

Short communication

Weather impact assessment and development of prediction model for yield loss in chilli anthracnose patho-system

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Chilli (*Capsicum annuum* L.) is one of the major spices grown in India occupying 781.74 thousand ha of land with the production of 1808.01 mt. The productivity estimated was 2.31 tha⁻¹ during 2018-19 (FAOSTAT, 2019). India is leading in chilli production and export contributing approximately 43.26 per cent of world's total chilli production (FAOSTAT, 2019) followed by China. Chilli growing states of the country represent both tropical and sub-tropical regions. It plays an important role to make Indian cuisine popular all over the world for its flavor, aroma and pungency. Besides being a taste maker chilli is an economically important crop of its medicinal and nutritional value.

Anthracnose also known as ripe fruit rot of chilli caused by *Colletotrichum capsici* (Sydow) Butler and Bisby, is the most devastating disease in India causing significant economic losses due to reduction in fruit quality and marketability (Saxena *et al.*, 2014). The characteristic symptoms of the disease are the appearance of small, black, circular spot on the ripe fruit with sunken necrotic lesions, concentric rings of acervuli in the infected region, deformity of fruit shape and lose of pungency. The formation of setae and sclerotia by the fungus makes the lesions turn black from brown colour leading towards reduction of dry weight, capsaicin and oleoresin content of the fruits (Mistry *et al.*, 2008).

Weather plays a critical role on the disease development as it helps in the growth of the pathogen, its dissemination as well as expression of the symptoms. Among the meteorological factors - temperature, relative humidity and rainfall are the most crucial for the development of anthracnose diseases (Bhattiprolu and Monga, 2018; Sahoo *et al.*, 2012). In order to formulate reliable and effective disease management strategies; it is of paramount important to find the relationship between disease progression and weather factors and resultant

yield loss estimation. Therefore, the study was outlined to explore the role of weather variables in the development of chilli anthracnose, yield loss assessment and further to formulate suitable prediction equation for its future projection to frame an efficient forecasting model.

Field studies were carried out at College of Agriculture, BCKV campus, Purba, Barddhaman in West Bengal. Local chilli variety 'Bullet' susceptible to anthracnose was chosen and one-month old seedlings were transplanted in the main field of 500 m² area at spacing 70x40 cm. Experiments were conducted during *kharif* season for the three consecutive years of 2017, 2018 and 2019 and the planting was done on 15th of July each year. All the necessary agronomic and cultural practices were followed to maintain congenial environment for proper growth and development of the plants. No chemical fungicide was sprayed and natural occurrence of the disease was considered throughout. Observations were taken on disease severity (PDI) at 7 days intervals just after the initiation of the disease till the harvest of the crop. Severity was indexed based on leaf area infected and computed following 0-9 rating scale by Mayee and Datar (1986), where 0= healthy, 1= Less than 1% area affected, 3= 1-5% Leaf/fruit area affected. 5= 6-25% Leaf/fruit area affected, 7= 26-50% Leaf/fruit area affected and 9= 61-100% Leaf/fruit area affected. The percent disease index (PDI) was calculated using the following formula:

$$PDI = \frac{\text{Sum of numerical ratings}}{\text{Total no. of samples} \times \text{maximum of rating Scale}} \times 100$$

Daily meteorological observations *viz.* maximum temperature (T_{max}), minimum temperature (T_{min}), morning relative humidity, total rainfall and number of rainy days recorded at nearby Meteorological Station, DSF, Purba Barddhaman were used for the study. Correlation between progress of disease severity and weather factors was calculated to define the quantitative relationship between

Table 1: Progression of disease severity (PDI) of anthracnose of chilli (*Colletotrichum capsici*) as influenced by the weather factors during three consecutive years

SMW	2017				2018				2019			
	Tmax	RH	RF	PDI	Tmax	RH	RF	PDI	Tmax	RH	RF	PDI
36	32.4	83	1.2	15.1	35.5	87	0.0	18.8	29.2	87	87.1	17.1
37	30.7	86	196.6	18.0	30.7	85	18.9	19.1	32.3	90	30.1	20.0
38	31.6	83	106.0	23.6	33.4	84	0.0	24.2	31.3	88	42.2	25.6
39	31.0	82	4.67	25.3	32.9	82	0.0	26.8	32.4	87	0.0	29.3
40	30.5	79	0.0	29.9	31.4	82	0.0	30.1	28.1	93	106.8	33.9
41	29.7	80	0.0	35.4	31.8	82	0.0	33.5	30.2	87	0.0	37.0
42	26.4	85	34.8	42.4	32.3	81	0.0	35.6	29.0	95	42.1	41.4
43	27.4	86	0.0	46.5	31.0	80	0.0	39.3	29.8	77	0.0	45.5
44	27.1	88	0.0	53.2	30.7	78	0.0	41.2	28.8	76	0.0	52.6

Tmax= Maximum temperature, RH= Relative humidity, RF= Rainfall, PDI= Percent Disease Index ; SMW= Standard Meteorological Week

Table 2: Correlation of anthracnose with weather factors in chilli for individual years

Variable	Correlation coefficient (r)		
	2017	2018	2019
Maximum temp (T _{max})	0.90**	0.58*	0.61*
Minimum temp (T _{min})	0.31 NS	0.37 NS	0.41 NS
Relative humidity (RH)	0.85**	0.95**	0.89**
Total rainfall (RF)	0.42*	0.58*	0.58*
Number of rainy days	0.55*	0.29	0.57*

two i.e. expressed through correlation co-efficient value (r). Multiple regression equation was used to identify the critical parameters for the disease development. Coefficient of determination (R²) was also calculated using the formula:

$$\hat{Y} = b_0 + b_1x_1 + b_2x_2 + \dots + b_nx_n$$

Where \hat{Y} = predicted disease severity, b_0 = intercept, b_1, b_2, \dots, b_n = regression co-efficient and x_1, x_2, \dots, x_n =independent variable

Before analysis the data, square root transformation of PDI value was calculated and over all statistical calculation was performed using MS Excel. The regression equations were developed individually for the three experimental years considering three years different independent weather variables and thus prediction equations were formulated.

Yield data were recorded from each plot and quantified by adding after each harvest and then converted

into yield qha⁻¹. To establish relationship between disease severity and yield loss, the correlation co-efficient was determined and linear regression equations has been developed using the formula:

$$Y = f(X) + C$$

Where Y= Yield, X= Disease severity (Percent disease index value) and C = Constant

Disease symptoms first appeared during 38th standard meteorological week (SMW) and continued till harvest of the crop to 46th SMW. Observations recorded upon initiation and during progression of the disease helped to identify the most vulnerable crop stages to the disease. Maximum PDI reached during fully grown ripe fruit stages at the time of harvest and the disease infection continued after post-harvest in storage (Table 1). Good amount of rainfall was received during the experimental period in well distributed manner except during the year 2018 where rainfall realized in only one spell (Table 1). Rainfall helped in the dispersal of spores thus severe losses recorded in rainy season also associated weather provided congenial environment for the fruits to get infected.

PDI recorded on anthracnose of chilli starting from the initiation of the disease revealed that disease first appeared 75-80 days after transplanting and showed a steady progress upto harvest. PDI value calculated against the standard meteorological week for the three experimental years showed similar pattern in disease progression (Table 1). In all the three experimental years,

much variation in the average temperature (27 to 32°C) was not observed, so the disease severity found to follow same pattern of progression though a variation observed in the amount of rainfall received and temperature trends to decrease starting from the 39th to 46th SMW (Table 1).

Correlation analysis between dependent variable (disease severity) with the independent variables (weather parameters) showed, maximum temperature (T_{max}), relative humidity (RH), total rainfall and number of rainy days shared a positive significant influence on anthracnose – chilli patho-system where as minimum temperature was found to have no impact on the disease development (Table 2). This was confirmed by the correlation coefficient value (r) calculated for the three years of experiment and was testified at 1 per cent and 5 per cent level of significance (Table 2) to prove the strength of the relationship between the dependent and independent variables. Our result is in corroboration of the report by Roberts *et al.*, (2001) who stated anthracnose of chilli was favoured by temperature of approximately 27°C with 80 per cent relative humidity. For the germination, infection and growth of the pathogen on the host, the duration of leaf surface wetness appears to be the most critical issue and generally infection prefers during warm, wet weather and these were all in conformity of research findings of Pernezny *et al.*, (2003), in *Colletotrichum*- pepper patho-systems and in *Colletotrichum*- betel vine patho-system by Sahoo *et al.*, (2012).

Correlation between disease severity and fruit yield determined for the three experimental years (pooled) which showed negative significant correlation:

$$Y = 50.64 - 0.413D \quad (R^2 = 0.984)$$

R^2 value close to 1 proved the goodness and feasibility of the model. The pooled mean indicated the declining trend i.e. attainable yield was 50.64 qha⁻¹ and yield losses were 0.41 qha⁻¹ for every 1 percent increase in disease severity.

Similar results on disease severity and yield loss were recorded by Saha and Das (2012) in early blight- tomato patho-system. Forecasting models for *Colletotrichum*– chilli pepper patho-system were developed by several scientists (Kang *et al.*, 2010) employing linear and non linear regression model and using logistic equations by taking into account hourly

data on leaf wetness-periods and temperature had been proved successful to forecast disease risk period thus could provide a recommended decision when to spray a curative fungicide.

The weather parameters tested through multiple regression equation *viz.*, maximum temperature, relative humidity, and rainfall were found critical for the development of anthracnose of chilli. The higher coefficient of determination value depict higher correlation (92.7 to 94.1%) between predicted and observed disease severity strongly support the feasible use of research data for the development of forecast model. As the climate vary greatly with geographical situation, so our research findings demand its validation over a wide range of climatic condition before releasing an efficient forecasting model.

ACKNOWLEDGEMENT

The authors are indebted to the Directorate of Research, and Associate Dean, College of Agriculture, Burdwan, BCKV for the support to conduct the experiment. We also acknowledge the contribution and support of DSF and BASF India Ltd. for undertaking the study.

Conflict of Interest Statement : The author(s) declare(s) that there is no conflict of interest.

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