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OCCURRENCE AND STATUS OF POWDERY MILDEW DISEASE ON MAJOR TEMPERATE FRUIT CROPS IN NORTH-WESTERN HIMALAYAN STATE OF JAMMU & KASHMIR (INDIA)

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ABSTRACT

Powdery mildew disease adversely affects almost all the major temperate fruit crops leading to huge economic losses. An assessment of powdery mildew disease in important temperate fruit crops of the North-Western Himalayan region of India was conducted during 2021 and 2022. Surveys were conducted in three major districts of Kashmir valley - Srinagar, Pulwama, and Ganderbal - during peak periods conducive to disease development. The disease incidence and intensity recorded in these districts across the key crops revealed moderate to severe infection in apple, pear, quince, grape, and plum, while peach, apricot, walnut, and almond exhibited comparatively lower levels. Quince showed the highest average disease incidence (29.68%) and intensity (24.52%), followed by pear (14.40% and 11.05%), plum (16.39% and 10.76%), grape (12.75% and 8.55%), apricot (9.49 and 7.36%) and apple (8.71% and 5.84%, respectively). In contrast, walnut (3.73% and 2.26%), almond (3.52% and 2.38%) and peach (4.38% and 3.83%) recorded the lowest values. These findings highlight the crop-specific susceptibility pattern and underscore the need for targeted disease management strategies to mitigate the disease pressure, safeguard yield, and ensure sound crop health and sustainable fruit production.

Keywords: Apple, almond, apricot, disease status, grapes, peach, pear, plum, powdery mildew, walnut

INTRODUCTION

Fruit production is one of the most dynamic and economically rewarding sectors of Indian agriculture, owing to its high returns per unit area and increasing market demand. In recent years, growing awareness regarding the nutritional and health benefits of fruits has significantly boosted their consumption, thereby strengthened the horticulture sector. Consequently, India has emerged as the world's 2nd largest fruit producer, contributing about 10.5% to the global fruit production with over 110 million metric tons annually from an area of 25.6 million ha (Anonymous, 2024). Jammu and Kashmir plays a vital role in temperate horticulture in India, where fruits cover more than half the cultivated area and account for 79.0% of production, adding significantly to the regional economy. High-value crops such as apple (*Malus x domestica*), walnut (*Juglans regia*), and almond (*Prunus dulcis*) dominate the horticultural landscape while pear (*Pyrus communis*), peach (*Prunus persica*), plum (*Prunus domestica*), apricot (*Prunus armeniaca*), and grape (*Vitis vinifera*)

contribute, with districts specializing in different crops. District-wise distribution indicates that Baramulla leads in apple production, Budgam in pear and almond, and Anantnag in walnut, peach, and plum production (Anonymous, 2022). Despite favourable conditions, fruit productivity in Jammu and Kashmir remains below the global standards due to the abiotic and biotic stresses, mainly destructive fungal infections.

Powdery mildew is one of the most widespread and economically important fungal diseases affecting horticultural crops worldwide. It infects more than 10,000 species of angiosperms, including numerous fruit crops of commercial importance (Amano, 1986; Braun and Cook, 2012; Marmolejo *et al*., 2018). The disease is caused by obligate biotrophic fungi belonging to the order *Erysiphales*, which comprises of 17 genera and over 873 species (Braun and Cook, 2012). These fungi are predominantly found in temperate regions. Powdery mildew pathogens are easily recognized by the presence of white, powdery fungal growth on aerial plant parts, including leaves, stems, flowers, and fruits. This growth consists of superficial mycelium bearing conidiophores and conidia, which facilitate rapid dissemination under favourable environmental conditions. The disease is particularly severe under moderate temperatures and high humidity, conditions commonly prevailing in temperate regions such as the Kashmir valley.

The impact of powdery mildew on plant health is profound, as it interferes with several physiological processes, including photosynthesis, respiration, transpiration, and nutrient uptake. Severe infections can result in premature leaf senescence, reduced fruit set, poor fruit quality, and overall decline in plant vigour, ultimately leading to significant economic losses. In fruit crops such as apple, grape, and stone fruits, powdery mildew not only reduces yield but also adversely affects marketability due to blemished produce. Powdery mildew has extensively been studied in certain crops, particularly apple (Surma *et al*., 2022), however, comprehensive information regarding its prevalence, distribution, and severity across a wider range of temperate fruit crops in Kashmir valley remains limited. Given the diversity of host crops and the variability in agro-climatic conditions across the districts, there is a pressing need for systematic assessment of disease status to better understand its epidemiology and economic impact. Therefore, the present study was aimed to assess the prevalence and severity of powdery mildew in major temperate fruit crops across the North-Western Himalayan region of India. The findings of this study are expected to provide a scientific basis for the development of effective and region-specific disease management strategies. Furthermore, such insights are expected to contribute to the promotion of sustainable agricultural practices, the enhancement of farmer income, and improved plant health management under the challenges posed by climate variability.

MATERIALS AND METHODS

Survey for powdery mildew disease

The survey of various fruit growing areas of three districts of Kashmir valley *viz*., Srinagar (Shalimar, Batapora, Theed, Gosu and Gulabbagh), Ganderbal (Batwina, Wusu, Zazuna, Khalmula and Gutlibagh) and Pulwama (Zahidbagh, Renzipora, Midoora, Charibugh and Hardumir) was carried out in the years 2021 and 2022 to ascertain the status of powdery mildew disease on major pome (apple, pear and quince), stone (peach, plum and apricot), nut (almond and walnut) and berry (grapes) crops The survey was conducted in the month of April for apple, July for grapes, quince and peach; whereas, for plum apricot and pear the surveyed was carried out in the month of August, and for almond and walnut in the month of September and October, respectively. From each district, five locations and from each location three sites were selected for recording the observations on per cent incidence and intensity of powdery mildew disease. However, in case of almond only ten locations comprising of three locations from district Srinagar (Shalimar, Brein and Badamwari), two locations from district Ganderbal (Shuhama and Badampur) and five locations from district

Pulwama (Malangpora, Renzipora, Parigam, Hari-parigam and Lajura) were surveyed as the crop is restricted to these locations in district Srinagar and Ganderbal. Although, samples were collected from plants grown under field conditions, however for almond and walnut the samples included few samples were collected from nurseries raised under open field and green house conditions, respectively. In order to record the incidence and intensity of powdery mildew disease on apple, four scaffold branches from four sides of each tree canopy were marked. Five terminals, randomly selected from each marked branch, were assessed. In all one hundred terminals were selected from each site for assessing the per cent disease incidence and intensity. For disease incidence and intensity on other fruit crops, one hundred leaves were randomly selected from each selected tree. The per cent disease incidence was calculated by the formula:

$$\text{Per cent disease incidence} = \frac{\text{Number of diseased leaves}}{\text{Total number of leaves observed}} \times 100$$

The disease intensity on fruit crops other than apple was calculated by adopting 0-5 disease scale (Lebeda, 1984) with slight modifications; wherein, 0 = free from mildew; 1 = 0.1-5% leaf area covered by mildew; 2 = 5.1-15% leaf area covered by mildew; 3 = 15.1-40% leaf area covered by mildew; 4 = 40.1-60% leaf area covered by mildew; and 5 = > 60% leaf area covered by mildew.

The per cent disease intensity on apple was calculated by adopting 0-5 grading scale (McKinney, 1923); wherein, 0 = free from mildew (healthy); 1= $\leq$ 25% mildewed annual extension growth (a.e.g); 2 = 26-50% mildewed a.e.g; 3 = 51-75% mildewed a.e.g; 4 = $\geq$75% mildewed a.e.g; and 5 = complete leaf fall plus bud necrosis.

The per cent mildewed annual extension growth was calculated using the following formula:

$$\text{Per cent mildew annual extension growth (a.e.g)} = \frac{\text{Mildewed length}}{\text{Total annual extension growth}} \times 100$$

Statistical analysis

Disease incidence and intensity (%) data collected from multiple locations with unequal numbers of observations was analysed using linear mixed model (LMM) and generalized linear mixed models (GLMM) to appropriately handle unbalanced data. Treatment was specified as a fixed effect, while location, year, and replication were modelled as random effects. This approach enabled robust analysis and validation of non-normal, unbalanced multi-location disease data, consistent with established methodologies (Madden *et al.*, 2002; Bates *et al.*, 2015; Makowski *et al.*, 2017).

RESULTS AND DISCUSSION

Disease status in terms of per cent disease incidence and intensity on different temperate fruit crops was recorded at peak disease periods based on symptom development (Fig. 1).

Powdery mildew status in apple

Powdery mildew disease in apple was prevalent at all the surveyed locations with overall mean disease incidence of 8.86 and 8.56%, and intensity of 5.59 and 6.08% during the years 2021 and 2022, respectively (Table 1). The disease incidence was higher in the year 2021 than in 1022. In cropping season 2021, the maximum average disease incidence of 13.93% was observed in district Srinagar, followed by 6.84% in Ganderbal and 5.81% in Pulwama. During cropping season 2022, the disease incidence was higher in district Srinagar (12.42%), followed by Ganderbal (8.12%) and Pulwama (5.13%). Over the years, disease incidence was highest in district Srinagar (13.18%), followed by Ganderbal (7.48%) and Pulwama (5.47%).

The disease intensity varied during both the years. Overall, the disease intensity was higher in 2022 (6.08%) than in 2021 (5.59%) (Table 1). During cropping season 2021, the disease intensity was higher (9.34%) in district Srinagar, followed by Ganderbal (4.02%) and Pulwama (3.42%).

Table 1: Powdery mildew incidence and intensity in apple in Kashmir during 2021-2022

Districts	Disease incidence (%)			Disease intensity (%)		
	2021	2022	Pooled mean	2021	2022	Pooled mean
Srinagar	13.93	12.42	13.18	9.34	8.41	8.88
Ganderbal	6.84	8.12	7.48	4.02	5.60	4.81
Pulwama	5.81	5.13	5.47	3.42	4.24	3.83
Mean	8.86	8.56	8.71	5.59	6.08	5.84
$CD_{0.05}$	1.30	1.32	1.17	0.93	0.97	0.86

*Mean of different locations

Similarly, during cropping season 2022, maximum disease intensity (8.41%) was noted in Srinagar, followed by Ganderbal (5.60%) and Pulwama (4.24%). Over the years, the disease intensity was higher in Srinagar (8.88%), followed by Ganderbal (4.81%) and Pulwama (3.83%).

Powdery mildew status in pear

The powdery mildew disease in pear was prevalent at all the surveyed locations with an average disease incidence of 13.68 and 15.13% and intensity of 10.37 and 11.73% during the years 2021 and 2022, respectively (Table 2). The disease incidence and intensity was higher in 2022 than 2021 on the crop. During the year 2021 cropping season, the maximum average powdery mildew incidence was 18.06% in Srinagar, followed by 11.53% in Ganderbal and 11.46% in Pulwama. Similarly, during cropping season 2022, the highest disease incidence of 19.86% was observed in district Srinagar, followed by 12.80% Ganderbal and 12.73% in district Pulwama. Over the years, the disease incidence was highest in district Srinagar (18.96%), followed by Ganderbal (12.16%) and Pulwama (12.09%).

The disease intensity on pear also varied at all the surveyed locations during both the years. Over the years, the disease intensity was highest in district Srinagar (13.37%), followed by Pulwama (9.93%) and Ganderbal (9.86%). During cropping season 2021, powdery mildew intensity was maximum in Srinagar (12.52%), followed by 9.31% in Ganderbal and 9.30% in Pulwama, while in 2022, the highest disease intensity was observed in district Srinagar (14.22%) followed by 10.56% in Pulwama and 10.42% in Ganderbal.

Fig. 1: Powdery mildew symptoms on different temperate fruit crops studied

Table 2: Powdery mildew incidence and intensity (%) in pear in Kashmir during 2021-2022

Districts	Disease incidence (%)			Disease intensity (%)		
	2021	2022	Pooled mean	2021	2022	Pooled mean
Srinagar	18.06	19.86	18.96	12.52	14.22	13.37
Ganderbal	11.53	12.80	12.16	9.31	10.42	9.86
Pulwama	11.46	12.73	12.09	9.30	10.56	9.93
Mean	13.68	15.13	14.40	10.37	11.73	11.05
$CD_{0.05}$	ns	ns	ns	ns	ns	ns

*Mean of different locations; ns-non significant

Powdery mildew status in quince

During the years 2021 and 2022, powdery mildew disease on quince was prevalent in all the surveyed locations with mean disease incidence of 28.26 and 31.10% and average disease intensity of 23.77 and 25.28%, respectively (Table 3). A higher level of disease was recorded in 2022 compared to 2021. During the year 2021 cropping season, the maximum average powdery mildew incidence was 35.73% in Srinagar, followed by 26.46% in Ganderbal and 22.60% in Pulwama. Similarly, during the cropping season 2022, the highest disease incidence of 37.20% was observed in district Srinagar, followed by 29.26% Ganderbal and 26.46% in Pulwama. Over the years, disease incidence was highest in district Srinagar (36.46%), followed by Ganderbal (27.86%) and Pulwama (24.73%).

Table 3: Powdery mildew incidence and intensity (%) in quince in Kashmir during 2021-2022

Districts	Disease incidence (%)			Disease intensity (%)		
	2021	2022	Pooled mean	2021	2022	Pooled mean
Srinagar	35.73	37.20	36.46	29.42	29.46	29.37
Ganderbal	26.46	29.26	27.86	21.94	23.66	22.80
Pulwama	22.60	26.86	24.73	19.97	22.86	21.41
Mean	28.26	31.10	29.68	23.77	25.28	24.52
$CD_{0.05}$	6.06	5.38	5.45	0.86	0.68	0.72

*Mean of different locations

Disease intensity on quince also differed at all surveyed locations during both the years (Table 3). Overall, the disease intensity was higher (25.28%) in 2022 than 2021 (23.77%). Over the years, disease incidence was highest in district Srinagar (29.37%), followed by Ganderbal (22.80%) and Pulwama (21.41%). During the cropping season 2021, powdery mildew intensity was maximum (29.42%) in district Srinagar, followed by 21.94% in Ganderbal and 19.97% in Pulwama, while in the year 2022, the highest disease intensity was observed in district Srinagar (29.46%), followed by 23.66% in Ganderbal and 22.86% in Pulwama.

Powdery mildew status in grapes

The powdery mildew status in grapes revealed the prevalence of disease at all the surveyed locations with an average disease incidence of 13.75 and 11.77% and average disease intensity of 9.34% and 7.77% during the years 2021 and 2022, respectively (Table 4). A higher level of disease incidence was recorded in 2022 than 2021. During the year 2021 cropping season, the maximum average powdery mildew incidence was 13.79% in district Srinagar, followed by 11.46% in Ganderbal and 10.06% in Pulwama. Similarly, during the cropping season 2022, the highest disease incidence of 15.53% was observed in district Srinagar, followed by 12.60% Pulwama and 11.26% in Ganderbal. Over the years, disease incidence was the highest in district Srinagar (14.66%), followed by Ganderbal (11.36%) and Pulwama (11.32%).

Disease intensity was also higher in 2022 (9.34%) than in 2021 (7.77%). Over the years, the disease intensity was highest in district Srinagar (10.74%), followed by Pulwama (7.68%) and Ganderbal (7.31%). During cropping season 2021, powdery mildew intensity was maximum in district Srinagar (9.91%), followed by 7.09% in Ganderbal and 6.33% in Pulwama, while in 2022, the highest disease intensity was observed in district Srinagar (11.47%), followed by 9.03% in Pulwama and 7.53% in Ganderbal.

Table 4: Powdery mildew incidence and intensity (%) in grapes in Kashmir during 2021-2022

Districts	Disease incidence (%)			Disease intensity (%)		
	2021	2022	Pooled mean	2021	2022	Pooled mean
Srinagar	13.79	15.53	14.66	9.91	11.47	10.74
Ganderbal	11.46	11.26	11.36	7.09	7.53	7.31
Pulwama	10.06	12.60	11.32	6.33	9.03	7.68
Mean	11.77	13.75	12.75	7.77	9.34	8.55
$CD_{0.05}$	3.68	ns	4.06	0.35	0.75	0.40

*Mean of different locations; ns-non significant

Powdery mildew status in peach

The data on the powdery mildew status in peach revealed that the disease was not prevalent at all the surveyed locations. The average disease incidence of 4.37 and 5.30% was recorded during the years 2021 and 2022, respectively (Table 5). A higher level of disease was recorded in 2022 compared to 2021. During the year 2021 cropping season, the maximum average powdery mildew incidence was 5.33% in district Pulwama, followed by 3.99% in Srinagar and 3.79 in Ganderbal. Similarly, during cropping season 2022, the highest disease incidence of 5.46% was observed in district Pulwama, followed by 5.33% in Srinagar and 5.13% in Ganderbal. Over the years, disease incidence was highest in district Pulwama (5.39%), followed by Srinagar (4.66%) and Ganderbal (4.46%).

Table 5: Powdery mildew incidence and intensity (%) in peach in Kashmir during 2021-2022

Districts	Disease incidence (%)			Disease intensity (%)		
	2021	2022	Pooled mean	2021	2022	Pooled mean
Srinagar	3.99	5.33	4.66	3.33	3.98	3.65
Ganderbal	3.79	5.13	4.46	3.25	3.80	3.52
Pulwama	5.33	5.46	5.39	3.57	5.10	4.33
Mean	4.37	5.30	4.38	3.38	4.29	3.83
$CD_{0.05}$	ns	ns	ns	ns	ns	ns

*Mean of different locations; ns = non-significant

Disease intensity also varied at all surveyed locations during both the years. Overall, the disease intensity was higher (4.29%) in 2022 than in 2021 (3.38%). Over the years, the disease intensity was highest in district Pulwama (4.33%), followed by Srinagar (3.65%) and Ganderbal (3.52%). During cropping season 2021, powdery mildew intensity was maximum (3.57%) in district Pulwama, followed by 3.33% in Srinagar and 3.25% in Ganderbal, while in 2022, the highest disease intensity (5.10%) was observed in district Pulwama, followed by 3.98% in Srinagar and 3.80% in Ganderbal.

Powdery mildew status in plum

Plum powdery mildew was pervasive in varying degrees at all the surveyed locations with an average disease incidence of 15.08 and 17.70% and intensity of 10.07 and 11.45% during the years 2021 and 2022, respectively. A higher level of disease was recorded in 2022 than in 2021 (Table 6). Over the years, the disease incidence was highest in district Srinagar (21.62%), followed by Ganderbal (15.29%) and Pulwama (12.89%). During the year 2021 cropping season, maximum mean powdery mildew incidence was 20.73% in district Srinagar, followed by 13.46% in Ganderbal and 11.06% in Pulwama. Similarly, during the cropping season 2022, the highest disease incidence of 22.52% was observed in district Srinagar, followed by 17.13% Ganderbal and 13.46% in district Pulwama.

Table 6: Powdery mildew incidence and intensity (%) in plum in Kashmir during 2021-2022

Districts	Disease incidence (%)			Disease intensity (%)		
	2021	2022	Pooled mean	2021	2022	Pooled mean
Srinagar	20.73	22.52	21.62	13.11	15.11	14.11
Ganderbal	13.46	17.13	15.29	10.06	10.69	10.37
Pulwama	11.06	13.46	12.89	7.04	8.92	7.98
Mean	15.08	17.70	16.39	10.07	11.45	10.76
$CD_{0.05}$	11.55	ns	ns	ns	ns	ns

*Mean of different locations; ns = Non-significant

Disease intensity varied greatly at all the surveyed locations during both the years. Overall, the disease intensity was higher (11.45%) in 2022 than in 2021 (10.07%). Over the years, the disease intensity was highest in district Srinagar (14.11%), followed by Ganderbal (10.37%) and Pulwama (7.98%). During the cropping season 2021, powdery mildew intensity was maximum (13.11%) in

district Srinagar, followed by 10.69% in Ganderbal and 7.04% in Pulwama, while in 2022, the highest disease intensity (15.11%) was observed in district Srinagar, followed by 10.69% in Ganderbal and 8.92% in Pulwama.

Powdery mildew status in apricot

The survey revealed that the powdery mildew disease occurred at all the surveyed locations, except Renzipora area of district Pulwama. The average disease incidence of 8.57 and 10.41% and average disease intensity of 6.76 and 7.96% was recorded during the years 2021 and 2022, respectively (Table 7). A higher level of disease was recorded in 2022 than in 2021. Over the years, the disease incidence was highest in district Srinagar (11.22%), followed by Ganderbal (9.79%) and Pulwama (7.92%). During the year 2021 cropping season, the maximum average powdery mildew incidence was 9.93% in district Srinagar, followed by 9.20% in Ganderbal and 6.59% in Pulwama. Similarly, during cropping season 2022, the highest disease incidence of 12.51% was observed in district Srinagar, followed by 10.40% Ganderbal and 8.33% in Pulwama.

Table 7: Powdery mildew incidence and intensity (%) in apricot in Kashmir during 2021-2022

Districts	Disease incidence (%)			Disease intensity (%)		
	2021	2022	Pooled mean	2021	2022	Pooled mean
Srinagar	9.93	12.51	11.22	7.34	9.46	9.08
Ganderbal	9.20	10.40	9.79	7.56	8.45	8.00
Pulwama	6.59	8.33	7.92	5.38	6.53	6.32
Mean	8.57	10.41	9.49	6.76	7.96	7.36
$CD_{0.05}$	ns	ns	ns	ns	ns	ns

*Mean of different locations; ns = Non-significant

Powdery mildew intensity on apricot varied at all surveyed locations during both the years. Overall, the disease intensity was higher (7.96%) in 2022 than in 2021 (6.76%) (Table 7). Over the years, the disease intensity was highest in district Srinagar (9.08%), followed by Ganderbal (8.00%) and Pulwama (6.32%). During the cropping season 2021, powdery mildew intensity was maximum (7.56%) in district Ganderbal, followed by 7.34% in Srinagar and 5.38% in Pulwama, while in 2022, the highest disease intensity of 9.46% was observed in district Srinagar, followed by 8.45% in Ganderbal and 6.53% in Pulwama.

Powdery mildew status in walnut

Walnut powdery mildew was absent in most of the surveyed locations. In district Srinagar one location (Gousu) and three locations each in district Ganderbal (Batwina, Zazuna and Khamula) and Pulwama (Zahidbagh, Renzipora and Hardumir) were completely disease-free. The average disease incidence of 3.15 and 4.31% and average disease intensity of 2.09 and 2.44% was recorded during the years 2021 and 2022, respectively (Table 8). A higher level of disease prevalence was recorded in 2022 than 2021. The disease incidence was highest in district Srinagar (6.63%), followed by Pulwama (2.87%) and Ganderbal (1.70%). During the year 2021 cropping season, the maximum average powdery mildew incidence was 6.13% in district Srinagar, followed by 1.93% in Pulwama and 1.39% in Ganderbal. Similarly, during the cropping season 2022, the highest disease incidence of 37.20% was observed in district Srinagar, followed by 29.26% Ganderbal and 26.46% in Pulwama.

Table 8: Powdery mildew incidence and intensity (%) in walnut in Kashmir during 2021-2022

Districts	Disease incidence (%)			Disease intensity (%)		
	2021	2022	Pooled mean	2021	2022	Pooled mean
Srinagar	6.13	7.12	6.63	4.28	4.69	4.48
Ganderbal	1.39	2.00	1.70	0.83	1.38	1.10
Pulwama	1.93	3.81	2.87	1.18	1.26	1.22
Mean	3.15	4.31	3.73	2.09	2.44	2.26
$CD_{0.05}$	ns	ns	ns	ns	ns	ns

*Mean of different locations; ns = Non-significant

Powdery mildew intensity on walnut varied at all surveyed locations during both the years. The overall disease intensity was higher (2.44%) in 2022 than in 2021 (2.09%). The disease intensity was highest in district Srinagar (4.48%) followed by Pulwama (1.22%) and Ganderbal (1.01%). During the cropping season 2021, powdery mildew intensity was maximum (4.28%) in district Srinagar, followed by 1.18% in Pulwama and 0.83% in Ganderbal, while in 2022, the highest disease intensity (4.69%) was observed in district Srinagar, followed by 1.38% in Ganderbal and 1.26% in Pulwama.

Powdery mildew status in almond

The powdery mildew disease in almond was prevalent only at Shalimar, Shuhama and Malangpora locations of district Srinagar, Ganderbal and Pulwama, respectively, and was absent at rest of the surveyed locations. The average disease incidence of 3.19 and 3.85% and average disease intensity of 2.30 and 2.46% was recorded during the years 2021and 2022, respectively (Table 9). A higher level of disease prevalence was recorded in 2022 compared to 2021. The disease incidence was highest in district Ganderbal (4.08%), followed by Srinagar (3.66%) and Pulwama (2.83%). During the year 2021 cropping season, the maximum average powdery mildew incidence was 4.16% in district Ganderbal, followed by 2.77% in Srinagar and 2.66% in Pulwama. Similarly, during cropping season 2022, the highest disease incidence of 4.55% was observed in district Srinagar, followed by 4.0% Ganderbal and 3.0% in Pulwama.

Table 9: Powdery mildew incidence and intensity (%) in almond in Kashmir during 2021-2022

Districts	Disease incidence (%)			Disease intensity (%)		
	2021	2022	Pooled mean	2021	2022	Pooled mean
Srinagar	2.77	4.55	3.66	2.26	2.48	2.37
Ganderbal	4.16	4.00	4.08	2.66	2.76	2.71
Pulwama	2.66	3.00	2.83	1.98	2.14	2.06
Mean	3.19	3.85	3.52	2.30	2.46	2.38
$CD_{0.05}$	6.29	8.31	1.04	0.80	0.84	0.82

*Mean of different locations;

The disease intensity varied at all the surveyed locations during both the years. Overall, the disease intensity was higher (2.46%) in 2022 than in 2021 (2.30%). Over the years, the disease intensity was highest in district Ganderbal (2.71%), followed by Srinagar (2.37%) and Pulwama (2.06%). During cropping season 2021, the powdery mildew intensity was maximum (2.66%) in district Ganderbal, followed by 2.26% in Ganderbal and 1.98% in Pulwama, while in 2022, highest disease intensity of 2.76% was observed in district Ganderbal, followed by 2.48% in Srinagar and 2.14% in Pulwama.

The survey conducted during the cropping season 2021 and 2022 in three districts of Kashmir valley *viz.*, Srinagar, Pulwama and Ganderbal revealed widespread occurrence of disease in apple, pear, quince, grapes and plum, however, the disease was absent at a few locations in peach, apricot, walnut and almond. The powdery mildew disease has been reported as one of the major fungal diseases of almost all the economically important crops worldwide, including fruit crops (Braun and Cook, 2012; Marmolejo *et al*., 2018). The higher level of disease was observed in all the test crops during cropping season 2022 compared to 2021, which was attributed to more disease favourable weather conditions during the year 2022, besides the inoculums build up over the years. The influence of environment factors on powdery mildew development is well documented (Naik and Kulkarni 2018; Basavaraj *et al*., 2019; Gulzar, 2024). Among the districts, the average disease intensity was highest in quince (29.37%), followed by plum (14.11%), pear (13.37%), grapes (10.74), apricot (9.08%), apple (8.88%) and walnut (4.48%) in district Srinagar, while in peach (4.33%) and almond (2.71%), disease intensity was highest in district Pulwama and Ganderbal, respectively. Most of the surveyed fruit orchards in district Srinagar were not commercial orchards so as such were poorly managed, which could be the reason for higher disease intensity in the district. The average disease intensity was highest in quince (24.52%), followed by pear (11.05%),

plum (10.76%), grapes (8.55%), apricot (7.36%) and apple (5.84%), and lowest in walnut (2.26%), followed by almond (2.38%) and peach (3.83%). The higher powdery mildew disease in fruit crops such as apple, quince, pear, plum, walnut, almond etc. is attributed to the fact that these crops did not invite much attention of farmers in terms of disease management, as these are either less affected by many economically important diseases or are less remunerative compared to apple. Amongst the surveyed locations, the highest average disease intensity was recorded at Shalimar in pear (20.23%), quince (32.76), grapes (14.68%), plum (16.99%), apricot (11.43%), walnut (9.83%) and almond (7.13%). The lowest average disease intensity amongst the locations was recorded at Hardumir in apple and pear, at Charibugh in quince and at Khalmula in grapes, while at a few locations the disease was altogether absent in case of peach (Gulabbagh, Zazuna, Zahidabagh and Charibugh), apricot (Renzipora), walnut (Gosu, Batwina, Zazuna, Khalmula, Zahidabagh, Renzipora and Hardumir) and almond (Brein, Badamwari, Badampur, Renzipora, Parigam, Hari-Parigam and Lajura). The higher level of disease at some locations is attributed either to the poor or non-adoption of disease management practices. Kaur (2019) reported varied levels of disease severity among the surveyed locations and attributed it mainly to the variation in weather conditions, cultural and other management practices at these locations. The varied level of powdery mildew disease at different surveyed locations has been also reported by other workers (Bankar *et al*., 2019; Rachid *et al.,* 2020; Surma *et al*., 2022)**.**

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Ethical consent: Since the present study did not involve any human participants or vertebrate animals. Therefore, no ethical approval and informed consent were required for this study.

Authors' contributions: All authors contributed equally in various capabilities in the present study.

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