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Effect of weather parameters on severity of septoria leaf spot disease of tomato

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Abstract
Septoria leaf spot of tomato caused by *Septoria lycopersici* Speg. is an economically important disease in all tomato growing areas of the world. The impact of weather parameters on per cent disease index (PDI) was analyzed during 2020-21 at college of agriculture, KSNUAHS, Shivamogga. The disease appeared at 3rd MW and had steep progression throughout the cropping period. Maximum and minimum temperature had significant positive correlation with PDI at 1 per cent and 5 per cent level of significance (0.829 & 0.577), respectively. While, minimum relative humidity had significant negative correlation (-0.710) with PDI at 1 per cent level of significance. The regression equation explained that 88.88 per cent variation in the PDI of the disease was due to weather variables. The data collected during the studies can be used for predicting the appearance of septoria leaf spot of tomato well in advance, thereby helping in the adoption of timely management practices.

Keywords: Tomato, septoria leaf spot, correlation and regression studies

Introduction
Tomato (*Solanum lycopersicum* L.) belongs to the family Solanaceae native to Peru in South America. It is one of the most popular and widely grown vegetable crops in India and throughout the world because of its varied climatic adaptability and high nutritional value and relatively short duration crop which gives high yield under well managed situations. Among the vegetables, tomato ranks next to potato in the world in terms of acreage and ranks first among the processing crops. Tomato is grown for its edible fruits, which can be consumed either fresh or processed to several products like puree, paste, soup, juices, ketchup and whole canned fruits, etc. While it is botanically a fruit, it is considered as a vegetable for culinary purposes. The fruit is rich in lycopene, which imparts attractive red color of fruit and yellow color due to carotenes; lycopene is the most potent natural antioxidant that may have beneficial health effects (Ishida and Chapman, 2004) [1]. Tomato also has high medicinal value; the pulp and juice are digestible, promoter of gastric secretion and blood purifier. Its nutritional values and proximate analysis shows that fresh (ripe) tomato contains 13 mg of Ca, 27 mg of P, 0.5 mg of Fe, 3 mg of Na, 244 mg of K, 900 (I.U) of vitamin A, 0.6 mg of thiamine, 0.4 mg of riboflavin, 0.7 mg of niacin and 233 mg of ascorbic acid (Nonnecke, 1989) [11]. Tomato is being exported in the form of whole fruits, as well as in processed form. Because of its nutritional value, tomatoes are called “Poor man’s apple”.

Under field conditions, several fungal, bacterial, nematode and some viral diseases infect tomato crop and cause severe yield loss. Among the fungal diseases, septoria leaf spot, early blight, wilt and buck eye rot and blossom end rot due to calcium deficiency are the major problems currently threatening the tomato production and productivity (Akram *et al*., 2014) [2]. Among these diseases, septoria leaf spot is probably the most common foliar disease infecting tomatoes under severe conditions it may lead to yield loss of up to 100 per cent (Mc Grath, 2015) [9]. The disease chiefly attacks the older leaves near the ground under favorable environmental conditions like, moderate as well as warm climate conditions, with symptom appear as small circular water soaked spots which up on enlargement developing into dark margins and grey centres (Singh, 2018) [14]. It leads to complete defoliation of leaves leading to a significant crop loss and results in preventing normal fruit production and matured fruits being subjected to sunscald (Ramakrishnan and Sundaram, 1954) [13]. The organism perpetuates on the debris which act as a primary source of infection. Secondary spread is due to pycnidiospores produced in pycnidia formed in leaf spots (Stoin Elizibeta, 1968) [15].

In India, the planting season is such that crop comes to maturity during July and September and the time is conducive for development of the disease. It is one of the most devastating foliar diseases in humid regions, particularly during the periods of rainfall, frequent dew or adaptability of sprinkler irrigation (Andrus *et al*., 1945, Delahaut and Stevenson, 2004) [3, 4] thereby failure of the crop is common. The spread of the disease is checked with the commencement of dry season.

Weather parameters play a vital role in the development of the disease. Septoria leaf spot develops more rapidly during periods when environmental conditions alternate between humidity and drought. Conidia of the pathogen are one of the most important means of dissemination and used in identifying and classifying the organism. It was well established that pathogen could survive on the infected seeds for several years. But, it is still speculative whether the seed-borne inoculums of *Septoria lycopersici* serve as a source for triggering a primary infection in the next season (Neergaard, 1945) [11]. Understanding the effect of weather factors on disease development is pre-requisite to manage this disease in a strategic way.

Material and Methods

A study was conducted during 2020-2021 in order to correlate weather parameters *viz*., temperature (° C), relative humidity (%) and rainfall (mm) with disease intensity of septoria leaf spot disease of tomato at College of Agriculture, KSNUAHS, Shivamogga. Seedlings of local hybrid F_1 JKTH 811 was transplanted in a plot of 8 × 5 m area with all cultural practices except for the management of septoria leaf spot disease. The observations on severity of septoria leaf spot were recorded for randomly selected 10 plants by following 0-9 scale given by (Mayee and Datar, 1986) [8] as in Table 1. at an interval of seven days starting from the day of transplanting till the end of the crop. Per cent disease index was calculated as described by Wheeler (1969) [16].

$$\text{PDI} = \frac{\text{Sum of the individual disease ratings}}{\text{No. of leaves observed} \times \text{Maximum disease grade}} \times 100$$

Table 1: Disease scale (Mayee and Datar, 1986) [8].

Scale	Description
0	No symptoms on the leaf, fruit
1	Very small, irregular spots covering less than 1 per cent of leaf area
3	Small irregular, brown spots covering 1-10 per cent of the leaf area
5	Small lesions, but enlarged with dark brown margin with a grey center covering 11- 25 per cent of the leaf area
7	Enlarged lesions, with dark brown margin with a grey center covering 26-50 per cent of the leaf area
9	Lesions coalesce to from irregular dark brown to black patches covering 51 per cent or more of the leaf area

Meteorological data was collected at weekly intervals from the meteorological station at College of Agriculture, Shivamogga. Data collected were correlated with severity of septoria leaf spot disease. Multiple regression co-efficient was calculated for the meteorological factors as independent variables with the prediction equation $Y= a+ b_1X_1+ b_2X_2……b_6X_6$, where Y = disease intensity, a is the constant, b_1, $b_2……b_6$ are regression co-efficients and X_1, $X_2…X_6$ are independent weather variables.

Result and Discussion

During cropping season, average maximum and minimum temperature was recorded between 16.93 to 31.84 °C, the average maximum and minimum relative humidity between 46.18 to 84 per cent with total rainfall 6.51 mm were found to be ideal condition for septoria leaf spot disease development (Table 2).

It was noticed that septoria leaf spot infection was first observed during 3rd meteorological week *i.e*., from January 21st to January 27th and recorded a PDI of 3.99. Then the disease progressed and reached a maximum PDI of 58.75 per cent during 11th meteorological week i.e. from March 15th to 21st and during the period temperature ranged between 20.60° to 34.60° C, with humidity between 36 and 87 per cent, which was congenial condition for the spread of the pathogen at maturity. Lohmeier *et al*. (2013) [7] observed the development of severe septoria leaf spot symptoms on lettuce at optimum temperatures between 10 ˚C and 30 ˚C with an extended period of leaf wetness. Hence results suggested that *S. birgitae* can cause disease under moderate as well as warm climate conditions.

The correlation of environmental factors with per cent disease index in susceptible local hybrid cultivar JKTH 811 was studied (Table 3). The relationship between disease severity (PDI) and weather parameters during the crop season indicated that maximum temperature, minimum temperature and maximum relative humidity positively correlated with PDI, since minimum temperature favored for sporulation. Maximum RH and PDI were positively correlated because prolonged periods of maximum RH >80 per cent causes severe defoliation. Whereas PDI had negatively correlated with minimum relative humidity and rainfall. Significant positive correlation coefficient of maximum and minimum temperature (0.829 and 0.577) was observed with PDI at 1 per cent and 5 per cent level of significance, respectively. Govardhan (2001) [5] reported the role of weather parameters on the development of septoria leaf spot disease in tomato and observed RH and rainfall were positively correlated with PDI, whereas temperature was negatively correlated with PDI. Gupta *et al*. (2020) [6] reported that minimum and maximum temperature were significantly correlated with PDI, whereas RH along with rainfall were significantly negatively correlated with PDI.

The multiple linear regression between PDI of leaf spot and weather parameters during 2020-21 indicated that the regression coefficients for maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall were observed to be -0.899, + 10.77, + 1.28, −1.97 and −0.27, respectively with an R^2 value of 0.888 indicating 88% of variation in disease intensity was due to weather parameters. Minimum temperature and minimum RH were significant in predicting disease intensity ($P< 0.05$). Linear regression equation was worked out from multiple linear regression analysis in order to predict the intensity of the disease depending upon weekly weather parameters prevailing during crop season.

$Y=112.2 + (-8.99) X_1 + 10.77 X_2^* + 1.28 X_3 + (-1.97) X_4^* + (-0.27) X_5$

*- Significant ($P< 0.05$)

Where

Y – Disease intensity
a – Constant
X_1 –Max. Temperature
X_2 –Min. Temperature
X_3 –Max. RH
X_4 –Min. RH
X_5 –Rainfall

The value of the coefficient of determination (R^2) showed 93.33 per cent variation in per cent disease intensity of weather factors in tomato crops (Parmar *et al*., 2020) [12].

Table 2: Effect of weather parameters on the severity of septoria leaf spot of tomato caused by *S. lycopersici* during 2020-2021.

Months	Meteorological Standard week	PDI	Temperature(◦C)		Relative humidity (%)		Rainfall (mm)
			Max.	Min.	Max.	Min.	
December 7-13	49	0	28.7	17.5	93	80	16.20
December 14-20	50	0	30.90	15.9	93	65	0.00
December 21-27	51	0	29.90	14.5	85	60	0.00
December 28-3	52	0	31.20	15.2	82	50	0.00
January 4-10 (2021)	1	0	29.70	18.3	86	64	59.00
January 11-17	2	0	30.10	17.7	80	64	0.80
January 18-24	3	3.99	31.80	16.1	74	46	0.00
January 25-31	4	5.88	31.80	14.1	82	34	0.00
February 1-7	5	10.98	31.60	15.1	77	37	0.00
February 8-14	6	29.92	31.50	13.5	87	29	0.00
February 15-21	7	37.77	30.90	14.7	84	34	0.60
February 22-28	8	48.88	31.80	18.4	78	46	27.60
March 1-7	9	51.92	34.10	19.7	83	35	0.00
March 8-14	10	55.75	34.60	18	89	28	0.00
March 15-21	11	58.75	34.60	20.60	87	36	0.00
March 22-28	12	58	36.30	21.2	84	31	0.00
Average/ Total			31.84	16.93	84	46.18	6.51

Table 3: Correlation of weather factors on severity of septoria leaf spot of tomato during 2020-21

Characters	PDI
PDI	1
Temperature (Max.)	0.829**
Temperature (Min.)	0.577*
Relative humidity (Max.)	0.035
Relative humidity (Min.)	-0.710**
Rainfall	-0.164

** - Significance at 1 per cent level * - Significance at 5 per cent level

Conclusion

The relationship between disease severity and weather parameters were studied and it was observed that disease severity varied every week. Disease severity had a positive correlation with weather parameters *viz.,* maximum temperature (0.8299), minimum temperature (0.5770) and maximum RH (0.0358) and significant positive correlation was observed with maximum and minimum temperature at 1 and 5 per cent level of significance. There was negative correlation with minimum RH (-0.7106) and rainfall (-0.1649). The multiple linear regression with an R^2 value of 0.888 showed variation of 88% in disease intensity was due to change in weather Paramers. Average temperature range between 16.93 to 31.84 °C, RH range between 46.18 to 84 per cent with rainfall 6.51 mm were found to be congenial for development of septoria leaf spot disease.

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