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Climatic Influence on the Growth and Severity of Powdery Mildew Fungi: A Review of Regional and Crop Specific Studies

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Abstract

Powdery mildew is a widespread foliar fungal disease caused by several obligate biotrophs in the order Erysiphales, affecting economically important crops and wild plants worldwide. Unlike most foliar fungi, powdery mildew thrives in dry yet humid conditions and is highly sensitive to climatic variables such as temperature, relative humidity (RH), and sunshine. This review synthesizes published studies on the relationship between climate and powdery mildew incidence across various agro climatic zones, with special reference to India. The results show that morning RH above 60%, moderate temperature (18–28°C), and low rainfall favor conidial germination and disease severity. Extremely high RH (>90%) or rainfall tends to inhibit disease development due to spore lysis or physical wash off. Studies also show variability among host species and regional responses. Understanding these interactions is essential for forecasting disease outbreaks, guiding fungicide application timing, and preparing climate resilient crop disease management strategies.

Uniquely, it thrives under dry but humid conditions and is highly influenced by climatic factors such as temperature, relative humidity (RH), and rainfall. This review compiles and analyzes findings from numerous regional studies, especially in India, to elucidate the impact of climatic variables on the development and severity of powdery mildew across different crops.

Conversely, excessively high RH or intense rainfall may inhibit disease progression by disrupting spore viability. Variability in pathogen behavior across crops and climatic zones highlights the importance of localized disease forecasting and climate-resilient management strategies. This synthesis provides crucial insights for timing fungicide applications, adjusting cropping patterns, and developing predictive models under evolving climate conditions.

Keywords: *Powdery mildew, climate, temperature, humidity, weather, disease forecasting, Erysiphales, conidia*

Introduction

Powdery mildew fungi are among the most prevalent and economically significant plant pathogens, known to infect over 10,000 plant species including cereals, fruits, vegetables, and wild flora (Glawe, 2008). The disease is characterized by white, powdery fungal growth primarily on leaf surfaces, often leading to chlorosis, necrosis, and reduced photosynthesis. Powdery mildew is unique in that it does not require free water for germination and can thrive under dry conditions with high relative humidity.

Climatic variables—especially temperature, relative humidity (RH), sunshine, and rainfall—have a profound influence on the life cycle and spread of powdery mildew. With ongoing climate variability and changing rainfall patterns, disease epidemiology is shifting, making it essential to understand how microclimate influences pathogen growth and infection dynamics. While many regional studies have documented powdery mildew occurrence and severity across crops like mango, wheat, ber, grapes, and pulses, a consolidated synthesis of climate based triggers across these systems remains sparse. This review aims to compile findings from diverse studies and assess how climate variables modulate powdery mildew development, with a focus on India.

Review of Literature

Multiple studies have demonstrated that powdery mildew incidence is intricately linked to environmental conditions. For instance, Pathak et al. (2018) reported that in mango (*Mangifera indica*), maximum disease severity occurred in March when RH ranged between 62–82% and temperatures were moderate (20–30°C). Similarly, Singh et al. (2015) observed that *Erysiphe cichoracearum* on cucurbits was most active during periods of low rainfall and high humidity. In grapevines, Uncinula necator was found to sporulate rapidly under temperatures of 25–28°C and RH of 75% (Chauhan et al., 2012).

In ber (*Ziziphus mauritiana*), Meena and Bhatnagar (2009) documented that cooler winters with minimal rainfall were optimal for conidial development.

Moreover, variation across regions shows that coastal humid zones support longer sporulation periods, whereas semi arid zones exhibit short-lived but intense outbreaks (Ramesh et al., 2016).

Climate change trends, such as warming winters and erratic rainfall, are anticipated to expand the disease's temporal and spatial distribution. Bhujbal and Pawar (2021) noted that fungal infections like powdery mildew are emerging earlier in the crop season under current climate regimes.

Discussion

The disease triangle—host, pathogen, and environment—is particularly sensitive to climatic fluctuations in the case of powdery mildew. Temperature and relative humidity are not just influencing factors but also determine the type and speed of disease development. A consistent pattern emerges where moderate temperatures (18–28°C) and moderate to high humidity (60–80%) are ideal for disease initiation. However, extremes like heavy rainfall or very high temperatures inhibit fungal growth by disrupting conidial integrity.

Geographical differences further complicate forecasting. A fungal strain in a humid coastal region may behave differently than one in an arid or semi arid zone. This underscores the need for localized forecasting models rather than generalized predictions. Advances in GIS, remote sensing, and microclimatic monitoring can aid real time forecasting and help tailor timely interventions like fungicide applications. The reviewed literature provides actionable thresholds for RH and temperature that can serve as indicators for disease risk mapping. Furthermore, these insights are valuable in designing climate resilient cropping calendars and disease management protocols.

Several studies across India have reported correlations between climatic conditions and powdery mildew outbreaks. Table 1 summarizes findings on key crops, indicating the optimal temperature and humidity conditions favoring pathogen development.

Table 1: Climatic factors such as temperature and relative humidity influencing the development and severity of powdery mildew on different host plants across various regions in India, based on published studies

No.	Host plant	Pathogen species	Temperature Range (°C)	Relative Humidity (%)	Location	Reference
1	Mango (inflorescence)	*Oidium mangiferae*	27–30 °C	Disease ↑ as RH drops below ~65%	South Gujarat	Bana et al. (2020)
2	Ber (Z. mauritiana)	*Oidium erysiphoides f. sp. ziziphi*	Tmin <23.6°C	RH >76%	Andhra Pradesh	Srinivasulu et al. (2017)
3	Ber (Rahuri)	*Oidium erysiphoides f. sp. zizyphi*	Lower Tmax	Morning RH ↑; Tmax ↓ disease	Rahuri, Maharashtra	More et al. (2019–20)
4	Wheat	*Blumeria graminis f. sp. tritici*	<23.6 °C	RH 45–63%	Himachal Pradesh	Mehta et al. (2018)
5	Black gram	*Erysiphe polygoni*	Tmax 29–30.5; Tmin 22–22.9 °C	RH 58–85%	Udaipur	Meena et al. (2024)
6	Indian mustard	*Erysiphe spp.*	Tmax 25–30 °C; Tmin >10 °C	RH <50% ↑ disease	Uttar Pradesh	Verma et al. (2023)
7	Grapevine	*Uncinula necator*	12.2–30.1 °C	RH >57.4%	Pune	Chavan et al. (1990–91)
8	Okra	*Erysiphe cichoracearum*	Max 26.8; Min 7.8–9.6 °C	RH 50–98%	Pune	Jotode (1995)
9	Wheat (Punjab)	*Blumeria graminis*	Cool months (Oct–Mar)	Moderate RH	Punjab	Singh (2014)
10	Black gram	*Erysiphe polygoni*	Mod–High Tmax & RH	Afternoon RH ↑ disease	Tamil Nadu	Beta-regression study

Life Cycle and Infection Process of Powdery Mildew

Powdery mildew fungi, members of the order Erysiphales, are obligate biotrophs that depend on living host tissue for growth and reproduction. Their life cycle typically begins with the dispersal and germination of conidia on the leaf surface under favorable conditions—moderate temperatures (18–28°C) and relative humidity above 60%. Unlike many fungal pathogens, they do not require free water to germinate.

Upon germination, the conidium develops a germ tube, which forms an appressorium to penetrate the plant epidermis. A specialized feeding structure, the haustorium, is then established inside the epidermal cells, allowing nutrient uptake while avoiding host defenses. Fungal hyphae remain mostly superficial and produce chains of conidia for secondary spread. Under stress or at the end of the season, the fungus may form sexual fruiting bodies (chasmothecia), contributing to overwintering and primary inoculum in the following season. Understanding this life cycle is essential for targeting key stages of disease progression and optimizing control strategies.

Conclusion

This review clearly shows that climate especially temperature and humidity has a big effect on how powdery mildew grows and spreads. The disease is most active when the weather is warm but not too hot (around 18–28°C) and when there is enough moisture in the air, even if it's not raining. High humidity, especially in the morning, helps the fungus grow and infect plants. On the other hand, very heavy rain or very high temperatures can reduce the chances of infection.

From the studies reviewed, it's clear that powdery mildew behaves differently in different regions and on different crops, depending on the local climate. That's why farmers and researchers need to focus on local weather patterns to predict when the disease might appear. This can help in planning when to use fungicides, choose resistant crop varieties, and carry out other preventive steps.

As the climate continues to change, powdery mildew could become more common in new places or appear earlier in the season. More research and regular field checks will help us find better and more eco-friendly ways to manage this disease in the future.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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