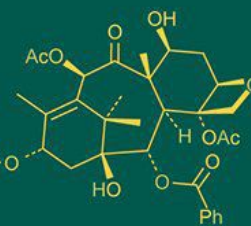
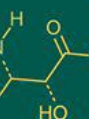
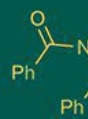
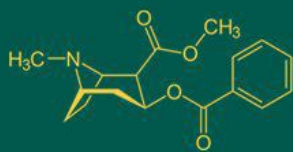


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Effect of weather parameters on severity of *Alternaria* blight of cumin caused by *Alternaria burnsii* in rajasthan

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Abstract

Agriculture is the main source of income for about 58% of India's people. Seed spices, which have seeds as their primary ingredient. Cumin is a widely favored seed spice globally, prized for its use in flavoring food, herbal remedies, and culinary applications such as soups, pickles, and vegetables. Weather data were analyzed using simple and multiple correlation and regression coefficient methods to establish a relationship with disease incidence, and linear equations were developed to predict disease intensity. The disease became noticeable from the third week of January to the first week of March. The results indicate significant variation in disease intensity due to various weather conditions. The correlation coefficient between individual weather variables and disease intensity was calculated for two crop seasons (*Rabi* 2022-23 and 2023-24). The disease intensity of *Alternaria* blight showed significant variation with all-weather variations. Maximum and minimum temperature, morning and evening relative humidity and rainfall was found significant with positive and negative correlation with per cent disease index. Multiple regression analysis indicates that there was 98 and 98.20 % influence of five meteorological factors and the remaining 2 and 1.8 % variations were unexplained during both the seasons, respectively.

Keywords: Cumin (*Cuminum cyminum*), *Alternaria* blight, *Alternaria burnsii*, Weather parameters, Disease severity

Introduction

Cumin (*Cuminum cyminum* L.) is believed to be originated from Mediterranean and near Eastern regions of the globe (Nabhan, 2014) [16]. India ranks first in terms of the acreage and production. Within India, it is extensively cultivated in Rajasthan, Gujarat and in some parts of Madhya Pradesh as *rabi* crop. Cumin is very popular and important among seed spices crops like coriander, fennel, fenugreek, Ajwain etc. The element in amount/100 g present in cumin contains energy 375 Kcal, carbohydrates 44.24 g, sugars 2.25 g, dietary fibers 10.5 g, fat 22.7 g and protein 17.81 g (Rai *et al.*, 2012) [17] and also contain 7.7% minerals and vitamins (vitamin-A, vitamin B₁, B₂, B₃, vitamin-C *etc.*) (Shankaracharya and Natarajan, 1971; Chadha, 2006) [18, 2]. It is also used in food and beverages industry as spice and condiment. Cumin is generally grown as a mono crop. The increasing population load and globalization has created high demand of cumin both in domestic and international markets. There is need to enhance the productivity levels to meet the increasing demand. The principal constraints to achieve high productivity are high yielding varieties, improper nutrient management and susceptibility of cumin to devastating diseases. The climatic conditions found in the two states of Rajasthan and Gujarat are more favorable for cumin cultivation, these two states contribute more than 80% in National area and production status. In India, cumin is grown as a *Rabi* crop, typically planted in October-November and harvested in February-March. Ensuring the proper seed rate is vital to achieve the desired plant population and maximize cumin production. The seed rate varies depending on the variety and planting method, with an ideal rate of 12 to 15 kg per hectare for cumin. Cumin thrives in a moderately cool and dry climate, with optimal temperatures ranging from 25 °C to 30 °C. Although it is a tropical plant, cumin can also grow well in a sub-tropical climate. Harvesting typically begins in the first week of March, depending on the planting date, with seeds being ready for collection around 110-120 days after sowing (DAS).

Cumin seeds can be separated by beating them on a clean threshing floor or using a cumin threshing machine (Malhotra and Vashishtha, 2008) [13].

This spice crop is subjected to many pathogens causing diseases which negatively influences the yield (Dange, 1995; Sharma *et al.*, 2010) [4, 19]. Cumin is highly susceptible to fungal diseases, especially when there is high humidity during flowering and fruit set. These diseases significantly affect the crop health. The plant is also very sensitive to rain, particularly during the harvesting period, as rain can lower both yield and quality. Frost damage is another major threat, especially during flowering and early seed formation. Cumin cannot tolerate shade and is extremely sensitive to any weather changes. For proper storage, dried cumin seeds should be kept in moisture-proof containers, away from direct sunlight. Factors such as fungal diseases, improper sowing dates, and successive planting are major contributors to reduce the cumin yield. Fungal diseases account for 38% of the yield reduction, while the sowing date contributes 30% and successive planting contributes 5% (Kamkar *et al.*, 2011) [10]. The average yield of cumin crop is low because of various factors such as non-availability of superior varieties, inappropriate crop production practices and susceptibility to diseases like *Alternaria* blight (*Alternaria* spp. Uppal, 1933)

[21], Fusarium wilt (*Fusarium oxysporum* f. sp. *cumini* Gaur, 1949) [6] and powdery mildew (*Erysiphe polygoni* D. C. Burns, 1921) [11].

Among various biotic stresses, *Alternaria* blight of cumin incited by *Alternaria* spp. is second most economically important disease after wilt. The disease was first noticed to be caused by *Alternaria* spp. from Bombay province and the causal agent was identified as *Alternaria burnsii* (Uppal *et al.*, 1938). In Rajasthan it was reported by Joshi (1955) [9].

Materials and methods

The experiment was conducted to investigate the effect of weather factors on the development of cumin blight on the susceptible cumin cultivar GC-4 during the *Rabi* seasons of 2022-23 and 2023-24 at the instructional Farm, Rajasthan College of Agriculture, Udaipur. Sowing of the susceptible cumin variety GC-4 was carried out in the 3rd week of November during both years. After germination, 40-day-old plants were inoculated with a spore suspension of *Alternaria burnsii* at a concentration of 2×10^6 conidia/ml. Disease severity was recorded from the initiation of symptoms and at seven-day intervals, using the 0-5 rating scale given by Jaiman *et al.*, (2013) [8].

$$\text{Per cent Disease Incidence (PDI)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

$$\text{Per cent Disease index} = \frac{\text{Sum of all numerical disease rating} \times 100}{\text{Total No. of plant assessed} \times \text{Maximum Grade}}$$

Grade	Per cent area infected	Disease reaction
0	No infection	Highly Resistant (HR)
1	0.1-10	Resistant (R)
2	10.1-25	Moderately Resistant (MR)
3	25.1-50	Moderately Susceptible (MS)
4	50.1-75	Susceptible (S)
5	> 75.1	Highly Susceptible (HS)

Various weather variables such as temperature, relative humidity (RH), and rainfall were recorded throughout the crop season, and their correlation with disease development was analyzed. The percentage disease intensity (PDI) was calculated for each reading until the crop reached maturity. Weekly meteorological data, including maximum and minimum temperature, morning and evening relative humidity, and rainfall, were obtained from the meteorological observatory at the instructional Farm, Rajasthan College of Agriculture, Udaipur.

Results

The first observation on per cent disease incidence was recorded during the first meteorological week (1-7 January) of each crop season and continued until the eleventh meteorological week (12-18 March). A total of eleven observations on disease incidence were recorded during both crop seasons. The data showed that the mean disease intensity ranged from 0.00 % - 36.38 % in tested cumin variety GC-4 during 1st to 11th meteorological week of *Rabi* season 2022-23 and it was observed 0.00 % - 25.94 % mean disease intensity during 1st to 11th meteorological week of *Rabi* season 2023-24.

During the period (*Rabi* 2022-23), average maximum and minimum temperatures ranged from 22.5 °C to 33.9 °C and 3.1 °C to 13.4 °C, respectively. The average morning relative humidity ranged from 62.1% to 83.7%, and the evening relative humidity ranged from 24.1% to 72.8%. During the period from the first to the eleventh meteorological week of *Rabi* 2023-24, the average maximum and minimum temperatures ranged from 23.3 °C to 31.5 °C and 6.1 °C to 11.8 °C, respectively, the average morning relative humidity ranged from 47.1% to 91.7%, and the evening relative humidity ranged from 19.0% to 43.7%. The regression and correlation coefficient between individual weather variables and disease intensity was calculated for the two crop seasons *Rabi* 2022-23 and 2023-24. During *Rabi* 2022-23, the observation with respect to progression of disease intensity of *Alternaria* blight was recorded (Table 1). The results for disease intensity of *Alternaria* blight showed significant variation with all-weather variations. The data showed that the value of *r* (0.637 and 0.646) for maximum and minimum temperature was found significant with positive correlation, value for *r* (-0.551) for relative humidity during morning hours was found significant with negative correlation and value of *r* (0.350) for relative humidity during the evening hours was found significant with positive correlation with PDI and value of *r* (0.195) for rainfall was found significant with positive correlation with PDI.

During *Rabi* 2023-24, the observation with respect to progression of disease intensity of *Alternaria* blight was recorded (Table 2). The results for disease intensity of *Alternaria* blight showed significant variation with all-weather variations. The data showed that the value of *r*

(0.673 and 0.569) for maximum and minimum temperature was found significant with positive correlation, value of r (-0.667 and -0.724) for relative humidity during morning hours and relative humidity during the evening hours was found significant with negative correlation and the value of r (0.00) shows absence of linear relationship between rainfall and PDI.

Multiple regression analysis (R^2) of PDI with epidemiological factors in Rabi

2022-23

Alternaria burnsii inoculated plants were periodically observed for per cent disease index (PDI). The effect on per cent disease, constant change in 1 °C maximum temperature resulted in 1.277-unit change PDI of disease. With a unit change in 1 °C minimum temperature disease will be decreased by -0.125 unit change in PDI of disease. In case of morning and evening relative humidity, 1% increase in morning relative humidity gave -0.127 unit change in disease index. However, 1% change in evening relative humidity resulted in -0.106 unit change in disease index. With increase in 1mm rainfall, disease was increased by 0.027 unit change in disease index. Multiple correlation coefficient (R^2) was 0.98 (98%). It indicates that there was

98% influence of five meteorological factors and the remaining 2% variations were unexplained (Table 3).

Multiple regression analysis (R^2) of PDI with epidemiological factors in Rabi

2023-24

Alternaria burnsii inoculated plants were periodically observed for per cent disease index (PDI). The effect on per cent disease, constant change in 1 °C maximum temperature resulted in 0.511-unit change PDI of disease. With a unit change in 1 °C minimum temperature disease will be decreased by 0.041 unit change in PDI of disease. In case of morning and evening relative humidity, 1% increase in morning relative humidity gave -0.285 unit change in disease index. However, 1% change in evening relative humidity resulted in 0.00 unit change in disease index which shows the absence of linear relationship between evening relative humidity and PDI. With increase in 1mm rainfall, disease was increased by -0.20 unit change in disease index. Multiple correlation coefficient (R^2) was 0.982 (98.20%). It indicates that there was 98.20% influence of five meteorological factors and the remaining 1.8% variations were unexplained (Table 4).

Table 1: Progression of *Alternaria* blight of cumin in relation to weather parameters (2022-23)

Week No.	Meteorological weeks	Temperature (°C)		R.H. (%)		X5	PDI* (%)
		X1	X2	X3	X4		
1	1 Jan.- 7Jan	22.5	3.1	77.5	35.1	0.0	0.00 (0.00)
2	8 Jan.-14 Jan	27.5	7.1	83.1	32.8	0.0	0.00 (0.00)
3	15 Jan - 21 Jan	22.3	1.8	77.7	34.1	0.0	0.00 (0.00)
4	22 Jan - 28 Jan	23.9	3.9	76.2	37.3	0.0	34.44 (35.93)
5	29 Jan - 4 Feb	23.7	6.8	83.7	37.8	37.2	34.63 (36.05)
6	5 Feb -11 Feb	29.8	7.4	73.4	30.2	0.0	35.11 (36.34)
7	12 Feb - 18 Feb	32.4	7.5	68.8	38.0	0.0	35.18 (36.38)
8	19 Feb -25 Feb	33.9	9.0	72.1	24.1	0.0	35.83 (36.77)
9	26 Feb - 4 Mar	33.1	11.4	69.2	56.8	0.0	36.14 (36.95)
10	5 Mar -11 Mar	32.7	11.6	62.1	55.2	2.4	36.25 (37.02)
11	12 Mar - 18 Mar	33.4	13.4	72.1	72.8	0.8	36.38 (37.10)
Total		315.20	83.00	815.90	454.20	40.40	283.96
Mean		28.65	7.55	74.17	41.29	3.67	25.81
SD		4.78	3.67	6.38	14.31	11.14	16.59
Regression		1.826	3.835	-1.698	0.789	0.564	

*PDI- per cent disease intensity, Values in parentheses are $\sqrt{\text{arcsine}}$ per cent angular transformed, X1- Maximum temperature, X2- Minimum temperature, X3- Relative humidity Morning, X4- Relative humidity evening, X5- Rainfall (mm)

Table 2: Progression of *Alternaria* blight of cumin in relation to weather parameters (2023-24)

Week No.	Meteorological weeks	Temperature (°C)		R.H. (%)		X5	PDI* (%)
		X1	X2	X3	X4		
1	1 Jan. - 7 Jan.	23.3	6.1	91.7	43.7	0.0	0.00 (0.00)
2	8 Jan. - 14 Jan.	25.1	7.1	84.6	39.7	0.0	0.00 (0.00)
3	15 Jan. - 21 Jan.	25.6	6.1	79.9	34.0	0.0	0.00 (0.00)
4	22 Jan. - 28 Jan.	25.7	4.8	79.6	30.7	0.0	23.23 (28.81)
5	29 Jan. - 4 Feb.	27.7	9.9	81.3	35.1	0.0	23.88 (29.25)
6	5 Feb. - 11 Feb.	25.5	8.3	73.4	35.4	0.0	24.43 (29.62)
7	12 Feb. - 18 Feb	26.4	7.4	76.4	30.4	0.0	25.23 (30.15)
8	19 Feb.- 25 Feb	28.4	9.0	63.7	25.1	0.0	25.42 (30.28)
9	26 Feb - 4 Mar	27.8	11.1	57.9	28.4	0.0	25.56 (30.37)
10	5 Mar - 11 Mar	28.8	9.0	47.1	24.1	0.0	25.84 (30.55)
11	12 Mar -18 Mar	31.5	11.8	55.6	19.0	0.0	25.94 (30.62)
Total		295.80	90.60	791.20	345.60	0.00	199.53
Mean		26.89	8.24	71.93	31.42	0.00	18.14
SD		2.24	2.19	13.90	7.17	0.00	11.68
Regression		3.130	2.257	-0.692	-0.849	-0.443	

*PDI- per cent disease intensity, Values in parentheses are $\sqrt{\text{arcsine}}$ per cent angular transformed, X1- Maximum temperature, X2- Minimum temperature, X3- Relative humidity Morning, X4- Relative humidity evening, X5- Rainfall (mm)

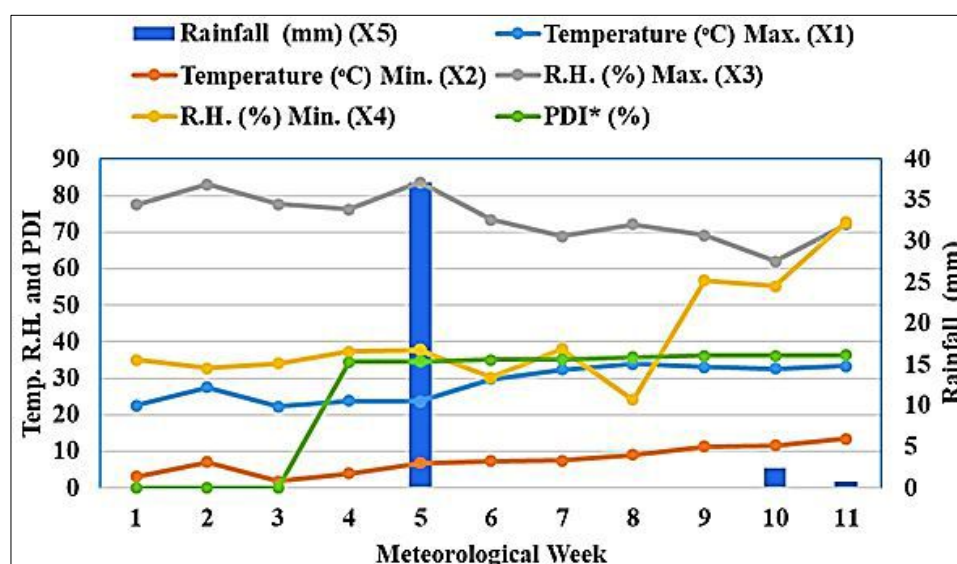
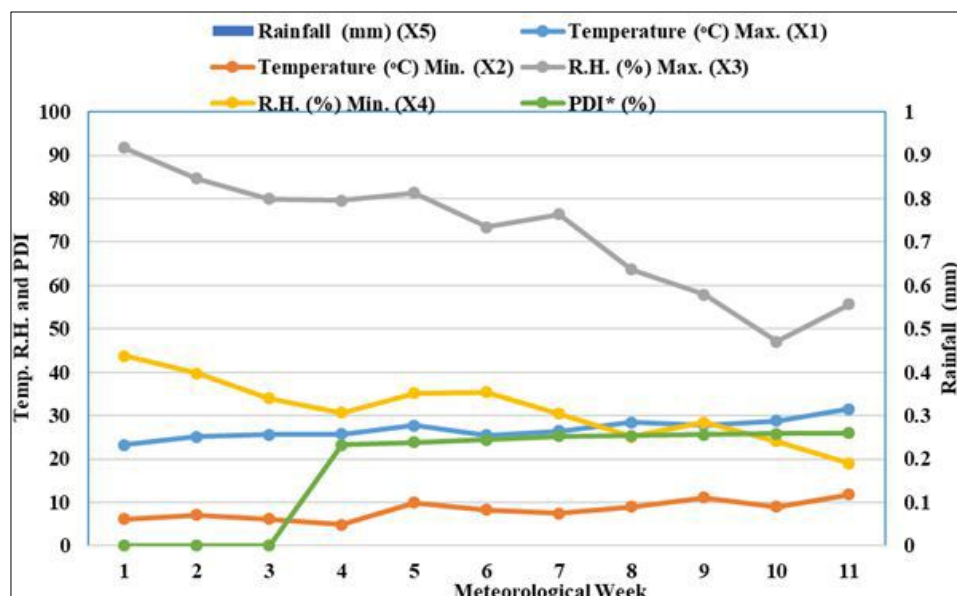
Table 3: Correlation matrix with per cent disease intensity of *Alternaria* blight of cumin and weather parameters on variety GC-4 during Rabi 2022-23 and 2023-24

Weather Variable	Correlation 2022-23	Correlation 2023-24
Temperature Maximum (°C)	0.637*	0.673*
Temperature Minimum (°C)	0.646*	0.569*
Morning Relative humidity (%)	-0.551*	-0.667*
Evening Relative humidity (%)	0.350	-0.724*
Rainfall (mm)	0.195	0.00

*Correlation is significant at 5 per cent level of significance

Table 4: Prediction equation and R² for predicting (Multiple regression equation 2022-23 and 2023-24)

Multiple regression equation 2022-23						R ²
Y= 20.016	+1.145 x ₁					0.879
Y= 40.299	+0.894 x ₁	-0.248 x ₂				0.919
Y= 44.723	+1.243 x ₁	-0.268 x ₂	-0.135 x ₃			0.963
Y= 36.789	+1.335 x ₁	-0.166 x ₂	-0.135 x ₃	-0.088 x ₄		0.979
Y= 33.264	+1.277 x ₁	-0.125 x ₂	-0.127 x ₃	-0.106 x ₄	+0.027 x ₅	0.980
Multiple regression equation 2023-24						R ²
Y= 20.017	+0.835 x ₁					0.816
Y= 28.853	+0.473 x ₁	-0.081 x ₂				0.893
Y= 28.275	+0.489 x ₁	+0.041 x ₂	-0.266 x ₃			0.980
Y= 28.275	+0.489 x ₁	+0.041 x ₂	-0.266 x ₃	+0.000 x ₄		0.982
Y= 29.033	+0.511 x ₁	+0.041 x ₂	-0.285 x ₃	+0.000 x ₄	-0.020 x ₅	0.982

**Fig 1:** Progression of *Alternaria* blight of cumin in relation to weather parameters (2022-23)**Fig 2:** Progression of *Alternaria* blight of cumin in relation to weather parameters (2023-24)

Discussion

In the present investigation, an attempt was made to study the effect of various weather factors on the initiation and development of *Alternaria* blight. These factors included maximum temperature (X1), minimum temperature (X2), morning relative humidity (X3), evening relative humidity (X4) and rainfall (X5). The pooled data revealed that the mean disease intensity was 25.81% and 18.14% during both the seasons.

The results for disease intensity of *Alternaria* blight showed significant variation with all-weather variations. Maximum and minimum temperature, morning and evening relative humidity and rainfall was found significant correlation with PDI. The value of r (0.637 and 0.646) for maximum and minimum temperature was found significant with positive correlation, value for r (-0.551) for relative humidity during morning hours was found significant with negative correlation and value of r (0.350) for relative humidity during the evening hours was found significant with positive correlation with PDI and value of r (0.195) for rainfall was found significant with positive correlation with PDI. Multiple regression analysis indicated that there was 98% influence of five meteorological factors and the remaining 2% variations were unexplained during *Rabi* 2022-23. The value of r (0.673 and 0.569) for maximum and minimum temperature was found significant with positive correlation, value of r (-0.667 and -0.724) for relative humidity during morning hours and relative humidity during the evening hours was found significant with negative correlation and the value of r (0.00) shows absence of linear relationship between rainfall and PDI. Multiple regression analysis indicated that there was 98.20% influence of five meteorological factors and the remaining 1.8% variations were unexplained during *Rabi* 2023-24. Kumar *et al.* (2002)^[12] reported that *Alternaria* blight in cumin occurs only after flowering and is heavily influenced by cloudy and humid weather conditions, particularly during February to March. The disease develops when the maximum temperature ranges from 20 °C to 35.3 °C, the minimum temperature ranges from 3.9 °C to 10 °C, and the mean relative humidity varies between 47.5% and 73.5%, along with a peak rainfall of 18.3 mm. In a separate study, Vihol (2004)^[23] observed that during the second standard week, the disease was favored by lower sunshine hours (6.9 hours), cloudy conditions lasting 4 to 5 days, and temperatures between 10.9 °C and 28.7 °C. The morning relative humidity ranged from 73.4% to 86.1%, which directly correlated with an increase in cumin blight intensity under field conditions. Sunder (2005)^[20] found that the severity of *Alternaria* blight was greatest during the 11th standard meteorological week, when the morning relative humidity reached 95%, the maximum temperature was 23.6 °C, and the minimum temperature was 12.9 °C. The present study suggests that all ten selected variables should be incorporated into multiple regression models for more effective prediction of *Alternaria* blight in cumin, particularly in arid and semi-arid conditions. Gemawat and Prasad (1972)^[7] found that sowing of cumin crop before 25th, November was suitable to reduce the disease incidence in Rajasthan. Extended date of sowing from October to December also increase the availability of continuous susceptible host in the area for longer periods (November to April) which results in spread of disease to the adjoining areas.

Champawat and Sharma (2009)^[3] studied the effect of temperature, relative humidity and rainfall on *Alternaria* blight of tomato caused by *Alternaria solani*. *Alternaria* blight of tomato was negatively correlated with all the parameter studied. The linear regression on the appearance of blight with weather parameters also gave significantly negative regression coefficients. The multiple regression analysis revealed that parameters contribute 77 per cent towards disease incidence, the effect of maximum temperature was negatively significant. Kumar *et al.* (2021)^[11] observed highest disease severity of leaf blight (14.80% & 15.7%) in the mid-June. High temperature (36.9°C & 38.1 °C), and relative humidity (94% & 96.4%) were found correlated with higher severity to *Alternaria* leaf blight. Meena *et al.* (2021)^[14] revealed that *Alternaria* blight of fennel is greatly favoured by relative humidity more than 80% and rainfall. A significant and positive correlation was recorded with morning and evening relative humidity whereas a negative non-significant correlation with maximum and minimum temperature. Fagodiya *et al.* (2022)^[5] showed the effect of various weather factors viz., temperature, relative humidity and rainfall under inoculated conditions on *Alternaria* leaf spot incited by *Alternaria alternata* and with staggered dates of sowing were taken to observe effect on disease progression and their effect on seed yield. Meno *et al.* (2022)^[15] showed that dispersal of *A. solani* and *A. alternata* in a potato field per hour in a day is influenced by the weather conditions that characterize the hour, but not the hour of the day. Specifically, the relative humidity and solar radiation were the most relevant weather parameters influencing the conidia concentration in the air and both in a linear model explained 98% of the variation of this concentration per hour.

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