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Status of powdery mildew disease of mulberry under temperate conditions

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Abstract
Powdery mildew is a major foliar disease of mulberry in Kashmir that causes significant qualitative and quantitative losses in leaf yield. To ascertain the current status of powdery mildew disease affecting mulberry during the peak season *i.e.* September-October, an extensive survey was conducted in six districts of Kashmir during 2021 and 2022. From each district, three locations were selected for recording observations on incidence and intensity of the disease. The overall disease incidence throughout Kashmir was found to be 71.43 percent. Mulberry plantations were more affected in district Anantnag with highest disease incidence (91.80%) and intensity (83.12%) and least in district Ganderbal with disease incidence and intensity of 27.0 percent and 28.28 percent, respectively. Among the locations surveyed, Sarnal Bala of district Anantnag exhibited the highest disease incidence of 95.70 percent whereas Rangil of district Ganderbal exhibited least disease incidence of 12.80 percent.

Keywords: Kashmir, mulberry, powdery mildew, status

Introduction
Mulberry (*Morus* spp.), belonging to the order Rosales, family Moraceae, and genus *Morus* (Zhang *et al*., 2011) [23] is widely distributed in the temperate, subtropical, and tropical regions of the world and has the ability to grow in a wide range of climatic, topographical, and soil conditions (Zeng *et al*., 2015) [22]. It has great economic importance in the sericulture industry as it serves as the sole food to the domesticated silkworm, *Bombyx mori* L. It is reported that about 90 percent of the silk protein produced by silkworms is directly derived from the protein of mulberry leaves (Petkov and Dona, 1979) [14].

Unlike other agricultural crops, leaf is the economic product in mulberry cultivation. Mulberry leaf contributes 38.2 percent towards the production of a successful cocoon crop followed by climate (37%), rearing techniques (9.3%), silkworm race (7.3%), and other factors contributing 6.6 percent (Miyashita, 1986) [11]. Therefore, the sustainability of sericulture industry heavily depends on the productivity of high-quality mulberry leaves. Quantity and quality of mulberry leaves play a major role in determining the quantity and quality of the silk produced by the silkworm (Sahu and Yadav, 1997) [15]. The quality of mulberry leaf is influenced by several factors such as variety, agronomic practices, biotic and abiotic components (Krishnaswami *et al*., 1970) [7].

Mulberry crop is prone to various diseases and pests around the year that adversely affect leaf yield and quality. Diseases, which are the main constraints in leaf production, are caused either by biotic or abiotic factors. Twenty diseases have been reported so far in mulberry caused by fungi, bacteria, viruses, mycoplasma and nematodes (Sukumar and Padma, 1999) [18]. Among the various diseases, leaf spot and powdery mildew are the two major economically important foliar diseases of mulberry in Kashmir valley which are the impediments in the production of quality leaf (Khan *et al*., 2004) [6].

Powdery mildew of mulberry caused by *Phyllactinia corylea* (Pers.) Karst. (Class Ascomycetes; Order Erysiphales; Family Erysiphaceae) was first reported from Ootacamund (Tamil Nadu) by Salmon, 1905 [16]. The disease was later reported from all major mulberry growing areas in India. However, its incidence and intensity vary between geographical locations and seasons (Dikshit *et al*., 2006; Abbas *et al*., 2010) [4, 1]. The disease is characterized by the appearance of white powdery patches on the abaxial surface of leaves. The corresponding portion of white powdery mildew patches on the others side of leaf develop chlorotic lesions.

The patches vary in size from 0.5 to 2.5 cm in diameter and become irregular, and quickly cover the entire lower surface. The leaves become yellow, coarse and less nutritive (Kumaraswamy and Urs, 1979) [8]. The disease causes 5-10 percent loss due to defoliation and an additional loss of 20-25 percent through destruction of leaf area (Sukumar and Ramalingam, 1989; Teotia and Sen, 1994) [19, 20].

In Kashmir valley, the peak period of the disease has been observed to be the month of August to November (Munshi *et al.*, 1994) [15]. None of the mulberry cultivars grown in the valley has been observed to be completely free from the diseases, although cultivars vary in their level of susceptibility (Munshi *et al.*, 1999) [16]. In the present study, survey of powdery mildew disease of mulberry from six districts of Kashmir valley was carried out during 2021 and 2022 in order to ascertain the current status of the disease.

Material and Methods
The survey was conducted on field plantation under natural inoculum, each year in September-October. Screening of the disease was carried out in 3 zones of Kashmir valley *viz.*, North, South and Central Kashmir to assess the prevalence of the disease. From each zone two districts were selected and each district was represented by three sites. From each site five plants; four from corners and one from the centre were selected. Three branches were randomly selected from each plant and all the leaves from selected branches were observed for recording disease incidence and intensity of the disease. To measure disease incidence, total number of leaves and the number of leaves infected with disease were counted on the selected branches. Mathematically,

$$\text{Percent disease incidence} = \frac{\text{Total no. of leaves infected}}{\text{Total no. of leaves observed}} \times 100$$

The percent disease intensity was recorded by visual observation using 0-5 scale adopted by Anonymous (1967[2]).

Grade	Leaf lamina covered by the symptom
1	0% leaf lamina covered by the symptom
2	1-10% leaf lamina covered by the symptom
3	11-25% leaf lamina covered by the symptom
4	26-50% leaf lamina covered by the symptom
5	>50% above leaf lamina covered by the symptom

The percent disease intensity was calculated as per the following formula:

$$\text{Percent Disease Index (PDI)} = \frac{\Sigma \, (n \times v)}{N \times S} \times 100$$

Where,
Σ = Summation
n = Number of leaves in each category
v = Numerical value of each category
N = Total number of leaves observed
S = Maximum numerical value/grade

Results and Discussion
In the present investigation, survey of mulberry plantations in six districts of Kashmir valley during September – October in 2021 and 2022 was conducted to record the status of powdery mildew disease. During the survey it was observed that disease is prevalent in all the mulberry growing areas of Kashmir with varying degrees of incidence and intensity. The data averaged for two years (Table 1) revealed an overall disease incidence of 71.43 percent throughout the Kashmir valley. The total incidence recorded over the two years was highest in district Anantnag (91.80%) followed by district Kupwara (87.50%). However, the incidence was least in district Ganderbal (27.0%). Among the different locations surveyed, highest incidence was recorded at Sarnal Bala (95.70%) followed by Pampore (95.10%). The least disease incidence was recorded at Rangil (12.80%) followed by Safapora (31.60%). The higher incidence of powdery mildew could probably be attributed to the climatic factors such as temperature and precipitation that may affect the establishment of powdery mildews on plant surface. Consequently, the effects of this fungus would vary depending on the specific habitats and seasons in which they occur (Uloth *et al.*, 2016; Singh *et al.*, 2021; Mir *et al.*, 2023) [21, 17, 10].

Like disease incidence, the disease intensity also varied at all the locations surveyed. The data presented in Table 2 revealed that disease intensity ranged between 21.54 to 93.0 and 23.78 to 89.84 percent during the years 2021 and 2022 respectively, with an overall intensity of 61.22 percent. Among the different districts surveyed, district Anantnag exhibited the maximum average disease intensity (83.12%) followed by Kupwara with an average intensity (74.91%), while minimum disease intensity of 28.28 percent was recorded in district Ganderbal. Among various locations surveyed, the maximum average disease intensity of 91.42 percent was recorded at Sarnal Bala of district Anantnag, while the minimum disease intensity of 22.66 percent was recorded at Rangil of district Ganderbal. The varied level of powdery mildew disease on mulberry at different locations has been also reported by Illahi *et al.*, 2011 [5]; Mir *et al.*, 2012 [9]; Chikkaswamy *et al.*, 2014 [3].

Table 1: Percent disease incidence of mulberry powdery mildew at different locations of Kashmir

District	Location	Disease incidence (%) 2021	Disease incidence (%) 2022	Mean (%)
Kupwara	Chogal	76.30	80.10	78.20 (63.365)cdef
	Arampora	87.30	92.30	89.80 (71.95)abc
	Buhama	95.20	93.80	94.50 (78.191)a
	Mean	86.26	88.73	87.50
Baramulla	Mirgund	78.50	81.90	80.20 (63.618)cdef
	Nihalpora	81.90	75.90	78.90 (62.84)def
	Dobiwan	88.20	83.0	85.60 (68.109)bcde
	Mean	82.86	80.26	81.56
Ganderbal	Nunnar	35.70	37.50	36.60 (36.721)i
	Rangil	14.90	10.70	12.80 (20.978)j
	Safapora	29.60	33.60	31.60 (33.848)i
	Mean	26.73	27.26	27.0

District	Location			
Budgam	Sangrampora	46.80	43.60	45.20 (42.21)[hi]
	Zanigam	73.10	74.98	74.04 (59.494)[ef]
	Wotligam	55.40	58.0	56.70 (48.882)[gh]
	Mean	58.43	58.86	58.64
Anantnag	Sarnal Bala	95.30	96.10	95.70 (79.355)[a]
	Krangsoo	91.60	86.80	89.20 (71.076)[abcd]
	Rampora	91.20	89.80	90.50 (72.973)[ab]
	Mean	92.70	90.90	91.80
Pulwama	Pampore	94.70	95.50	95.10 (77.609)[a]
	Pahhu	82.70	85.10	83.90 (66.678)[bcde]
	Banegund	68.30	66.10	67.20 (55.42)[fg]
	Mean	81.90	82.23	82.06
	Overall Mean	71.48	71.37	71.43
	C.D.			7.956
	SE(d)			3.978

Figures in parenthesis are angular transformed *values*

Table 2: Percent disease intensity of mulberry powdery mildew at different locations of Kashmir

District	Location	Disease intensity (%) 2021	Disease intensity (%) 2022	Mean (%)
Kupwara	Chogal	51.92	55.06	53.76 (47.184)[e]
	Arampora	80.60	82.76	81.68 (65.217)[bc]
	Buhama	91.80	86.80	89.30 (70.949)[ab]
	Mean	74.77	75.05	74.91
Baramulla	Mirgund	74.29	71.03	72.66 (58.497)[d]
	Nihalpora	56.94	55.82	56.38 (48.688)[e]
	Dobiwan	77.29	72.23	74.76 (60.085)[cd]
	Mean	69.50	66.36	67.93
Ganderbal	Nunnar	31.50	37.22	34.36 (35.715)[fg]
	Rangil	21.54	23.78	22.66 (28.414)[h]
	Safapora	26.01	29.67	27.84 (31.797)[gh]
	Mean	26.35	30.22	28.28
Budgam	Sangrampora	31.59	34.41	33.00 (35.025)[fgh]
	Zanigam	64.39	68.13	66.26 (54.665)[d]
	Wotligam	39.04	37.20	38.12 (38.074)[f]
	Mean	45.0	46.58	45.79
Anantnag	Sarnal Bala	93.0	89.84	91.42 (73.197)[a]
	Krangsoo	85.34	87.66	86.50 (68.662)[ab]
	Rampora	69.56	73.32	71.44 (57.829)[d]
	Mean	82.63	83.60	83.12
Pulwama	Pampore	85.88	85.04	85.46 (67.678)[ab]
	Pahhu	69.76	65.24	67.5 (55.324)[d]
	Banegund	50.23	47.61	48.92 (44.368)[e]
	Mean	68.62	65.96	67.29
	Overall Mean	61.14	61.29	61.22
	C.D.			5.614
	SE(d)			2.807

Figures in parenthesis are angular transformed values

Conclusion
Powdery mildew is an important major foliar disease of mulberry in Kashmir causing considerable damage every year. Therefore, an extensive survey was conducted in six districts of Kashmir *viz.,* Kupwara, Baramulla, Ganderbal, Budgam, Anantnag and Pulwama to ascertain the current status of mulberry powdery mildew across Kashmir valley. Survey data revealed an overall disease incidence of 14.90 to 95.30 percent, during the year 2021 and 10.70 to 96.10 percent during 2022. The highest average disease incidence (91.80%) was observed in district Anantnag whereas least disease incidence (27.0%) was recorded in district Ganderbal. Similarly, the average disease intensity over the two years was found to be highest in district Anantnag (83.12%) and lowest in district Ganderbal (28.28%).

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