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Population dynamics of whitefly population infesting chilli as influenced by various weather parameters

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Abstract
Field experiments were conducted during *Rabi* 2019-20 and *Rabi* 2020-21 at Warangal and Rajendranagar respectively as an attempt to investigate the effect of different weather factors on the population of whiteflies which are predominant vectors for chilli leaf curl complex. Weather data for both the crop seasons were collected and correlated with the whitefly population. The correlation analysis for whitefly population with weather parameters during *Rabi* 2019-20 and 2020-21 indicated that there existed positive and significant correlation of whiteflies with minimum temperature, morning humidity and wind velocity; but negative correlation with evening relative humidity and sunshine hours. Regression analysis between whitefly population and weather parameters indicated that minimum temperature and wind velocity accounted for 39 and 46 percent total variation in whitefly population in both the seasons respectively.

Keywords: Correlation, regression, weather factors, whitefly population

Introduction
Chilli is predisposed to multitude of viral, fungal, bacterial, nematode and phytoplasma diseases. Viruses are known to incite wide range of symptoms like mosaic, ring spot, curling, yellowing etc. Among them, chilli leaf curl is ubiquitous and infect entire plants in the field with variable symptoms such as leaf curling, puckering and reduced size of leaves, closely set internodes and dwarfing of plants. These symptoms produce witch broom appearance and affect fruit setting (either failure or small deformed fruit formation).

In an epidemic of chilli leaf curl disease at Jodhpur (Rajasthan), it was concluded that several isolates were effectually transmitted by whitefly, all of which produced severe leaf curl symptoms in chilli. Senanayake *et al.* (2012) [4] reported that a single whitefly was able to transmit the virus, and eight or more whiteflies per plant resulted in 100 percent transmission. The minimum acquisition access period (AAP) and inoculation access period (IAP) were 180 and 60 min, respectively. The virus was only able to infect five species, *viz*, *C. annuum*, *Carica papaya*, *S. lycopersicum*, *N. tabacum* and *N. benthamiana*, out of the 25 species tested from various families, *viz.*, Asteraceae, Caricaceae, Cucurbitaceae, Euphorbiaceae, Leguminosae, Malvaceae and Solanaceae.

Begomoviruses are a serious constraint in the cultivation of several crops in the Indian subcontinent. The genus Begomovirus (family Geminiviridae) contains numerous viruses that infect dicotyledonous species and are transmitted by whiteflies *Bemisia tabaci.* Leaf curl disease of chilli or hot pepper (*Capsicum annuum*) is now a serious problem in India. The disease is characterized by leaf curling, puckering, vein clearing and vein swelling symptoms. The size of leaves and branches is reduced considerably in severely affected plants resulting in a bushy appearance. Such plants bear very few flowers and very few fruits (Joshi and Dubey 1976) [2]. Weather parameters like temperature, relative humidity, sunshine and rainfall were played limiting factors for the buildup of whitefly population. On chilli crop contribution of maximum temperature, minimum temperature and relative humidity was 83 to 91, 75 to 85 and 78 to 85, respectively in whitefly population development.

Materials and Methods
The field experiment was conducted at a farmer's field in Warangal during *Rabi* 2019-20 and at College farm, PJTSAU, Rajendranagar during *Rabi* 2020-21. The population of whiteflies in chilli cv. Sindhuri was recorded at weekly intervals from 11th standard week to 19th standard

week during *Rabi* seasons. The first count of whitefly/plant was recorded in the crop in all the modules from 2 WAT onwards. Meteorological observations with regard to ambient (maximum and minimum) temperature (ºC), percent relative humidity (at 07 00 and 14 00 hrs), wind speed (km per hr) and sunshine hours prevailing at farms during the crop seasons *i.e.*, during the peak infestation of whiteflies, the crop was in active growth stage (45-60 DAT). The number of whitefly was counted on five randomly selected plants by observing six leaves (two upper, two middle and two lower), randomly during early morning hours in each plot when it remains on leaves with the help of a hand lens of 10X magnification. Simultaneously, weather parameters *viz.*, temperature, humidity, wind speed and sunshine hours were recorded during the entire period of experiment. Correlation of insect population with temperature (maximum and minimum), relative humidity, rainfall, wind speed and sunshine hours was worked out to find out relationship, if any, exists between them.

Results and Discussion

The effect of weather parameters during different weeks of crop growth in *Rabi* 2019-20 at Warangal was presented in Table 1. The population of whiteflies in chilli cv. Sindhuri was recorded at weekly intervals from 11th standard week to 19th standard week. The first count of whitefly/plant was recorded in the crop in all the modules from 2 WAT onwards. During the peak infestation of whiteflies, the crop was in active growth stage (45-60 DAT). The average maximum and minimum temperatures recorded were 37.8 and 23.6 °C, respectively and the average relative humidity forenoon and afternoon were 89.6 and 56.3 percent respectively. The whitefly population declined as the crop reached senescence.

Population of whiteflies at various intervals was found to be affected by climatic conditions. The overall correlation matrices drawn for whitefly population with weather is given in Table 2. The correlation analysis for whitefly population with weather parameters indicated that there existed positive and significant correlation of whiteflies with minimum temperature, morning humidity and wind velocity; but negative correlation with evening relative humidity and sunshine hours. The correlation analysis indicated significant and positive correlation with minimum temperature (0.9180), morning humidity (0.8667) and wind velocity (0.9007). However, it was negatively correlated with maximum temperature (-0.8153) and evening relative humidity (-0.6889) (Fig. 1 and 2).

Regression analysis of weather parameters with whitefly population in chilli cv. Sindhuri during *Rabi* 2019-20 at Warangal is presented in Table 3.

The multiple linear regression equation after step down elimination was Y= -33.85 + 1.197 X_2 + 0.515 X_7, which indicated that an increase of one unit minimum temperature increased the whitefly by 1.19 units and one unit increase in wind speed increased the whitefly population by 0.51 units. The weather factors collectively influenced the infestation of whitefly to the extent of 46 percent (R^2 = 0.46).

The effect of weather parameters during different weeks of crop growth in *Rabi* 2020-21 at Rajendranagar was presented in Table 4. The population of whiteflies in chilli cv. Sindhuri was recorded at weekly intervals from 11th standard week to 19th standard week. The first count of whitefly/plant was recorded in the crop in all the modules from 2 WAT onwards. The mean whitefly population during *Rabi* 2020-21 ranged from 1.2 whiteflies/plant with peak incidence during 4th standard week (2021) followed by 5th standard week (2021). The average minimum and maximum temperatures recorded were 31.6 and 15.6 °C respectively and the average relative humidity forenoon and afternoon were 95 and 43 percent. Further whitefly population was at its peak during 45-60 DAT. The population gradually decreased with age of the plants.

The overall correlation matrices were drawn for whitefly population with weather parameters during *Rabi* 2020-21 are given in Table 5. There was positive correlation of whitefly population with minimum temperature and wind velocity and negative correlation with morning, evening relative humidity and sunshine hours. Of these weather parameters, significant positive correlation existed between whitefly population and minimum temperature (0.7031) and wind velocity (0.9347) (Fig. 3 and 4).

Regression analysis of weather parameters with whitefly population in chilli cv. Sindhuri during *Rabi* 2020-21 is presented in Table 6. The multiple linear regression equation after step down elimination was Y= -31.85 + 1.187 X_2 + 0.505 X_7 indicating an increase of one unit of minimum temperature and evening relative humidity increased the whitefly population by 0.548 units and 0.0683 units, respectively. While, one unit increase in rainfall decreased whitefly population by 0.0871 units. The weather factors collectively exerted a variation of whitefly infestation to an extent of 56 percent (R^2=0.56).

The studies clearly indicated that involvement of different weather parameters in fluctuation of the population of whiteflies during different growing seasons. A similar study by Janu and Dahiya (2017) [1] explained successful correlation between weather parameters and whitefly population. Further, positive correlation between whitefly population and minimum temperature, rainfall and relative humidity and negative correlation with maximum temperature.

A similar study by Lakshmi *et al.* (2020) [3] explained successful correlation between weather parameters and whitefly population. Further, positive correlation between whitefly population and minimum temperature, rainfall and relative humidity and negative correlation with maximum temperature. The results of field study indicated the difference in incidence of viral complex with the age of the crop. Irrespective of the treatments imposed, progressive increase in disease incidence was observed up to 65 days age of the crop.

Table 1: Effect of weather parameters on whitefly population during *Rabi* 2019-20

Standard meteorological week	Period	Temperature		Relative humidity		Sun shine hours	Wind speed	Whitefly population
		Max	Min	RH I	RH II			
11	12-18 MAR	33.1	20.7	90.4	55.6	7.7	2.6	3.1
12	19-25 MAR	36.6	23.9	92.3	47.7	9	2.8	3.2
13	26 MAR-01 APR	36.1	22.6	89	53.1	8	3	3.5
14	02-08 APR	35.6	23.6	90.6	55.1	9	3.1	4.2
15	09-15 APR	37.8	23.6	89.6	53.3	9.5	2.5	4.4
16	16-22 APR	37.3	24.7	84	46.8	9.5	3.1	4.9
17	23-29 APR	37.7	24.3	91.9	50.8	5.9	3.3	5.5
19	30 APR -06 MAY	39.2	25.3	83.7	47.9	9	2.7	6

Table 2: Overall correlation matrix of whitefly population/plant with weather parameters during *Rabi* 2019-20 at Warangal

	Temp °C (max)	Temp °C (min)	RH I (%)	RH II (%)	Sunshine hours (h)	Wind velocity (km/h)	Whitefly population
Temp °C (max)	1.0000	0.9160	-0.46695	-0.6699	0.1875	0.1082	-0.8153*
Temp °C (min)		1.0000	0.2580	0.6119	-0.32323	0.3232	0.9180**
RH I (%)			1.0000	0.4990	-0.0835	-0.2110	0.8667*
RH II (%)				1.0000	-0.2402	0.2289	-0.6889
Sunshine hours (h)					1.0000	-0.4630	0.0372
Wind velocity (km/h)						1.0000	0.9007**
Whitefly population							1.0000

Table 3: Regression analysis of weather parameters with whitefly population in during *Rabi* 2019-20

Step No.	Variable detected	Coefficient of determination (R^2)
1	Nil	0.4624**
2	X_5	0.4622**
3	X_5 and X_2	0.456
4	X_5,X_1 and X_4	0.433**
5	X_5, X_1, X_4 and X_3	0.411**
Regression equation Y= -33.85 + 1.197 X_2 + 0.515 X_6		

X_1 – Maximum temperature; X_2 – Minimum temperature; X_3 – Relative humidity I X_4 – Relative humidity II; X_5 – Sunshine; X_6 – Wind velocity

* Significant at 5% level ** Significant at 1% level

Table 4: Effect of weather parameters on whitefly population during *Rabi* 2020-21

Standard meteorological week	Period	Temperature		Relative humidity		Sun shine hours	Wind speed	Whitefly population
		Max	Min	RH I	RH II			
11	12-18 MAR	33.1	20.7	90.4	55.6	7.7	2.6	3.1
12	19-25 MAR	36.6	23.9	92.3	47.7	9	2.8	3.2
13	26 MAR-01 APR	36.1	22.6	89	53.1	8	3	3.5
14	02-08 APR	35.6	23.6	90.6	55.1	9	3.1	4.2
15	09-15 APR	37.8	23.6	89.6	53.3	9.5	2.5	4.4
16	16-22 APR	37.3	24.7	84	46.8	9.5	3.1	4.9
17	23-29 APR	37.7	24.3	91.9	50.8	5.9	3.3	5.5
19	30 APR -06 MAY	39.2	25.3	83.7	47.9	9	2.7	6

Table 5: Overall correlation matrix of whitefly population/plant with weather parameters during *Rabi* 2020-21 at Rajendranagar

	Temp °C (max)	Temp °C (min)	RH I (%)	RH II (%)	Sunshine hours (h)	Wind velocity (km/h)	Whitefly population
Temp °C (max)	1.0000	0.0320	-0.6150	-0.6504	0.6450	0.3766	-0.1632
Temp °C (min)		1.0000	0.3952	0.3952	-0.6551	0.4992	0.7301*
RH I (%)			1.0000	0.5260	-0.6075	-0.3741	-0.8938**
RH II (%)				1.0000	-0.5673	0.3137	-0.7709*
Sunshine hours (h)					1.0000	-0.5673	0.5543
Wind velocity (km/h)						1.0000	0.9347**
Whitefly population							1.0000

Table 6: Regression analysis of weather parameters with whitefly population in during *Rabi* 2020-21

Step No.	Variable detected	Coefficient of determination (R^2)
1	Nil	0.4844**
2	X_5	0.4162**
3	X_5 and X_1	0.484
4	X_5, X_2 and X_4	0.423**
5	X_5, X_1, X_4 and X_3	0.479**
Regression equation Y= -31.85 + 1.187 X_2 + 0.505 X_6		

X_1 – Maximum temperature; X_2 – Minimum temperature; X_3 – Relative humidity I X_4 – Relative humidity II; X_5 – Sunshine; X_6 – Wind velocity

* Significant at 5% level ** Significant at 1% level

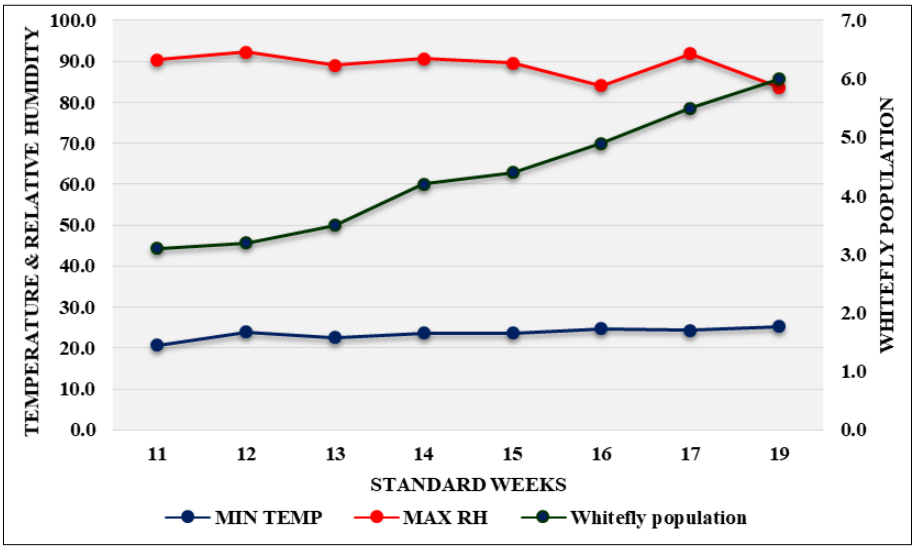

Fig 1: Effect of minimum temperature and relative humidity on whitefly population during *Rabi* 2019-20

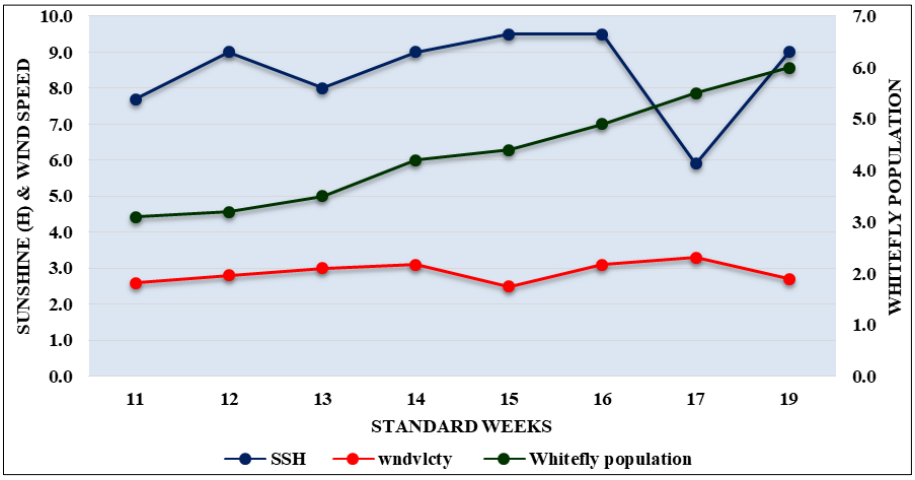

Fig 2: Effect of sunshine hours and wind velocity on whitefly population during *Rabi* 2019-20

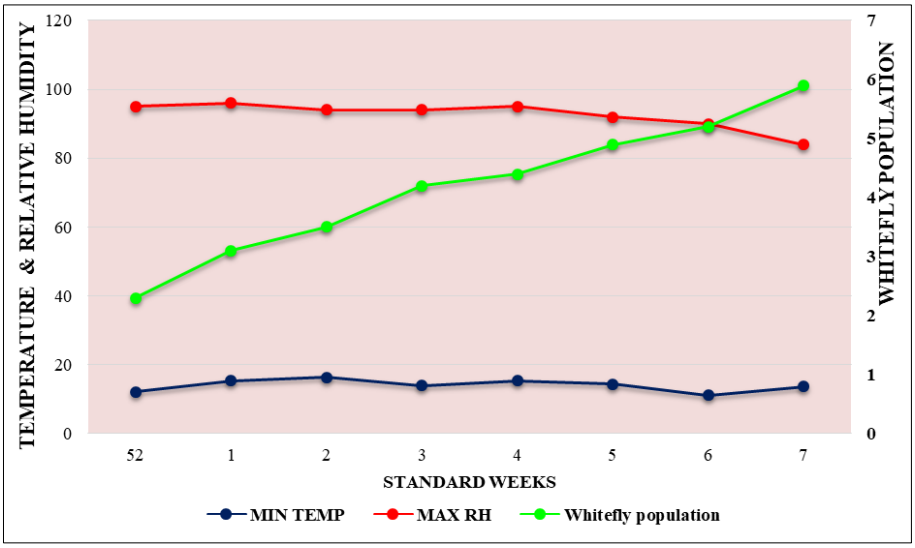

Fig 3: Effect of minimum temperature and relative humidity on whitefly population during *Rabi* 2020-21

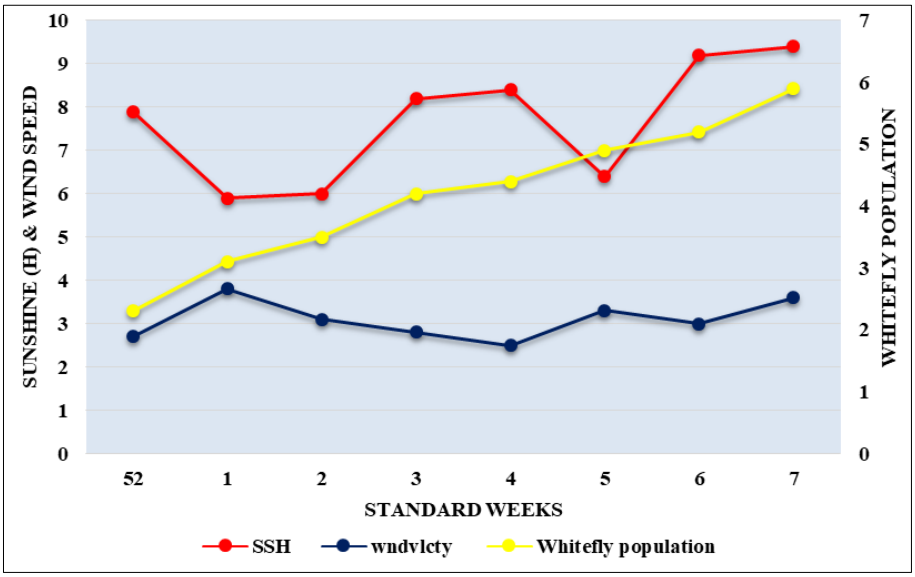

Fig 4: Effect of sunshine hours and wind velocity on whitefly population during *Rabi* 2020-21

Conclusion

Population of whitefly, *Bemisia tabaci* with temperature (max. and min.) and sunshine (hrs) had a negative significant correlation, while morning and evening relative humidity had a positive correlation but wind speed had non – significant positive correlation. The potential of these parameters can be deeply investigated so, it can come handy in manipulation of microclimate of the crop to reduce the infestation of the pest.

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