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Gayatri Kumari Padhi
Research Scholars, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Labani Maity
Research Scholars, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Arup Chattopadhyay
Professor, AICRP on Vegetable Crops, Bidhan Chandra KrishiViswavidyalaya, Mohanpur, Nadia, West Bengal, India

Arunava Samanta
Associate Professor, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Correspondence
Gayatri Kumari Padhi
Research Scholars, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Population dynamics of whitefly (*Bemisia tabaci* Genn.) in chilli and screening of genotypes against chilli leaf curl virus

Gayatri Kumari Padhi, Labani Maity, Arup Chattopadhyay and Arunava Samanta

Abstract
The present investigation was carried out to study the seasonal incidence of whitefly in Chilli and its correlation with different weather parameters alongside, fifteen genotypes were subjected for screening against Chilli Leaf Curl Virus. The incidence of whitefly was started from the 45th standard week of (observations-2.07 adults/three leaves) (Fig no.1), and reached its peak in the 48th standard week of observations (7.07adult/three leaves) and again declined subsequently upto 1st standard week of observations with a population of 1.80 adult/three leaves. Then gradually, its incidence reached the peak again in 4th and 5th standard week of observations (6.40 adults/three leaves) and gradually declined. The incidence of whitefly was found to be significantly negatively correlated with maximum temperature (rTemp max=-0.179*) and only negatively correlated with minimum temperature (rTemp min=-0.062) while negatively correlated with with rainfall and sunshine hours with rRF=-0.253* and rSS=-0.281 respectively. Genotypes namely 13/CHVar-1 and 13/CHVar-2 were found to show resistance to CLCV (Chilli Leaf Curl Virus) in field conditions.

Keywords: whitefly, Chilli, Chilli leaf curl virus, seasonal incidence, correlation

Introduction
Chilli is considered as one of the commercial spice crop. It is the most widely used as a universal spice, named as *wonder spice* [10]. Different varieties are cultivated for various uses like vegetable, pickles, spice and condiments [10]. Chilli (botanically known as *Capsicum annuum* L.), also called red pepper belongs to the genus capsicum, under the solanaceae family. It is believed to have originated in South America [9]. About five species of Chilli have been domesticated in India. They are annuum, frutescens, chinense, baccatum and pubescens [9]. Pungency in chilli is due to the alkaloid "capsaicin" contained in the pericarp and placenta of fruits. World Area and Production: Chilli is raised over an area of 1832 thousand hectares in the World; with a production of 2959 thousand tons [6]. India is not only the largest producer but also the largest consumer of chilli in the world. Chillies are the most common spice cultivated in India. Chilli is a universal spice of India. In India, Chillies are grown in almost all the states throughout the country. In India, the area under chilli (*Capsicum annuum / Capsicum frutescens)* is 774,870 ha and the total production of chilli in India is 149,214 tonnes [8] Andhra Pradesh is the largest producer of Chilli in India and contributes about 26% to the total area under Chilli, followed by Maharashtra (15%), Karnataka (11%), Orissa (11%), Madhya Pradesh (7%) and other states contributing nearly 22% to the total area under Chilli. (Government of India)(Reference).The production of Chilli, in India, is dominated by Andhra Pradesh which contributes nearly 57% to the total production. Karnataka is the second largest producer contributing 12% to the total production (Source: Spice Board, India).
The pest profile of chilli is complex with more than 293 insect and mite species debilitating the crop in the field as well as in storage [2]. 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 [11]. Chilli crop is attacked by a large number of pathogens but heavy losses sre caused due to 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 White

Fly (*Bemisia tabaci* Genn.). In India, Senanayake *et al*. (2006) have reported first time chilli leaf curl virus on chilli crop. 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 [5]. Hence an incidence study on sucking pests population dynamics would give an idea about peak period of their activity and may be helpful in developing pest management strategy. The incidence of whitefly in Chilli and the role of the abiotic factors influencing the population dynamics of the same is to be studied which will give us a vivid idea. The susceptibility of the genotype of chilli towards Chilli leaf curl virus which is transmitted by Whitefly is an important study to be uptaken for the further breeding approaches to be carried forward. The identification of resistant or susceptible genotypes is a step forward for advanced pest management strategy. So, field screening of the chili genotypes is to be done for assessment of their susceptibility towards Chilli leaf curl virus. The basic objective of the study is to study the population dynamics of whitefly in the pertaining season and to study the susceptibility of different chilli varities against Chilli leaf curl virus (CLCV).

Materials and Methods

The studies on population dynamics of Whitefly and screening of the chilli genotypes were carried out in 2015-2016 at AICRP on Vegetable Crops, "C" Block Farm, B.C.K.V., Kalyani, Nadia. As per the objectives the experiment was divided into two parts-i) Studies on population dynamics of Whitefly in Chilli (Var-Bullet) in relation to the weather parameters-Chilli plots of 4 m X 3m was laid out with spacing of 60cm X 45cm and 25 days old seedlings were transplanted in the month of November. Observations on incidence of whitefly were recorded from five randomly selected and tagged plants in an interval of seven days. Data on weather parameters were obtained and correlation of weather parameters and whiteflies were computed. ii) Screening of Chilli genotypes against Chilli Leaf Curl Virus.-The experiment was laid down in RBD with plot size 4m X 3m with spacing of 60cm x 45cm with 15 genotypes transplanted in the month of November. Screening of the following genotypes i.e Kashi Anmol, ARCH228, LCA_334, 13/CHVar-1, 13/CHVar-2, 13/CHVar-3, 13/CHVar-4, 13CHHYB-1, 13CHHYB-2, 13CHHYB-3, 13CHHYB-4, 13CHHYB-5, 13CHHYB-6, 13CHHYB-7 and 13CHHYB-8 was done in 30days interval. Critical information in the assessment of disease is the amount of disease that is present. This can be measured as the proportion of a plant community that is diseased (disease incidence) or as the proportion of plant area that is affected (disease severity). Hence, Percent disease index (PDI) of leaf curl virus was determined for all genotypes at an interval of 30days after transplanting on the basis of following disease scoring scale (0–9) [3], It is as follows:

Table 1: Percent Disease indexing in Chilli against Chilli Leaf Curl Virus [3].

Grade	Description	Category
0	Leaf curl symptoms absent	Immune
1	Very mild curling of 1–10% leaves	Resistant
3	Curling, puckering symptoms on nearly11–25% leaves	Moderately resistant
5	Curling, puckering symptoms on nearly26–50% leaves	Moderately susceptible
7	Severe curling, puckering symptoms on nearly 51–75% leaves with stunting of the plants and small leaves	Susceptible
9	All leaves of the plant >75% showing severe symptoms, severe stunting of plants, bushy appearance and pronounced small leaves	Highly susceptible

PDI in % was calculated at 120 days after planting with the following formula:

$$PDI = \frac{\Sigma \text{ Numerical ratings}}{\text{Highest grade of rating} \times \text{total number of plants examined}} \times 100$$

The calculation of PDI was then followed by DMRT statistical analysis for comparison of the means.

The statistical analysis was carried out by correlating the abundance of whitefly with different weather parameters. The Percent Disease Index (PDI) was subjected to DMRT for comparison of means.

Results

Seasonal Incidence of Whitefly

The incidence of whitefly was started from the 45th standard week of observations (2.07 adults/three leaves) (Fig.1), and reached its peak in the 48th standard week of observations (7.07adult/three leaves) and again declined subsequently upto 1st standard week of observations with a population of 1.80 adult/three leaves. Then gradually, its incidence reached the peak again in 4th and 5th standard week of observations (6.40 adults/three leaves), and subsequently declined till 9th standard week of observations. The peak incidence of whitefly can be conferred in the 48th, 5th and 6th standard week of observations with population of 7.07, 6.40 and 6.40 adults/three leaves respectively. (Fig.1)

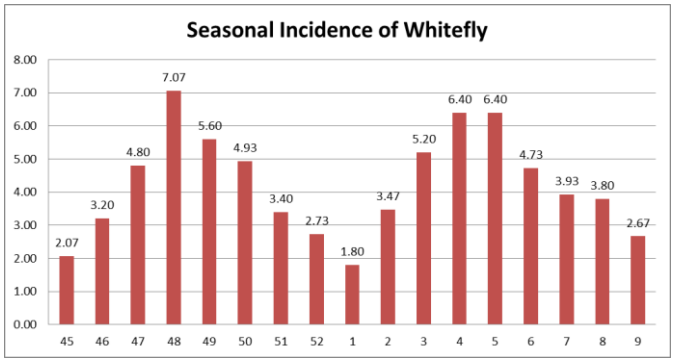

Fig 1: Seasonal Incidence of Whitefly recorded in different Standard Weeks of observations

Correlation of incidence of Whitefly with different weather parameters

The data on weather parameters taken was correlated with the incidence of whitely and the correlation values were worked out statistically for test of significance too. The incidence of whitefly was found to be significantly negatively correlated with maximum temperature($r_{Temp\ max}$=-0.179*) and only negatively correlated with minimum temperature($r_{Temp\ min}$=-

0.062).The incidence was found negatively correlated with maximum relative humidity while positively correlated with minimum relative humidity with $r_{RH\ max}$ and $r_{RH\ min}$ values as -0.086 and 0.133 respectively. It was also observed that higher temperature was conducive for rapid multiplication and activity of *B. tabaci.* There was negative correlation of whitefly with rainfall and sunshine hours with $r_{RF=}$-0.253* and r_{SS}=-0.281 respectively.

Table 1: Correlation of Whitefly with different Weather Parameters

	White Fly	Temp Max	Temp Min	Rh Max	Rh Min	Rainfall	Sunshine Hrs
White Fly	1.000						
Temp Max	-0.179*	1.000					
Temp Min	-0.062	0.909*	1.000				
RH Max	-0.086	0.015	0.151	1.000			
RH Min	0.133	-0.163	0.104	0.436	1.000		
Rainfall	-0.253*	0.547	0.324	0.166	-0.628	1.000	
Sunshine Hrs	-0.281	0.295	0.327	0.464	0.222	0.261	1.000

Screening of Chilli genotypes against Chilli Leaf Curl Virus

Fifteen genotypes were subjected to screening against Chilli leaf curl Virus and the percent disease index was calculated at an interval of 30days by the help of the abive mentioned formula given by [3]. Then it was subjected to statistical analysis through DMRT (Duncans Multiple Range Test). The grading was done while taking observations at 30days interval and PDI was calculated accordingly. Final grading was referred as bench mark for assigning the degree of resistance or susceptibility of the genotypes. However, the results denoted that no variety out of the fifteen genotypes were fully immune to CLCV (Chilli Leaf Curl Virus). Genotypes namely 13/CHVar-1 and 13/CHVar-2 were found to show resistance to CLCV (Chilli Leaf Curl Virus). Some genotypes namely 13/CHVar-4, 13CHHYB-5 and 13CHHYB-8 were found to be moderately resistant. Moderately susceptible genotypes were as follows ARCH228, 13/CHVar-3, 13CHHYB-2, 13CHHYB-4, 13CHHYB-6.The genotypes which came under susceptible and highly susceptible group were Kashi Anmol, LCA_334, 13CHHYB-1, 13CHHYB-3. (Table-2).

Some genotypes like 13CHHYB-1, 13CHHYB-3 and Kashi Anmol initially beared lower PDI (Percent Disease Index) but gradually developed susceptibility towards CLCV (Chilli Leaf Curl Virus).Genotypes mainly 13/CHVar-2 and 13/CHVar-4 were inferred to be continuously with lower PDI (Percent Disease Index) from transplanting to harvest. The highest grading was inferred by the most susceptible genotypes. (Table -2)

Table 2: Mean PDI (Percent Disease Index) % calculated at an interval of 30Days through DMRT (Duncan's Multiple Range Test)

Sl.no	Varieties	Mean PDI at 30DAT (%)	Mean PDI at 60DAT (%)	Mean PDI at 90DAT (%)	Mean PDI at 120DAT (%)	Inference incurred from final ratings
1	Kashi Anmol	14.67^{ab}	22.67^{abc}	62.67^{bcd}	86.67^{fgh}	HS
2	ARCH228	24.00^{b}	36.00^{cdef}	57.33^{bc}	68.00^{cde}	MS
3	LCA_334	25.33^{b}	46.67^{ef}	81.33^{cd}	92.00^{gh}	HS
4	13/CHVar-1	20.00^{ab}	37.33^{cdef}	53.33^{abc}	60.00^{c}	MR
5	13/CHVar-2	9.33^{ab}	22.67^{abc}	40.00^{ab}	44.00^{b}	R
6	13/CHVar-3	10.67^{ab}	21.33^{abc}	60.00^{bc}	73.33^{cdef}	S
7	13/CHVar-4	1.33^{ab}	9.33^{a}	29.33^{a}	40.00^{a}	R
8	13CHHYB-1	12.00^{ab}	24.00^{abcd}	90.67^{d}	96.00^{h}	HS
9	13CHHYB-2	30.67^{b}	50.67^{f}	65.33^{bcd}	78.67^{def}	S
10	13CHHYB-3	14.67^{ab}	30.67^{bcde}	78.67^{bc}	88.00^{fgh}	HS
11	13CHHYB-4	16.00^{ab}	41.33^{def}	60.00^{bc}	68.00^{cde}	MS
12	13CHHYB-5	18.67^{ab}	32.00^{bcde}	52.00^{abc}	58.67^{bc}	MR
13	13CHHYB-6	13.33^{ab}	24.00^{abcd}	60.00^{bc}	68.00^{cde}	MS
14	13CHHYB-7	26.67^{b}	46.67^{ef}	74.67^{cd}	84.00^{efg}	HS
15	13CHHYB-8	10.67^{ab}	17.33^{ab}	65.33^{bcd}	66.67^{cd}	MR

*Figures bearing same alphabets are not significantly different than others and vice versa.

*Gradings are R- Resistant, MR- Moderately resistant.MS- Moderately susceptible, S- Susceptible, HS- Highly susceptible.

Discussions

Sitaramaju *et al*. (2010) reported that the whitefly population was positively correlated with mean temperature and negatively correlated with mean R.H. The negative correlation with maximum relative humidity was also supported by the evidence given [13]. It was suggested that rain may act to suppress oviposition and/or increase the mortality of nymphs adults or emigration. The negative association between the whitefly population and RH and rainfall was due to *B. tabaci*. adults which were largely controlled by rains and strong winds [13]. The study made by Gupta *et al.*, (1997) on impact of abiotic factors on population build up of white fly on cotton crop in IARI, New Delhi reported negative correlation of relative humidity and rainfall on population build up of white fly [7, 14].

Conclusion

The incidence of whitefly was started from the 45th standard week of observations and reached its peak in the 48th standard week of observations again declined subsequently upto 1st standard week of observations with a population of 1.80 adult/three leaves with, its incidence reaching its peak again in 4th and 5th standard week of observations (6.40 adults/three leaves), and subsequently declined till 9th standard week of observations. The incidence of whitefly was found to be significantly negatively correlated with maximum temperature and only negatively correlated with minimum temperature. The incidence was found negatively correlated

with maximum relative humidity while positively correlated with minimum relative humidity, and negatively correlated with rainfall and sunshine hours.

Genotypes namely 13/CHVar-1 and 13/CHVar-2 were found to show resistance to CLCV (Chilli Leaf Curl Virus). The genotypes such as Kashi Anmol, LCA_334, 13CHHYB-1, 13CHHYB-3 can be inferred under susceptible and highly susceptible group.

The seasonal incidence of whitefly and it correlation with different abiotic factors are an important study to be made to modulate the pest management strategies and to study the impact of changing climatic conditions on pest population dynamics. The screening of the genotypes is a step forward for resistant breeding and as well as to determine the susceptibility of various genotypes in a given environmental scenario.

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