Evaluation of Antibiosis Resistance in Eight Melon Genotypes to *Tetranychus urticae* (Acari: Tetranychidae)

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Summary: According to previous researches, most of the *Tetranychus urticae* (Koch, 1836) controlling programs specifically in melon are unsuccessful; hence researchers suggest that using of resistant genotypes would be the best way to control the pest. So, resistance of eight applicable melon genotypes including Barg ney, Garmak Isfahan, Rish baba, Shah abadi, Khatooni, Amir panji, Yellow qanari and Ananasi in 250 replications to *T. urticae* were evaluated in laboratory conditions at 25±1°C, relative humidity of 60±5% and a photoperiod of 16L:8D hours. Biological and life table parameters of *T. urticae* on melon genotypes were determined in laboratory experiments. The results indicated that the shortest adult longevity was recorded for males and females reared on Rish baba and Shah Abadi, respectively. The range of oviposition period was from 6.00±1.49 days on Shah Abadi to 9.21±1.57 days on Amir panji. In addition, the highest amount of net reproductive rate [6.69±1.29] and intrinsic rate of increase [0.126±0.014] and the lowest value of generation time [15.19±0.56 days] were obtained when the two spotted spider mites fed on Barge Ney. Besides, Ananasi was the genotype with the lowest amount of net reproductive rate [0.70±0.08] and intrinsic rate of increase [0.011±0.003] and the highest value of generation time [29.98±0.84 days]. Based on biology and life table parameters, Barge Ney was the most favorable genotype for development of *T. urticae*, while Ananasi was the most inadequate for the mite development.

Key words: Antibiosis, Biology, melon, population growth parameters *Tetranychus urticae*

Introduction

Among the mites belong to the family Tetranychidae, the two spotted spider mite, *Tetranychus urticae* (Koch, 1836) (Acari: Tetranychidae), is the one that can cause damages to cucurbits such as melon. In hot and dry weather huge scale commercial melon *Cucumis melo* (Linnaeus, 1758) is cultivated and commonly attacked by mites that have over 20 generations per year (Scully *et al.* 1991). So, the mite can amplify its population which is economically detrimental in suitable conditions due to the short generation time and high net reproductive rate (Carey and Bradley 1982). This mite damages the leaf of plants by producing irregular patterns of small light colored spots (Scully *et al.* 1991) and network of webs that cover the lower leaf surface and petiole region (Davidson and Lyon 1979). Production of host plants reduces because of the destruction of chloroplast in leaves and subsequently declination of photosynthesis (Martinez-Ferrer *et al.* 2006). Chemical control is the main method of combating the two spotted spider mite (Badii *et al.* 2004) and nowadays most fields are treated with acaricides to control the pest (DeAngelis *et al.* 1983; Morris *et al.* 1996) while these treatments impact natural enemies via lethal and/or sublethal effects (Croft 1990, Desneux *et al.* 2007). In addition, the mite populations can rapidly develop resistance to acaricides after application for several times. So, there must be an alternative method to control the two spotted spider mite which should be safe and practical. However, host plant resistance is the strategy for sustainable management of *T urticae* in order to decrease pesticide applications. Moreover, effecting on plant development, pest population augmentation, herbivores damages and efficiency of natural enemies are the advantages of host plant resistance (Zehnder *et al.* 2007). Besides, host plants have a great influence on both biology and reproductive potential of the pest because the chemical contents and morphology of the leaf surface of host plants are the factors that can affect the reproduction; mortality and developmental rate of the mite (Toros 1974, Van de Vrie *et al.* 1972) So, usage of host plant resistance method is an assured way to immune natural enemies. The present study was designed primarily to provide data on biology and fecundity of a population of *T. urticae* on different melon genotypes under laboratory conditions and consequently to evaluate resistance of these experimental melon genotypes against the mite.

Materials and methods

1.1. Plant and mite culture

Melon genotypes availed in this study was chosen on the basis of ordinarily applicable melon genotypes. Seeds of eight melon genotypes including Barg ney, Garmak Isfahan, Rish baba, Shahabadi, Khatooni,

Amir panji, Yellow canary and Ananasi were tested to determine the host plant genotypes effects on biology and population growth parameters of *T. urticae*. The seeds of melon genotypes were obtained from laboratory of Horticulture department, University of Tehran. Melon plants were subsequently grown in pots of 15 cm diameter filled with sterilized potting media (cocopit and perlit) and held in a greenhouse at 25±5°C, 50±20% RH, and a photoperiod with at least 16 h of light. Application of Christalon (containing Fe, Mg, Zn, Cu) was made in order to nourishing the plants. Only the leaves at the 5-6 true leaf stage were used to organize leaf discs for using in the experiments. The mite populations were maintained for at least one generation on each genotype before experiments' commencement.

A colony of two spotted spider mite was established from a collection made on infested greenhouses of Pakdasht in Tehran province, Iran. The mites were reared in growth chamber on bean plants *Phaseulus vulgaris* (Linnaeus, 1758); held at a temperature of 25±1°C, relative humidity of 60±5% and a photo period of 16L:8D hours. Regular addition of new infested bean plants was performed to conserve the colony.

1.2. Antibiosis tests

The biology and population growth parameters of *T. urticae* were determined on experimental melon genotypes at 25±1°C, 60±5% r.h. and a photoperiod of 16L:8D hours. To perform the experiments, the leaf disc method was used (Naher *et al.* 2006). The experiments were done in 250 replications. Females of *T. urticae* were transferred to leaf discs and after 24 hours females and excessive eggs were removed. Incubation period of egg stage, developmental times and survivorship of larvae, nymphs and quiescent stages were monitored and recorded every 12 hours until adulthood. After emergence of the adults and providing mates for females, eggs were counted daily until the last female was died, in order to attain female longevity, and duration of pre-oviposition, oviposition and post-oviposition periods. To prevent nutritional deficiencies, every 5-6 days leaf discs were changed with fresh ones.

1.3. Statistical analysis

All demographic parameters were calculated based on Carey (2001). The effect of different melon genotypes on different parameters was analyzed by one-way-ANOVA. The jackknife technique (Maia *et al.* 2000) was used to calculate the variance of the population growth parameters. For each parameter, differences among parameters on different genotypes were determined by Student- Newman- Keuls (SNK) test.

Results

2.1. Developmental time

The mean developmental time of *T. urticae* on eight melon genotypes for both sexes are summarized in Table 1. There was no significant difference among the mean duration of embryonic development, Deutochrysalis, Deutonymph and Teliochrysalis on different genotypes for both sexes. It can be derived from the data that females and males fed on Khatooni and Barge Ney spent more time in larval stage. In addition, the maximum value of protochrysalid viability was recorded on Shah Abadi and Yellow canary for females and males, respectively. Furthermore, Protonymph period of the females lasted 1.73 days to the utmost on Khatooni and ranged from 0.50±0.00 to 1.20±0.20 days for males. According to obtained data, it didn't cause any statistical difference in the duration of total developmental time, longevity and life span when females and males were nourished on each eight melon genotypes. The results indicated that feeding on Shah Abadi caused females passed the total developmental time longer than other females (15.50±2.02 days) while males survived this stage the most when they fed on Barge ney (14.30±2.20 days). In addition, the shortest adult longevity was recorded for the males and females reared on Rish baba and Shah Abadi, respectively (9.08 days).

2.2. Oviposition period and fecundity

All reproductive periods and fecundity of female mites which reared on eight melon genotypes are depicted in Table 2. According to data, females were generally found to have the longest pre-oviposition period on Ananasi (5.33±1.64 days). It can be also revealed that the maximum number of days that females spent in oviposition period was 9.21±1.57 days on Amir Panji and Khatooni caused females maintain in post-oviposition period for 1.09 days; longer than other genotypes. Furthermore, females laid the least number of eggs per oviposition day when they were reared on Shah Abadi (1.68±0.35 eggs). Additionally, the mites demonstrated the highest total fecundity when fed on Rish baba (37.29±7.77 eggs) and Shah Abadi showed the minimum value (11.50±2.88 eggs) but there was no significant difference among genotypes.

2.3. Age-specific survival rate (l_x)

The charts of age-specific survival rates (l_x) on various melon genotypes are exhibited in Figure 1. Survival rate at age of adult emergence of *T. urticae* on Barge Ney was 23.44% which was the highest value of l_x and befallen on day 9. The most mortality percentage of the mite at the same age occurred when they reared on Amir Panji (93.09%).

Table 1. The mean (±SE) of different development stages, adult longevity and life span of *Tetranychus urticae* (Koch, 1836), female and male, on different melon genotypes.

Stages	sex	P-value	Ananasi	Yellow canary	Amir panji	Khatooni	Shah abadi	Rish baba	Garmak Isfahan	Barge ney
Egg	♀	0.1499	5.50±0.28^{a}	5.00±0.20^{a}	5.75±0.17^{a}	5.61±0.27^{a}	6.16±0.38^{a}	6.05±0.33^{a}	5.22±0.14^{a}	5.61±0.31^{a}
	♂	0.3283	5.50±0.00^{a}	5.16±0.33^{a}	5.50±0.00^{a}	5.16±0.27^{a}	4.80±0.60^{a}	5.50±0.15^{a}	5.40±0.18^{a}	6.30±0.60^{a}
Larvae	♀	0.0001	2.00±0.28^{ab}	1.80±0.17^{ab}	1.75±0.11^{ab}	2.41±0.27^{a}	1.10±0.10^{b}	1.33±0.23^{b}	1.33±0.16^{b}	1.21±0.12^{b}
	♂	0.6513	1.00±0.00^{a}	1.33±0.33^{a}	1.00±0.00^{a}	1.41±0.23^{a}	1.00±0.00^{a}	1.16±0.27^{a}	1.30±0.20^{a}	1.60±0.29^{a}
Protochrysalis	♀	0.0186	1.00±0.00^{ab}	1.32±0.14^{ab}	1.08±0.08^{ab}	1.38±0.12^{ab}	1.66±0.30^{a}	1.38±0.13^{ab}	0.66±0.08^{b}	1.30±0.15^{ab}
	♂	0.9787	1.00±0.00^{a}	1.33±0.33^{a}	1.00±0.00^{a}	1.16±0.16^{a}	1.30±0.25^{a}	1.08±0.20^{a}	1.00±0.15^{a}	1.10±0.40^{a}
Protonymph	♀	0.0021	1.50±0.00^{ab}	1.07±0.16^{ab}	1.33±0.10^{ab}	1.73±0.16^{a}	1.41±0.15^{ab}	1.50±0.09^{ab}	1.33±0.11^{ab}	0.88±0.14^{b}
	♂	0.6994	0.50±0.00^{a}	0.66±0.16^{a}	0.66±0.16^{a}	1.00±0.22^{a}	1.20±0.20^{a}	0.91±0.15^{a}	0.80±0.20^{a}	1.10±0.36^{a}
Deutochrysalis	♀	0.2821	1.83±0.16^{a}	1.30±0.13^{a}	1.25±0.11^{a}	1.03±0.08^{a}	1.25±0.25^{a}	1.22±0.08^{a}	1.05±0.15^{a}	1.41±0.18^{a}
	♂	0.9622	1.00±0.00^{a}	1.00±0.00^{a}	0.83±0.16^{a}	1.08±0.23^{a}	1.10±0.10^{a}	1.00±0.22^{a}	1.20±0.12^{a}	1.12±0.12^{a}
Deutonymph	♀	0.1259	1.50±0.28^{a}	1.46±0.20^{a}	0.91±0.15^{a}	1.30±0.12^{a}	1.58±0.08^{a}	1.88±0.42^{a}	1.27±0.12^{a}	1.13±0.11^{a}
	♂	0.2892	1.00±0.00^{a}	1.00±0.00^{a}	0.66±0.16^{a}	1.16±0.27^{a}	1.60±0.29^{a}	1.40±0.29^{a}	1.00±0.00^{a}	0.90±0.18^{a}
Teliochrysalis	♀	0.2636	1.83±0.16^{a}	1.60±0.22^{a}	1.25±0.11^{a}	1.37±0.16^{a}	1.30±0.12^{a}	1.11±0.16^{a}	1.36±0.12^{a}	1.13±0.13^{a}
	♂	0.5776	1.00±0.00^{a}	1.00±0.00^{a}	1.33±0.16^{a}	1.58±0.39^{a}	1.10±0.10^{a}	1.08±0.20^{a}	1.00±0.15^{a}	1.50±0.27^{a}
Total	♀	0.1688	15.16±0.72^{a}	13.28±0.48^{a}	13.33±0.45^{a}	15.38±0.85^{a}	15.50±2.02^{a}	14.77±0.99^{a}	12.50±0.43^{a}	13.05±0.87^{a}
	♂	0.5033	11.00±0.00^{a}	10.50±0.50^{a}	11.00±0.00^{a}	12.58±0.67^{a}	12.10±0.62^{a}	13.33±0.98^{a}	11.70±0.75^{a}	14.30±2.20^{a}
Longevity	♀	0.4804	12.33±0.72^{a}	10.46±1.16^{a}	13.66±1.88^{a}	10.72±0.53^{a}	9.08±1.12^{a}	10.64±0.96^{a}	9.66±1.74^{a}	10.17±1.15^{a}
	♂	0.1754	10.50±0.00^{a}	9.50±1.32^{a}	12.00±1.04^{a}	10.58±1.65^{a}	13.80±0.71^{a}	9.08±1.04^{a}	10.80±0.51^{a}	10.50±1.01^{a}
Life span	♀	0.2834	26.00±1.55^{a}	24.38±0.94^{a}	27.00±1.94^{a}	26.50±1.07^{a}	22.91±2.67^{a}	24.71±1.04^{a}	21.50±1.49^{a}	22.42±2.04^{a}
	♂	0.5492	21.50±0.00^{a}	25.00±3.75^{a}	23.00±1.04^{a}	23.16±1.43^{a}	25.90±0.91^{a}	22.41±0.87^{a}	22.50±0.63^{a}	24.80±1.73^{a}

The means followed by same letters in each row are not significantly different ($p \leq 0.05$, SNK).

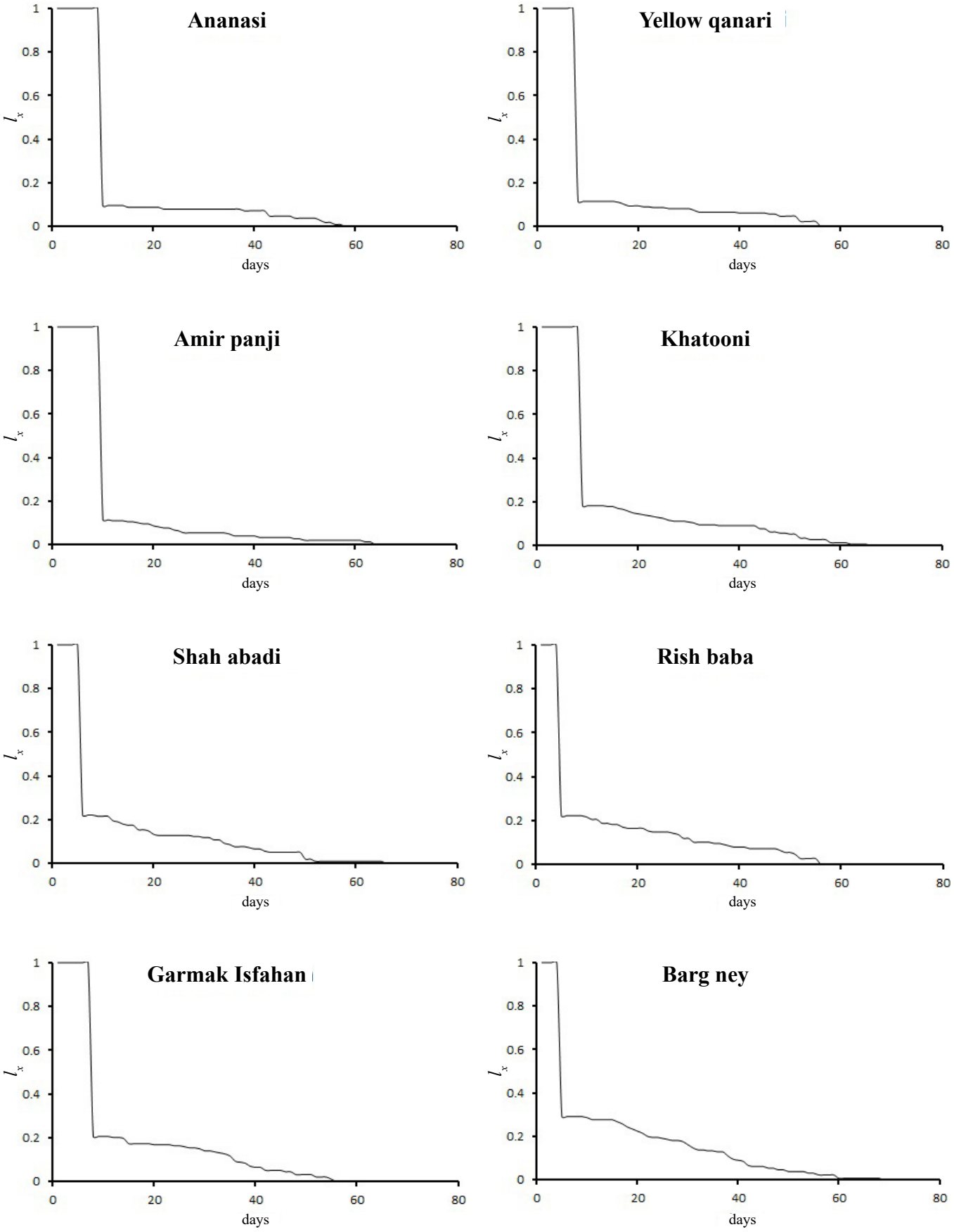

Fig 1. Age-specific survival rate (l_x) of *Tetranychus urticae* (Koch, 1836) on different melon genotypes.

2.4. Population growth parameters

According to the data presented in Table 3, the intrinsic rate of increase (r_m) of the mite was the highest in Barge Ney. However, the r_m value of spider mites calculated on the eight experimental genotypes in this study was ranged from 0.011 to 0.126 individuals per female per day. In addition, the net reproductive rate (R_0) was 6.69 on Barge Ney and 0.70 on Ananasi which was the maximum and minimum values, respectively. Additionally, the finite rate of increase (λ) on Barge Ney was higher (1.134) than on other genotypes. However, this parameter was lower on Ananasi (0.988) as compared to the other melon genotypes. Besides, the lowest values of mean generation time and doubling time were recorded when the mites reared on Barge Ney. The population of the mite doubled once every 5.84 days on Barge Ney and 62.31 days on Khatooni which were the shortest and longest duration of *DT*, respectively. Furthermore, among the tested genotypes, the cohort nurtured on Barge Ney was superlative in gross reproduction rate (GRR).

Discussion

Today, there is infrequent information about the evaluation of resistance in melon genotypes to *T. urticae* and this study comprehensively present profitable data in the case of this issue and totalize our previous findings in this context. It can be derived from Table 1 that different tested melon genotypes couldn't apply any significant difference on various developmental periods of males. Plant chlorophyll malnutrition in males may be the proof of this matter. Our results also showed that the embryonic developmental time was longer than periods of the other pre-imaginal stages. According to data of these experiments, the mean duration of embryonic development of the mites on melon genotypes was longer than those Modarres Najafabadi *et al.* 2012 were reported on bean varieties (2 days). In addition, the duration of female larval stage and longevity on experimental melon genotypes were close to those related by other researchers on different host plant species (Kasap 2004, Razmjou *et al.* 2009; Sedaratian *et al.* 2009) and didn't confirm the data acquired by some other researchers (Skorupska 2004, Razmjou *et al.* 2009, Sedaratian *et al.* 2009; Modarres Najafabadi 2012). These diversities might be due to the effect of host plant species followed by differences in nutrients and allelochemichals, and experimental conditions. Also, regarding to the effect of geographical regions, the primary mite populations applied in these studies, might have variable specifications which could lead to diverse conclusions and effects.

According to data of all reproductive periods, the best reproductive implementation of the mite was on Amir Panji due to the longest oviposition period; the longest egg laying duration, the more population for the subsequent generations. The data obtained in this study for duration of oviposition period are in accordance with Modarres Najafabadi (2012) results on bean genotypes (6.98 – 8.95). Conversely, the length of oviposition period reported by Kasap (2004) for the same species on apple cultivars was ranged from 17 to 23.8 days which was two times higher than our results. Also, Nazeh *et al*. (2012) found that the oviposition period of *T. urticae* was 11.8 and 14.4 days on two pear varieties and the duration of this period was 12.06 days in the study conducted by Razmjou *et al*. (2009) on soybean varieties. These adversities may relate to the differences in host plant species and consequently the leaf structure, especially the form and number of trichomes. Since thick and dense leaf piles act as disrupt elements for laying eggs (Peters and Berry 1980a, b, Yano *et al.* 1998). Besides, although females nourished on different melon genotypes, no significant effect was observed for daily and total fecundity.

The age-specific survivorship curves of the mite demonstrated similar trends on all experimental melon genotypes. The curves were dominantly downward in association with the age of the mites as the downturn was steep at the early ages and then decreased gradually. As mites in each developmental phase had dissimilar responses to a particular genotype, the survival rates are variable adjusting to various developmental stages of the pest. An illustration of what it means is the extreme slump in survivorship curves of the embryonic developmental stage in all tested genotypes.

Principally, the intrinsic rate of increase (r_m) solely summarizes adequate information about the physiological qualities of a particular species related to its increase capacity. Since all elements that influence development, reproduction, survival and generation time of a pest can modify the value of r_m, this parameter is a reasonable indicator for evaluating the performance of a pest on various plant species and resistance of a host plant to a particular pest (Southwood and Henderson 2000). While high levels of r_m are indicative of the host plant susceptibility to damaging pest, low levels of this parameter are indicative of their resistance against the pest. According to data, the highest value of r_m, R_0 and finite rate of increase was observed in mites fed on Barge Ney. So, *T. urticae* had the greatest opportunity for population increase on this genotype. Besides, Ananasi was an unsuitable host plant, suggesting that it is more resistant to two-spotted spider mite than other genotypes. To compare, the intrinsic rate of increase for *T. urticae* was ranged from 0.231 to 0.243 on apple cultivars (Kasap 2004) which was higher than those acquired on melon genotypes. Also, the value of r_m obtained in this study was lower than the values declared by Razmjou *et al*. (2009) on soybean varieties (0.211 to 0.292) and Modarres Najafabadi (2012) on bean cultivars 0.129 to 0.269 for the same species. The possible reason for disagreement of these data compared with our data are due to the chemical quiddity along with quality and quantity of contents in host plant species which can affect the pest physiology and

Table 2. The mean (±SE) pre- and post-oviposition periods and fecundity of *Tetranychus urticae* (Koch, 1836) reared on different melon genotypes.

Genotypes	Pre-oviposition period	Oviposition	Post-oviposition period	Daily fecundity	Total fecundity
Barge ney	1.41±0.07^{b}	7.92±1.04^{a}	0.64±0.26^{a}	4.09±0.62^{a}	36.00±7.18^{a}
Garmak Isfahan	1.85±0.38^{b}	6.57±1.73^{a}	0.28±0.18^{a}	2.66±0.67^{a}	22.14±7.55^{a}
Rish baba	1.72±0.31^{b}	8.57±1.06^{a}	0.28±0.19^{a}	3.41±0.58^{a}	37.29±7.77^{a}
Shah abadi	1.50±0.27^{b}	6.00±1. 49^{a}	0.83±0.40^{a}	1.68±0.35^{a}	11.50±2.88^{a}
Khatooni	1.71±0.11^{b}	7.36±0.56^{a}	1.09±0.62^{a}	2.43±0.33^{a}	17.82±2.72^{a}
Amir panji	2.00±0.12^{b}	9.21±1.57^{a}	0.83±0.47^{a}	2.98±0.09^{a}	32.83±5.35^{a}
Yellow Canary	2.23±0.37^{b}	6.61±1.23^{a}	0.66±0.22^{a}	2.53±0.47^{a}	22.77±5.82^{a}
Ananasi	5.33±1.64^{a}	6.66±0.88^{a}	0.33±0.33^{a}	1.76±0.14^{a}	11.67±1.45^{a}
P-value	≤0.0001	0.3178	0.8322	0.0326	0.0558

The means followed by same letters in each column are not significantly different ($p \leq 0.05$, SNK).

Table 3. The population growth parameters (±SE) of *Tetranychus urticae* (Koch, 1836) on different melon genotypes.

parameters	Barge ney	Garmak Isfahan	Rish baba	Shah abadi	Khatooni	Amir panji	Yellow canary	Ananasi	***P*-value**
r_m	0.126±0.014^{a}	0.071±0.018^{ab}	0.082±0.009^{ab}	0.019±0.004^{b}	0.033±0.009^{b}	0.031±0.009^{b}	0.060±0.015^{ab}	0.011±0.003^{b}	≤0.0001
R_0	6.69±1.29^{a}	3.30±0.81^{ab}	3.46±0.72^{ab}	0.86±0.21^{b}	1.42±0.21^{b}	1.51±0.24^{b}	1.72±0.44^{b}	0.70±0.08^{b}	≤0.0001
λ	1.134±0.016^{a}	1.073±0.020^{ab}	1.086±0.010^{ab}	0.994±0.010^{c}	1.021±0.009^{bc}	1.026±0.009^{bc}	1.035±0.015^{bc}	0.988±0.003^{c}	≤0.0001
T	15.19±0.56^{c}	15.26±0.27^{c}	17.43±0.26^{c}	25.36±0.10^{b}	17.13±0.65^{c}	16.30±0.46^{c}	16.69±0.54^{c}	29.98±0.84^{a}	≤0.0001
DT	5.84±0.54^{c}	8.96±2.77^{c}	9.06±1.47^{c}	37.53±6.954^{b}	62.31±7.19^{a}	45.71±2.48^{b}	38.60±4.65^{b}	41.34±15.83^{b}	≤0.0001
GRR	43.35±7.024^{a}	28.12±4.774^{ab}	27.08±5.484^{ab}	9.74±0.934^{b}	18.95±2.124^{ab}	25.34±2.454^{ab}	30.80±5.06^{ab}	10.75±0.66^{b}	0.002

The means followed by same letters in each row are not significantly different ($p \leq 0.05$, SNK).

contractions between host plant and the pest (Stoute *et al.* 2006). One more proof for these discrepancies can be expressed as the intrinsic rate of increase is sui generis for each specific pest species and is variable in various environmental conditions. Accordingly, obtained data from this study are indicative of the striking resistance of melon genotypes to *T. urticae* which could be the most important and pragmatic way to suppress the mite population in cooperation to other methods. Indeed, applying resistant plants is so beneficial since it decreases the necessity of frequent application of pesticides and therefore conserves the population of natural enemies (Desneux *et al.* 2007). However, more studies should be conducted to learn more about the resistant plants, the compounds and enzymes that cause different types of resistance in various host plants and the performance of *T. urticae* on different host species in laboratory and field conditions.

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