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Population dynamics of whitefly, *Bemisia tabaci* (Gen.) and its natural enemies on cotton cultivars

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ABSTRACT

The whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is a most notorious pest of many agricultural and horticultural crops. The present investigation was carried out to understand the occurrence of whitefly and its natural enemies during *Kharif* 2021 at, CCS Haryana Agricultural University, Hisar (Haryana). Three cotton cultivars Desi (HD 432), American (H1098i), *Bt* cotton (RCH773BGII) were sown. The population of whitefly (adults/4 leaves) remained below ETL in June-July and crossed the ETL in the month of August. In all cotton cultivars, the highest population of whitefly adults was observed during 34th SMW (3rd week of August) in *Bt* (3.98 adults/leaf), American (2.78 adults/leaf) and Desi cotton (2.37 adults/leaf). Similarly, the highest population of nymphs was observed during 35th SMW (4th week of August) in Bt (33.04 nymphs/leaf) followed by American (30.69 nymphs/leaf) and Desi cotton(27.41nymphs/leaf). Among natural enemies,predators like spiders and coccinellids were the dominant. Maximum parasitization of whitefly nymphs was observed in *Bt* (32.13%) followed by American (20.21%) and minimum in Desi cotton (16.34%). Our study recorded that the population of whitefly was maximum on Bt cotton followed by American and then Desi cotton. The weather parameters such as temperature (maximum and minimum) and average wind velocity influenced the buildup of whitefly and its natural enemies population in all three cotton cultivars.

Key words: *Whitefly, Cotton, Natural enemies, Spiders, Coccinellids, Chrysoperla, Parasitoids.*

Introduction

Cotton plays a significant role in India's agricultural economy. It is attacked by 162 species of insect pests from seed germination to harvesting stage indicating that biotic stresses are highly important (Dhawan, 2004). The introduction of *Bt* cotton in India in 2002 altered the pest scenario. Bollworm complexes, previously regarded as major pests, have been reduced to minor pests, whereas sucking pests have emerged as serious pests due to the lack of sucking pest-tolerant genes (Kumar *et al*., 2021). Among these insects, whitefly, *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae), is one of the most noxious pests of cotton and numerous crops around the world (Abd-Rabou and Simmons, 2010). The high invasiveness is caused by a variety of biological attributes, such as profound biotic potential, multiple generations, migration capacity, resistance to high temperatures, and interactions between whiteflies and different host plants (Mugerwa *et al*., 2019; Vyskoèilová *et al*., 2019). During 2014-2015, the cotton grown in North India was hit by an alarming outbreak of this insect, which resulted in massive crop losses. Due to climate change, the pest status of cotton has changed and abiotic fac-

tors influenced the rise and fall of pests and their biotic potential (Pathania *et al*., 2020).In addition to this, there were different reasons of whitefly outbreak viz., application of broad-spectrum chemical insecticides excessively on *Bt* cotton resulting in resurgence of whitefly (Virk *et al*., 2004), resistance develops in different genetic groups of *B. tabaci* (Krishna and Qaim, 2012), which makes insecticides less effective and makes chemical control in response to changing climate conditions impossible (Horowitz *et al*., 2020). This has negative effects on the non-target organism's abundance in ecosystem as well as the environment and human health (Devine and Furlong, 2007). A major factor in reducing the number of pests in the crop ecosystem is the number of natural enemies linked to pests (Inbar and Gerling 2008).Thus, it's important to understand *B. tabaci'*s population dynamics and interactions with natural enemies with consideration of local climatic conditions to develop effective and long-lasting management techniques to control the whitefly.Therefore, the objectives of this study were to understand the seasonal abundance of cotton whitefly and its natural enemies in different cotton cultivars which will be helpful in ecofriendly pest management.

Materials and Methods

The experiment was conducted during *Kharif* 2021 at the Experimental Area, Department of Entomology, CCS Haryana Agricultural University, Hisar (Haryana) to generate information on population dynamics of whitefly and its natural enemies. Three cotton cultivars Desi (HD 432), American (H1098), Bt cotton (RCH773BGII) were sown in plot size 150 m^2 each. The fields were raised according to the recommended agronomic practices of CCS Haryana Agricultural University, Hisar (Anonymous, 2022) at the different growth stages of the crop and kept under unsprayed conditions during the study. The adult and nymphal population of whiteflies were monitored at weekly interval from 28th to 44th SMW (Standard Meteorological Week) in each cotton cultivar. Observation was taken on underside of four fully formed leaves from upper, middle and lower canopy of 10 randomly selected plants from each cultivar. The population of natural enemies was also monitored at weekly interval from 28th to 44th SMW in each cultivar. 10 plants from each cultivar were sampled at a weekly interval to examine the natural enemies of whitefly. The population of natural enemies (Chrysopids, coccinellid, spider) from three randomly selected leaves from top, middle and lower canopy of the plant. For the parasitoids, cotton leaves infested with immature stages of whitefly were collected and transferred to the laboratory. With the help of a stereozoom microscope the number of parasitized nymphs (black or brown coloured) was counted. The parasitization rate was calculated based on the number of parasitized nymphs to the total number of nymphs collected on each sample date.The data on weather parameters obtained from the Meteorological Observatory of the Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar were utilized for computing the Pearson correlation coefficients.

Results

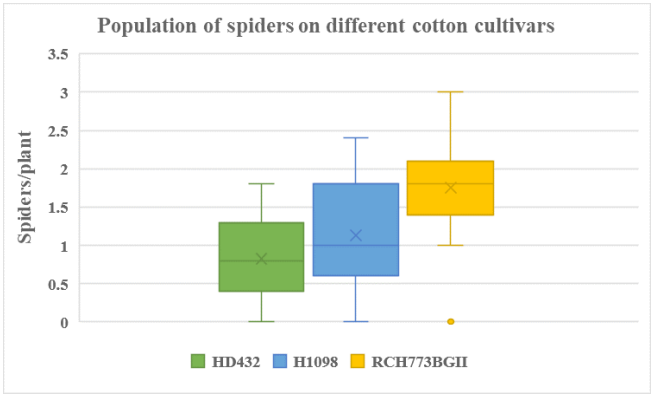
Population dynamics of whitefly on cotton cultivars: The population of pest remained active during the entire cropping season. In all cotton cultivars, the peak incidence of whitefly adults was observed during 34thSMW(3rd week of August) in *Bt* (3.98 adults/leaf), American (2.78 adults/leaf) and Desi cotton (2.37 adults/leaf). Similarly, the peak incidence of nymphs was observed during 35th SMW(4th week of August) in Bt (33.04 nymphs/leaf) followed by American (30.69 nymphs/leaf) and Desi cotton (27.41nymphs/leaf).

Population dynamics of whitefly natural enemies on cotton cultivars: The population of different natural enemies like spiders, coccinellids, *Chrysoperla*spp. and parasitoids recorded throughout the season in all three cotton cultivars. The population of whitefly crossed the ETL for a few times during the entire season. The population of natural enemies increased with the growth of crop and pest both. In case of spiders, the peak population was observed in 32nd and 42nd SMW in all three cultivars and highest population was recorded on the *Bt* cotton. The increasing trend in the population of coccinellids was recorded from 30th to 39th SMW and a peak was observed in 40th SMW in all three cultivars (2.00, 2.20 and 2.60 coccinellids/plant on Desi, American and *Bt* cotton, respectively). While the population of *Chrysoperla* spp. was very less throughout the season. Initially, the population of *Chrysoperla* spp. was recorded in 30th SMW only on *Bt* cotton (0.20 *Chrysoperla* spp./plant). Peak popula-

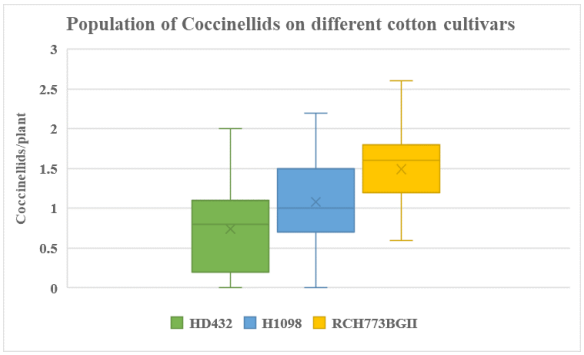
tion was observed in 38th SMW in all three cultivars (1.00, 1.20 and 1.60 *Chrysoperla* spp./plant on Desi, American and *Bt* cotton, respectively). The activity of parasitoids was observed throughout the season on all three cultivars. Two peaks of nymphal parasitization were observed during the entire cropping season. First peak was observed in 37thSMW in all three cultivars 15.78, 19.24 and 29.69 per cent parasitization in Desi, American and *Bt* cotton, respectively. The second peak was reported in 42nd SMW with 16.34 per cent in Desi, 20.21 per cent in American and 32.13 per cent in *Bt* cotton. The maximum parasitization was observed in *Bt* (32.13%) followed by American (20.21%) and minimum in Desi cotton (16.34%).

Effect of weather parameters on abundance of *B. tabaci* and their natural enemies

According to present research, the maximum and minimum temperature did not appear to have any significant effect on whitefly population. The nymphal and adult population of whitefly showed that any increase in morning relative humidity favoured the buildup of the *B. tabaci* population (Table 1). Whitefly adult and nymphal population showed a non-significant but negative correlation with average wind velocity in all three cultivars. Under the influence of the wind, the adult population of whitefly may be blown away, and the pest may then shift to the lower canopy. The population of spiders was significantly negatively correlated with maximum and minimum temperature in all three cotton cultivars. However, the spiders, coccinellids and parasitoids were negatively associated with the average wind velocity in American and Desi cotton and with parasitoids in *Bt* cotton. In American and Desi cotton, only spiders' abundance was negatively correlated with relative evening humidity, while morning relative humidity was positively correlated with spiders' abundance in all three cultivars.



(a) Spiders



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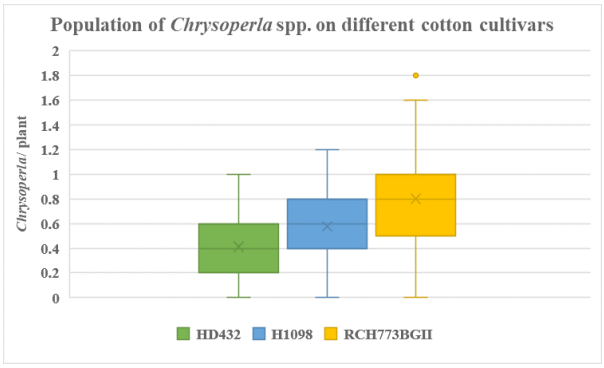
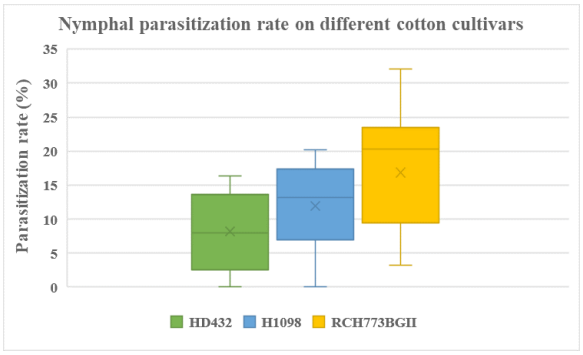


(c) *Chrysoperla* spp.



(d) Nymphal parasitization (%)

Fig. 1. Population density of natural enemies of whitefly in Desi (HD432), American (H1098) and Bt cotton (RCH773BGII)

Table 1. Pearson correlationbetween population of whitefly and natural enemies with weather parameters during *Kharif* 2021 in different cotton cultivars

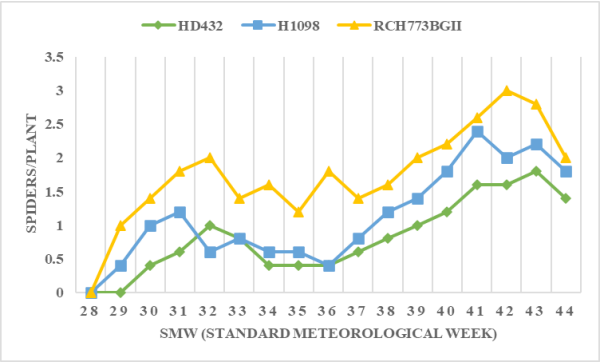
Whitefly/NEs	RCH773BGII					H1098					HD432				
	T_{max}	T_{min}	RH_m	RH_e	AWV	T_{max}	T_{min}	RH_m	RH_e	AWV	T_{max}	T_{min}	RH_m	RH_e	AWV
Spiders	-0.662**	-0.657**	0.279^{NS}	-0.428^{NS}	-0.885**	-0.633**	-0.745**	0.085^{NS}	-0.566*	-0.859**	-0.587*	-0.795**	-0.043^{NS}	-0.673**	-0.819**
Coccinellids	-0.430	-0.171^{NS}	0.429^{NS}	0.062^{NS}	-0.504*	-0.379^{NS}	-0.162^{NS}	0.416^{NS}	0.005^{NS}	-0.600*	-0.438^{NS}	-0.312^{NS}	0.343^{NS}	-0.128^{NS}	-0.661**
Chrysoperla spp.	-0.270^{NS}	-0.231^{NS}	0.303^{NS}	-0.134^{NS}	-0.562*	-0.460^{NS}	-0.231^{NS}	0.411^{NS}	0.083^{NS}	-0.456^{NS}	-0.312^{NS}	-0.261^{NS}	0.329^{NS}	-0.076^{NS}	-0.466^{NS}
Parasitoids	-0.223^{NS}	-0.114^{NS}	0.201^{NS}	0.040^{NS}	-0.300^{NS}	-0.344^{NS}	-0.168^{NS}	0.341^{NS}	0.034^{NS}	-0.486*	-0.458^{NS}	-0.267^{NS}	0.321^{NS}	-0.027^{NS}	-0.520*
Whitefly Adults	0.085^{NS}	0.145^{NS}	0.567*	0.021^{NS}	-0.110^{NS}	0.066^{NS}	0.119^{NS}	-0.514*	0.103^{NS}	-0.080^{NS}	0.251^{NS}	0.204^{NS}	0.508*	0.404^{NS}	-0.116^{NS}
Whitefly Nymphs	0.087^{NS}	0.189^{NS}	0.517*	0.169^{NS}	-0.231^{NS}	0.078^{NS}	0.205^{NS}	0.501*	0.201^{NS}	-0.180^{NS}	0.155^{NS}	0.249^{NS}	0.494^{NS}	0.213^{NS}	-0.211^{NS}

*Significant at 5% level of significance ** Significant at 1% level of significance ^{NS}Non-significant

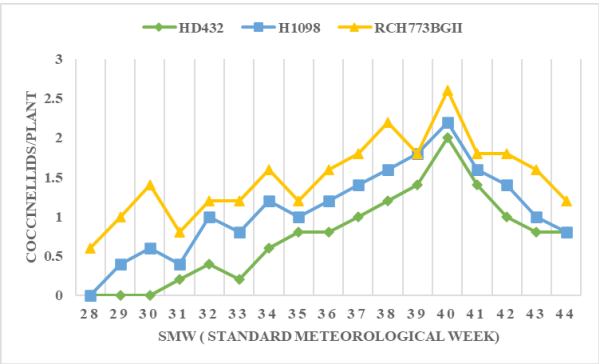
Discussion

In the present studies whitefly adult and nymphal population had two peaks during the entire cropping period (34th and 41stSMW) and (35th SMW and 41st SMW) in *Bt*, followed by American and Desi cotton. The number of whitefly adults decreased as a result of the adverse effects of heavy rainfall during 38th and 39th SMW. The variation in seasonal abundance and peaks of *B. tabaci*is attributed due to differences in geographical regions, ecotypes of whitefly and prevailing climatic conditions. Several researchers have reported a higher *B. tabaci* population on *Bt* cotton hybrids compared to varieties (Soujanya *et al*., 2010; Mehra and Rolania, 2020). Mehra and Rolania (2020) also observed the similar results that whitefly adult populations attained two peaks in the 34th and 38th SMW (i.e., the 3rd week of August and 3rd week of September). In our study, we also recorded a high density of predators' viz., spiders, coccinellids and *C. zastrowisillemi* in all three cotton cultivars. In cotton, spiders (Ghavami, 2008; Sangha *et al*., 2018), coccinellids (Shanga *et al*., 2018) and *C.zastrowi sillemi* (Naranjo and Ellsworth, 2005; Kaur *et al*., 2021) are the main predators of sucking pests including *B. tabaci* (Naranjo and Ellsworth, 2009). Spiders have been directly or indirectly linked to pests over the study period. While working in the cotton ecosystem, several workers reported various spider species as predators (Kavitha *et al*., 2003; Kannan *et al*., 2004; Phulse and Udikeri, 2014). During present findings, spider population reached its peak twice during the study period as and when *B. tabaci* population was high. The peak of spider's population was observed in 32nd SMW and 42nd SMW in all three desi, American and *Bt* cotton. These findings are in close agreement with Kedar (2014) who revealed that there were two peaks of spider's population was observed, first during late July (i.e., 29th and 30th SMW) and second during early October (i.e., 40th and 41st SMW), respectively. Two coccinellids predators were found to feed on *B. tabaci* on cotton and their population density was closely associated with whitefly population. The density of coccinellids was higher at the mid-stage of crop and they effectively reduce the early establishment of whitefly in mid-stage of cotton. Earlier, it was reported by Kapadia and Puri (1989) on *B. tabaci* on cotton from Maharashtra. The peak appearance of coccinellids was observed during first week of October (i.e., 40th SMW) in all three culti-

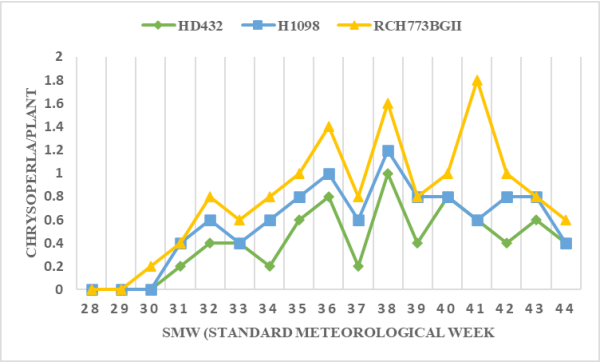
vars. Similar findings were reported by Kedar (2014) on cotton variety and hybrids.The activity of *Chrysoperla* spp. and parasitoids was seen on all three cotton cultivars. The *Chrysoperla* spp. population first appeared during 31st SMW in all three cultivars. Two peaks of parasitoids were observed in 37th and 42nd SMW in all three cultivars. Sharma *et al.* (2003) also reported two peaks of parasitization of *B. tabaci* nymphs. Kapadia and Puri (1989) from Maharashtra found similar two peaks of parasitization of *B. tabaci* by *Encarsia transvena* (Timberlake) and *Eretmocerus mundus* Mercet nymphal parasitoids in Maharashtra. Several other workers reported nymphal parasitization by several parasitoids (Gerling *et al*., 2001; Li *et al*., 2011; Malik and Karut, 2012 and Melouk *et al*., 2013). Weather parameters, particularly relative morning humidity has been suggested to be primary factors affecting the abundance of *B. tabaci* and the temperature and average wind velocity have and affected the abundance of natural enemies harbouring in *Bt*, American and Desi cotton. The weather factors strongly influence the seasonal abundance of *B. tabaci* in cotton (Shera *et al*., 2013; Pathania *et al*., 2020). Earlier studies also suggested that relative humidity strongly influenced the seasonal abundance of *B. tabaci* in *Bt* cotton (Pathania *et al*., 2020). However, the temperature did not affect the seasonal abundance of *B. tabaci* in all three cotton cultivars and the same has been reported by Pathania *et al*. (2020). Further, the relationship between climatic variables, pest and their natural enemies is an important component to understand seasonal dynamics and provides immense practical information for pest management (DeBach and Rosen, 1991; Hassell, 2000). The large canopy of *Bt* cotton also provides shade that favour to maintain the humidity which helps in the predation and survival of the spider complex (Agnew and Smith, 1989; Dhaka and Pareek, 2007). In our study, temperature has a negative influence on the abundance of spider complex in *Bt*, American and Desi cotton, though several spider's species show seasonal adaptation and can tolerate higher or lower temperatures to increase the biotic potential based on the available prey density (Daiqin and Jackson, 1996) and microclimate of the habitats



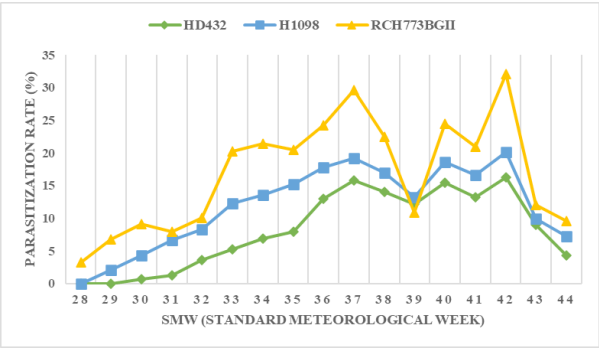
(a) Spiders



(b) Coccinellids



(c) *Chrysoperla* spp.



(d) Nymphal parasitization (%)

Fig. 2. Population dynamics of natural enemies of whitefly in in Desi (HD432), American (H1098) and Bt cotton (RCH773BGII)

(Dhaka and Pareek, 2007; Kruse *et al*., 2008). In our findings, the average wind velocity had a positive effect and favoured the abundance of coccinellids and *C. zastrowi sillemi* in *Bt*, American and Desi cotton. Jagadish *et al*. (2004) reported relative humidity and temperature influence the development and colonization of *Chrysoperla carnea* in fields due to effect of these climatic parameters on the biological attributes such as development, egg production, adult longevity (Bezerra *et al*., 2012; Ranjbar Aghdam and Nemati, 2020) and predation rate which is directly linked with the abundance of chrysopids (Dhaka and Pareek, 2007). In our study, we found that relative humidity did not affect the abundance and parasitism along with the nymphal density of *B. tabaci* observed in *Bt*, American and Desi cotton. Pandey *et al*. (2007) reported that relative humidity has not influenced the abundance and parasitism of *Encarsia* spp. parasitizing whitefly, *Acaudaleyrodesrachipora* (Singh). Though, in our study, the temperature had no direct effect on the parasitism and density, however, optimum temperature is crucial for development, reproduction and parasitism by *Encarsia* spp. (Ismail *et al*., 2014; Kidane *et al*., 2015; Zilahi-balogh *et al*., 2006; Chen *et al*., 2015). Therefore, the climatic factors have essential role in buildup of natural enemies and their abundance for the biological suppression of *B. tabaci* in the cotton ecosystem. The results produced suggested a strong correlation between the population of whitefly and abundance and activity of natural enemies in cotton cultivars. The activity of natural enemies decreases when the population of whitefly declines. It implies that the natural enemies contribute significantly to the biological suppression of whitefly in cotton. Furthermore, the information generated on the effect of weather factors on the seasonal abundance of *B. tabaci* and their natural enemies is a prerequisite in planning for pest management. Such data may be helpful in monitoring, predicting and planning of successful management strategies that useimportant natural enemies as a biocontrol agent in integrated pest management or the use of need-based safer insecticides for sustainable cotton production.

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Author Contribution Statement

M.Y: For collection, analysis and interpretation of data; drafting of manuscript. K.R: Advisor of the research work and for drafting the manuscript. A.Y: Analysed the data anddrafting of the manuscript. D.K:Co-advisor for the research work and edited the manuscript. All authors read and approved the manuscript.

Conflict of Interest

No conflict of interest.

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