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Influence of different weather parameters on development of early blight of tomato in Gird region of Madhya Pradesh, India

N. Shivajyothi, Prashant Kumar Singh, Shyam Kishor Patel, Prashant Singh, M. Harindra and Talapati A.C. Vydyanad

[1]School of Agriculture, ITM University, Gwalior, M.P., India

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ABSTRACT

The most devastating disease in all tomato-growing regions of the world is early blight, also known as target leaf spot of tomato, which is caused by the necrotrophic fungus *Alternaria solani.* The effect of environmental conditions on the emergence of early blight was researched during the winter of 2021–2022. The illness always began to show symptoms during the 47th Standard Meteorological Week (SMW) and quickly spread throughout the growing season. Maximum temperature, minimum temperature, and evaporation all had statistically positive correlations, however maximum relative humidity and the severity of early blight disease were shown to be strongly negatively correlated. The stepwise regression model predicted that the minimum humidity and maximum temperature would account for 80% of the variation in the disease severity. A model created utilising the experimental data can be utilised to forecast the development of tomato early blight, which will aid in the adoption of timely management techniques.

Key words: *Epidemiology, Weather parameters, Correlation, Stepwise regressions, Early blight of tomato*

Introduction

After potato (*Solanum tuberosum*), the second most popular vegetable grown is the tomato (*Solanum lycopersicum* L.). It belongs to the Solanaceae family, is a native of South America, and is presently cultivated in about 140 different countries. The tomato crop is grown on 0.81 million hectares in India, second just to China in terms of area and production, with an annual output of 20510 thousand tonnes and a productivity of 16100 kg/ha (Anon., 2017). India has a wide range of agroclimatic areas where it is grown, from moderate to dry. Diseases are regarded as the primary production restrictions that cause the decline in yield among the various biotic and abiotic factors. Early blight causes tomato crops to completely defoliate when there is a heavy rain, high moisture percent in environment, and high temperature (Chaerani and Voorrips, 2006). It has been reported that this disease has caused yield reductions of 20-30 % in the USA (Christ and Maczuga, 1989), 30–65% in India (Munde *et al.*, 2013). 5–40% in Israel (Olanya *et al.*, 2009). Additionally, the disease causes collar rot in seedlings, which results in a 20–40% loss (Sherf and MacNab, 1986). For every 1% rise in early blight intensity, crop decrease is estimated to be 1.36 % (Sahu and Das, 2012). At various phases of tomato plant growth and development, the pathogen of early blight is responsible for inducing a range of symptoms on all the aerial part of plants (Verma and Verma, 2010). The symptoms began as minute, darkish circular lesions on the leaves and eventually spread to another arial parts of plant like stems and petioles and petioles, resulting in defoliation and a reduction in yield and fruit quality (Gudmestad *et al*., 2013). The oldest leaves typically get primary infections first, which then spread upward to finally damage the youngest leaves (Foolad *et al*., 2002). The pathogen can remain in the soil for a long time on infected plant debris as vegetative mycelia of conidia without its primary host (Runno-Paurson *et al*., 2015). It can also survive on different crops, such as *Solanum tuberosum*, *Capsicum*, and *Solanum melongena* (Ellis and Gibson, 1975). Weather factors significantly influence how the disease develops. The three primary variables that influence the onset of early blight epidemiological conditions in tomatoes are temperature, leaf wetness duration, and moisture percent in environment (Olanya *et al*., 2009). The disease spreads quickly when there are intermittent periods of rain followed by warm, dry weather.

In the lack of cultivars resistant to early blight, fungicides are highly advised (Gudmestad *et al.*, 2013). Huge amounts of chemical fungicides are used in the production of vegetables, which raises the cost of farming, exposes farmers to health risks, leaves behind pesticide residues (Paranagama *et al*., 2003), leads to the emergence of pathogens with fungicide resistance (Kirk *et al*., 2005), and is a growing source of concern for environmentalists and public health officials. To effectively and fairly schedule fungicidal treatments to prevent tomato early blight, a better understanding of disease epidemiology is required. This will boost the fungicidal efficacy and remove the obstacles previously connected with the use of fungicides (Frenguelli, 1998). For the purpose of improving the efficacy of management practises, a number of epidemiological models based on temperature (°C), relative humidity (%), evaporation (mm), sunshine hours (hours) and rainfall (mm) have been developed (Bal *et al*., 2008; Saha and Das, 2014; Devi and Chanu, 2012; Gupta *et al*., 2020).

In Madhya Pradesh, there are very few published studies on tomato early blight epiphytotics. Despite the fact that the disease has caused fruit production and quality to significantly fall in prior years. The appears of tomato early blight in the Madhya Pradesh is exacerbated by the lack of an appropriate tolerant/resistant cultivars against the disease, the persistence of the inoculum in the soil, secondary hosts, early blight-infected plant debris, and the whims of the local environment. Considering the aforementioned information, the current research was carried out in the year 2021-22 to know the impact of weather factors on early blight of tomato in the Madhya Pradesh.

Materials and Methods

The current research was done during rabi 2021–2022 at the Crop Research Center, Farm Turari, ITM University, Gwalior, to determine the role that weather factors on onset and progression of tomato early blight. During the second week of November, Pusa Puby seedlings were grown in a nursery and transplanted in field at 60 × 45 cm spacing. To grow a healthy crop, these suggested tomato cultivation methods were all implemented. In the experimental plots, no preventative spraying of any fungicide was done, allowing the disease to spread. Five randomly selected plants were labelled in each replication, and every seven days starting on the day of transplantation, PDI of tomato early blight was observed on leaves (Singh *et al.*, 2011). The percent disease index (Mckinny, 1923) was computed using the data. The data of meteorological parameters like temperature, humidity, rainfall and evaporation were collected from the Meteorological Observatory, College of Agriculture, Gwalior (M.P.). The weather data were correlated with the weekly PDI data in order to determine the Pearson Correlation Coefficient (r), which was used to assess the relationships between the disease and the climatic parameters. Additionally, regression equations were calculated. Stepwise multiple linear regressions were used to further analyse the data and validate the linearity of weather parameters and disease severity for the development of the disease prediction model.

$$DS = \frac{A \times 100}{B \times C}$$

Where,

DS=Disease severity

A=Sum of individual rating

B=Number of leaves examined

C=Maximum disease rating

Results and Discussion

Progressive disease development

During the development of early blight, the maximum temperature was ranged from 14.40 to 28.60 °C, the minimum temperature from 4.70 to 11.60 °C, the maximum relative humidity from 86.70 to 97.80

Table 1. Descriptive statistics of weather parameters and the severity of blight of tomato

Variable	Min	Max	Mean	SD
Maximum Temperature (°C)	14.40	28.60	22.46	2.93
Minimum Temperature (°C)	4.70	11.60	7.87	1.81
Maximum Relative Humidity (%)	86.70	97.80	90.68	3.24
Minimum Relative Humidity (%)	42.50	69.80	58.81	5.99
Rainfall (mm)	0.00	30.60	3.21	5.05
Evaporation (mm)	0.70	4.50	2.03	0.76
Disease severity (%)	3.25	52.25	22.55	13.12

%, the minimum relative humidity from 42.50 to 69.80 %, the evaporation from 0.70 to 4.50 mm and the rainfall ranged from 0.00 to 30.60 mm (Table 1). Minilar experiment was conducted by Pandey *et al.* (2011) who reported that the maximum temperature during early blight development was 14 to 18 °C, minimum temperatures of 6-21 °C, maximum relative humidity of 54-93 percent, and minimum relative humidity of 20-68 percent. Similar experiment was conducted by According to Sahu *et al*. (2014), the high early severity of tomato appeared during a time when the relative humidity levels were on average 65 percent, the maximum temperature ranged from 25.6 to 28.3 °C, and the minimum temperature ranged from 13.6 to 14.6 °C. Initial symptoms of early blight were recorded in 12 SMW with an average PDI of 15.97 under natural field condition. 27.5 °C and 12.8 °C maximum temperature and minimum temperature, respectively were observed during the period, while max. RH was around 82 per cent, min. RH was around 81 per cent and weekly average rainfall around 11 mm (Gupta *et al*. (2020).

Correlative analysis and Stepwise regression

During the present investigation, correlation coefficient was calculated between disease severity of early blight and weather factors like max. and min. temperature, max and min RH, average rainfall and evaporation, it was found that the early blight severity significantly correlated with the maximum temperature, minimum temperature, and evaporation, having Pearson correlation coefficient value of 0.8453, 0.5660 and 0.7907, respectively, significantly negative correlation (-0.5351) was observed between maximum humidity and disease severity. Based on correlation analysis, disease severity was not significantly influenced by remaining two weather parameters viz., minimum humidity (0.0915) and rainfall (-0.1606). According to Sahu *et al*. (2014), there was a statistically negative correlation between early blight severity and maximum RH (-0.541), minimum RH (r=–0.593), and rainfall (r=–0.531). According to study by Devi *et al*. (2017), the relationship between early blight severity and two meteorological parameters like max. temp. and relative humidity was significantly positive. According to Parmar *et al*. (2020), maximum and minimum temperatures had significantly negative correlation. Furthermore, they asserted that the coefficient of determination's value (R2 = 0.933) showed that weather factors had a 93.30% influence on the progression of tomato early blight.

A stepwise regression analysis was performed considering six environmental factors (Max and min. temperature, max. and min. RH, rainfall and

Table 2. Correlation of weather parameters with the severity of early blight of tomato

Weather factors	Correlation coefficient (r)
MaximumTemperature (°C)	0.8453
Minimum Temperature (°C)	0.5660
Maximum Relative Humidity (%)	-0.5351
Minimum Relative Humidity (%)	0.0915
Rainfall(mm)	-0.1606
Evaporation (mm)	0.7907

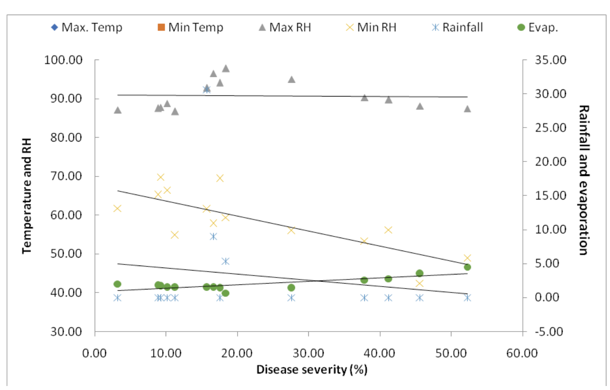

Fig. 1. Regression line between disease severity and weather parameters

Table 3. Stepwise regression of meteorological factors and the severity of tomato early blight

Variable	Coeff	SE	t-stat	Stand Coeff	p-value	VIF
Intercept (b)	3.5026	0.3894	8.9944	0.00	0.000002	
MaximumTemperature (°C)	0.6688	0.1303	5.1320	0.7273	0.000327	1.0973
Maximum Relative Humidity (%)	-0.3558	-0.1458	-2.4408	-0.3459	0.032774	1.0973

R square (R^2) equals 0.7986; adjusted R-squared =0.7620)

evaporation) as independent factors and early blight severity as dependent factor. The stepwise regression analysis revealed that out of six variables two variables maximum temperature and maximum relative humidity were found suitable for explaining variation in severity of early blight. The regression model as significant and was Y = 3.50 + 0.6689 (Max. temp.) - 0.3558 (Max. RH). The r square value of the model was 0.7986 which means 79.86% of the variation present in disease severity was explained by maximum temperature and maximum relative humidity. Our results agree with those of other researchers who have also noted that meteorological factors account for 94% of the variation in early tomato blight (Sahu *et al*., 2014; Ruth *et al*., 2016; Gupta *et al*., 2020; Parmar *et al*., 2020; Sudarshan *et al*., 2020).

Conclusion

The severity of early blight and relevant weather data were correlated to investigate towards how tomato early blight spread. Tomato early blight disease severity correlated positively with maximum temperature and negatively with maximum relative humidity. The model that was created showed that the maximum relative humidity and temperature influenced 79.86 percent of the variation in the tomato early blight severity. The results of this study will aid in the creation of a regional system for disease forecasting for the tomato early blight disease. As a result, this model may be verified and used in agricultural consulting to manage disease.

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