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Development and Reproduction of *Bemisia tabaci* on Three Tomato Varieties

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Abstract: Sweet potato whiteflies, *Bemisia tabaci* (Gennadius) (Homoptera: *Aleyrodidae*) were used to determine the biology and life table parameters on three tomato, *Lycopersicon lycopersicum* (L.) Karst varieties viz., Man Yuan Hong (MYH), Hong Mei Wang (HMW) and F₁ Hybrid Hong Yue Lian Cherry (HYLC). The longest (21.80±0.74) and the shortest developmental time (19.10±1.2) have been investigated on HYM and HYLC varieties, respectively. The highest survival rates (24.28%) from egg to adult on MYH variety and lowest survival rates (16.90%) on HYLC variety have been investigated. Lifetime fecundity and daily mean fecundity varied among the host species with highest fecundities on HMW tomato. The highest intrinsic rate of increase (0.15) and lowest finite rate (1.90) on MYLC tomato, the lowest intrinsic rate (0.14) and highest finite rate (1.97) on MYH tomato whereas the intermediate intrinsic rate (0.145) and finite rate (1.93) on HMW tomato have been investigated. The generation time is the period required for whitefly on tomato plant to complete one generation.

Key words: *Bemisia tabaci*, development, reproduction, tomato varieties

INTRODUCTION

Whitefly, *Bemisia tabaci* (Gennadius) is a worldwide insect pest of vegetables, ornamental plants and field crops. It belongs to the family *Aleyrodidae* under the order Homoptera. Whitefly has four distinct developmental stages-egg, nymph, pupae and adult. All stages feed on the underside of leaves. The eggs of this insect are very small, about 0.2 mm long and 0.1 mm in diameter. Egg is attached by a stalk to the leaf and is elliptical in shape. Newly laid eggs are smooth and whitish-yellow in colour. As the eggs approach hatching, they turn brown. *B. tabaci* goes through four nymphal instars, ranging in approximate size from 0.3 mm in the first instar (crawler) to 0.6 mm in the fourth instar. All immature stages are thin and flat, elliptical in shape and greenish-yellow in colour. At the end of nymphal duration, it enters into the pupal stage. There is no exuviation between the fourth nymphal instar and pupal stage. The pupa is yellow in colour and 0.7 mm in length and has two conspicuous red eyes and the body is raised or convex in shape, but appearing oval and flat from above (Azab *et al.*, 1971; Butler *et al.*, 1983; Byrne and Bellows, 1991; Mandour, 2004). Whitefly can seriously injure plants by sucking juices from them causing wilting, stunting, irregular ripening of fruits or even death (Oliveria *et al.*, 2001). In addition, several molds, collectively called sooty molds because of their black appearance, can grow on this honeydew resulting in an unsightly, sticky mess. Sooty mold can block sunlight from reaching the leaf surface thus reducing photosynthesis and can make fruit unmarketable. The adult can also transmit plant viruses from infected to healthy plants. Whitefly is

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phloem feeder and can contribute to reduce the productivity by directly consuming the carbohydrates and other nutrients carried in plant vascular system leading to chlorotic foliage, stunted growth and depleted vigor. The biological phenomena of *Bemisia tabaci* on tomato plant have not been investigated thoroughly. Some sporadic works have been carried out with *Bemisia tabaci* on tomato plant. Whitefly biology and life table parameters of three bean species (Musa, 2003; Musa and Ren, 2005), cauliflower (El-Halay *et al.*, 1991), cotton and cucumber (Powell and Bellows, 1992), cotton (Horowitz *et al.*, 1994) and tomato (Islam, 2005; Sharaf *et al.*, 1985; Hendi *et al.*, 1984) have been investigated to some extent. Information of development and reproduction of *Bemisia tabaci* on tomato is very limited. Therefore, the present research has been undertaken to investigate the development and reproduction of *Bemisia tabaci* on three tomato varieties.

MATERIALS AND METHODS

Insect Materials

The Sweet potato whiteflies, *Bemisia tabaci* (Gennadius) were used for the present piece of research work. The work was done in the Department of Entomology, South China Agricultural University (SCAU), Guangzhou, China, during the study period from October 2004 to March 2005. The insects were collected from cucumber plants in the greenhouse, which served as stock colony. The second generations of adult's *B. tabaci* colony were used to infest the test materials in this study.

Host Plant Culture

Three tomato, *Lycopersicon lycopersicum* (L.) Karst varieties namely Man Yuan Hong (MYH), Hong Mei Wang (HMW) and F₁ Hybrid Hong Yue Lian Cherry (HYLC) of the family Solanaceae were used in this study to determine the biology and life table parameters of *B. tabaci*. The seeds were collected from the Guangdong Agricultural Institute in Guangzhou, South China. The viable seeds were placed in petri dishes soaked with water and covered with cotton wool to facilitate sprouting. The sprouted seeds were established in plastic containers with well-fertile sterilized soil and then confined in bioassay cage 60×60 cm where they grew to two-leaf stage. The experimental design consisted of 3 treatments in a completely randomized block design (RCBD) with 5 replicates. The test materials in each treatment and replicate are equally treated with well-sterilized organic manures and watered daily to four-leaf stage ready for infestation.

Development and Survivorship

Around five hundred adult whiteflies of undetermined sex collected from the stock colony were used the test materials for the host plant of three tomato varieties-Man Yuan Hong, Cherry tomato and Hong Mei Wang. One hundred adults were aspirated into each bioassay case and maintained for 24 h. for the oviposition of eggs. The adult whiteflies were removed 24 h. later (Musa, 2003; Musa and Ren, 2005). Each plant species were placed in growth chamber and controlled experimental conditions at 25±1°C, Relative Humidity of 70±10% and photoperiod of 12 h L: 12 h D for the period October-January for the development and survival of the nymphs. The number of hatched eggs and nymphs were counted and recorded daily under microscope.

Female Adult Longevity and Fecundity

The sex ratio of the newly emerged adult whiteflies from the cohort populations were separated and determined according to sex. Each female was confined in a micro cage, clipped to the undersurface part of the leaf and maintained in the bioassay cages (Musa, 2003; Musa and Ren, 2005). The bioassay cages were then kept in experimental chamber under the same aforementioned experimental conditions.

Daily number of oviposited eggs and the life span of the female adult were recorded to calculate the fecundity and longevity, respectively (Musa, 2003; Musa and Ren, 2005). As a precaution to nullify the influence of honeydew secretion on egg oviposition, the tested materials were replaced every two days with fresh ones.

Life Table and Demographic Parameters

A life table was constructed using sex ratio, survivorship, age-specific fecundity of adults and survivorship and developmental time of all immature stages to calculate intrinsic rate of increase (r_m), finite rate of increase (λ), net reproductive rate (R_0), mean generation time (T_c) and doubling time (T_d) using formulas of Andrewartha and Birch (1954).

$$R_m = (\ln R_0)/T$$

$$R_0 = \sum l_x m_x$$

$$T_c = \sum x l_x m_x / \sum l_x m_x$$

$$\lambda = e^{r_m}$$

$$T_d = \ln(2)/r_m$$

Intrinsic rate of increase (r_m) is the maximum exponential rate of increase by a population growing within defined physical conditions (Carey, 1993).

Net reproductive rate (R_0) is the mean number of daughters produced per cohort of females over their lifetimes (Carey, 1993).

Finite rate of increase (λ) is the ratio of population size at each time step (Carey, 1993).

Doubling time (T_d) is the time taken for the population to double in size from a fixed point in time (Gotelli, 1995).

l_x is the survivorship at the age x .

m_x is the number of offspring produced by an average individual of age class x .

Data Analysis

Developmental time and survivorship of eggs at each nymphal stage were calculated. Adult longevity and fecundity were analyzed among treatments of tomato variety. Non-linear regressions of longevity on fecundity were performed using SAS software (2001). All parameters were analyzed among treatments of tomato varieties using the generalized linear model (GML) procedure of SAS; means were separated by the least significant test (LSD) after a significant F-test at $p = 0.05$ (SAS Institute, 2001).

RESULTS AND DISCUSSION

Developmental Time of *B. tabaci*

Development of *B. tabaci* is indicated by the time required to transform from one stage to another. The longest period (21.80 ± 0.74) and the shortest developmental time (19.10 ± 1.2) have been investigated on HYM and HYL varieties, respectively (Table 1). Plant species differ greatly in terms of their suitability as host for specific insects when measured in terms of insect survival and reproductive rates. The quality of host plant as a food for herbivorous insects such as whiteflies may vary because of both genetic variation and environmental factors. The host plant availability, food quality and hairy trichomes are the three most important factors affecting whitefly development and survival. Based on the results obtained in this study less time is required for *B. tabaci* to complete its life cycle on MYH variety. Similar result has been reported on cauliflower (El-Halay *et al.*, 1991).

Survivorship of *B. tabaci*

The highest survival rates (24.28%) from egg to adult have been observed on MYH tomato whereas the lowest survival rates (16.90%) have been observed on HYLC tomato (Table 2). The eggs of reared on MYH tomato variety indicated the highest survival rate than those on HMW and HYLC tomato. The survival rates of *B. tabaci* fed on MYH variety seem to be high and fairly constant across the stages except for the pupal stage. The lowest survival rate has been recorded on the pupal stage 16.90% on HYLC variety and consequently high mortality. The values for egg stage indicated that about 72.67% of the eggs oviposited on MYH variety hatched into the first nymphal stage; egg mortality therefore is observed to be considerably low. The incubation periods for population fed on MYH variety is relatively shorter than other two varieties. The egg and third and fourth nymphal exhibited the lowest mortality on tomatoes at 30°C (Hendi *et al.*, 1984).

Longevity and Fecundity of *B. tabaci*

The longest (13.95±0.31) and shortest (12.20±0.31) female adult longevity has been observed on HMW and HYLC varieties respectively (Table 3). Lifetime fecundity and daily mean fecundity varied among the varieties with highest fecundity (97.45±3.65) have been observed on HMW tomato whereas lowest lifetime fecundity (80.05±3.40) and daily mean fecundity has been observed on HYLC variety (Table 3). Statistically, there is no significant difference of lifetime fecundity between MYH and HMW varieties and there is no significant difference of daily mean fecundity among three tomato varieties during present investigation (Table 3). The proportion of female adults emerged from the cohort eggs coupled with daily number of eggs laid per female are used to construct the age and the fecundity life tables of the *B. tabaci* on three varieties.

Table 1: Mean±SE of duration of the different developmental stages of *B. tabaci* reared on three tomato varieties

Tomato variety	Developmental time (days)							
	Egg to 1st instar	1st to 2nd instar	2nd to 3rd instar	3rd to 4th instar	4th instar to pupa	Pupa to adult	Egg to adult	Range (days)
MYH	6.0±0.16a	2.50±0.16b	2.70±0.12b	2.40±0.10a	2.40±0.10a	3.10±0.10a	21.80±0.74a	17-21
HMW	6.80±0.20a	2.80±0.12ab	2.60±0.10b	2.40±0.24a	2.50±0a	3.10±0.24a	20.20±0.9b	18-22
HYLC	7.0±0.35a	3.30±0.20a	3.30±0.25a	2.80±0.30a	2.40±0a	2.90±0.10a	19.10±1.2c	19-24

Table 2: Survival of *B. tabaci* on three tomato varieties

Tomato variety	Survival rates (%)							
	Egg to 1st instar	1st to 2nd instar	2nd to 3rd instar	3rd to 4th instar	4th instar to pupa	Pupa to adult	Egg to adult	
MYH	72.67a	71.55a	80.51a	84.34a	87.27a	79.32a	24.28a	
HMW	68.80a	75.93a	80.13a	84.92a	81.63ab	66.59ab	19.20b	
HYLC	67.22a	77.61a	82.34a	81.94a	74.92b	63.82b	16.90b	

Table 3: Mean±SE of longevity and fecundity of *B. tabaci* on three tomato varieties

Tomato variety	n	Lifetime fecundity	Daily mean fecundity	Longevity	Range
MYH	20	94.45±3.81a	5.70±0.81a	13.90±0.31a	10-16
HMW	20	97.45±3.65a	5.98±0.61a	13.95±0.31a	12-18
HYLC	20	80.05±3.40b	4.71±0.79a	12.20±0.31b	8-14

Mean values with the different letter(s) are significantly different at p = 0.05 level

Table 4: Life table parameters of *B. tabaci* on three tomato varieties

Tomato variety	Net reproductive rate (R ₀)	Generation time (T _c)	Intrinsic rate of increase (r _m)	Finite rate of increase (λ)	Doubling time (T _d)
MYH	53.00	28.34	0.14	1.97	4.95
HMW	50.93	26.44	0.145	1.93	4.78
HYLC	43.15	24.55	0.15	1.90	4.62

Life Table and Demographic Parameters of *B. tabaci*

There is no significant difference of the values of intrinsic rate of increase (r_m) among population on three tomato varieties. The highest intrinsic rate (0.15) of increase and lowest finite rate (1.90) have been investigated on MYLC variety and the lowest intrinsic rate (0.14) and highest finite rate (1.97) have been observed on MYH tomato variety whereas the intermediate intrinsic rate (0.145) and finite rate (1.93) have been observed on HMW variety (Table 4). The differences of r_m values among the cohort studied on three varieties are due to difference in adults' pre-reproductive period, fecundity and ovipositional pattern as reflected the generation time. The values of intrinsic rate of increase are highest for soybean and lowest for garden bean in both periods (Musa, 2003; Musa and Ren, 2005). The generation time is the period required to complete one generation. MYH and HMW variety have a better plant architecture with more trichomes increasing the surface area for egg oviposition. Probably these types of plant are more suitable for *B. tabaci* in terms of growth and development as evidenced by the survivorship and developmental time. Gross reproductive rate and net reproductive rate differences among cohorts or populations of *B. tabaci* may have been the result of host plant effects.

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