# Progress and severity of early blight of tomato in relation to weather variables in Jammu province

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## ABSTRACT

Early blight of tomato caused by *Alternaria solani* is an economically important disease in all the tomato growing areas worldwide. The effect of weather variables on the per cent disease intensity(PDI) index of early blight were analyzed during the early summer season of five consecutive years from 2013 to 2017. The disease invariably appeared in the 12[th]Standard Meteorological Week (SMW) and had steep progression throughout the cropping period. Maximum and minimum temperatures had significantly positive correlation, whereas, maximum and minimum relative humidity along with rainfall had significantly negative correlation with the PDI of early blight of tomato. The model developed by stepwise regression explained that 83per cent variation in the PDI of the disease was due to maximum temperature. The model developed based on the data collected during the studies can be used for predicting the appearance of early blight of tomato, thereby helping in the adoption of timely management measures.

*Key words:* Early blight, epidemiology, correlation, stepwise regressions, tomato

India contributes about 19.0 and 11.1 per cent in terms of total area and production of tomato, respectively, in the world. Whereas, in India, tomato contributes to 8 and 12 per cent of total area and production, respectively of vegetable cultivation.In Jammu and Kashmir,tomato is cultivated over an area of 358000 ha with production and productivity of 8.8 lakh tonnes and 24.83 tonnesha[-1], respectively (Anonymous, 2017). However, tomato crop is severely infected by various abiotic (extreme temperatures, salinity, drought and excessive moisture) and biotic (insect pests and diseases) stresses from nursery to harvest.

Amongst the biotic stresses, early blight caused by *Alternaria solani* (Ellis & Martin) Sorauer, causes complete defoliation of tomato crop under heavy rainfall, high humidity and high temperature (24–29°C) conditions (Chaerani and Voorrips, 2006). In the United States, 20 to 30 per cent (Christ and Maczuga, 1989),in Israel 5 to 40 per cent (Rotem and Feldman, 1965; Olanya *et al.,* 2009); in India30 to 65 per cent (Mathur and Shekhawat, 1986; Prasad and Naik, 2004; Munde *et al.,* 2013) reduction in yield has been reported due to this disease. The pathogen also causes collar rot of seedlings resulting in 20-40 per cent loss (Sherf and MacNab, 1986). For every one per cent early blight intensity, 1.36 percent yield reduction has been estimated (Saha and Das,2012).

*A. solani* is responsible for causing various types of symptoms on all the above ground parts of the tomato plants during different stages of plant growth and development (Peralta *et al.*, 2005; Verma and Verma, 2010). Initially, small and dark concentric lesions emerge on the leaves followed by symptoms on the stems and petioles (Gudmestad *et al.,* 2013), eventually causing defoliation and reducing yield and fruit quality (Foolad *et al.,*2002). Primary infections normally occur on the oldest leaves and move upward eventually affecting the youngest leaves.

The pathogen has the ability to survive for longer periods in the soil as mycelia or as conidia on infected plant debris in the absence of main host (Runno-Paurson *et al.,* 2015) and is also able to survive on other host plants like potato, eggplant and pepper (Ellis and Gibson, 1975). Environmental factors play a major role in the development ofthe disease. Temperature, leaf wetness duration and relative humidity are the main contributing factors for the onset of early blight epiphytotic conditions in tomato (Vloutoglou and Kalogerakis, 2000; Olanya *et al.,* 2009). Under intermittent conditions of rains followed by warm and dry weather, the disease spreads very rapidly.

In the absence of the availability of resistant cultivars, systemic and contact fungicides are widely recommended for the management of early blight (Gudmestad *et al.,* 2013). Enormous uses of synthetic fungicides in vegetable
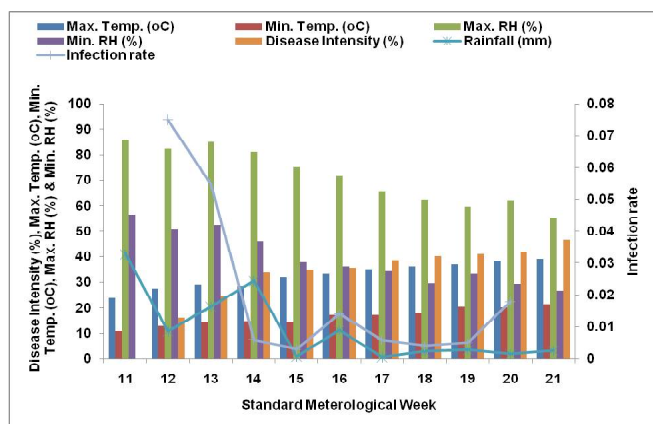
**Fig. 1:** Effect of weather variables on the intensity of early blight of tomato

production is accountable for increased cost of cultivation, exposure to the health hazards, pesticide residues (Paranagama *et al.,* 2003), development of fungicide resistant strains of the pathogen (Kirk *et al.*, 2005) and also the subject of growing concern for both environmentalist and public health authorities.

For the proper and rational timing of fungicidal sprays for the management of the early blight of the tomato, better understanding of disease epiphytotics is crucial to increase the fungicidal efficacy and to overcome the limitations that have been associated with the fungicidal application (Frenguelli, 1998). Various epidemiological models based on the temperature, relative humidity and rainfall have been developed for the prediction of foliar diseases for enhancing the efficacy of the management practices (Díaz *et al.,*1998; Wiik, 2002;Bal *et al.,* 2008; Kaur *et al.,* 2011;Devi and Chanu, 2012; Saha and Das, 2014; Gupta *et al.*, 2017).

There are negligible published studies regarding early blight epiphytotics of tomato in Jammu region. Though in recent years the disease has caused serious losses in the fruit yield and quality due to the disease.Non-availability of suitable resistant variety against early blight, perpetuation of the inoculum in the soil and infected plant debris/collateral hosts,and the regional climatic vagaries act as the compounding factors for the severity of the disease in Jammu region. Keeping in view of above facts, present studies were conducted during 2013-2017 with an aim of study the effect of weather variables on the infection and development of early blight in tomato in Jammu region.

## MATERIALS AND METHODS

The present investigations regarding the effect of weather variables such as temperature, relative humidity and rainfall in the initiation and development of early blight

of tomato on cv. Pusa Ruby were conducted during the early summer seasons from 2013 to 2017, at the University Research Farm, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha. Seedlings of Pusa Ruby were raised in the nursery under poly-house and the healthy seedlings were transplanted in to the field in first fortnight of February, with row to row and plant to plant spacing of 60 x 45 cm. The experiment was laid out in Randomized Block Design (RBD) with four replications for each treatment for the successive five years (2013-2017). All these rcommended practices for the cultivation of tomato were adopted to raise healthy crop (Anonymous, 2010). In order to develop the disease, no protective spray of any fungicide was conducted in the experimental plots. Five plants were selected randomly in each replication, labelled and severity of early blight was recorded on leaves at seven-day intervals, starting from the date of transplanting,using 0-9 grade scale (Mayee and Datar, 1986). Based on the data,percent disease index (Mckinny,1923) and apparent infection rate (r) (Vander Plank, 1963) were calculated.

The weekly data on the weather variables (maximum and minimum temperature, maximum and minimum relative humidity and rainfall) were collected from the Agro-meteorological Section of the University. The data regarding weather variables were correlated with the recorded weekly PDI to calculate the Pearson's correlation coefficient (r), for assessing the association among the significant weather variables with the disease. The data were further subjected to the step-wise multiple linear regressions in order to analyse the linearity of the independent (weather) and dependent (PDI) variables for developing the model for disease prediction. Correlation and stepwise regression analysis were calculated using XLSTAT.

## RESULTS AND DISCUSSION

### Progressive disease development

Under natural conditions,during the 2013-2017, the primary infection of early blight on cv. Pusa Ruby appeared in the 12 SMW having average PDI of 15.97. During the period maximum temperature of 27.5°C, minimum temperature of 12.8°C, maximum relative humidity of 82.4 per cent, minimum relative humidity of 50.8 per cent and rainfall of 10.9 mm was recorded (Fig. 1). The disease increased sharply from 15.97 to 33.76 per cent during12 – 14SMW,which had corresponding maximum temperature of 27.5 to 28.52°C, minimum temperature of 12.8 to 14.6°C, maximum relative humidity of 82.4 to 81.2 per cent, minimum
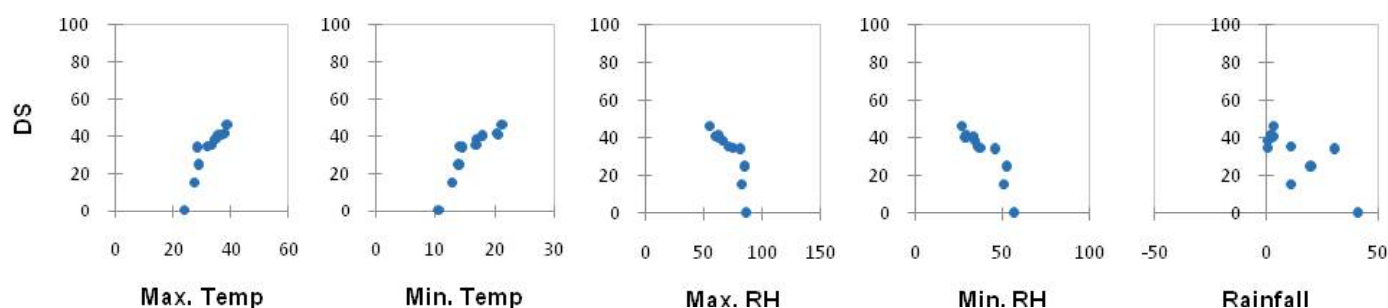
**Fig. 2:** Scatter plot of weather variables and the intensity of early blight of tomato

**Table 1:** Descriptive statistics of weather variables and the intensity of early blight of tomato

| Variable | Minimum | Maximum | Mean | Std. deviation |
|---|---|---|---|---|
| Disease intensity (%) | 0.000 | 46.550 | 31.268 | 14.094 |
| Max. temp. (°C) | 23.880 | 39.060 | 32.320 | 5.021 |
| Min. temp. (°C) | 10.800 | 21.420 | 16.260 | 3.582 |
| Max. RH (%) | 55.200 | 85.800 | 72.400 | 11.258 |
| Min. RH (%) | 26.600 | 56.600 | 40.300 | 10.451 |
| Rainfall (mm) | 0.600 | 41.020 | 12.404 | 14.005 |

**Table 2:** Correlation of weather variables with the intensity of earlyblight of tomato

| Weather variable | Disease intensity(%) |
|---|---|
| Max. temp. (°C) | 0.915 |
| Min. temp. (°C) | 0.874 |
| Max. RH (%) | -0.829 |
| Min. RH (%) | -0.909 |
| Rainfall (mm) | -0.771 |

relative humidity of 50.8 to 46.0 per cent and rainfall of 10.9 to 30.5 mm. The apparent infection rate varied from 0.03 to 0.075.

During the development of early blight, disease ranging from 0.00 to 46.55 per cent, the maximum temperature was in the range of 23.8 to 39.0°C, minimum temperature 10.8 to 21.4°C, maximum relative humidity 55.2 to 85.8 percent, minimum relative humidity 26.6 to 56.6 percent and rainfall of 0.6 to 41.0 mm (Table 2). In the Gangetic plains of Utter Pradesh, maximum temperature of 14.0 to 38.0°C, minimum temperature of 6.0 to 21.0°C, maximum relative humidity 54-93 percent and minimum relative humidity 20-68 percent during the development of early blight in tomato was reported by Pandey (2011). Sahu *et al.* (2014) also recorded high disease severity of early blight of tomato during the period when maximum temperature of 25.6-28.3°C, minimum temperature of 13.6-16.4°C and average

relative humidity of 65 per cent prevailed. Pandey (2003) recorded apparent infection rate (r) ranging from 0.1106 to 0.0307 in early blight of tomato.

***Correlation and stepwise regression***

While conducting the correlation analysis of PDI of early blight of tomato with prevalent weather variables (maximum and minimum temperature, maximum and minimum relative humidity and rainfall), it was observed that the maximum and minimum temperatures had significantly positive correlation with the PDI, having correlation co-efficient (r) values of 0.91 and 0.87, respectively, (Table 3), whereas, maximum and minimum relative humidity, and rainfall had significantly negative correlation with the disease severity, having correlation coefficient (r) values of -0.82, -0.90 and -0.77, respectively (Fig. 2). Sahu *et al.* (2014) reported that relative humidity during morning (r=-0.550 in 2011-12 and -0.541 in 2012-13), evening (r=-0.593 in 2012-13) and rainfall (r=-0.531 in 2012-13) had significantly negative correlation with PDI of early blight of tomato.

In Pusa Ruby, the developed stepwise regression equation was highly significant in predicting the severity of early blight of tomato (Table 3). Among the various weather parameters, 83 per cent variation was explained by the maximum temperature, thereby predicting an increase/decrease in disease severity by 2.56 per cent per week by per unit increase/decrease in maximum temperature, if all the
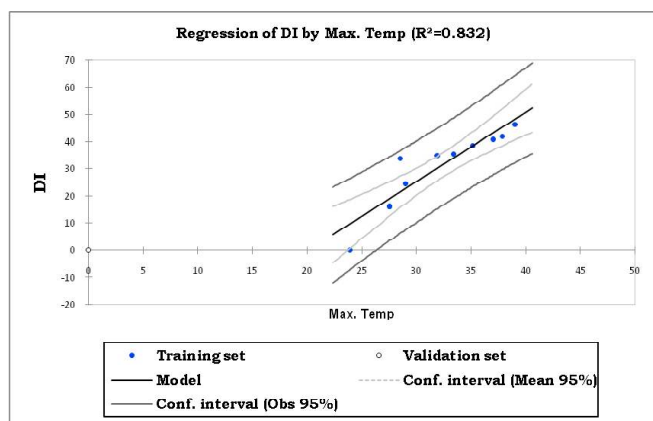
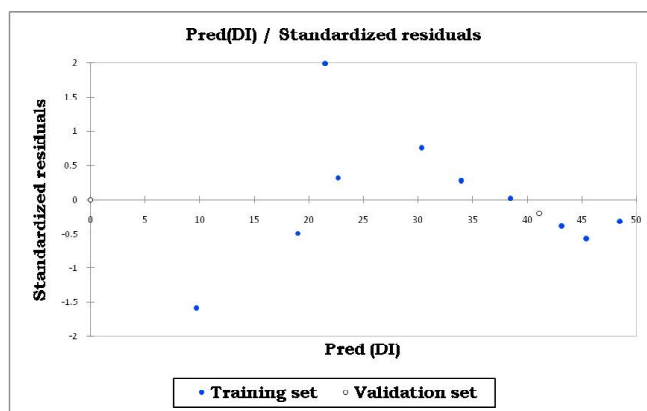**Fig. 3:** Disease intensity predicted versus actual observation (95 % CI).



**Fig. 4:** Residuals versus predicted values of the intensity of early blight of tomato

**Table 3:** Stepwise regression of weather variables with the intensity of early blight of tomato

| Variety | Model | R² | Adjusted R² | F Value | RMSE | Mallows' Cp |
|---------|-------|-----|-------------|---------|------|-------------|
| Pusa Ruby | Y=-51.47+2.56 Tmax | 0.832 | 0.811 | 39.591 | 6.129 | 3.070 |

Y = Disease intensity

other predictors remained constant (Fig. 3&4). Our findings are in agreement in other workers who have also recorded that 94 per cent variation in early blight of tomato was explained by the weather factors (Sahu *et al.,* 2014; Ruth *et al.,* 2016).

## CONCLUSION

To study the progress of early blight of tomato, five years disease data was correlated with corresponding weather data. The weather variables *viz*., maximum and minimum temperatures had significantly positive correlation, with the PDI of early blight of tomato. The developed model exhibited that 83 per cent variation in the PDI of early blight of tomato was influenced by maximum temperature. The information generated in this study will be useful for developing localized disease forecasting system for early blight of tomato. Thus, this model may be validated and utilized in the agro-advisories for management of the disease.

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