Indian Journal of Ecology (2022) 49(2): 543-548
DOI: https://doi.org/10.55362/IJE/2022/3558

Manuscript Number: 3558
NAAS Rating: 5.79

Role of Weather Parameters on Development of Early Blight of Tomato Caused by *Alternaria solani*

G.K. Sudarshan, M.S. Nagaraj[1], S.B. Yogananda[1] and A.P. Mallikarjuna Gowda[1]

University of Horticultural Sciences, Bagalkot-587 104, India
[1]University of Agricultural Sciences, Bengaluru-560 065, India
E-mail: sudarshangk16@gmail.com

***Abstract*:** The field experiment as conducted to study on the influence of weather parameters on the intensity and development of early blight of tomato during *Rabi*, 2018-19 and 2019-20 at Agriculture Research Station, Gunjevu, Holenarasipur taluk, Hassan district. The epidemiological studies clearly revealed that per cent disease index (PDI) progressing at a linear rate as the growth of the plant advances and weather parameters like minimum temperature, evening relative humidity, morning relative humidity rainfall, number of rainy days found significant and in negative correlation with disease development. The multiple linear regression analysis clearly revealed that coefficient of multiple determinants (R^2) was 0.94 indicating that these weather factors responsible up to an extent of 94.00 per cent for early blight disease development. The regression equation also reveals that increase in 1 per cent of morning relative humidity the PDI increased by 0.446%. While, when there was increase in 1° C of minimum temperature the per cent disease severity decreased by 12.606 per cent.

***Keywords*:** Early blight, *Alternaria solani*, Weather parameters, Correlation, Regression analysis, Epidemiology

Tomato (*Solanum lycopersicum* L.) is the most widely accepted vegetable crop after potato belongs to nightshade family (Solanaceae) and is native to the Andean region of South America and presently cultivating in around 140 countries. India ranks second, next to China both in area and production of tomato crop where tomato occupies in an area of 0.81 million hectares with yearly production of 20.51 million tonnes and productivity of 16.10 tonnes ha^{-1} (Anonymous 2018). In India, it is cultivated in a different agroclimatic zones ranging from temperate to arid. Among the different biotic and abiotic factors, diseases are considered as the main production constraints which are responsible for the reduction in yield. Early blight caused by *Alternaria solani* (Ellis and Martin) Jones and Grout is considered as important foliar disease and pathogen is a soil inhabiting air borne pathogen responsible for blight, collar rot and fruit rot of tomato. Meteorological parameters are the critical components of disease triangle. Early blight of tomato will occur frequently and severely in regions with heavy dew, high humidity, rainfall and relatively high temperatures. Chothani et al (2017) observed that increase in disease severity index (DSI) of early blight of tomato was comparatively higher in the maximum and minimum temperatures (35.2-38.3°C), Evening RH (30-58 %) and wind speed (1.2-2.2 km hr^{-1}) during 41th to 46th Standard meteorological week (SMW), which were most congenial for disease development. The abiotic factors like minimum temperature and evening relative humidity were negatively highly correlated, while maximum temperature had negative significant impact on *Alternaria* leaf blight of tomato. Wind speed showed positive and highly significant effects on development of early blight. Similarly, Pandey (2011) reported that *Rabi* sown tomato was susceptible to early blight .Meteorological parameters are the critical components of disease triangle. Early blight of tomato will occur frequently and in severely in regions with heavy dew, high humidity, rainfall and relatively high temperatures. Considering the importance of the early blight in tomato an attempt was made to know the influence of weather factors on disease development.

MATERIAL AND METHODS

The effect of weather factors like temperature (maximum and minimum), relative humidity (morning and evening in per cent), rainfall (mm) and a number of rainy days on the intensity and development of early blight of tomato was observed at Agricultural Research Station, Gunjevu, Hassan. The location comes under the Southern transition zone (Zone-7) of Karnataka state at 12.874°N latitude, 76.379° E longitude with an altitude of 874m above the mean sea level. The experiment was conducted during *Rabi*, 2018-19 and 2019-20. The susceptible cultivar, Alankar seedlings of 25 days old was transplanted in the main field with a spacing of 90cm x 45 cm in a plot size of 30m x 10 m. Twenty plants were selected randomly, labeled and the severity of blight was recorded using a 0-9 scale (Mayee and Datar, 1986). These values were converted to Per cent

Disease Index (PDI) using Wheeler's formula (1969).The observations were made on disease intensity and severity starting from the first day of its appearance and till the end of the crop. It was correlated with weather parameters by simple correlation and multiple regression analysis was also carried out.

RESULTS AND DISCUSSION

Disease development (PDI): The first appearance of the early blight was noticed on 21 days after transplanting in 2018-19 and 23 days after transplanting during 2019-20. The early blight disease during 2018-19 was initiated during 39th SMW, that is during September 3rd week (6.77 %) and the disease severity progressively increased throughout the cropping period (Table 1). The disease development was initially slow but it reached to the maximum of 57.77 per cent during the 5th SMW of 2019. The maximum temperature ranged from 27.29 to 30.80°C, minimum temperature ranged from 11.00 to 14.50 ° C with morning relative humidity between 78.34 to 98.00 per cent and evening relative humidity ranged from 60.21 to 79.25 per cent along with rainfall 56.40 mm to 88.10mm has favoured the development of the early blight during *Rabi*, 2018-19. Similarly during 2019-20 the early blight disease was initiated during 39th SMW (4.44 %) and the disease severity progressively increased throughout the cropping period and it has reached to maximum PDI of 62.22 per cent on 5th SMW of 2020 (Table 2). The maximum temperature ranged from 26.07 to 30.56°C, minimum temperature ranged from 11.10 to 15.25°C with morning relative humidity between 86.83 to 98.25 per cent and evening relative humidity ranged from 60.15 to 78.83 per cent along with rainfall 7.20 mm to 79.40 mm during disease initiation stage favoured the development of the early blight during *Rabi*, 2019-20.

Correlation and multiple linear regression analysis between early blight severities of tomato in relation to weather parameters: During 2018, among the different weather parameters maximum temperature showed non-significant relationship with PDI. Minimum temperature was significantly negatively correlated with PDI. Morning relative humidity and evening relative humidity were significantly negatively correlated with PDI. The rainfall and number of rainy days showed significantly negatively correlated with PDI (Table 3). However, as per the correlation analysis of PDI with inter dependent weather parameters such as minimum temperature with morning relative humidity, minimum temperature with rainfall and minimum temperature with number of rainy days have shown a significantly positive

Table 1. Effect of weather parameters on disease development of early blight of tomato during 2018-19

SMW	Max. T (°C)	Min. T (°C)	Morning RH (%)	Evening RH (%)	Rainfall (mm)	Rainy days	PDI
38	28.90	15.50	100.00	78.43	21.00	1.00	0.00
39	29.50	15.50	98.00	78.23	88.10	4.00	6.77
40	29.75	14.50	98.00	79.25	14.20	2.00	15.22
41	29.85	14.50	96.00	71.36	40.00	2.00	21.44
42	30.07	14.02	94.56	70.00	56.40	3.00	29.11
43	30.87	14.25	98.36	70.00	0.00	0.00	35.11
44	30.89	13.75	98.25	69.87	0.00	0.00	39.55
45	30.85	13.02	96.00	68.45	0.00	0.00	43.33
46	27.91	12.75	95.36	67.56	0.00	0.00	44.66
47	27.35	12.65	94.23	66.78	0.00	0.00	45.77
48	27.45	12.25	94.25	65.24	0.00	0.00	47.77
49	27.29	12.18	86.56	65.32	0.00	0.00	49.11
50	28.21	11.85	84.65	64.36	0.00	0.00	52.12
51	28.57	11.56	84.23	63.54	0.00	0.00	52.88
52	28.86	11.36	83.58	63.85	0.00	0.00	53.11
1	29.60	11.16	81.26	62.89	0.00	0.00	53.55
2	29.80	11.00	80.54	62.78	0.00	0.00	53.77
3	29.70	11.15	79.35	62.48	0.00	0.00	54.22
4	30.80	11.26	78.48	60.45	0.00	0.00	56.22
5	30.70	11.00	78.34	60.21	0.00	0.00	57.77

SMW- Standard Meteorological Week

correlation. Interaction effects of minimum temperature with morning relative humidity were significantly positive correlated with PDI of early blight. Similarly rainfall interaction effects with rainy days have shown significantly positive correlation with early blight severity. The data subjected to multiple linear regression analysis to find out the relative contribution of independent variables (weather factors) on dependent variable (PDI). The regression equation reveals that coefficient of multiple determinants (R^2) was 0.978 indicating that it was highly significant for the data and weather parameters influenced 97.80 per cent variation in the development of the disease (Table 4). The regression equation also reveals that increase in 1 per cent of morning relative humidity the PDI increased by 0.908. While, when there was increase in 1° C of minimum temperature and 1% of evening relative humidity the per cent disease severity decreased by 8.382 and 1.840 respectively.

During 2019, among the different weather parameters

Table 2. Effect of weather parameters on disease development of early blight of tomato during 2019-20

SMW	Max. T (°C)	Min. T (°C)	Morning RH (%)	Evening RH (%)	Rainfall (mm)	Rainy days	PDI
38	26.50	15.25	98.25	78.32	67.20	2.00	0.00
39	26.07	15.16	98.00	78.83	79.40	2.00	4.44
40	26.14	15.25	98.25	78.00	48.80	3.00	6.55
41	28.21	14.42	98.10	76.85	7.20	2.00	14.33
42	29.57	14.23	98.00	76.16	35.00	4.00	26.55
43	30.00	13.78	96.52	76.24	30.60	0.00	34.55
44	29.25	13.48	90.00	75.64	20.00	0.00	39.11
45	28.25	13.16	96.35	75.00	0.00	0.00	39.55
46	26.16	12.58	96.00	72.36	0.00	0.00	45.33
47	26.91	12.36	86.83	71.28	0.00	0.00	49.77
48	26.17	12.35	88.83	70.16	0.00	0.00	53.33
49	27.16	12.14	90.16	70.25	0.00	0.00	55.55
50	27.91	11.78	90.50	69.85	0.00	0.00	56.22
51	27.92	11.59	99.50	68.48	0.00	0.00	58.22
52	28.12	11.56	94.00	66.48	0.00	0.00	59.33
1	28.18	11.48	91.83	65.40	0.00	0.00	60.22
2	28.84	11.35	92.66	64.12	0.00	0.00	60.88
3	29.35	11.15	97.00	63.26	0.00	0.00	61.22
4	30.18	11.26	92.66	62.56	0.00	0.00	61.77
5	30.56	11.10	92.33	60.15	0.00	0.00	62.22

SMW- Standard Meteorological Week

Table 3. Correlation between per cent disease index of early blight of tomato in relation to weather parameters (2018-19)

Parameter	Y	X1	X2	X3	X4	X5	X6
Y PDI	1.00						
X1 Maximum temperature (°C)	-0.092	1.00					
X2 Minimum temperature (°C)	-0.954**	0.131	1.00				
X3 Morning RH (%)	-0.778**	-0.029	0.901**	1.00			
X4 Evening RH (%)	-0.964**	0.056	0.963**	0.849**	1.00		
X5 Rainfall (mm)	-0.718**	0.128	0.659**	0.426	0.625**	1.00	
X6 Rainy days	-0.768**	0.150	0.713**	0.469*	0.709**	0.966**	1.00

** - Significant at 1% probability
* - Significant at 5% probability
Where,
Y= PDI, X1 =Maximum temperature (°C), X2 = Minimum temperature (°C)
X3 = Morning Relative humidity (%), X4 = Evening Relative humidity (%)
X5= Rainfall (mm), X6= No. of Rainy days

except maximum temperature all other weather parameters *viz.,* minimum temperature , morning relative humidity, evening relative humidity , rainfall and rainy days were showed significant and negative correlation with PDI. It is precise to consider interaction effect of interdependent weather parameters for correlation of early blight disease severity rather than correlation of weather parameters with progress of disease during the season. The correlation analysis of PDI with inter dependent weather parameters such as maximum temperature with evening relative humidity, minimum temperature with morning and evening relative humidity, minimum temperature with rainfall and minimum temperature with number of rainy days have showed significantly positive correlation. Interaction effects of maximum temperature with evening relative humidity have significant and negative correlation. Whereas, minimum temperature with morning relative humidity, minimum temperature with evening relative humidity , minimum temperature with rainfall and minimum temperature with number of rainy days has significant and positive correlation with PDI of early blight. The multiple linear regression equation reveals that, coefficient of multiple determinants (R^2) was 0.98 indicating that these weather factors responsible up to an extent of 98.80 per cent for early blight disease development (Table 6). The regression equation also reveals that increase in 1°C of maximum temperature and 1 per cent of evening relative humidity the PDI increased by 1.187 and 1.425 respectively. While, when there was increase in 1°C of minimum temperature and 1per cent morning relative humidity the per cent disease severity decreased by 19.115 and 0.501 respectively.

The correlation analysis of pooled data of 2018-19 and 2019-20 revealed that, among the different weather parameters except maximum temperature (r = 0.089) all

Table 4. Multiple linear regression of per cent disease index of tomato early blight in relation to weather parameters (2018-19)

Parameter	X1 Maximum temperature (°C)	X2 Minimum temperature (°C)	X3 Morning relative humidity (%)	X4 Evening relative humidity (%)	X5 Rainfall (mm)	X6 No. of rainy days
β –value(RC)	0.669	-8.382	0.908	-1.840	-0.247	4.867
SE of β (r)	0.723	3.024	0.292	0.603	0.143	3.147
Intercept (α)			170.509			
R^2 value			0.978			

Multiple linear regression equation $Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6$

$Y = 170.509 + 0.669\ X_1 - 8.382X_2^{*} + 0.900\ X_3^{**} - 1.840\ X_4^{**} - 0.247X_5 + 4.867X_6$

Table 5. Correlation between per cent disease index of early blight of tomato in relation to weather parameters (2019-20)

Parameter	Y	X1	X2	X3	X4	X5	X6
Y PDI	1.00						
X1 Maximum temperature (°C)	0.418	1.00					
X2 Minimum temperature (°C)	-0.982**	-0.406	1.00				
X3 Morning RH (%)	-0.571**	-0.029	0.507**	1.00			
X4 Evening RH (%)	-0.880**	-0.476*	0.937**	0.401	1.00		
X5 Rainfall (mm)	-0.872**	-0.326	0.851**	0.510*	0.705**	1.00	
X6 Rainy days	-0.788**	-0.197	0.773**	0.567**	0.617**	0.704**	1.00

Table 6. Multiple linear regression of per cent disease index of tomato early blight in relation to weather parameters (2019-20)

Parameter	X1 Maximum temperature (°C)	X2 Minimum temperature (°C)	X3 Morning relative humidity (%)	X4 Evening relative humidity (%)	X5 Rainfall (mm)	X6 No. of rainy days
β –value (RC)	1.181	-19.116	-0.504	1.424	0.009	0.828
SE of β (r)	0.529	2.541	0.216	0.441	0.059	1.001
Intercept (α)			199.191			
R^2 value			0.98			

Multiple linear regression equation $Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6$

$Y = 199.191 + 1.181X_1^{*} - 19.116\ X_2^{**} - 0.504\ X_3^{**} + 1.424\ X_4^{**} - 0.009\ X_5 + 0.828\ X_6$

Table 7. Correlation between per cent disease index of early blight of tomato in relation to weather parameters (2018 and 2019)

Parameter	Y	X1	X2	X3	X4	X5	X6
Y PDI	1.00						
X1 Maximum temperature (°C)	0.089	1.00					
X2 Minimum temperature (°C)	-0.959	-0.072	1.00				
X3 Morning RH (%)	-0.567**	-0.136	0.689**	1.00			
X4 Evening RH (%)	-0.851**	-0.285	0.901**	0.683**	1.00		
X5 Rainfall (mm)	-0.765**	-0.057	0.727**	0.398**	0.628**	1.00	
X6 Rainy days	-0.771**	-0.007	0.730**	0.433*	0.623**	0.833**	1.00

Table 8. Multiple linear regression of per cent disease index of tomato early blight in relation to weather parameters (2018 and 2019)

Parameter	X1 Maximum temperature (°C)	X2 Minimum temperature (°C)	X3 Morning relative humidity (%)	X4 Evening relative humidity (%)	X5 Rainfall (mm)	X6 No. of rainy days
β –value (RC)	0.651	-12.606	0.446	0.173	0.028	-1.589
SE of β (r)	0.590	1.545	0.161	0.339	0.062	1.184
Intercept (α)	132.307					
R^2 value	0.94					

Multiple linear regression equation $Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6$

$Y = 132.307 + 0.651\ X_1 - 12.606\ X_2^{**} + 0.446\ X_3^{**} + 0.173\ X_4 - 0.028\ X_5 - 1.589\ X_6$

other weather parameters *viz.,* minimum temperature (r = -0.959), morning relative humidity (r = - 0.567), evening relative humidity (r = -0.851), rainfall (r = - 0.765) and rainy days with correlation co-efficient of -0.771 showed significant and negative correlation with PDI (Table 7). It is precise to consider interaction effect of interdependent weather parameters for correlation of early blight disease severity rather than correlation of weather parameters with progress of disease during the season. The correlation analysis of PDI with inter dependent weather parameters such as minimum temperature with morning and evening relative humidity, minimum temperature with rainfall and minimum temperature with number of rainy days has showed significant and positive correlation. Interaction effects of minimum temperature with morning relative humidity (0.689), minimum temperature with evening relative humidity (0.901), minimum temperature with rainfall (0.727) and minimum temperature with number of rainy days (0.730) has significant and positive correlation with PDI of early blight.

The multiple linear regression analysis of the pooled that clearly revealed that coefficient of multiple determinants (R^2) was 0.94 indicating that these weather factors responsible up to an extent of 94.00 per cent for early blight disease development (Table 8). The regression equation also reveals that increase in 1per cent of morning relative humidity the PDI increased by 0.446. While, when there was increase in 1°C of minimum temperature the per cent disease severity decreased by 12.606. Parmar et al (2020) reported that maximum temperature and minimum temperature was highly significant and negatively correlated with PDI with correlation coefficients of -0.913 and -0.875 respectively. Further, they also reported that value of coefficient of determination (R^2 = 0.933) indicating that weather factors were influenced up to an extent of 93.00% for early blight disease development.

CONCLUSION

The epidemiological studies represented that per cent disease index (PDI) progressed in linear rate as the growth of the plant advances and weather parameters like minimum temperature, evening relative humidity, morning relative humidity rainfall, number of rainy days found significant and in negative correlation independently with individual factors with disease development. But, in reality under field conditions weather factors influence one another and have interaction with each other have significant positive influence and the development of early blight disease in tomato and more precise to consider interaction effect.

REFERENCES

Anonymous 2018. *Indian Horticulture Database*, National Horticulture Board, Gurgaon, India. p134.

Chothani EP, Kapadiya HJ, Acharya MF and Bhaliya CM 2017. Impact of weather parameters on early blight epidemiology in tomato crop. *International Journal of Current Microbiology and Applied Science* **6**(11): 3160-3166.

Mayee CD and Datar VV 1986. *Phytopathometry,* Marathwad Agricultural University, Parabhani, p.95.

Pandey KK 2011. Weather based relation on different components of epiphytotic for early blight of tomato. *Vegetable Science* **38** (2): 143-146.

Parmar TD, Gohel NM and Kalola AD 2020. Effect of weather parameters on intensity of early blight of tomato. *International Journal of Current Microbiology and Applied Science* **9**(4): 12-17.

Roopa RS, Yadahalli KB and Kavyashree MC 2016. Effect of epidemiological parameters on severity of early blight of tomato. *Indian Journal of Phytopathology* **69**(4S): 266-269.

Saha P and Das S 2013. Assessment of losses due to early blight *(Alternaria solani* Ell. and Mart.*)* and influence of weather factors on disease development in tomato. *Journal Agriculture Meteorology* **15**(1): 82-85.

Sahu DK, Khar CP, Singh HK, Patel R and Thakur MP 2014. Epidemiological studies on early blight disease of Tomato. *The Bioscan* **9**(3): 1345-1350.

Wheeler BEJ 1969. *An Introduction to plan diseases*. John Wiley and sons Ltd. London, p301.

Received 22 November, 2021; Accepted 12 March, 2022