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Biology of whitefly, *Bemisia tabaci* (Genn.) (Hemiptera, Aleyrodidae) on resistant and susceptible cotton genotypes

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Abstract
Biology of whitefly, *Bemisia tabaci* was studied on resistant (LHDP-1 and Supriya), moderately resistant (CCH-4474 and GJHV-517) and susceptible (TCH-1819 and Bunny) cotton genotypes under screen house condition. The data on the biology (incubation period, nymphal period, total developmental period, oviposition period, fecundity and sex ratio) were conducted. All the genotypes showed significant differences against whitefly biology. The genotype Bunny was observed to be more preferred for egg laying (59.25 eggs/two pairs) followed by TCH-1819, while other genotypes were less susceptible for egg laying. Longest incubation period was found on the genotype Supriya (6.00 days) and shortest was on GJHV-517 (5.50 days). Oviposition period, longevity and sex ratio was observed to be higher in the genotype TCH-1819 when compared to other genotypes. Total developmental period (20.42 days) and pre-oviposition period (2.50 days) was found to be maximum in Supriya, while it was minimum in all other genotypes.

Keywords: *Bemisia tabaci*, cotton genotypes, biology

Introduction
The whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is a highly destructive pest throughout the tropical and subtropical regions of the world infecting vegetables, ornamental plants and agronomic crops (Oliveira *et al*. 2001) [18]. *B. tabaci* has become a worldwide pest in the last 20 years (Anthony *et al*. 1995, Qiu *et al*. 2006) [2, 21]. This international pest causes damage by feeding directly on the plant sap, excreting honeydew which ultimately hampers plant's photosynthetic activities due to the development of sooty mold and transmitting 111 plant viruses (Brown 2000, Martin *et al*. 2000, Jones 2003, Mugiira *et al*. 2008) [4, 15, 13, 16]. In India, *B. tabaci* was first described in 1905 and by 1919 it became a serious pest of cotton in Punjab (Immaraju 1989) [9]. This pest can cause a loss of 10-92% in seed cotton yield due to transmission of cotton leaf curl virus (CLCuV) in Punjab (Singh *et al*. 1994) [22]. Several studies on the biology of *B. tabaci* have been carried out under diverse environmental conditions and reported that the life cycles varied mainly depending upon the temperature, relative humidity and the host plant (Patel *et al*. 1992, Palaniswami *et al*. 2001) [20, 19]. In order to achieve maximal effects of pest control in minimal use of pesticides, accurate estimation of pest behaviour, life cycle and densities in field condition is a prerequisite. Accurate information on biological parameters on specific host plant is required for implementing sustainable management practices, which facilitate the present study to determine the development and reproduction of *B. tabaci* under screen house conditions on cotton genotypes.

Materials and Methods
The biology of the whitefly was studied on six cotton genotypes *viz*., Bunny, CCH-4474, GJHV-517, LHDP-1, TCH-1819 and Supriya during January, 2017. These genotypes were selected based on preliminary screening of 19 genotypes. The duration of various developmental stages, *i.e.* eggs, nymphal instars, pupae and adult were recorded. The genotypes were grown in earthen pots to the 14-leaf stage following Jindal and Dhaliwal (2009) [11] and placed in a screen house to avoid any outside whitefly infestation. In each treatment leaf cage was attached to the lower leaf surface of fully opened top leaf @ 1 cage per plant on 4 cotton plants as replications (Fig. 1).

In each leaf cage, three pairs of freshly emerged adult, *B. tabaci* from colonies maintained separately in the screen house were confined for egg laying. After 24 hours, adults were removed along with leaf cages. The leaf portion under each leaf cage was marked and observed under stereomicroscope binocular using x40 for number of eggs laid. Only 10 eggs were selected and the rest were removed carefully with a needle and a fine brush. Again the leaf cages were attached to the leaves on marked area to prevent oviposition by *B. tabaci* from outside, and moving of crawlers outside the marked area.

The marked area was observed daily under stereomicroscope binocular (x40). The time period between laying of eggs and appearance of the crawlers was taken as incubation period. Further, the observations on different nymphal instars were recorded every 24 hours. The pupal period was the time between appearance of pupae and adult emergence. The period from egg laying to appearance of adult was considered as the total developmental period. The adults emerged were collected, anaesthetized and sexed under microscope for recording the effect of different genotypes on sex ratio of *B. tabaci*. The adult longevity was studied using leaf cage, 8 leaf cages/treatment, (4 for male and 4 for female) were attached to fully opened cotton leaves. The mortality of adults in each cage was recorded daily and the mean longevity of each sex was calculated. Fecundity was studied by releasing two pairs of freshly emerged adults into a leaf cage, and the numbers of eggs were counted under the microscope.

Fig 1: Leaf cages attached to cotton leaves

Results and Discussion

The data on the biology of whiteflies among the six cotton genotypes are presented in Table 1 and Fig. 2.

Table 1: Comparative biology of whitefly, *B. tabaci* on cotton genotypes.

Entry	Incubation period (days)	Nymph (days)				Total developmental period (days)	Pre oviposition period (days)	Oviposition period (days)	Post oviposition period (days)	Fecundity (no.)	Adult longevity (days)		Sex ratio
		1st instar	2nd instar	3rd instar	4th instar						Male	Female	
Bunny	5.63 ± 0.25	5.00 ± 0.41^{cd}	3.63 ± 0.48^{bc}	1.75 ± 0.50	4.00 ± 0.82^{c}	16.50 ± 0.71^{c}	1.75 ± 0.50	4.00 ± 0.82^{c}	2.50 ± 0.58^{bc}	59.25 ± 7.09^{d}	4.50 ± 1.29	9.75 ± 0.96^{c}	2.08
CCH-4474	5.75 ± 0.29	5.56 ± 0.13^{b}	3.90 ± 0.46^{ab}	1.75 ± 0.50	3.50 ± 1.29^{b}	18.52 ± 0.31^{b}	1.75 ± 0.50	3.50 ± 1.29^{b}	1.50 ± 0.58^{a}	41.50 ± 3.70^{b}	3.25 ± 1.26	6.50 ± 1.29^{ab}	2.00
GJHV-517	5.50 ± 0.00	5.38 ± 0.25^{bc}	3.50 ± 0.00^{bc}	1.50 ± 0.58	4.00 ± 0.82^{c}	17.19 ± 0.38^{c}	1.50 ± 0.58	4.00 ± 0.82^{c}	1.75 ± 0.50^{ab}	49.00 ± 7.62^{bc}	4.50 ± 1.29	9.75 ± 0.96^{c}	2.50
LHDP-1	5.63 ± 0.25	6.06 ± 0.43^{a}	4.31 ± 0.55^{a}	2.25 ± 0.50	3.25 ± 0.50^{a}	19.87 ± 0.80^{a}	2.25 ± 0.50	3.25 ± 0.50^{a}	1.50 ± 0.58^{a}	32.00 ± 3.92^{a}	3.50 ± 0.58	7.00 ± 1.41^{b}	1.88
Sup Riya	6.00 ± 0.71	5.54 ± 0.32^{b}	4.44 ± 0.31^{a}	2.50 ± 0.58	3.25 ± 0.50^{a}	20.42 ± 1.07^{a}	2.50 ± 0.58	3.25 ± 0.50^{a}	1.25 ± 0.50^{a}	27.50 ± 5.45^{a}	3.00 ± 0.82	5.00 ± 0.82^{a}	1.75
TCH-1819	5.63 ± 0.25	4.88 ± 0.25^{d}	3.25 ± 0.29^{c}	1.75 ± 0.50	4.25 ± 0.96^{d}	16.24 ± 0.35^{c}	1.75 ± 0.50	4.25 ± 0.96^{d}	2.75 ± 0.50^{c}	57.00 ± 4.97^{cd}	4.75 ± 1.50	10.50 ± 1.73^{c}	2.63
S.Ed	NS	0.221	0.278	0.372^{NS}	0.053	0.468	NS	0.053	0.381	4.000	0.825^{NS}	0.874	-
CD (P=0.05)		0.465	0.584	0.783	0.112	0.985		0.112	0.802	8.394	1.733	1.836	

Mean of four replications

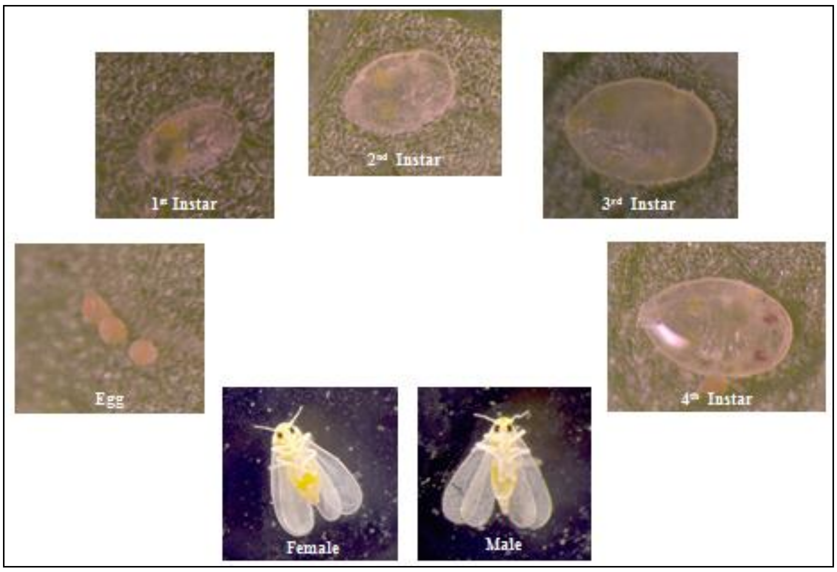

Fig 2: Developmental stages of whitefly, *B. tabaci* (Gennadius) (Hemiptera: Aleyrodidae)

Egg and Nymphal period

The eggs were laid singly on the lower surface of leaf. The incubation period was statistically non- significant between the selected genotypes. The incubation period on the genotypes, Bunny, CCH-4474, GJHV-517, LHDP-1, Supriya and TCH-1819 were 5.63, 5.75, 5.50, 5.63, 6.00 and 5.63 days, respectively. The duration of first instar varied from 4.88 to 6.06 days. The shorter mean first instar duration was observed in TCH-1819 (4.88 days) which was statistically on a par with Bunny (5.00 days). The longer mean first instar duration was observed on entry LHDP-1 (6.06 days). The first instar duration was completed in 5.54 days on Supriya which was statistically on a par with GJHV-517 (5.50 days) and CCH-4474 (5.56 days). The freshly moulted second instar nymph was whitish yellow in colour, oval and flat. There was a significant difference among the genotypes on the second instar developmental period. In TCH-1819, this stage lasted for 3.25 days which is followed by GJHV-517 (3.50 days) and this was statistically on a par with Bunny (3.63 days), whereas in LHDP-1, the duration of second instar was 4.31 days which was statistically on a par with Supriya (4.44 days) and CCH-4474 (3.90 days).

The third instar duration was shorter in Bunny (4.62 days) which was statistically on par with the GJHV-517 (5.19 days) and was longer in Supriya (6.06 days) which was statistically on par with LHDP-1 (6.00 days). In TCH-1819 the duration of third instar was 5.36 days which was statistically on par with CCH-4474 (5.69 days). The maximum duration of fourth instar was observed in LHDP-1 (4.04 days) which was statistically at par with the Supriya (3.83 days) and the duration was minimum in TCH-1819 which was lost for 2.75 days. There was no significant difference observed in Bunny (3.25 days) and GJHV-517 (3.13 days). In CCH-4474 the fourth instar lasted for 3.38 days. A similar result was reported by Deotale *et al*., 1992 [8]; Jindal *et al*., 2007 [12]; Ahmad and Rizvi, 2014 [1]; Kedar *et al*., 2014 [14]; Chandi and Kular, 2015 [6]; Chintkuntlawar *et al*., 2016 [7] and Sri *et al*., 2017 [23].

Total developmental period

The total developmental period from egg to adult was significantly different among the cotton genotypes. The total development period was minimum of 16.24 days in TCH-1819, which was statistically on par with the Bunny (16.50 days) and GJHV-517 (17.19 days) however the maximum developmental period of 20.42 days was observed in Supriya which was statistically at par with LHDP-1 (19.87 days). These results corroborate the findings of Musa and Ren (2005) [17] and Thomas *et al*. (2011) [24] documented differences in biology and developmental stages of *B. tabaci* on soyabean and cotton genotypes, respectively.

Pre-oviposition, oviposition and post-oviposition period

The result showed that there was no significant difference in pre-oviposition period. The pre-oviposition period was of 1.50 days in GJHV-517, while it was longer in Supriya (2.50 days). The oviposition period of the female was significantly different among the entries tested. The oviposition period was higher on TCH-1819 (4.25 days) while it was shorter on LHDP-1 (3.25 days) which was statistically on par with Supriya (3.25 days). In CCH-4474 it was 3.50 days and in GJHV-517 it was 4.00 days which was statistically on par with Bunny (4.00 days). The post oviposition period of female was significantly different among the cotton genotypes. The post oviposition period on Supriya was 1.25 days which was statistically on par with LHDP-1 (1.50 days) and CCH-4474 (1.50 days). In the Bunny, it was 2.50 days which was followed by GJHV-515 (1.75 days). The post oviposition period was longer in TCH-1819 (2.75 days).

Fecundity, adult longevity and sex ratio

The number of eggs laid by two pairs of whitefly was significantly less on Supriya (27.50 eggs/two pairs) which was statistically at par with LHDP-1 (32.00 eggs/two pairs). The genotypes, CCH-4474 and GJHV-517 were statistically on par with each other registering 41.50 and 49.00 eggs/two pairs, respectively. The fecundity was higher in Bunny (59.25 eggs/two pairs) which was statistically on par with TCH-1819 (57.00 eggs/two pairs). The results are similar with those of Carabalı *et al*. (2010) [5] who stated that the fecundity of *B. tabaci* ranged from 16 to 41 eggs/female and it varies based on host plants. No significant differences in the male longevity were found among the selected test genotypes. The male longevity was minimum on Supriya (3.00 days) and maximum on TCH-1819 (4.75 days). The data showed that there was a significant effect of genotypes on female longevity. The mean female longevity was minimum on Supriya (5.00 days) and maximum on TCH-1819 (10.50 days). The genotypes, GJHV-517 (9.75 days) and Bunny (9.75 days) were statistically on par with TCH-1819. In LHDP-1, the female survived for 7.00 days which was at par with CCH-4474 (6.50 days). The higher sex ratio was observed in TCH-1819 (2.63) as against the lower sex ratio in Supriya (1.75), while it was 1.88, 1.20, 2.08 and 2.50 in LHDP-1, CCH-4474, Bunny and GJHV-517, respectively. The finding on longevity of male and female was more alike to that of 4-7 and 9-18 days, respectively on cotton (Deotale *et al*., 1992) [8] and 3.30 ± 0.41 days for male and 5.65 ± 0.63 days for female on tomato (Jamuna *et al*., 2016) [10].

Conclusion

Whitefly (*B. tabaci* Genn.) has shown a greater host preference to the cotton genotype TCH-1819 as compared to other genotypes by documenting a short developmental period and a comparative high longevity and sex ratio. Hence the genotype, TCH-1819 was susceptible and the genotypes, Supriya and LHDP-1 were less preferred and having resistant factors against the whitefly, *B. tabaci*

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