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Two-sex life table of cotton whitefly *Bemisia tabaci* on two varieties of cotton (*Gossypium hirsutum*)

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Abstract

In order to study the effects of different host plants on population development of cotton whitefly *Bemisia tabaci*, a greenhouse experiment was conducted at Agricultural Biotechnology Research Institute of Iran, Karaj in 2012. In this experiment the effects of two cotton varieties (Varamin and Sahel) was evaluated on pre-adult developmental time, pre-adult mortality, adult longevity, mean daily and total eggs number, sex ratio and life table parameters of *Bemisia tabaci*. Results indicated that the pre-adult developmental time of *Bemisia tabaci* on the var. Varamin and Sahel was 21.08 and 18.04 days, respectively. Also the adult longevity of females on the var. Varamin and Sahel was 11.12 and 14.58 days, respectively. *Bemisia tabaci* reached the adult stage faster on var. Sahel than var. Varamin. The fecundity of *Bemisia tabaci* on var. Sahel was more than that on var. Varamin. No significant difference was observed between the sex ratio of *Bemisia tabaci* on two cotton varieties. Intrinsic rates of increase in *Bemisia tabaci* on var. Varamin and Sahel were 0.08 and 0.14, respectively. The results indicated that the life history of *Bemisia tabaci* was influenced by host plant quality and var. Varamin was not a suitable host for this pest.

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Introduction

Bemisia tabaci (Gennadius) (Homoptera: Aleyrodidae), the tobacco whitefly, is a polyphagous insect that is widely distributed throughout the tropic and subtropic areas. *Bemisia tabaci* is an important pest of a wide range of crops belonging to the different botanical families (Makkouk, 1978). It causes direct damage by feeding, and also causes indirect damage from its heavy secretion of honeydew on the plants, which serves as a growing medium for sooty mold fungus. It is also vector of plant virus diseases such as tomato yellow leaf curl virus (TYLCV) and cucumber vein yellowing virus (CVYV). These viruses are major problems for tomato and cucurbits crops, often causing yield reductions (Makkouk, 1978).

The population of every species has a different host range (Costa and Russel, 1975) and difference in growth and reproduction arising from rearing on different host plants (Coudriet *et al.* 1985; Gerling *et al.* 1986). The developmental time of *Bemisia tabaci* from egg to adult was significantly different according to the host plant that feeds on it (Coudriet *et al.* 1985). Chemical control is the important method for management of *Bemisia tabaci*, however, this pest can rapidly develop the resistance to the insecticides and therefore the sole reliance on insecticides for their control is unsustainable in the long term (Byrne *et al.* 2003). Natural enemies such as parasitoids and predators, are potential agents for using in classical biological control of this pest (Gerling *et al.,* 2001; Ren *et al.* 2001; Qiu *et al.* 2005), and host plant resistance. However, management of *Bemisia tabaci* is challengeable because of its intercrop movement, high reproductive potential and its under leaf habitat.

Recognizing the host plants that have low quality for *Bemisia tabaci* could be used for biological control of *Bemisia tabaci*. Information about the life history of *Bemisia tabaci* could be used to suggest methods for integrating host plant resistance, biological control and other nonchemical tactics into management practices for this pest. Therefore, the objectives of this study were to compare *B. tabaci* oviposition and development on two cotton varieties including Sahel and Varamin and evaluating the additional life history characteristics.

Materials and methods

Source of materials

The cotton plants *Gossypium hirsutum* (var. Varamin and Sahel) were grown in 25 cm plastic pots filled with peat and perlit substrate. The pots were placed in net covered cages (75cm×75cm×75cm) in a controlled greenhouse conditions at temperature of 23±4◦C, 60% relative humidity, 16 h light: 8 h dark photoperiod. The cotton plants with 4-8 true leaves were used in this experiment. The cotton whiteflies, *Bemisia tabaci* (Homoptera: Alyrodidae) originally were collected from the cotton field in Ghorgan, Iran, and were reared on cotton plants in a controlled greenhouse conditions that was explained above.

Experimental procedure

Newly emerged cotton whiteflies were placed in an oven at 60 ◦C for 48 h to determine adult dry weight using a microbalance (sensitivity 0.001 mg). The 100 eggs of *Bemisia tabaci* that had developed since birth on both two cotton lines in 4 generations were selected randomly and the numbers from 1 to 100 were allocated to them for assessment. First instar nymphs slowly move and then fixe and transform to second instar nymphs and until the emergence of adult do not move. The pupas did not have nutrition thus we could separately keep them in micro capsules until emergence of adults.

Larval mortality and development were checked every 24-h until the adult stage. After the emergence of adults, males and females were paired and checked daily to record survival and number of eggs laid until females dead. To determine the sex ratio of *Bemisia tabaci* offspring, the 60 eggs or more were collected from females of different ages every three day after the beginning of ovi-position. Totally, 13 egg samples were collected in the experiment. Also the hatch rate and sex ratio of these eggs were recorded.

Data analysis

Developmental time of all individuals, including males, females, and those dying before the adult stage, and female daily fecundity were analyzed according to the age-stage, two-sex life table (Chi and Liu, 1985; Chi, 1988). The age-stage specific survival rate (sxj) (where x = age and j = stage), the age-stage specific fecundity (fxj), the age-specific survival rate (lx), the age-specific fecundity (mx), and the population parameters (r, the intrinsic rate of increase; λ, the finite rate of increase, λ=er ; R_0, the net reproductive rate; T, the mean generation time; GRR, the gross reproductive rate, GRR=$\sum$ mx) were calculated accordingly. The age-specific survival rate includes both male and female and was calculated according to Chi and Liu (1985). The life table studies are extremely time consuming and replication is impractical, therefore we used the Bootstrap method (Sokal and Rohlf, 1995; Meyer *et al.* 1986) to calculate the means and standard errors of the life table parameters. Data analysis and population parameters (r, R_0, T, and λ) were calculated by TWO-SEX-MSChart program (Chi, 2005, http://140.120.197.173/Ecology/prod02.htm, Chung Hsing University).

Results and discussion

The results showed that the pre-adult development ratio was significantly affected by cotton variety (Table 1). Pre-adult developmental time of *Bemisia tabaci* on the var. Varamin and Sahel were 21.08 and 18.06 days, respectively. The mean comparison with t-student showed (P≤0.0001) that the development time of *Bemisia tabaci* was significantly different on cotton varieties. The development time of *Bemisia tabaci* on var. Varamin was longer than that on var. Sahel.

Also the adult longevity for males on the cotton var. Varamin and Sahel were 6.12 and 8.01 days and for females were 11.12 and 14.58 days, respectively. *Bemisia tabaci* reached the adult stage faster on var. Sahel than var. Varamin that was due to more fecundity for females on var. Sahel. The means of daily egg, total egg and sexual ratio of *Bemisia tabaci* was shown in table 2. Results showed that female fecundity in var. Varamin was significantly (P≤0.0001) lower than that in var. Sahel. Also there was no significant difference between sex ratio of var. Varamin and Sahel. The death rate in *Bemisia tabaci* pre-adult stage was low for both cotton var. Varamin and Sahel (Table 3). The number of death at egg, 1 std nymph and 2 std nymph stages was low and at 3 std nymph and pupa stages was 0.

Table 1. The pre-adult development time (day) of *Bemisia tabaci* on two cotton varieties (mean ± SE).

Stage	Var. Sahel	Var. Varamin
Egg	5.32±0.07	6.31±0.08
1 std nymph	3.30±0.05	4.78±0.1
2 std nymph	2.20±0.05	4.08±0.08
3 std nymph	3.01±0.05	5.51±0.07
Pupa	4.21±0.08	6.19±0.09
Total	18.04±0.46	21.08±0.5

Table 2. Daily egg, total egg and sexual ratio of *Bemisia tabaci* on two cotton varieties (mean ± SE).

	Var. Sahel	Var. Varamin
Daily oviposition	8.49±0.10	6.18±0.04
Total oviposition	87.19±26.1	68.89±01.1
Sexualratio Fe:Ma	1:1.34	1:1.31

Table 3. Number of death in pre-adult stages of *Bemisia tabaci* on two cotton varieties.

Stage	Var. Sahel	Var. Varamin
Egg	5	6
1 std nymph	6	7
2std nymph	1	1
3 std nymph	0	0
Pupa	0	0

The life table parameters were calculated based on data of the entire cohort, i.e., both sexes and the variable developmental rates among individuals.

Calculated parameter and standard errors of the intrinsic rate of increase (r), net reproductive rate (R_0), mean generation time (T), and the finite rate of increase (λ) obtained by using age-stage specific two sex model (Table 4). The statistical analysis showed that there was significant difference between r, R_0 and T and age-stage parameters of *Bemisia tabaci* on var. Varamin and Sahel based on two-sex life table (*P* ≤ 0.05). Our results showed that lower development time and earlier ovi-position of *Bemisia tabaci* on var. Sahel was due to larger intrinsic rate of increase (r). Also the mean generation time (T) in var. Varamin was longer than that in var. Sahel.

Results showed that the body weight of *Bemisia tabaci* on var. Varamin and Sahel was 90.8±1.98µg and 112.23±1.28µg, respectively. The body weight of *Bemisia tabaci* on var. Varamin was significantly (P≤0.0001) lower than that on var. Sahel. The cotton var. Varamin negatively affected the fitness of *Bemisia tabaci* as the pre-adult longevity and fecundity. The mechanisms that determine *Bemisia tabaci* choice of a plant as substrate for progeny development have been only partially elucidated. It seems whiteflies attraction and ovi-position could be possibly due to differences in physical and chemical characteristics of the leaves of the two cotton varieties. These characteristics include plant color, texture, free metabolites in the sap, quantity of trichomes in the leaves and nutritional state (Van Lenteren and Noldus, 1990; Bentz *et al.* 1995; Chu *et al.* 1995; Andres and Connors, 2003).

Generally hairy plant species have been found to be preferred over smooth ones up to feeding and attachment of eggs to the leaf epidermis. This premise was supported by Butler and Wilson (1984), who reported that *Bemisia tabaci* showed higher preference for hairy-leaf varieties of cotton to smooth ones. Mc Auslane *et al.* (1996) also reported a positive correlation between hairiness and ovi-position of *Bemisia tabaci* on soybean.

The smaller *r* value in var. Varamin indicated that *Bemisia tabaci* grew slower on var. Varamin than var. Sahel. The relatively poor host attribute of var. Varamin for *Bemisia tabaci* caused delay in development. The cotton var. Varamin had different characteristics that affect on life table parameters of *Bemisia tabaci*. These results are according to same researches that showed the antibiotic plant resistance generally reduces fitness of herbivore such as size. For example: the smaller adult aphid size could affect population growth in the field through lower or delayed reproduction (Byrne *et al.* 2003).

Table 4. Life table parameters of *Bemisia tabaci* on two cotton varieties (mean ± SE).

	Var. Sahel	Var. Varamin	*t*-student	*P*
r	0.14±0.00	0.08±0.00	2.0	0.04*
λ	1.13±0.00	1.08±0.00	1.4	0.23
R_0	21.81±2.25	16.43±1.62	2.02	0.04*
T	27.22±0.28	34.62±0.34	10.79	0.000*
GRR	33.56±2.01	30.35±10.0	1.19	0.09

* 5% significance level

We conclude that in comparison to var. Sahel, the var. Varamin had significant effects on the development time and fecundity of *Bemisia tabaci*. This effect may be due to changes in host quality responsible for herbivore/cotton plant interactions. Delayed development of the *Bemisia tabaci* on var. Varamin could make it possible for integration with other control tactics such as biological control. But the cotton var. Varamin may affect negatively on natural enemies. Therefore, the results of our preliminary study may well be useful in implementing controls and determining different crops effects on non-target insects like natural enemies of *Bemisia tabaci* such as parasitoids and predators.

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