Original Research Article

Effect of abiotic factors on seasonal incidence of whitefly, *Bemisia tabaci* on tomato, *Solanum lycopersicum* L. crop

Abstract

A field experiment was conducted during the *Rabi* seasons of 2021-22 and 2022-23 to study the influence of various meteorological parameters on the population dynamics of whitefly, *Bemisia tabaci* (Hemiptera: Aleyrodidae), infesting tomato (*Solanum lycopersicum* L.). The study was carried out at the Central Experiment Station, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. During *Rabi* 2022-23, the whitefly population ranged from 0.07 to 7.13 per three leaves per plant, while in *Rabi* 2023-24, it ranged from 0.05 to 7.52 per three leaves per plant. The peak population of whitefly was consistently observed during the 13th Standard Meteorological Week (SMW) in both seasons. Pooled data for both years revealed that the whitefly population ranged from 0.06 to 7.33 per three leaves per plant, with a peak observed during the 13th SMW. Correlation analysis showed that the whitefly population had a significant negative correlation with evening relative humidity (r = -0.685) but a significant positive correlation with evaporation (r = 0.760**) and wind speed (r = 0.803**). In *Rabi* 2023-24, the whitefly population was positively correlated with maximum temperature (r = 0.648**), bright sunshine hours (r = 0.618**), wind speed (r = 0.940**), and evaporation (r = 0.875**), while showing a significant negative correlation with morning relative humidity (r = -0.649**).The coefficient of determination (R^2) indicated that weather parameters contributed to 90% and 91% of the total variation in the whitefly population during *Rabi* 2022-23 and 2023-24, respectively. The findings highlight the critical role of meteorological factors in influencing the population dynamics of *B. tabaci* on tomato during the *Rabi* season.

Keywords: *Bemisia tabaci*, Tomato, abiotic factors, seasonal incidence, correlation

Introduction

Tomato (*Solanum lycopersicum* L.) are among the most widely cultivated and economically significant crops worldwide, contributing substantially to food security and agricultural economies. India is the second-largest producer of tomato, following China, with a cultivation area of 872.9 thousand hectares, a production of 21,238.1 thousand metric tons (MT), and a productivity rate of 24.33 MT/ha. In Maharashtra, tomatoes are grown on 55.23 thousand hectares, producing 1,332.09 MT, with a productivity of 24.12 MT/ha (Anonymous, 2023). Among various sucking insect pests, whitefly (*Bemisia tabaci* Genn.) is one of the most destructive pests infesting tomatoes, causing significant yield losses (Barro *et al*., 2011). The pest's destructive nature is attributed to its high degree of polyphagy, ingestion of phloem sap, excessive honeydew secretion, and its role as a vector for viruses such as Tomato Yellow Leaf Curl Virus (TYLCV) (Brown *et al*., 2002). The honeydew secreted by whiteflies reduces the cosmetic value of the tomato, diminishes the leaf area available for photosynthesis, and supports the growth of sooty mold, leading to both quantitative and qualitative yield losses (Oliveira et al., 2001).Whiteflies are among the most invasive pests, affecting a wide range of vegetables and essential crops globally (Abdel-Baky and Al-Deghairi, 2008). Since the late 1980s, *B. tabaci* has emerged as a major pest, not only due to its direct feeding on phloem sap but also its ability to act as a vector for viral diseases such as TYLCV, which severely hampers plant vitality and yield (Abdel-Baky and Al-Deghairi, 2008). The global spread of whiteflies and the magnitude of crop losses they cause have generated keen interest in understanding their biology and ecology (Barro *et al*., 2011). Environmental factors, particularly temperature and relative humidity, significantly influence the population dynamics and development of whiteflies. Seasonal population dynamics studies have shown that whitefly populations peak under specific climatic conditions, which play a crucial role in devising pest management strategies (Thakoor *et al*., 2020). Whiteflies deplete plant nutrients by feeding on the phloem, resulting in stunted growth in tomato plants (Pizetta *et al*., 2021). Furthermore, as vectors of TYLCV, whiteflies can cause severe yield losses, with infection rates ranging from 40% to 87% in susceptible genotypes (Srinivasan *et al*., 2012).Despite extensive research on the impacts of whiteflies on tomato crops, there remains a critical gap in localized studies on their seasonal abundance and correlation with weather factors. Recorded the seasonal patterns of whitefly infestations and their relationship with meteorological parameters is essential for the development of effective pest management strategies. This study aims to investigate the seasonal patterns of whitefly infestations in the Konkan region, evaluate their impact on tomato yield, and provide insights into weather-driven population dynamics. The findings will support the development of timely and effective management practices to mitigate yield losses and enhance tomato crop productivity.

Material and methods

A field experiment was carried out at the Vegetable Improvement Scheme, CES, Wakawali, during the *Rabi* seasons of 2022–23 and 2023–24 to investigate the seasonal incidence of whitefly on tomato. The tomato cultivar *Konkan Vijay* was grown in plots measuring 27.72 m² with a spacing of 60 × 60 cm.

Observations recorded

Ten plants were selected randomly for observation. Population was counted on three leaves top, middle and bottom and expressed as number on three leaves. The observations of pests infesting tomato were recorded at weekly interval (SMW) in a crop season. All recommended cultivation practices were followed. At the same time a corresponding weekly record of meteorological data viz. minimum and maximum temperature, morning and evening per cent relative humidity, wind speed, evaporation, bright sunshine was maintained. The influences of different meteorological parameters on pest population were studied by graphical super imposition technique (Wade *et al*., 2020).

Statistical analysis

The data on whitefly infestation in tomato crops were averaged, and correlation and regression analysis were conducted to examine the relationship between whitefly populations and weather parameters. These analyses were performed using Microsoft Excel.

Result and discussion

Seasonal incidence of whitefly, *B. tabaci* infesting tomato

The data on seasonal incidence of whitefly infesting tomato during *Rabi* 2022-23, *Rabi* 2023-24 and pooled data are presented in Table 1 and graphically depicted in Fig.1.

The data revealed that, during *Rabi* 2022-23 the incidence of whitefly population ranged from 0.07 to 7.13 /three leaves /plant. The pest incidence was first noticed in the 51st SMW (17th December to 23rd December) *i.e.* 0.07 /three leaves /plant, then incidence increased continuously up to the 13th SMW (26th March to 1st April) and remained till maturity of the crop. The maximum pest incidence (7.13 /three leaves /plant) was recorded in 13th SMW (26th March to 1st April) and minimum pest incidence (0.07 whitefly /three leaves/plant) was recorded in 51st SMW (17th December to 23rd December).

During *Rabi* 2023-24 the incidence of whitefly population ranged from 0.05 to 7.52

/three leaves /plant. The pest incidence was first noticed in the 51st SMW (17th December to 23rd December) *i.e.* 0.05 /three leaves /plant, then incidence increased continuously up to the 13th SMW (26th March to 1st April) and remained till maturity of the crop. The maximum pest incidence (7.52 /three leaves/plant) was recorded in 13th SMW (26th March to 1st April) and minimum pest incidence (0.05/three leaves/plant) was recorded in 51st SMW (17th December to 23rd December).

The pooled data of both the years revealed that, the incidence of whitefly population was in the range of 0.06 to 7.33 /three leaves /plant. The pest incidence started from 51st SMW (17th December to 23rd December) *i.e.* 0.06 /three leaves /plant, then incidence increased continuously up to the 13th SMW (26th March to 1st April) and remained till maturity of the crop. The maximum pest incidence (7.33/three leaves/plant) was recorded in 13th SMW (26th March to 1st April) and minimum pest incidence (0.06/three leaves/plant) was recorded in 51st SMW (17th December to 23rd December).

Table 1: Seasonal incidence of whitefly, *B. tabaci* infesting tomato during *Rabi* 2022-23, *Rabi* 2023-24 and pooled data

SMW	Period	Mean no. of whitefly/three leaves/plant		
		2022-23	2023-24	Pooled
49	03 Dec – 09 Dec	0.00	0.00	0.00
50	10 Dec – 16 Dec	0.00	0.00	0.00
51	17 Dec – 23 Dec	0.07	0.05	0.06
52	24 Dec – 31 Dec	0.11	0.05	0.08
1	01 Jan – 07 Jan	0.22	0.08	0.15
2	08 Jan – 14 Jan	4.18	3.11	3.65
3	15 Jan – 21 Jan	4.18	4.19	4.19
4	22 Jan – 28 Jan	5.81	4.85	5.33
5	29 Jan – 04 Feb	5.30	5.80	5.55
6	05 Feb – 11 Feb	5.45	6.31	5.88
7	12 Feb – 18 Feb	5.61	6.45	6.03
8	19 Feb – 25 Feb	6.11	6.81	6.46
9	26 Feb – 04 Mar	5.61	6.90	6.25
10	05 Mar – 11 Mar	6.10	7.01	6.56
11	12 Mar – 18 Mar	6.31	7.20	6.76
12	19 Mar – 25 Mar	6.90	7.29	7.10

13	26 Mar – 01 Apr	7.13	7.52	7.33
SD (±)		**2.76**	**3.08**	**2.91**
SMW- Standard Meteorological Week				

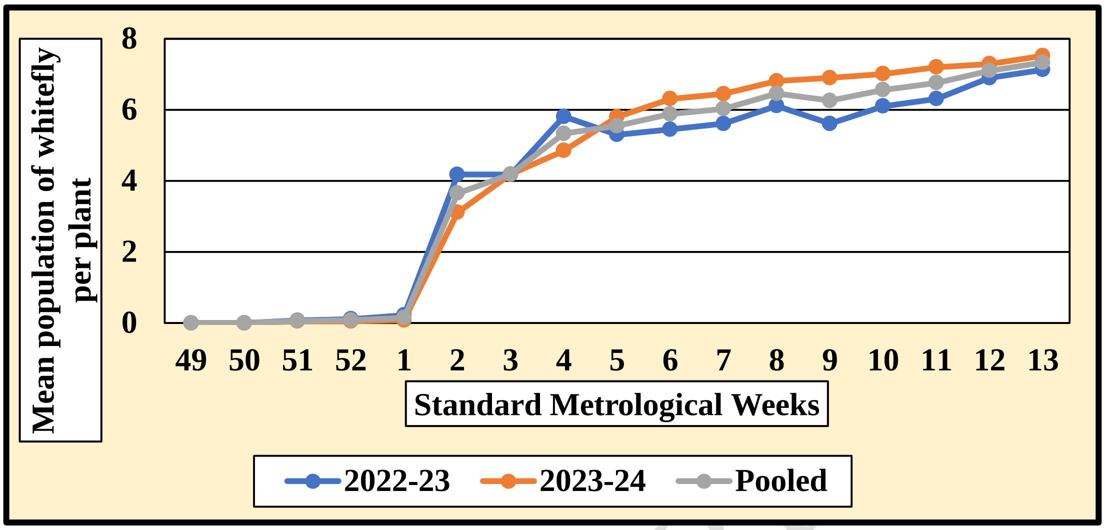

Fig. 1: Seasonal incidence of whitefly infesting tomato during *Rabi* 2022-23, *Rabi* 2023-24 and pooled data

Correlation and regression between whitefly population and weather parameters

Correlation studies

The data on correlation coefficient of mean population of whitefly in relation to different weather parameters during *Rabi* 2022-23 and *Rabi* 2023-24 are shown in table 2.

During *Rabi* 2022-23, the mean population of whitefly exhibited positive correlation with maximum temperature and bright sunshine hours while negative correlation with minimum temperature and morning relative humidity. The evening relative humidity (r=-0.685**) recorded negative highly significant correlation with mean population of whitefly whereas wind speed (r=0.803**) and evaporation (r=0.760**) recorded highly positive significant correlation with mean population of whitefly. Other parameters were non-significantly correlated with whitefly population.

Table 2: Correlation coefficient of whitefly, *B. tabaci* infesting tomato in relation to different weather parameters during *Rabi* 2022-23 and *Rabi* 2023-24

Weather parameters	**Correlation coefficient (r)**	
	2022-23	**2023-24**
Temp. Max.	0.400	0.648**
Temp. Min.	-0.077	-0.075

RH-I	-0.316	-0.649**
RH-II	-0.685**	-0.452
BSS	0.149	0.618**
WS	0.803**	0.940**
EVP	0.760**	0.875**

* Correlation is Significant at the 0.05 level 'r' value = 0.482

** Correlation is significant at the 0.01 level 'r' value = 0.606

The mean population of whitefly during *Rabi* 2023-24 showed negative correlation with minimum temperature and evening relative humidity. The whitefly population had positive highly significant correlation with maximum temperature (r=0.648**), bright sunshine hours (r=0.618**) and wind speed (r=0.940**) and evaporation (r= 0.875**) whereas negative highly significant correlation with morning relative humidity (r= -0.649**).

Multiple linear regression studies

The multiple regression was worked out between whitefly population and weather parameters during *Rabi* 2022-23 and regression coefficient (b) and intercept (a) are presented in Table 3.

The regression equation of *Rabi* 2022-23 was worked out is as follows

$$\mathbf{Y=52.730-0.529\,X_1 -0.929\,X_2 +0.027\,X_3 -0.301\,X_4 -1.583\,X_5 +3.066\,X_6 + 1.054\,X_7}$$

The coefficient of determination (R^2) represents the proportion of common variation in the two variables. The investigation revealed that the weather parameters contributed for 90 per cent of total variation in the population of whitefly on tomato.

Table 3: Multiple linear regression between whitefly, *B. tabaci* and weather parameters during *Rabi* 2022-23

Sr. No.	Weather parameters	Regression coefficient (b)	S.E. (b)	't' values
(X_1)	**Temp. Max.**	-0.529	0.514	-1.029
(X_2)	**Temp. Min.**	-0.929	0.239	-3.881
(X_3)	**RH-I**	0.027	0.094	0.295
(X_4)	**RH-II**	-0.301	0.179	-1.675
(X_5)	**BSS**	-1.583	0.521	-3.037
(X_6)	**WS**	3.066	2.512	1.220
(X_7)	**EVP**	1.054	1.288	0.818

Intercept (a) = 52.730, N=15, F value = 12.116, R^2 = 0.90

During *Rabi* 2023-24, the multiple regression was worked out between whitefly population and weather parameters and regression coefficient (b) and intercept (a) are presented in Table 4.

The regression equation worked out of *Rabi* 2023-24 is as follows

$$Y= -20.424 + 0.051 X_1 -0.152 X_2 +0.217 X_3 -0.062 X_4 -0.126 X_5 +3.344 X_6+1.132X_7$$

The coefficient of determination (R^2) represents the proportion of common variation in the two variables. The investigation revealed that the weather parameters contributed for 91 per cent of total variation in the population of whitefly on tomato.

Table 4: Multiple linear regression between whitefly, *B. tabaci* and weather parameters during *Rabi* 2023-24

Sr. No.	Weather parameters	Regression coefficient (b)	S.E. (b)	't' values
(X_1)	**Temp. Max.**	0.051	0.351	0.146
(X_2)	**Temp. Min.**	-0.152	0.242	-0.626
(X_3)	**RH-I**	0.217	0.192	1.126
(X_4)	**RH-II**	-0.062	0.072	-0.871
(X_5)	**BSS**	-0.126	0.648	-0.194
(X_6)	**WS**	3.344	1.301	2.570
(X_7)	**EVP**	1.132	1.141	0.991
Intercept (a) =-20.424, N=15, F value = 13.409, R^2 = 0.91				

Discussion

The findings of Chavan *et al*. (2013) revealed that the whitefly population initiated soon after transplanting with an initial population of 0.37 whiteflies per leaf and reached its peak (6.01 whiteflies per leaf) at 11th weeks after transplanting (WAT). A significant negative correlation was observed between the minimum temperature and the whitefly population during their study. Similarly, Mishra *et al.* (2017) reported that whitefly incidence began in the 4th week of August and peaked in the last week of September, corresponding to the 39th standard meteorological week (SMW).However, the findings of Dhatonde (2014) and Indirakumar *et al*. (2016) contradict the present results, as they reported a peak whitefly population during January. This discrepancy could be attributed to variations in transplanting dates, climatic conditions, and field management practices. The current results align with those of Subba *et al.* (2017), who observed that the whitefly population reached its maximum levels between the 11th and 18th SMW, specifically during the 2nd and 3rd weeks of March, with a peak density of 0.47 whiteflies per leaf. Kahar and Mondal (2020) found that whitefly populations positively correlated with temperature and sunshine hours but negatively with humidity, with weather parameters explaining 41.1% to 66.5% of population variation. Similarly, Sharma *et al.* (2017) observed peak whitefly incidence on tomato during the 21st SMW, with temperature and sunshine showing positive effects and humidity and rainfall negative, accounting for 89% variation. These results align with the present study, highlighting temperature and humidity as key factors influencing whitefly populations.

Conclusion

The seasonal incidence of whitefly on tomato crops is strongly influenced by weather parameters, including maximum and minimum temperatures, morning and evening relative humidity, bright sunshine, wind speed, and evaporation. Analysis indicates that whitefly populations peak under specific climatic conditions, highlighting the pivotal role of meteorological factors in pest dynamics. Understanding these seasonal patterns is essential for devising timely and effective pest management strategies, contributing to improved crop protection and optimized yields.

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