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Impact of Weather Parameter on Early Blight Epidemiology in Tomato Crop

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A B S T R A C T

Increase in disease severity index (DSI) of early blight of tomato was comparatively higher in the maximum and minimum temperatures (35.2 – 38.3^{0}C), Evening RH (30-58 %) and wind speed (1.2–2.2 km/hr) during 41th to 46th Standard meteorological week (SMW), which were most congenial for disease development. The abiotic factors like minimum temperature (r= 0.90) and evening relative humidity(r= 0.77) were negatively highly correlated, while maximum temperature (r= 0.59) had negative significant impact on alternaria leaf blight of tomato. Wind speed showed positive and highly significant effects (r= 0.69) on development of early blight. The partial regression between leaf blight and abiotic factors indicated that an increase in 1^{0}C in maximum temperature, an increase in 1 km/hr wind speed and one per cent in evening RH, increase the early blight to the tune of 3.62, 6.56 and 0.14 DSI, respectively. The value of coefficient of determination (R^2) indicating 88.45 per cent variation in disease severity of weather factors in tomato crop. The severity of early blight of tomato progress with increase in maximum temperature and wind speed whereas it declined with increase in minimum temperature on tomato.

Introduction

Tomato (*Lycopersicon esculentum* Mill) regard as poor man's apple. Early blight caused by *Alterrnaria solani* is one of the world's most catastrophic diseases incurring loss both at pre and post-harvest stages in tomato. Early blight of tomato is economically the most important disease of tomato in USA, Australia, Israel, UK and India, where significant reductions in yield (35% to 78 %) have been observed (Datar and Mayee, 1972; Basu, 1974; Jones *et al.*, 1993). Datar and Mayee (1985) reported that *A. solani* caused yield loss of tomato fruit by 78% at 72% disease intensity and each 1% increase in disease intensity reduced tomato yield by 1.36%.

The correlation between weather and disease severity has been recognized by many authors in different parts of the world (Raghavendra, 2006; Sangeetha and Siddaramaiah, 2007; and Devi and Chanu, 2012). Atmospheric Alternaria spores, temperature and humidity are the factors that closely correlate with the occurrence of this disease. With an aim to find out the role of various weather factors on infection and development of early blight in tomato, the study was conducted.

Materials and Methods

A field experiment was conducted during *rabi* 2016-17 at Instructional farms of Agronomy,

JAU, Junagadh (Gujarat tomato-2) variety with large plot technique (20 m x 1.8 m) in the experiments. The standard method was used for other cultural practices. The disease severity was recorded from 20-tagged plants on 0-5 scale as suggested by Pandey *et al.*, (2003).The disease severity index (DSI) was calculated using the formula (Wheeler, 1969).

$$\text{Disease severity index} = \frac{\text{Sum of all individual ratings}}{\text{No. of leaves examined x Maximum disease scale}} \times 100$$

The experiment was kept unsprayed for natural development of disease throughout the crop duration. Weekly weather parameters like maximum/minimum temperature (^{0}C), morning/evening relative humidity (%), rainfall (mm), rainy days sunshine hours (hr) and wind speed (km/hr) were studied and recorded from the Department of Meteorology JAU, Junagadh. They were correlated to weekly disease severity index by calculating the Karl person's correlation coefficient (r). Correlation coefficient values were tested individually for their significance at 5 and 1 % probability level using SPSS18.

Further, the data were subjected to multiple liner regression analysis to find out the linearity of the independent variables for prediction of disease. The following prediction equation was used:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8$$

Where, Y is the disease severity index, a is the intercept (constant) b_1 to b_8 is the partial regression coefficient associated with each X_i,i = 1, 2, 3, 4, 5, 6, 7, 8 are the weather variables, X_1 is the maximum temperature (^{0}C), X_2 is the minimum temperature (^{0}C), X_3 is the morning relative humidity (%), X_4 is the evening relative humidity (%), X_5 is the rainfall (mm), X_6 is the rainy days, X_7 is the sunshine hours (hr.), X_8 is wind speed (km/hr).

Regression equation for most probable factor (4) is as under.

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$$

Where, Y is the disease severity index, a is intercept (constant), b_1 to b_4 is the partial regression coefficient associated with each X_i, viz., X1 = maximum temperature (^{0}C), X_2= minimum temperature (^{0}C), X_3=evening relative humidity (%), X_4=wind speed (km/hr).

Results and Discussion

Crop was sown on 1st September 2016 (36 standard week) and early blight appeared during the 40th standard week in tomato crop. Data showed that DSI increased progressively and maximum disease severity index (DSI) of early blight was recorded on the 7th (62.45%) standard week.

Progressive disease development

Disease development under natural conditions was found to be influenced by environmental factors (Table 1). The data from crop seasons revealed that first appearance of early blight was noticed 33 days after planting (DAP) which was recorded on 40th standard meteorological week in 2016-17. So, 36 to 39 SMW data were considered as incubation period of early blight in tomato crop. The development of the disease was initially slow but, it reached to maximum during the 7th SMW (62.45%) which happened in the month of February.

During the cropping period maximum temperature showed ranged from 29.1^{0}C (51st SMW) to 38.5 (40th SMW). Minimum

temperature ranged from 10.4^{0}C (4th SMW) to 24.7 ^{0}C (38th SMW). The relative humidity (RH) during morning ranged from 56 (51st SMW) to 91 (38st SMW) per cent and evening RH ranged from 22 (51st SMW) to 80 (38th SMW) per cent. However, rainfall was noted to the tune of 0 mm to 119.8 mm (38th SMW); rainy days 0 to 4 (38th SMW); sunshine hours ranged from 3.6 (38th SMW) to 9.8 (39th SMW) hours and wind speed ranged from 1 to 5.3 km/hr.

Increase in disease severity index was comparatively higher in the temperature ranged from 35.2 – 38.3^{0}C (maximum) and 17.1–24.4^{0}C (minimum) 26.80–31.35 ^{0}C average minimum and maximum temperature, 30-58 (Eve. RH) and 1.2–2.2 (wind speed) during 41th to 46th SMW were most congenial for disease development. These finding are in agreement with the earlier findings (Broker and Patil, 1995; Rajiv Kumar and Singh, 1996; Das *et al.*, 1998 and Kemmitt, 2002, Sahu *et al.*, 2014).

Correlation study

Correlation coefficient study revealed that, maximum temperature was significant, whereas morning temperature and evening relative humidity highly significant with negative effect on development of early blight. Wind speed showed positive and highly significant effects (r= 0.69) on development of early blight (Table 2).

Regression studies

During the year 2016-17, the coefficient of multiple determinants (R^2) was 0.9065 indicating 90.65% of variation in early blight development explained by the set of variable in the study (Table 3). The maximum temperature (X_1) had positive effect 3.61 increased the development of early blight. This indicated that the increase in temperature by 1^{0}C increased the development of early blight by 3.61%, during 2016-17.

The multiple liner regression equation was fitted to the data and the equation arrived for the weather parameters was $Y = 3.6775 + 3.6101^{**}X_1 - 5.4207^{**}X_2 + 0.1712X_3 + 0.2721X_4 - 0.1959X_5 - 1.2276^{**}X_6 - 3.8526^{**}X_7 + 5.6490^{**}X_8$.

This revealed that when there was increase in one unit of maximum temperature (1^0 C), morning humidity (1%), evening RH (1%) and wind speed (1 km/hr.), the per cent disease index increase by 3.61, 0.17, 0.27 and 5.64 units, respectively; while when there was increase in one unit of minimum temperature (1^0 C), rainfall (1 mm), rainy days (1 day) and sunshine hours (1 hr), the per cent disease severity index decreased by 5.42, 0.19, 1.22 and 3.85 units, respectively.

There were five weather parameters predicted highly (positive or negative) significant impact on DSI of *A. solani.* The weather factors influenced the disease incidence to the extent of 90.65 per cent. These finding are in agreement with the earlier finding of Sahu *et al.*, (2014). Who was noted that the minimum temperature negative highly significant correlation with early blight disease development on both the year.

In order to know the predictive abilities of weather parameters to DSI of early blight, the multiple regression analysis was carried out by taken disease severity index (Y) as dependent variable and weather parameters (X) as independent variable.

Among the eight weather parameters most probable and precise result, four weather parameter that showed significant correlation with DSI or had moderate or very high direct or indirect effect on DSI were considered for multiple regression analysis.

Table.1 Effect of weather parameters on disease development and severity of early blight of tomato during Rabi 2016-17 at J.A.U. Junagadh

St. Week	Alt. blight %	Increase in DSI	Maxi Temp. ^{0}C	Mini Temp. ^{0}C	Morning RH %	Evn. RH %	Rainfall mm	Rainy days	Sunshine Hr.	Wind speed	Meaning daily temp
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
36	0.00	0.0	33.1	23.0	79	48	0	0	6.8	1.9	28.05
37	0.00	0.0	34.9	22.7	83	56	94.5	1	6.0	1.9	28.80
38	0.00	0.0	32.5	24.7	91	80	119.8	4	3.6	2.4	28.60
39	0.00	0.0	31.2	22.7	82	66	0	0	9.8	2.1	26.95
40	1.50	1.50	38.5	24.3	75	47	0	0	8.4	1.3	31.40
41	5.25	3.75	38.3	24.4	81	58	10.4	1	7.7	2.1	31.35
42	14.90	9.65	37.2	23.7	72	48	0	0	9.0	1.3	30.45
43	18.25	3.35	37.4	21.2	64	34	0	0	8.9	1.2	29.30
44	30.51	12.26	35.2	19.6	67	38	0	0	8.9	1.8	27.40
45	35.25	4.74	36.5	17.1	70	30	0	0	8.7	2.2	26.80
46	42.36	7.11	35.8	19.4	66	35	0	0	8.4	2.2	27.60
47	44.52	2.16	36.4	19.4	70	48	0	0	6.7	1.0	27.90
48	46.44	1.92	32.3	17.7	68	33	0	0	6.8	5.0	25.00
49	47.67	1.23	33.7	14.0	66	28	0	0	8.1	2.5	23.85
50	49.79	2.12	29.8	12.0	64	29	0	0	8.0	3.9	20.90
51	50.45	0.66	29.1	11.2	56	22	0	0	8.5	4.7	20.15
52	52.34	1.89	30.1	12.4	64	31	0	0	8.0	4.0	21.25
1	53.45	1.11	31.5	13.8	74	30	0	0	8.3	3.2	22.65
2	55.45	2.00	30.2	12.3	79	34	0	0	8.3	3.5	21.25
3	56.56	1.11	29.2	11.7	72	33	0	0	8.3	4.4	20.45
4	57.56	1.00	29.8	10.4	75	39	0	0	8.9	2.7	20.10
5	58.67	1.11	31.4	14.6	82	37	0	0	8.5	4.1	23.00
6	60.76	2.09	31.0	12.5	79	34	0	0	9.2	3.8	21.75
7	62.45	1.69	30.8	16.1	73	33	0	0	7.1	5.3	23.45
Range of diff. weather parameter			29.1-38.5	-	56-91	22-80	0-119.8	0-4	3.6-9.8	1-5.3	-
Total	844.1300	-	795.9000	420.9000	1752.0000	971.0000	224.7000	6.0000	190.9000	68.5000	-
Mean	35.1721	-	33.1625	17.5375	73.0000	40.4583	9.3625	0.2500	7.9542	2.8542	-
Sd	23.3270	-	3.0880	4.9445	8.0163	13.6030	30.4222	0.8470	1.2935	1.2864	-
Correlation	-	-	-0.5988	-0.9087	-0.4321	-0.7760	-0.4809	-0.4528	0.2911	0.6940	-
SE of r	-	-	0.1670	0.0870	0.1880	0.1315	0.1828	0.1859	0.1995	0.1501	-
Cal t	-	-	3.5858	10.4407	2.2979	5.9010	2.6301	2.4358	1.4591	4.6228	-

Table.2 Correlation coefficient between weather parameters and early blight severity index

Sr. No.	Weather parameters	Correlation coefficient 'r' value
1	Maximum temperature	-0.5988*
2	Minimum temperature	-0.9087**
3	Morning relative humidity	-0.4321
4	Evening relative humidity	-0.7760**
5	Rainfall	-0.4809
6	Rainy days	-0.4528
7	Sunshine hour	0.2911
8	Wind speed	0.6940**

Significant at (p= 0.05) level (R value 0.582), n=22Significant at (p= 0.01) level (R value 0.663)

Table.3 Multiple regression equation for production of Alternaria blight in tomato crop

Sr. No.	Particulars	Regressioncoefficient'b' value
1	Constant (Intercept)	3.6775
2	Maximum temperature (X_1)	3.6101**
3	Minimum temperature (X_2)	-5.4207**
4	Morning relative humidity (X_3)	0.1712
5	Evening relative humidity (X_4)	0.2721
6	Rainfall (X_5)	-0.1959
7	Rainy days (X_6)	-1.2276**
8	Sunshine Hour (X_7)	-3.8526**
9	Wind speed (X_8)	5.6490**
10	R Square (R^2)	0.9065
11	Adjusted R Square	0.8566

Significant at (p= 0.05) level (R value 0.582), n = 22Significant at (p= 0.01) level (R value 0.663)

Table.4 Regression analysis of disease severity index with meteorological factors

No.	Independent variable	Constant'a'	Regression coefficient 'b'	Multiple determination 'R^2'	Std. Error of Reg. coeff. (b_i)	Std. error of Estimate
1.	**Early blight with maxi. and mini. temperature, evening RH, wind speed**					
	Max. Tem.	-19.9733	3.6293**	0.8845**	1.5619	52.1289
	Mini. Tem.		-5.1104**		1.1045	
	Eve. RH		0.1402		0.2978	
	Wind speed		6.5660**		2.6497	

Based on the multiple regression studies of most probable factor (4) the following equation were fitted for early blight of tomato crop (Table 4). Regression equation is Y = -19.97 + 3.6293** X_1 – 5.1104** X_2+ 0.1402 X_3 + 6.5660** X_4, R^2 = 0.8845.

The predication equation indicated that an increase in 1 ^{0}C maximum temperature increase the early blight to the tune of 3.62 DSI. Similarly an increase in 1 km/hr wind speed increases the early blight to the tune of 6.56 DSI. Conversely, an increase of 1 ^{0}C

minimum temperature reduced the early blight to the tune of 5.11 DSI. The value of coefficient of determination (R^2) were worked out to the tune of 0.8845 indicating 88.45 per cent variation in disease severity of weather factors during the year 2016-17 in tomato crop (Table 4).

The multiple regression fit was found highly significant for the data with R^2 = 0.8845 for the DSI significance of the coefficient is presented in Table 4 out of four weather parameters selected for study, maximum temperature and wind speed was found to be positive and minimum temperature negative impact on DSI, while evening RH showed non-significant. The present result is corroborate the finding of Champawat and Sharma (2009) they studied the influence of environmental factors such as temperature, relative humidity and rain fall on the development of *Alternaria* blight of tomato from Rajastan. The similar result were also recorded by Sahu *et al.*, (2014) while working with minimum temperature negative highly significant regression effect with early blight disease development in tomato.

From the results presented, it is very clear that the severity of early blight of tomato progress with increase in maximum temperature and wind speed whereas declined with increase in minimum temperature on severity of early blight of tomato. The R^2 value indicated that some unknown factors might be involved in early blight development.

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