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Factors influencing dynamics of powdery mildew severity in tomato

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ABSTRACT

Levels of powdery mildew (*Leveillula taurcica*) severity in tomato varied during *kharif* seasons (2012-2016). Seasonal mean severity during 2012 (48.3%), 2013 (43.4%) and 2016 (47.2%) was at par and significantly higher over 2014 (34.1%) and 2015 (24.8%). Progression of powdery mildew severity was steeper beyond 10 weeks after planting. Cultivars (NC 501 and Shivam) and planting periods between mid-May and June end did not impact the disease severity. Positive and negative influences of maximum and minimum temperature, respectively of the concurrent week were noted. Maximum and minimum temperature congenial for disease progression under field conditions was found to be 28.4 to 30.1°C and 19.1-20.8°C, respectively. With only 3% variation of powdery mildew severity explained by temperature the way forward would be to understand the effect of agronomic practices on crop canopy and phenology of tomato production to effectively manage the disease.

Key words: Powdery mildew, disease severity, tomato, temperature

INTRODUCTION

Tomato is cultivated in 0.79 MHa in India with a production of 19.76MT (Anon, 1) of which contribution by Karnataka is 0.064 MHa and 2.08 MT, respectively. Major yield limiting biotic factors in tomato include gram pod borer, tobacco caterpillar, whitefly, leaf miner, thrips and mites among insects and leaf curl, early blight, late blight, powdery mildew, bacterial wilt, *Fusarium* wilt, bacterial spot and bud necrosis among diseases. Powdery mildew caused by *Oidium* state of *Erysiphe lycopersici* was of less significance till a decade back. However, in combination with early blight, powdery mildew causes significant yield loss in certain parts of the country (Ilhe *et al*., 7). Powdery mildew along with early and late blight are major fungal diseases of tomato in Bengaluru rural and Kolar districts of Karnataka. Considering the increasing epidemics of powdery mildew, it has become imperative to understand the impact of climate change on host pathogen interaction to outline appropriate management strategies (Chowdappa, 3). Cultivars exhibit varied disease progress depending on their resistance and interaction with other growing conditions including climate (Castro, 2). In the present study, status and dynamics of powdery mildew severity on tomato was investigated in relation to factors such as cultivars, planting periods and the prevalent weather factors in Bengaluru rural district of Karnataka.

MATERIALS AND METHODS

Observations on powdery mildew severity were a part of studies on pest dynamics in relation to climate change on tomato under National Innovations in Climate Resilient Agriculture (NICRA) during *kharif* 2012-16. Ten farmer's fields across 10 villages accounting a minimum of one-acre per field were considered for sampling powdery mildew severity at weekly intervals following disease appearance till harvest during each study season. NS 501 and Shivam were the common cultivars grown by farmers during the study seasons following standard package of practices. Five spots per field were sampled with observations of disease grade based on 0-5 scale (Correll *et al*., 4) in ten plants per spot. Per cent severity of powdery mildew for each spot and of each field was calculated using the formulae ((Vennila *et al.,* 11) given below.

$$S_i = 100 \times \sum_{j=0}^{J} \frac{j \times y_{ij}}{10 \times J} \qquad S_p = \frac{1}{I} \sum_{i=1}^{I} S_i$$

Severity grade per spot (S_i) Severity grade per field (S_p)

where, i= spot no, i=1,2,…,5; j= severity grade, j=0,1,…,5; J= maximum disease grade; I=total number of spots; Y_{ij} =Number of plants in ith spot with jth severity grade. Mean severity across five spots per field for a given week of observation was calculated for individual fields. Data sets on progression of disease amongst sampled fields of five seasons (2012-16) along standard meteorological weeks (SMW) were compiled. Severity of powdery mildew on basis of crop age (CA) (expressed in weeks) with respect to each period of observation was calculated considering respective periods of planting in individual fields. Data sets were assembled on the powdery mildew dynamics pertaining to individual fields with common cultivars (NS 501 and

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Shivam) and periods of planting (PP) grouped into three *viz.,* May second fortnight (May II FN), June first fortnight (June I FN) and June second (June II FN). Data on weather variables *viz*., maximum and minimum temperature (MaxT & MinT in °C), morning and evening humidity (RHM & RHE in %), sunshine hour (SS in h/day), wind velocity (wind in m/h), total rainfall (RF in mm) and rainy days (RD) were gathered for study period (2012-2016) from the meteorological observatory of Bengaluru urban. Data sets on standard meteorological week (SMW) at weekly intervals were used to assess the influence of weather parameters on powdery mildew severity through multiple regression analysis. Differences in powdery mildew severity across seasons, cultivars and planting periods were tested using one-way ANOVA following *arcsine* transformation of data sets based on disease dynamics of 2012-16 with their means compared using Duncan Multiple Range Test (DMRT). Graphical depiction of disease progression worked out along crop age for the common periods of seasons was made. Relationships between powdery mildew severity and eight weather variables each of current, one and two lags on SMW basis aggregated over seasons (2012-16) were worked out using multiple linear regression models based stepdown selection procedure. One-way ANOVA on contributory weather variables for period of *kharif* tomato season (May II FN –October II FN) was also performed. All the statistical analyses were done using SAS 9.4 (SAS., 10).

RESULTS AND DISCUSSION

Powdery mildew initiated during fifth, seventh and eighth weeks after planting (WAP) during 2012, 2013 and 2014, respectively. Diseases initiation was in fourth WAP during 2015 and 2016. Seasonal mean disease severity was at par amongst 2012 (48.3%), 2013 (43.4%) and 2016 (47.2%) and significantly higher over 2014 (34.1%) and 2015 (24.8%) with the latter two seasons also at par. Statistically, the differences for severity between cultivars (NS 501:41.0% & Shivam:40.8%) and amongst planting periods (May II FN (38.0%); June I FN (40.4%) & June II FN (33.9%)) were non-significant (Fig.1). Disease severity in respect of seasons (2012-16) along crop age revealed more or less similar trends of disease progression but for levels of severity with narrow differences between seasons within the two statistically similar groups (1) 2014 & 2015 and (2) 2012, 2013 & 2016 at the crop age of 10 WAP indicating the increasing disease manifestation beyond flowering stage. Increased powdery mildew severity at flowering and fruiting with change of sink-source relationships (Jarvis *et al.,* 8) supports the higher severity beyond 10 WAP during all seasons. Maximum severity at the end of crop season (14 WAP) in respect of two groups of seasons namely 2014, 2015 and 2012, 2013, 2016 was 45% and 80%, respectively (Fig.2). With no differences for the powdery mildew severity between cultivars and the planting periods, it is possible that the weather of the seasons could have played a role.

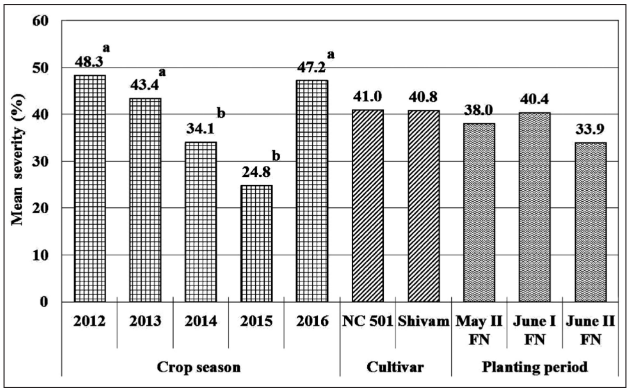

Fig. 1. Mean powdery mildew severity (%) across seasons, cultivars and planting periods

The weather variables of different periods ranging from a week to fortnight affect the severity levels of diseases. Step down regression approach identifies only the significant variables of influence. Hence, dependence of powdery mildew severity (%) in relation to weather variables corresponding to current, one and two lag weeks were considered for multiple linear regression model (MLR). Since the trends of disease severity during all seasons were the same, aggregate datasets of 2012-2016 were used to identify the nature and degree of weather factor influence. Such a MLR brought out an equation of the form: powdery mildew severity (%) =0.431 + 0.025 $MaxT_0$ - 0.024 $MinT_0$ (R^2: 0.036*; $p<0.05$) where T_0 represents the weather factor of the current week.

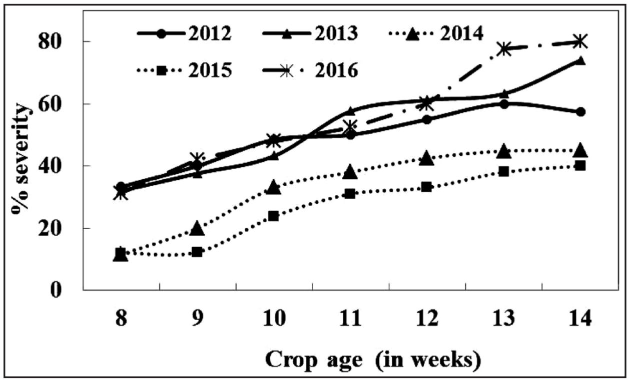

Fig. 2. Progression of powdery mildew during *kharif* seasons (2012-2016)

The positive effect of maximum temperature and an equally negative impact of minimum temperature imply the importance of increased temperature in positive progression of the disease (as indicated by positive intercept). Maximum temperature was positively correlated to powdery mildew severity in moong (Khare *et al*., 9). Progression of powdery mildew in respect of the contributory weather variables of maximum and minimum temperature along the crop growth are furnished in Fig 3. It was also found that gradual but steady increase of maximum and minimum temperature along the season (as inferred through trend lines) could have influenced disease progression of powdery mildew. The significant but lowest R^2 leaves larger scope for exploration of additional factors determining disease severity. An attempt to look into the variations in seasonal means of temperature revealed significant differences (Table 1). While the order of increase for maximum temperature was 2015 & 2012 >2016, 2014&2013, it was 2016, 2015&2014> 2013&2012, 2015&2016 >2014, 2012>2013 for minimum and mean temperature, respectively. Such a trend did not completely explain the differences in disease severity between two groups of seasons (Fig.1) pointing to the factors other than temperature involved. Association of high levels of powdery mildew severity with high vegetative vigour (Jarvis *et al*. 8) and cultural practices that favour vegetative vigour predispose host to an increased development of disease. Reports of high nitrogen supply increasing severity of tomato powdery mildew *Oidium lycopersicum* (Hoffland *et al*. 6) and a very dense cum poorly ventilated canopy offering favourable micro-climate (Halleen and Holz, 5) are available.

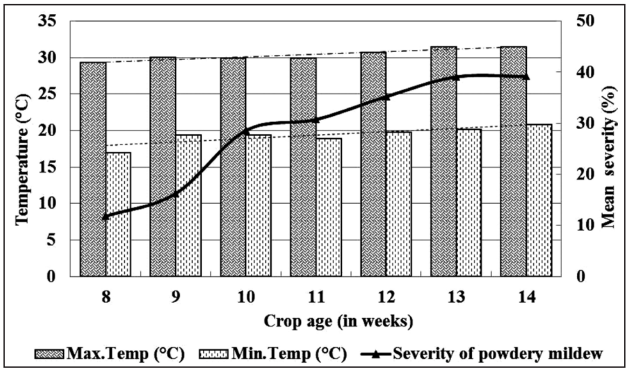

Fig. 3. Disease severity *vis a vis* temperature along with their trend lines

Table 1. Mean seasonal temperature for study seasons of *kharif* tomato at Bengaluru urban.

Weather variable (°C)	2012	2013	2014	2015	2016	F value & its significance#
Max T	30.1^{a}	28.4^{b}	28.8^{b}	30.4^{a}	28.9^{a}	5.04**
Min T	19.1^{b}	19.3^{b}	20.6^{a}	20.6^{a}	20.8^{a}	9.38**
Mean T	24.6^{b}	23.9^{c}	24.7^{b}	25.5^{a}	24.9^{ab}	6.20**

#: significance of 'F' denoted by *: $p<0.05$; **: $p<0.01$

Considering the high severity seasons (2012, 2013 and 2016) of powdery mildew in the current study, it is inferred that the ranges of maximum, minimum and mean temperature congenial for disease progressions under field conditions were 28.4 to 30.1°C, 19.1-20.8°C and 23.9-24.9° C, respectively at the eastern dry zone of Karnataka. Investigation on the interaction of atmospheric variable of temperature with other system variables of tomato production would enhance further understanding of additional factors determining powdery mildew severity.

AUTHORS' CONTRIBUTION

Conceptualization of research (SV, MNB, VS); Designing of the experiments (SV, MNB, VS); Contribution of experimental materials (SV, VS); Execution of field/lab experiments and data collection (VS); Analysis of data and interpretation (SV, MNB, SKY); Preparation of the manuscript (SV, MNB, VKS).

DECLERATION

All the authors declare no conflict of interest

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