STUDY OF HOST PREFERENCE AND THE COMPARISON OF SOME BIOLOGICAL CHARACTERISTCS OF *BEMISIA TABASI* (GENN) ON TOMATO VARIETIES

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Abstract: The resistance of 8 tomato varieties to cotton white fly, *Bemisia tabaci* (Genn) (Hemiptera: Aleyrodidae), was evaluated in four greenhouse experiments. In the first experiment, we evaluated the attractiveness and preference for oviposition in a free-choice test (randomized blocks, 8 treatments, and 5 replications). In the other experiments, we evaluated the no-choice preference for oviposition (randomized blocks, 4 treatments, and 4 replications). The whitefly egg-adult cycle was monitored using a statistical design in randomized blocks with four replications. The percentage mortality of immature stages was also determined (randomized blocks with four replications). In the free-choice test, the tomato variety Rio Grande was the most attractive to adults, while the variety Chef-falat had the lowest number of adults. Also in this assay, the variety CAL-JN3 presented the lowest number of eggs, while the variety Ergon presented the highest number of eggs. In the no-choice test, the varieties Chef-falat and CAL-JN3 remained resistant. Consequently, for these two varieties non-preference is the oviposition resistance mechanism. The egg-adult cycle varied from 26.02 days (Ergon) to 26.66 days (CAL-JN3). The total mortality varied from 20.52 (Ergon) to 33.97 (CAL-JN3). Considering all the characteristics, the variety CAL-JN3 was the most resistant to *B. tabaci* among all the tomato varieties studied, while variety Ergon was susceptible.

Key words: *Bemisia tabaci*, biological characteristics, host preference, resistance, tomato

INTRODUCTION

Tomato [*Lycopersicon esculentum* (Solanaceae)] is a greenhouse product grown in most parts of the world. The stems and leaves are covered with a fine fluff (Mound 1965a). The compound and alternate leaves have different color intensities (depending on the variety). These parts are important in attracting pest insects such as *Bemisia tabaci* (Genn) (Hemiptera: Aleyrodidae).

Cotton white fly *B. tabaci* is one of the most important pests of tomato. The fly sucks the plant sap (Schuster *et al*. 1996) reducing the quality and quantity of the sap (Mound 1965b). This insect exists as an economic pest in most places of the world (Greathead 1986; Martin 1987; Byrne and Houk 1990; Gerling 1990). This pest also transmits various viral diseases (Dickson *et al.* 1956; Duffus 1987; Bedford *et al.* 1994).

The cultivation of pest-resistant plants is one way to counter pests. Resistant genotype can affect the morphology, biology, and physiology of pests and can play a part in reducing the population of pests (Toscano *et al.* 2002; Fancelli *et al.* 2003; Cunha *et al.* 2005; Bogorni and Vendramim 2005; Baldin *et al.* 2007). In recent years, studies conducted in the field of production and use of crop varieties resistant to insects, has helped to significantly increase food production in major agricultural areas. In most pests management programs the subject of plant resistance to insects (Smith *et al.* 1994; Yasarakinci and Hincal 1996), and the subject of the host preference of pests (Jounior *et al.* 2003) are important. Resistance effects, which appear in a cropping season as well as in consecutive cropping seasons, are cumulative over time (Panda and Khush 1995). The longer it is used the higher its gained profit is (Smith *et al.* 1994). In most cases, insect-resistant varieties decrease the physical ability and physiological status of insect pests. These factors then increase the efficiency and host finding of predators and parasites, and also increase the pathogen's effect (Smith *et al.* 1994).

Cultivation of insect-resistant crop varieties may control plant diseases transmitted by insects. If there are persistent viruses, plant resistance to their transmitters usually reduce virus-spread by slowing down their replication (Panda and Khush 1995). If pest resistant varieties are used with chemical control methods, the costs of chemical control and problems related to insecticides which remain in the environment, will be reduced. In particular, using substances of natural origin in the chemical method will be very useful, because there are few known harmful effects of these substances on hu-

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man health and animals. Consequently, the application of resistant plant varieties plays an important role in reducing environmental pollution.

There are several factors that make resistant plants inappropriate host plant species for pests (Coudriet *et al.* 1985; Powell and Bellows 1992a, b; Bellows *et al.* 1994; Samih *et al.* 2005). Different parts of a plant, the leaf age (Mound 1965a; Ohnesorge *et al.* 1980), and the hairy leaves (Mound 1965; Bethke and Henneberry 1984) are effective for feeding and egg laying, selection and changes in the *B. tabaci* populations (Hassell and Southwood 1978). Fuzz and fluffs can be a physical barrier (Duffy, 1986), and also provide a suitable microclimate for vegetarians (Mound 1965b; Willmer 1986). There are several defense mechanisms against pests, such as: the number of trichoms (Toscano *et al.* 2002), type of trichom (Snyder *et al.* 1998), and different glandular trichomes chemicals substances as well as the cuticle thickness of fruit (Leidl *et al.* 1995) in tomato plants. Studies performed by Setiawati *et al.* (2009) on *B. tabaci* host preference of about six tomato varieties, demonstrated that the variety which has a high density of glandular trichomes will decrease the egg laying and feeding of *B. tabaci* nymphs. Studies carried out by Butler *et al.* (1988) showed that low numbers of *B. tabaci* on smooth tomato leaves can be attributed to the openness of the plant canopy cover. More light, wind, higher temperatures, and lower humidity are allowed in with an open canopy. The extensive genetic diversity of the tomato plant make it possible to target corrective programs which provide resistance to the *B. tabaci* pest (Toscano *et al.* 2002).

Plant resistant varieties affect biology (Shraf *et al.* 1985; Oriani and Lara 2000; Fekrat and Shishebor 2007), mortality (Fancelli and Vendramim 2002; Oriani and Lara 2000), and biotypes of a species (Bethke *et al.* 1991; Samih and Izadi 2006). Such resistant varieties effectively change *B. tabaci* populations. There is an importance placed on eating fresh tomato products, especially tomatoes for the family table. There is also an irregular use of toxins to control *B. tabaci* by farmers who have greenhouses. Keeping these two above points in mind, this research focused on the tomato plant as a host. In this study, several varieties of tomatoes that are grown in different regions of Iran were evaluated for their effect on host preference and biological characterization of *B. tabaci*, and the resistance of these tomato varieties to the *B. tabaci* pest.

MATERIALS AND METHODS

Collection, identification, conditions, and location of the experiments

Adult whitefly insects were collected by an aspirator in July 2010 from the cotton in the educational field of Vali-e-Asr University of Rafsanjan, Iran. The insects were then transferred to the greenhouse in order to be identified, and to breed. In order to exactly identify the species, taxonomic studies were used to examine and identify the pupae as *B. tabaci* (Samih *et al.* 2007). After species confirmation, adults insects collected from the field were transferred to the research greenhouse of the crop protection department at Vali-e-Asr University of Rafsanjan (temperature: 27±2, humidity: 60±5, photoperiod of light to darkness 16:8) to be used for this research study.

Host Plants

In this study, cotton plants were cultivated to keep an insect source, and tomato varieties were cultivated for the experiments. The plants were grown in the greenhouses in disposable plastic pots. The diameter of the pots was 15 cm and the height was 20 cm. The pots were filled with prepared GABA soil (Dasht-e-Sabz Atieh Company, Science and Technology Park, 2010) and were watered manually once every two days. Distilled water was used to prevent secondary contamination of the plants. To improve plant growth, the nutrient solution N.P.K (Bayer Co.) was used twice a week when watering. After the plants were established, the pots were transferred into cages. The cages were 80x50x60 cm and were covered by a 12 mesh silk fabric (to avoid contamination).

Mass rearing of *B. tabaci*

Adults insects collected from the field, were reared to be used in this study. The insects were mass produced on the cotton plants. The pots of plants were in cages. The dimensions of the cages were 80x50x60 cm and they were covered by 12 mesh silk fabric (to avoid contamination). Due to an increase in pest density after 1 or 2 generations, the previous pots were replaced with new pots every 15 days.

Attraction of adult insects and egg laying preference of *B. tabaci* in the free choice test

In this study, eight common tomato varieties grown in Iran including Rio Grande, Viva, Chef-Falat, CH-Falat, CAL-JN3, Ergon, Early Urbana I, and Early Urbana II were cultivated in greenhouse conditions, and then were studied. After the bushes reached the 2–4 leaf stage one plant only, was maintained in each pot and the other bushes were removed. Pots containing the tomato bushes were randomly arranged in the circular space inside a 40x50x80 cm cage. Then, 50 adult insect pairs of the same age, were released in the cage center. The insects on the bushes were counted 72 hours after the beginning of infection. To determine egg laying preference in the free choice test, 72 hours after the plants were infected, the eggs on the plant were counted with the help of binoculars. To obtain the number of insects attracted as well as the number of eggs per unit of leaf area, the leaf area was measured by a leaf area meter. Then, the number of insects and eggs were calculated. This experiment was repeated 5 times.

Egg laying preference in the no choice test

In this experiment, three tomato varieties were selected. In the free choice test, these three varieties had been the least preferred (Viva, Chef-Falat, CAL-JN3) when compared with the variety that had been preferred the most (Ergon). (The preferred variety was compared with non-preferred varieties). Selected tomato varieties were given separately to the insects. For this purpose, a solution of water and food was poured into transparent disposable cups. A cap was put on each cup, In the middle of the cap there was a hole through which the plant stem passed. Then, a tomato stem containing two primary leaves of the bush was cut off and placed in pots. On these cups, another cup covered with a net acted as a cup cage. The edges of the cups were taped to each other. On the top cup, a small hole was made to place a cup vial for releasing the adult insects. To determine egg laying preference, 15 pairs of adult insects of the same age, were transferred to the aforementioned cages. After 72 hours, the *B. tabaci* was removed from the plant, then the eggs on the leaves were counted. As in the previous experiment, the leaf area was measured and the number of eggs per unit area was calculated.

Developmental period of the before-maturity stages of *B. tabaci* on selected varieties

The developmental period of the before-maturity stages was evaluated on tomato cultivars (Viva, Chef-Falat, CAL-JN3, and Ergon). To this purpose, the solution of water and food was poured into transparent disposable cups. A cap was put on each cup. In the middle of the cap there was a hole through which the plant stem passed. Then, the tomato stem containing two primary leaves of the bush, was cut off and placed in pots. On these cups another net covered cup acted as a cup cage. Two cup edges were taped to each other. On the top cup, a small hole was made to place a cup vial for releasing adult insects. To determine the duration period of the egg growth, 15 adult pairs of the same age, were released inside the cup cage. After 24 hours, the adults were removed from the plant. Then those leaves containing eggs were examined every day with the help of binoculars. The egg-hatching time was recorded. In this way, the duration of egg growth was determined for at least 100 eggs. After the eggs hatched and the first instar nymphs on the leaves were established, a location map showing the establishment of the first instar nymphs on the leaves was prepared. Based on this map, the duration of the nymphal period and the beginning of the pupation stage which was noted with the appearance of red eyes, were determined. The time between the appearance of the red eyes and the exiting of the adults was considered as the pupation duration. This time period was determined and calculated. In this way, the length of growth from egg to maturity was measured. This experiment was repeated 4 times.

Mortality before maturity

During test performance related to the development period duration of the stages taking place before maturity, the percentages of eggs, nymphs and pupae casualties were determined. Determination was based on counting the number of: eggs laid, the first instar nymphs and pupae, and adults insects leaving the pupae stage, then subtracting the aforementioned numbers from each other. Based on this test, each biological stage from egg to pupa was determined.

Data analysis

Data analysis was performed by SPSS 16.0 software. Mean values obtained were compared by Duncan's multiple range test.

RESULTS AND DISCUSSION

Attraction of adult insects and egg laying preference of *B. tabaci* in the free choice test

A comparison between tomato varieties, regarding the free choice test of *B. tabaci*, is given in table 1. The results showed a significant difference, at the level of one percent (1%), between different varieties in terms of attracting adult insects and number of eggs per unit area. The maximum number of adult insects per unit of leaf area was observed on Rio and the minimum number on Viva and Chef-Falat. The maximum number of egg was observed on Ergon and minimum number on CAL-JN3. Therefore, different varieties were effective in the free choice of *B. tabaci*, based on the attraction rate of adult insects, and on egg laying. This reaction has also been observed in research studies on *B. tabaci* fed tomato germplast (Muigai *et al.* 2002), and on tomato genotypes (Toscana *et al.* 2002) and potato (Silva *et al.* 2008).

Table 1. Mean attraction of adult (the number per unit of leaf area) and the mean of the egg laying (the number of eggs per unit of leaf area) of *B. tabaci* in different varieties of tomatoes in the free choice test

Cultivar	Number of adults [cm^2]	Number of eggs [cm^2]
Rio	4.16±0.18 a	34.74±1.75 c
CH - falat	3.60±0.32 b	42.44±2.11 b
Early Urbanaunegen I	2.52±0.31 c	25.3±0.04 e
Ergon	3.76±0.31 b	46.04±2.54 a
Viva	2.08±0.19 d	22.20±0.62 f
Chef - falat	2.04±029 d	19.76±0.97 g
Early urbanaunigen II	2.56±0.19 c	32.28±1.09 d
CAL-JN3	2.34±0.28 cd	19.44±1.43 g

The similar characters in a column indicate the lack of a significant difference at a 5% level

Egg laying preference in the no choice test

The comparison between tomato varieties, regarding the no choice test of *B. tabaci,* is given in table 2. The results showed a significant difference, at a level of one percent (1%), between selected varieties due to the egg laying rate. The lowest number of eggs was observed on Chef-Falat and then CAL-JN3, and statistically no significant difference was observed between them. In the comparison between tomato varieties, Viva had an in between position, and the highest number of eggs was observed in Ergon. These were the results in the no free choice test of the *B. tabaci* and these results were also observed on tomato varieties based on egg laying preference (Muigai *et al.* 2002; Toscana *et al.* 2002; Setiawati *et al.* 2009).

Table 2. The mean number of eggs per unit of leaf area of *B. tabaci* in different varieties of tomatoes in the no choice test

Cultivar	Number of eggs [cm^2]
CAL-JN3	20.78±0.08 c
Chef-falat	19.92±0.24 c
Viva	24.94±0.52 b
Ergon	29.46±0.48 a

The similar characters in a column indicate the lack of a significant difference at a 5% level

Developmental period of the before-maturity stages of the *B. tabaci* on selected varieties

A comparison between the tomato varieties, regarding the egg-to-adult period, is given in table 3. In this test, no significant difference was observed between the selected varieties in terms of the egg incubation period as well as the duration of the pupation period. Our results were consistent with the study performed by Fancelli and Vendramim (2002) where there was the same average of the egg incubation period on different hosts. A significant difference was observed for the nymphal period; the difference was on the level of one percent. The longest and shortest nymphal periods were recorded in CAL-JN3 and Ergon, respectively. A longer nymphal period may be due to a variety's low quality for insect feeding, and may show antibiosis resistance. This behavior was also observed when considering the difference of the host effect on the duration of the *B. tabaci* nymphal period, in the research of Coudriet *et al.* (1985); and Mohanty and Basu (1986). But it is not consistent with the results of Fancelli and Vendramim (2002) whose work showed the same *B. tabaci* nymphal period on different tomato varieties. This disparity is probably due to the difference in varieties. Also, the results of this study are consistent with the report of Oriani *et al.* (2011), who found that there is a significant difference in the time it took to complete the developmental period from egg to adult.

Variety effect on before-maturity mortality

A comparison between the tomato varieties based on before-maturity mortality is given in table 4. In this test, no significant difference was observed between the selected varieties due to egg stage and pupation casualties, while a significant difference was observed, at a one percent level, due to nymphal stage casualties. The highest and lowest nymphal casualties were observed in CAL-JN3 and Ergon, respectively. A significant difference was also observed, at a one percent level, between selected varieties, due to casualties of the before-maturity stages. The highest and lowest casualties were seen in CAL-JN3 and Ergon, respectively. The results of this study are consistent with the report of Byrne and Draeger (1989). They found the same percentage average of *B. tabaci* egg casualties on two plants of cotton and young lettuce. Wagner (1995) found that there was a significant difference in *B. tabaci* egg casualties on two different varieties of cotton. Oriani *et al.* (2011) observed that there was the same viability percentage of eggs on tomato varieties. Moreover, the results of our study are consistent with the report of Fekrat and Shishebor (2007) that states there is no signifi-

Table 3. Developmental period of the before-maturity stages of *B. tabaci* on selected varieties

Stage	Viva	Ergon	Chef-falat	CAL-JN3
Egg	7.68±0.07 b	7.79±0.12 ab	7.78±0.03 ab	7.96±0.03 a
Nymph	14.37±0.08 b	14.14±0.06 c	14.45±0.04 ab	14.61±0.08 a
Pupa	4.39±0.05 a	4.31±0.09 a	4.42±0.06 a	4.43±0.06 a
Egg to Adult	26.07±0.11 b	26.02±0.12 b	26.41±0.08 a	26.66±0.10 a

The similar characters in a row indicate the lack of a significant difference at a 5% level

Table 4. The mortality percentage of *B. tabaci* before-maturity stages on different varieties of tomatoes

Stage	Viva	Ergon	Chef-falat	CAL-JN3
Egg	3.65±1.38 a	3.70±1.27 a	3.57±1.45 a	4.03±0.86 a
Nymph	18.76±1.56 b	13.27±0.95 c	20.43±1.29 a	24.47±0.39 a
Pupa	4.31±1.59 a	3.55±0.69 a	4.77±1.01 a	5.46±0.94 a
Total	26.73±0.96 b	20.52±0.80 c	28.77±2.08 b	33.97±2.04 a

The similar characters in a row indicate the lack of a significant difference at a 5% level cant difference in pupation stage casualties on different hosts. Also, the results of the current study are consistent with the reports of Coudriet *et al.* (1985), Mohanty and Basu (1986) and Oriani *et al.* (2011) which state that there is a significant difference in the casualty rate of *B. tabaci* nymphs on different hosts.

Fekrat and Shishebor (2007) studied the mortality and growth of *B. tabaci* on potato, tomato, and eggplant under laboratory conditions. The results of these researchers (compared with the current study) concerned the duration of the period from egg-to-adult insect, on tomato for 20 days (26.07–26.66). Therefore, the duration of the *B. tabaci* developmental period increased on the tested varieties and showed more resistance to selected varieties than were shown in the results of the studies performed by Fekrat and Shishebor (2007). The percentage of mortality from the immature stages was 18.1 (20–34) on tomato.

Baldin and Beneduzzi (2010) evaluated the egg growth to adult insect period, and mortality of *B. tabaci* on squash varieties, under laboratory conditions. The highest developmental period duration was recorded on Sandy (1.25) and the shortest developmental period duration was recorded on No vita plus (7.16). The highest nymphal mortality rate was observed on Sandy (64%) and the lowest on No vita plus (0%). Their results are consistent with the current study, which shows that in a variety with a shorter growth period, the percentage of casualties is less, and in a variety with a longer growth period, the percentage of casualties is more. So, when a plant variety is more undesirable for *B. tabaci*, its growth period takes longer to be completed, it produces a lower number of generations during the year. On the other hand, the percentage of casualties is more on an undesirable variety and over time the insect population will be reduced.

CONCLUSION

According to the obtained results, the varieties of Chef-Falat, CAL-JN3 and Viva showed antixenosis resistance. These varieties attracted fewer insects and there was also a lower insect spawning rate on these varieties. In addition, CAL-JN3 showed antibiosis resistance due to increased casualties in the nymphal stage and an increased duration of the developmental period. Ergon showed more sensitivity than the rest of the varieties because more adult insects were attracted to it, and there was also a higher spawning rate on Ergon than there was on the rest of the varieties. The duration of the developmental period as well as the casualty rate of the developmental stages of the insect were less for Ergon than the rest of varieties.

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