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Chenesh Patel
Department of Entomology, GBPUA & T, Pantnagar, Uttarakhand, India

RM Srivastava
Department of Entomology, GBPUA & T, Pantnagar, Uttarakhand, India

Deeksha MG
Davison of Entomology, IARI, New Delhi, Delhi, India

Roopam Kunwar
Department of Entomology, GBPUA & T, Pantnagar, Uttarakhand, India

Jahanvi Tiwari
Department of Entomology, GBPUA & T, Pantnagar, Uttarakhand, India

Khanika Pal
Department of Entomology, GBPUA & T, Pantnagar, Uttarakhand, India

Corresponding Author
Chenesh Patel
Department of Entomology, GBPUA & T, Pantnagar, Uttarakhand, India

Influence of abiotic factors on seasonal incidence of *Bemisia tabaci* (Gennadius) on tomato

Chenesh Patel, RM Srivastava, Deeksha MG, Roopam Kunwar, Jahanvi Tiwari and Khanika Pal

Abstract
The present investigation on the seasonal dynamics of whitefly (*Bemisia tabaci*) on tomato (cv. Pant Tomato 3) was performed out at the Vegetable Research Centre, GBPUA&T, Pantnagar, during the *Kharif* crop seasons 2017-18 and 2018-19. Seasonal incidence revealed that whitefly first occurred during the 38th (2017-18) and 39th SMW (2018-19) standard week, peaking during the 48th (2017-18) and 49th SMW (2018-19). Maximum humidity and evaporation exhibited a positive association with the adult whitefly population, while temperature (maximum and minimum), rainfall, wind velocity, and sunshine hours exhibit a negative correlation. Taken together, the major weather parameters studied, caused 78.00 per cent variation in the whitefly population (R^2 value).

Keywords: Abiotic factors, *B. tabaci*, population, seasonal incidence, tomato

Introduction
Tomato is a popular and widely grown vegetable all over the world. It is a profitable commercial vegetable crop grown on a small scale, and it is one of the most promising areas for horticulture development (FAO, 1989) [1]. In many tropical and subtropical countries, *Bemisia tabaci* (Genn.) is a major pest of tomato (Block, 1982) [2]. One of the limiting factors preventing the successful cultivation of a tomato crop is the presence of whiteflies. This insect pest can directly harm tomato by feeding on the phloem or indirectly by transmitting plant viruses such as Tomato Yellow Leaf Curl Virus (TYLCV) (Mehta *et al.* 1994) [3]. Furthermore, the pest secretes honeydew, which encourages the growth of sooty mould and reduces yield quantitatively and qualitatively. Because whitefly infestations can easily go unnoticed until they reach the threshold, and because of the magnitude of losses associated with whitefly generation, there is a huge interest in its population abundance and seasonal occurrence (Sharma *et al.* 2017) [4]. Tomato cultivation is totally reliant on the use of insecticides, which can help manage the whitefly population, but it has significant environmental consequences in many ways, so alternative strategies must be devised (Broekgaarden *et al.* 2011) [5]. Detailed understanding of insect seasonal incidence and population dynamics in tomato crops is required for effective whitefly management. In this context, weather attributes such as temperature, relative humidity, sunshine and rainfall were found to be limiting factors in the development of whitefly populations (Marabi *et al.* 2017) [6].
Several employees had previously reported whitefly infestations due to favourable weather conditions (Das *et al.* 2011) [7]. In order to provide initial information on *B. tabaci* seasonal population build-up assessment and management, the current study looked into the impact of several weather parameters on the population dynamics of whitefly on tomato crops.

Methods and Materials
The current study was conducted at the Vegetable Research Centre of GB Pant University of Agriculture and Technology, Pantnagar-263145, Udham Singh Nagar, Uttarakhand, between 2017-18 and 2018-19. The tomato variety 'Pant Tomato 3' was grown in an open field with a plot size of 5m X 3m to investigate the seasonal incidence of whitefly as well as the influence of existing meteorological conditions on its population dynamics. The experiment was carried out in pesticide-free conditions. Data on whitefly incidence was collected at weekly intervals started shortly after transplantation. The whitefly population was counted on three compound leaves (upper, middle, and lower) per plant on ten plants chosen at random from each plot at weekly intervals during the early morning hours when insects are least active.

Throughout the experiment, weekly meteorological data was collected from Pantnagar's Department of Agrometeorology, including maximum and minimum temperatures, morning and evening relative humidity, sunlight hours, and wind speed (Fig. 1a & 1b). Using SPSS (Version 20, SPSS, Inc. Chicago, II, USA) and the R programme, correlation studies were done between the incidence of whitefly population and major weather parameters to assess the impact of weather on the population fluctuation of *B. tabaci*.

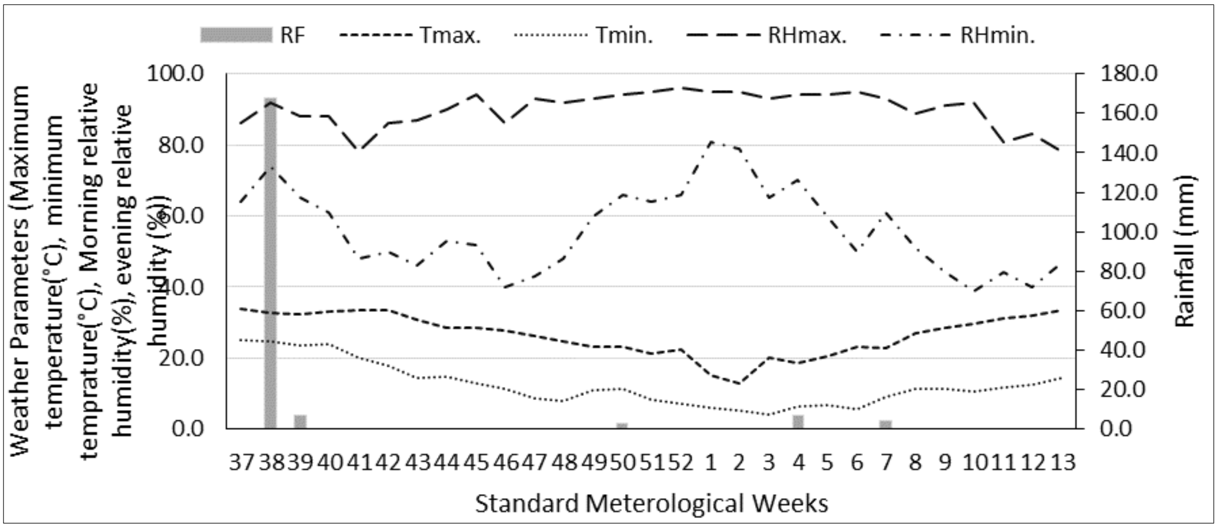

Fig 1a: Weekly weather parameters during 2017-18

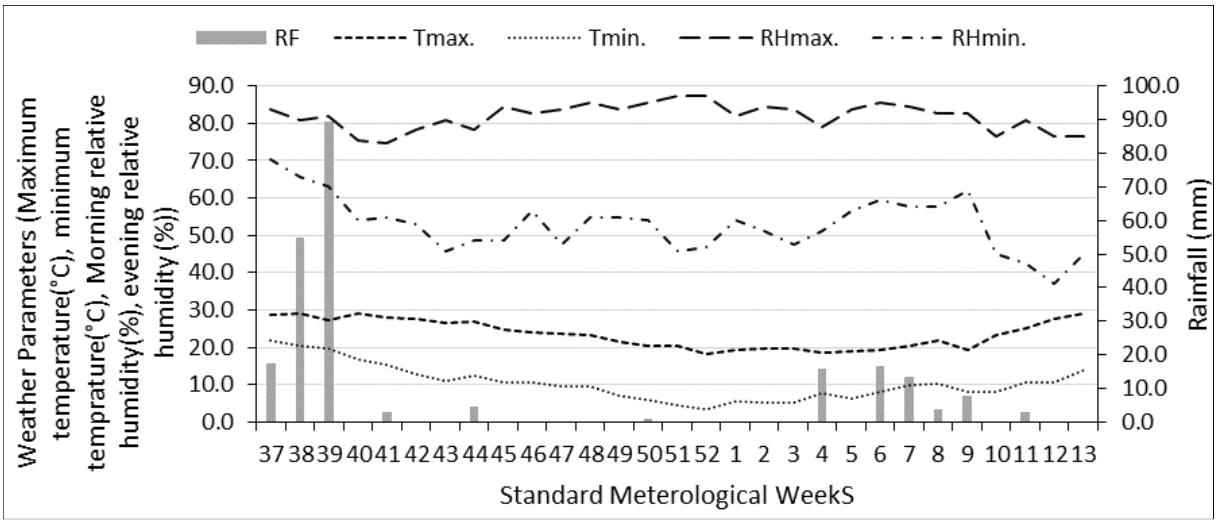

Fig 1b: Weekly weather parameters during 2018-19

Results and discussion

Incidence of *B. tabaci* in tomato and correlation with abiotic factors

During the 39th and 38th standard meteorological weeks (SMW), whiteflies first appeared on tomato plants immediately after transplanting, and their population rapidly increased as the crop stage progressed. The findings corroborated those of Meena and Bairwa (2014) [8], who hypothesised that the occurrence of whitefly adults began as a result of whitefly switching to a different host crop. On tomato, the population of *B. tabaci* adults ranged from 0.00 to 5.40 ± 0.13 per three leaves in 2017-18 and from 0.00 to 6.20 ± 0.244 per three leaves (mean SE; N = 10) in 2018-19 (Fig. 2). The population peaked on tomato at 48th SMW (5.40 adults per three leaves) and 49th SMW (6.20 adults per three leaves) in both years. Berragani *et al.* (2015) [9] found that during this period, maximum temperature (range: 21 to 26 °C) and minimum temperature (range: 6.60 to 10.90 °C), morning relative humidity (range: 92 to 95 per cent), and evening relative humidity (range: 48 to 64 per cent) are favourable for *B. tabaci* multiplication and spread in tomato, which could be due to differences in prevailing climatic conditions.

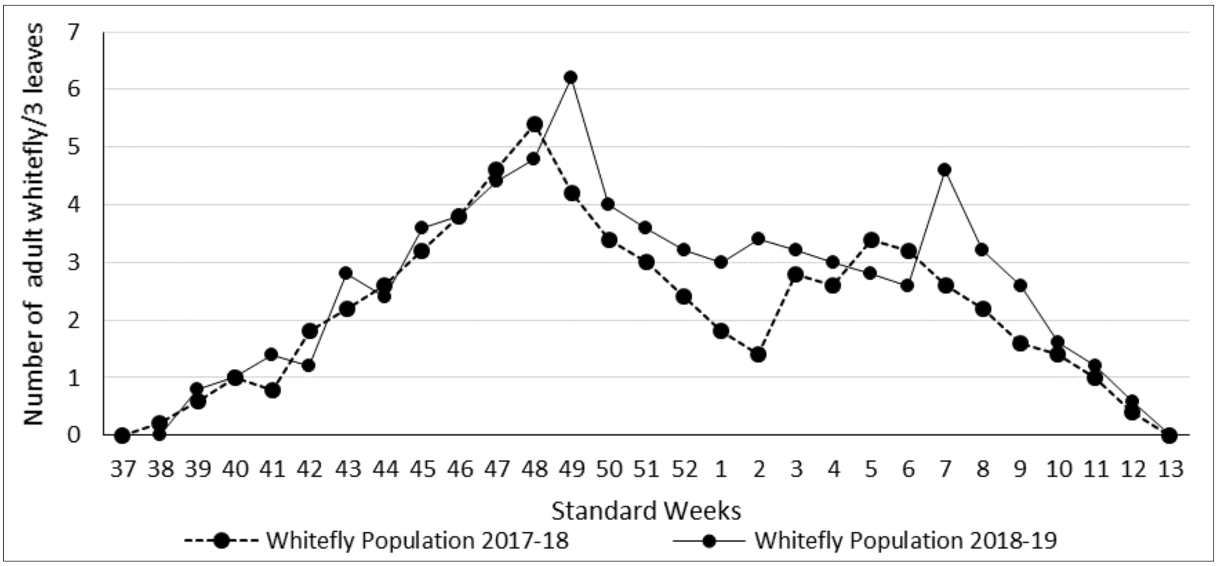

Fig 2: Seasonal incidence of *B. tabaci* on tomato in relation to climatic factors during 2017–2019

In tomato, correlation analyses demonstrated a significant negative correlation between whitefly and Tmax. (r =-0.62), Tmin. (r =-0.66), and WS (r =-0.58), as well as a significant positive correlation with RHmax. (r =0.65). This finding is consistent with those of Pandey *et al.* (2008)[10] and Mathur *et al.* (2012) [11], who found a significant negative association between whitefly populations and maximum and minimum temperature, as well as a positive correlation with relative humidity. The current findings contradict those of Dhatonde and Pandya (2014) [12], who claimed that it could be owing to differences in ecological conditions and their interaction with the insect. The whitefly adult population in tomato showed a significant negative correlation with wind speed (r =-0.58), which is confirmed by Khan *et al.* (2010) [13], who also reported that wind speed adversely affected the whitefly adult population and either blew off or the whiteflies may move to the lower canopy (Table 1).

Table 1: Correlation matrix (Pearson's) for weather-based observations with *B. tabaci* population in tomato from 2017–2019

Variables	TWf	Tmax.	Tmin.	RHmax.	RHmin.	RF	SSH	WS
Tmax.	-0.63**							
Tmin.	-0.66**	0.87**						
RHmax.	0.65**	-0.77**	-0.58*					
RHmin.	NS	NS	NS	0.44*				
RF	-0.38*	NS	0.52**	NS	0.48**			
SSH	-0.37*	0.70**	NS	-0.61**	-0.72*	NS		
WS	-0.58**	NS	0.57**	NS	NS	0.62**	NS	
Evap.	-0.75**	0.88**	0.69**	-0.82**	0.41*	NS	0.74**	0.46*

TWf: whitefly adult population/3 leaves on tomato; Tmax.: maximum temperature (°C); Tmin.: minimum temperature (°C); RHmin.: minimum relative humidity (%); RHmax.: maximum relative humidity (%); RF: rainfall (mm); SSH: sunshine(Hrs.); WS: wind velocity (Km-h) and Evap.: evaporation(mm). Bold digits in the table indicate the "–" correlation data; data followed by '*' indicates their significant correlation at $P< 0.05$ and data followed by '**' indicate their significant correlation at $P< 0.01$; NS: not significant

The regression equation revealed that various weather factors, such as temperature (max. and min.), relative humidity (morning and evening), rainfall, wind velocity, sun shine hours and evaporation had an influencing effect on population of *B. tabaci* on tomato with reasonable accuracy (R^2= 0.78).

Y_1 = 4.78 + 0.131T (max.) – 0.005 T (min.) + 0.149 RH (mor.) – 0.092 RH (eve.) – 0.006 (Rf) – 0.208 (SS) – 0.025 (WV) – 1.125 (Evap.)

Y_1 = adults whitefly/3 leaves in tomato

Conclusion

According to this study, whitefly population growth is highest in November and December, and it spreads quickly during these months. Thus, establishing and implementing management measures can be essential in sustainable vegetable cultivation.

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