Chapter – 2

REVIEW OF LITERATURE
Sericigenous insect, *Antherea assama* Westwood, is a commercially important worm. It is native to Assam and produces unusual golden yellow coloured muga silk of international repute. Muga culture is restricted to North East India, more particularly to Brahmaputra valley, possibly due to its unique climatic conditions that favour growth of muga silkworm as well as its host plants (Choudhury, 1970). Production of high quality leaves of food plants by modern scientific techniques is the main goal of sericulture industry. Plant protection is an integral and important component of modern production technology and contributes substantially in increasing productivity potential in Sericulture. Jolly *et. al.*, (1976) reported that nutritionally rich food plants are required for healthy growth of silkworm. Production of muga silk depends upon the quality of leaves. The nutritional value of leaf, however, varies greatly owing to a number of factors among which the diseases play an important role (Dandin *et. al.*, 2003). Being a perennial plant, som plants are exposed to different environmental vagaries and pathogens prevailing in the region throughout the year. As a result, fungi cause number of diseases (Das *et. al.*, 2003). Babulal *et. al.* (2000) reported that a considerable amount of leaf yield is lost regularly due to foliar diseases in som plant. Feeding of such infected leaves yielded poor Effective Rate of Rearing (ERR).

An extensive survey of literature revealed that a limited quantum of work has been done on pathological aspects i.e. eco-pathology, epidemiology and management of diseases of som plant (*Persaea bombicina*). However, works on the other crops related to the present investigations have been also reviewed in this chapter.
Host plant

The muga silk is endemic to the North Eastern region (former undivided Assam). It is widely cultured in Assam, which accounts for more than 95% productivity (Saratchandra, 2006). 'Som' (*Persaea bombicina* Kost), 'Soalu' (*Litsea monopetela*, Roxb.Pers). and 'Gansarai' (*Cinnamomum glanduliferum* Meissn) are the primary food plants of muga silkworm (Kangilal *et. al.*, 1940; Rajaram and Samson, 1991). Som (*Persea bombycina* Kost) is a commercially important chief host plant of golden silk producer silkworm, *Antheraea assama*. It is grown abundantly through out the humid and sub-tropical zone (Choudhury, 1970; Hooker, 1885 and Thangavelu *et. al.*, 1988). It was formerly known as *Machilus bombycina* (Bennet, 1987). It is a woody tree, belonging to the family lauraceae, under order Laurales (Bennet, 1987). Leaves of som is the commercially importance part of the plant as regards to muga silkworm culture (Choudhury, 1961). The quality of leaves affect health and survival of silkworms. Growth, development and economic characters of silkworms are influenced to a great extend by the nutritional contents of the food plants. Better the quality of leaves greater is the possibility of obtaining a good cocoon crop (Khanikar and Unni, 2006). It is reported that quantitative characters like shell ratio and reel ability are better in som leaves fed muga worms than soalu ones (Choudhury, 1970).

*P. bombycina* is indigenous to North East India. Its distribution extends from Lower Himalayans to Almora as far as Nepal, Burma and Indonesia up to an altitude of 1,500 MSL (Chaudhury, 1961; Hooker, 1885; Kanjilal, 1992). In northeastern India, it is widely distributed in Assam, Meghalaya, Arunachal Pradesh, Tripura, Mizoram, Nagaland, Manipur and North Bengal. In Northern India, it is available in plenty in Uttaranchal and Himachal Pradesh (Chaudhury, 1981).
Although muga food plants are available in other parts of the country, the commercial production of muga silk has been mostly restricted to Assam and Meghalaya only (Thangavellu et al., 1988). The muga culture has been mostly restricted to Assam and Meghalaya only (Thangavelu et al., 1988) and it is more concentrated in Upper Assam and leaves are mostly utilized for commercial crop rearing (Sarmah et al., 2006). Dhemaji, Lakhimpur, Sivasagar, Dibrugarh, Golaghat, Jorhat of Upper Assam and Kamrup of Lower Assam are the major sericulture districts of Assam and are good producer of muga cocoon (Choudhury, 2006).

One full grown tree of 12-20 years growth can support the rearing of 5 to 10 layings and yield 500 cocoons in one season. (Thangavellu et al., 1988). Potential leaf yield of som is about 4MT h\(^{-1}\) y\(^{-1}\). But present productivity at farmer’s level is about 16 MT (Chakravorty, 2006). The yield gap of about 33% is due to non-adherence to the recommended package and practices by the farmers (Chakravorty, 2006). Diseases, unfavourable weather, insect pests, poor agronomical inputs, unwanted weeds are the main reasons for reduction in leaf production that ultimately affect silk production.

**Diseases**

The plant diseases significantly reduce plant productivity (Sivaprabakasam, 1993). Muga food plants too are prone to various diseases that affect the normal growth of the plant and render the leaves unsuitable for muga silkworm rearing and ultimately affect cocoon yield (Thangavellu et al., 1988; Das et al., 2003). Destruction of leaf due to various diseases of host plants is posing serious problems before the muga farmers. A number of fungi, Bacteria and viruses are
known to cause significant economic losses in sericulture the world over (Rao et. al., 1981; Sastry, 1984).

The annual loss in leaf yield in sericulture is about 20-30 % (Philip et. al., 1994). Diseased leaves have been stated to be inferior in quality and unsuitable for feeding of silkworm (Rangaswamy et. al., 1976). Leaf spot, leaf blight, red rust and leaf curl were other major diseases that cause loss in leaf yield from 13.8% -33.5% (Das and Benjamin, 2000). Thangavelu et. al., 1988 also reported leaf spot, red rust, grey blight, leaf curl and wilt as severe diseases of muga food plant som. Das et. al. (2005) reported anthracnose disease, caused by Colletotrichum gloeosporioides Penz., from som plants from Assam. Das et. al. (2007) reported a serious foliar disease of som characterized by brown colour spots surrounded by yellow margin. It was caused by Phyllosticta persae.

Agroclimatic conditions

Climatic factors like temperature, relative humidity, soil characters, rainfall etc. play an important role in the development of a disease (Upmanyu et. al., 2004). Govindaiah and Sharma (2001) reported the highest disease incidence while the plants were pruned at ground level (40 cm above the ground level). About 21-25% of reduction in disease severity was observed under middle pruning. Further they recommended that under high amount of phosphorus (300:180:120 kg NPK) fertilizer the disease incidence was significantly fewer (40-45%). Sinha (2001) reported that geographical distribution of plant diseases and their seasonal development is mostly conditioned by weather and soil condition. Das et. al. (2005) surveyed the incidence of leaf spot disease of som (Persea bombycina) and reported that the disease appeared during second week of May and increased gradually till maturity. Disease intensity was
maximum in July. Rajkhowa and Chakrovorty (2003) studied the five foliar diseases of mulberry in agroclimatic condition of Assam and reported that the disease intensity of *Pseudocercospora* leaf spot was highest during October-November (15.06%) and *Myrothasium* leaf spot was significantly lower with maximum intensity (2.25%) during August-September. Leaf rust was more prevalent during May-June (11.31%). Ravikumar et al. (2003) surveyed the occurrence of major diseases of mulberry in Karnataka and reported the prevalence of powdery mildew, bacterial blight and wilt in severe form in all the areas surveyed. Powdery mildew disease of mulberry occurs from spring to autumn in temperate countries while it is more prevalent during August to February under Indian conditions (Biswas et al., 1992). Philip et al. (1994) reported that in mulberry disease severity is more predominant in post rainy and winter seasons and persist up to February, which coincides with silkworm rearing period.

**Disease resistance**

Host varieties are known to respond differently to attack by their pathogens and such responses vary within certain ranges *i.e.* while some are prone to diseases and when infected with a pathogen develop moderate to severe symptoms, others respond differently and suffer only little or no damage, these being respectively known as susceptible and resistant varieties (Sinha, 1988). The most appropriate and economical strategy to manage plant diseases is through exploitation of host resistance, which is not only environmental friendly but convenient to be adopted at farmer's level too (Dutta et al., 2005). Chaudhuri (1981) grouped *Persea bombycina* into different categories based on the shapes of leaves such as, “Naharpatia”, “Jampatia”, “Ampatia” and “Kathalpatia” etc. Bharali (1984) reported 16 morphotypes on the basis of organoleptic tests of the som leaf. Thangavelue et al. (1988) reported existence of four
varieties of som and identified them as “Naharpotia”, “Ampotia”, “Jampotia” and “Kathalpotia”. On the basis of leaf size and shape, stem, inflorescence, colour of the sprouted leaves and size of the plants of som Raja ram et. al. (1993) described eight morphotypes of som and named them as Som cultivars – S-I, S-II, S-III, S-IV, S-V, S-VI, S-VII and S-VIII. Kataky and Hazarika (1993, 1996), however, categorized the som plant into three groups viz. most preferred, preferred and least preferred based on feeding performance of A. assama. On the basis of bio-chemical analysis, bioassay and post cocoon parameters Siddiqui et. al. (2000) reported that S-6, S-4, S-3 and S-5 were palatable and superior for sustainable yield of muga cocoon, whereas three morphovariants viz. S-1, S-2 and S-7 were less preferred by the muga silkworm.

Several workers have studied on screening of different mulberry genotypes against fungal diseases and they also studied the factors responsible for disease resistance in mulberry genotypes against foliar diseases and recommended that the genotypes resistant to foliar diseases have leaves with more wax, thicker surface and palisade layer, lesser stomatal frequency, more number of palisade cells/mm and higher palisade index value. These factors play an important role in providing defense against the penetration and inversion of pathogens (Govindaiah et. al., 1989; Yadav et. al., 1993; Fotadar et. al., 1998; Philip, 1991; Philip and Govindaiah, 1996; Rajkhowa and Chakrovorty, 2003). Dhakate et. al. (2006) suggested that in case of brinjal wild species namely Solanum gilo and Solanum integrifolium were the immune species against the fruit rot disease. Singh and Tripathi (2004) tested seventy nine germplasm of field pea against Uromyces rust disease and concluded that the varieties viz. HUP2, KPMR 171, JP 9 and JSP22 showed the minimum apparent infection rate (r=0.0643) unit\(^{-1}\) day\(^{-1}\).
Epidemiology

Epidemiology is an important aspect of study of plant diseases. It deals with outbreak and spread of diseases in a host population (Singh, 1996). Das and Benchamin (2000) reported grey blight as one of the major foliar disease of Som plant that occurred during March to September with 48-59% of the plant infection and 13.8-21.6% leaf area destruction. Leaf loss in grey blight disease was estimated at 1273 kg hectare\(^{-1}\) annum\(^{-1}\). *Pestalotiopsis disseminata* was identified as the causal organism of the serous disease, grey blight, of som (Bharali, 1969). *Pestalotiopsis disseminata* is reported by many workers to cause severe diseases to other crops (Sridhar, 1978; Singh, 1996; Philip and Govidaiah, 1995; Singh and Devi, 2001). Rajendran (1971) studied leaf spot and fruit rot disease in *Achras sapota* (sapota) caused by *Pestalotia sapoticola*. Similarly, Raj *et al.* (1982) reported *Pestaletioptis* rot in *Carica papaya* incited by *P. palmarum*. Another fruit rot disease in *Carica papaya* caused by *Pestalotia versicolor* was reported from Judhpur by Vyas and Panwar (1976). Fail and Langenheim (1990) studied the infection processes of *Pestalotia subcuticularis* on leaves of *Hymenaea courbaril* and reported that spores germinated within 6 to 12 hours and epidermal penetration occurred within 12 to 24 hours after germination. Pratheesh Kumar *et al.* (2000) studied the development of leaf rust and dispersal of urediniospores in mulberry and found that rust severity increased with increasing shoot age irrespective of pruning time. Das *et al.* (2004) reported that weather parameters were significantly co-related with disease intensity of leaf spot disease of *Persea bombycina*.

Das *et al.* (2006) studied *Colletotrichum gloeosporioides* Penz. causing anthracnose disease of *Persea bombycina* and found that the spores remained viable in infected plant debris up to 12 to 13\(^{th}\) month in soil conditions. The initial survivability
(100%) was completely lost within 6 months when plant debris placed at 20 and 25 cm depth. Diseased plant debris and infested soil served as primary source of inoculum of the pathogen. The percent conidial germination, number of germ tubes, length of germ tubes and the frequency of penetration of *Cercospora moricola* were studied by Sukumar and Ramalingam (1989). They recorded higher infection on young leaves and the intensity gradually decreased with increased leaf age of mulberry plant. Biswas *et. al.* (1992) studied the effect of diurnal variation on the dispersion of conidia of mulberry powdery mildew and reported that during daytime conidia liberation was more.

**Disease management**

**Fungicides**

Many fungicides have been successfully used in the control of plant diseases. Philip and Govindaiah (1995) reported that foliar blight disease of mulberry caused by *Pestalotiopsis disseminata* can be controlled by spraying 0.05% Blitox (Copper oxichloride) or Bavistin (Carbondezim). These fungicides at 0.05, 0.1 and 0.2% concentration completely suppressed the mycelial growth of the fungus. Bhanumathi and Ravishankar (2007) evaluated five systematic fungicides and two contact fungicides against leaf blight of *Syzygium cumini* caused by *Pestalotiopsis sp*. These fungicides showed 100% growth inhibition of the test fungus. Harsh *et. al.* (1987) tested different fungicides against *Pestalotiopsis varsicolar*, the causal organism of foliar disease of *Diospyros melanoxylon*. They reported that 0.1% Bavistin and 0.3% Dithane M-45 were more effective to control the disease under *in vitro* condition. Pandey *et. al.* (2006) tested different fungicides against *Pestalotiopsis mangiferae* and reported that in *in vitro* condition Carbendazim in 0.1% concentration was most effective to inhibit complete growth of *P. mangiferae* colony. Several workers (Tripathi *et. al.*, 1987; Sukumar *et. al.*,...
1994; Gunesekhar, et. al., 1995; Yokoyama, 1996; Vala, 1996; Chattopadhyay, 1999; Wong and Wilcox, 2001; Upadhya and Gupta, 2003; Islam et. al., 2004; Joshi et. al., 2004; Quadri et. al., 2004; Harlapur et. al., 2007; Shahnaz et. al., 2007) have studied the effect of various fungicides in controlling different diseases in different plants / hosts. Usually the fungicides were effective in controlling the diseases they are used for.

Govindaiah et. al. (2002) based on the results of their work in mulberry recommended Foltaf and Kavach (@0.2%) for controlling leaf rust infection. They also indicated that the fungicides sprayed leaves could use for rearing of silkworm with no toxicity to the worms. Quadri et. al. (2004) used Foltaf and Kavach to control leaf spot disease in mulberry. The fungicides controlled the incidence of the disease and improved the leaf yield by 28% over the control. Das et. al. (2003) recommended three sprays Indolfin M-45 to control the leaf spot of som. The World Health Organization (WHO) has banned many agriculturally important pesticides due to wide range of toxicity caused by them to non-target organisms including humans. (Barnard et. al., 1997).

**Plant extracts /Botanicals**

Fungicides are expensive, require skilled labour and may be phytotoxic. Furthermore, continuous use of these chemicals may pose ecobiological problems. Consequently, it is desirable to search for an alternative by using the natural biological balance to control plant diseases. Ahmed and Grainge (1982) tested plant products to control plant diseases. 1134 out of 5280 plant species tested possessed insecticidal, fungicidal, bactericidal and antiviral properties. Agarwala (1978) reported the antifungal activity of *Allium sativum*. Muthulakshmi and Seetharaman (1993) studied five plant species namely *Angle marmelos*, *Prosopis juliflora*, *Ipomoea cornea*, *Ocimum sanctum* and *Bougainvillea spectabilis* against *Alternaria tenuis* the causal organism of fruit rot.
disease of chilli. They reported that leaf extract of *Angle marmelos* (10%) was the most effective followed by that of *Prosopis juliflora* both *in vitro* and *in vivo* conditions.

There have been several studies on use of plant extracts for controlling plant diseases (Sarvamangala *et. al.*, 1993; Amadioha, 2003; Sinha *et. al.*, 2003; Ghanti *et. al.*, 2006; Harlapur *et. al.*, 2007; Ogbebor *et. al.*, 2007). Many of them have reported that plant extracts were effective in the control of several plant diseases (Sarvamangala *et. al.*, 1993; Phillip and Sharma, 1999; Shivapuru and Gupta, 2002; Upadhya and Gupta, 2003; Harlapur *et. al.*, 2007).

**Biological control**

The most common method to check plant disease is the use of fungicides, but their frequent and indiscriminate use often leads to pollution and development of resistance in pathogens (Kumar and Dubey, 1991). Because of high cost and pollution hazards associated with the use of pesticides, insecticides, fungicides etc. use of biological methods for controlling plant pests and diseases is likely to be the best alternatives to conventional chemical control methods (Chakraborty *et. al.*, 2005). Biological control of plant diseases through the use of antagonistic microorganisms is very promising (Cook and Baker, 1983; Shishido *et. al.*, 2005).

Biological control frequently involves the exploitation of organisms in the environment to decrease the capacity of the pathogen to cause disease without disturbing the ecological balance (Chakraborty *et. al.*, 2005). The problems mostly faced with the method of disease control and in the development of environment friendly protection strategy of crop plants are what to use, how to use, and when to use. This generates the idea on the use of antagonistic organisms in the control. *Pseudomonas*
fluorescens have been reported to induce systemic resistance in plants against several pathogens (Weller, 1988; Maurhofer et. al., 1994; M. Piga et. al., 1997).

The potential use of *Trichoderma spp.* as bioagents have been reported by several workers (Kapil and Kapoor, 2005; Rajeswari et. al., 2007). *Trichoderma* is a well-known antagonist in soil and its ability to interact with pathogen by exhibiting competition; antibiosis and hyper-parasitism make it an attractive agent for the management of foliar diseases (Blakeman and Fokkema, 1982). It has been identified as potential biocontrol agent of many important plants diseases (Lewis and Papavizas, 1987; Monga and Sheo Raj, 1996). Harman et. al. (2004) applied *Trichoderma* to fruits, flowers and foliage to control the disease. Fluorescent pseudomonads play an important role in biological control of plant pathogens, dominate in the rhizosphere and possess several properties that have made them as biocontrol agent of choice (Johri et. al., 1997). Sivakumar et. al. (2000) advocated that two applications of *P. fluorescens* @ 5 or 6 g/liter on sheath after the inoculation of the pathogen gave maximum control of leaf and sheath blight disease of maize. Shivapratap et. al. (2000) tested the antagonistic potentiality of eight isolates of *Trichoderma* and isolate of *Gliocladium virens* against *Cercospora moricola*. They recorded *T. harzianum* and *T. viride* as antagonistic organism to *C. moricola*. Nandakumar et. al. (2001) also observed that *Pseudomonas fluorescens* when applied alone or in combination significantly reduced the sheath blight incidence both under glass house and field conditions. Singh and Singh (2002) studied the control of sheath blight of rice by using different *Trichoderma* spp. and observed that foliar spray with *Trichoderma* spp. @ 2gm/lt gave maximum reduction of blight disease in rice. Awadhiya (2007) studied the control of chickpea wilt complex and their control by bioagents. The antagonists applied for control of wilt disease were *Trichoderma viride*.
and *Pseudomonas fluorescens* in different combinations. Harlapur *et al.* (2007) *in vitro* tested eight biocontrol agents namely five *Trichoderma* spp, *Aspergillus niger*, *Pseudomonas fluorescens* and *Bacillus subtilis* against *Exserohilum turcicum* (Pass) for their antagonistic activity by using dual culture method and suggested that all the fungi and bacteria inhibited the growth of *E. turcicum*. An *in vitro* evaluation of different promising fungal and plant growth promoting bacteria against dieback disease of chilli was carried out by Patel *et al.* (2007). It was observed that *Trichoderma viride*, *Trichoderma harzianum*, *Trichoderma hamatum* and *Pseudomonas fluorescens* caused maximum suppression and the reduction was at par with chemical fungicides.

**Toxicity of chemicals and botanicals**

Gamo and Hirobe (1977) reported that hazardous effect of pesticide residues are also transmitted to the silkworm eggs, embryos and pupae that could affect later generation. Govindaiah *et al.* (1994) tested the effect of fungicides on multivoltine and bivoltine races of silkworm and found that there was no adverse effect on the servility, growth and cocoon character of the silkworm and the fungicide sprayed leaves can be used for rearing even after first day of spray. Gunasekhar *et al.* (1995) studied the residual toxicity of fungicides on silkworm growth and cocoon character by feeding sprayed leaves and reported that feeding of the fungicides namely bavistin, kavach, karthane, foltaf, dithane M-45, sulfex and blitox sprayed leaves, even first day after spray, did not show any adverse effect on silkworm growth and cocoon character. Govindaiah *et al.* (2002) reported fungicide sprayed leaves can be used for silkworm rearing even after first days of spray.