International Journal of Applied and Natural Sciences (IJANS)
ISSN (P): 2319-4014; ISSN (E): 2319-4022
Vol. 7, Issue 2, Feb – Mar 2018; 11-24

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

SURVEY OF MAJOR FOLIAR FUNGAL DISEASES OF *QUERCUS SERRATA* FROM VARIOUS PARTS OF MANIPUR

Ningthoujam Tiken Sing [1]***, Harjeet Singh*** [2] ***& Mutum Shyamkesho Singh*** [3]

[1]*Scientist-C, P3 Unit, Muga Silkworm Seed Organization, Pailapool, Cachar, Assam, India*

[2]*Lecturer, Department of Sericulture Poonch Campus, University of Jammu, Poonch, India*

[3]*Professor, Department of Life Science, Manipur University, Canchipur, Imphal India*

ABSTRACT

*India is the second largest producer of silk next to China. All the 5 varieties of silk viz., Mulberry, Tropical Tasar, Muga, Eri and Oak tasar are produced in India. Oak tasar silk is produced in North Eastern and North Western Himalyan states. Several foliar fungal diseases on oak species Quercus serrata, the primary food plant were found a great threat in the rearing of oak tasar silkworm Antheraea proylei Jolly. In the monthly fixed spot survey at the high altitude areas of hills districts and low lying areas of valley district of Manipur state, 4 spp. of fungi were recorded as major foliar diseases of Q. serrata. They were leaf rust (Cronartium quercum), Powdery mildew (Phyllactinia corylea), Sooty mould (Chaetophoma quercifolia) and Leaf blister (Taphrina caerulescens). The investigation established a disease calendar to understand the epidemiology of these diseases in different Districts of Manipur. Incidence of these diseases recorded from April to November every year. Incidence and severity of these diseases vary from month to month and place to place which may be due to micro climatic conditions and altitudes of the particular place. Among the 4 diseases highest incidence (**18.44**%) and severity (**3.92**%) are recorded with Leaf rust and minimum damage is caused by leaf blister.*

KEYWORDS: *Oak Tasar Silk, Foliar Fungal Diseases, Survey, Disease Incidence*

Article History

Received: *09 Jan 2018* **|** ***Revised:*** *17 Jan 2018* **|** ***Accepted:*** *05 Feb 2018*

INTRODUCTION

India is the only country that produces all 5 varieties of commercial silk viz., mulberry, tropical tasar, muga, eri and oak tasar. The country is the second largest producer of silk next to China. Oak tasar silk is produced in the Himalayan states of Jamu and Kashmir, Himachal Pradesh, Uttarkhand, West Bengal, Sikkim, Assam, Arunachal Pradesh, Nagaland, Manipur and Mizoram (FAO Sericulture Manuals 1987). Based on food preference and commercial silk production, *Quercus serrata* is considered to be a primary host plant of the silkworm *Antheraea parole* Jolly in the North Eastern states. The raw silk production in the country has reduced by 0.6% from 28,708 MT in 2014-15 to 28,523 MT in 2015-16 and earns Rs 2495 crores from the export of silk. The decline in the raw silk production is contributed by many factors including leaf diseases. The growth and development of silkworm larvae and subsequent quality cocoon production mainly depend on quality leaf production (Srikantaswamy *et.al.*, 1990). Among the factors, fungal diseases of the host plant leaf, which appears during the silkworm rearing period adversely affects the leaf quality and quantity and resulted the

loss upto 30-40% silk production. In North-east India, lies the picturesque state of Manipur which is having a small plain area in the centre, encircled by the hill ranges has total land area of 22,327 Sq km. Out of this total land area an area of 15,154 Km^2 comes under forest cover. The oak forest accounts about 40,000 ha in the state. Out of which only about 20,000 ha can be exploited for oak tasar silkworm rearing (FAO Sericulture Manuals, 1987).

Foliar Disease Survey

Foliar disease survey is important first step for establishing a disease calendar to predict the do's and don'ts of oak tasar silkworm rearing and also to develop appropriate control measures. The most important disease of oaks occur when the trees are grown under cultivation and are treated improperly (Raabe, 1979). Ghosh *et al.* (1992) have found all the 4 diseases in the limited areas of valley districts of Manipur state and does not represent for the entire state. Yarwood (1956) reported that obligate parasite can't be cultured. Disease incidence and severity vary from season to season (Srikantaswamy *et al.*, 1990). The incidence of leaf rust (Sukumar *et al.*, 1996) and powdery mildew (Krishnaprasad and Siddarramaiah, 1979) on mulberry leaf depends upon many factors like season, temperature, humidity. The oak leaf rust disease is most often occurs from late spring to late autumn seasons. However, powdery mildew (Raabe, 1979) and leaf blister on oak leaves actually favored by warm days, cool nights and reduced light intensities. Sooty mould incidence is also observed more during warm, humid and cooler periods. A systematic survey to know the prevalence of different known diseases in Manipur comprising hills and valley districts are lacking.

Material and Method

Survey of foliar fungal diseases was undertaken in 18 sites of 7 districts of the state during the period from April to November for 2 years. Survey sites were selected based on altitude, topography of the site, systematic and non systematic plantation available at many districts with private individuals, Department of Sericulture (DOS), Government of Manipur and Central Silk Board, Government of India. Every site was surveyed 16 times at monthly intervals covering approximately 400-500 ha. One hundred twenty five random plants (25 plants/block), in 5 random blocks with a minimum of 3 ha in a particular area of the selected sites were studied.

Study sites

All survey sites were geo-referenced using GPS (Global positioning system) and located in the Google images by plotting GPS data. The survey locations lies between $93^0 42' 18.71'' E$ to $94^0 07' 46.68'' E$ Latitude and $24^0 23' 40.21'' N$ to $25^0 14' 22.35'' N$ Longitude and altitude of 2579 to 3850 ft above the mean sea level. Pruning of trees in the study sites were found taking place during the month of December every year at 4-5 ft height for silkworm rearing.

Meteorological data were recorded at 6 places. Data collection and observation of infected tree for all the fungal disease were made in the first week of every month.

The pooled average values of incidence and severity of the foliar diseases of *Q. serrata* for the two years study period were calculated on the monthly basis and site wise basis.

Disease Incidence (DI)

The disease incidence was calculated by the following formula suggested by Mc Kinney (1923).

$$DI = \frac{\text{No. of infected leaves}}{\text{Total no. of leaves}} \times 100$$

Percent Disease Index (PDI)

The intensity of each disease was recorded by scoring all the studied 25 plants of each survey spot using 0 to 5 scales of Gunasekhar and Govindaiah (1994). Further, the PDI was calculated with the above scales using the formula of Wheeler (1969) and Vidyasagar and Rajasab (2001).

Score Description (Gunasekhar and Govindaiah, 1994).

Grade I = No infection

II = 0 - 5 % Small scattered disease specks covering 5 per cent or less leaf area

III = 6 – 25 % Small disease lesions covering 6-25 per cent of leaf area.

IV = 26 – 50 % Disease lesions big patches covering 26-50 per cent of leaf area.

V= 51 – 100 % Big patches covering 51 per cent or more of leaf area.

Percent Disease Index (Wheeler, 1969; Vidyasagar and Rajasab, 2001)

$$PDI = \frac{\text{Sum of numerical values}}{\text{Total no. of leaves} \times \text{Maximum grading (5) observed}} \times 100$$

Numerical values were obtained from product of number of infected leave and value of each grade.

Correlation between Weather Parameters and Foliar Disease Incidence and Severity

Correlation analysis of experimental data to determine the effect of weather factors in relation to foliar disease incidence and disease severity was calculated using Karl Pearson's simple correlation method with the help of stastical software viz., SPSS -7.5 version and Indostat packages.

RESULTS AND DISCUSSIONS

During the survey period, average maximum temperature was found to be varying between 19.06-31.12^{0}C with an average of 26.10^{0}C. Average minimum temperature is also varied from 10.66-23.08^{0}C and average minimum temperature is 18.48^{0}C. Relative humidity ranged widely between 58.28-84.81% during the survey period. The maximum rainfall recorded in the month of August was 219.22 mm and minimum of 1.016 mm in month of April. Different growth stages of foliage were recorded during different seasons. New leaf sprouted in the month of February at lower altitude areas whereas in the higher altitude leaf sprouting initiated from the month of March. All the three major foliar fungal diseases such as leave rust (LR), powdery mildew (PM), sooty mould (SM) were recorded in all the locations except leaf blister (LB) which was recorded only in 7 sites located in higher altitude areas. Tables 3 and 4 showed pooled values of disease incidence and disease severity of all the 18 survey sites during different months of the study period, respectively. Table 5 and 6 show the pooled value of disease incidence and disease severity respectively for the whole study period recorded at 18 survey sites, respectively.

Leaf Rust

Infected oak leaves have yellow to orange pustules on the upper sides of the leaves known as tell stage. This stage is produced on a *Q. serrata* leaf (Sadato Yamazaki and Keizo Katsuya, 1987). It is generally associated with semi tender leave and matured leave. It required favorable temperature and moisture conditions necessary for spore production. The infected area also increased as the season advanced. It increased till September and decreased with the lowering of temperature and humidity. The susceptible foliage produced by sprouts from recently cut oak stumps tended to prolong uredial spread. (Nighswander and Patton, 1965). Highest LR values of pooled percent disease incidence (18.44%) and pooled percent disease severity (3.92%) were recorded during the month of July. The corresponding minimum values of disease incidence (1.78%) and disease severity (0.36%) were observed during the month of April.

When the site wise data was examined, it was found that the maximum pooled percent disease incidence of leaf rust (19.03%) and pooled percent disease index (4.10%) were recorded at site 10 i.e. T. Khullen farm (Table 5 and 6). The minimum corresponding values of disease incidence (2.63%) and disease severity (0.60%) were observed at Haotak farm of Bishenpur district. These months were dry and dry weather limited the spread of urediospores resulting decreased infection of oak leaves with age. This observation is in concurrence with the findings of Nighswander and Patton, (1965). Katsuya Nakamura and Kazumara Mitsuhashi (1948) quantified the aecidiospore of *C. quercuum* which spread over and mode of attacked the "Konara" (*Q. Serrata*) trees and sorted out various infection grade according to a certain standard.

Powdery Mildew

The incidence of PM on *Q. serrata* leaf started from April in most sites, but in one site having steep slope facing prolong period of sunlight since early morning appears from June. The infection was observed on the tender leaves and gradually spread to the older leaves which were inconformity with the findings of Joji and Yoshihiro (1958). Initial appearance of the disease on newly sprouted leaves might have been favoured by pruning and other agricultural practices during winter season. A similar observation was also made by Raabe (1979). White-to-gray powdery fungal growth blankets the leaves of trees infected with powdery mildew. Infected leaves have a faint indistinct spot on the upper leaf surface and a white to off-white powdery growth on the lower side and were slightly disfigured in severe cases. It is a disease of the new growth and rarely affects mature or matured foliage. Since the disease prefers young leaves, the new growth is often distorted into classic 'witches' broom symptoms agrees the observations of Nef and Perrin (1999). Disease incidence was increased from the initial appearance and reached peak either during the month of May or June and negligible incidence was observed during rainy season or during late autumn season. By the end of the season, all the leaves of infected trees may show symptoms of yellowing, distortion and color loss.

The data on survey revealed that the powdery mildew incidence varied from month to month and locality to locality, because of type of plantation (systematic and nonsystematic), environmental conditions and buildup of inoculum. Variations in powdery mildew incidence and severity at the widespread natural conditions have been reported by earlier workers (Jhooty and Munshi, 1990; Chakravorty *et al.*, 2003). According to the pooled value analysis highest disease incidence and severity was observed in the month of May which might be due to low relative humidity of the atmosphere. High incidence of powdery mildew disease on mulberry plantations during dry period such as in the months March to June was observed by Dikshit *et al.* (2006). During May there were broad range of temperature and humidity indicating ability to infect leaf by *P. corylea*. Under these conditions, germination of spores took place due to presence of considerable amount of water in the cell (Sucharzewska, 2009). From the data, it was revealed that the incidence of powdery mildew

disease was observed in all seasons which are conformity with the findings of Biswas *et al.* (1995) however, difference in seasonal incidence and severity was also observed which might be due to weather conditions. Biswas *et al.* (1993) also reported that atmospheric temperature, relative humidity and rainfall markedly influenced the disease intensity and infection. Correlation analyses of powdery mildew with weather factors showed that the disease had highly significant positive relation with minimum temperature which was in conformity with the findings of Gangwar and Thangavelu (1998). High rainfall during July, August and matured leaves during November reduced incidence and severity of the disease to either absence or less. These observations were also in conformity with the findings of Sucharzewska (2009). Pooled value data analysis revealed that the average PM disease incidence and severity was found highest at Yaikhongpao farm with a record of disease incidence (15.83%) and percent disease index (4.76%) followed by T. Khullen farm (disease incidence 13.54% and percent disease index 3.77%) of Senapati district where favourable weather conditions for development and spread of the disease were prevailing in these areas and minimum was recorded at Haotak with disease incidence of 2.63% but minimum percent disease index of 0.16% was recorded at Langol farm. Difference in initiations of disease incidence from place to place might be due to factors like microclimatic conditions and other weather parameters prevailed in and around the plantations. In places like Langol and Dolansabi private farms the initial appearance of the disease was delayed which might be due to higher atmospheric temperature forming unsuitable conditions in and around the trees. Because these two places have steep inclined hill slope facing east and south which received more sunlight. According to Singh (2003) during the month of April environmental temperature rose and resting stages of powdery mildew present in the soil might have been injured leading to death. In general, high rate of disease multiplication in natural conditions was recorded in the months of May to June which coincides with cool night and dry weather. These results were in agreement with Yarwood (1956).

Sooty Mould

Infected *Q. serrata* by SM disease shows no gross ill effects. Most of the leaves of the plant near the ground have developed thin covering of sooty mould. In the later stages of the disease the whole leave becomes covered with a black felt of mycelium, only a few leaves at the apices of the branches remained unaffected. The infection of the trees by this disease was also irregular in nature. It was found appearing during the month of April and increased upto May. Interestingly the disease was very mild or completely disappeared during rainy months of July and August. Except in two study sites (Yumnam Khunou farm and Dolansabi farm), the disease was absent during the month of August. It again reappeared during autumn seasons when rainfall decreased. In most the sites the highest incidence of the disease were observed during November.

Seasonal incidence of *C. quercifolia* disease on *Q. serrata* was observed throughout the survey sites showing association of the pathogen with the plantations. Incidence and severity was observed varied from place to place and month to month. Percent disease incidence and percent disease severity was observed depending upon the aphid population which secreted sugary substance on the leaf. From the pooled value analysis it was observed that the disease incidence and severity were highest during autumn season followed by spring season and minimum was recorded during the rainy months. The pattern of incidence and severity of the disease in all the places either in the hills or in the valley areas were observed same. In many places the incidence was either minimum or absent during the month of July and August when there was high rainfall which might have washing effect on the fungal biomass along with the insect excreted honey dews. Sooty mould has high significant negative correlation with maximum temperature, maximum relative humidity and

rainfall. This observation was in conformity with observations of Roversi *et al.* (1999). After the rains sooty mould incidence was observed to be started from the month of September again in many places and reached highest during the month of November. The re-initiation of disease might have been started from the fungal propagules remain over the leaf surface (Srivastava and Thakre, 2006). The reason for highest incidence and severity during the month November was due to heavy infestation of aphids on the under surface of *Q. serrata* leaves. Pooled value analysis showed the highest disease incidence and severity was recorded at Regional Tasar Research Station farm located in the valley district and lowest was recorded at Taphou Kuki private farm located in higher altitude areas of hill districts of Senapati in the month of November. The altitudinal effect on the disease incidence and severity might have been depending upon insect population. The scale insects that secreted honey dew on oak leaves are more at the forest edge trees and concentrations were found when humidity was low but high in temperature that allows more concentration of honey dew as the water evaporates (Gamper *et al*., 2011). But in the present study highest disease incidence and severity was recorded at a farm located away from forest area. The result can draw a finding that the aphid population which might have many other alternate host plant in and around the forest for its incidence was not available near the Regional Tasar Research Station farms. In the absence of alternate host plants aphid population might have infested on the oak tree only and as a result higher quantity of honey dew secretions are available only on the oak leaves of the farm. Being located at low altitude, higher temperature was available and this condition might have provided more incidence and severity in the farm.

Leaf Blister

Infections of this disease begin as the new leaves emerged in the spring which was in conformity with the findings of Stephen (1914). Data from the pool value analysis showed that highest incidence was recorded in the month of May and closely followed by June. After incidence in the early spring on the leaves, damage due to this disease was more severe during summer months of May and June. Nancy (1999) suggested that higher incidence and severity on leaf blister might be due to rapid formation of layer of asci between the outer epidermal wall and the cuticle of leaf after initiation of disease. From the survey it was noted that there was only one incidence period that is during the initial stage of leaf sprouting. Incidence of the disease was recorded from the month of April to September every year. The disease incidence and severity was found lowest during the month of September. Seymour (1963) reported that environmental conditions were important in determining the severity of this disease. Cool moist conditions being most favorable for development of this fungus. This condition prevails during the month of May to June in the hills. That is why higher incidence and disease severity was recorded in the higher altitude areas among the survey sites. Drawing a line between attitudinal differences of survey sites was not possible, but it could be concluded that higher altitude areas of the survey sites were having more incidence and severity. Pooled value analysis showed that there was significant difference in leaf blister incidence and severity from place to place and highest percent disease incidence and percent disease index were observed at T. Khullen farm followed by Yaikhongpao farm. The minimum disease incidence and percent disease index were observed at Murei private farm. Cool, wet weather which was required for ascospore germination on young leaves might have prevailed in these sites and as a result the places have more severity. Less incidence and severity of the disease might be due to non-availability of favourable weather conditions. At Murei private farm minor incidence for two months were observed during the survey period. An important finding of this study was non observation of the disease in all the 9 survey sites located in plain areas and foot hill areas. These survey sites might have no source of disease inoculum. Stephen (1914) reported that the infected leaves on the ground from the previous growing season may also serve as an overwintering source for disease multiplication. Most of the farms located in Imphal west and Imphal east districts are prone to human interference for farm

maintenance which might have terminated the fungus during winter period. Grasses growing in these farms were either burnt or disinfected with chemicals during lean period for farm maintenance. This may be one of the reasons that might have resulted total absence of the disease.

Correlation between Disease Parameters and Weather Parameters

Correlation between disease parameters (percent disease incidence and percent disease severity) and weather parameters (temperature, relative humidity and rainfall) were calculated using Karl Pearson's simple correlation method. Table 7 and 8 showed the correlation between percent disease incidence and percent disease index with different weather parameters. The results reveal that all the weather parameters have positive and high significant correlation with leaf rust incidence and severity. A significant positive correlation was also found between incidence and severity of powdery mildew with minimum temperature, minimum relative humidity and rainfall days whereas negative correlation was recorded with maximum temperature, maximum relative humidity and quantity of rainfall. Pattern of relationship between weather parameters with incidence and severity of sooty mould was also found similar with powdery mildew. Strong negative correlation with rainfall days also observed that was different from powdery mildew. In case of leaf blister high significant correlation was recorded with maximum relative humidity and rainfall but maximum temperature and minimum relative humidity were negatively correlated.

Table 1: Salient Features of Manipur

Total land area of State 22,327 Sq km
Area of *Quercus serrata* plantations 40,000 ha
Latitude 23.80^0 N to 25.68^0 N
Longitude 93.03^0 E to 94.78^0 E
Average **rainfall 1467.5 mm**
Average Temperature 19.46^{0}C
Humidity range 48 - 100 %
Seasons in Manipur Spring, Summer and Rainy, Autumn and winter

Table 2: Disease Symptoms Associated with the Pathogens

Diseases Symptoms
Leaf rust Pustules with yellow, orange or brown spores
Powdery mildew White powdery sporulation on surface
Sooty mould Chimney soot appearance on the dorsal surface of the leave
Leaf blister Raised blisters or bulges appear on the upper leaf surface and depressions on the underside. These depressions are often light green to yellow

Table 3: Monthly Variation in Incidence (%) of Different Diseases of Quercus serrata (Mean Data of 18 Survey Sites for 2 Years)

Months	Leaf Rust	Powdery Mildew	Sooty Mould	Leaf Blister
April	1.78	4.06	0.67	0.62
May	5.41	10.31	1.42	1.62
Jun	10.08	9.47	0.64	1.55
July	18.44	5.34	0.14	0.88
August	17.41	3.38	0.02	0.42
September	11.34	2.83	0.54	0.07
October	5.61	1.77	2.16	0.00
November	2.28	0.36	6.22	0.00
Total	9.04	4.69	1.48	0.65
STD	13.82	9.23	3.17	2.04
SE	0.81	0.54	0.19	0.12
F	9.33**	5.93**	22.87**	4.04**

*Significant at 5%, ** Significant at 1%

Table 4: Monthly Variations in Severity Index (%) of different Diseases of Quercus serrata (Mean Data of 18 Survey Sites for 2 Years)

Months	Leaf Rust	Powdery Mildew	Sooty Mould	Leaf Blister
April	0.36	1.06	0.19	0.17
May	1.09	2.79	0.32	0.48
Jun	2.19	2.78	0.18	0.48
July	**3.92**	1.47	0.03	0.23
August	3.72	0.97	0.01	0.12
September	2.40	0.86	0.15	0.03
October	1.27	0.50	0.57	0.00
November	0.49	0.11	1.69	0.00
Total	1.93	1.32	0.39	0.19
STD	2.93	2.78	0.84	0.68
SE	0.17	0.16	0.05	0.04
F	9.53**	5.01**	24.56**	3.14*

*Significant at 5%, ** Significant at 1%

Table 5: Pooled Value of Percent Disease Incidence on Quercus serrata Leaves at Different Locations (Mean of 18 Survey Sites for Two Years)

Survey Sites		Leaf Rust	Powdery Mildew	Sooty Mould	Leaf Blister
1	RTRS farm	3.55	1.91	3.89	0.00
2	RTRS Langol farm	3.31	0.62	1.69	0.00
3	DOS Khonghampat farm	14.97	1.63	2.19	0.00
4	Sangaithel Pvt. farm	5.62	4.65	1.53	0.00
5	DOS Yumnam Khunou farm	18.81	2.28	0.78	0.00
6	DOS Chingarel farm	3.89	1.71	1.27	0.00
7	Dolansabi pvt farm	8.79	1.42	1.06	0.00
8	DOS Gwaltabi farm	5.40	1.04	2.39	0.22
9	Murei pvt farm	13.90	0.88	1.42	0.05
10	Field Lab T. Khullen farm	**19.03**	13.54	0.68	3.91
11	REC Yaikhongpao farm	3.13	15.83	0.97	1.83
12	Taphou Kuki pvt farm	17.00	10.25	0.58	1.16
13	DOS Thamnapokpi farm	16.27	1.01	0.65	0.49
14	Kuraopokpi pvt farm	3.40	0.66	0.60	0.00
15	DOS Thumkhonglok farm	3.34	10.91	0.75	2.42
16	Haotak pvt farm	2.63	11.18	1.50	1.40
17	DOS Baulzang farm	10.85	2.69	2.42	0.14

Table 5 Contd.,					
	Survey Sites	**Leaf Rust**	**Powdery Mildew**	**Sooty Mould**	**Leaf Blister**
18	L. Gamnom pvt farm	8.89	2.27	2.21	0.00
	Total Mean	9.04	4.69	1.48	0.65
	STD	13.82	9.23	3.17	2.04
	SE	0.81	0.54	0.19	0.12
	F	3.56**	6.44**	1.24	6.06**

*Significant at 5%, ** Significant at 1%

Table 6: Pooled Value of Percent Disease Severity on Quercus serrata Leaves at Different Locations (Mean of 18 Survey Sites for Two Years)

Survey Sites		**Leaf Rust**	**Powdery Mildew**	**Sooty Mould**	**Leaf Blister**
1	RTRS farm	0.74	0.52	1.03	0.00
2	RTRS Langol farm	0.73	0.16	0.42	0.00
3	DOS Khonghampat farm	3.27	0.44	0.58	0.00
4	Sangaithel pvt farm	1.24	1.14	0.39	0.00
5	DOS Yumnam Khunou farm	**3.92**	0.59	0.23	0.00
6	DOS Chingarel farm	0.83	0.53	0.37	0.00
7	Dolansabi pvt farm	1.91	0.51	0.29	0.00
8	DOS Gwaltabi farm	1.10	0.25	0.66	0.07
9	Murei pvt farm	2.75	0.22	0.39	0.01
10	Field Lab T. Khullen farm	4.10	3.77	0.21	1.24
11	REC Yaikhongpao farm	0.70	4.76	0.24	0.59
12	Taphou Kuki pvt farm	3.67	3.12	0.15	0.32
13	DOS Thamnapokpi farm	3.56	0.25	0.18	0.12
14	Kuraopokpi pvt farm	0.71	0.16	0.17	0.00
15	DOS Thumkhonglok farm	0.72	3.22	0.19	0.70
16	Haotak pvt farm	0.60	2.65	0.38	0.30
17	DOS Baulzang farm	2.35	0.73	0.60	0.02
18	L. Gamnom pvt farm	1.86	0.69	0.59	0.00
	Total Mean	1.93	1.32	0.39	0.19
	STD	2.93	2.78	0.84	0.68
	SE	0.17	0.16	0.05	0.04
	F	3.61**	5.74**	1.19	4.85**

*Significant at 5%, ** Significant at 1%

Table 7: Correlation between Percent disease Incidence of Leaf Diseases with Weather Parameters

Diseases	**Temperature ^{0}C**		**Relative Humidity %**		**Rainfall**	
	Maximum	**Minimum**	**Maximum**	**Minimum**	**Quantity (mm)**	**Days (Nos)**
Leaf rust	0.105	0.268 (**)	0.290 (**)	0.197 (**)	0.312 (**)	0.330 (**)
Powdery mildew	-0.026	0.124 (*)	-0.142 (*)	0.198 (**)	-0.153 (**)	0.050
Sooty mould	-0.243 (**)	0.492 (**)	-0.169 (**)	0.087	-0.332 (**)	-0.411 (**)
Leaf blister	-0.056	0.043	0.175 (**)	-0.148 (*)	0.165 (**)	0.038

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 8: Correlation between Percent Disease Index of Leaf Diseases with Weather Parameters

Diseases	**Temperature ^{0}C**		**Relative Humidity %**		**Rainfall**	
	Maximum	**Minimum**	**Maximum**	**Minimum**	**Quantity (mm)**	**Days (Nos)**
Leaf rust	0.108	0.273 (**)	0.289 (**)	0.195 (**)	0.312 (**)	0.330 (**)
Powdery mildew	-0.021	0.115	-0.129(*)	0.196 (**)	-0.169 (**)	0.043
Sooty mould	-0.258 (**)	0.508 (**)	-0.171 (**)	0.088	-0.339(**)	-0.425 (**)
Leaf blister	-0.042	0.031	0.162 (**)	-0.155 (*)	0.161 (**)	0.025

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 9: Meteorological Data of Imphal West and Imphal East Districts during the Study Period

Month	Temperature ^{0}C		Relative Humidity (%)		Rainfall	
	Maximum	Minimum	Maximum	Minimum	Quantity (mm)	Days (Nos)
April	28.82	17.15	78.50	29.00	47.18	5.5
May	31.12	20.43	83.50	32.00	73.61	11
Jun	30.12	21.84	91.50	40.50	57.88	14
July	29.85	23.08	92.00	61.00	96.83	18.5
August	30.10	21.99	94.00	60.50	219.22	12.5
September	30.95	21.25	91.50	57.00	108.77	12
October	28.79	18.50	95.00	52.00	68.61	6
November	24.20	10.66	92.50	47.00	4.00	1

Table 10: Meteorological Data of Bishenpur District During the Study Period

Month	Temperature ^{0}C		Relative Humidity (%)		Rainfall	
	Maximum	Minimum	Maximum	Minimum	Quantity (mm)	Days (Nos)
April	23.00	15.44	64.09	50.98	12.06	3.5
May	24.40	19.58	72.88	59.39	39.62	6
Jun	24.25	21.20	82.16	63.18	74.16	10
July	24.65	22.37	84.93	69.82	158.49	21
August	24.05	22.85	86.45	74.73	141.32	16.5
September	24.45	21.17	84.48	67.91	34.91	12
October	21.95	20.60	83.85	65.71	11.48	5.5
November	19.15	15.75	79.08	61.25	1.322	3.5

Table 11: Meteorological Data of Ukhrul District during the Study Period

Month	Temperature ^{0}C		Relative Humidity (%)		Rainfall	
	Maximum	Minimum	Maximum	Minimum	Quantity (mm)	Days (Nos)
April	28.23	18.35	76.23	41.09	30.63	12.5
May	28.18	19.28	79.87	55.61	73.85	10.5
Jun	23.73	16.51	92.53	80.03	113.7	15.5
July	22.71	17.19	96.51	88.79	194.15	20.5
August	22.23	16.97	93.54	81.79	176.3	17.5
September	22.28	16.20	92.26	81.13	74.35	10.5
October	22.24	14.51	85.74	74.26	98.55	7
November	19.06	11.27	80.46	60.93	2.66	2

Table 12: Meteorological Data of Chandel District during the Study Period

Month	Temperature ^{0}C		Relative Humidity (%)		Rainfall	
	Maximum	Minimum	Maximum	Minimum	Quantity (mm)	Days (Nos)
April	28.55	14.95	71.38	46.70	1.016	3.5
May	29.38	17.01	86.76	55.06	42.417	11.5
Jun	28.50	20.49	73.86	68.08	72.65	12
July	28.32	21.44	85.9	69.44	196.47	17.5
August	27.53	20.67	87.25	74.55	209.05	11.5
September	26.83	20.05	87.35	69.80	96.1	11
October	26.30	19.60	72.30	61.80	45.85	8.5
November	24.80	17.75	66.91	54.00	3.8	3.5

Table 13: Meteorological Data of Senapati District during the Study Period

Month	Temperature ^{0}C		Relative Humidity (%)		Rainfall	
	Maximum	Minimum	Maximum	Minimum	Quantity (mm)	Days (Nos)
April	25.69	12.38	92.00	32.00	71.00	2.5
May	27.65	17.71	91.50	33.50	105.55	11
Jun	27.81	19.31	91.00	38.00	234.2	8.5
July	26.87	20.65	92.00	53.50	133.05	14
August	25.40	20.62	94.50	51.00	180.4	22
September	25.82	20.03	91.00	55.00	147.3	11
October	25.01	17.75	91.00	46.00	9.60	3
November	24.75	10.96	85.50	34.50	0	0

Table 14: Meteorological Data of Churchandpur District during the Study Period

Month	Temperature ^{0}C		Relative Humidity (%)		Rainfall	
	Maximum	Minimum	Maximum	Minimum	Quantity (mm)	Days (Nos)
April	28.29	18.03	76.07	39.22	4.19	2.5
May	27.83	19.47	80.63	57.85	56.39	8
Jun	27.50	20.93	81.08	67.97	85.34	8.5
July	27.64	21.23	83.66	70.22	242.06	20.5
August	26.19	20.60	85.03	73.58	157.1	18
September	24.87	18.97	79.56	67.49	48.17	10
October	26.05	19.31	86.44	70.43	13.97	5
November	23.38	13.14	84.76	52.35	2.03	2

Plate: Symptoms of all the 4 Major Foliar Fungal Diseases of Q. SERRATA

REFERENCES

1. *Biswas, S., Mandal, S.K. and Chinya, P.K. (1993). Development of powdery mildew disease in mulberry and its control. Sericologia 33(4):653-662.*
2. *Biswas, S., Mandal, S.K., Teotia R.S., Nair, B.P. and Sengupta, K. (1995). Intensity of mulberry powdery mildew in West Bengal with some measures to control. Indian J. Seric. 34(2):114-117.*
3. *Chakravorty, R., Neog, K., Das, R. and Dutta, P.K. (2003). Seasonal incidence of major foliar fungal diseases of mulberry in north east India. Indian J. Seric. 42(2): 122-127.*
4. *Dikshit, B.K., Dash, B.D. and Purohit, K.M. (2006). Studies on the incidence of mulberry foliar diseases in agro-climatic conditions of Koraput district in Orissa. In Pro. Regional Sericulture Research Station, Central Silk Board, Dehradun: 109-111.*
5. *FAO Manuals. 1979. Non-mulberry silks. FAO Agricultural Services Bulletin (eds. Jolly, M.S., Sen, S.K., Sonwalker, T.N. and Prasad, G.K.) 2nd Edition.*
6. *Gamper, H.A., Koptur, S., Garcia-Franco, J. and Stapper, A.P. 2011. Alteration of forest structure modifies the distribution of scale insect, Stigmacoccus garmilleri, in Mexican tropical montane cloud forests. J. In. Sci.11:1-14.*
7. *Gangwar, S.K. and Thangavelu, K. 1998. Varietal and seasonal occurrence of powdery mildew (Phyllactinia corylea Pers. Karst) disease of mulberry in Tamil Nadu. Sericologia 38(2):357-362.*
8. *Ghosh, M.K., Das, P.K., Noamani, M.K.R. and Chakraborty, R. 1992. Occurrence of Fungal diseases in Quercus serrata Thunb. Indian Silk, 30(12):17-19*
9. *Gunasekhar, V. and Govindaiah (1994). Disease assessment keys for three major diseases of mulberry. Indian J. Seric. 33(2):122-125.*
10. *Joji, A. and Yoshihiro, M. (1958). Leaf order of mulberry leaves infected by Phyllactinia corylea on the incipient stage. J. Seric. Sci. Jap. 4(5):257-262.*
11. *Jhooty, J.S. and Munshi, G.D. (1990). Mode of perpetuation of powdery mildew of pea in North-Western India. Indian Phytopathology 43:455-456.*
12. *Katsuya Nakamura and Kazumara Mitsuhashi 1948. An Example on the survey of the effective range, Cronartium quercuum infects to the intermediate hosts Japanese Forestry Society (NII-Electronic library service): 203-205.*
13. *Krishnaprasad, K.S. and Siddarramaiah, A. L., (1979) Studies on the development of powdery mildew. Indian J. Seric., 28, 9-13.*
14. *Mc Kinney, H.H.(1923) Influence of soil temperature and moisture on infection of wheat seedlings by Helminthosporium sativum. J. Agric. Res., 26 : 195-210.*
15. *Nancy, R.P. (1999). Report on plant disease (Leaf Blister). Dept. of Crop Science, University of Illinois, Technical Bulletin : 663.*

16. *Nef, L. and Perrin, R. 1999. Damaging agents in European forest nurseries. Practical handbook. European Communities, Italy.*
17. *Nighswander, J.E. and Patton, R.F. 1965 The epidemiology of the jack pine – oak gall rust (Cronartium quercuum) in Wisconsin Can. J. Bot. 43(12): 1561–1581.*
18. *Raabe, R. D. 1979. Diseases of Oaks in California. In Proc. of the symposium on the Ecology, management & utilization of California oaks. June 26-28, Claremont, California:195-202.*
19. *Roversi, P.F., Binazzi, A. and Pelagatti, O. 1999. An unusual outbreak of the oak aphid Myzocallis boerneri Stroyan (Myzocallidinae) on Quercus suber L. in Tuscany (I) and identification of the sooty mould fungi grown on the honeydew. Redia 80:53-60.*
20. *Sadato Yamazaki and Keizo Katsuya 1987. Axenic cultures of Cronartium quercuum and their pathogenicity. Ann. Phytopath. So. Japan 53:643-646.*
21. *Seymour, C.P. 1963. Leaf blister of Oak. Technical Bulletin on Plant Pathology, Florida Dept. of Agriculture. Circular No. 12.*
22. *G. Savithri, P. Sujathamma & CH. Ramanamma, Glory of Indian Traditional Silk Sarees, International Journal of Textile and Fashion Technology (IJTFT0, Volume 3, Issue 2, May-June 2013, pp. 61-68*
23. *Singh, R.S. 2003. Introduction to principles of plant pathology, 4th Edn Oxford and IBH publishing Co. pvt. Ltd New Delhi:59.*
24. *Smitarani Saikia & Binita Baishya Kalita, Properties of Blended Fabric Made from Bamboo and Eri Silk Fibres, International Journal of Agricultural Science and Research (IJASR), Volume 5, Issue 3, May-June 2015, pp. 361-366*
25. *Srikntaswamy, K., Gupta, V.P. and Ranukeswarappa, J.P. 1990. Incidence, severity and yield loss due to leaf spot of mulberry caused by Cercospora moricola Indian J. Seric 38(1): 8-11.*
26. *Srivastava, V.K. and Thakre, R.P. 2006. Management of sooty mould of 'Nagpur' mandarin orange (Citrus–Reticulata blanco) by chemical fungicides. Pestology XX(8):20-25.*
27. *Stephen, V. (1914). Leaf Blister of Oak Technical Bull. of University of Arkansas, United States Department of Agriculture. http://www.uaex.edu.*
28. *Sucharzewska, E. 2009. The development of Erysiphe alphitoides and E. hypophylla in the urban environment. Acta Mycologica 44(1):109-123.*
29. *Sukumar, J. and Ramalinam, A. 1986. Epidemiology of Cercospora leaf spot disease of mulberry. I. stage of infection spots and conidial production. Sericologia, 26, 549-553.*
30. *Vidyasagar, G.M. and Rajasab, A.H. 2001. Effect of neem (Azadirachta indica), parthenium (Hysterophorus) and garlic (Allium sativum) extracts on the incidence of powdery mildew of mulberry caused by Phyllactinia corylea. Indian J. Seric.40 (1):81-85.*

31. *Wheeler, B.E.J. 1969. An introduction to plant diseases. John Willey and Sons Ltd., London: p374.*

32. *Yarwood., C.E. 1956. Obligate Parasitism Annual Review of Plant Physiol*