BİTKİ KORUMA BÜLTENİ 2016, 295 - 307
ISSN 0406-3597
DOI 10.16955/bkb.92708

The effect of some watermelon varieties on the biology of *Aphis gossypii* Glover (Hemiptera: Aphididae)

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ABSTRACT

The development, reproduction, and population growth parameters of melon aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae), were studied on four watermelon varieties (Crimson Sweet, Crimson Tide F_1, Galactica and Sürme) under controlled conditions (25±1°C temperature, 65±5% humidity and 16:8 hours long day light conditions) in growth chamber. The effect of watermelon varieties on the biology of *A. gossypii* was determined as significant. The highest fecundity was recorded on Galactica (58.97 offspring/female), followed by Crimson Tide F_1 (57.80 offspring/female), Sürme (57.25 offspring/female) and Crimson Sweet (57.03 offspring/female) respectively. The highest net reproduction rate (Ro) was observed on Crimson Tide F_1 (22.40 offspring), while the lowest was on Sürme (18.61 offspring). The value of intrinsic rate of increase (rm) ordered from the highest to the lowest as Crimson Tide F_1 0.371, Galactica 0.365, Sürme 0.359 and Crimson Sweet 0.353 respectively.

Keywords: *Aphis gossypii*, intristic rate of increase, reproduction, life table, watermelon varieties

ÖZ

Bazı karpuz çeşitlerinin *Aphis gossypii* Glover (Hemiptera: Aphididae)'nın biyolojisi üzerine etkisi

Aphis gossypii Glover (Hemiptera: Aphididae)'nın gelişme, üreme ve popülasyon artışı ile ilgili parametrelerinin belirlenmesi çalışmaları dört farklı karpuz çeşidi üzerinde (Crimson Sweet, Crimson Tide F_1, Galactica ve Sürme) kontrollü koşullara sahip iklim kabininde (25±1°C sıcaklık, %65±5 orantılı nem ve 16:8 saat uzun gün aydınlatmalı) yürütülmüştür. Karpuz çeşitlerinin *A. gossypii*'nin biyolojisi üzerine önemli etkisi olduğu saptanmıştır. En yüksek doğurganlık Galactica çeşidi üzerinde (58.97 nimf/ergin) kaydedilirken, bu çeşidi sırasıyla Crimson Tide F_1 (57.80 nimf/ergin), Sürme (57.25 nimf/ergin) ve Crimson Sweet (57.03 nimf/ergin) çeşitleri izlemiştir. En yüksek net üreme oranı (Ro) Crimson Tide F_1 çeşidi üzerinde (22.40 nimf) gözlenirken, en düşük oran Sürme çeşidi üzerinde (18.61 nimf) gerçekleşmiştir.

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Alınış (Received): 09.05.2016, Kabul ediliş (Accepted): 18.05.2016

A. gossypii'nin kalıtsal üreme yeteneği (rm) en yüksekten en düşüğe doğru Crimson Tide F_1 0.371, Galactica 0.365, Sürme 0.359 ve Crimson Sweet 0.353 olarak sıralanmıştır.

Anahtar kelimeler: *Aphis gossypii*, kalıtsal üreme yeteneği, üreme gücü, yaşam tablosu, karpuz çeşitleri

INTRODUCTION

Cultivation of watermelon carries so many troubles such as plant protection and growth problems. One of the most important plant protection problems is aphid damage. The melon aphid, *Aphis gossypii*, Glover (Hemiptera: Aphididae) is a serious pest of so many cultivars including watermelon. This aphid can cause damage by giving direct injury to reduce the plant's vigor or even kill the plant (Akkaya 1995, Büyük and Özpınar 1999, Ölmez 2000), or by giving indirect injury as a vector of so many viral diseases (Düzgüneş ve Tuatay 1956). *A. gossypii* could reproduce in a short period and could give many generations in suitable conditions (Aldryhim et al. 1995, Lodos 1986). This pest has so many host plants and could pass from one host plant to another host plant (Satar et al. 2009), it could change its genetic structure according to host plant source (Thomas et al. 2009). It has both alate and apterous individuals, and could resist against pesticides (Afshari et al. 2009, Hollingsworth et al. 1994).

At present, in order to control aphids unfortunately insecticides are compulsory. The use of insect resistant varieties has been a major successful control tactic against vegetable pests, often resorted to because of the difficulty of using pesticides on these edible plants (Chambliss and Jones 1966, Hafiz and Hagag 1997, Howe et al. 1976, Kooistra 1971). There is effect of some highly important factors such as morphological, physical, biochemical content, aroma, color and food quality of leaves of host plant on development time, longevity, survival rate, and reproduction of *A. gossypii* (Robert 1987). Therefore, knowledge of host plant effects on the biological parameters of the melon aphid is essential.

The aim of this study was to determine the effect of different watermelon varieties on biological parameters such as development, longevity and reproduction of melon aphid under laboratory condition, and provide information to create better IPM tactics.

MATERIALS AND METHODS

Plant source

Seedling of four watermelon varieties (Crimson Sweet, Crimson Tide F_1, Galactica and Sürme) were reared in climatic room at 25±1ºC, a relative humidity 65±5%, and photoperiod of 16:8 (L:D) h. Each variety planted in pots (15 cm diameter by 25 cm height) with a mixture of soil, sand, and natural fertilizer. The pots were watered on alternate days and every two weeks. New plants were planted to make available

leaves until the end of the study.

Aphis gossypii source

The melon aphids had been collected from watermelon field of Diyarbakır, Turkey. The melon aphids were reared on watermelon; laboratory clones of melon aphid were established from apterous specimens. The aphid clones were maintained separately on the leaves of their respective host plant varieties in a climatic room, held at 25±1°C temperature, a relative humidity 65±5%, and a light regime (16 h light; 8 h dark). The offspring had been reared before the aphid individuals were used in the experiments.

Determination of development period of immature nymphs

Randomly selected apterous females from the stock culture were transferred separately onto an excised watermelon leaf disc, placed upside down on wet filter paper in each Petri dish. The nymph born within 24 h from the Petri dish was transferred individually to each of the fresh-cut leaf discs in a Petri dish (9 cm diameter 1.5 cm deep) with a small camel's-hair brush, and placed in a growth chamber (maintained at 25±1ºC and 65±5% RH and 16:8 L:D). All replications in which the nymphs died within 24 h after transfer were omitted. The filter papers in the Petri dishes were wetted daily, and the aphids were transferred to new watermelon leaf discs every 2–3 days. The nymph and adult on each Petri dish were controlled daily under a stereoscopic microscope, and their survival recorded. The presence of the discarded exuviae were used to determine when molting had occurred.

Determination of survivorship rate of immature nymphs

Survivorship rate of *A. gossypii* for each instar period determined on four watermelon varieties. In order to determine survivorship rate of *A. gossypii*, Petri dishes controlled daily and mortality of any aphid recorded according to each stage of aphid and each variety of watermelon.

Determination of life table parameters of *Aphis gossypii*

Experiment was designed according to block design method. For each watermelon variety 20 plastic Petri dishes and three replications (totally 60 aphids for each watermelon variety) were tested. When the immature nymphs become adults, they were observed daily for reproduction and survival on each watermelon variety, all newborn nymphs were removed from each Petri dish after counting and these observations continued until the mature aphid died. Development times for each nymphal instar, duration of adult pre-reproduction, reproduction, and post-reproduction periods, lifetime fecundity and average daily reproduction were calculated for each aphid individual. All tested watermelon variety leaves were provided every 1 or 2 days throughout the study period.

Data analysis and statistics

Data analysis and statistic effect of different varieties on the biology of melon aphid were assessed by constructing a life table, using age-specific survival rates (lx) and fecundity (m_x) for each age interval (x) per day. The intrinsic rate of increase (r_m) was calculated by iteratively solving the equation $\sum e^{-mrx} Lx\ m_x = 1$ where the age-specific survival rate (lx) is the proportion of individuals in the original cohort alive at age x, and the age-specific fecundity (m_x) is the mean number of female progeny produced per female alive in the age-interval x. The net reproductive rate, $R_o = \sum lx\ m_x$, was also calculated (Birch 1948). In addition, life table parameters of *A. gossypii* were calculated from the data collected by a computer program TWOSEX (Chi 1997). Nymphal development times, adult life span, fecundity, and daily reproduction were evaluated by analyzing one way ANOVA and Duncan's Multiple Range Tests determined classification of differences between treatments (SPSS 1999). Differences at probability level $P \leq 0.05$ were considered significant.

RESULTS

Determination of development period of immature nymphs

Development time for immature stages of *A. gossypii* (1st, 2nd, 3rd and 4th stages, total immature stage and adult longevity period) on four watermelon varieties was presented in Table 1. According to statistical analysis, there was not any difference between varieties in terms of 1st and 2nd instars period of *A. gossypii*, while there was an important statistical difference between varieties in terms of 3rd, 4th instars period, development time and adult longevity (Table 1; $P \leq 0.05$). The melon aphid developed higher on Sürme variety (4.30 d) than on Crimson Sweet variety (4.70 d). While Sürme was the lowest and differed as one group (4.30 d), Crimson Sweet (4.70 d) and Galactica (4.62 d) were the highest and differed as another group. Crimson Tide F_1 (4.55 d) shared the common character of both groups (Table 1; $P \leq 0.05$). There was an important statistical difference between varieties in terms of adult longevity. While Sürme (11.2 d) and Crimson Tide F_1 (11.6 d) were the lowest and differed as one group, Crimson Sweet (13.4 d) was the longest and differed as another group. Galactica variety (12 d) shared the same and common character of both groups (Table 1). The shortest development time and adult longevity of *A. gossypii* was those that feed on Sürme variety, while the longest was on Crimson Sweet variety.

Determination of survivorship rate of immature nymphs

The most mortality occurred in the first instars (30-35%) on all varieties (Table 2). The mortality of second, third and fourth instars were not differed (10-15%). Survivorship rate was ordered from the least to the most as Sürme variety 81.8%, Crimson Tide F_1 variety 85.1%, Crimson Sweet variety 85.4% and Galactica variety 86.2% respectively (Table 2; $P \leq 0.05$).

Table 1. Development periods (days ± SE) of immature stages and adult longevity of *Aphis gossypii* on four watermelon varieties

	n	Crimson Sweet	Sürme	Galactica	Crimson Tide F_1
First instars	60	1.10±0.04 a	1.07±0.03a	1.15±0.05 a	1.13±0.04 a
Second instars	60	1.17±0.05 a	1.13±0.04a	1.17±0.05 a	1.19±0.05 a
Third instars	60	1.18±0.05 a	1.05±0.03b	1.03±0.02 b	1.07±0.04 b
Fourth instars	60	1.12±0.04 ab	1.05±0.03b	1.27± 0.06 a	1.25±0.07 a
Total of immature	60	4.70±0.19 a	4.30±0.06b	4.62±0.09 a	4.55±0.07 ab
Adult longevity	60	13.40±0.53 a	11.20±0.53b	12.00±0.53 ab	11.60±0.53 b

Means within a row sharing the same letter are not significantly different ($P \leq 0.05$, Duncan multiple range test).

Generally, survivorship rate of *A. gossypii* was near each other except for a little bit difference of Sürme variety. The average of survivorship of all instars on four watermelon varieties occurred as 84.6%. According to literatures survivorship of *A. gossypii* on different hosts reported as 80% in Steenis and El-Khawass (1995), 81% in Xia et al. (1999), and 94.2% in Ölmez Bayhan et al. (2006).

Table 2. Survivorship rate of each instar period of *Aphis gossypii* on four watermelon varieties

Varieties	n	First instars survivorship rate (%)	Second instars survivorship rate (%)	Third instars survivorship rate (%)	Fourth instars survivorship rate (%)	Mean survivorship rate (%)
Crimson Sweet	203	69.5	87.2	91.9	92.9	85.4
Sürme	200	69.0	82.6	88.6	87.1	81.8
Galactica	203	70.4	87.4	92.0	94.8	86.2
Crimson Tide F_1	161	65.2	88.6	94.6	92.1	85.1

Determination of life table parameters of *Aphis gossypii*

Life table parameters of *A. gossypii* such as net reproduction rate (R_o), intrinsic rate of increase (r_m), generation time (T_o), fecundity, longevity, pre-reproduction, reproduction and post-reproduction periods were given in Table 3. Survival rates (lx) and fecundity (mx) for per day for each age interval (x) were given on Figure 1.

The intrinsic rate of increase (r_m), net reproduction rate (R_o) and generation time (T_o) were calculated for the aphid on four different watermelon varieties (Table 3). The largest r_m occurred with 0.371 female/female/day on Crimson Tide F_1, while the lowest occurred with 0.353 female/female/day on Crimson Sweet. The longest net reproduction rate (female offspring per adult female), R_o was on Crimson Tide F_1 (22.40), while the shortest on Sürme variety (18.61) respectively (Table 3). The longest generation time (T_o) of the melon aphid on Crimson Sweet with 8.51 days, while the shortest on Sürme variety 8.14 days respectively (Table 3).

Total adult longevity of female on four watermelon varieties varied significantly

(Table 3). The mean longevity of adult females reared on Crimson Sweet variety had the longest period (17.93 d), while individuals on Sürme variety had the shortest period (15.28 d). Crimson Tide F_1 (16.13 d) and Galactica varieties (16.57d) shared common effect of both groups (Table 3). According to literatures adult longevity of *A. gossypii* on different hosts were reported as 15.8 d in Xia et al. (1999), 12.1- 18.4 d in Hafiz (2002), 15.0 d in Santos et al. (2004), 22 d in Ölmez Bayhan et al. (2006) and 9.6-20.2 d in Hafiz (2008). There is no any similarity between this study and literatures, because of using different host plant species or varieties and because of different conditions.

Total fecundity of *A. gossypii* was not significantly differed among the tested watermelon varieties (Table 3). The average nymph production of female (offspring per female) ordered from the highest to lowest as Galactica (58.97), Crimson Tide F_1 (57.80), Sürme (57.25) and Crimson Sweet (57.03). According to literatures fecundity of *A. gossypii* on different hosts were as 28.39 offspring per female in Xia et al. (1999), 40.2-59.3 in Hafiz (2002), 44.75 in Anand and Spokata (2004) and 46.5 in Ölmez Bayhan et al. (2006). There is no any similarity between this study and literatures, because of using different host plant species or varieties and because of different conditions.

Pre-reproduction period of adults was significantly differed among the four watermelon varieties. While Crimson Tide F_1 had the shortest period (0.30 d), Sürme had the longest period (0.52 d) (Table 3). Reproduction period of adults was significantly differed among the four watermelon varieties. While Sürme had the shortest reproduction period (8.17 d), Crimson Sweet had the longest reproduction period (9.85 d) (Table 3). According to literature reproduction period of *A. gossypii* was 10.3 d in Xia et al. (1999) and 9.9-16.4 d in Hafiz (2002). There is no any similarity between this study and literatures because of using different host plant species or varieties. Post-reproduction period of adults was not significantly differed among the four watermelon varieties. While Crimson Sweet had the longest post-reproduction period (2.42 d), Crimson Tide F_1 had the shortest post-reproduction period (1.82 d) (Table 3). According to literatures post-reproduction period of *A. gossypii* was 0.8-1.0 d in Hafiz (2002) and 0.9- 1.9 d in Hafiz (2008). There is no any similarity between this study and literatures because of using different host plant species or varieties.

The highest value of Gross Reproduction Rate (GRR) was on Crimson Tide F_1 61.15, while the lowest was on Sürme variety 54.92 respectively (Table 3). According to literatures GRR was found 40.2-59.3 (Hafiz 2002) and 50.51 (Anand and Spokata 2004). There is no any similarity between this study and literatures; due to different host plant species, varieties, and conditions.

The values of intrinsic rate of increase (r_m) was converted into finite rate of increase (λ) and it was confirmed that the population of *A. gossypii* had the capacity to multiply about 1.45 on Crimson Tide F_1, 1.44 on Galactica, 1.43 on Sürme, and 1.42 on Crimson Sweet per day (Table 3). According to literature Xia et al. (1999) were

reported the highest finite rate of increase (λ) as 1.47, Hafiz (2002) was reported as 1.27-1.34, Anand and Spokata (2004) were reported as 1.46, and Hafiz (2008) was reported as 1.22-1.32. There is no any similarity between this study and literatures because of using different host plant species, varieties, and different conditions.

Table 3. Mean±SE development, reproduction, fecundity per female, longevity and life table parameters of female of *Aphis gossypii* over four watermelon varieties

Biological Parameters	**Crimson Sweet**	**Sürme**	**Galactica**	**Crimson Tide F_1**
Pre-reproduction Period	0.38±0.07 ab	0.52±0.07 a	0.47±0.07 ab	0.30±0.06 b
Reproduction Period	9.85±0.37 a	8.17±0.34 b	8.98±0.31 ab	9.02±0.39 ab
Post-reproduction Period	2.42±0.34 a	2.12±0.25 a	1.92±0.28 a	1.82±0.23 a
Longevity of Female	17.93±0.60a	15.28±0.52b	16.57±0.47 ab	16.13±0.51b
No. Progeny/Female (Fecundity)	57.03±1.83a	57.25±2.26a	58.97±1.79 a	57.80±2.48a
Generation Time (T_o)	8.51	8.14	8.38	8.38
Net Reproduction Rate (R_o)	20.08	18.61	21.29	22.40
Intrinsic Rate of Increase (r_m)	0.353	0.359	0.365	0.371
Gross Reproduction Rate (GRR)	55.18	54.92	56.61	61.15
Finite Rate of Increase (λ)	1.42	1.43	1.44	1.45

Means within a row sharing the same letter are not significantly different ($P \leq 0.05$, Duncan multiple range test).

DISCUSSION

Aphis gossypii is known as a polyphagous species. It is widely accepted that *A. gossypii* performance varies widely among different host plants. Furthermore, recent studies provided strong evidence that genetically distinct host races exist in *A. gossypii*. Cotton aphid clones from cucumber performed badly on chrysanthemum and similarly those from chrysanthemum developed poorly on cucumber (Guldemond et al. 1994). Genetically distinct forms of *A. gossypii* were also reported from cotton and cucumber (Kersting et al. 1998). The existence of host incompatibility and host races is a common phenomenon in *A. gossypii* (Satar et al. 1999).

Studies of the biology allow people to get basic information for use strategies to control insect pests (Cividanes 2010). In order to develop strategies for controlling *A. gossypii* and understanding its biological parameters so many studies under different conditions have conducted on so many plant species and varieties in the world.

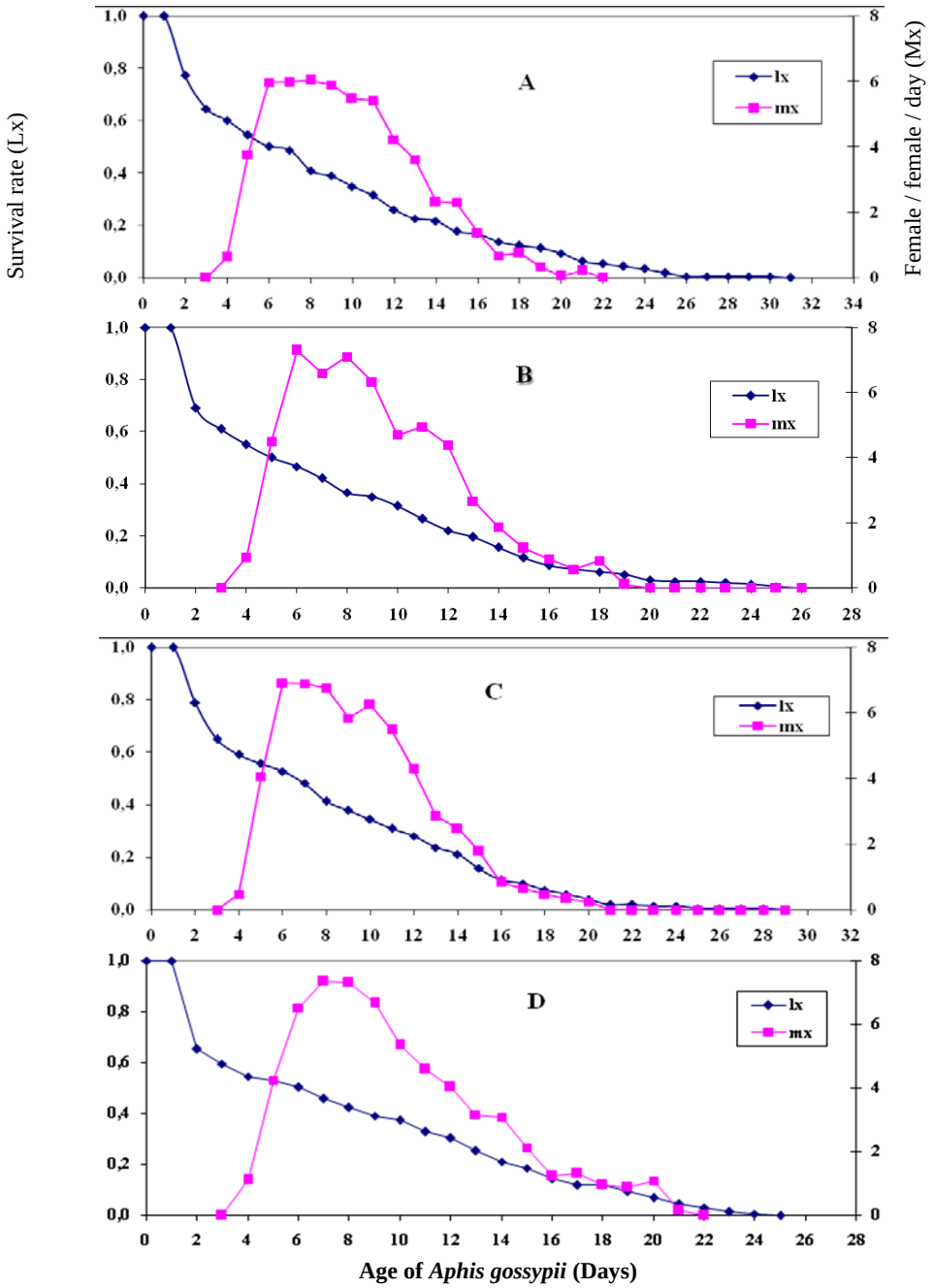

Figure 1. Life table of *Aphis gossypii* on four watermelon varieties (A: Crimson Sweet, B: Sürme, C: Galactica and D: Crimson Tide F_1)

For example, some studies focused on effect of different temperatures (Anand and Spokata 2004, Liu et al. 2000, Satar et al. 2005, Steenis and El-Khawass 1995, Tezcan 1991), different photoperiods (Liu et al. 2000), different climatic conditions in fields, greenhouses or seasonal periods (Aldryhim et al. 1995). Some studies focused on feeding and living behavior of *A. gossypii* such as alate aphid biology or apterous aphid biology (Hafiz 2002, Hafiz 2008) or feeding on different part of the same host plant for determining effect of feeding on middle, upper and lower leaves (Steenis and El-Khawass 1995). Some other studies focused on feeding on *Bacillus thuringiensis* (Bt) or without Bt (Garzo et al. 2002), feeding on different dozes of neem (a natural insecticide) (Ölmez Bayhan et al. 2006, Santos et al. 2004) and genetic diversity (Garzo et al. 2002). In addition, some studies focused on preference of host plant varieties (Hafiz 2002, Hafiz 2008, Razmjou et al. 2006a, Razmjou et al. 2006b, Satar et al. 1999, Sezgin and Özgökçe 2009, Shah et al. 2010, Steenis and El-Khawass 1995, Xia 1999). Even though many studies carried out on cotton, okra or common mallow plants in order to find a better solution to control *A. gossypii*, there is not any study on the biology of *A. gossypii* on watermelon, so this is the first study on the biology of *A. gossypii* on watermelon varieties in the world.

By this study life table parameters of *A. gossypii* such as instars periods, development time, fecundity, intrinsic rate of increase (r_m), net reproduction rate (R_o), the values of generation time (T_o), finite rate of increase (λ), pre-reproduction, reproduction, post-reproduction periods, Gross Reproduction Rate (GRR) and survivorship rate of *A. gossypii* were determined on four different watermelon varieties. According to results; as significant differences were found in some parameters, it could be said that watermelon varieties has significant effect on life table parameters of *A. gossypii*.

Generally, biological parameters of melon aphid divided into three groups. While Sürme is represented one group, Crimson Tide F_1 another group, Crimson Sweet and Galactica generally established common effect of both groups (Table 1, Table 2 and Table 3). Sürme variety was more suitable for melon aphid than other watermelon varieties in terms of development time, adult longevity, reproduction, and population growth. Sürme variety showed more significant difference than the other varieties nearly in all biological parameters of *A. gossypii*. This variety is a domestic type of watermelon in Diyarbakir province and until now, it has not registered, so still carry its natural character. The highest performance of *A. gossypii* such as the values of generation time (T_o), longevity, adult longevity, and development time performed on Sürme variety, while the least survivorship rate also performed on this variety. It could conclude that this was due to more preference of this variety by pest than the other varieties. Sürme variety has different morphological structure and shape such as big fruits and leaves, more hairiness. Therefore, it could be concluded that morphological, physiological, and chemical structure of this variety might be attracted *A. gossypii*. Ullah (1978) investigated in relationship between *A. gossypii* and hairy intensity of cotton varieties in Pakistan and put forwarded that the less hairy varieties the less affected than hairier varieties. Dunnam and Clark (1939)

indicated that *A. gossypi* more prefers hairy cotton varieties than the other varieties. Moreover, it could be concluded that this variety has different chemical component so resist to *A. gossypii* prevent damage of pest and its development. Because the presence of cucurbitaceous has been associated with the toxic effect of cucumber leaves, which proved that cucurbitaceous evolved in wild cucurbits as a mechanism to protect them from generalized herbivores such as *Tetranychus urticae* (Koch) (Andeweg and De Bruyin 1959, Da Costa and Jones 1971). The first nymphs produced by adult females could have occurred any time during the 24h intervals between observations. Additionally, as occurred in this study, O'Brien and Graves (1992) noted high reproductive rate early compared to late in an aphid's life. *A. gossypii* fecundity performance and life expectancy were the highest at the beginning adult days and decreasing gradually day by day with the advancement of the age (Shah et al. 2007). Although the effect of watermelon varieties on life table parameters of *A. gossypii* was determined, but for controlling this polyphagous pest species further studies should be carried out.

ACKNOWLEDGMENTS

We are indebted to Prof. Dr. Hsin Chi for his personal assistance and his life table program (Age Stage, two-sex life table analysis). We are also thankful for providing us to carry out this project for their assistance and supporting "Scientific Research Projects Coordination of Dicle University" (DUSRPC Project No: 10-ZF-08) and "General Directorate of Agricultural Research and Policies of Ministry of Food, Agriculture and Livestock" (GDAR Project No: 10 / 10-01 / 01-06)

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