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Population dynamics of whitefly, *Bemisia tabaci* (Gennadius) and its parasitoid, *Encarsia lutea* (Masi) on *Bt* cotton under Haryana conditions

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Abstract
The present study investigated the population dynamics of whitefly, *Bemisia tabaci* (Gennadius) and its parasitoid, *Encarsia lutea* (Masi) on *Bt* cotton hybrid BIO-6588 (BG II) under unsprayed conditions at Hisar. Peak population of whitefly adults (20.3 whitefly adults/leaf) was observed during 9th to 18th September. Nymphal population (34.1 whitefly nymphs/leaf) and per cent parasitization (28.1%) were observed maximum during 19th to 28th September. Whitefly nymphal parasitization by *E. lutea* varied from 6.0 to 28.1 per cent during the period of study (June to October). Total rainfall had significant and negative impact on the whitefly adult (r = -0.62) and nymphal population (r = -0.60). All the remaining weather factors showed non-significant correlation with whitefly population. Moreover, no significant correlation was found between parasitization and the weather factors.

Keywords: *Bt* cotton, *Bemisia tabaci*, *Encarsia lutea*, population dynamics, correlation

Introduction
Cotton, *Gossypium hirsutum* L. has a unique place in Indian as well as global economy. India is the global leader in terms of acreage under cotton and in 2018-19, a productivity of 507 kg/ha was reported from 12.25 million hectare area, which accounts for 24.0 per cent of the world's cotton output [1]. In India, insect-pest complex has incredibly changed since the introduction of *Bt* (*Bacillus thuringiensis*) cotton in 2002 [2, 3]. Prior to its introduction, the crop was under a severe threat of bollworms (American bollworm, pink bollworm and spotted bollworm) and to conquer this transgenic cotton was introduced in India. Few years later, a very high population of sap sucking insect-pests was witnessed on *Bt* cotton in each cropping season as a constraint in the production.

Amongst all the sap sucking insect-pests, whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) poses a serious threat to *Bt* cotton [4, 5, 6]. It causes immense damage to the cotton crop directly by feeding on phloem sap to an even greater extent and indirectly, the honeydew secreted by the nymphs acts as a medium for black sooty mold which affects the photosynthetic activity by the leaves. Polyphagy, multivoltinism, high reproductive rate, short life cycle, ability to migrate great distances and vectoring are the key biological attributes extrapolating the severity of this pest [7, 8]. Whitefly has been labeled as a 'Super vector' by [9] as it has been reported to vector 100-150 plant viruses [10, 11, 12]. These features aid whitefly to adapt on a wide variety of host plant species for a longer period under unfavorable environmental conditions even when it does not have any dormant (diapause) stage in its life cycle [13]. Abiotic (temperature, rainfall and relative humidity) and biotic (predators and parasitoids) factors naturally regulate whitefly population build up and also considered as key natural mortality factors [14, 15, 16, 17, 18]. Predators and parasitoids are primarily bioagents, which biologically manage whiteflies in the field. *Encarsia* and *Eretmocerus* spp are the primary genera of the whitefly parasitoids; that feed and parasitize the nymphal instars to improve their fitness and to produce their new generations [19, 20, 21, 22, 23, 24, 25, 17].

In recent years, whitefly has grown to the status of unmanageable levels leading to failure of all control practices. Indiscriminate or non-judicious use of pesticides is another contributing factor to high population build up of this pest. This has resulted in severe outbreak of this pest during early and mid stages of crop growth leading to emergence of number of problems such as insecticide resistance, resurgence of pest population, toxicity to non-target organisms, contamination in food chain and alteration in species dynamics [26].

In recent past, [3] reported the epidemic of whitefly in Northern parts of India. Therefore, keeping the above views in consideration, population dynamics of *B. tabaci* and its parasitoid, *Encarsia lutea* (Masi) was studied in Hisar district, lying in the cotton growing belt of South Haryana.

Materials and methods

Location and period of the study

Study on population dynamics of whitefly, *B. tabaci* on the cotton crop were carried out during *Kharif*, 2017 (June to October) at the Experimental area, Department of Entomology, CCS Haryana Agricultural University, Hisar, Haryana (29º 10'N latitude and 75º 43'E longitude at 215 m above mean sea level).

Material utilized during the experiments

The following materials were used to lay down the experiment and to record the observations: paper bags, marker pen, test tubes, petridishes, needles, camel hair brush, hand lens (10x), glass vials, marking tags, marking pencil, stereozoom binocular microscope with attached digital camera, etc.

Methodology followed

Transgenic cotton hybrid BIO-6588 (BG II) was sown during May, 2017 in an area of 400 m^2 following recommended package and practices. The crop was kept unsprayed for the pest buildup and subsequently parasitoid activity. Plants were examined for the presence of whitefly and its nymphal-pupal parasitoid, *E. lutea* at ten day intervals throughout the cropping season (June to October). All the observations on whitefly adult, nymph and parasitoid were made before 10:00 A.M.

Whitefly adult population was recorded from upper, middle and lower leaves of the ten randomly selected plants in the field. Thirty sampled leaves were brought to the laboratory in polybags to examine the presence of immature stages and parasitized nymphs of whitefly under a stereozoom binocular microscope. Black pupae of whitefly were considered as parasitized pupae by *E. lutea* [27]. The observations on whitefly parasitoid, *E. lutea* were recorded by counting the black pupae on sampled leaves at 10 days intervals and converted into per cent parasitism.

Mean population of whitefly (adult and nymph) and its parasitoid was subjected to correlation analysis with weather parameters (maximum and minimum temperature, morning and evening relative humidity, sunshine hours and rainfall) obtained from the Agrometeorological observatory, Department of Agrometeorology, CCSHAU, Hisar.

Results and discussion

Population dynamics of *Bemisia tabaci* adults and nymphs

Population dynamics of *B. tabaci* and its parasitoid, *E. lutea* was studied during 2017 (June to October) at ten day intervals. Whitefly remained active throughout the period of study. Peak population of whitefly adults (20.3 whitefly adults/leaf) was observed during 9th to 18th September. Nymphal population (34.1 whitefly nymphs/leaf) and per cent parasitization (28.1%) were observed maximum during 19th to 28th September (Fig. 1). The peak incidences of whitefly on cotton during the last week of July to mid-August were recorded by [28]. The results on peak activity period are in accordance with [6] who reported peak populations of whitefly adults and nymphs during 38th and 39th SMW (Standard Meteorological Week) i.e. 3rd and 4th week of September. Bairwa *et al.* (2016) [29] also reported high population of whitefly during the month of August (34th SMW). In conformity, [30, 31, 18] also reported high population of whitefly during the month of September on cotton crop.

Parasitization of *Bemisia tabaci* nymphs by *Encarsia lutea*

Whitefly nymphal parasitization by *E. lutea* varied from 6.0 to 28.1 per cent during the period of study (June to October) (Fig. 1). Similarly, Sharma *et al.* (2004) [32] and Karut and Akdagcik (2006) [33] noticed highest nymphal parasitization i.e. 45.0 and 77.6 per cent by *E. lutea* on cotton crop, respectively. Likewise, Karut and Kazak (2007) [34] revealed that parasitism rate of *E. lutea* was higher than *Eretmocerus mundus* (Mercet) on untreated cotton. Recently, Rawal *et al.* (2018) [35] recorded highest parasitization (32.1%) of whitefly nymphs on *Bt* cotton sown at Hisar district. In contrary to present study, Sangha *et al.* (2018) [36] reported comparatively lower parasitization by *Encarsia* spp on whitefly nymphs (5.20%) on cotton in Punjab, attributed to presence of other biological control agents.

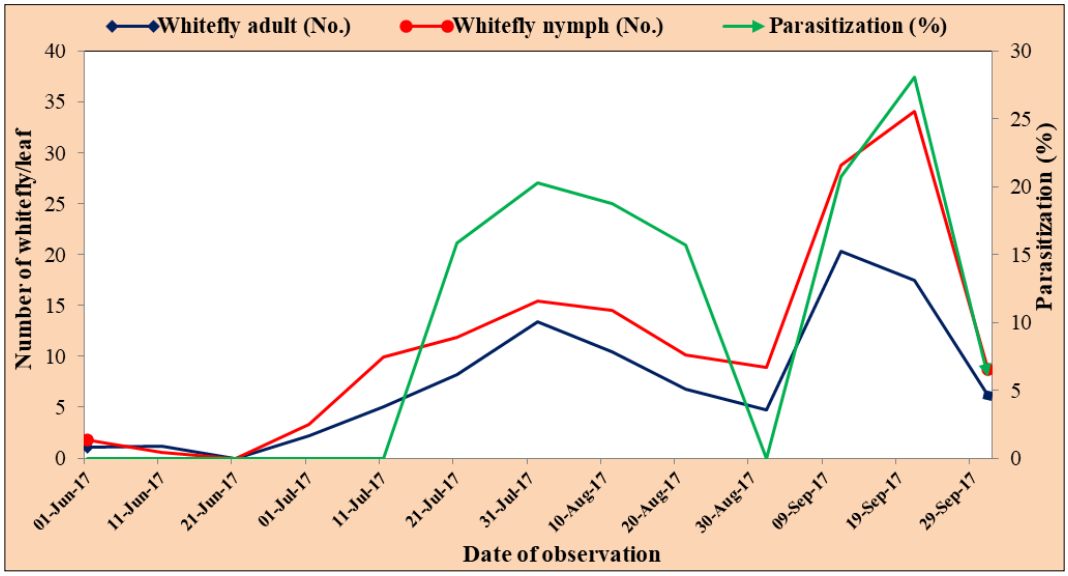

Fig 1: Seasonal abundance of *Bemisia tabaci* and its parasitization by *Encarsia lutea* (2017)

Correlation of *Bemisia tabaci* and *Encarsia lutea* population with weather parameters

The correlation between weather factors and population densities of whitefly adults and nymphs revealed that rainfall had significant and negative impact on the whitefly adult (r = -0.62) and nymphal population (r = -0.60). All the remaining weather factors showed non-significant correlation with whitefly population. Moreover, no significant correlation found between parasitization and any of the weather factors (Table 1). Correlation studies by Sharma *et al*. (2004) [32] revealed that temperature, relative humidity and rainfall correlated negatively with parasitized pupae of whitefly. The findings are in accordance with Sharma and Yogesh Kumar (2014) [37] who recorded significant negative correlation of whitefly population with temperature, evening relative humidity and rainfall. The findings of Kedar (2014) [17] are also in partial agreement with present study, who reported that weather parameters seemed to have no effect on per cent whitefly parasitization. Mehra and Rolania (2017) [18] reported significant and positive correlation of whitefly adult population with morning relative humidity and sunshine hours while nymphal population showed significant and positive correlation with sunshine hours. Rolania *et al*. (2018) [38] also observed significant negative correlation of whitefly population with maximum temperature.

Table 1: Correlation of *Bemisia tabaci* and its parasitoid, *Encarsia lutea* with weather parameters on cotton

Weather Parameters	2017		
	Whitefly adult	Whitefly nymph	Parasitization
Maximum Temperature (°C)	-0.32	-0.30	-0.39
Minimum Temperature (°C)	-0.30	-0.35	-0.19
Morning Relative Humidity (%)	0.35	0.30	0.33
Evening Relative Humidity (%)	-0.15	-0.22	0.01
Total Rainfall (mm)	-0.62*	-0.60*	-0.51

*Significant at p=0.05

Conclusion

It is concluded from the present study that on unsprayed *Bt* cotton the population of *B. tabaci* adults and nymphs attained peak during the month of September. Under unsprayed conditions the nymphal parasitoid, *E. lutea* got established and resulted in 6.0-28.1 per cent parasitization of *B. tabaci* nymphs. Among the weather parameters, rainfall had significant and negative correlation with whitefly population in cotton field.

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