

Epidemiology of Powdery Mildew of Apple caused by *Podosphaera leucotricha* (Ell. and Ev.) Salm. in Kashmir, India

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ABSTRACT

Apple is an economically important horticultural crop that is affected by a number of diseases, including powdery mildew. The disease spread is affected by the environmental conditions during the growth period. The germination and appressoria formation of conidia of powdery of apple initiated after 2 and 4 h, respectively at $20 \pm 2^\circ\text{C}$ in moist saturated atmosphere. Sporulation started 96 h after incubation on susceptible apple leaves. Cardinal temperatures for powdery mildew development were 10, 20 and 30°C . Relative humidity levels of 32 percent and above favoured development of powdery mildew. Temperature had negative significant correlation, whereas relative humidity had positive non-significant correlation with incidence of disease.

Key words: Disease development, Epidemiology, *Podosphaera leucotricha*, Apple

Introduction

Powdery mildew of apple (*Malus domestica*) caused by *Podosphaera leucotricha* is a serious disease problem in apple growing areas in India (Bhat *et al.*, 2015). The life cycle of the pathogen is closely associated with the host and different environmental conditions that affect the host also affect the pathogen. Mildew infection starts around April, and rapid curling and crinkling of leaves can occur as a result of infections along the leaf margin causing premature drop of flower buds, flowers and netlike russetting on fruits resulting in heavy yield losses. With the global increase in temperature the dynamics of powdery mildew infection is also sure to change. Although information regarding epidemiological parameters of apple powdery mildew is available

worldwide, information pertaining to apple growing areas of Jammu & Kashmir, India is lacking. Hence the present studies were undertaken to bridge this knowledge gap.

Materials and Methods

Preparation of inoculum: Conidial inoculum of *Podosphaera leucotricha* was nourished on one- or two-year-old apple saplings which were inoculated by dusting conidia on leaves (Jhoo and McKee, 1965) and incubated at $20 \pm 2^\circ\text{C}$ in moisture saturated atmosphere for 24 h and thereafter transferred to growth chamber at $20 \pm 2^\circ\text{C}$ temperature, 12 h photo-period and 60-80 per cent relative humidity. Young sporulating colonies/lesions were developed after 4-5 days inoculation of these leaves. Viable

conidia were obtained from these plants by blowing off old conidia.

Relative humidity studies: Different levels of relative humidity (RH) were created using saturated salt solutions (Tute, 1969) in properly sealed desiccators. Young twigs with 2-3 leaves were clipped from plants grown in high density plants areas. The cut ends of these twigs were dipped in water in a flask, having double layer of polythene sheet tightly fastened over its mouth. The twigs were inserted through holes in the sheets and the holes were sealed with an adhesive tape. The leaves on the twigs were inoculated and flasks were kept in desiccators maintaining different RH levels at 20 °C and 12 h photo period. Data on disease intensity was recorded after 5 days using 0-10 scale wherein 0=no disease, 1=1-10 %, 2=11-20 %, 3=21-30 %, 4=31-40 %, 5=41-50 %, 6=51-60 %, 7=61-70 %, 8=71-80 %, 9=81-90 % and 10=91-100 per cent area covered by powdery mildew.

Temperature studies: Detached leaves maintained on moist cotton in petri plates were used to study the effect of temperature on powdery mildew. They were inoculated by dusting conidia and incubated in BOD incubators, maintained at different temperatures with 12 h photo period. Disease severity was recorded on 15 leaves in each treatment, seven days after inoculation. Hyphal length was measured with the help of collotypes strips (Butlar and Mann, 1959). Sporulation was measured after 9 days of incubation by cutting circular discs of 0.8 cm diameter from sporulating leaves. They were washed in one ml tap water containing ethanol with hypodermic syringe in small glass vials, thoroughly shaken and counts were made with the help of hemocytometer.

Results

Disease development under controlled conditions

Conidial germination on leaf surface incubated at 20 °C and saturated atmosphere started after 2 h by producing a single germ tube. Appressorial initials were formed on germ tube which developed into lobate appressorium. Appressorium formation was started after 4 h. Primary hyphae were well developed after 24 h and a radiating mycelial mas was formed 48 h after inoculation. Conidiophore initials were well developed 73 h after seeding the leaves with conidia. Conidiophores, each bearing a single conidium, were produced after 96 h of inoculation.

Temperatures of 15(72 µm), 20(102 µm), 25(149 µm) and 30 °C (144 µm) produced well developed hyphae after 24 h with the exception of 10 °C (0 µm). Hyphal growth was comparatively faster at 20 and 25 °C than at other temperatures after 48,72 and 96 h. Maximum hyphal growth after 72 and 96 h was recorded at 20 °C (491, 794 µm), followed by 25 °C (480,777 µm), 15 °C (297,480 µm), 30 °C (290,384 µm) and 10 °C (141,297 µm).

Optimum levels of disease and sporulation developed at 20 °C. Temperatures of 10 and 30 °C did not favor development of disease and sporulation (Table 1).

Hyphal length was measured at different RH. At 0 and 8 per cent RH most of the germinated conidia were shriveled and scanty mycelium developed. However, increased RH levels provided increased hyphal growth. Maximum hyphal length after 72 and 95 h was recorded at 100 per cent (502,795 µm), followed by 92 (492,757 µm), 75 (544,596 µm) and 32 per cent (450,500 µm) RH.

Table 1. Development of powdery mildew symptoms on detached leaves of *P. leucotricha* at different temperatures.

Temperature (°C)	Disease rating	Sporulation (X10 ⁴)
10	0.86	0.63
15	6.69	6.63
20	8.20	10.40
25	6.41	8.16
30	0.78	0.00

Similarly, disease development was normal at or above 32 per cent RH. Relative humidity levels of 75, 92 and 100 per cent were better for disease with average disease rating of 4.97, 4.94 and 5.55. Relative humidity levels of 0(0.1) and 8(0.88) per cent did not favour disease development.

Disease development under field conditions

Disease first made its appearance at apple town Sopore on 14th April, 2022 and 10th April 2023 respectively. Maximum and minimum temperatures during preceding week ranged between 20- 32 °C and 22-30 °C with average RH of 64 and 75 per cent in both years.

Correlation coefficients between disease severity and weather parameters showed that maximum and average temperature has negative significant

correlation with disease. However, correlation coefficient with average RH, sunshine and rainfall were positive and non-significant (Table 2).

Table 2. Correlation coefficients between severity of disease and weather parameters

Disease Severity	Correlation Coefficients
Maximum temperature	-0.68*
Average temperature	-0.75*
Maximum RH	0.51 ^{NS}
Sunshine	0.39 ^{NS}
Rainfall	0.31 ^{NS}

*NS, respectively indicate significant and non-significant (P=0.05)

Discussion

During the present investigations, powdery mildew of apple developed best between 15 and 25 °C. Temperatures of 10 and 30 °C were found uncondusive for powdery mildew development and sporulation. Spore to spore development occurred in 96 h at 20 °C. Our results on development of disease is in fair accordance with those of Peries (1962). Mieslerova *et al.* (2022) also found the temperatures between 13 and 30 °C to be optimal for development

Relative humidity requirements for powdery mildew of apple appeared to be in a wide range like other powdery mildew fungi such as *Erysiphe polygoni*, *Uncinula necator* (Zaracovitis, 1965). Hyphal growth and disease development was normal at or above 32 per cent. Similar observations have also been reported by Quinn and Powell (1982) and Bhat *et al.* (2015). The dispersal and germination of conidia is inhibited by high moisture, though it is required for release and dispersal of ascospores (Mieslerova *et al.*, 2022).

In Kashmir, powdery mildew appeared in April when average RH under field conditions prevailed between 64 and 80 per cent. Disease appearance in these months does not seem to be limited by RH as requisite RH levels (32 or above) were always available in nature. Availability of suitable temperature and primary inoculum appears to be the deciding factors for initiation and development of apple powdery mildew.

References

- Bhat, K, A., S.H. Peerzada and Ali, Anwar, 2015. Alternaria epidemic of apple in Kashmir. *African Journal of Microbiology Research*. 9 (12): 831-837.
- Butlar, E.F. and Mann, M.P. 1959. Use of cellophane tape for mounting and photographing phytopathogenic fungi. *Phytopathology*. 49: 321-323.
- Delp, C.S. 1954. Effect of temperature and relative humidity on the grape powdery mildew fungus. *Phytopathology*. 44: 615-626.
- Jhooty, J.S. and Mckeen, W.E. 1965. Studies on powdery mildew of strawberry caused by *Sphaerotheca macularis*. *Phytopathology*. 55: 281-285.
- Mieslerová, B., Cook, R.T., Wheeler, C.P. and Lebeda, A. 2022. Ecology of Powdery Mildews—Influence of Abiotic Factors on their Development and Epidemiology. *Critical Reviews in Plant Sciences*. 41(6): pp.365-390.
- Peries, O.S. 1962. Studies on strawberry mildew caused by *Sphaerotheca macularis*. I. Biology of the fungus. *Ann. Appl. Biol.* 50:211-224.
- Quinn, J.A. and Powell, Jr.C.C. 1982. Effects of temperatures, light and relative humidity on powdery mildew of begonia. *Phytopathology*. 72:480-484.
- Tute, J. 1969. *Plant Pathological Methods. Fungi and Bacteria*. Burgess Publishing Co, Minnerapolis.
- Zaracovitis, C. 1965. Attempts to identify powdery mildew fungi by conidial characters. *Trans. Br. Mycol. Soc.* 48: 553-558.