour. Two dark sports are present on the apical angle and two larger ones on the cubital angle of the forewings of the female and an additional dark one near the costal margin in the forewing of the male

Type of damage : Reduction in leaf yield due to feeding of caterpillars on mulberry leaves.

Symptom : Branches of mulberry plants without leaves are observed.

Period of occurrence : During March to August.

Management : As in *S. Obliqua.*

WASP MOTH

Amata passalis Fb. (Amatidae) : This is a minor pest of mulberry and is also known as wasp-moth.

Life Cycle : Freshly laid eggs are white in colour but gradually change to yellow colour and finally turns to dark brown in colour a day before hatching. A single female lays round shaped 500 eggs on the ventral side of mulberry leaves. Hatching takes place in 6-7 days. The freshly emerged caterpillar is dull white in colour with thin brownish hairs all over the body. The head capsule is shiny and the prothoracic segment is provided with a light brown shield. The larvae are active and scraps the chlorophyll layer of leaf. As the larvae grow, the body colour changes to brown and start feeding on mulberry leaves. The full grown caterpillar measures 20 to 25 mm in length (Fig. 36). When the caterpillars are disturbed it emits a defensive fluid. The larval period lasts for about 32 days with seven moults. The caterpillar pupates in the folds of leaves within a silken web. The pupa is pink in colour and measures 14 to 18 mm in length. The pupal duration is 10-12 days. The adult males are elongated with narrow and slender abdomen whereas the females are stout and bulky. The thorax and the abdominal segments are brick red in colour. Wings are brownish black in colour. There are seven transparent spots in the forewing (Fig. 37).

Type of damage : Reduction in leaf yield.

Symptom : Branches without leaves are noticed.

Period of occurrence : Mostly during February to August.

Management : (i) Collection and destruction of egg masses and young gregarious caterpillars (ii) Application of 0.2% DDVP (Nuvan). Safe period is 17 days.

CERYX GODARTI

Ceryx godarti Bdv. (Amatidae) : This is a minor pest of mulberry.

Life Cycle : About 130-235 eggs are laid by each female moth in batches. Eggs are deposited on the lower surface of the tender leaves. The eggs which are round in shape and pale yellow in colour hatch in about 5 days. Young larvae are light brown in colour and bear hairs on the all the segments. Caterpillars undergo four moults. Fully grown up caterpillar measures about 22-25 mm in length. Caterpillar at this stage is almost black in colour and thickly covered with hairs. Larval stage lasts for about 30 days. The pupation takes place under the dry leaves and a thin cocoon is made out of its hairs and secreted silk. Pupa is dark copper brown in colour measuring 11-14 mm in length. Pupal stage lasts for about 12-13 days. The adult males are with a narrow abdomen whereas the females are with broad abdomen. If not mentioned otherwise, various stages of this pest generally resembles *A.passalis*. The forewing and hindwing of adult *C.godarti* have 6 and 3 clear areas lacking scales as compared to 7 and 4 such spots respectively in *A.passalis*.

Type of damage : Reduction in leaf yield.

Symptom : Branches without leaves are observed.

Period of occurrence : Mostly during February to August.

Management : As in *A.passalis*

Orthoptera

MAJOR

WING LESS GRASS-HOPPER

Neorthacris acuticeps nilgriensis Uvarov (Acrididae) : This is a polyphagous insect species and commonly called as wingless grasshopper. Major damage by this pest is noticed in rainfed areas.

Life Cycle : Adults are green in colour (Fig.38). Female lays on an average 6-8 egg pods, each having 11-18 eggs. Egg pods are deposited in the loose soil

at a depth of 2-3 cm. Eggs hatch in about 28-31 days and nymphs undergo six moults before they reach the adult stage. Early instar nymphs are light brown in colour whereas late instar nymphs are green in colour (Fig.39). It completes its life cycle in 5-6 months.

Type of damage : Nymphs and adults of this pest voraciously feed upon the mulberry leaves and leaf yield is reduced considerably.

Symptom : Branches of plants without leaves are observed in the mulberry garden.

Period of occurrence : Generally, the attack is recorded during July-August.

Management : (i) Exposing egg masses by deep ploughing for destruction by natural enemies. (ii) Spraying 0.5% BHC. Leaves from sprayed garden can be used for silkworm rearing 15 days after treatment.

Coleoptera

MINOR

STEM GIRDLER

Sthenias grisator F. (Cerambycidae) : This insect species is commonly known as stem girdler beetle.

Life Cycle : Adult (Fig. 40f) deposits eggs (Fig. 40b) underneath the bark of the girdled branch (Fig. 40a) at night. The incubation period is about eight days. The grub tunnels into the Wilting branches and feeds. Grubs (Fig. 40c,d) pupate (Fig. 40e) inside the tunnel. The whole life cycle lasts for 7-8 months. Adult insect is a stout built longicorn beetle with strongly developed mouth parts.

Type of damage : This beetle has a peculiar habit of ringing the stems. The bark and wood are neatly cut all around the main stem or branch leaving a clear girdle (Fig. 40a). The portion above the girdle gradually wilts and dies.

Symptom : Girdled branches of the plant or wilting plants are observed in the garden.

Period of occurrence : Throughout the year.

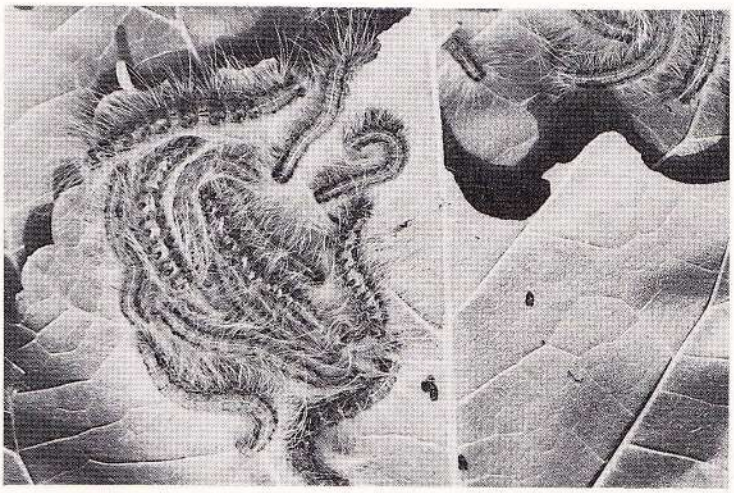


Fig.33. Moringa hairy caterpillar feeding on mulberry

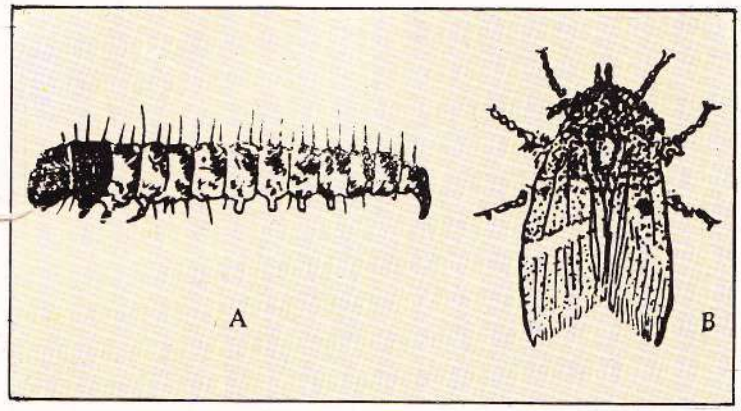


Fig.34. Tussock caterpillar a. Caterpillar, B. Adult

Fig.35. Egg mass of Tussock moth on mulberry leaf

Fig.36. Caterpillar of wasp-moth

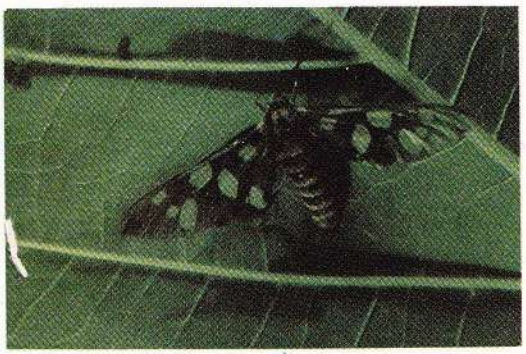
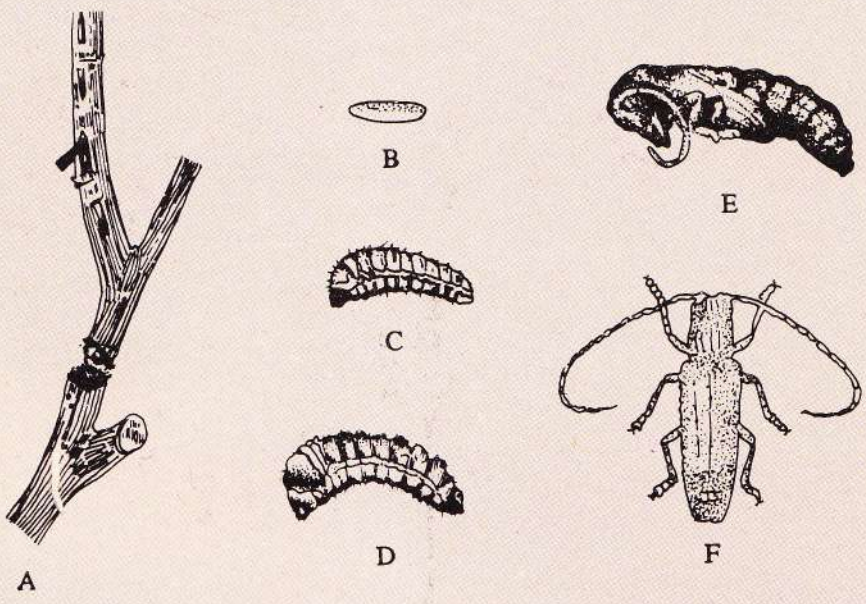


Fig.37. Adult wasp-moth

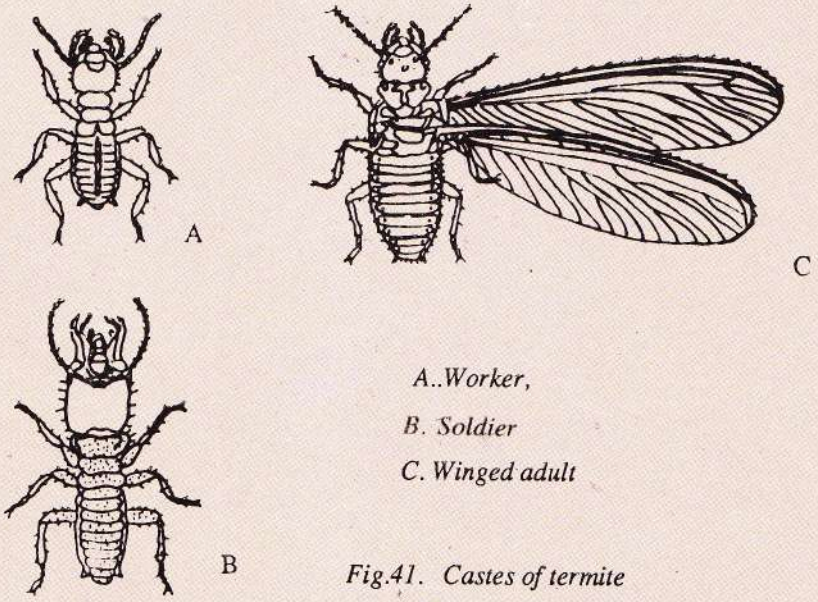
Fig.38. Adult wingless grasshopper on mulberry

Fig.39. Nymph of wingless grasshopper



A. Affected mulberry stem, B. egg, C and D. Grubs, E. Pupa, F. Adult.

Fig.40. Developmental stages of stem girdler beetle

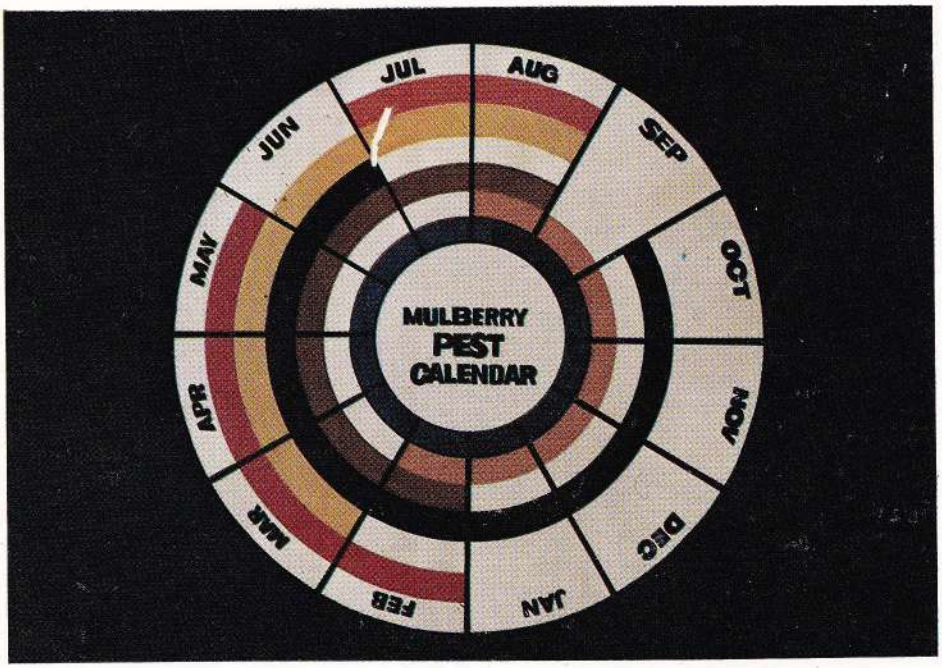


A..Worker,

B. Soldier

C. Winged adult

Fig.41. Castes of termite



Black Scale Insect
Leaf Hopper
Mealy Bug
Wingless Grasshopper
Tussock Caterpillar
Termites
Wasp Moth
Ceryx Godarti Bdv.
Bihar Hairy Caterpillar
Cutworm
Moringa Hairy Caterpillar
Mulberry Thrips
Stem Girdler

Fig.42. Pest calender showing the period of maximum occurrence of various pests of mulberry

Management : (i) Infested branch or stem showing the symptom of beetle attack should be cut and destroyed by burning (ii) Swabbing the base of main stem or branches with 0.1% BHC solution or with 0.1% Malathion emulsion, prevents the attack by the beetle and safe periods are 11 days and 13 days respectively.

Isoptera

MINOR

TERMITES They are commonly known as white ants. Various species of termites occasionally cause damage to mulberry worth reckoning.

Life cycle : Wings are present only in the sexually mature males and females (Fig. 41c). During the swarming season wings of these sexually mature members are broken off following a shorter flight. The individuals separate in pairs and a cell is excavated in the soil or wood where the repeated mating takes place. The eggs are normally deposited singly. Mature queen lays several thousand eggs. Incubation period varies from 24-90 days. Duration of development and number of nymphal instars vary greatly with the caste (Fig. 41a, b) and usual environmental factors. Workers of a colony cause the main damage.

Type of damage : Termites attack is found in all types of soil but more frequent in sandy and red loamy soil. They feed upon the roots and bark of young and old plants.

Symptom : Termites attack results in the mortality of the plant. Drying plants are seen in the garden.

Period of occurrence : Usually from October onwards and continues till the onset of monsoon.

Management : (i) Location and destruction of termite colonies by removing Queen termite (ii) Mounds can also be treated by Phorate -10 G @ 50 g per mound or 50 ml of Chlordane 20 EC (iii) Before undertaking new plantation, the soil should be treated with 5% Aldrin or Chlordane (iv) In case of established plants swabbing or drenching at the base with 1% Chlordane, the safe period is 20-25 days.

Forms, Formulations and Application of Insecticides

From sericulture point of view plant protection may be defined as the science and technology of protecting mulberry plants from their natural enemies. Since it directly concerns with the control of harmful pests, plant protection is also generally called as pest control.

To make best use of the available recommendations for the insecticidal control of the insect pests of mulberry it is essential to have fundamental knowledge on various important aspects. These include:

1. Forms and formulations of insecticides.
2. Determination of the volume of insecticide required per acre of mulberry garden.
3. Calculations for dilutions of insecticides.
4. Proper execution of spraying and dusting.

Undesirable drift residues result in the contamination of the leaves of mulberry garden due to application of insecticides in the adjacent field crops. It is, therefore, equally important to know the safe period of various insecticides commonly used against several insect pests of different crops.

Forms and Formulations of Insecticides

Insecticides are manufactured in its pure form and is referred as technical grade material. Due to chemical and physical characteristics of the technical grade material these toxicants are not very useful. These insecticides, therefore, are formulated through different processes into usable forms either for different application or for their dilution followed by application. The formulated forms of insecticides also improve their properties for satisfactory storage, effective application, safety to the applicatior and the environment and for economy.

Various commonly used formulations of insecticides can be classified as solid, liquid and gaseous.

Solid Formulations

a. Dusts (D) : The dust formulations are mixture of toxicants and inert diluent to form a dry, free flowing powder. The concentrations of toxicant mostly ranges from 0.1 to 50%.

b. *Wettable powders (WP) or Water dispersible powders (WDP)* : These are essentially concentrated dusts containing a wetting agent i.e. surface active agent to facilitate the mixing of the powder with water to prepare the desirable strength before spraying. Water dispersible powder in addition contains a dispersing agent for uniform dispersion of the solute in the suspension.

Such powders usually contain 50% to 75% inert diluents. They sink rather quickly to the bottom of sprayer tanks. The tank, therefore, should be shaken repeatedly while spraying.

c. *Water Soluble Powders (SP)* : The title is self explanatory. The technical grade insecticides is a finely ground water soluble solid and contains nothing else to assist its solution in water. It is merely added to the proper amount of water in the spray tank where it dissolves immediately. Unlike WP or WDP, water soluble powders are true solutions and do not settle to the bottom.

d. *Granulars (G)* : These formulations consist of inert material with the toxicants absorbed on to them. Granular formulations are classified as extruded (AA-type or impgregnated) and non-extruded (AA-type or surface coated). The former readily disintegrates in water whereas the latter resist disintegration in water. Though both the types of granules differ in physical characters their innert diluent may consists of either the regular volatile material (RVM) or low volatile material (LVM).

e. *Capsules, Baits and Pellets* : Capsules are the insecticide formulations which have essentially a very small mass of toxicant enveloped in a thick coating material from which the toxicant diffuse slowly. Baits are formulations which consist of small quantities of toxicants combined with food material attractive to the pests. As regards pellets, the toxicant is mixed with polyvinyl chloride and a plasticizer which releases the toxicant over a period of time.

Liquid Formulations

These formulations are applied as sprays in the form of solution, suspension and emulsion.

a. *Solutions* : They are homogenous mixture of two or more substances and usually are not soluble in water. However, most of them are soluble in organic solvents like xylene, carbon tetrachloride, kerosene, etc.

b. *Suspensions* : They are also referred as Flowable or Sprayable suspensions (F or S). They consist of finely divided solid particles dispersed in a liquid medium by means of a wetting agent. Therefore, they mix well with water as a suspension and can be sprayed, but with the same tank-settling characteristics as mentioned in case of WP.

c. ***Emulsion*** : There are two types of emulsion, the first is the oil in water (O/W) type. In this, oil is dispersed in water. This is also referred as emulsifiable concentrate (EC). EC is the concentrated oil solution of the technical grade toxicant with enough emulsifier added to make the concentrate mix (emulsify) readily with water for spraying. The emulsifiers (they belong to a wider group of chemicals termed as surface active agents - SAA or surfactants) are generally a detergent like material that makes possible the suspension of oil droplets in water to form an emulsion.

The second type is invert emulsion. This is a change from oil in water emulsion to water in oil (W/O). The invert emulsion is opaque in concentrated form resembling face cream. This type of emulsion is principally applied as herbicide. Spray of invert emulsion results in reduced drift and are applied in sensitive situation. Application of invert emulsions has not been widely accepted because of the need for specially designed equipment.

d. ***Water Miscible Liquids*** : They readily mix with water. They do not become milky when diluted in water. In these formulations the technical grade material may be water miscible initially or it may be alcohol miscible and formulated with an alcohol to become water miscible.

e. ***Concentrate Insecticide Liquids*** : They are applied in a concentrate form without diluting in water at ultra low volume (ULV) rates. ULV formulations contain highest possible concentration of the toxicant which is sprayed by micronising to a droplet size of 70-120μ by means of spinning disc sprayer.

Gaseous Formulations

These include the formulations which may be available in liquid or solid state but act in gaseous or vapour state.

a. ***Aerosols*** : These contain the toxicant dissolved in an inert liquid which is gaseous at ordinary temperatures but liquifiable under pressure. When the pressure is released the solution is discharged through a fine nozzle, the solvent evaporates and the toxicant is dispersed in a very finely divided state.

b. ***Fumigants*** : Insecticides in gaseous forms are known as fumigants and most often formulated as liquids. These are generally useful in completely closed spaces.

Determination of the Volume

The insecticidal agents however potent would not be effective as a plant protection agent if it is not applied properly. One of the important aspects , therefore is to find out required volume of the insecticide for uniform coverage of the mulberry garden.

In practice, selection of the volume of liquid for its application is usually left to the users discretion. This is also so, especially because the deposit of toxicant achieved is proportional to the concentration of insecticide in the spray but independent of the volume of spray applied. However, the recent trend has been to bring about effective control of insect pests with considerable reduction in the volume of application material without loss of efficiency. For field crops, high, medium, low, very low and ultra low volume (usually abbreviated to HV, MV, LV, VLV and ULV) are terms used to describe the rate of application in litres per acre for >240, 80-240, 20-80, <2.5-20 and <2.5 respectively. Reduction in the volume of application material helps in effective coverage of the target with minimum contamination of the environment. This can be done by using improved sprayer components and also by selecting optimum droplets size. Use of appropriate droplet uniform in size and density according to the target is referred to as controlled droplet size application (CDA). Optimum droplet size ranges between 10-15µm, 30-50µm, 40-100µm and 250-500µm for the targets like flying insects, insects on foliage, foliage and soil respectively.

The volume of spray per unit area depends upon the output of the particular sprayer owned by the user, the spread and height of mulberry plants at the time of treatment and the number of plants per acre. Because of the influence of these variables on the volume of insecticide required, it is not possible to prescribe the actual volume needed by the sericulturists at the time of insecticide application. It is, therefore, suggested to treat small number (ten or more) of mulberry plants selected randomly at the time of application and subsequently the total quanity required for treating the mulberry garden can be easily worked out with the help of the table given below :

Spacing	No.of Plants/Acre
30 cm x 30 cm	44,444
60 cm x 30 cm	22,222
60 cm x 60 cm	11,111
90 cm x 60 cm	7,407
90 cm x 90 cm	4,938

All the aspects described under application techniques should be strictly followed at the time of assessment of volume of application material.

Calculation of Dilutions

The active toxicant in a commercial formulation suitable for direct application

is rarely available because small quantity of active ingradient has to be distributed on a large area. Dilution, therefore, becomes another important aspect for consideration.

To obtain the weight or volume of solid or liquid formulation of commercial insecticide available in market for the preparation of a solid or liquid containing a desired (or recommended) percentage of toxicant, the following formula can be applied.

A. where

$$d = \frac{a \times b}{c}$$

a = % of toxicant desired (recommended)

b = Wt (in g or kg) of dust or volume (in ml or lt) of liquid required for application c = % of toxicant available in the commerical insecticide formulation

d = Wt (in g/kg) or volume (ml or lt) of commercial formulation required

B. After obtaining the value of d the following calculation should be carried out to obtain the weight or volume of diluent (e),

value of (b) - value of (d) = e

C. Mix well the diluent (value of e) by weight (in case of solid formulation or by volume (in case of liquid formulation) to commercial formulation (value of d) to obtain the required quantity of desired strength of particular insecticide.

Example: Prepare 150 lts of 0.2% dimethoate, from the commercial formulation dimethoate 30% EC.

a = 0.2% dimethoate
b = 150 litres
c = 30% EC
d = ?

$$\frac{0.2 \times 150}{30} = 1 \text{ litre (d)}$$

150 i.e. (b) — 1 i.e. (d) = 149 litres i.e. (e)

Therefore to obtain 150 litres of 0.2% dimethoate from dimetheote 30% EC (Commercial formulation), 1 litre of dimethoate 30% EC should be added to 149 litres of water. In case of dust formulation levigated china clay can be used as inert diluent.

To determine the weight of solid formulation of commercial formulation sold in market for the preparation of a liquid for spray containing a desired (recommended) percentage of toxicant the step mentioned above under (B) need not be carried out. After obtaining the volume of d (in g/kg), the determined weight of solid formulation should be added to the volume of liquid diluent considered for b.

Example: Prepare 100 litres of 0.5% BHC from commercial formulation BHC 50% WP available in the market. Follow step mentioned above under (A).

$$\frac{0.5 \times 200 \text{ (lts)}}{50} = 2.00 \text{ kg or } \frac{0.5 \times 200000 \text{ (ml)}}{50} = 2000 \text{ g}$$

Mix 2 kg or 2000 g of BHC 50% WP in 200 litres or 2,00,000 ml of water.

Application Techniques

Effective spraying or dusting are technical jobs and must be planned prior to execution. This includes prevention of waste, uniform coverage of the target and avoiding hazards to the operator. Guidelines for effective and safe use of insecticides are presented below.

Before Application

a. Identify the pest followed by the observation on the symptoms or damage or features of pest.
b. Use insecticides when incidence is high, otherwise adopt other suggested measures.
c. If more than one insecticide is recommended, select the least toxic to mammals.
d. Read the label of containers and literature supplied along with the insecticide (Also refer Appendix-I).
e. Ensure that all protectuve devices are available.
f. First aid medicines in case of any symptoms of accidental poisoning are available.
g. Check application equipment for leaks and ensure its proper working.
h. Inform the owners of adjacent fields of your insecticide application programme.
i. Carry the commercial formulation of the insecticide to the field in its original containers.

While Diluting Insecticides

a. Wear appropriate protective device to avoid contamination with skin.
b. Do not allow children near the diluting or mixing place.
c. Never work alone while handling insecticides.
d. Recheck the instructions on the label.
e. Avoid splashing while pouring liquid formulations.
f. Avoid solid formulation puffing up into the face.
g. Never eat drink smoke or chew while diluting or applying.
h. Don't draw the liquid into tubes by sucking with the mouth. Use graduated vessel to measure liquids.
i. Use glass rod stick for stirring the liquid.
j. Persons with sores or open wounds should never be allowed to carry out this work.

During Application

a. Avoid application during the hot hours of the day.
b. Apply dust in early morning when the plants are wet with dews.
c. Start application of dust/liquid from the downward wind edge of the the field and proceed upwind so that operators proceed into unapplied areas.
d. Never apply insecticides if the wind is blowing towards grazing livestock or regularly used pastures.
e. Don't blow clogged nozzles or hoses with your mouth. Use thin wires.
f. When a mulberry garden is sprayed many droplets fall between the row (i.e. in the inter-row space) and finally on to the soil. Similarly in case of spraying to run-off stage all the droplets which fall on foliage cannot be retained and the surplus liquid drips down to lower leaves and then to the soil. Once the run-off starts retention of toxicant on leaves is less than if spraying stops just before run-off. Therefore, for effective spraying and also to prevent waste of application material as far as possible run-off stage should be avoided.
g. Underleaf coverage is also very important. For this purpose, a goose neck lance (a metal or bamboo tube attached to the outer end of the hose of sprayer) should be used. While spraying the top surface, the lance should be held with the nozzle facing downwards and then the lance should be slightly twisted in a cork screw movement so that the nozzle faces upwards for underleaf spraying.
h. It is desirable to calibrate the working capacity of the particular equipment

in use in terms of one filling with reference to the growth of crop on hand and the total volume required per unit area.

i. When the application of insecticide on one side of the swathe (lane) is completed the neighbouring lane should be sprayed by turning back to the starting side (if there is no wind) otherwise the operator should walk back with the equipment shut-off and start working on the second lane from the starting side only. In case there is any change of the sprayer dust material enveloping the operator or getting blown into his face, it is better to apply the insecticides on two occasions with opposing wind direction to cover both the sides of the plant.

After Application

a. Never leave insecticides in application equipment. Clean equipments before keeping it.

b. Remove and clean protective devices used during application.

c. Destroy empty containers and contaminated packing material by burying or burning them. If containers are burnt, do not stand in the smoke. In case of burying, metal containers should be made unserviceable by jamming.

d. Keep unused insecticides safely out of the reach of children and pet animals.

e. Any other specific precautions suggested by manufacturers should be scrupulously followed.

f. Harvest of mulberry leaves for feeding to silkworms followed by the application of insecticides should be undertaken strictly after the safe period indicated with each recommendation to avoid loss of silkworm crops due to residual toxic effect of the applied insecticides.

Safe period of various insecticides available commercially

Insecticides are widely used for the control of insect pests of several field crops. Improper method of their application results in undesirable drift residues to adjacent field crops. Accordingly mulberry gardens have also been found contaminated due to use of insecticides in the nearby crops.

Since silkworms are highly sensitive to insecticides harvest of mulberry leaves before the safe period should be completely avoided. In case, if this is not followed scrupulously and contaminated leaves are harvested from the garden either located adjacent to field crops applied with insecticides or directly treated with insecticides silkworm larvae develop toxic symptoms followed by the loss of the crop. These symptoms include :

a. Vomitting of the digestive juice

b. Swinging of the anterior half of the body

c. Shortening of the body due to loss of the body fluid

d. Muscle contraction and

e. Paralysis followed by death of the silkworm larva.

To avoid loss of silkworms crops (due to feeding of contaminated leaves) mulberry leaves should be harvested on or after the number of days shown against each insecticide in the table given below.

Safe periods of various insecticides against silkworm

Name of insecticides*	Concentration (% active ingradient)	Safe period** (in days)
Monocrotophos	0.01	11
(Nuvacron)	0.05	13
Demeton	0.01	07
(Metasystox)	0.05	11
Aldrin	0.01	11
(Aldrex)	0.05	13
Phosphomidon	0.01	11
(dimecron)	0.05	13
Dichlorovos	0.01	07
(Nuvan)	0.05	11
Methyl parathion	0.01	07
(Metacid)	0.05	13
Carbaryl	0.05	09
(Sevimol)	0.10	11
Quinalphos	0.05	07
(Ekalux)	0.10	13
Dimethoate	0.05	07
(Rogor)	0.10	11
Endosulfan	0.05	09
(Thiodan)	0.10	17
Phosalone	0.05	09
(Zolone)	0.10	11
BHC	0.05	07
(BHC)	0.10	11
Chlordane	0.05	11
(Termex)	0.10	13
Malathion	0.50	13
(Cythion)	1.00	17

* *Names in parantheses are the trade names of insecticides*

** *Safe periods have also been indicated with each insecticide recommended for mulberry pest control.*

Appendix

References

APPENDIX I

List of Common Pesticides :

FUNGICIDES :

Bavistin 50 WP
(2-methoxy carbamoyl-Benzimidazole)

Calixin EC
(N-Tridecyl-2, 6-dimethyl marpholine)

Dithane M-45
(Zinc ion + manganese ethylene disdithiocarbomate)

Karathane EC (Dinacap)
{2-1(methylheptyl)-4, 6-dinitrophenol and 2-1(methylheptyl)-4, 6-dinitrophenyl crotonate}

Sulfex (Sulphur 80% WP)

Deltan-75
{(N-Trichloromethyl) Thio-4-cyclohexene, 1, 2 dicarboximide}

Foltaf 80 W
(N-1,1,2,2, tetrachloroethylene) Sulphonyl-cis-4-cyclohexene 1,2, dicarboximide.

Captaf 75 SD
(N-(Trichloromethyl) thio-4-cyclohexene) 1,2-dicarboximide

NEMATICIDES/INSECTICIDES :

Furadon 3G
(Carbofuran G (3% ai)

2, 3-dihydro-2, 2 dioxethyl benzofluron-7-methyl carbonate (sebufos 10g)

Rugby 10 G (Sebafos 10 G)
(0-ethyl S, S-disecbutyl phosphorodithioate) (10% ai)

Rogor 30E
(Dimethoate 30%)

Dimethyl s(N-methyl Carbomoyl-methyl) phosphorothiolo thioate

Temik 10 G (Aldicarb)
(2-methyl-2 (methylthio) propionaldehyde O-(methylcarbamoyl) Oxime

Nemacur
Ethyl-3-methyl-4(methylthio)-phenyl- (1-methylethyl) Phosphoramidate (C.A.)

Aldrex 30 EC
(2-Pyridine-2-aldoxime-N-methyl-iodide.

APPENDIX II

Abbreviations used in the text

°C	Degree centrigrade
etc	And so on
ha	Hectare
lb	Pound
m	Meter
ppm	Parts per million
Vol	Volume
Wt.	Weight
yr	Year
ie	That is
ai	Active ingredient
EC	Emulsifiable concentrate
WP	Wettable powder
SD	Seed Dressing
D	Dust
G	Granule.

APPENDIX III

Precautionary measures for spraying of fungicides/insecticides.

Wrong		Right
	Do not allow children for spraying.	
	Do not mix by hand, use rod for mixing.	
	Do not spray in hot sun, spray in cool hours.	
	Do not blow nozzle, use a needle or thin wire to clean.	
	Do not spray against the wind, keep away from spray mist and dust drift.	
	Wash the hands or take bath before eating.	

Courtesy : *Bayer India Ltd.*

APPENDIX IV

Meaning of the commonly used terminology on the containers of Insecticides

Toxicity	How poisonous
Oral toxicity	How poisonous it is to man or animals when it is swallowed
Dermal toxicity	How poisonous it is when absorbed through skin.
Inhalation toxicity	How poisonous it is when inhaled.
Acute toxicity	How poisonous it is after a single exposure.
Chronic toxicity	How poisonous it is when a man or animal is exposed to small repeated doses.
Lethal	Deadly
LD_{50}	Amount (Lethal dose)of toxicants of active ingredient that can kill 50% of the tested population through oral ingestion or dermal absorbtion. LD_{50} is given as mg/kg of body weight.
LC_{50}	Acute inhalation toxicity necessary to kill 50% of the test organism, LC_{50} values are measured in mg/lt.
Hazard	The chance that it may harm the beneficial organism including man from the use of toxicant formulation. Hazard should not be confused with toxicity.
Risedue	Toxicant deposit remaining on the treated crops for sometime after the application.
Tolerance	The maximum amount of residue which may safely remain on a harvested crop. It is measured in parts per million (PPM).

Expanded forms of various abbreviation used on the labels of containers are given while describing different formulations of insecticides.

REFERENCES

Part I : Diseases of Mulberry and their control

AHUJA, S. (1983).
Comparative efficacy of some nematicides against root-knot nematode, *Meloidogyne incognita* in tomato, okra, brinjal and cauliflower. Third Nematol. Symp., H.P. Agrie. Univ., Solan P.43.

ALAM, M.M., KHAN, A.M. & SEXENA, S.K. (1979).
Mechanism of control of plant parasitic nematodes as a result of the application of organic amendments to the soil. V. Role of phenolic compounds. Ind. J. Nematal. 9:136-142.

BELCHER, JANESE, V. & HUSSEY, R.S. (1977).
Influence of *Tagetus patula* and *Arachis hypogia* on *Meloidogyne incognita*.
Plant Dis. Rep. 61(7) : 527-528.

BRODIE BILL B. , GOOD, J.M. & JAWORSKI, C.A. (1970).
Population dynamics of plant nematodes in cultivated soil. Effect of summer cover crops in old agricultural land. J. Nematol. 2(2) : 147-151.

CHOWDHARY, S.K. & RAJ, S.K. (1986).
Fusarium solani (Mart.) Sacc., A new pathogen causing leaf spot disease in mulberry and its control. Sericologia, 26(2) : 125-130.

DISANZO (1981).
Effect of foliar application of carbofuran and a related compound on plant parasitic nematodes under green house growth chamber conditions. J. Nematol. 13(1):20-24.

GOVINDAIAH (1991)
Studies on root-knot nematode*Meloidogyne incognita* infesting mulberry. Ph.D; thesis University of Mysore, Mysore, India.

GOVINDAIAH, GARGI & SHARMA, D.D. (1987).
Furarium diseases of mulberry. News Letter, CSR&TI, Mysore, 2(3) Oct. pp.5.

GOVINDAIAH, GARGI, SHARMA, D.D .& SURYANARAYANA, N. (1988 b).
Leaf blight of mulberry caused by *Fusarium pallidoroseum* (Cooke) Sacc. International Congress on Tropical Sericulture Practices organised by the Central Silk Board, Bangalore. Abstract, pp13.

GOVINDAIAH, GUNASEKHAR, V. & SHARMA, D.D. (1988 a).

In vitro control of *Myrothecium roridum* causing tar-leaf spot of mulberry (*Morus alba* L.). News Letter, Central Sericultural Research & Training Institute. Srirampuram, Mysore 3(3), Oct. pp.5-6.

GOVINDAIAH, SENGUPTA, K. SHARMA, D.D., G ARGI & GUNASEKHAR, V. (1989 a)
A new leaf spot disease of muulberry caused by *Myrothecium roridum* Tode ex Fr.Curr.Sci., 58(7):398.

GOVINDAIAH, SHARMA, D.D., SENGUPTA, K., GUNASEKHAR, V. SURYANARAYANA, N. & MADHAV RAO, Y.R. (1989 b).
Screening of mulberry varieties against major fungal diseases. Indian J. Seric. 35; 207-213.

GOVINDAIAH, SURYANARAYANA, N., SHARMA, D.D. & GARGI (1989 C)
Effect of mulching of green leaves for the control of root-knot nematode in mulberry. Indian J. Nematol. 19:25-28.

HORI, S. (1901)
Black blight of mulberry, a bacterial disease. Dainiponsanshikaiho 164; 9-12 (in Japanese).

KHAN, A.M., ALAM, M.M. & AHMED, R. (1974).
Mechanism of control of plant parasitic nematodes as a result of the application of oil cakes to the soil. Indian J. Nematol. 4: 93-96.

KOSTKA, S.J., TATTAR, T.A., SHERALD, J. L. & HURTT, S.S. (1986)
Mulberry leaf scorch, new disease caused by a Fastidious, xylem - Inhabiting bacterium. Plant Disease 70: 690-693.

KRISHNA PRASAD, K.S. & SIDDARAMAIAH, A.L. (1978).
Studies on the bacterial leaf blight of mulberry in Karnataka. Indian J.Seric. 17(1) : 61-63.

KUNO, H., HITOSHI, M., KOHNO, S., TASHIRO & HISHIZAKI (1980).
Ultra structural studies of powdery mildew of mulberry *(Morus bombycis)* caused by *Phyllactinia moricola.* Fitopatol. Brans. 5(1) : 11-20.

LAMBERTI, F. & TAYLOR, C.E. (1979).
Root-knot nematodes (*Meloidogyne* species). Systemics, biology and control. London. Academic Press.

LEAR, B. (1959).

Application of castor pomae and cropping of castar bean to soil to reduce nematode population. Plant Dis. Rep.43: 459-460.

MANKU, R. (1963).
Effect of organic soil amendments on nematode populations. Phytopathol.53 : 881-882.

MUNSHI, N.A., TASNEEM NISAR, M.A. & DAS, B.C. (1985).
New leaf spot desease of mulberry. Science & Culture 52(7) : 238-239.

NARAYANA, E.S., KASHIVISHWANATHAN, K. & IYENGAR, M.N.S. (1966).
A note on the occurrence of root-knot nematode, *Meloidogyne incognita* (Kofoid and White) in local mulberry. Indian J. Seric. 5 : 33-34.

NOMANI, M.K.R., MUKHERJEE, P.K. & KRISHNASWAMI, S. (1970).
Studies on the effect of feeding multivoltine silkworms (*Bombyx mori* L.) larvae with mildew affected leaves. Indian J.Seric. 9 : 49-52.

PANDOTRA, V.R. (1966).
Notes on fungi of Jammu and Kashmir. I. Proc. Ind. Acad. Sci.54 : 68-73.

PATEL, M.K., KAMAT, M.N. & BHISDE (1949)
Indian Phytopath. 2 : 148.

RAMAKRISHNA,T.S. (1952).
Additions to fungi of Madras-XII. Proc. Ind. Acad. Sci. 35 : 111.
RAMAKRISHNA, T.S. & SUDAN, N.V. (1954).
Phyllactinia corylea in India. Indian Phytopath.7 : 61-68.

RAYCHAUDHURY, S.P., GANGULY, B. & BASU, A.N (1965).
Studies on the mosaic disease of mulberry. Plant Dis. Rep.49(12) : 981.

REDDY, D.D.R. & SESHADRI, A.R. (1971).
Studies on some systemic nematicides, evaluation for systemic and contact action against the root-knot nematode, *Meloidogyne incognita*. Indian J. Nematol. 1 : 199-208.

SAITO, H., YAMADA, N., NAICHNISHI, H. & MATUO, T. (1978).
Chlamydospore formation of *Fusarium lateritium* f sp. *mori* and *F. solani* f sp. *mori* in soil extract and detection of both fungi and other fusaria from the soil of Furarium blight occurring mulberry fields. J.Seri. Sci. Japan 47 : 193-200.

SHARMA, P.D. (1974).
A new leaf spot disease of mulberry in India. Curr.Sci. 43 : 429.

SHIRATA, A., ITOT, S.S., TAKAHASHI, K. & ISHIE, T. (1980).

Effect of temperature on fungal growth and pathogenicity of *Fusarium* spp. isolated from mulberry twig blight and tolerance of the isolates to the antifungal substances orginating from the mulberry shoots. Bull. Seri. Exp. Stn. (Japan) 27 : 807-830.

SIDDARAMAIAH, A.L., KRISHNA PRASAD, K.S.& HEGDE, R.K. (1978).
Epidemiological studies of mulberry leaf spot caused by *Cercospora moricola* Cooke. Indian J.Seric. 16 : 44-47.

SIKDHAR, A.K., GOVINDAIAH, MADHAVA RAO, Y.R., JOLLY, M.S. & GIRDHAR, K. (1986).
Control of root-knot nematode disease of mulberry by Termik 10 G and oil-cakes. Indian J.Seric., 25 : 33-35.

SINHA, S.K.& SAXENA, S.E. (1966).
First record of bacterial blight of mulberry in India caused by *Pseudomonas mori* (Boyer at Lambert) Stevens. Indian Phytopath. 19(3) : 318-319.

STEWART, R.E. (1948).
Investigations on the leaf spot disease of black mulberies caused by *Septogloeum mori* (Briose and Cavara). J.Royal Society Australia 34 : 87-104.

SUKUMAR, J. & DAYAKAR YADAV, B.R. (1988).
Occurrence of a bud blight disease of mulberry caused by *Fusarium lateritium* f sp. *mori* type-A in India - A new report. Curr.Sci.57(1) : 49-50.

SUKUMAR, J. & RAMALINGAM, A. (1981).
Splash dispersal in *Cercospora moricola*. Science & Culture 47 : 173-175.

SULLIA, S.B. & PADMA, S.D. (1987).
Acceptance of mildew affected mulberry leaves by silkworm (*Bombyx mori* L.) and its effects on cocoon characteristics. Sericologia 27(4) : 693-696.

TAKAHASHI, K. & SATO, M. (1978).
The shoot soft rot of mulberry caused by *Erwinia caratovora* var. *caratovora* (Jones) Dye. J.Seri.Sci. Japan 47 : 143-153.

VANGUNDY, S.D. (1985).
In: An Advanced Treatise of *Meloidogyne*. Vol.I (Eds. J.N. Sasser & C.C.Carter) IMP, North Carolina State Univ., pp.177-182.

YADAV DAYAKAR, B.R. & SUKUMAR, J. (1987).
Occurrence of a new stem blight and collar-rot disease of mulberry from India. Sericologia 27(2) : 205-206.

Part II : Pests of Mulberry and their controle

BORRER, D.J., DELONG, D.M. & TRIPLEHORN, C.A. (1981) *An Introduction to the study of Insects.* S.C. Publishing Co., USA, 827 p.

BROOKS, A. & HALSTEAD, A. (1980) *Garden Pests and Diseases,* M.B. Publishing Co., London, 96p.

KARIAPPA, B.K. & NARASIMHANNA, M.N. (1981) Studies on the life history of Wingless grasshopper, *Neorthacris acuticeps nilgriensis* uvarov (Acrididae : Orthoptera) - a pest of mulberry. Indian J. Seric. 20(1) : 27-30.

KUMAR, PRADIP, RAM KISHORE & DATTA, R.K. (1991) Mortality of the silkworm Larvaw (*Bambyx mori* L.) on feeding mulberry leavessprayed with insecticides IV *National Symposium on Growth,Development and Control Technology of Insect Pests*, October 2-4, Muzaffernagar.

KUMAR, PRADIP, RAM KISHORE, NOAMANI, M.K.R & SENGUPTA, K. (1992) Effect of feeding tukra affected mulberry leaves on silkworm rearing performance. *Indian J. Seric* (in press).

KUMAR, PRADIP, RAM KISHORE, SING, B.D., NOAMANI, M.K.R & SENGUPTA, K. (1989) Residual toxic effect of some insecticides against larvae of silkworm, *Bombay mori* L. *Oriental Entomology Congress,* Agra.

KUWANA, Z., GORD, I., TAKASHI, E.& YOKIO, T. (1980) Effect of synthetic insecticides on sericultural pest, insects and mulberry leaves. *Bull. Seri. Exp. Sta.* 22 : 550-551.

MATTHEWS, G.A. (1979) *Pesticide application methods.* Longman Inc., New york, 334 p.

NAYAR, K.K., ANANTHAKRISHNAN, T.N. & DAVID, B.V. (1985) *General and applied entomology.* Tata McGrow Hill Publishing Co. Ltd., New Delhi. 589 p.

RAMKRISHNA AYYAR, T.V. (1984) *Handbook of economic entomology in South India.* International Books and Periodicals Supply Service, New Delhi, 528 p.

Rangaswami, G., Narasimhanna, M.N., Kashivishwanathan, K. & Sastry, C.R. (1976) *Manual of Sericulture Vol I : Mulberry Cultivation.* FAO, Rome, 150 p.

SESHAGIRI RAO, D. (1972) *A Handbook of Plant Protection* S.V. Rangaswami and Co., Bangalore, 841 p.

SINGH, KAMALA (1972) studies on the life history and morphology of the *Amata passalis* Fb. (Amatidae : Lepidoplera) - a pest of mulberry. *Indian J. Seric.* 11(1) : 41-46.

SIREAR, P. & SINGH, D.S. (1982) Formulation of insecticides and its role in insect pest management. In *Principles and concepts of Integrated Pest Management* (R.A. Agrwal, G.P. Gupta, Premkishore, Dinesh Chandra eds), ICAR, New Delhi, 69-76 pp.

ULLAL, S.R. & NARASIMHANNA, M.N. (1978) *Handbook of Practical Sericulture.* Central Silk Board, Bangalore, 166 p.

VENUGOPALA PILLAI, S. (1968) Obseravations on the *fuproctis Fraterna* M. (Lymantridae: Lepidoptera) - a pest of the mulberry plant in Mysore. Indian J. Seric. 7(1) : 45-47.

VENUGOPALA PILLAI, S. (1968) Bionomic of the *Eupterote mollifera* W. (Eupterotidae : Lepidoptera) - a pest on the mulberry plant *Indian J. Seric.* 7(1) : 52-55.

VENUGOPALA PILLAI, S. (1968) Studies of the bionomics of the *Ceryx godarti* Bdv.

(Syntomidae : Lepidoptera), *Indian J. Seric.*, 7 (1) : 74-78.