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SEASONAL FLUCTUATION OF WHITEFLY POPULATIONS AND THEIR CORRELATION WITH METEOROLOGICAL PARAMETERS IN *KHARIF* CHILLI

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ABSTRACT

The seasonal dynamics of whitefly (*Bemisia tabaci*) populations on chilli (*Capsicum annuum* L.) were studied in relation to abiotic factors during *Kharif* 2023 and 2024. In *Kharif* 2023, whiteflies per three leaves increased from 0.00 (SMW 27th) to a first peak of 3.67 whiteflies per three (SMW 36th), declined during heavy rainfall (SMW 38–39th), and peaked again at 3.72 whiteflies per three (SMW 41st) under dry conditions. Population build-up coincided with moderately high maximum temperatures (27.37–31.51°C), stable minimum temperatures (23–23.9°C), high morning relative humidity (80–89%), and moderate evening humidity (50–67%). Correlation analysis revealed a significant positive association with maximum temperature ($r = 0.637$, $p \leq 0.01$) and negative associations with evening relative humidity ($r = -0.643$, $p \leq 0.01$) and total rainfall ($r = -0.566$, $p \leq 0.05$). In *Kharif* 2024, whitefly populations exhibited a gradual increase with peaks at SMW 38th (3.40 whiteflies per three) and SMW 41th (3.27 whiteflies per three), influenced by warm temperatures, moderate humidity, and low rainfall. Minimum temperature showed a highly significant negative correlation ($r = -0.701$, $p \leq 0.01$), while evening relative humidity again exhibited a strong negative effect ($r = -0.798$, $p \leq 0.01$). Regression models explained 68% (2023) and 71% (2024) of population variation based on temperature, relative humidity, rainfall, and wind speed. The study highlights that whitefly abundance is strongly influenced by temperature and evening relative humidity, with rainfall acting as a suppressive factor, providing critical insights for pest forecasting and management in chilli.
***Keywords* :** *Bemisia tabaci* Genn., seasonal abundance, abiotic factor, temperature, relative humidity, rainfall, wind velocity, correlation, regression

Introduction

Chilli (*Capsicum annuum* L.), a member of the family Solanaceae, is one of the most important spice crops of India and the world. India is the largest producer, exporter and consumer of chilli, and chilli (popularly known as mirchi in Hindi) is an integral component of Indian cuisine. Nearly 400 types of chillies are cultivated across diverse agro-climatic regions of the country. Green chillies are valued not only for pungency and flavour but also for their nutritional attributes, being rich in vitamin C, vitamin E and β-carotene. In addition, capsaicin present in chilli has been reported to enhance insulin secretion, regulate blood sugar levels and aid in fat metabolism. The average productivity of chilli in India is about 3,240 kg ha^{-1} (Spices Board of India, 3rd Advance Estimates, 2023–24). India leads global chilli production with 27.82 lakh tonnes, followed by Bangladesh (6.63 lakh tonnes), Thailand (3.29 lakh tonnes) and China (3.26 lakh tonnes) (Chilli Outlook, April 2025). Within India, Andhra Pradesh is the leading chilli-producing state (1,185.27 thousand metric tonnes), followed by Telangana, Madhya Pradesh, Karnataka and other states (Statista).

Despite its economic and nutritional importance, chilli cultivation is constrained by a complex pest scenario. More than 293 species of insect pests and mites have been reported to attack chilli in the field and during post-harvest handling (Veena *et al*., 2017). Among these, the whitefly, *Bemisia tabaci* Genn. (Gennadius), has emerged as a key pest. Both nymphs and adults feed on phloem sap, resulting in direct loss of plant nutrients and physiological imbalance. The excretion of honeydew promotes the development of black sooty mould on leaf surfaces, which interferes with photosynthesis and leads to leaf yellowing, curling and deformation. More importantly, *Bemisia tabaci* Genn. is an efficient vector of begomoviruses, particularly Chilli leaf curl virus (ChiLCV), and over 600 plant species are reported to be affected by viruses transmitted by this pest, with ChiLCV alone capable of causing up to 100% yield loss under severe epiphytotic conditions (Czosnek *et al*., 2017; Thakur *et al*., 2018). ChiLCV and Chilli leaf curl disease (ChiLCD) often predispose plants to secondary pest outbreaks such as thrips and mites, further aggravating crop damage.

Management of *Bemisia tabaci* Genn. in chilli is largely reliant on synthetic insecticides. However, indiscriminate and repeated use of insecticides has led to several problems including development of resistance in *Bemisia tabaci* Genn. populations, resurgence of pests, adverse effects on natural enemies, environmental contamination and potential risks to human and animal health (Erdogan *et al*., 2008; Roditakis *et al*., 2009). Under these circumstances, a clear understanding of the seasonal incidence and population dynamics of *Bemisia tabaci* Genn.in relation to abiotic factors is essential for designing eco-friendly and need-based management strategies. Hence, the present investigation was undertaken to study the population dynamics of whiteflies on chilli and their relationship with prevailing weather parameters during *Kharif,* with a view to generating information useful for forecasting pest outbreaks and optimizing management practices.

Material and Methods

The studies on seasonal fluctuation of whitefly populations and their correlation with meteorological parameters in chilli were carried out during *Kharif* 2023 and 2024 at the Instructional Farm, Department of Entomology, Post Graduate Institute, MPKV, Rahuri, Maharashtra. For studying the seasonal incidence of whitefly, healthy seedlings of the leading chilli variety 'Navtej' were raised in plastic nursery trays and transplanted to the main field after one month at a spacing of 60 cm × 45 cm, at the mid-height of the ridges. All recommended agronomic practices were followed to raise a healthy crop. However, no plant protection measures were imposed throughout the cropping season to allow natural build-up of the pest. Observations on whitefly incidence were recorded at weekly intervals from five randomly selected and tagged plants.

The meteorological parameters, viz., maximum and minimum temperature (°C), relative humidity (%), wind velocity, and total rainfall (mm) corresponding to different standard meteorological weeks during the crop period were obtained from the Department of Agronomy, Post Graduate Institute, MPKV, Rahuri. The relationship between whitefly population and these weather parameters was worked out. The data were subjected to statistical analysis, and correlation coefficients were computed using OPSTAT software.

Table 1 : Experimental details

Season & year	*Kharif* - 2023 *Kharif* – 2024
Crop	Chilli
Variety	Navtej
Design	Non-Replicated
Plot Size	3 x 3 m
Spacing	60 x 45 cm
Date of transplanting	1st July 2023 and 3rd July 2024

Results and Discussion

The weekly data on whiteflies infestation recorded during both *Kharif* season 2023 and 2024 described in following headline.

Seasonal dynamics of whitefly (*Bemisia tabaci* Genn.) population in chilli and its relationship with abiotic factors during *Kharif* 2023

The data illustrated in Table 2 and Fig. 1 during *Kharif* 2023 revealed that, whitefly population on chilli (per three leaves) increased steadily from SMW 27 to 36th, starting at 0.00 and gradually rising through 0.27–0.53 (SMW 28–30th) to 1.53–2.87 (SMW 31st–34th), with a first peak of 3.40 and 3.67 whiteflies per three leaves at SMW 35 and 36th. This build-up coincided with moderately high maximum temperatures (27.37–31.51°C), stable minimum temperatures (23.0–23.9°C), high morning relative humidity (80–89%) and moderate evening humidity (50–67%), which were favourable for multiplication. The population then declined to 2.87 and 1.33 per three leaves (SMW 37–39th) with heavy rainfall (82.6–94.6 mm), indicating an adverse effect of intense rains. With reduced rainfall and drier weather from SMW 40th onwards, whiteflies again increased from 2.20 to 3.72 and 3.60 per three leaves (SMW 41st –42nd), before declining to 3.13 and 2.47 (SMW 43rd–44th) as minimum temperature and relative humidity fell. Wind speed (0.53–5.14 km/h) showed no clear association with whitefly incidence.

Correlation analysis for 2023 showed a significant positive relationship with maximum temperature (r = 0.637, p ≤ 0.01), confirming that higher daytime temperatures favoured population build-up. Minimum temperature (r = -0.398) and morning relative humidity (r = -0.366) were negatively but non-significantly related to whiteflies, indicating a limited direct effect. In contrast, evening relative humidity (r = -0.643, p ≤ 0.01) and total rainfall (r = -0.566, p ≤ 0.05) exhibited significant negative correlations, highlighting that higher evening humidity and more rainfall were detrimental, likely due to unfavourable microclimate and wash-off. Wind speed (r = -0.455) also showed a negative but non-significant association.

The regression equation $Y = -11.295 + 0.437X_1 + 0.215X_2 - 0.075X_3 + 0.075X_4 - 0.732X_5 - 0.031X_6$ with $R^2 = 0.68$ showed that about 68% of the variation in whitefly population was explained by maximum and minimum temperature, relative humidity, wind speed and rainfall.

Seasonal dynamics of whitefly (*Bemisia tabaci Genn.*) population in chilli and its relationship with abiotic factors during *Kharif* 2024

The weekly data presented in Table 3 and Fig. 2 recorded during *Kharif* 2024, the whitefly population on chilli (per three leaves) showed a gradual build-up with distinct peaks in relation to weather conditions. The population was absent during SMW 27–28th and then increased to 0.40 and 0.80 (SMW 29–30th), followed by 1.07–1.40 (SMW 31st–32nd) and 2.20 at SMW 33rd under warm temperatures, high morning and moderate evening relative humidity, and very low rainfall, which favoured multiplication. A temporary decline to 1.73 at SMW 34th coincided with very high rainfall and higher evening humidity, indicating suppression by heavy showers. The population remained moderate (1.40–2.73) during SMW 35–37th and reached a major peak of 3.40 at SMW 38th under warm, comparatively drier conditions with scanty rainfall. Thereafter, it fluctuated between 2.60 and 3.27 (SMW 39–42th), with heavy rainfall causing reductions and dry to moderately wet conditions supporting higher levels. Towards SMW 43rd–44th, whiteflies remained moderate (2.73–2.87) as minimum temperature and evening humidity declined.

In 2024, the correlation pattern with weather parameters differed somewhat. Maximum temperature showed a positive but non-significant correlation (r = 0.248), suggesting it did not independently govern infestation that year. In contrast, minimum temperature showed a highly significant negative correlation (r = -0.701, p ≤ 0.01), implying that lower night temperatures were associated with higher whitefly populations. Morning relative humidity (r = -0.057) and total rainfall (r = -0.162) exhibited weak, non-significant negative correlations. As in 2023, evening relative humidity had a strong, highly significant negative correlation (r = -0.798, p ≤ 0.01), again indicating that higher evening humidity was unfavourable for whitefly multiplication. Wind speed (r = -0.328) remained negatively but non-significantly related.

Overall, across both years, evening relative humidity consistently showed a strong, significant negative relationship with whitefly incidence, while maximum temperature (2023) and minimum temperature (2024) emerged as key temperature-related factors influencing population dynamics, with rainfall exerting an additional significant negative effect in 2023. In 2024, the equation $Y = 3.519 + 0.031X_1 - 0.313X_2 + 0.052X_3 + 0.026X_4 - 0.552X_5 - 0.006X_6$ with $R^2 = 0.71$ indicated that these abiotic factors together accounted for 71% of the variation in whitefly incidence.

The results align with several prior studies on whiteflies population dynamics and their correlation with abiotic factors. Desai *et al.* (2009) observed a negative and significant correlation of whitefly population with evening relative humidity, and a positive and significant correlation with maximum temperature. Similar findings were reported by Atwal and Dhaliwal (2007) and Latif and Akhter (2013), who stated that heavy rainfall reduced the whitefly population. Yadav *et al.* (2014) reported that maximum temperature showed a significant positive correlation (r = 0.63) with whitefly population, while minimum temperature was non-significantly correlated. Average relative humidity exhibited a significant negative correlation (r= –0.34), whereas rainfall showed a significant negative correlation with whitefly population. Padhi *et al.* (2017) reported that the incidence of whitefly was negatively correlated with minimum temperature (r= –0.062) and significantly negatively correlated with rainfall (r= –0.253*). Further, Yadav *et al.* (2022) found that maximum temperature had a significant positive correlation (r = 0.603) with mean whitefly population. However, morning and evening relative humidity recorded non-significant negative correlations ($r = -0.387^{NS}$ and $r = -0.163^{NS}$, respectively), and rainfall also showed a non-significant negative correlation ($r = -0.154^{NS}$) with whitefly population.

Table 2 : Weekly fluctuation of whitefly population and associated weather parameters (*Kharif* 2023).

SMW	Whiteflies/ 3 leaves	Abiotic factors					
		Temperature		Relative humidity		Wind Speed	Total Rainfall
		Maximum	Minimum	Morning	Evening		
27	0.00	31.86	24.97	81.57	59.71	3.47	92
28	0.27	30.31	24.06	83.14	60.71	5.14	27.4
29	0.40	29	23.87	86.14	67.14	3.86	13.8
30	0.53	27.37	23.41	89.57	76.57	3.86	26
31	1.53	29.17	23.69	84.29	65.43	4.44	1.6
32	1.80	29.63	23.7	80.71	55.14	4.21	1.6
33	2.40	30.63	23.77	79.29	54.29	4.26	1.4
34	2.87	29.54	23.56	82	59	3.46	8
35	3.40	31.51	23.04	86.43	50	2.4	12.2
36	3.67	31.14	23.94	80.43	62.14	4.54	8.8
37	2.87	31.2	23.54	82.71	52.86	3.04	21
38	1.33	30.17	23.89	84.71	59.86	2.34	82.6
39	1.33	29.43	23	94.14	68.86	1.29	94.6
40	2.20	31.77	22.67	87.71	45.29	1.57	15.4
41	3.72	33.94	22.27	84.57	35.43	1.21	0
42	3.60	33.74	22.31	80.14	37.14	0.74	0
43	3.13	32.6	19.59	75.14	26.57	0.53	0
44	2.47	31.77	17.57	74.29	31.29	0.69	0
SMW: Standard Meteorological Week							

Table 3 : Weekly fluctuation of whitefly population and associated weather parameters (*Kharif* 2024)

SMW	Whiteflies / 3 leaves	Abiotic factors					
		Temperature		Relative humidity		Wind Speed	Total Rainfall
		Maximum	Minimum	Morning	Evening		
27	0.00	31.6	24.27	83.14	58.43	4.61	6.6
28	0.00	30.4	23.53	83.86	63.43	3.51	39.2
29	0.40	30.34	23.67	87.29	63.43	2.8	79.8
30	0.80	29.17	23.67	84.71	67.14	3.49	31.6
31	1.07	29.97	23.61	82.71	61.57	4.09	3.6
32	1.40	29.66	23.04	84.29	64.29	2.64	3
33	2.20	32.31	22.9	86.71	54.57	2.03	1.4
34	1.73	29.2	22.67	90.29	73.86	1.63	253.4
35	1.40	29.83	22.84	83.14	61.57	2.93	36.8
36	2.73	29.49	22.61	85	61.71	2.4	4
37	1.87	30.23	21.47	78.43	58.57	2.86	3.2
38	3.40	31.71	20.99	81	52.57	2.47	3
39	2.73	30.03	22.66	87.43	65.14	2.16	86
40	2.60	32.49	21.7	82.71	50.29	1.54	0
41	3.27	30.09	21.84	87.71	66.29	1.29	16.2
42	2.73	31.06	22.1	88.14	64.29	1.16	8
43	2.87	30.69	19.64	79.43	55	1.11	6.4
44	2.73	31.53	18.17	80	44.33	1.17	0
SMW: Standard Meteorological Week, Max.: Maximum, Min.: Minimum							

Table 4 : Relationship of whitefly population with temperature, relative humidity, wind speed and rainfall during *Kharif* 2023 and 2024

Year	Abiotic factor					
	Temperature		Relative humidity		Wind Speed (km/hr)	Total Rainfall (mm)
	Maximum	Minimum	Morning	Evening		
Kharif-2023	0.637**	-0.398^{NS}	-0.366^{NS}	-0.643**	-0.455^{NS}	-0.566*
Kharif-2024	0.248^{NS}	-0.701**	-0.057^{NS}	-0.328^{NS}	-0.798**	-0.162^{NS}
** = $p \leq 0.01$, * = $p \leq 0.05$						

Table 5 : Predictive regression models and R² values for whitefly population in relation to abiotic factors (*Kharif* 2023–2024)

Year	Regression equation	R^2 value
***Kharif*-2023**	$Y = -11.295 + 0.437X_1 + 0.215X_2 - 0.075X_3 + 0.075X_4 - 0.732X_5 - 0.031X_6$	0.68
***Kharif*-2024**	$Y = 3.519 + 0.031X_1 - 0.313X_2 + 0.052X_3 + 0.026X_4 - 0.552X_5 - 0.006X_6$	0.71

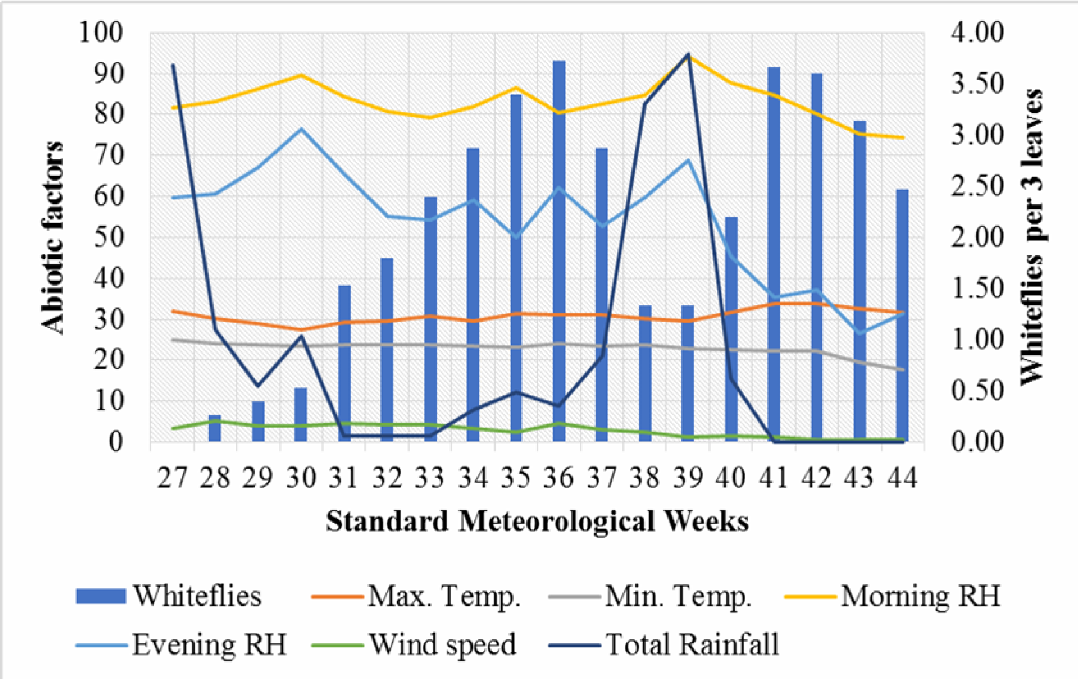

Fig. 1: Weekly fluctuation of whitefly population and associated weather parameters (*Kharif* 2023)

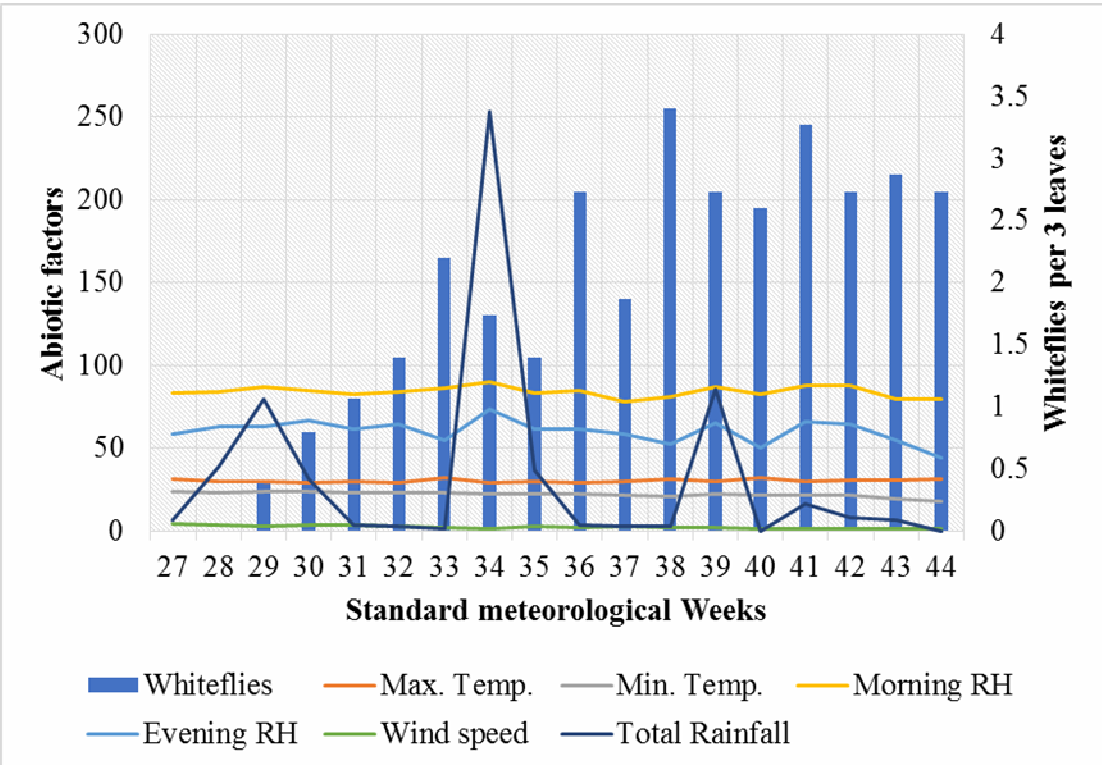

Fig. 2: Weekly fluctuation of whitefly population and associated weather parameters (*Kharif* 2024)

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