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Weather-driven Forecasting of Whitefly Populations in Tamil Nadu's Cotton Ecosystem

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The current research aimed to investigate the correlation between the population dynamics of *Bemisia tabaci* and other invasive whitefly species, including *Paraleyrodes bondari, Aleyrodicus dispersus,* and *Aleyrodicus rugioperculatus*, and weather factors from January to August 2022, covering two seasons: winter and summer. The primary objectives were to monitor whitefly population trends and analyse their relationship with various meteorological parameters. The results revealed that the overall whitefly population peaked during the 9th Standard Meteorological Week (SMW) of January 2022, with 9.80 individuals per three leaves, and the 31st SMW of August 2022,

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with 8.93 individuals per three leaves. Pearson correlation analysis indicated a positive correlation between whitefly populations and minimum and maximum temperatures, as well as minimum relative humidity, while rainfall showed a negative correlation. Insights into population dynamics and their association with weather factors are crucial for developing weather-based pest forecasting systems. Accurately predicting peak pest activity periods can facilitate effective pest management strategies, thereby enhancing agricultural productivity.

Keywords: Whiteflies; cotton; population dynamics; correlation; weather factors; regression.

1. INTRODUCTION

Cotton (*Gossypium* spp., Malvaceae) is one of the world's largest and most important cash crops, with over 75 countries producing it (Jabran et al., 2019). India, the world's top cotton producer, produced 371 lakh bales from a total of 129.57 lakh hectares with a productivity yield of 487 kg/ha (FAOSTAT, 2022). *Bemisia tabaci* Gennadius, often known as the common whitefly, is an important pest in agricultural and horticultural ecosystems, causing both direct and indirect damage. It acts as a vector for between 100 and 11 viral pathogens, resulting in yield losses of up to 50% (Jones, 2003). In India, there are 443 whiteflies classified into 64 genera that attack a wide number of agricultural, horticultural, and forestry crop plants (Selvaraj et al., 2017). Insect-pest damage is one of the most significant causes of low productivity (Shekhar et al., 2018). The presence of favourable environmental factors, such as high temperatures and low rainfall, has resulted in whitefly outbreaks during crop development (Natarajan, 1990). Since the start of the wet season, the numbers of the majority of whitefly species have decreased, particularly *Aleyrodicus dispersus* (Nechols and Nafus, 1995). In 2012 and 2013, a survey was undertaken in fourteen separate cotton-growing locations in southern Pakistan. In these circumstances, the quantity of whiteflies and parasitism is related to the temperature and relative humidity. Across the fourteen districts, both the relative humidity and the average temperature showed a positive association (Ahmad et al., 2018). According to Curnutte et al. (2014), they investigated the effect of temperature on the *B. tabaci* biotype at three different temperatures (25°C, 28°C and 33°C). Temperature had an effect on whitefly oviposition, nymphal survival and reproduction rates, with net reproductive rates dropping to 36.4 percent at 33°C. Between 2015 and 2017, *B. tabaci* was the most destructive cotton pest on the planet. As a result, we assessed the dynamics of *B. tabaci* infestations in cotton and predicted the factors affecting their abundance. It varied from 0.15 to 28.10 whiteflies per 3 leaves during the kharif 2016-2017. Whiteflies first appeared on the 29th SMW (0.15 whiteflies/3 leaves) (Nikam et al., 2019). Climate change has a direct or indirect impact on the population, survival, development, outbreaks, reproductive capability and activity of pests as well as predators and parasites. Successful pest prediction methodologies are required to avoid farmer losses and assist farmers in improving production. The focus of this study was to investigate whitefly population dynamics and their relationship to weather variables as needed to help scientists understand population trends under similar weather conditions. In the present situation, our small contribution will help us take a step forward towards protecting cotton crops from sucking pest.

2. MATERIALS AND METHODS

Cotton field trials to study pest population dynamics were established at the Department of Cotton, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University (TNAU), Coimbatore (11.0122° N, 76.9354° E). The cotton variety CO17 was sown in January 2022 on a plot measuring 60 m² to investigate the population dynamics of various whitefly species. The crop was cultivated and maintained according to standard agronomic practices, excluding the use of insecticides throughout the trial, to ensure a natural observation of pest dynamics. Whitefly incidence was recorded weekly from the 2nd to the 34th Standard Meteorological Week (SMW). Four whitefly species, *Bemisia tabaci, Paraleyrodes bondari, Aleyrodicus dispersus,* and *Aleyrodicus rugioperculatus* were counted on 20 randomly selected plants. For each plant, three leaves were chosen (one from the upper canopy, one from the middle canopy, and one from the lower canopy) to count adult whiteflies. The data collected was used to identify the optimal periods for observing whitefly incidence in cotton, facilitating informed decision-making for pest management strategies. Weather parameter data, including maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall, wind speed, evaporation, solar radiation, and sunshine hours, were obtained from the Agro Climate Research Centre, Coimbatore. The relationship between the insect population and these meteorological factors was analyzed using Pearson correlation coefficients and regression analysis. The findings were calculated based on the standard meteorological weeks and associated observations to evaluate pest population dynamics.

2.1 Statistical Analysis

The data was subjected to a Pearson correlation and multiple linear regression between whitefly population dynamics and weather factors. Where in Correl (X, Y) is the simple correlation coefficient. X is the first variable, i.e., the abiotic component and Y is the second variable, i.e., the population of insect pests. A multiple linear regression analysis was done for the relationship between the pest population and the weather parameters. The prediction model, in the form of a multiple regression equation, was developed using 2022-year data. The observed and predicted values were compared using different performance indices, viz., regression coefficient, standard error, T-value, P- value and R^2.

3. RESULTS AND DISCUSSION

Several whitefly species have been identified as pests in various cotton ecosystems around the world. Recently, whiteflies have become a serious pest of cotton during 2022, it appeared in epidemic form in Tamil Nadu. There were some favourable environmental conditions that led to the whitefly complex outbreak in Tamil Nadu. Apart from *Bemisia tabaci*, the purpose of this study was to describe the weather-based forewarning model for new invasive whitefly species such as *Paraleyrodes bondari, Aleyrodicus dispersus* and *Aleyrodicus rugioperculatus* and to gain a thorough understanding of the interaction between crop growth stage, meteorological parameters and pest dynamics. A whitefly infestation is a frequent problem for growers in almost every region and a huge outbreak of this tiny insect has caused a severe challenge for cotton growers in northern India. Many fields were totally devastated, forcing growers to abandon the harvest. Because the whitefly problem is so intricate, new pest control strategies should be developed that take into account the species' basic biology, ecology, migration, population dynamics and management, as well as crop production methodology and host plant growth habits.

3.1 Population Dynamics of the Whitefly Complex in the Cotton Ecosystem

Whitefly populations originally emerged in cotton fields during the third SMW, but they did not become an issue until the fifth SMW. However, it reached its peak population in the 9th SMW with a population of 9.8 no./3 leaves in the winter season (Table 1) and the 25th SMW with a population of 10.72 no./3 leaves in the summer season (Table 2). When the crop was reaching its harvesting stage, the population started to decline and this population was confirmed to be below the economic injury level by the 13th SMW.

3.2 Population Dynamics of the *B. tabaci* Cotton Ecosystem

In the winter season, *B. tabaci* population and weather parameters revealed that maximum temperature (r = 0.34) and wind speed (r = 0.44) had a positive influence on *B. tabaci* population development during the experiment period. Minimum temperature (r = -0.24), morning relative humidity (r = -0.53), evening relative humidity (r = -0.72) and total rainfall (r = -0.75) all had statistically negative correlations.

Maximum temperature (r = 0.20), wind speed (r = 0.13) and solar radiation (r = 0.23) all had a favourable influence on *B. tabaci* population growth over the investigation period. In the instance of minimum temperature (r = -0.17) and morning relative humidity, however, there was a substantial negative association in the summer season (Table 3).

3.3 Population Dynamics of the *P. bondari* on Cotton Ecosystem

The correlation of the *P. bondari* population with weather parameters revealed that maximum temperature (r = 0.16) and wind speed (r = 0.28) had positive influences on the population growth of *P. bondari* during the winter season. Whereas, a significantly negative correlation was observed in the cases of minimum temperature (r = -0.37), morning relative humidity (r = -0.43) evening relative humidity (r = -0.65) and total rainfall (r = -0.79).

The weather factor, maximum temperature (r = 0.11), minimum temperature (r = 0.03) and wind speed (r = 0.16) all had a favourable influence on *P. bondari* population growth over the summer. Morning relative humidity (r = -0.25), evening relative humidity (r = -0.44) and total rainfall (r = -0.98) all showed a strong negative correlation (Table 3).

3.4 Population Dynamics of the *A. dispersus* on Cotton Ecosystem

The results of a correlation study of the *A. dispersus* population and weather parameters revealed that maximum temperature (r = 0.43) and wind speed (r = 0.24) all had a favourable influence on *A. dispersus* population increase over the winter season. There were statistically negative correlations between the minimum temperature (r = -0.19), morning relative humidity (r = -0.60), evening relative humidity (r = -0.80) and total rainfall (r = -0.96).

The results of a correlation study of the *A. dispersus* population with weather parameters revealed that maximum temperature (r = 0.11), minimum temperature (r = 0.03) and wind speed (r = 0.19) all had a positive impact on *A. dispersus* population growth during the summer. Morning relative humidity (r = -0.26), evening relative humidity (r = -0.45) and total rainfall (r = -0.98) all showed a strong negative correlation (Table 3).

3.5 Population Dynamics of the *A. rugioperculatus* on Cotton Ecosystem

In the winter season, the weather factor, maximum temperature (r =0.38) and wind speed (r = 0.37) all had a favourable influence on *A. rugioperculatus* population growth over the study period. In the cases of minimum temperature (r = -0.27), morning relative humidity (r = -0.60), evening relative humidity (r = -0.81) and total rainfall (r = -0.89), there was a strong negative correlation.

The weather factor, maximum temperature (r = 0.18), minimum temperature (r = 0.03) and wind speed (r = 0.11) all had a favourable influence on *A. rugioperculatus* population growth over the investigation period (Table 3). Morning relative humidity (r = -0.20), evening relative humidity (r = -0.47) and total rainfall (r = -0.97) all showed a strong negative correlation (Table 3).

The correlation between the minimum temperature and the whitefly population was positive and significant. The rainfall was negatively correlated and significant. The impact of wind speed was positive and non-significant. The regression analysis revealed a positive relationship between the population of whiteflies and temperature and rainfall. The simple regression equations yielded positive results for maximum temperature and wind speed but negative results for morning and evening relative humidity and rainfall (Tables 4 -7).

The present findings are in close conformity with the observation of the author (Kataria et al., 2019), who reported that among different abiotic factors, maximum temperature, minimum temperature and maximum showed a positive correlation, whereas minimum relative humidity and rainfall showed a significant negative correlation with whitefly population in cotton. Similarly, the number of whiteflies was shown to be positively connected with maximum and minimum temperatures (Selvaraj and Ramesh, 2012). Shera et al. (2013) discovered that the population of *B. tabaci* was positively correlated with maximum and minimum temperatures. During 2013 and 2014, the population of whiteflies was negatively correlated with maximum and minimum temperatures, relative humidity and rainfall. A similar observation on the correlation between whiteflies and rainfall was made by Kalkal et al. (2015). In 2015, it was observed that the population of whiteflies has a significant positive correlation with minimum temperature (r = 0.657) and evening humidity (r = 0.833) whereas there was no significant correlation with maximum temperature, morning humidity or rainfall. The results of this study in 2015 were the opposite of those of another study by Kadam et al. (2014). During 2016, the population of whiteflies had a non-significant positive correlation with maximum and minimum temperatures and morning and evening humidity, whereas it had a negative correlation with rainfall. According to Josephrajkumar et al. (2019), increasing temperature and decreasing relative humidity are responsible for the pest's development. Weather factors are useful to assist in the spread of the pest. Kataria et al. (2019) noted that minimum temperature, maximum temperature and minimum relative humidity were positively correlated, whereas total rainfall and bright sunshine hours were negatively correlated with the whitefly population in cotton. Singh et al. (2017) discovered that whitefly population in cotton was positively correlated with minimum temperature, maximum temperature, and minimum relative humidity.

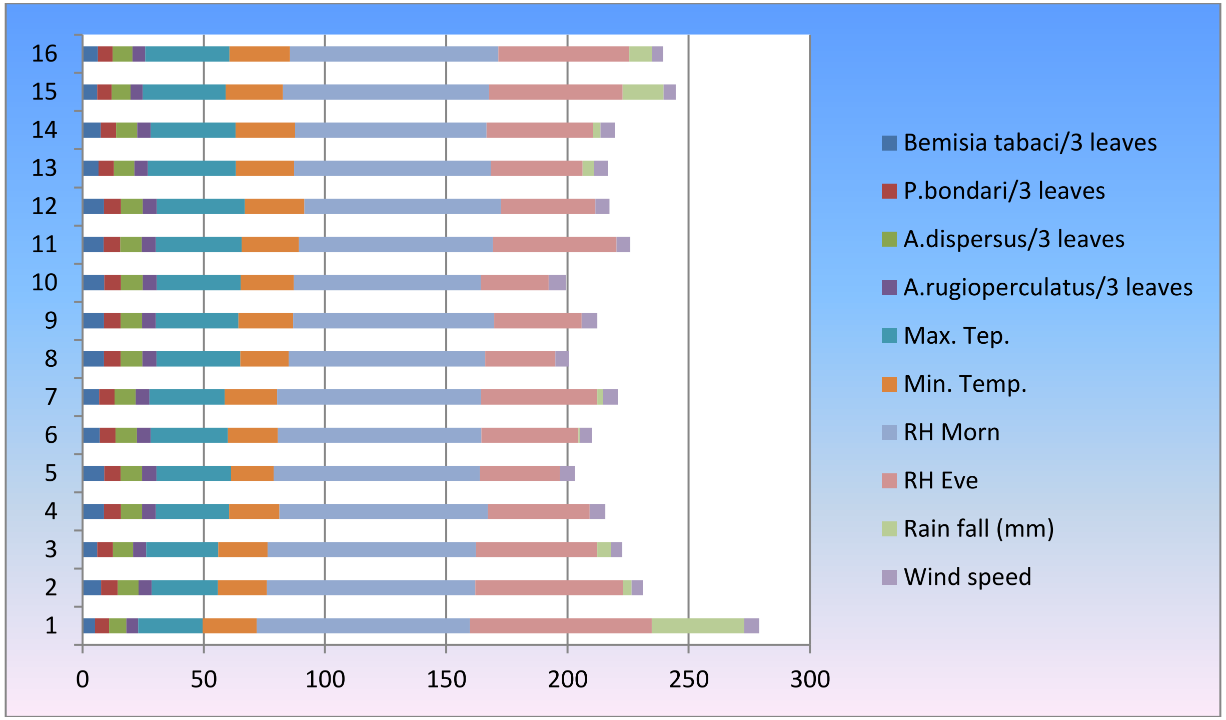

Fig. 1. Correlation between weather parameters and whitefly complex density during season I

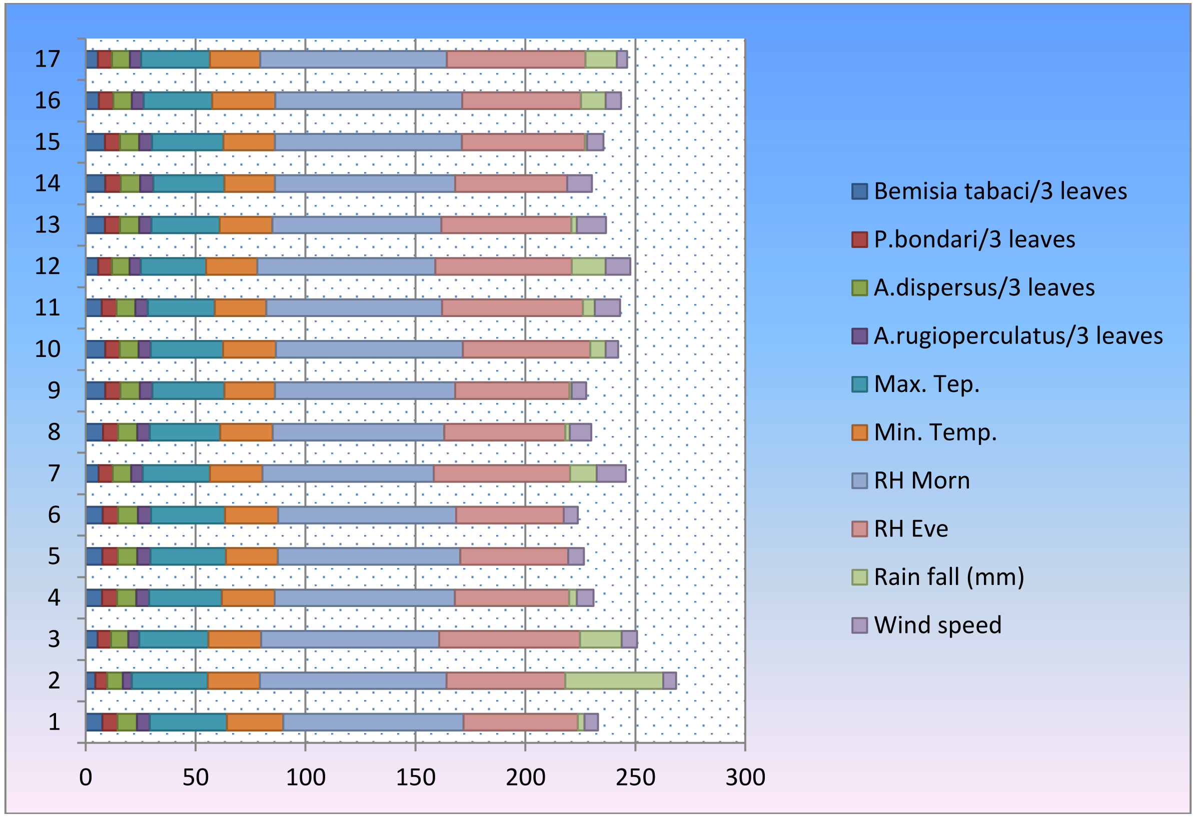

Fig. 2. Correlation between weather parameters and whitefly complex density during season II

Table 1. Population dynamics of whitefly complex in cotton ecosystem with weather factor under unprotected field condition (winter season)

SMW	***B. tabaci* / 3 leaves**	***P. bondari* /3 leaves**	***A. dispersus* /3 leaves**	***A. rugioperculatus* /3 leaves**	**Temperature (°C)**		**Relative Humidity (%)**		**Rain falls (mm)**	**Wind speed (km h-^{1})**
					Max	**Min**	**Morning**	**Evening**		
2 (8-14 Jan)	5.07±0.11	5.84±0.03	7.22±0.07	4.83±0.01	26.6	22.2	88	75	38.1	6.3
3 (15-21 Jan)	7.63±0.12	6.84±0.02	8.57±0.04	5.5±0.04	27.3	20.2	86	61	3.4	4.6
4 (22-28 Jan)	6.01±0.04	6.47±0.003	8.40±0.16	5.32±0.10	29.8	20.3	86	50	5.5	4.8
5 (29 Jan-4 Feb)	8.89±0.10	6.93±0.06	8.76±0.20	5.67±0.12	30.2	20.7	86	42	0	6.5
6 (5-11 Feb)	8.96±0.13	6.79±0.04	8.81±0.19	5.90±0.02	30.8	17.6	85	33	0	6.2
7 (12-18 Feb)	7.07±0.12	6.58±0.13	8.72±0.02	5.71±0.10	31.9	20.5	84	40	0.5	5.1
8 (19-25 Feb)	6.84±0.05	6.35±0.13	8.69±0.08	5.64±0.03	31.1	21.7	84	48	2.4	6.2
9 (26 Feb-4 Mar)	9.58±0.11	6.91±0.04	8.93±0.013	5.80±0.14	34.6	20	81	29	0	5.5
10 (5-11 Mar)	8.77±0.14	6.87±0.10	8.86±0.06	5.74±0.01	34.1	22.5	83	36	0	6.5
11 (12-18 Mar)	8.94±0.20	6.95±0.08	8.91±0.04	5.88±0.08	34.5	22	77	28	0	7.2
12 (19-25 Mar)	8.71±0.07	6.87±0.16	8.88±0.06	5.79±0.003	35.4	23.6	80	51	0	5.7
13 (26 Mar-1Aprl)	8.89±0.18	6.94±0.14	8.92±0.21	5.85±0.10	36.3	24.6	81	39	0	5.8
14 (2-8 Aprl)	6.63±0.01	6.29±0.02	8.52±0.13	5.43±0.12	36.3	24.1	81	38	4.6	5.9
15 (9-15 Aprl)	7.47±0.07	6.37±0.02	8.69±0.009	5.59±0.02	35	24.5	79	44	3	6.1
16 (16-22 Aprl)	6.05±0.03	5.96±0.04	7.74±0.13	5.03±0.04	34.2	23.7	85	55	17	5
17 (23-29 Aprl)	6.29±0.07	6.11±0.09	8.23±0.17	5.28±0.13	34.7	24.9	86	54	9.4	4.6

Table 2. Population dynamics of whitefly complex in cotton ecosystem with weather factor under unprotected field condition (summer season)

SMW	***B. tabaci* /3 leaves**	***P. bondari* /3 leaves**	***A. dispersus* /3 leaves**	***A. rugioperculatus* /3 leaves**	**Temperature (°C)**		**Relative Humidity (%)**		**Rain fall (mm)**	**Wind speed (km h-^{1})**
					Max	**Min**	**Morning**	**Evening**		
18 (1-7 May)	7.65±0.111	6.85±0.10	8.79±0.20	5.88±0.10	35.1	25.6	82	52	3	6.1
19 (8-14 May)	4.39±0.08	5.45±0.01	7.06±0.09	4.18±0.07	34.5	23.6	85	54	44.6	5.7
20 (15-21 May)	5.44±0.04	6.08±0.13	7.85±0.02	4.97±0.02	31.4	24.1	81	64	19	6.9
21 (22-28 May)	7.51±0.08	6.79±0.07	8.76±0.09	5.80±0.14	33	24.1	82	52	3.5	7.5
22 (29 May -4 Jun)	7.62±0.05	6.93±0.03	8.97±0.02	5.99±0.07	34.3	23.6	83	49	0	7.2
23 (5-11 Jun)	7.82±0.06	6.98±0.09	8.94±0.18	5.94±0.009	33.7	24.1	81	49	0	6.4
24 (12-18 Jun)	5.87±0.11	6.46±0.10	8.39±0.06	5.27±0.07	30.6	23.8	78	62	12	13.3
25 (19-25 Jun)	9.92±0.16	7.80±0.14	9.81±0.13	6.60±0.08	32.1	23.9	78	55	2	9.9
26 (26 Jun -2 July)	8.87±0.16	6.89±0.06	8.89±0.14	5.75±0.10	32.7	23	82	52	1	6.6
27 (3-9 July)	8.90±0.02	6.63±0.34	8.56±0.17	5.54±0.02	32.9	24	85	58	7	5.7
28 (10-16 July)	7.27±0.03	6.71±0.11	8.63±0.14	5.69±0.10	30.4	23.4	80	64	5.5	11.4
29 (17-23 July)	5.71±0.05	6.23±0.05	8.03±0.04	5.05±0.09	29.8	23.2	81	62	15.5	11.2
30 (24-30 July)	8.79±0.19	6.79±0.13	8.76±0.05	5.62±0.01	31	23.9	77	59	2.5	13.3
31 (31 July -6 Aug)	8.93±0.17	6.94±0.004	8.94±0.06	5.89±0.02	32.4	23	82	51	0	11.1
32 (7-13 Aug)	8.82±0.15	6.77±0.09	8.83±0.22	5.77±0.01	32.5	23.4	85	56	1	7.4
33 (14-20 Aug)	5.96±0.08	6.56±0.02	8.47±0.08	5.38±0.08	31.2	28.7	85	54	11.3	7
34 (21-27 Aug)	5.64±0.07	6.37±0.06	8.12±0.19	5.13±0.10	31.3	22.8	85	63	14.2	4.7

Table 3. Correlation coefficient: relation between weather parameters (X) and the mean number of whitefly complexes per three leaves (Y)

Seasons	**Weather parameters**	**Correlation coefficient (r) ***			
		B. tabaci	***P. bondari***	***A. dispersus***	***A. rugioperculatus***
Winter	X1-Max Temperature (ºC)	0.3465	0.1674	0.4343	0.3831
	X2 -Min Temperature (ºC)	-0.2431	-0.3739	-0.1964	-0.2771
	X3-Mor Relative Humidity (%)	-0.5397	-0.4397	-0.6090	-0.6055
	X4-Eve Relative Humidity (%)	-0.7271	-0.6534	-0.8060	-0.8156
	X5-Rainfall (mm)	-0.7576	-0.7939	-0.9671	-0.8915
	X6-Wind Speed (km h-^{1})	0.4447	0.2833	0.2405	0.3717
Summer	X1-Max Temperature (ºC)	0.2062	0.1153	0.1138	0.1890
	X2 -Min Temperature (ºC)	-0.1742	0.0358	0.0366	0.0305
	X3-Mor Relative Humidity (%)	-0.1533	-0.2565	-0.2627	-0.2022
	X4-Eve Relative Humidity (%)	-0.4208	-0.4462	-0.4522	-0.4703
	X5-Rainfall (mm)	-0.8310	-0.9837	-0.9834	-0.9702
	X6-Wind Speed (km h-^{1})	0.1328	0.1652	0.1906	0.1180

** Significant at P=0.05*

Table 4. Multiple regression of the *B. tabaci* population with weather parameters

Seasons	**Multiple regression**	**Tmax (°C)**	**Tmin (°C)**	**RH mor (%)**	**RH eve (%)**	**RF (mm)**	**WS (Kmh^{-1})**
Winter	Coefficient	0.300	-0.398	0.006	0.066	-0.103	0.931
	Standard Error	0.271	0.307	0.132	0.065	0.040	0.456
	T- Value	1.108	-1.298	0.045	1.009	-2.564	2.043
	P- Value	0.297	0.227	0.965	0.339	0.030	0.071
	R^2	0.766					
	Regression equation	$Y_{B.tabaci}$ = -1.725+0.300X1-0.398X2+0.006X3+0.066X4-0.103X5 +0.931X6					
Summer	Coefficient	0.325	-0.178	0.147	0.009	-0.111	0.175
	Standard Error	0.313	0.167	0.141	0.082	0.023	0.159
	T- Value	1.039	-1.063	1.042	0.109	-4.727	1.104
	P- Value	0.323	0.313	0.322	0.916	0.001	0.296
	R^2	0.791					
	Regression equation	$Y_{B.tabaci}$=-12.063+0.325X1-0.178X2+0.147X3+0.009X4-0.111X5 +0.175X6					

$Y_{B.tabaci}$: mean number of B. tabaci / three leaves (Y)

X1 - Maximum Temperature (ºC); X2 - Minimum Temperature (ºC); X3 - Morning Relative Humidity (%); X4 - Evening Relative Humidity (%); X5 - Rainfall (mm); X6 - Wind Speed (kmh^{-1})

Table 5. Multiple regression of the *P. bondari* population with weather parameters

Seasons	**Multiple regression**	**Tmax (°C)**	**Tmin (°C)**	**RH mor (%)**	**RH eve (%)**	**RF (mm)**	**WS (kmh^{-1})**
Winter	Coefficient	0.006	-0.055	-0.026	0.008	-0.031	0.108
	Standard Error	0.080	0.091	0.039	0.019	0.012	0.134
	T- Value	-0.074	-0.605	-0.657	0.393	-2.641	0.806
	P- Value	0.943	0.560	0.528	0.704	0.027	0.441
	R^2	0.751					
	Regression equation	$Y_{P.bondari}$=9.300+0.006X1-0.055X2-0.026X3+0.008X4-0.031X5 +0.108X6					
Summer	Coefficient	0.012	0.009	0.001	-0.008	-0.033	0.006
	Standard Error	0.021	0.011	0.010	0.006	0.002	0.011
	T- Value	0.573	0.785	0.069	-1.488	-20.842	0.573
	P- Value	0.579	0.451	0.946	0.168	0.000	0.579
	R^2	0.986					
	Regression equation	$Y_{P.bondari}$=6.634+0.012X1+0.012X2-0.001X3-0.008X4-0.033X5 +0.006X6					

$Y_{P.bondari\,:}$ mean number of P. bondari / three leaves (Y)

X1 - Maximum Temperature (ºC); X2 - Minimum Temperature (ºC); X3 - Morning Relative Humidity (%); X4 - Evening Relative Humidity (%); X5 - Rainfall (mm); X6 - Wind Speed (kmh^{-1})

Table 6. Multiple regression of the *A. dispersus* population with weather parameters

Seasons	**Multiple regression**	**Tmax (°C)**	**Tmin (°C)**	**RH mor (%)**	**RH eve (%)**	**RF (mm)**	**WS (kmh^{-1})**
Winter	Coefficient	0.000	-0.019	-0.023	0.003	-0.044	0.082
	Standard Error	0.036	0.041	0.017	0.009	0.005	0.060
	T- Value	-0.007	-0.460	-1.290	0.375	-8.366	1.357
	P- Value	0.994	0.656	0.229	0.716	0.000	0.208
	R^2	0.968					
	Regression equation	$Y_{A.\ dispersus}$ = 10.466+0.000X1-0.019X2-0.023X3+0.003X4-0.044X5+0.082X6					
Summer	Coefficient	0.026	0.013	0.009	-0.011	-0.042	0.023
	Standard Error	0.022	0.012	0.010	0.006	0.002	0.011
	T- Value	1.193	1.138	0.911	-1.817	-25.677	2.013
	P- Value	0.260	0.282	0.384	0.099	0.000	0.072
	R^2	0.991					
	Regression equation	$Y_{A.\ dispersus}$ = 7.365+0.026X1+0.013X2+0.009X3-0.011X4-0.042X5+0.023X5					

$Y_{A.\ dispersus:}$ mean number of A. dispersus / three leaves (Y); X1 - Maximum Temperature (ºC); X2 - Minimum Temperature (ºC); X3 - Morning Relative Humidity (%); X4 - Evening Relative Humidity (%); X5 - Rainfall (mm); X6 - Wind Speed (kmh^{-1})

Table 7. Multiple regression of the *A. rugioperculatus* population with weather parameters

Seasons	Multiple regression	Tmax (°C)	Tmin (°C)	RH mor (%)	RH eve (%)	RF (mm)	WS (kmh^{-1})
Winter	Coefficient	0.033	-0.064	-0.014	0.008	-0.026	0.131
	Standard Error	0.039	0.044	0.019	0.009	0.006	0.065
	T- Value	0.852	-1.450	-0.764	0.843	-4.451	2.008
	P- Value	0.416	0.181	0.465	0.421	0.002	0.076
	R^2	0.915					
	Regression equation	$Y_{A.\ rugioperculatus}$ =6.116+0.033X1-0.064X2-0.014X3+0.008X4-0.026X5+0.131X6					
Summer	Coefficient	0.076	0.014	0.018	0.002	-0.041	0.025
	Standard Error	0.030	0.016	0.013	0.008	0.002	0.015
	T- Value	2.569	0.887	1.328	0.263	-18.257	1.633
	P- Value	0.028	0.396	0.214	0.798	0.000	0.134
	R^2	0.981					
	Regression equation	$Y_{A.\ rugioperculatus}$=1.251+0.076X1+0.014X2+0.018X3+0.002X4-0.041X5+0.025X6					

$Y_{A.\ rugioperculatus:}$ mean number of A. rugioperculatus / three leaves (Y)

X1 - Maximum Temperature (ºC); X2 - Minimum Temperature (ºC); X3 - Morning Relative Humidity (%); X4 - Evening Relative Humidity (%); X5 - Rainfall (mm); X6 - Wind Speed (kmh^{-1})

Temperature and rainfall have a greater impact on the diversity and spread of Aleyrodids than any other weather element that correlates with pest population dynamics. Over all, the performance of pest population dynamics shows that when the temperature is high, the population of whitefly species is also high. At the same time, if rainfall is low in that particular region, it directly affects the population of whitefly species.

4. CONCLUSION

The population of whiteflies varies in different seasons of the year depending upon the atmospheric humidity, temperature and rainfall. Temperature, humidity, rainfall, and wind speed could all be major contributors to fluctuations in the whitefly population. The population of the whitefly complex and temperature (max. and min.) had a positive and significant correlation, while morning and evening relative humidity and rainfall had a negative correlation, and wind speed had a non-significant positive correlation. This study will be useful in forewarning the farmers to update their management practices, resulting in higher crop productivity, financial benefit and environmental safety.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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