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Epidemiology and management of powdery mildew of apple in nurseries

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ABSTRACT : Powdery mildew of apple caused by *Podosphaera leucotricha* causes heavy losses in nurseries.

Keywords : Apple, powdery mildew, *Podosphaera leucotricha*, weather factors, correlations, management

INTRODUCTION

Powdery mildew (*Podosphaera leucotricha*) is a serious disease of apple and causes heavy losses both in orchards as well as in nurseries. In nurseries, the disease is more severe and after infection, seedlings are killed in one season. The damage caused by powdery mildew may be manifested as a direct fall in the yield, because of suppression or distortion of plant growth and in nurseries, because of sudden death of seedlings. There is no definite evidence available regarding the conditions which help the outbreak of apple mildew. Trouble in some localities is worse in hot and dry season, whereas in others, warm and moist summers or cool, damp sunless weather favoured the disease (Butler and Jones, 1961). Therefore in the present investigations, effect of epidemiological parameters on disease development and its management was studied.

MATERIALS AND METHOD

1. Effect of temperature and relative humidity on conidial germination under *in vitro* conditions. Optimum temperature for conidial germination was worked out by uniformly dusting the conidia from freshly sporulating colonies over the sterilized dry and clean glass slides kept on glass rod triangles placed in petri plates (90 mm) containing cotton wool moistened with sterilized distilled water. Petri plates containing slides were subsequently transferred to incubators maintained at 5,10,15,20,25,30 and 35C. After 48 hrs of incubation, slides were examined microscopically to record conidial germination and germ tube length. About 300 conidia selected randomly from different microscopic fields were examined to calculate per cent germination and germ tube length.

To find out the effect of relative humidity on conidial germination, eight humidity levels viz., 100.0, 99.10, 98.20, 96.90, 95.60, 89.90, 85.70 and 80.50 per cent were maintained using sulfexic acid of known specific gravity as recommended by Stevens (1916). Equal amounts (25 ml) of required solutions were poured in petriplates, used as humidity chambers and conidia from freshly sporulating colonies were uniformly dusted over the sterilized, clean dry glass slides kept in these humidity chambers. Sides of each petri plate were sealed with parafilm and subsequently transferred to an incubator maintained at 25 $\pm$1 C. All the treatments were replicated four times. After 48 hrs of incubation, a total of 300 conidia selected randomly from different microscopic fields were examined to calculate per cent conidial germination and germ tube length.

2. Role of meteorological factors on disease development under field conditions. In order to find out the role of meteorological factors on disease development, severity of powdery mildew of apple was recorded in the nursery of Department of Pomology, UHF, Nauni during the crop season, 2004 starting from first week of May. Simultaneously, meteorological data on temperature, relative humidity and cumulative rainfall were also recorded. Simple, partial and multiple correlations and regression equations between disease severity and above three independent factors were worked out.

3. Post-symptom anti-sporulating activity of fungicides. To determine the post symptom anti-sporulating activity, leaves of established apple plants were inoculated with conidia of *P. leucotricha* taken from infected apple leaves with the help of camel hairbrush. A small drop of water (5µl) was placed on the corner of each inoculated leaf with the help of a micropipette to provide humidity for conidial germination. After the appearance of the symptoms, twenty leaves (5 leaves per plant) each having 5 to 10 mildew pustules (one treatment) were tagged and subjected to seven fungicides spray treatment and a check (only water). After 3,5,7 and 10 days of single spray, five tagged leaves were removed from each treatment and one lesion (5mm2) per leaf was cut with the help of a cork borer and washed into 5 ml of distilled water with the help of a camel hair brush (Gupta and Gupta, 1991). One drop (0.1ml) of conidial suspension was placed on a haemocytometer to record the number of conidia and reduction (%) in number of conidia over control was calculated by the method given by Vincent (1947).

4. Evaluation of fungicides against powdery mildew under field conditions. A field trial was laid out at the experimental farm of HRS, Kandaghat with seven fungicides

viz., Contaf (0.05%), Score (0.05%), Bavistin (0.05%), Karathane (0.04%), Sulfex (0.025%), Bright (0.25%) and Glow (0.05%) against powdery mildew of apple in randomized block design during April to August 2004 and each treatment was replicated thrice. Spray application of fungicides was started with the initiation of disease i.e. in the first week of April. In all, five sprays were applied at fortnightly intervals and observations on disease incidence and disease severity were recorded ten days after the last spray.

RESULTS AND DISCUSSION

1. Effect of temperature on conidial germination under *in vitro* conditions. Data (Table 1) revealed that conidia of *P. leucotricha* could germinate over a wide range of temperature (5-35°C), however, with the increase in temperature, there was an increase in conidial germination. Maximum germination (49.94%) was obtained at 25°C closely followed by 30°C (47.05%) and 20°C (46.19%), though both were statistically at par with each other. Minimum germination was recorded at 5°C followed by 35°C giving 28.36 and 33.59 per cent, respectively. These results are in conformity with the observations of Coyier (1968) and Monler (1971).

Table 1 : Effect of temperature on conidial germination under *in vitro* conditions.

Temperature (°C)	Conidial germination (%)	Germ tube length (µm)
5	28.36 (24.06)	8.75
10	36.09 (32.76)	14.17
15	37.58 (33.62)	15.25
20	46.19 (42.82)	15.33
25	49.94 (44.97)	18.33
30	47.05 (43.31)	17.75
35	33.59 (31.52)	9.33
$CD_{0.05}$	(1.54)	2.93

Figures in parentheses are arc sine transformed values

Data further showed that maximum germ tube length of conidia of *P. leucotricha* was recorded at 25°C (18.33 m) closely followed by 20°C (17.75 mm), though statistically at par with each other. Several workers have reported a temperature range of 20-26°C to be optimum for germ tube growth of most powdery mildews (Monler, 1971 and Hewitt, 1974).

2. Effect of relative humidity on conidial germination. It is evident from the data (Table 2) that conidia germinated at all the humidity levels tested ranging from 80.50 to 100.00 per cent. Conidial germination was highest at 95.60 per cent RH (84.71%) followed by 89.90 per cent (79.49%) and 96.90 per cent (79.00%), however, all were statistically at par with each other. Conidial germination was minimum at 100 per cent (45.06%) relative humidity. These results are in agreement with the observations of Yarwood (1936) who suggested that powdery mildews are normally favoured by dry weather and reasons for this observation are the mechanical damage to conidiophores by rain.

Table 2 : Effect of relative humidity on conidial germination under *in vitro* conditions.

Relative humidity levels (%)	Conidial germination (%)	Germtube length (µm)
100.00	45.08 (42.16)	7.85
99.10	53.01 (46.95)	8.37
98.20	66.63 (54.32)	9.67
96.90	79.00 (62.74)	9.95
95.60	84.71 (67.07)	13.03
89.90	79.49 (63.22)	12.60
85.70	73.21 (59.68)	11.24
80.50	71.41 (58.15)	10.83
$CD_{0.05}$	(5.59)	1.45

Figures in parentheses are arc sine transformed values

With regard to germ tube length at different humidity levels, maximum germ tube length (13.03 mm) was observed at 95.60 per cent RH followed by 89.90 per cent and 85.70 per cent RH giving 12.60 m and 11.24 mm long germ tube, respectively.

3. Role of meteorological factors on disease development under field conditions. The information of weather parameters and disease development (Figure 1) revealed that the disease appeared in the first week of May and severity of the disease ranged from 0.02 to 12.33 per cent. It assumed serious proportions during the months of June and July. Since the progress is dependent on meteorological parameters such as mean air temperature, relative humidity and cumulative rainfall, therefore, simple, partial and multiple correlations were worked out to establish the relative contribution of these factors in the spread of the disease.

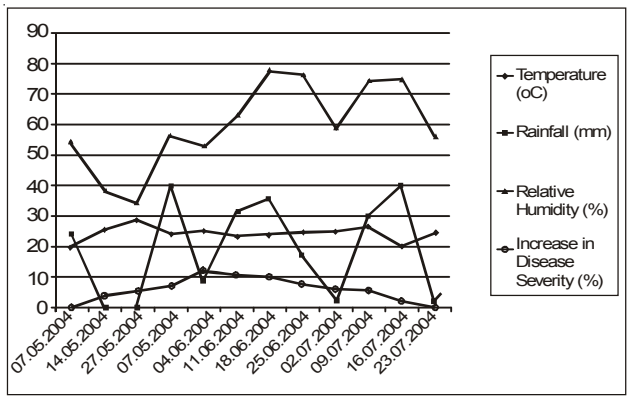

Fig.1. Effect of meteorological factors on development of powdery mildew on apple.

The data revealed (Table 3) that value of simple correlation coefficient between disease severity and relative humidity was highly significant and positive (0.6742) showing consistent effect of relative humidity on disease development. Similarly, correlation coefficient between mean

air temperature and disease severity was found significant and negative (-0.5149). These results to a greater extent corroborate the findings of various workers (Monlar, 1971 and Grushin, 1988) who reported high incidence of the disease under high humidity conditions.

Table 3 : Simple and partial correlation coefficients between disease severity and meteorological factors.

Meteorological factor	Disease severity	
	Simple correlation	Partial correlation
Temperature	-0.5149*	0.3449
Relative humidity	0.6742	-0.6642*
Rainfall	0.1751	0.2350

*Significant at 5%

Data further indicated that partial correlation between disease severity and relative humidity (-0.6642) was highly significant and negative whereas with temperature and rainfall, it was positive but non-significant.

The multiple correlation coefficient (Table 4) between disease severity and group of independent variable was found to be 0.6194 which indicates that 61.94 per cent change in disease severity was caused by mean air temperature, relative humidity and cumulative rainfall collectively, whereas the rest of the variation was due to unexplained factors (error variation) and the factors not included in the investigations. Similarly, many workers have reported that occurrence of apple mildew was favoured by a relatively mild, dry climate (Videnov, 1972 and Khan, 1989).

Table 4 : Multiple correlation and regression equation between disease severity and meteorological factors.

R^2		Multiple coefficient determination	(%)	Regression equation
0.6194	61.94	X_1 =	X_2 =	X_3 =
Y_1=	-122.76 +	1.5600 × 1 +	2.0870 × 2* +	0.04614 × 3
	(115.19)	(92.5470)	(0.1055)	(0.1083)

*Significant at 5 per cent

Where : Y_1 = Disease severity, X_1 = Mean air temperature, X_2 = Relative humidity, X_3 = Rainfall

4. Post symptom anti-sporulant activity of fungicides. It is evident from the data (Table 5) that Bavistin 3 days after first spray caused significant reduction (37.78%) in the number of conidia followed by Score (35.56%), Karathane (35.49%) and Contaf (31.11%), however, all were statistically at par with each other while sulfex (21.11%) was least effective. By 5th day, all fungicides continued to reduce the conidial number, Bavistin being the best giving 33.33 per cent reduction. On 7th day, reduction level further came down and a similar trend was observed on 10th day.

Table 5 : Effect of fungicides on formation of conidia of *P. leucolricha* on apple leaves.

Fungicides	Conc. (%)	Number of days								Overall mean	
		3		5		7		10			
		Total number of conidia	Reduction (%)	Total number of conidia	Reduction (%)	Total number of conidia	Reduction (%)	Total number of conidia	Reduction (%)	Total number of conidia	Reduction (%)
Bright	0.25	63.33	29.63 (32.92)	71.33	20.74 (26.95)	72.67	19.26 (24.94)	76.33	15.20 (22.68)	70.91	21.21 (27.12)
Bavistin	0.025	56.00	37.78 (37.91)	60.00	33.33 (35.26)	68.00	24.44 (29.53)	75.33	16.30 (23.66)	64.83	27.96 (31.59)
Sulfex	0.05	62.00	31.11 (33.89)	66.00	26.67 (31.08)	72.67	19.26 (25.97)	72.67	19.26 (25.97)	68.33	24.07 (29.22)
Glow	0.04	58.00	35.49 (36.51)	67.33	25.19 (29.98)	73.33	18.52 (25.37)	76.67	14.82 (22.55)	68.83	23.50 (28.60)
Karathene	0.05	57.33	35.56 (36.60)	66.00	26.67 (31.08)	69.33	22.96 (28.33)	76.00	15.56 (23.09)	67.17	25.19 (29.78)
Score	0.05	71.00	21.11 (27.29)	74.00	17.78 (24.88)	74.67	14.81 (22.59)	75.33	12.59 (20.67)	73.75	16.57 (23.86)
Contaf	0.05	62.00	31.11 (33.90)	64.00	28.83 (32.40)	72.00	20.00 (26.54)	78.00	13.33 (21.37)	69.00	23.32 (28.55)
Control		90.00	-	90.00	-	90.00	-	90.00	-		
Overall mean		**64.96**	**31.68 (29.86)**	**69.83**	**25.60 (30.23)**	**70.08**	**19.89 (26.18)**	**77.54**	**15.29 (22.85)**		

$CD_{0.05}$

Fungicides	(2.75)	Fungicides	(2.09)
No. of days	(1.94)	No. of days	(1.47)
Fungicides x No. of days	(5.47)	Fungicides x No. of days	(4.16)

On the basis of overall reduction in conidia production, Bavistin was found best (27.96 %) followed by Karathane (25.19%) and Glow (23.50%) while Score (16.57%) was least effective. The overall mean reductions of conidial formation at 4 durations indicated that there was significant decrease on 3rd day which further decreased and was minimum on 10th day of spray. It also showed that with the increase in number of days, there was corresponding decrease in conidia production giving thereby a negative correlation between number of days on conidia production. The reduction in conidial formation by Bavistin consonance the findings of Gupta and Gupta (1991) and Sharma and Gupta (1994) who observed that Bavistin is effective in controlling apple powdery mildew and its anti-sporulant activity lasted for 21 days.

5. Evaluation of fungicides against powdery mildew under field conditions. It is evident from the data (Table 6) that all the fungicides were effective in reducing incidence and severity of the disease. Minimum incidence was recorded in Karathane (13.92%) followed by Contaf (18.37%), Sulfex (18.99%) and was maximum in Glow (24.41%), however, all were statistically at par with each other. Maximum disease incidence of 47.82 and 30.09 per cent was recorded in case of Bright and Bavistin, respecitively.

Table 6 : Effect of various fungicides on powdery mildew incidence and severity on apple nursery plants under field conditions.

Treatment	Conc. (%)	Disease incidence (%)	Disease severity (%)
Bright	0.25	47.82 (43.75)	38.33 (38.240
Bavistin	0.025	30.09 (33.23)	24.00 (29.30)
Sulfex	0.05	18.99 (25.82)	13.78 (21.78)
Glow	0.04	24.41 (29.51)	17.78 (24.74)
Karathane	0.05	12.92 (21.03)	9.33 (17.41)
Score	0.05	17.59 (24.69)	12.00 (20.26)
Contaf	0.05	18.37 (24.91)	14.23 (21.73)
Control	-	69.77 (56.87)	73.34 (59.31)
$CD_{0.05}$		7.25	7.77

Data further showed that minimum disease severity was registered in plants sprayed with Karathane followed by Sulfex and Glow giving 9.33, 13.77 and 17.48 per cent disease severity, respectively. Bright and Bavistin, on the other hand, recorded highest disease severity of 38.33 and 24.33 per cent, respectively. Reduction in disease incidence and severity by use of fungicides has been reported by various workers (Srivastava and Roy, 1984, Mandoza *et. al.*, 1991 and Sharma *et. al.*, 1992).

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