Effect of environmental factors in the development of powdery mildew in okra [*Abelmoschus esculentus* (L.) Moench]

ABSTRACT

In order to study the effect of environmental factors in the development of powdery mildew in okra [*Abelmoschus esculentus* (L.) Moench] an experiment was carried out at the College of Agriculture, IGKV, Raipur, Chhattisgarh during *kharif* (2019-20).The correlation analysis revealed that the age of the crop was significantly, positively correlated and T max, T min and morning RH were significantly, negatively correlated with the disease severity. In addition to this by linear regression analysis, it was observed that plant age (69%), maximum temperature (62%), minimum temperature (60%) and morning relative humidity (46%) contributed in percent disease severity. Based on the proportional measures of extent of infection at different times the apparent rate of infection was found maximum during 70-84 DAS. At this time when the disease progress the average maximum temperature was 29.3℃, minimum temperature 14.9℃, morning relative humidity 87.6% and evening relative humidity 38.33%.

Keywords: *Powdery mildew, environmental factors, percent disease index, okra, correlation, simple linear regression, rate of infection*

INTRODUCTION

Okra, scientifically known as *Abelmoschus esculentus* (L.) Moench, and commonly referred to as Lady's finger or *Bhindi*, is a significant vegetable crop grown in India within tropical and sub-tropical climates. It belongs to the Malvaceae family.

Diseases significantly contribute to the limited yield of okra (Sastry and Singh, 1974). Among these diseases, fungal infections like powdery mildew (*Erysiphe cichoracearum* DC), leaf spot (*Cercospora abelmoschi*), leaf blight (*Rhizoctonia solani*), damping off (*Pythium* spp., *Rhizoctonia* spp. and *Fusarium* spp.) and viral diseases such as yellow vein mosaic, enation leaf curl are frequently encountered. Powdery mildew stands out as a particularly significant disease and its common occurrence leads to a substantial reduction in okra yield (Khalikar*et al*., 2011; Dahivelkar*et al.,* 2017).

Powdery mildew disease exhibits symptoms characterized by the presence of white, powder like spots on both the leaf and stems. As the disease advances, the mildew extends along

the entire length of the plant (Kothari and Shekhawat, 1972; Singh *et al*., 1988; Vijaya, 2004; Stephen and Chartfield, 2005; Bem*et al*., 2013;Adam, 2016).

Powdery mildew has a pattern in time and space and is influenced by multiple factors. The disease initiation and progress are weather dependent and some weather parameters, if not all, can critically influence the epidemic. With this background, the present research work was aimed to identify the critical weather parameters associated with the development of disease under field conditions.

MATERIAL AND METHODS

The experiment was conducted at Horticultural Farm, College of Agriculture, Raipur Chhattisgarh. The per cent disease index of powdery mildew was recorded from the tagged plants of each plot at weekly intervals.

Percent Disease Index (PDI)

It was calculated using the formula (Wheeler, 1969).

$$PDI = \frac{\text{Sum of all the numerical values X 100}}{\text{Total no. of leaves observed X Maximum grade}}$$

The disease was rated according to the disease rating scale (Table 1) as given by (Shivanna, 2003).

Table 1: Disease rating scale for powdery mildew

Grade	PDI	Reaction
0	0	Immune (No disease)
1	1-10%	Highly resistant (HR)
2	11-25%	Moderately resistant (MR)
3	26-50%	Moderately susceptible (MS)
4	51-75%	Susceptible (S)
5	More than 75%	Highly susceptible (HS)

Meteorological data

Data consisting of mean maximum and minimum temperature (^{0} C), rainfall (mm), relative humidity (%) and wind speed (km/hr) of *kharif* 2019 were collected from Agricultural Meteorology department of IGKV, Labhandi, Raipur, Chhattisgarh. The averages of all the variables were calculated. To determine the influence of various physical factors of the environment on the development of powdery mildew disease of okra the data were correlated with different meteorological parameters using the following formula

$$r = \frac{Cov(X,Y)}{\sigma x \times \sigma y} = \frac{\sum_{i=1}^{n}(X-\bar{X})}{\sqrt{\sum_{i=1}^{n}(X-\bar{X})^2} * \sqrt{\sum_{i=1}^{n}(Y-\bar{Y})^2}}$$

Where, X = values of the x-variable in a sample

Y = values of the y-variable in a sample

n = Total no. of observations

r = Correlation coefficient

Test of significance of correlation coefficient:

The test of significance of correlation coefficient means to test the hypothesis, whether or not the correlation coefficient is zero in the population that we test.

H: = ρ = 0 vs. H_1 :ρ ≠ 0

Test Statistics t =$\frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$

t-test value n-2 degrees of freedom

Also the data were further subjected to simple linear regression analysis to know the relationship between disease severity with different weather parameters.

Simple linear regression formula

The formula for a simple linear regression is:

$$y = \beta_0 + \beta_1 X + \epsilon$$

- **y** is the predicted value of the dependent variable
- **B_0** is the intercept**,**
- **B_1** is the regression coefficient,
- **x** is the independent variable,
- **e** is the error of the estimate.

Apparent rate of infection (r) and area under disease progress curve AUDPC (A-value) for powdery mildew severity was also calculated.

Apparent rate of infection (r)

The apparent rate of infection (r) serves as a measure of the speed at which an epidemic progresses. The formula for computing apparent rate of disease development as introduced by (Vanderplank, 1963), is calculated as r - value:

$r = 2.3/t_2 - t_1 \{\log x_2/1 - x_2 - \log x_1/1 - x_1\}$

Where, *r* is the apparent infection rate in non-logarithmic phase, x_1 is the disease index at initial week time (t_1), x_2 is the disease index at subsequent week time (t_2). The apparent rate of infection was computed at 7 days interval for genotype.

RESULT AND DISCUSSION

Disease Severity and progress of powdery mildew

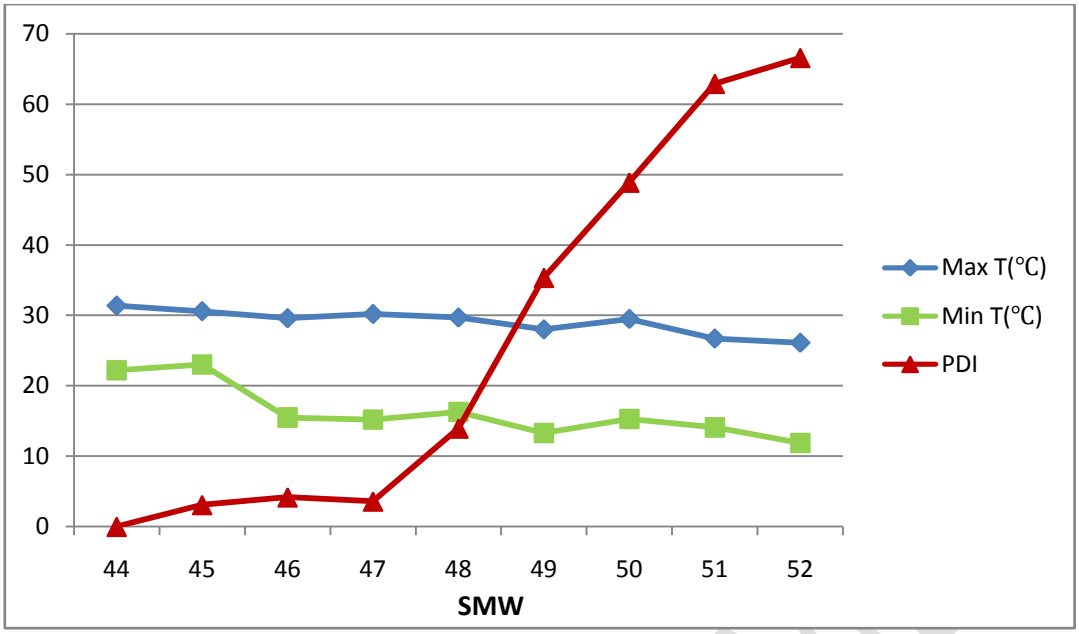
The okra crop under study was found disease-free up to 49 days after sowing and the initiation of the disease was first noticed on 56 days after sowing with 3.09 % disease severity. Disease severity was found highest during maturity at 52 Standard Meteorological Week (SMW) where it was 66.58%.

During the cropping period, maximum temperature ranged from 26.1 to 33℃, minimum temperature ranged from 11.9 to 25.5℃, relative humidity during morning ranged from 81 to 92%, relative humidity during evening ranged from 34 to 74%, wind speed was erratic and ranged from 1.2 to 4.5 km/hr (Table 2). Fig 1, 2, 3 and 4 shows the relationship of disease severity with the environmental factors, temperature, relative humidity, wind speed and age of the crop respectively. Data depicts that 30 ℃ temperature from 44 to 47 SMW favours for inoculums build up and thereafter as temperature declines favours disease progress in exponential fashion, this shows temperature range from 26 to30℃ were highly congenial for exponential disease progress (PDI). Disease progress and relative humidity showed negative relation with each other. Whereas wind speed and age showed positive relation with the disease progress.

Table 2: Meteorological parameters and Powdery mildew severity on local susceptible check variety

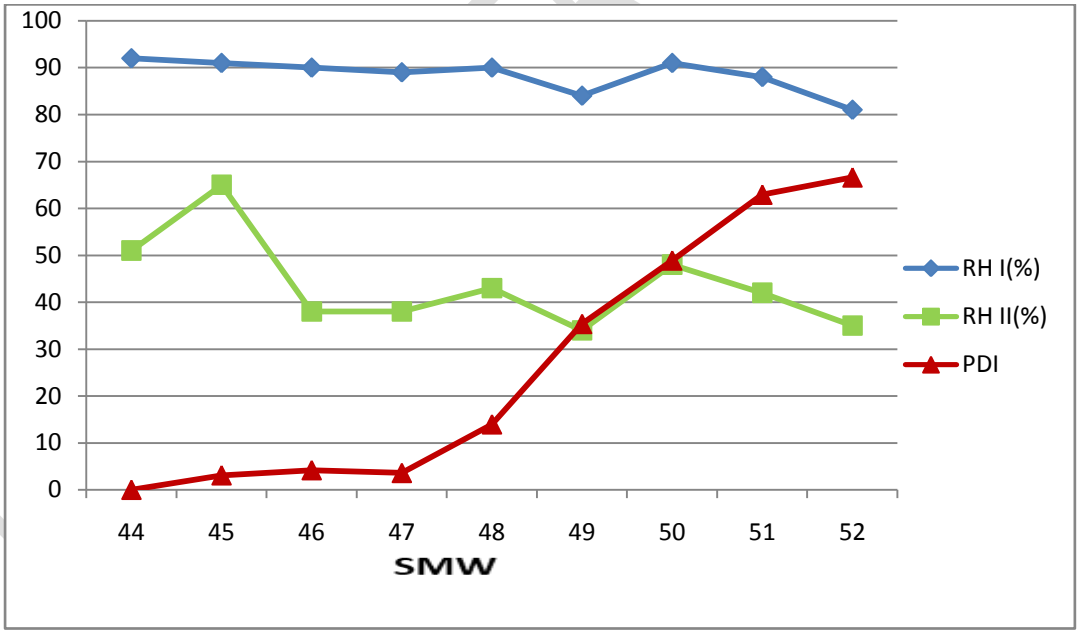
SMW	Age of crop	Temperature (°C)		RH (%)		Wind speed (km/hrs)	PDI
		Max	Min	Mor	Eve		Local susceptible check
38	7	33	25.5	88	63	3.6	0
39	14	30.2	24.2	91	74	4.5	0
40	21	32	24.3	90	64	3.8	0
41	28	31.3	23.6	91	64	2.4	0
42	35	30.9	21.8	92	65	2.6	0
43	42	28.1	22.2	92	71	3.7	0
44	49	31.4	22.2	92	51	1.2	0
45	56	30.6	23	91	65	3	3.09
46	63	29.6	15.5	90	38	1.8	4.18
47	70	30.2	15.2	89	38	1.4	3.59
48	77	29.7	16.3	90	43	2	13.95
49	84	28	13.3	84	34	2.4	35.35
50	91	29.5	15.3	91	48	1.7	48.87
51	99	26.7	14.1	88	42	1.9	62.9
52	105	26.1	11.9	81	35	2.5	66.58

SMW- Standard Meteorological Week; Temperature (Max and Min) - Temperature (Maximum and Minimum); RH- Relative Humidity; Mor- Morning. Eve - evening; PDI - Percent Disease Index.



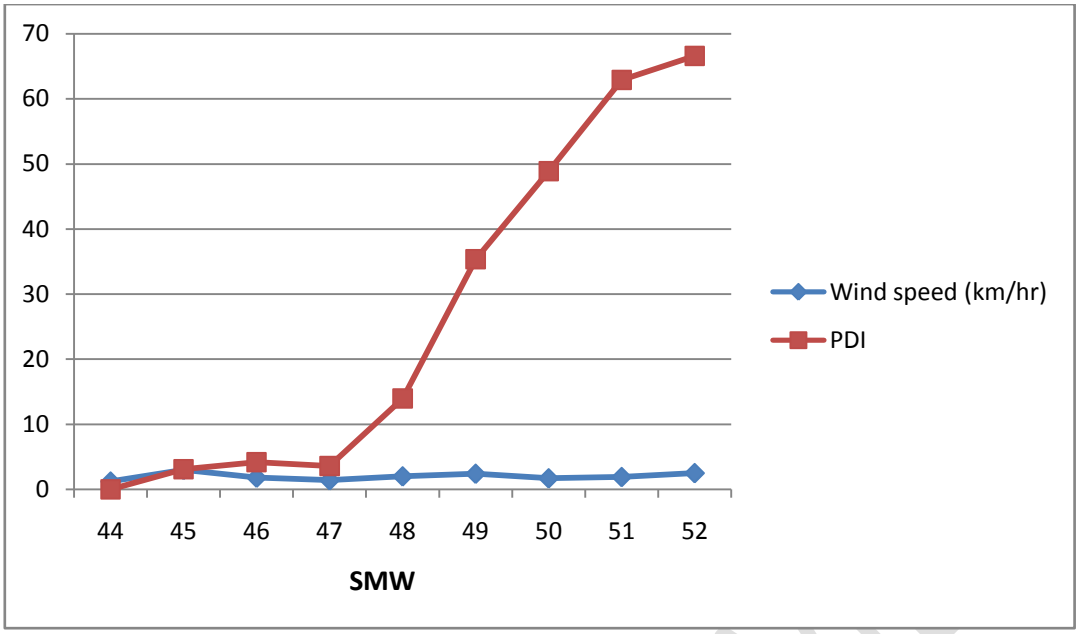
SMW-Standard Meteorological weak

Fig 1 Relation of disease severity with maximum and minimum temperature



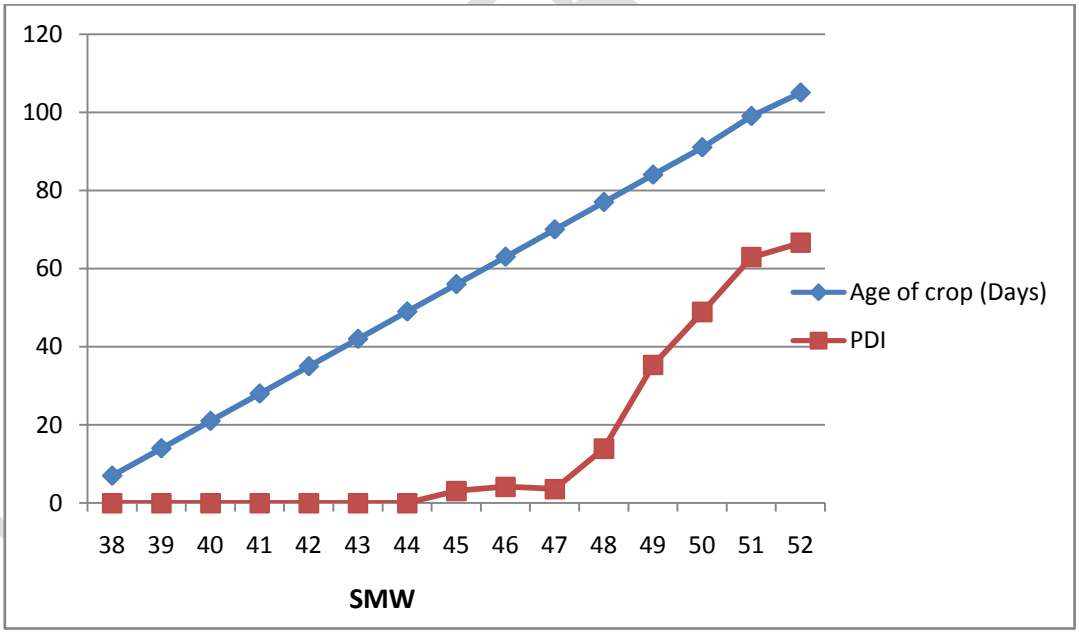
SMW-Standard Meteorological Weak

Fig 2 Relation of disease severity with morning (RH I) and evening (RH II) relative humidity



SMW-Standard Meteorological Week

Fig 3 Relation of disease severity with wind speed



SMW-Standard Meteorological Week

Fig 4 Relation of disease severity with age of the crop

Table 3: Simple correlation between disease severity and meteorological factors in local susceptible check

S.N.	Weather parameters	Correlation coefficient (r)
1	Maximum temperature(°C)	-0.8952*
2	Minimum temperature(°C)	-0.6940*
3	Relative humidity I %	-0.6517*
4	Relative humidity II %	-0.3876
5	Wind Speed (km/hrs)	0.2375
6	Plant Age	0.8346*

**significant at 5% (Table value is 0.514)*

It was observed from the correlation analysis that maximum temperature (-0.8952), minimum temperature (-0.6940) and relative humidity I (-0.6517) exhibited a significant negative correlation with the disease severity, whereas rainfall, relative humidity II were observed to be negative but non-significantly correlated with disease. Wind speed exhibited non-significant positive correlation with the disease. The age of the crop exhibited significant and positive correlation (0.8346) with the disease severity (Table 3).

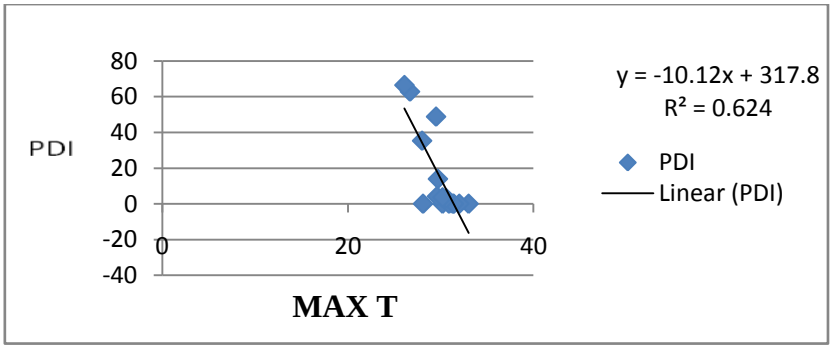
Percent Disease Index (PDI) and relative humidity were negatively correlated with each other this might be due to the reason that the conidia of *Erysiphe* contains more than 90% water and does not require much humidity from the environment for its germination. Wind speed showed a positive relation with the disease progress (PDI) which is necessary for inoculum build-up in the field.

In order to understand the relative importance of various weather parameters in explaining disease severity, the partial regression coefficients were also computed taking the disease severity as the dependent variable and maximum and minimum temperature, morning relative humidity and age as the independent variable. In a simple regression analysis (Table 4) the impact of weather parameters on the disease severity showed that age exerted 69 per cent role in variation which was highest than any other factor and was followed by

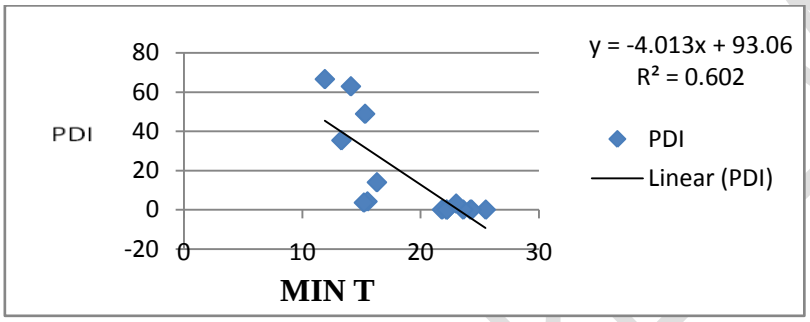
maximum temperature (62 per cent), minimum temperature (60 per cent) and relative humidity I (46 per gcent).

Table 4: Simple regression models along with coefficient of determination of individual weather factors on the disease severity of powdery mildew of okra in local susceptible check

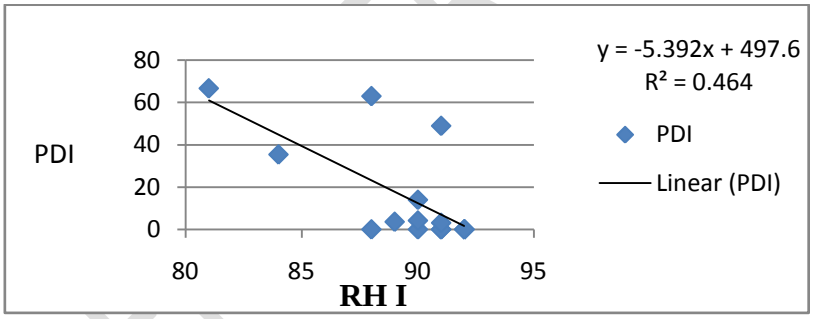
Weather Parameter	**Regression Equation**	**R^2**
Maximum Temperature	y = -10.12x + 317.8	0.624
Minimum Temperature	y = -4.013x + 93.06	0.602
Relative Humidity I	y = -5.392x + 497.6	0.464
Plant Age	y = 0.653x - 20.74	0.696



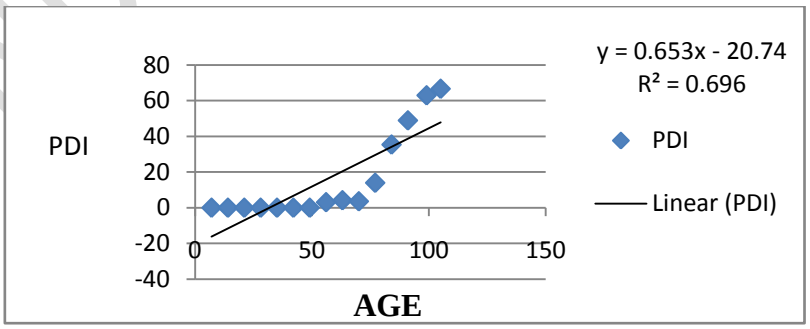
(a)



(b)



(c)



(d)

Fig5. Simple linear regression analysis of different weather parameters and disease severity (a) maximum temperature (b) minimum temperature (c) RH I (d) age

Our results corroborate with the findings of various workers who reported a negative correlation of the temperature and relative humidity with the severity of the disease, (Thakur and Agrawal, 1995; Gupta *et al*., 2001). (Ruppel and Tomasovic, 1977) also reported that powdery mildew disease severity increased with the age of the plant.

Disease progress based on proportional measures of extent of infection at different times (viz, 56-70, 70-84 and 84-99 days after sowing was calculated (Table 5).

Table 5: Apparent rate of infection

Rate of infection 'r'			Average 'r'
56-70 DAS	**70-84 DAS**	**84-99 DAS**	
0.0031	0.0260	0.0025	0.0105

DAS- Days After Sowing

The apparent rate of infection was found to be maximum during 70 -84 days showed higher rate of progress of the disease. The average maximum temperature during this period was 29.3 ℃, minimum temperature 14.9 ℃, morning relative humidity 87.6% and evening relative humidity 38.33 % (table 2). Our findings align with previous research, demonstrating a higher disease progression between 66 to 87 days of crop age, specifically during the fruiting stage, as reported by (Sharma, 2016). Favourable range of temperature and relative humidity for disease development was observed to be 10 to 33°C and 45 to 95%, respectively in okra as noted by (Band *et al.,* 2007) and average temperature range between 19.7 to 28.9 ℃, humidity range between 60.2 to 87.7 per cent was found to be an ideal condition for powdery mildew disease development in sesamum, (Jagtap *et al*., 2019). The growth stage of the plant seems to be a crucial factor in the development of powdery mildew, as noted by (Sivaprakasam *et al*., 1981), (Sharma, 1992) and (Mishra and Shirsole, 2017).

CONCLUSION

Powdery mildew is a major fungal disease of okra. The environmental factors affect the development of the powdery mildew disease. The T (max), T (min) and morning RH showed a significant but negative correlation with the severity of the disease, whereas age of the crop was found to be significant and positively correlated with disease severity in the local susceptible check variety studied. The disease progress was highest during 70-84 days after sowing when the average maximum temperature was 29.3 ℃, minimum temperature 14.9 ℃, morning relative humidity 87.6% and evening relative humidity 38.33 %. The result of regression analysis showed age, maximum & minimum temperature and morning relative humidity accounted for 69 per cent, 62 per cent, 60 per cent and 46 per cent of the variation in the disease, and were identified as a responsible factors of epidemic development.

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