



Impact of Weather Variables on Severity and Progression of Powdery Mildew on Rapeseed-mustard in Haryana

Manmohan Baghel, Jagdeep Singh, Rajni Kant Sharma¹, Mamta, Prashu², Renu³ and Muhammad Sani Gambo⁴

Department of Plant Pathology, ¹Department of Chemistry, CCS Haryana Agricultural University, Hisar-125 004, India

²Maharishi Markandeshwar Deemed University, Ambala-133 207, India

³Department of Computer Science and Application, Baba Mastnath University, Rohtak-124 021, India

⁴Department of Crop Science, Kano University of Science and Technology Wudil-3244, Nigeria

E-mail: mmbaghel@gmail.com

Abstract: Powdery mildew is a major devastating disease rapeseed-mustard causing significant reduction in yield as well as quality. Present investigation was under taken to study the impact of weather variables on disease severity and progression of powdery mildew. The maximum disease intensity was in variety Varuna (51.3%) followed by RH-30 (46.0%). The minimum disease intensity was in varieties HC-9002 and YSPb-24 (17.3%). Powdery mildew intensity on pods was also maximum on Varuna (36.7%) and minimum was on GSH-1. The minimum speck size was in the variety GSH-I (2.87mm) whereas maximum in RH-9304 (5.20mm) whereas in all other varieties, speck size ranged between 3.40 to 4.67 mm. The progression was maximum up to the mid of March and there after progression was slowed down. At the end of March progression was static in all the varieties. Temperature (maximum) and relative humidity (morning) played pivotal role on the severity and progression of powdery mildew disease on leaves. The R² values were observed in the range of 0.70 to 0.92 indicating that most of the weather variables contributed significantly in powdery mildew progression.

Keywords: Powdery mildew, Weather variables, Severity, Rapeseed-mustard, Progression

Oilseeds cultivation is undertaken across the country in about 29.17 million ha, largely under rainfed areas covering 72 percent and producing around 37.70 million tonnes of oilseeds. In India, area, production and yield of rapeseed and mustard was 29.17 million ha, 37.70 million tonnes and 1292 kg/ha in *rabi* 2022-23, respectively (Anonymous 2023). The average productivity of Indian mustard in India is very low as compared to the developed countries. There is wide gap between the potential and the realized yield at the farmers' field, which is affected by number of biotic and abiotic stresses. The fungal foliar diseases are one of the major factors. Among them, white rust [*Albugo candida* (Pers.) Kuntze], alternaria blight [*Alternaria brassicae* (Berk.) Sacc.], downy mildew [*Peronospora parasitica* (Pers. ex. Fr.) Fr.], powdery mildew [*Erysiphe cruciferarum* Opiz. ex. Junell] and sclerotinia rot [*Sclerotinia sclerotiorum* (Lib.) de Bary]] are the most important diseases. Powdery mildew of rapeseed-mustard, caused by *Erysiphe cruciferarum* result in significant yield losses, sporadically, depending on the prevailing weather conditions (Meena et al 2014, Singh et al 2024). This disease was minor importance, but in the recent years, became widespread throughout the mustard growing regions of India. The meagre information is available on severity of six genera of *Brassica* (*Brassica juncea*, *B.*

campestris var. yellow sarson, *B. campestris* var. brown sarson, *B. carinata*, *B. Napus* and *B. alba*) in India. The main objectives of the present investigations were to study the effect of environmental factors on severity and progression of these foliar diseases.

MATERIAL AND METHODS

The field experiments were conducted CCS Haryana Agricultural University, Hisar, India, which is situated in the subtropics at latitude 29°10'N and longitude 75°46'E with elevation of 215.2 meters above the mean sea level. These experiments were laid out in a randomized block design with three replications and plot size 1.8x2 m². The crop was raised in field keeping row to row distance 30 cm and plant to plant of 15 cm. Ten varieties (RH-9801, RH-30, RH-9304, RH-781, Varuna, YSPb-24, BSH-1, HC-9002, GSH-1 and *B. alba*) belonging to six genera *viz.*, *Brassica juncea*, *B. campestris* var. yellow sarson, *B. campestris* var. brown sarson, *B. napus*, *B. Carinata* and *B. Alba* were grown. Recommended agronomic practices were adopted (Anonymous 2021). Weather data were obtained for periods from the observatory of Department of Agriculture Meteorology, CCS, Haryana Agricultural University, Hisar, Haryana (India). Daily maximum temperature (X₁), minimum temperature (X₂),

evaporation morning (X_3), evaporation evening (X_4), relative humidity morning (X_5), relative humidity evening (X_6), wind speed (X_7), sunshine (X_8) and rainfall (X_9) and the average data were used for analysis. Data were analysed statistically using SAS 9.3 software (SAS Institute Inc., Cary, USA). Data on severity of powdery mildew was recorded by recommended rating scale (0-9) of AICRP-RM on ten randomly selected leaves from each plot/replication at regular intervals till the maturity of the crop. The percent disease intensity was calculated McKinney (1923). Disease progression in terms of pustule size, spot size and speck size (mm) were measured with the help of scale on each cultivar after appearance of the disease on ten randomly selected tagged leaves at four days intervals till the maturity of the leaves.

$$DI(\%) = \frac{\text{Sum of all numerical rating}}{\text{Total number of leaves assessed} \times \text{Maximum disease grade}} \times 100$$

RESULTS AND DISCUSSION

Symptomatological studies of powdery mildew: Powdery mildew appeared in the form of dirty white floury patches on both sides of leaves as well as on the pods. With the increase in time, the floury patches increased in size and coalesced to cover the entire leaves, pods, and stem (Fig. 5A-F). The green pods showed white patches in the initial stage of infection. Later, such pods were completely covered with white mass of mycelium and conidia (Fig. 5 C-D). Pods heavily covered with powdery mass remained empty or produce few seeds at base with twisted sterile tips. In the end of season, cleistothecia appeared on the both sides of infected leaves, stem, and pod. Powdery mildew symptoms were seen at different stages of the plant growth. Symptoms occurred in the initial stages in the case of rapeseed-mustard, jasmine, little gourd and ber. Based on the morphological studies of the pathogen mycelium of the fungus is amphigenous, white, septate spreading and persistent. Conidia are hyaline, borne singly or in short chain measuring $48.90 \times 24.90 \mu\text{m}$ in size and cylindrical in shape (Nayak et al 2023 and Saharan et al 2019). Conidia germinate only from one end the germ tube. Conidiophore length is $116.25 \mu\text{m}$. Perithecia scattered, globose at first yellowish orange, becoming brown to dark brown and black with maturity, $90-130 \mu\text{m}$ in diameter (Table 1). Kumar et al (2015) also reported that conidia are hyaline, borne singly or in short chain measuring $25-45 \times 12-16 \mu\text{m}$ in size and cylindrical in shape. Conidia germinate only from one end the germ tube. Nanjundan et al (2020) reported that disease was recorded on all the plant parts leaves, stem, branches, and siliquae were covered with larger colonies of *E. cruciferarum*. A total of 996 accessions were found 'moderately

susceptible' exhibiting heavy infection on leaves, stem, and branches and 11 entries were found as 'highly susceptible'.

Role of weather variables on the severity of powdery mildew: Disease intensity of powdery mildew on leaves were maximum in Varuna (51.3%) followed by RH-30 (46.0%). The minimum disease intensity was in HC-9002 and YSPb-24 (17.3%) but there were no significant differences between varieties RH-9801 and RH-9304 in relation to powdery mildew intensity. However, the disease did not appear on *B. Alba* (Table 3). Similarly, the maximum disease intensity on pods was on Varuna (36.7%) (Table 2). Mir et al (2023) revealed that powdery layer of white spores is a common appearance of most powdery mildews and some notable examples are powdery mildew of *Brassica* (*E. cruciferarum*), powdery mildew of grasses and cereals (*Erysiphe graminis*) and gooseberry (*Sphaerotheca morsuvae*). Crucifer powdery mildew disease is caused by *E. cruciferarum*. *Erysiphe* spp. which infects all leaves, stems, and siliques, significantly reduces *Brassica* crop yields by lowering plant growth and seed development. There are number of weather variables which are very crucial to influence the powdery mildew development in to epidemic form with host pathogen

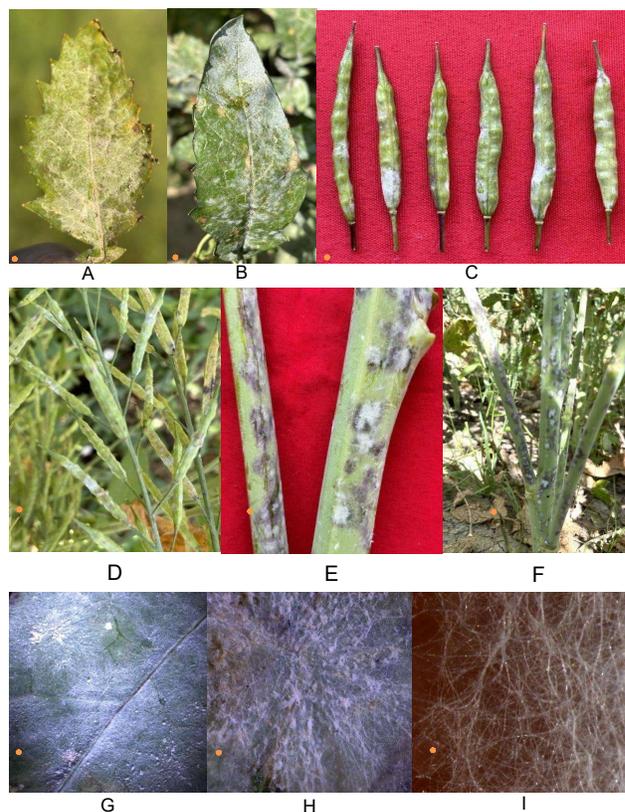


Fig. 1. A-B) Symptoms of powdery mildew on leaves; C-D) on siliqua; E&F) on stem and branches; G-I) Magnification showing hyphal network of powdery mildew on *Brassica juncea*

interaction. Maximum temperature in the range of 27.9-32.1°C was most favourable for disease development. Minimum temperature in the range of 8.7-12.8°C during March favoured severity of disease. Morning and evening relative humidity in the range of 90.6-91.3 percent and 32.4-37.3 percent was most appropriate for disease development after with increase in morning and evening relative humidity disease showed decreasing trend (Table 2). Nayak *et al* (2023) reported that percent disease index (PDI) of powdery mildew was positively correlated with the maximum and minimum temperature whereas, it was negatively correlated with maximum RH, minimum RH and rainfall in Indian mustard varieties Ganga, Varuna, Giriraj and RH-0749. Mehta (2019) reported that epidemic development of powdery mildew under field conditions, moderate temperature, low humidity, minimum rainfall, or dry season during February and March are more favourable in Haryana. Mean temperature between 16-28°C, mean RH below 60 percent and low or no rainfall are the most congenial weather factors for the development of the disease under field conditions.

Role of different weather variables on the progression of powdery mildew: Disease appeared in all varieties in the

first week of March except *B. alba* (disease did not appear). The minimum speck size was in GSH-I (2.87mm) whereas maximum in RH-9304 (5.20mm) whereas in all other varieties, speck size ranged between 3.40 to 4.67 mm. The progression was maximum up to the mid of March and there after progression was slowed down. At the end of March progression was static in all the varieties, but, disease progressed well in the staggering dates of observations and reached maximum in the end of crop season (Table 3). Manmohan and Mehta (2016) reported that progression of powdery mildew on both varieties (Varuna and RH-9801) with four dates of sowing and both pacing (30 × 15 cm and 45 × 20 cm) showed that the maximum speck size 5.39 mm In variety RH-9801, also the speck size increased with delay in date of sowing in both the spacing. The minimum progression of spot size 1.00 mm was observed in pacing 30 × 15 cm in the beginning of disease appearance which reached to maximum speck size 5.39 mm in pacing 30 × 15 cm at the end of observations.

Regression analysis between disease progression and weather variables: The most of weather variables were the major determinants in the disease progression and showed the variability in disease progression due to different weather

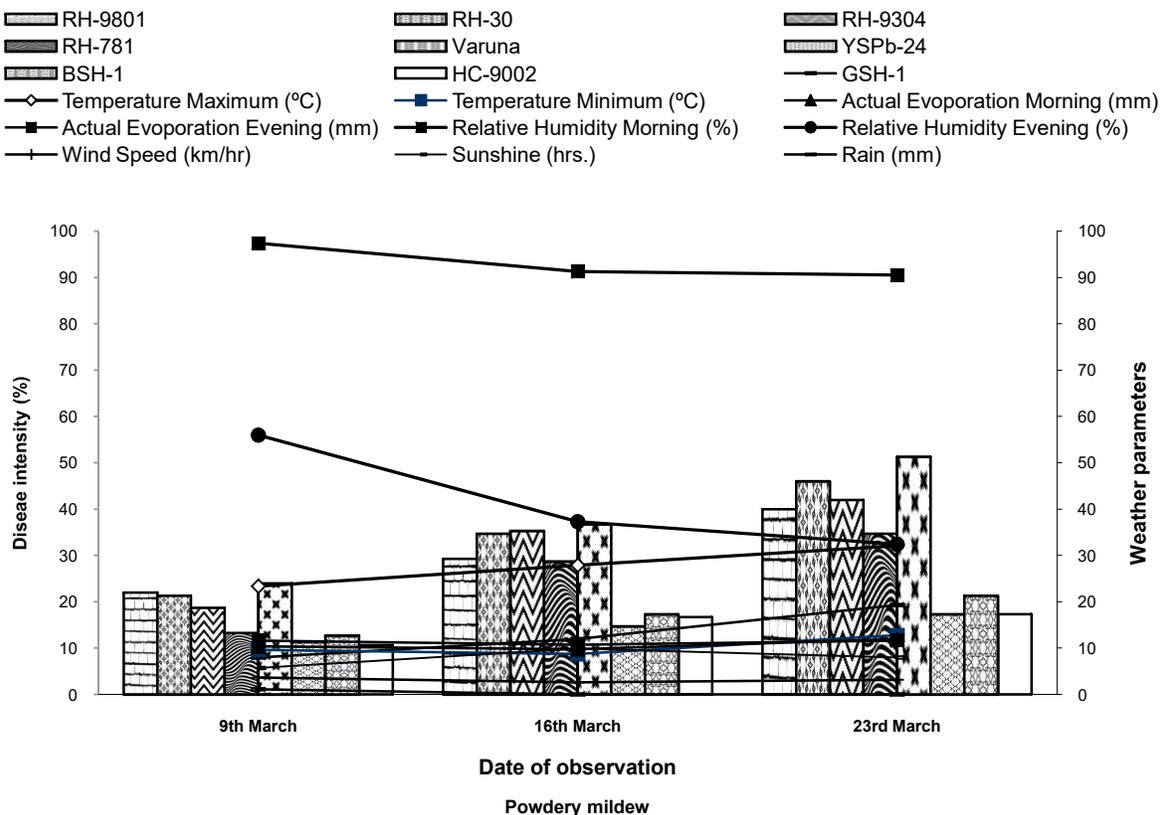


Fig. 2. Disease intensity (%) of powdery mildew on different cultivars of Indian mustard in relation to weather variables

parameters. The maximum R^2 i.e. 0.92 was on RH-30 followed by Varuna, YSPb-24 and minimum was on BSH-1 which indicated that in addition to weather variables included here other factors such as varietal resistance and some unknown factors have significant role in the disease development. The BSH-1 and *B. alba* appeared as resistant to powdery mildew with the expression of slow mildewing components whereas other varieties belonging to *B. juncea* group appeared as susceptible to the disease showing faster powdery mildew development under field conditions (Table 4). Razdan et al (2012) found maximum temperature, morning relative humidity and rainfall influence the disease incidence which is in corroboration with the present findings. Talukdar et al (2017) concluded that decrease of evening

relative humidity and bright sunshine hours during the growing period aggravated the disease in late sown crops.

Correlation matrix between disease progression and weather variables: The temperature (maximum) had significant positive role in the progression of powdery mildew on all the varieties/cultivars except BSH-1, where it was positive but non-significant. Similarly, relative humidity (morning) also had significant and positive role in the disease progression on all the varieties/cultivars except *B. alba* (disease did not appear). Sunshine has negative and significant correlation in all the varieties. Other weather variables such as temperature minimum, relative humidity (evening), and average evaporation (evening) had positive but non-significant correlation in disease progression on all

Table 1. Description of symptoms and morphological characters of powdery mildew on *Brassica* sp

Symptoms on plant and stage	: Circular to irregular patches on the upper surface leaves, flowering and siliqua
Genera	: <i>Erysiphe cruciferarum</i>
Host	: <i>Brassica</i> spp.
Mycelia	: Amphigenous white
Conidia and conidiophores morphology	: Oblong to cylindrical or oval borne conidia singly or in short chains. cylindrical composed of 3-4 cells
Germ tube and appressorium	: Simple (non-forked) emerging apically or basally
Fibrosin bodies	: -
Conidial size(μ m)	: Length: 48.90 μ m,Width: 24.90 μ m
Conidiophore length (μ m)	: 116.25
Foot cell length	: 41.20

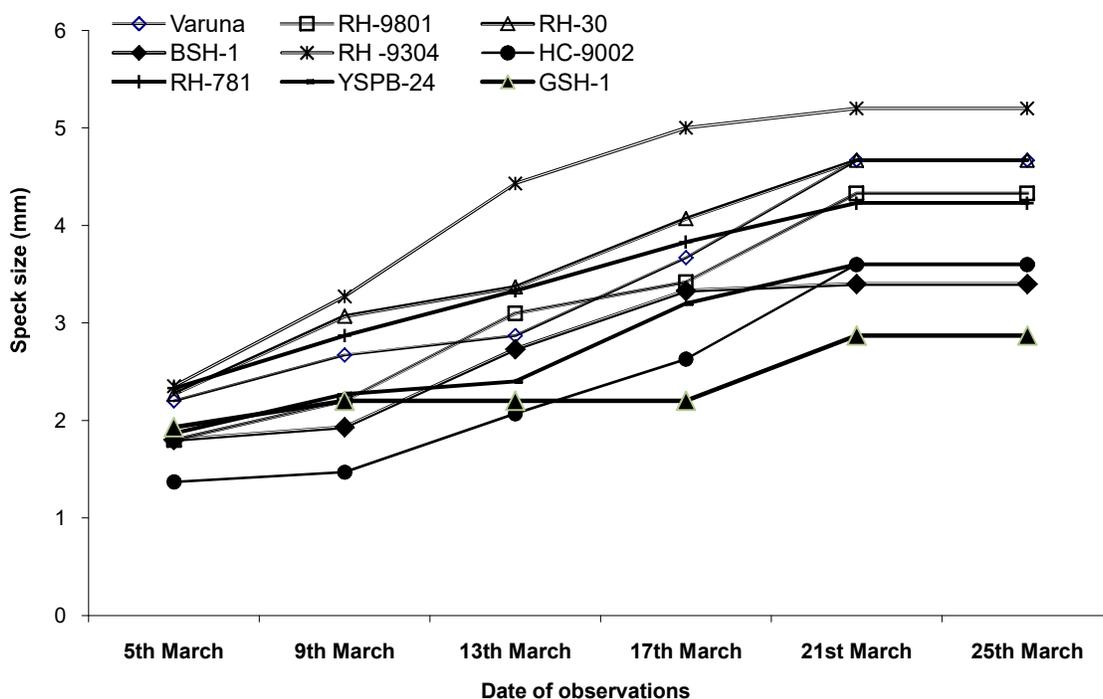


Fig. 3. Progression of powdery mildew on nine cultivars of rapeseed-mustard

Table 2. Effect of weather parameters on the severity (%) of powdery mildew on different varieties of rapeseed-mustard

Disease	Date of observations	Weather variables										Disease severity (%)						
		Temp. °C max.	Temp. °C min.	RHM%	RHE%	WS (km/hr)	SS (hrs.)	Rain (mm)	RH-9801	RH-30	RH-9304	RH-781	Varuna	YSPb-24	BSh-1	HC-9002	GSH-1	CD at 5%
Powdery mildew on leaves	09th March	23.4	9.6	97.4	56.0	3.7	5.7	1.1	22.0	21.3	18.7	13.3	24.0	11.3	12.7	10.7	8.0	4.7
	16th March	27.9	8.7	91.3	37.3	2.6	9.9	0.0	29.3	34.7	35.3	28.7	36.7	14.7	17.3	16.7	12.0	3.4
	23rd March	32.1	12.8	90.6	32.4	3.2	8.0	0.0	40.0	46.0	42.0	34.7	51.3	17.3	21.3	17.3	19.3	1.9
	Mean	27.8	10.4	93.1	41.9	3.1	7.9	0.4	30.4	34.0	32.0	25.6	37.3	14.4	17.1	14.9	13.1	3.3
Powdery mildew on pods	20th March	31.90	12.10	89.00	34.00	3.70	8.20	4.60	22.00	21.30	18.70	13.30	24.00	11.30	12.70	10.70	8.00	4.70
	29th March	32.00	13.30	84.00	35.00	5.20	8.90	10.30	29.30	34.70	35.30	28.70	36.70	14.70	17.30	16.70	12.00	3.40
	Mean	31.95	12.70	86.50	34.50	4.45	8.55	7.45	25.65	28.00	27.00	21.00	30.35	13.00	15.00	13.70	10.00	4.05

Table 3. Effect of weather variables on cumulative and periodical progression of powdery mildew specks size (mm) on cultivars of rapeseed-mustard

Date of observations	Weather variables										Periodical Progression of powdery mildew					
	Temp. max. (°C)	Temp. min. (°C)	RH.M. (%)	RH.E. (%)	WS (km/hr)	SS (hrs.)	Rain (mm)	RH-9801	RH-30	RH-9304	RH-781	Varuna	YSPb-24	BSh-1	HC-9002	GSH-1
5th March	20.03	10.63	100.00	80.00	3.40	1.13	1.65	1.8	2.27	2.35	2.33	2.2	1.87	1.8	1.37	1.93
9th March	25.10	8.88	95.50	42.50	3.83	8.90	0.33	2.20 (0.40)*	3.07 (0.80)	3.27 (0.92)	2.87 (0.54)	2.67 (0.47)	2.27 (0.40)	1.93 (0.13)	1.47 (0.10)	2.20 (0.27)
13th March	26.13	7.85	89.50	37.25	2.95	9.83	0.00	3.10 (0.90)	3.37 (0.30)	4.43 (1.16)	3.33 (0.46)	2.87 (0.20)	2.40 (0.13)	2.73 (0.80)	2.07 (0.60)	2.20 (0.00)
17th March	30.50	10.70	94.75	37.75	2.08	9.88	0.00	3.42 (0.32)	4.07 (0.70)	5.00 (0.57)	3.83 (0.50)	3.67 (0.80)	3.20 (0.80)	3.33 (0.60)	2.63 (0.56)	2.20 (0.00)
21th March	33.05	14.20	87.00	33.25	3.38	6.93	0.00	4.33 (0.91)	4.67 (0.60)	5.20 (0.20)	4.23 (0.40)	4.67 (0.10)	3.60 (0.40)	3.40 (0.07)	3.60 (0.97)	2.87 (0.67)
25th March	30.98	11.28	88.50	36.50	4.13	9.15	1.15	4.33 (0.00)	4.67 (0.00)	5.20 (0.00)	4.23 (0.00)	4.67 (0.00)	3.60 (0.00)	3.40 (0.00)	3.60 (0.00)	2.87 (0.00)

*Periodical progression

the varieties/cultivars (Table 6). Mehta (2019) reported that number of environmental factors which are very crucial to influence the powdery mildew development of crucifers in to epidemic form after host-pathogen interaction. To cause the infection in susceptible host after landing of pathogen conidia on host surface their germination and formation of appressoria is maximum between 15-20°C temperatures.

CONCLUSIONS

The maximum disease intensity was recorded in variety Varuna followed by RH-30. The minimum disease intensity was in varieties HC-9002 and YSPb-24 .The, temperature (maximum) and relative humidity (morning) played pivotal role in development powdery mildew disease. The coefficient

of determinants (R^2) indicated that weather variable splay significant role in powdery mildew development and progression. The meteorological parameters can be used to develop weather-based disease prediction model which can be very helpful for issuing disease forewarning so that necessary precautions can be taken to manage disease incidence.

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Table 4. Regression equation for the progression of powdery mildew on various mustard varieties in relation to weather parameters

Varieties	Regression equation	R ²
RH-9801	Y= -14.50+0.52X ₁ -0.11X ₇	0.80
RH-30	Y= -20.30+0.76X ₁ -0.12 X ₇	0.92
RH-9304	Y=-16.10+0.52X ₁ -0.10 X ₇	0.80
RH-781	Y= - 11.30+0.45X ₁ -0.10 X ₇	0.81
Varuna	Y= -17.11+0.65X ₁ -0.11 X ₇	0.87
YSPb-24	Y= - 10.60+0.45X ₁ -0.06 X ₇	0.85
BSH-1	Y= - 8.90+0.40X ₁ -0.05 X ₇	0.70
HC-9002	Y= - 10.10+0.39X ₁ -0.05 X ₇	0.80
GSH-1	Y= - 0.80+0.80X ₁ -0.01 X ₇	0.74
<i>B. alba</i>	Disease did not appear	
X ₁ = Temperature (Maximum)	X ₅ = Average Evaporation (Morning)	
X ₂ = Temperature (Minimum)	X ₆ = Average Evaporation (Evening)	
X ₃ = Relative Humidity (Morning)	X ₇ = Wind Speed	
X ₄ = Relative Humidity (Evening)	X ₈ = Sunshine	

Table 5. Correlation matrix between powdery mildew (speck size, mm) and weather parameters in mustard varieties

Weather variables	RH-9801	RH-30	RH-9304	RH-781	Varuna	YSPb-24	BSH-1	HC-9002	GSH-1	<i>B. alba</i>
T. maximum (X ₁)	0.90*	0.92*	0.92*	0.90*	0.95*	0.68	0.88*	0.91*	0.65	-
T. minimum (X ₂)	0.42	0.41	0.42	0.45	0.42	0.63	0.45	0.43	0.60	-
Av. Evap. morning (X ₃)	0.61	0.55	0.59	0.61	0.58	0.54	0.65	0.63	0.50	-
Av.Evap. evening (X ₄)	-0.83*	-0.85*	-0.84*	-0.82*	-0.85*	-0.68	-0.82*	-0.84*	-0.68	-
RH morning (X ₅)	0.82*	0.82*	-0.82*	0.83*	0.82*	0.88*	0.82*	0.83*	0.85*	-
RH evening (X ₆)	0.25	0.28	0.26	0.25	0.28	0.20	0.25	0.27	0.20	-
Wind speed (X ₇)	-0.64	-0.63	-0.26	-0.63	-0.63	-0.48	-0.64	-0.64	-0.48	-
Sunshine (X ₈)	-0.79*	-0.70	-0.78*	-0.81*	-0.72	-0.80*	-0.81*	-0.75*	-0.82*	-

-Disease did not appear

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