CHAPTER 1

INTRODUCTION

The agriculture based industries play a major role in the rural economy of the country. Sericulture is one of such vital agro based industry which comprises of various inter-linked activities from cultivation of food plants and maintenance of the leaves for quality cocoon production from the silkworm, realing of cocoon and proceesing of the cocoon for production of silkfibre. All five varieties of natural silk are found in India viz. Eri, Muga, Oak tasar, Tasar and Mulberry silk. India continues to be the second largest silk producer mainly due to mulberry raw silk produced by certain states of the country in the global platform (13.4%). In India production of silk was recorded 23000 MT during 2011-12, out of which 18186 MT was mulberry silk, while 3110 MT was Eri silk, 127 MT was Muga silk and production of Tasar silk was 1577 MT respectively. (Source: Regional Office, Central Silk Board, Guwahati, Assam). Among all these commercially exploited silk the Mulberry silk is produced throughout the country, tribal inhabiting central India and sub Himalayan region produces tropical Tasar and temperate Oak Tasar, while Eri silk and golden Muga silk is produced only in Brahmaputra valley of Assam province in NE region. The non-mulberry silks (Eri, Muga and Tasar) are now being popularized as Vanya silk. Except Eri silk worm, other non-mulberry silkworms are reared on trees of open fields and natural forests. While rearing of Eri silkworm is done in indoor environment condition and they are completely domesticated (Ahmed and Rajan, 2011).

Sericulture along with silk weaving is the part and parcel of cultural heritage of the people of North-East India. The climatic condition of North-East India favours the growth of Eri and Muga silkworm. The golden silk producing muga silkworm is found only in the North Eastern part of India and it has restricted distribution. The number of sericulture village in North-East region is about 38,000 and approximately 1.9 lakh families are engaged in this industry in Assam. According to Unni *et* al. (2009), Assam is the only state in the country producing all the varities of silk. Among these diverse silkworm varieties , muga silkworm *Antheraea assamensis* Helfer is endemic to North East Region of india producing the golden coloured exquisite silk, unavailable in other parts of the world.

Assam is famous as the land of golden silk. From the time of Ramayana, Assam was probably known as a place of "cocoon rearers". The beauty and richness of Assam's silk was also extrolled by Koutilya in Arthassastra. Assam was mentioned as Suvarnakanan in the Mahabharata which means the silk producing province, where mainly muga and pat fabrics are produced. The first official record of muga silkworm relates to 1662. It is believed that the *Tai-Ahom* community of upper Assam has introduced the muga culture into Assam which is a remarkable contribution to Assamese culture by *Tai-Ahoms*. It was also reported by various authors that alongwith *Tai Ahoms*, the *Rabha* and *Garo* community of lower part of Assam also practiced the rearing of muga silkworm to a limted extend. (Dalton, 1872; Chowdhuri, 1980; Anonymous, 1981; Buragohain, 1994; Gogoi, 1996; Borthakur, 2003; Phukan and Chowdhury, 2006). The soil, topography and ecology of Assam are best suited for the rearing of muga silkworm. As mentioned earlier that muga silkworm rearing is done in outdoor environment on tress of open fields and natural forests, but attempts are being made to maintain it under semi-domesticated conditions for the improvement of its economic traits (Thangavelu and Sahu, 1983; Tikader *et* al., 2013). Ahmed and Rajan, (2011) mentioned that the golden silk produced by the muga silkworm of Assam is the unique product of India and it is unavailable in the other parts of the world due to peculiar behavioural adaptation of the insect and requisite climatic condition. Muga culture has been practiced in the different states of North Eastern region of India, out of which Brahmaputra valley of Assam itself produces about 90.55 percent of the India's total muga silk and hence it is considered as the main production zone of muga silk. In Assam, muga production is mainly practiced in Dibrugarh, Dhemaji, Goalpara, Golaghat, Jorhat, Kamrup, Kokrajhar, Lakhimpur, Sivasagar, Tinsukia and Udalguri districts. Muga, *Antheraea assama* West wood (= *Antheraea assamensis* Helfer) culture comprises of continuous chain of several activities starting from production of egg, silkworm rearing, production of cocoons, reeling of the cocoons and weaving for production of yarn and fabrics.

Though muga silkworms are polyphagous, multivoltine and semi-domesticated in nature but they feed primarily on two host plants. *Persea bombycina* Kost. (syn: *Machilus bombycina* King.) commonly known as "Som" and *Litsea monopetala* Roxb. (syn: *Litsea polyantha* Juss.) commonly known as "Sualu". Other food plants include "Dighloti" (*Litsea salcifolia*) and "Mejankari" (*Litsea citrata*). In accordance with Assamese calendar the six different generations of Muga silkworm in a year are known as i) *Jaruwa*-Winter (December-January) ii) *Chatuwa*-Early spring (February-March) iii) *Jethuwa*-Spring (April-

May) iv) *Aheruwa*-Early summer (June-July) v) *Bhodia*- Summer (August-September) vi) *Kotia* –Late summer or Early winter (October-November). According to reports of various workers, of all these generations the Early winter (*Jaruwa*) and Spring (*Jethuwa*) generations produce silk best in quality and quantity. (Bora *et* al., 1988; Barah *et* al., 1989 and Borthakur., 2003). Muga silk culture is practiced in the districts of upper Assam and certain parts of lower Assam. In lower Assam the Goalpara district produces some quantities of muga cocoon. Goalpara district is located between latitudes 25.53° and 26.30° North and 90.07° and 91.05° East. Sericulture in Goalpara district existed almost as a practice among the people since a long time. Goswami and Bhattacharya, (2013) mentioned that due to the climate suitable for silkworm rearing Goalpara district has been given the geographical identification mark. Dhemaji, Dibrugarh, Lakhimpur and Sibsagar district of upper Assam produces commercial muga cocoons in bulk quantities. Where as according to the report of Regional Muga Research Station (RMRS), Boko, (2000) the Eastern and Western part of Goalpara district and South west part of Kamrup district of lower Assam constitute important muga growing areas where mostly seed cocoons are produced. Choudhuri, (1981) mentioned a proverb in Assamese, "*Namonir sonch ujanir goch*" in his study which means, seed cocoon from lower Brahmaputra valley reared in upper Brahmaputra valley always ensures succesful harvest of cocoons.

Som, the primary food plants of muga silkworm is medium sized evergreen tree which belongs to family Lauraceae. Leaves are usually aromatic and in natural habitat alternate leaves grows abundantly. It is distributed mainly in Assam particularly in Brahmaputra valley up to an elevation of about 500 meters which is extended to Khasi and Jayantia hills, Meghalaya in India, along the lower Himalaya and as far as to the West of Nepal.(Hooker, 1885; Kanjilal *et* al., 1992; Rahman *et* al., 2012). According to Seth (2000), although the plant grows abundantly in almost all parts of India, Nepal, Myanmar, Cambodia, Malaysia and Indonesia but commercial use of *Persea bombycina* (King ex Hook. F.). Kost. is restricted to only Northeast India. Researchers have reported variations among Som. (Bharali, 1985; Sengupta *et* al., 1993). The macro and micro morphological variation may differ according to their growth, yield of leaf, size and shape of the leaf along with colour, different taste and odour. Rahman *et* al., (2012) studied on various Som genotypes on the basis of Random Amplified Polymorphic DNA (RAPD) analysis from Goalpara district of Assam. Among 16 species of som described by Hooker (1885), only four eco types of som are preferred by muga silkworm. The nutritive value of leaf has a considerable influence on the growth and development of silkworms. According to Ahmed *et* al. (2012), the effective rate of rearing (ERR) of silkworms feeding on som leaves are always higher alongwith the quantitative characters such as shell weight , silk ratio and better coccon reelability. Importance of better nutrition for rearing of mulberry silkworm has been widely recognized in India and overseas (Takeuchi, 1960; Krishnaswami *et* al., 1970; Fonseca *et* al. 1993; Sarkar *et* al., 1997, Bongale and Chaluvachari, 1995). These kinds of studies are very few in case of muga silkworms. The host plants (leaves) play a significant role on health and survival of silkworms. Khanikar and Unni (2006) reported that better the leave quality of the host plant, greater the possibility of obtaining good quality cocoons. Similarly, Chakraborty *et* al. (2006) mentioned growth of silkworm, coccon quality and quantity of raw silk entirely depends upon the quality of leaves. Diseases, unfavourable weather conditions, insect pests, poor agronomical practices, unwanted weeds are the main reasons for low productivity. The muga foodplant som is vulnearable to many foliar diseases that affect the normal growth of the plant, quantity and quality of leaves and ultimately coccon production (Das *et* al., 2003). Grey blight is one of the major foliar fungal diseases of muga host plant som caused by *Pestalotiopsis disseminata* (Thum) Stey. This has been reported as a major epidemic disease of som causing 13.8-41.6% leaf yield loss (Bharali, 1969; Das & Benchamin, 2000).The appearance, symptoms, progress and development of the disease on the som leaves were studied by Keith *et* al. (2006) and Das *et* al. (2010).

Nutritional constituent of host plant leaves greatly influence the growth and development as well as economic characters of silkworms (Krishnaswami *et* al., 1970; Muthukrishnan and Pandian, 1987; Reddy and Ramanujan, 1989). A successful muga culture mainly depends on nutritional status of the leaf of food plants, rearing of silkworm on them and which could result to maximum cocoons production superior in quality in terms of pupation or silk content. Foliar constituents like moisture, crude fiber, fat, minerals,nitrogen content, protein, sugar and starch content etc are the important parameters of food plants and based on these characterstics the performance and productivity of the muga silk culture is measured. Dutta *et* al. (1997) reported that as the leaf quality directly influences the growth, survival and health of silkworm, food plants selection with superior nutritive value for healthy silkworm development is of great importance and for obtaining better cocoon quality. Yadav and Goswami (1992) mentioned that certain significant variation might occur on the leaf contents of Som but it contributes a better nutritional value for muga silkworm rearing and silk content superior in quality. Alongwith feeding behaviour of muga silkworm

Hazarika *et* al. (1995) found some relationship between soluble protein and total phenol content of Som. Sharma and Devi (1997) studied rearing performances of muga silkworm on Som and Soalu plant in different seasons and found that the during autumn Som leaves remained ideal while Soalu leaves were suitable in the late spring for rearing of muga silkworm. Siddique *et* al. (2000) estimated the biochemical composition of 14 morphovariants of *Persea bombycina* and identified at least 4 high yielding, nutritive as well as palatable and superior variants for sustainable yield and cocoon production. Das and Benchamin (2000) identified 8 morphovariants of *som* on the basis of different chemical parameters in Assam. Chowdhury *et* al. (2000) studied the effect of the essential oils of *Litsea cubeba* Pers. (=*Litsea citrata* Blume) on rearing performance of muga silkworm and silk quality in Assam. Neog *et* al. (2007) studied the rearing performance as well as biochemical constituents of som leaves and reported that biochemical constituents of leaf influence the rearing performance of muga silkworms. They also reported superiority of tetraploid genotypes over diploid plants. The sustainability of muga silk industry depends on commercial cocoons production in large quantity without uninterrupted flow from producer to consumer level through diversification of various products and to maintain its sustenance with emerging urban industrialization. Chaudhuri *et* al. (1999) reported that muga silk worm's commercial cocoon productivity is determined by the availability of seed cocoons quality in the pre seed and seed crops which is measured in terms of productivity potential realized from egg layings of a particular mother moth. The gap between the seed cocoon (either pre-seed or seed crop) production is one of the major factors affecting the muga silk industry as both the seed crops always fall either in summer or in winter making these crops uncertain. Zamal *et al.* (2010) mentioned that the climatic conditions during the commercial crops should remain within temperature 20-31ºC with the relative humidity of 65-95% as the optimum limit. They further reported that temperature between 18º-26ºC and a relative humidity between 70- 85% shows the best conditions for the commercial rearing. During last few decades' atmospheric pollution, global warming, variability in temperature and relative humidity, abnormal rainfall pattern, flood and drought has caused low crop yield in spite of all efforts and utilization of resources. Besides all these parameters pesticides used in neighbouring tea gardens, pollution from the bricks kiln industries, burning of natural gases emitting from oil wells and seismic survey by ONGC for oil exploration etc are the other reasons enlisted for the heavy loss of muga silkworm (Annonymous, 2010). Being reared in outdoor, muga silk worm may not be able to adjust to the new changing environment (Singh and Maheshwari, 2003) and thus the differential seasonal conditions greatly influence the growth and development of muga silkworm in the form of cocoon weight, pupa weight, shell weight percentage, potential fecundity, reelability and denier of the silk (Chiang, 1985; Yadav and Goswami, 1992; Yadav, 2000).There is a significant relationship between cocoon weight and shell weight of muga silkworm and their variations can be correlated to geographical area, environmental conditions and host plant significantly during the rearing period of muga silkworm. Quality of muga silkworm seed plays a vital role in the productivity, sustainability and profitability of muga silk industry. Although there are several muga seed farms established in different parts of Assam, there is lack of scientific temperament among the rearers for proper management and production of seed and except for a few farms, commercial zone for muga silk worm rearing is not specific. Hence, in muga sector the seed multiplication is an important area and to reduce the wide gap between the demand and supply for production of commercial cocoon it needs immediate attention and improvement of disease free layings (dfls). The traditional commercial muga rearers of Assam generally collect wild, healthy seed cocoons from foot hills and other higher altitudinal areas of neighbouring hilly states like Arunachal Pradesh, Meghlaya and Nagaland for the production of commercial crop which signifies that the climatic variation, effect of altitude and food plant preference play a great role in muga cocoon production. Thangavelu *et* al. (1998) reported 34 ecoraces of *Antheraea mylitta* while *Antheraea assama* is believed to be a single race. However, several authors reported a wide range of colour polymorphism and voltinism in its wild counterpart in higher altitudinal areas of Arunachal Pradesh, Meghalaya and Nagaland (Sengupta and Singh, 1974; Thangavelu *et al.*, 1987; Bora *et al.*, 1990; Sengupta *et* al., 1995; Sahu and Bindroo, 2007). The climatic and topographical variations among different states of North East India provides enormous opportunities for exploration of wild muga silkworm strains which can be used along with the cultivated strains and through hybridisation process production of disease resistant and high yielding varities might be possible which will improve the muga industry. Thangavelu and Borah (1986) mentioned that in the cultivated population diapause was a rare occurrence but during the winter season diapause occured in the wild population. Prasad and Sinha (1982) in their study found that in winter season i.e. December and January, preservation of pupae at high altitude was detrimental, while in case of semi-domesticated muga silkworm pupae did not diapause at high altitude. Yadav and Sampson (1987) reported Mizoram was quite sustainable for Muga culture due to hot and humid climatic condition. They specially mentioned about Mamit sub division located at the height of 2978 m from the sea level. Choudhury *et* al. (1999) analyzed muga cocoon productivity in nine different locations in Assam, Arunachal Pradesh and Meghalaya. They reported that diurnal shift in temperature, humidity, rainfall, number of rainy days and altitude have pronounced effect on muga cocoon productivity. Sengupta *et al.* (1995) successfully conducted a trial on rearing of muga silkworm on Som and Sualu in a cooler place like Dehradun in Uttarkhand. Rearing and grainage performance of muga silkworm during four crops of muga silkworm viz. Jaruwa, Bhodia, Kotia and Aheruwa in Doon valleys were found to be better than in Assam (Khatri, 2003). In Terai region of West Bengal, Biswas and Ray (2006) reported the effect of environmental factors on seed production of muga silkworm. Muga culture has been introduced in Cochbehar district of West Bengal and Sikkim recently although production is not yet commercialised due to several constraints in its cultivation. Som and Sualu fed muga silkworms produces golden yellow silk, however when muga silkworms reared on the secondary host plants like mejangkari *Litsea citrata,* the silk produced is known as Mejangkari silk which was glossy creamy white shade and it was admired for its durability and luster (Saikia and Goswami, 1997). Choudhury (2005) reported that once upon a time, Dibrugarh, Golaghat, Jorhat, Karbi Anglong, Sivasagar and Tinsukia districts of Assam; Ri-Bhoi district of Meghalaya; Mokokchung district of Nagaland and Changlang and Tirap districts of Arunachal Pradesh were abundant with Mejankari plantation. But, due to large scale deforestation, severe flood recurrence, land occupations by tea industries and Jhum cultivation in the hilly areas depletation of Mejankari trees occured in the plains of Assam. Nutrititive constituents of food plants and their variability with seasons are closely related to silk worm rearing (Yokoyama, 1963).Studies have been reported on host plant preference and rearing performance on Som, Soalu, Dighloti, Mejankari and Gonsoroi from Assam (Barah *et al.*, 1992; Saikia and Goswami, 1997; Gogoi and Goswami, 1998) and also from other part of India (Jaya Prakash *et al.*, 2004; Khatri *et al.*, 2004).

Leaf surface (phylloplane) microorganisms influence the growth of their host plants either positively by increasing the stress tolerance and resistance to various diseases or negatively as pathogens (Cordier *et* al., 2012; Bhuyan *et* al., 2013). Leaf surrounding areas are one of the major microbial habitat that provides shelter to various microbial communities like bacteria, fungi, algae, actinomycetes and protozoa etc. (Morris and Kinkel, 2002; Kim *et* al., 2012; Bhuyan *et al.*, 2013). Several stimulatory & inhibitory substances are present on the surface of a leaf that regulate the microbial colonization on phyllosphere. (Leveau, J., 2009).

The filamentous fungi are present predominantly as spores whereas rapidly sporulating species, bacteria and yeast colonize this habitat more actively. The nature and leaf surface microbial population types of economic crops have received considerable attention (Sinha, 1965; Leben, 1965; Dickinson and Preece, 1976). Interactions of surface microflora with leaf pathogens and its impact in disease development has also been studied with reference to some cereal crops (Barnes, 1971; Blakeman & Brodie, 1976; Sarkar and Samadar, 1978). The influence of surface microflora has been further enhanced by recent studies showing the existence of cyclic pattern of appearance of air phylloplane litter soil microflora (Adhikari & Tiwari, 1991).

Studies revealed that a variety of bacteria, fungi and algae live in leaf surfaces and rhizosphere soil. Among them some secrete phytoalexin compounds such as benzoic acid, scopolin, pistin on the leaf surface while few of them produces toxic byproduct and others probably secrete various growth substances. On the other hand few others again either initiate or prevent disease development on the leaves. Very few works has been reported on the composition of the phylloplane mycoflora of muga host plants Som (*P. bombycina*) and Sualu (*Litsea polyantha*) along with any disease causing organisms.

Hence a systematic study were conducted on major som cultivation sites of Goalpara district of Assam for major foliar disease of som, intensity of various diseases, epidemiology of most common diseases of the district, study on air, soil and phylloplane mycoflora alongwith physicochemical properties of soil and biochemical properties of leaf for two consecutive years and management of the dominant foliar disease of som using both systemic and non systemic fungicides with the following objectives:

1. Survey of different som cultivation sites of the district for collection of diseased samples.
2. Study symptoms, intensity of diseases and quantum of loss caused to the foliage.
3. Epidemiology of the most common diseases of the district.
4. Qualitative and quantitative study of soil, air and phylloplane mycoflora.
5. Management of the dominant disease using systemic, non-systemic fungicides and plant extracts.