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Severity, weather influence and prediction of early blight of Tomato for Eastern dry zone of Karnataka

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ABSTRACT

Early blight onset varied from 25 to 28 standard meteorological weeks (SMW) with mean of maximum severity levels of 86.7-100% during five years of *kharif* 2012-2016. Mean and maximum PDI of early blight was found significantly and positively correlated with morning and evening relative humidity of both lagged by one and two weeks. Relation between minimum temperature and early blight was significantly negative. The multiple linear regression predicting the mean severity accounted 79.0%. Variability due to maximum temperature and morning relative humidity two weeks and a week prior, respectively and wind velocity prior to two weeks. Maximum temperature and wind velocity of two lagged weeks accounted for 78.0% variability of maximum severity of early blight. Validations using 2016 data sets indicated suitability of prediction models beyond 30 SMW, however, the scope for refinement of models existed by removing the cumulative error arising out of mean and maximum severity considered across fields and accounting all individual fields *per se*. Weather based models developed considering crop age could also be more robust and needs further investigation.

Key words: *Alternaria solani*, PDI, *Solanum lycopersicum*, Weather variables.

Tomato (*Solanum lycopersicum* L.) productivity (21.2 t/ha) is quite low owing to cultivation of open pollinated varieties that are vulnerable to insect pests, diseases and abiotic factors. Among pests, leaf curl, bacterial wilt, late blight and early blight cause severe crop loss at the time of unseasonal climatic conditions. Tomato early blight *(Alternaria solani* Ell. & Mart.) is an economically important disease worldwide including India with moderate to high severity levels recorded across the country from time to time (Prasad & Naik 2004; Patel & Chaudhary, 2010). Saha and Das (2012) reported a yield loss of 0.75 to 0.77 t/ha for a unit % increase in disease severity. In Eastern dry zone of Karnataka, early blight of tomato is becoming increasingly important during recent years (Ramanujam *et al*., 2015). The relationship between disease progression and weather variables is of paramount importance across diseases and crops and studies on disease scenario and its forecast for a geographical area allow for possible preparedness and precautions to be taken for disease management. In the present study, seasonal variations on occurrence and influence of weather variables on *A. solani* during *kharif* on tomato at Bengaluru located in Eastern dry zone of Karnataka were investigated with purpose of developing weather based predictions.

Materials and Methods

Study was carried out as a part of National Innovations in Climate Resilient Agriculture

(NICRA) to understand the field level impact of climate variations on pest dynamics of tomato with participation of Indian Institute of Horticultural Research (IIHR), Hessaraghatta, Bengaluru located in Eastern dry zone of Karnataka. The *e* pest surveillance implemented for study of pest population dynamics under NICRA following standard sampling plan and procedures (http://www.ncipm.org.in/nicra/NICRAAdminPanel New/Dashboard.aspx) had ten fields of farmers selected from Bengaluru North taluk of Bengaluru urban district. The major cultivars grown during the periods of study were Shivam, Arka Sourabh, Arka Abha and Abhinava. In each field, five randomly selected spots were considered for recording severity of early blight on weekly basis from ten plants/spot based on standard 0-5 scale. Per cent disease index (PDI) for all fields was calculated for each SMW individually. Mean and maximum PDIs across fields along the SMWs and crop age were used for inter seasonal comparisons among 2012-16 seasons. Meteorological observations *viz.*, minimum and maximum temperatures (°C), morning and evening RH (%), rainfall (mm), sun shine hours (hr/day) and wind velocity (km/hr)) from IIHR, Bengaluru for the period of 2012-15 served as a source of independent variables for analysis of disease weather relations. Weather variables (minimum & maximum temperature (°C), morning and evening RH (%), rainfall (mm), sun shine hours (hr/day) and wind velocity (km/hr) and early blight severity (%) of 2012-15 seasons along SMWs were used for correlation. Stepwise multiple linear regressions (MLR) (Montgomery *et al.,* 2012) were built using weather variables lagged up to two weeks as regressors with arcsin transformed severity values of early blight on SMW basis. MLRs were run using SAS 9.3® to arrive at prediction models for mean and maximum severity of early blight. Developed models were validated using 2016 early blight severity along SMWs.

Results and Discussion

Increase in frequency and gravity of tomato early blight in response to ongoing climate change is a reported phenomenon. In India, climate change

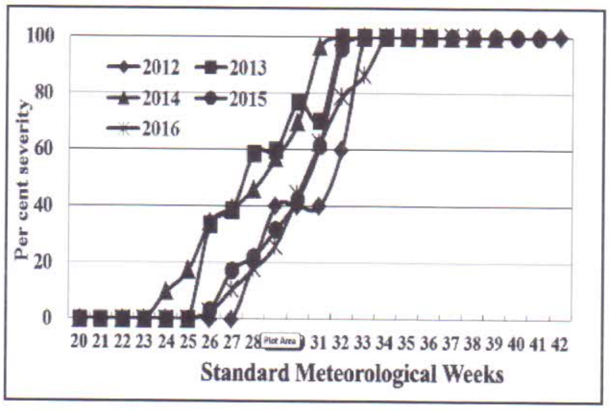

Fig. 1a. Seasonal severity of early blight in respect of SMWs

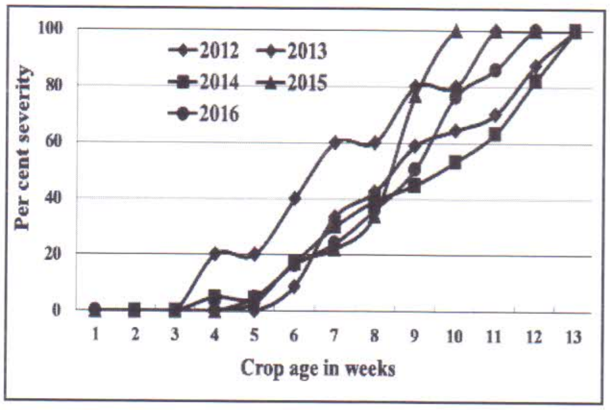

Fig. 1b. Seasonal severity of early blight *vis a vis* crop age

related outbreaks on several crop diseases have been reported by Chowdappa (2010). Present study explored the dynamics of early blight severity over seasons on tomato at Bengaluru, where the disease is of significance during *kharif.* Early blight initiated during 24 and 28 during 2014 and 2012, respectively while in 2013, 2015 and 2016 early blight initiated during 26 SMW and reached almost cent per cent between 31-34 SMWs (Fig. 1a). Maximum severity (>20%) was recorded during 26 to 29 SMW during all seasons. As the dates of transplanting across fields were different, severity levels of early blight based on weeks of transplanting (WAT) were worked out. Field occurrence of early blight over seasons (2012-16) at Bengaluru coincided with mean temperature range of 20.4 to 26.9° C and mean RH of 50.3 to 72.9 % falling with values

Table 1. Correlation coefficients between early blight and weather factors

Weather variable[#]	Mean severity			Maximum severity		
	Current week	One week prior	Two weeks prior	Current week	One week prior	Two weeks prior
MaxT	-0.117	-0.188	-0.409	-0.225	-0.326	-0.522*
MinT	-0.447*	-0.302	-0.165	-0.521*	-0.380	-0.260
MRH	0.675**	0.715**	0.675**	0.647**	0.674**	0.628**
ERH	0.414*	0.525*	0.442*	0.484*	0.574**	0.491*
RF	0.248	0.137	0.221	0.212	0.139	0.250
SunShine	-0.172	-0.343	-0.291	-0.202	-0.358	-0.335
Wind	-0.344	-0.330	-0.263	-0.356	-0.334	-0.265

[#]: Early blight severity was related to weather of corresponding to different (current, a week and two weeks prior) periods; **: significant at P < 0.01; *: significant at P < 0.05.

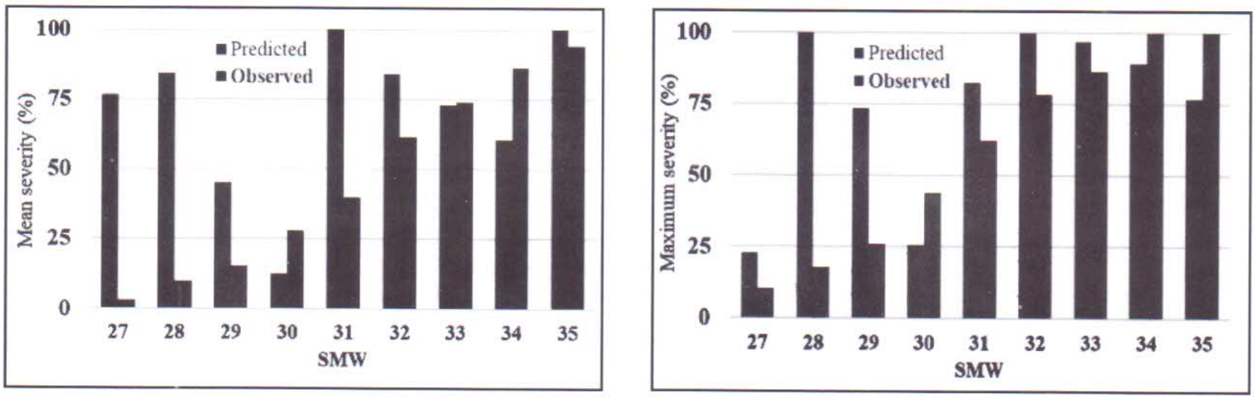

Fig. 2. Predicted and observed mean and maximum severity of early blight

reported by Soni *et al.* (2017) relating to high degree of *Alternaria solani* in fields wherein temperature range was 20-33.9°C coupled with RH of 38.4-84.8%. While early blight appeared 3 WAT during 2012 and 2013, it appeared at 5 WAT during 2015 and 2016 (Fig. 1b). Greater than 20% severity beyond fourth and seventh weeks in respect of 2012 and rest of seasons was recorded. Attainment of cent per cent severity was during 10 WAT in 2015 followed by 11 WAT in 2012 and at 12 WAT during 2016. Severity of 100% was attained 13 WAT during 2013 and 2014. Increased severity of early blight with crop age was evident across all seasons. The observed differences in time of start and levels of severity across seasons on SMW and crop age basis indicate role of crop phenology influencing the progression of early blight. Degree of susceptibility of tomato plants with increasing crop age was well established (Pandey & Pandey, 2003). Bhat *et al.* (2017) reported early blight in semi-arid region of Karnataka.

Correlation analysis of mean and maximum PDIs of early blight with weather variables indicated significant and positive influence of morning and evening RH prevalent during one and two weeks before besides that of current week. Morning RH had higher influence on early blight. Despite the general negative impact of maximum and minimum temperatures on mean as well as maximum early blight severity significance of current week's minimum temperature and of maximum temperature lagged by two weeks had significant negative effect on the maximum severity of early blight. Reports of early blight favoured by warm temperatures and extended periods of leaf wetness from frequent rains, overhead irrigations, or dews exist. Sunshine, wind velocity and rainfall effects were insignificant (Table 1).

Prasad and Naik (2004) reported 39-55% severity of early blight across Raichur, Dharwad and Gulbarga districts located in hot semi-arid eco region similar to Bengaluru of Eastern dry zone of Karnataka. Saha and Das, (2015) reported a positive and significant effect of average temperature, RH and total rainfall and negative significant effect of bright sunshine hrs on early blight severity from the sub-humid ecoregion of West Bengal. Significant role of temperature, humidity and rainfall reported for development of early blight on tomato in cold arid eco region of Jammu by Rani *et al*., (2015). Such variations in the nature and significance of associations could also be due to effect of cropping pattern, cultivar susceptibility and inoculum level at all places.

Chowdappa (2010) also reported similar results on impact of climate change in fungal diseases.

The multiple linear equations (1) and (2) to predict mean and maximum disease severity of early blight on tomato developed using 2012-15 data set for Eastern dry region are:

$$PDI_{mean} = -8.701 + 0.75MRH2 - 0.125MaxT2 - 0.043\ Wind2 \qquad R^2 = 0.79$$

$$PDI_{max.} = -9.541 + 0.215MRH1 - 0.191MaxT2 - 0.054\ Wind2 \qquad R^2 = 0.78$$

Where, $MaxT_2$ and MRH_1 are the maximum temperature and morning RH, respectively of two and one lag week and $wind_2$ denote the wind velocity prior to two weeks. The adequacy of the fitted prediction model measured by coefficient of the determination R^2 indicated 79 and 78% of variations in respect of mean and maximum severity of early blight in fields explained by weather variables accounted in the equations. Validation of the developed models using 2016 early blight disease progression indicated higher deviations of predicted from observed values during early stages of crop growth up to 31 and 29 SMWs in respect of mean and maximum severity (Fig. 2).

With the severity greater than 50% differences of predicted and observed severity were narrow indicating near suitability of the present models beyond 31 SMW. Differing period of initiations of disease, cultivar susceptibility, inoculum levels and cultural practices could be additional factors influencing severity in addition to prevalent weather. Prediction of onset of early blight based on weather followed by its effect on disease progression could be a viable approach to arrive at models with higher prediction accuracy. Further, investigation into development of prediction for crop stage specific severity could yield better models as SMW based approach amalgamates severity across all crop stages for each period of observation. Additionally, considering data set of all individual fields for model development instead of single series of disease progression generated across fields wherein accumulation of error could be obviated thus improving the prediction accuracy.

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