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Correlation of whitefly population with weather parameters and management of leaf curl of chilli

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Abstract
The present research discusses the population dynamics of whitefly (*Bemisia tabaci* Genn.) o chilli with weather parameters in the Experimental field, College of Agriculture, Indore, (MP) during Kharif 2016. This investigation revealed that whitefly activity commenced from 33rd SMW and continued upto 43rd SMW. The peak population was observed on 37th SMW. The population exhibited positive significant correlation with maximum temperature, positive non-significant correlation with minimum temperature, negative non-significant correlation with the relative humidity, negative significant correlation with the wind speed and rain fall. When the population was correlated with the abiotic factors of the previous week, the population exhibited a positive non-significant correlation with maximum temperature and minimum temperature, negative non-significant correlation with the relative humidity and wind speed, negative significant correlation with rain fall. The crop could be protected from leaf curl by spraying insecticides viz., Fipronil, Pyriproxifen+Fenpropathrin, Buprofezin, Neemoil+ *P. fluorescens* (alternate) sprays at 10days interval after leafcurl appearance.

Keywords: Population dynamics, viruliferous whitefly, leaf curl, meteorological week, abiotic factors

Introduction
Chilli (*Capsicum annuum* L.) an indispensible vegetable cum spice crop, grown for its fruits, is used fresh in green as well as ripe and ripe dried form for its pungency. India occupied about 0.806 mha and production of 1.30mt during 2013-14, takes the lion's share of 36% of global production not only being the largest producer but also the largest consumer of chilli in the world. Chilli crop is infested by many insect pests, among which, sucking pest complex viz., whiteflies; *Bemisia tabaci*, thrips; *Scirtothrips dorsalis* and mites; *Polyphagotarsonemus latus* and pod borers, viz, *Helicoverpa armigera* and *Spodoptera litura* are prominent (Reddy *et al*, 1983) [16]. Chilli crop is attacked by a large number of pathogens but heavy losses are caused by viruses. Several viral diseases attack this crop and induce mild to severe mosaic, mosaic mottle, leaf curl, leaf roll, bushy stunt and necrosis symptoms. The leaf curl disease of chilli is caused by chilli leaf curl virus transmitted by viruliferous Whitefly (*Bemisia tabaci* Genn.). In India, *Senanayake et al*. (2006) [18] have reported first time chilli leaf curl virus on chilli. Due to variation in the agro climatic conditions of different regions insects show varying trends in their incidence also in nature and extent of damage to the crop. Besides, abiotic factors also play a key role in determining the incidence and dominance of a particular pest or pest complex (Butani, 1976) [5]. The study on population dynamics of whitefly and the virus transmitted by it would give an idea about their peak period of activity and in developing pests management strategy leading to reduced leaf curl and crop losses. Hence, considering the importance of whitefly an attempt has been made to study its population dynamics and its correlation with weather parameters. The present studies were under taken during 2016 *Kharif* by keeping in view the importance of management of whitefly with different insecticides, neem and bacterial antagonistic, since it is a potent vector.

Materials and Methods
Studies on seasonal incidence of whitefly, *B. tabaci* on chilli with incidence of leaf curl and with prevailing weather factors were worked out during July 2016, in the research field, Department of Plant Pathology, College of Agriculture, Indore (22.7106ºN lattitude and 75.8917ºE longitude above MSL). The observations on the leaf curl incidence were recorded visually at weekly intervals from mid-August to October (starting 20 days after transplanting) by counting the population on ten randomly selected plants per plot of size 4 x 3 m^2 which were maintained without employing any plant protection measures. The population of whiteflies were recorded from three leaves one each from the upper, middle and lower position on five randomly selected plants.

The numerical count method described by Heathcoate (1972) [8] was used to record the population of whitefly. The population was counted only on three leaves as per the method suggested by Satpathy (1973) [17]. The whitefly population was averaged and expressed as number of adults/ 3 leaves. The observations were recorded from 6:30 to 8:30 AM. Scoring of leaf curling for individual plants of each treatment were rated using the following scale mention in table 1 (Niles, 1980) [14].

The weather data were collected from meteorological observatory, CoA, Indore such as maximum temperature, minimum temperature, relative humidity, wind speed and rain fall. Weather factors along with leaf curl incidence were correlated with the whitefly population using the formula and test of significance were worked out.

Formula for calculating correlation coefficient

$$r_{x1y1} = \frac{\sum x1y1 - \sum x1 \sum y1/n}{\sqrt{[\sum x1^2 - (\sum x1)^2/n][\sum y1^2 - (\sum y1)^2/n]}}$$

Where,

rx1y1 = Simple correlation coefficient between x1 and Y1.

x1 = Independent variable i.e. abiotic component.

y1 = Dependent variable i.e. Pest.

n = Number of observations.

The correlation coefficient (r) values were subjected to the test of significance using t test (Gupta *et al*, 2016) [7]

$$t = \frac{r}{\sqrt{1 - r2 \times \sqrt{n-2}}}$$

Table 1: Scoring procedure for pests

Symptoms	Score
No symptoms	0
0–5% curling and clearing of upper leaves	1
6-25% curling, clearing of leaves and swelling of veins	2
26–50% curling, puckering and yellowing of Leaves and swelling of veins	3
51–75% leaf curling and stunted plant growth and blistering of internodes	4
More than 75% curling and deformed small leaves, stunted plant growth	5
with small flowers and no or small fruit set	

Management of leaf curl with neem oil and insecticides

The seed of capsicum hybrid HPH 12 were sown in portrays using coco peat as growing media for nursery production. The trays were tapped gently to fill the cells properly and the seeds were sown one per cell, to a depth of 0.5 cm and the seeds were watered lightly, are grown under naturally ventilated shade net house.

The experiment was conducted to know the efficacy of neem oil, a bioagent and insecticides in managing the disease in the field from July to December 2016 in Randomized Block Design with 3 Replications and 11 treatments in plot size of 4m × 3m at a distance of 45 cm row-row × 60 cm plant to plant. The seedlings were transplanted at the age of 6-7 weeks.

Table 2: Insecticide used in the treatment plots.

The treatment details were		
T1	Fipronil (Fipgen-Green land crop science pvt. Ltd)	2-3ml/l
T2	Pyriproxifen+Fenpropathrin (Sumipremt 20 EC-Sumitomo	0.5-1ml/l
	Chemical India Pvt. Ltd)	
T3	Buprofezin (Phentom-Insecticides Pvt. Ltd)	2.5ml/l
T4	Spiromecifen (Oberon 240SC)	0.8-1ml/l
	Fenpropathrin (Meothrin- Sumitomo Chemical India Pvt. Ltd)	
T5	Fenpropathrin	1.5ml/l
T6	Dimethoate (Rogar-Cheminova)	1.5-2ml/l
T7	Diafenthiuron (Pegasus- Syngenta)	1.25mg/l
T8	Spiromecifen -› Buprofezin (alternatively)	0.3- 0.5ml/l
T9	Control	Water
T10	Multineem spray	1-2ml/l
T11	Neem spary-› *P. fluorescens* (alternatively)	1-2ml/l

Percent disease incidence was calculated by following formula suggested by Nene (1972) [13] and Vincent (1927) [20]:

$$\text{Percent disease incidence} = \frac{\text{No.of disease units}}{\text{Total assesed units}} \times 100$$

Reduction in disease incidence: Percent disease reduction was calculated by following formula:

$$\text{Percent disease reduction} = \frac{C - T}{C} \times 100$$

Where, C = Per cent disease incidence in untreated control.

T = Per cent disease incidence in treated plot.

Results and Discussion

Whitefly population initially 1.1 Adults/3 leaves during 33rd SMW, later from 34th SMW showed an increasing trend with 0.67 Adults /3 leaves reached its peak at 37th SMW with 25.93 Adults/3 leaves as there was no rainfall and 30.7ºC of Max. temperature then started decreasing from 38th SMW with 11.67 Adults/3 leaves till 40th SMW with 5.13 Adults /3 leaves, Average rainfall was 30mm, 0mm, and 9.3mm. whitefly population showed notable numbers during 41st, 42nd and 43rd SMW with 5.13, 7.9 and 4.03 Adults /3 leaves respectively during the observation period. The whitefly population was observed to be negligible during corresponding high rainfall weak (Table 2).

Correlation of whitefly population with abiotic factors of the same week: The population exhibited a positive significant correlation with maximum temperature (r=0.25), positive non significant correlation with minimum temperature (r=0.158). These results are in conformity with the findings of Meena *et al.* (2013) [10] but contradictory with the Rawal *et al.* (2016) [15] findings, observed that whitefly population were negatively correlated with maximum temperature, minimum temperature and (Bokan *et al.* 2015) [2] correlated Whitefly population negatively correlated with

minimum temperature. A negative non significant correlation with the relative humidity (r= -0.14) corroborate with the earlier findings as reported by Meena *et al.* (2010) [9] and Yadav *et al.* (2015) [21] that the increase in maximum temperature during the crop growth results in higher population of whitefly. Results are in contradictory with the authors who related maximum temperature as negatively correlated and relative humidity as positively correlated with whitefly population and also with (Rawal *et al* 2016) [15], who showed whitefly populations and relative humidity were positively correlated. Identical results were also observed by Nandini (2010) [12], for negative significant correlation with the wind speed(r= -0.23) and rain fall (r= -0.29) in relation to population of whitefly.

Correlation of whitefly population with abiotic factors of the previous week: The white fly population exhibited a positive non significant correlation with maximum temperature (r=0.04) and minimum temperature (r=0.02), negative non significant correlation with the relative humidity (r= - 0.17) and wind speed (r= - 0.14), negative significant correlation with rain fall (r= - 0.28) as presented in table 3, fig 3. Mehra and Krishna (2017) observed a positive correlation of the whitefly population with sunshine and morning hour relative humidity, however presently the whitefly population observed an increase with reduction in the relative humidity. Thus a high maximum temperature of 28.1-32.9^{0}c; high minimum temperature of 20.4-24.5 ^{0}c; low relative humidity 70.1-79.2%; low wind speed of 0.1to 1.2 KM/hr and less rainfall of 0.00-7.1mm favoured the whitefly population build up which inturn was responsible for increasing leaf curl.

Table 2: Correlation of whitefly population with leaf curl incidence and abiotic factors of the same week

SMW	Whitefly population	Meteorological parameters				
		Max temp (ºC)	Min temp (ºC)	RH (%)	Wind Speed	Rain fall(mm)
33	1.1	27.4	23.1	84.1	4.5	1.4
34	0.67	24.9	22.6	88.5	1.8	107.4
35	2.06	28.9	24.3	84.9	1.1	69.9
36	5.39	28.1	23	81.1	2.4	9.2
37	25.93	30.7	24.5	79.2	1.2	0.0
38	11.67	30	24.4	83.7	0.6	30.0
39	1.37	32.9	24.3	74.6	1.0	0.0
40	1.73	30.3	24.9	82.1	0.6	9.3
41	5.13	31	24	75.7	0.8	7.8
42	7.9	31.1	20.4	70.1	0.1	0.0
43	4.03	32.1	17.9	71.8	0.3	0.0
Co efficient of correlation (r)		0.25	0.158	-0.14	-0.23	-0.29

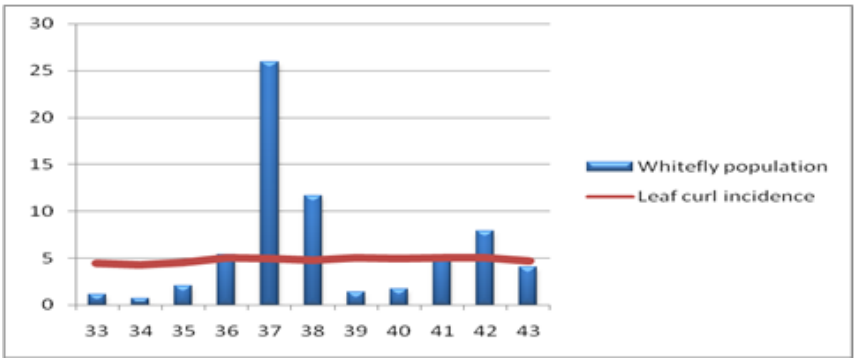

Fig 1: Correlation of population of whitefly with leaf curl incidence.

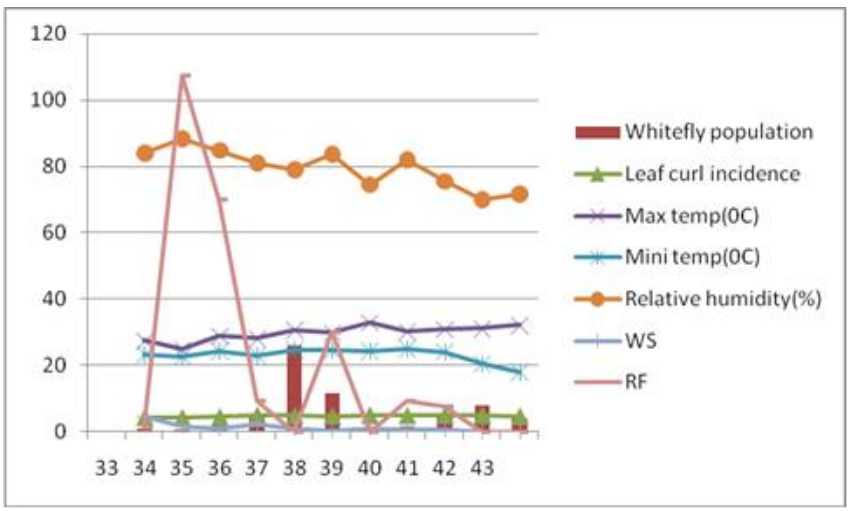

Fig 2: Correlation of population of whitefly with abiotic factors of the same week

Table 3: Correlation of whitefly population with the abiotic factors of the previous week.

WF	SMW	Max Temp (°C)	Min Temp (°C)	RH%	Wind velocity	Rain fall
1.10	32	26.4	22.9	90.4	7.1	66.2
0.67	33	27.4	23.1	84.1	4.53	1.40
2.06	34	24.9	22.6	88.5	1.81	107.40
5.39	35	28.9	24.3	84.9	1.12	69.90
25.93	36	28.1	23.0	81.1	2.39	9.20
11.67	37	30.7	24.5	79.2	1.17	0.00
1.37	38	30.0	24.4	83.7	0.57	30.00
1.73	39	32.9	24.3	74.6	1.04	0.00
5.13	40	30.3	24.9	82.1	0.63	9.30
7.90	41	31.0	24.0	75.7	0.83	7.80
4.03	42	31.1	20.4	70.1	0.13	0.00
Correlation coefficient(r)		0.04	0.02	-0.17	-0.14	-0.28

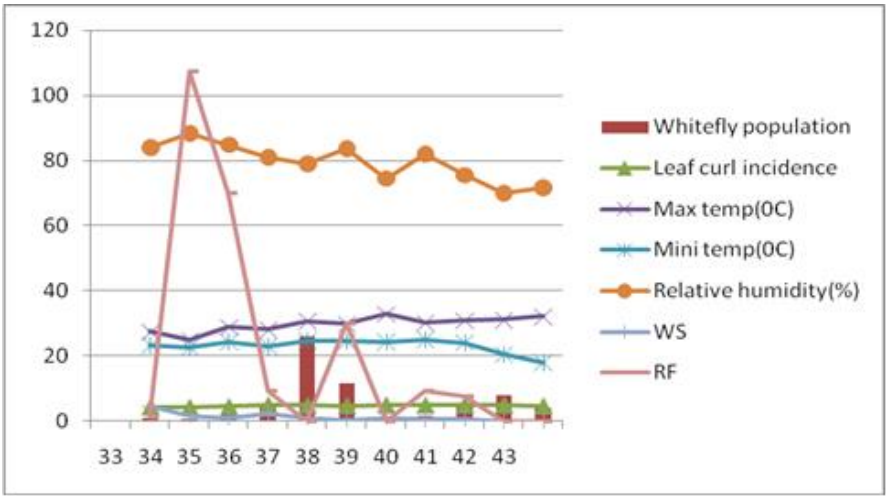

Fig 3: Correlation of population of whitefly with abiotic factors of the previous week

Management of leaf curl

The relative efficacy of different treatments in percent reduction of leaf curl incidence at 10 days intervals after treatment was significant (Table 3). Insecticides wise Pyriproxifen+Fenpropathrin, Fipronil, alternative spray of Neem and *P. fluorescens* showed 14.0%, 13.4% and 12% of disease reduction respectively compared to check plot showed 100% disease incidence. Buprofezin and Multineem spray are showing identical results i.e. 90% disease control. No disease reduction was observed from Diafenthiuron and Spiromecifen sprays. Alternative spray of Spiromecifen and Buprofezin, Fenpropathrin, Dimethoate showed very minute reduction of leaf curl incidence wise 1.33, 2, 2.7% respectively. Results are in contradict with the findings of Singh and Singh (2014) [19] have found that the leaf curling symptom due to feeding of mites and thrips was lowest in spiromesifen treated chill.

Mean percent reduction of leaf curl over control was found highest with Pyriproxifen+Fenpropathrin (14%), followed by Fipronil (13.4%), alternative spray of Neem and *P. fluorescens* (12%). The minimum leaf curl incidence was observed by 7 application of Pyriproxifen+Fenpropathrin, Fipronil, alternative sprays of Neem and *P. fluorescens*, Multineem and Buprofezin at 10 days intervals. Insecticides have been reported to significantly reduce the incidence of pest in chilli also insecticides of tobacco leaf curl virus. Since *Aphis gossypi*, unspecified thrips and mites by virtue of sap feeding resulted in the leaf curl which is recovered by insect control but reduction in curling due to virus is achieved only management of its whitefly vector (Bodhade *et al*, 1985) [1]. In this context Borah (1995) [4] could observe effective control of whitefly by use of Dimethoate at 0.03 and 0.045% on Mung bean and on Okra (Borah and Nath, 1995) [3]. Presently the neem formulation was also tested alone and in combination with bioagent *P. fluorescence* and were found to reduce the whitefly population. These have been found to reduce the vector population for chilli leaf curl virus in red chilli (Chakrabarti 2000) [6].

Table 4: Management of leaf curl of chilli with neem oil and insecticides.

Treatments	Mean leaf curl incidence (%)	Disease Control (%)
T1-Fipronil	86.6	13.40
T2-Pyriproxifen+Fenpropathrin	86.0	14.00
T3-Buprofezin	90.0	10.00
T4-Spiromecifen	100.0	0.00
T5-Fenpropathrin	98.0	2.00
T6-Dimethoate	97.33	2.67
T7-Diafenthiuron	100.0	0.00
T8- Spiromecifen -›Buprofezin (alternatively)	98.67	1.33
T9-Control	100.0	-
T10-Multineem spray	90.0	10.00

T11-Neem spary-› *P. fluorescens* (alternatively)	88.0	12.00
S. Em±	0.14	
C. D. at 5%	0.76	

Conclusion

It has concluded from the above findings that slow winds, low rainfall, lesser relative humidity, and higher maximum and minimum temperatures favour buildup of whitefly population. Among the insecticide neemoil and bacterial bioagent Fipronil, Pyriproxifen + Fenpropathrin, Buprofezin and Neem spary-› *P. fluorescens* (alternatively) at 10 days intervals offered 10-14% reduction in the leafcurl incidence.

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