EFFECT OF DIFFERENT CONSTANT TEMPERATURES ON THE DEVELOPMENT AND REPRODUCTION OF *BEMISIA TABACI* (GENN.) (HOM.: ALEYRODIDAE)

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ABSTRACT: The development, survivorship and reproduction of *Bemisia tabaci* were studied. Experiments were conducted in a growth chamber under 55 ± 5% RH and 16:8 h (L: D) photoperiod on caged plants of tomato, *Lycopersicon esculentum* Mill. (Var. Chef) at four constant temperatures (20, 24, 28, and 32°C) in Kerman. The developmental periods from egg to adult varied from 29.14 days at 20°C to 13.836 days at 32°C. The developmental periods of nymphs varied from 16.68 days at 20°C to 6.74 days at 32°C and the developmental periods of pupa stage varied from 5.53 days at 20°C to 2.34 days at 32°C. Survivorships from egg to adult were 82.71% at 28°C, 79.73% and 82.46% and 58.94% at 20, 24 and 32°C respectively. The average longevity of females ranged from 17.64 days at 20°C to 6.64 days at 32°C and males lived an average of 12.52 days at 20°C to 5.42 days at 32°C. The number of eggs per day per female ranged from 2 to 8 and the average number of eggs laid per female per day varied from 6.8 at 28 °C to 4.92 at 32°C. The average number of eggs per female varied from 92.58 eggs at 24°C to 44.74 eggs at 32°C. Both the longevity and oviposition of *B. tabaci* females at different temperatures were significantly different ($P < 0.05$).

KEY WORDS: *Bemisia tabaci,* reproduction, temperature, survivorship, Kerman.

The sweet potato whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is a phytophagous insect, whose nymphs and adults suck the phloem sap, causing direct damage due to host plant weakness. It is a cosmopolitan and very polyphage species with more than 500 hosts (Bellows et al., 1994). In addition to direct feeding damage this pest is important due largely to its role in transmission of variety of plant viruses (Perring, 2001) and by the excretion of honeydew, it reduces the quality of harvested products (Perkins & Bassett, 1998; Heinz, 1996; Henneberry et al., 1998). It is vector more than of 60 plant viruses (Bedford et al., 1994).

In tomato, besides the damage caused by nymphal and adult feeding, this insect can transmit limiting plant viruses, and caused a physiological disorder (irregular ripening on fruits), depreciating the commercial value of the product (Brown & Bird, 1992; Schuster et al., 1990). The development time and stage survival of B. tabaci and their fecundity were studied on various plants and temperatures. For example Buttler et al. (1983) studied longevity of *B. tabaci* at 26.7 and 32.2°C on cotton and Sharaf & Batta (1985) investigated mean number of eggs of *B. tabaci* on tomato at 14 and 25 °C and Azab et al. (1971) were studied at 26.7 and 32.2 °C on cotton.

The objectives of this study were to compare *B. tabaci* oviposition and development at four various temperatures.

MATERIALS AND METHODS

The experiment was carried out in a growth chamber under 55 ± 5% RH and 16:8 h (L: D) photoperiod and at four constant temperatures 20.0 ± 0.5, 24.0 ± 0.5, 28.0 ± 0.5 and 32.0 ± 0.5 °C, on caged plants of tomato, *Lycopersicon esculentum* Mill. The germinated seeds of tomato were grown individually in 12 cm diameter plastic pots and used in the experiment at the 4–6 leaf stage. These pots were placed into cages (60 x 60 x 100 cm). The whitefly was maintained on cucumber, *Cucumis sativus* L. (Cucurbitales: Cucurbitaceae), plants in a greenhouse, and approximately 50 male and female adults were collected using an aspirator and transferred on tomato seedlings and a sub colony maintained in rearing cages in the growth chamber for two generations before being used in the experiments.

Development and survival of immature

This experiment was conducted in five replicates for each treatment (four constant temperatures). For holding every adult over a leaf, the clips cages (3 cm diameter and 1.5 cm high), into which a small hole had been punched for ventilation were used. Approximately 20 pairs of *B. tabaci* adults were released into leaf-clip cages attached to the underside of the leaves of host plant with the aid of paper clips. Adults were allowed to lay eggs for 24 h before being removed. More than 400 eggs were kept for studying of eggs and nymphs and life table on each of treatments. A small pen mark was used to place identifying marks next to whitefly eggs on each of leaves. The infested plants were placed in incubator and development and survival of each whitefly immature stages on the host plant were recorded daily until all the whiteflies emerged.

The emerged adult whiteflies were counted and used for daily longevity and fecundity studies. Sex of adults was checked under a stereomicroscope and male were separated from females based on their smaller size and narrower end of their abdomen and were used for determine sex ratio.

For assessing longevity of adults and fecundity, for each treatment, fifty 14-h-old female and fifty male were used (10 females for each replicate per treatment). One female adult was placed together with one male in clip cages on 10 leaves (one leaf for every female) from the middle parts of the host plants; the remaining leaves were cut. After 24 h of release, the transferring of the female to the new leaf continued until the death of the adult. The number of egg/female/day and the number of eggs laid by female whitefly over her lifetime and survivorship were recorded. Fecundity and longevity data were used to calculate daily and lifetime fecundity of *B. tabaci*.

Data for developmental time, survival, longevity and fecundity on the four temperatures were subjected for analysis of variance; the means were separated using the Minitab software.

RESULTS AND DISCUSSION

Immature development and survivorship

The results of effect of various temperatures on developmental periods of immature stages are shown in table1. As shown as with increasing temperature from 20 to 32 °C the development period is decreased. The shortest development period was at 32 °C with 13.836 days and the longest development period with 29.143 days was shown at 20 °C. The developmental periods of immature stages of *B. tabaci* was carried out by researchers on many plants such as aubergine (Fekrat & Shishebor, 2004), potato (Buttler et al., 1983) cotton (Azab et al., 1971;

Buttler et al., 1983; Powell & Bellows, 1992a) and cucumber (Powell, 1990; Powell & Bellows, 1992b).

The mean developmental time for *B. tabaci* on aubergine at 20, 25 and 30 °C was calculated 29.35, 24.87 and 14.95 days respectively (Fekrat & Shishebor, 2004) and on potato at 25.4 and 31 °C was reported 16 and 11.6 days respectively and on cotton at constant temperatures 20, 25, 30 and 32.5 °C was mentioned 48.7, 27.8, 17.8 and 16.6 days respectively (Buttler et al., 1983). Powell et al. (1992a) reported the mean preimaginal developmental period of *B. tabaci* on cotton at 20, 25.5, 29 and 32 °C 28.5, 17.7, 19.11 and 18.27 days and on cucumber 38.2, 20.2, 17.3 and 17.4 days respectively. Mansaray et al. (2009) were reported development of immature stages of *B. tabaci* at 26 °C on Soybean18 and on Garden bean 21.19 days.

The observed mean developmental time for *B. tabaci* at 20 °C (29.143 days) was close to the value (28.5 days) reported by Powell 1990) and (29.35 days) reported by Fekrat & Shishebor (2004), under similar conditions of temperature and relative humidity.

The results of variance analysis revealed that there were significant differences between periods of eggs (f= 589.55; df=3; p=0.000), nymphal period (f=6469.39; df=3; p=0.000) and pupal period (f=1100.29; df=3; p= 0.000) at various temperatures. Also there were significant differences between developmental times of all immature stages (f= 6400.84; df=3; p=0.000). Generally, developmental time vary greatly with temperature.

The results of preadult mortality rate at exprimented temperatures were shown in table 2. The highest mortality was at 32 °C and the lowest mortality was at 28 °C. The optimum temperature for development and decrease mortality determined interval 24 to 28 °C. Fekrat & Shishebor (2004) were reported the total percent mortality of immature whitefly at 20,25, 30 and 35 0^{C}, 15.5, 10.3 11.9 and 100% respectively.

Adult longevity was recorded as part of the fecundity experiment. Although most females died by day 13 and 17 at four constant temperatures, some females were longed lived surviving to 21 days at 20 °C and 16 days at 24 °C . The mean longevity of females varied from 17.64 days at 20 °C to 6.64 days at 32 °C and the mean longevity of males varied from 12.52 days at 20 °C to 5.42 days at 32 °C. With increase the temperature decrease longevity (table 3). The mean longevities of males differ significantly (F=53.24; df=3; P= 0.000) at the four experimental temperatures and the mean longevities of females differ significantly (F=111.13; df=3; P= 0.000) at same temperatures. In additional longevity of females was longer than longevity of males. The adult longevity of this pest was studied by many researchers. Butler et al. (1983) were studied longevity of *B. tabaci* at 26.7 and 32.2 °C on cotton plants and reported the female longevity 8 and 10.4 days and male longevity 8 and 11.7 days respectively. The adult longevity of *B. tabaci* were studied by Fekrat & Shishebor (2004) at four constant temperatures (20, 25, 30 and 35 °C) on aubergine and reported 18.14, 3.14, 8 and 7 days for females and 12.71, 9.78, 5.92 and 3.57 days for males respectively. These results are closed to the values observed in our experiments. At another experiment that was conducted at 27 °C on cotton, the female longevity showed 12.9 and the male longevity 9.7 days respectively. These results special at 32.2 °C were slightly higher than results of our experiments.

The results of investigation on daily oviposition and total fecundity are shown in table 4. Whit increasing temperature the number of daily eggs of a female increased and at 32 °C again decreased. The highest daily eggs were seen 7 eggs at 28 °C. The analysis variance showed differ significantly (f= 15.02; df=3, P=000) between mean of fecundity at four experiment temperatures. The highest total fecundity between treatments was seen at 24 °C with 91.02 eggs. Ofcourse the most number of eggs belong a female was seen at 20 °C that was 115 eggs and the lowest number of eggs was 26 eggs that seen at 32 °C. Sharaf & Batta (1985) investigated mean number of eggs of *B. tabaci* on tomato at 14 and 25 °C and reported 56 and 76 eggs respectively that is a little lower than results of this experiment. Azab et al. (1971) were studied the number of eggs of *B. tabaci* at 26.7 and 32.2 °C on cotton and mentioned 81 and 72 eggs respectively. Also the mean number eggs of this pest are reported 203 eggs on tomato at 30 °C (Gerling et al., 1986) and on cotton 309 eggs at 25-26 °C (Powell & Bellows, 1992a) and at 27 °C 128 eggs (Von et al., 1983) and 95 eggs at 30 °C (Powell & Bellows 1992a) and on eggplant at 25-27 °C 50 eggs (Powell & Bellows, 1992a) and on potato at variable temperature 22-28 °C 161 eggs.

Sex ratio (female: male) was 0.83:1 or 45.35% at 20 °C but with increasing the temperature this ratio changed to 1.29:1 (female: male) or 57.2% at 32 °C.

Sex ratio (female: male) of *B.tabaci* was reported by Mansaray *et al.* (2009), 1: 0.934 or 51.85% females (n = 150) at 26 °C.

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Table 1. Development (mean±SD) of immature stages of *Bemisia tabaci* at four constant temperatures.

Stage	20 °C	24 °C	28 °C	32 °C
Egg	6.936±0.08	5.864±0.08	4.804±0.14	4.751±0.05
Nymphs	16.678±0.18	13.769±0.16	8.705±0.05	6.742±0.05
Pupa	5.529±0.06	4.383±0.10	2.757±0.11	2.343±0.10
Total	29.143±0.27	24.016±0.21	16.266±0.14	13.836±0.12

Table 2. Percent of mortality in immature stages of *Bemisia tabaci* at four constant temperatures.

Stage	20 °C	24 °C	28 °C	32 °C
Egg	6.844±1.32	6.89±0.38	5.154±1.42	16.326±3.80
Nymphs	12.68±0.89	9.604±1.12	10.592±1.86	21.466±2.19
Pupa	0.744±1.12	1.042±1.02	21.546±1.44	3.268±1.18
Total	20.298±2.76	17.536±1.34	17.292±2.80	41.06±4.50

Table 3. Longevity (mean± SD) of male and female of *B. tabaci* at four constant temperatures.

Sex	20 °C	24 °C	28 °C	32 °C
Female	17.64± 0.82	11.8±0.99	8.36±1.37	6.64±0.84
Range	(14-21)	(8-16)	(6-9)	(5-9)
Male	12.52±1.10	9.94±1.13	6.92±0.92	5.42±0.66
Range	(15-18)	(6-13)	(5-8)	(4-6)

Table 4. Mean of daily and total fecundity and sex ratio of *B. tabaci* at four constant temperatures.

	20 °C	24 °C	28 °C	32 °C
Egg /Day	5 ± 0.51	5.74±0.7	6.8±0.72	4.92±0.78
Range	(4-6)	(5-7)	(5-8)	(2-6)
Fecundity	92.58±16.23	90.62±12.11	70.84±10.40	44.74±11.87
Range	(62-115)	(69-117)	(48-88)	(26-62)
Sex ratio(female: male)	0.83:1	0.93:1	1.14:1	1.29:1