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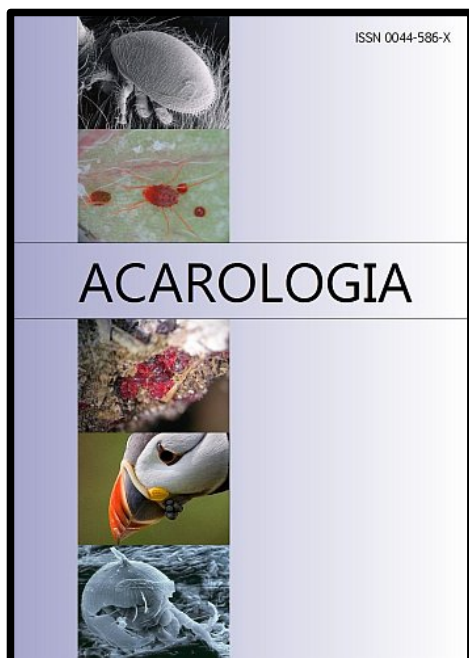
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Comparative life table analysis of *Tetranychus urticae* Koch (Acari: Tetranychidae) on ten rose cultivars

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ABSTRACT — Life history parameters of plant feeders are useful tools to evaluate resistance or susceptibility of host plants including different cultivars. This study compared population growth parameters of *Tetranychus urticae* Koch on 10 rose cultivars, including Bella Vita, Cool Water, Dolce Vita, Maroussia, Orange Juice, Pink Promise, Roulette, Tea, Valentine, and Persian yellow in laboratory conditions at 24 ± 1 °C, $65\pm 5\%$ relative humidity, and a photoperiod of 16:8 (L:D) h. The results revealed that mite survival rate varied from 66.5% on Bella Vita to 85.9% on Persian yellow. The immature development time was different among the tested rose cultivars and ranged from 9.35 days on Orange Juice to 12.30 days on Bella Vita. The highest fecundity rate was recorded on Pink Promise. Consequently, population growth parameters were also significantly affected. The lowest intrinsic rate of increase (r_m) was recorded on Roulette and this parameter was relatively higher on Cool Water, Orange Juice, and Persian yellow. In addition, the highest net reproductive rate (R_0) was observed on Pink Promise, which was significantly higher than Roulette, Tea, and Valentine cultivars. The longest mean generation time (T) was calculated on Roulette and the shortest on Cool Water, Tea, and Orange Juice. The lowest performance of the two-spotted mite on Roulette could indicate that this is a suitable cultivar against mite infestation. Differences in mite susceptibility of tested rose cultivars here highlighted have the potential to be used for integrated pest management of *T. urticae* in ornamental rose cultivations.

KEYWORDS — two-spotted spider mite; development; life table; fecundity; plant resistance; rose plant

INTRODUCTION

The cultivation of ornamental plants that are used as cut flowers, flowering, and non-flowering potted plants is an important component in agriculture (Peronti and Sousa-Silva, 2002). Among the ornamental plants, rose plants of *Rosa* spp. (Rosaceae) with their showy and often fragrant blooms are important ornamental shrubs and an exceptionally valuable decorative element of green areas in the cities (Jaskiewicz, 2006; Bidarmania *et al.*, 2015). Dif-

ferent rose species and cultivars are cultivated because of their habits, effective coloring of the leaves in different seasons, as well as their decorative fruit. In addition to ornamental aspects of rose plants, valuable rose oils distilled from rose petals are used for the production of medicinal agents, perfumes, cosmetics, and other aromatherapy products utilized in the industry (Seneta and Dolatowski, 2003; Jaskiewicz, 2006; Demirozer, 2012).

Rose is the most popular perennial ornamental

plant all over the world (Bidarmania *et al.*, 2015). Rose plants are cultivated in most countries in the northern hemisphere such as in China, France, Bulgaria, Egypt, India, Morocco, Turkey, and Iran (Demirozer, 2012). Roses are susceptible to several pests and diseases that reduce flower growth and quality. The phytophagous two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), has a broad host-plant range and is a serious pest of several crops worldwide (Tsagkarakou *et al.*, 2002; Tehri, 2014). This mite is a generalist species that can feed on hundreds of host plants and causes considerable damage to field, greenhouse and horticultural crops, as well as ornamental and fruit-bearing trees including Rosa (Helle and Sabelis, 1985; Sedaratian *et al.*, 2010; Jafari *et al.*, 2012; Jalalvandi *et al.*, 2015).

Feeding activity of spider mite leads to the appearance of typical yellow chlorotic spots on leaves with profuse webbing on the underside of leaves. In severe infestations, leaves may fall and the flowering may be considerably reduced (Khodayari *et al.*, 2008). The short life span and high reproductive potential causes a fast-growing population that allows the mite to achieve economic injury level in appropriate conditions, resulting in a rapid decline of host plant yield and quality (Carey and Bradley, 1982; Fathipour *et al.*, 2006).

The control of this mite has relied on conventional chemical control (Badii *et al.*, 2004), with frequent pesticide applications to achieve effective control. However, due to fast development rate, high fecundity and ability to develop resistance to most available pesticides (Cranham and Helle, 1985; Hoyt *et al.*, 1985), this mite is difficult to control with pesticides. Therefore, the use of alternative control measures is needed against this mite due to the difficulties associated with its control and the huge economic losses it causes on many crops. Host plant resistance is an alternative, safe procedure for limiting herbivores because it is economically and environmentally secure (Wermilinger *et al.*, 1991; Panda and Khush, 1995; Li *et al.*, 2004; Zehnder *et al.*, 2007). Three mechanisms, called antixenosis, antibiosis, tolerance, or some combinations are known as being involved in plant resis-

tance to pests (Painter, 1951; Kogan and Ortman, 1978; Smith, 2005). Among them, antibiosis is the most important. It has a direct effect on the survival and developmental rates, adult longevity, and fecundity (Sedaratian *et al.*, 2010; Khanamani *et al.*, 2012).

At present, *T. urticae* is one of the most important pests of rose shrub all over the world (Grbic *et al.*, 2011; Bidarmania *et al.*, 2015). Despite the economic importance of this mite, little information is available concerning the development and reproduction of this pest on various rose cultivars. Hence, in current research, it was planned to investigate the development, longevity, and reproductive potential of *T. urticae* in relation to different rose cultivars affecting population growth. Results here presented provide complementary knowledge on resistant rose cultivars which could be useful in predicting the spider mite population growth. It can then contribute to enhance integrated pest management programs for this mite in urbanized areas and commercial Rosa potting breedings.

MATERIALS AND METHODS

Stock cultures

The shrubs of ten rose cultivars used in this study were obtained from Rose Farm Incorporation in Tehran, Iran. They are the most commonly cultivated rose cultivars in commercial floricultures and urbanized areas in Iran. All the rose cultivars were imported ones, including Bella Vita, Cool Water, Dolce Vita, Maroussia, Orange Juice, Pink Promise, Roulette, Tea, Valentine, and Persian yellow. All the selected cultivars had similar external characteristics such as leaf color and density of leaf pubescence, except for flower size and color. All the plants were kept in a greenhouse at 25 ± 5 °C, 50-70% relative humidity, and natural light conditions (14-16 hours of light during plant growing season in Ardabil, northwest of Iran). All rose cultivars were grown in 30 cm pots filled with suitable soil, which was composed of 60% loam soil with 40% additives such as peat, sand, sawdust, and manure to improve physical soil traits. In order to establish spider mite colonies, two shrubs of each rose cultivar were kept in large

wood-framed cubic cages ($2 \times 2 \times 1$ m) and were infested with *T. urticae*. The mites used in the experiments were originally collected from rose shrubs grown in university campus in Ardabil, Iran, during May 2012 and were transferred onto related host plants in the greenhouse. Spider mites were reared for at least four generations before they were used for the experiments.

Development and mortality

All the experiments were conducted in a growth chamber at 24 ± 1 °C, $60 \pm 5\%$ relative humidity, and a photoperiod of 16:8 (L:D) h. To evaluate the developmental time and immature survival rate, adult mites were randomly selected from the rearing colonies and placed on the leaf discs of host plant using a fine-hair brush. Leaf discs of host plants were cut and placed upside down on a cotton layer in petri dishes (8 cm diameter $\times$ 2 cm height) with an opening in the center of the lid for ventilation. The discs were surrounded with wet cotton to keep the leaf discs fresh and avoid the escape of mites. Three terminal branches of rose bushes were selected for testing. The last three leaves from apical part on each of the selected branches were cut and each leaf was confined inside a petri dish.

In order to do the experiments, pairs of female and male mites were randomly selected from the colony and transferred onto each leaf disc. The mites were allowed to mate and lay eggs for 24 hours. After this period, a newly laid egg was selected to remain in the cage and all the other adults and eggs were removed. Overall, there were five potted plants for each rose cultivar to evaluate the development and survival rate of 60 individualized eggs per treatment. These leaf discs were checked daily under a stereomicroscope and mortality and survivorship of different stages were recorded. The observations continued until the emergence of adults.

Reproduction and life table parameters

After maturity and adult appearance, the females were coupled with males obtained in the same experiment on respective cultivars. Each pair of female and male adults in a petri dish was considered

as a replication unit and there were a total of 20 replicates for each examined cultivar. Daily observations were made to determine female fecundity and survivorship of individuals until the death of the last female mite. The reproduction period, adult longevity, and fecundity rate were determined. The following population growth parameters were calculated from fertility and survivorship schedules (Birch, 1948; Carey, 1993): intrinsic rate of increase (r_m), mean generation time (T), finite rate of increase (λ), net reproduction rate (R_0), gross reproduction rate GRR, and doubling time (DT).

Statistical analysis

Effect of rose cultivars on developmental time, reproduction period, adult longevity, and fecundity was analyzed using one-way ANOVA. If significant differences were detected, multiple comparisons were made using Student-Newman-Keuls (SNK) method ($P < 0.05$). Statistical analysis was performed using SPSS statistical software version 16.0 (SPSS, 2007). Differences in R_0 , T , λ , DT , and r_m values were tested for significance by estimation of variances through Jackknife procedure (Maia *et al.*, 2000).

RESULTS

Development and mortality

Tetranychus urticae successfully developed to adulthood on all rose cultivars examined and the results of its biological attributes, including immature survival rate and developmental times, are presented in Table 1. The survivorship of immature stages (from egg to adult) was ranged from 66.50% on Bella Vita to 85.92% on Persian yellow.

Development times of all immature stages, including incubation period ($F = 6.261$; $df = 9,528$; $P < 0.01$), larval period ($F = 7.671$; $df = 9,499$; $P < 0.01$), and nymphal period ($F = 9.285$; $df = 9,453$; $P < 0.01$) were affected by the rose cultivar. Moreover, total development time (from egg to adult) of *T. urticae* was significantly affected by host plants ($F = 32.136$; $df = 9,453$; $P < 0.01$) and this mite developed faster on Orange Juice cultivar. Total developmental

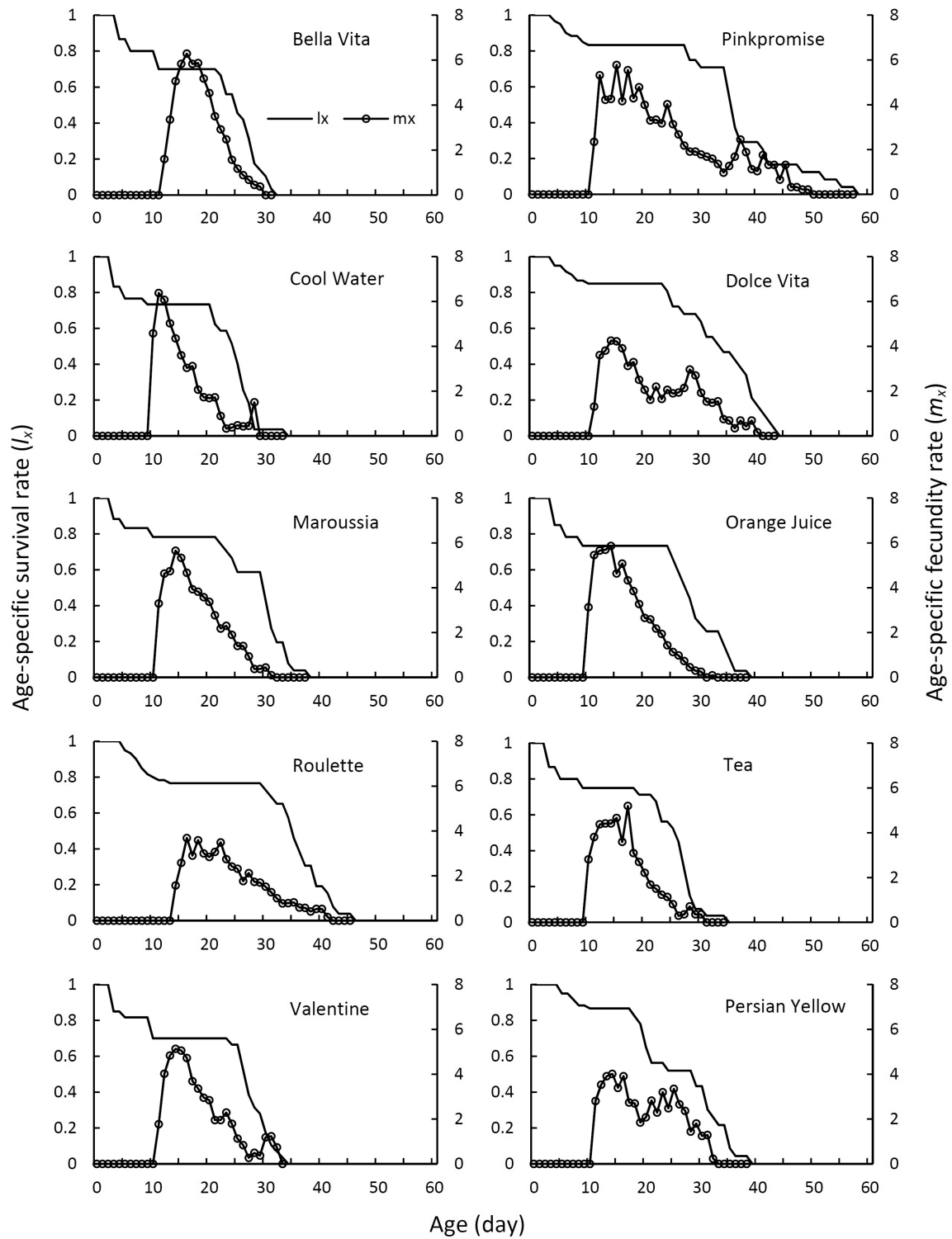


FIGURE 1: Age-specific survival rate (l_x) and age-specific fecundity (m_x) of *Tetranychus urticae* on ten rose cultivars.

TABLE 1: Immature survival rate (%) and developmental time (mean $\pm$ SE) of *Tetranychus urticae* reared on various rose cultivars.

Rose cultivar	Immature survival rate (%)	Developmental time (day)			
		Egg incubation	Larval period	Nymphal period	Total developmental time (egg to adult)
Bella Vita	66.5	4.75 $\pm$ 0.16 a	2.60 $\pm$ 0.11 a	4.95 $\pm$ 0.14 a	12.30 $\pm$ 0.13 a
Cool Water	70.29	4.10 $\pm$ 0.10 bcd	1.80 $\pm$ 0.09 abc	4.05 $\pm$ 0.11 cd	9.95 $\pm$ 0.13 d
Dolce Vita	84.18	4.85 $\pm$ 0.13 a	2.05 $\pm$ 0.08 ab	4.65 $\pm$ 0.20 ab	11.55 $\pm$ 0.17 b
Maroussia	76.68	4.05 $\pm$ 0.05 cd	1.85 $\pm$ 0.08 abc	4.90 $\pm$ 0.10 a	10.80 $\pm$ 0.12 c
Orange Juice	70.77	4.00 $\pm$ 0.16 d	1.70 $\pm$ 0.10 bc	3.65 $\pm$ 0.11 d	9.35 $\pm$ 0.18 e
Pinkpromise	82.33	4.15 $\pm$ 0.08 bcd	1.80 $\pm$ 0.09 abc	4.05 $\pm$ 0.08 cd	10.00 $\pm$ 0.13 d
Roulette	76.78	4.60 $\pm$ 0.24 ab	2.20 $\pm$ 0.17 a	4.20 $\pm$ 0.19 bc	11.00 $\pm$ 0.24 c
Tea	72.75	3.95 $\pm$ 0.08 d	1.60 $\pm$ 0.11 c	4.25 $\pm$ 0.12 bc	9.80 $\pm$ 0.17 d
Valentine	66.8	4.55 $\pm$ 0.12 abc	1.75 $\pm$ 0.09 bc	4.35 $\pm$ 0.13 bc	10.65 $\pm$ 0.16 c
Persianyellow	85.92	4.40 $\pm$ 0.12 abcd	2.00 $\pm$ 0.00 abc	4.70 $\pm$ 0.11 ab	11.00 $\pm$ 0.07 c

Mean values in a column followed by different lowercase letters are significantly different on the basis of ANOVA with Student-Newman-Keuls procedure (SNK) ($P < 0.05$).

time ranged from 9.35 ± 0.18 days on Orange Juice to 12.30 ± 0.13 days on Bella Vita rose cultivars. The age-specific survival rate (lx) of *T. urticae* on ten rose cultivars is shown in Figure 1. Age-specific survival rate generated similar curves among the cultivars. However, the declining trend of survival rate was slower on Pink Promise than the other cultivars.

Adult longevity and fecundity

Different rose cultivars significantly affected the longevity and fecundity of *T. urticae* (Table 2). The longevity of female *T. urticae* adults feeding on rose cultivars was different ($F = 13.099$; $df = 9, 190$; $P < 0.01$). The adult females that spent their immaturity period on Pink Promise lived for a long time. Similarly, oviposition period of the spider mite varied between the rose cultivars ($F = 8.912$; $df = 9, 190$; $P < 0.01$) and ranged from 13.35 ± 0.47 days on Bella Vita cultivar to 23.05 ± 1.64 days on Pink Promise cultivar (Table 2). The egg hatching rate on different rose cultivars varied from 70.0% on Bella Vita and Valentine to 86.0% on Persian yellow cultivar. Sex ratio of offspring was influenced by rose cultivars and ranged from 65.0% on Roulette to 75.0% on Cool Water cultivar. There was a significant difference in the total fecundity rate of *T. urticae* on the tested cultivars ($F = 8.979$; $df = 6, 190$; $P < 0.01$) and the highest value was 125.2 ± 10.1 (eggs/female) on Pink Promise cultivar. Figure 1 shows the age-

specific fecundity (mx) curves of *T. urticae* on different rose cultivars. These curves revealed that the age-specific fecundity schedule fluctuated throughout the oviposition period; however, a clear peak is evident at the beginning of the oviposition period on most cultivars. These curves showed an asymmetrical pattern, which skewed toward older individuals.

Life table parameters

The values of life table parameters of *T. urticae* on different rose cultivars are listed in Table 3. The gross reproduction rate (GRR) of spider mite was different between rose cultivars ($F = 2.674$; $df = 9, 190$; $P < 0.01$) and the mite reared on Pink Promise cultivar showed the highest GRR value (75.15 ± 7.59 eggs) but those on Cool Water cultivar had the lowest GRR value (49.22 ± 3.90 eggs). The net reproductive rate (R_0) of *T. urticae* showed a significant difference ($F = 2.988$, $df = 9, 190$, $P < 0.01$) between the rose cultivars tested. The cohort reared on Pink Promise had the highest value of R_0 and the lowest values of this parameter were calculated on Roulette, Tea, and Valentine cultivars. The intrinsic rate of increase (r_m) values differed between the ten rose cultivars ($F = 20.488$; $df = 9, 190$; $P < 0.01$). The highest and lowest r_m values were observed on Cool Water (0.253 ± 0.005) and Roulette (0.169 ± 0.004), respectively. The mean generation time (T) was also found

TABLE 2: Biological parameters of *Tetranychus urticae* female adults reared on various rose cultivars.

Rose cultivar	Sample size	Total fecundity	Oviposition period	Female adult longevity	Life cycle	Sex ratio (%)	Egg hatching rate (%)
Bella Vita	20	66.5±5.9b	13.35±0.47d	16.05±0.69d	28.35±0.66 c	71	70
Cool Water	20	66.9±4.8b	15.35±0.57bcd	19.40±0.60c	29.35±0.62 c	75	73
Dolce Vita	20	80.1±7.7b	19.00±1.41b	24.90±1.47b	36.45±1.47ab	68	85
Maroussia	20	78.7±5.3b	16.45±0.66bc	20.15±0.91c	30.95±0.90 c	70	78
Orange Juice	20	59.9±4.8b	16.75±0.71bcd	21.55±0.95bc	30.90±0.93 c	68	73
Pinkpromise	20	125.2±10.1a	23.05±1.64a	28.90±1.85a	38.90±1.83 a	66	83
Roulette	20	73.0±6.9b	17.75±1.14bc	24.15±0.94b	35.15±1.01 b	65	76
Tea	20	65.8±3.9b	14.10±0.73cd	17.45±0.70cd	27.25±0.71 c	71	75
Valentine	20	66.5±5.9b	14.10±0.54cd	18.40±0.67cd	29.05±0.67 c	73	70
Persianyellow	20	64.8±6.6b	14.40±1.15cd	17.80±1.51cd	28.80±1.52 c	69	86

Mean values in a column followed by different lowercase letters are significantly different on the basis of ANOVA with Student-Newman-Keuls procedure (SNK) ($P < 0.05$)

to be significantly different on the rose cultivars ($F = 22.216$; $df = 9,190$; $P < 0.01$) and our results revealed that the shortest generation time was on Cool Water and the longest on Roulette cultivar. A similar trend was displayed for doubling time (DT), which exhibited a significant difference on rose cultivars ($F = 120.179$; $df = 9,190$; $P < 0.01$). In addition, the finite rate of increase (λ) of *T. urticae* was significantly different between the rose cultivars tested ($F = 20.473$; $df = 9,190$; $P < 0.01$) and was higher on Cool Water.

DISCUSSION

Host plant resistance has been effectively used in developing pest management programs for several crop pests (Wilson, 1994; Dent, 2000; Sarfraz *et al.*, 2007). It is well recognized that the host plant quality can affect life history traits of their herbivore insects by impairing growth, increasing mortality, and reducing the fecundity rate (Price *et al.*, 1980). Host plants are different in chemical and morphological characteristics that influence their suitability as hosts for different herbivore insects (Ave and Tingey, 1986; Storer and van Emden, 1995; Awmack and Leather, 2002; Golizadeh *et al.*, 2016).

Our study showed that the performance of *T. urticae* varied considerably depending upon rose cultivars. The lower immature survival rate of spider mite was observed on Bella Vita. Similarly, a lower immature survival rate was reported for rose aphid, *Macrosiphum rosae* on Bella Vita cultivar (Golizadeh

et al., 2016). This result could indicate that Bella Vita is a cultivar with poor nutritional quality or with secondary plant substances for these two important pests of rose plants. Moreover, *T. urticae* showed the longest developmental time on Bella Vita cultivar. On the other hand, the population maintained on Orange Juice cultivar had a comparatively faster developmental rate. Faster developmental rate on a particular host cultivar may allow a short life cycle and rapid population growth, which would be subsequently reflected in final population size. Shorter developmental times and higher reproduction of herbivore insects on a host plant indicate higher susceptibility of a host plant (van Lenteren and Noldus, 1990; Liu *et al.*, 2004; Golizadeh and Razmjou, 2010; Golizadeh *et al.*, 2016).

In this study, the females reared on Pink Promise cultivar showed the highest fecundity rate and longevity. The higher fecundity rate on Pink Promise cultivar suggested that the quantity and/or quality of nutritional contents were more appropriate for *T. urticae* than the other rose cultivars. Different fecundity rates have been reported for spider mite on various soybean cultivars (Sedaratian *et al.*, 2010), eggplant cultivars (Khanamani *et al.*, 2012), cucumber accessions (Shoorooei *et al.*, 2012), ornamental crop Gerbera (Krips *et al.*, 1998), bean varieties (Fathipour *et al.*, 2006; Ahmadi *et al.*, 2007) and various leguminous plants (Razmjou *et al.*, 2009). Presumably, larval and nymphal feedings on nutritionally poor plants can

TABLE 3: The mean ($\pm$ SE) population growth parameters of *Tetranychus urticae* reared on various rose cultivars.

Rose cultivar	Gross reproductive rate (GRR: female/female)	Net reproductive rate (R0: female/female)	Intrinsic rate of increase (r_m) (female/female/day)	Finite rate of increase (λ : female/day)	Generation time (T: days)	Doubling time (DT: days)
Bella Vita	57.56 $\pm$ 3.92ab	39.28 $\pm$ 2.24ab	0.217 $\pm$ 0.011c	1.242 $\pm$ 0.013c	16.78 $\pm$ 0.99bc	3.16 $\pm$ 0.19bc
Cool Water	49.22 $\pm$ 3.90b	38.88 $\pm$ 2.67ab	0.253 $\pm$ 0.005a	1.288 $\pm$ 0.007a	14.39 $\pm$ 0.14d	2.73 $\pm$ 0.06d
Dolce Vita	61.47 $\pm$ 5.63ab	47.64 $\pm$ 4.60ab	0.215 $\pm$ 0.004c	1.239 $\pm$ 0.005c	18.06 $\pm$ 0.30b	3.22 $\pm$ 0.07b
Maroussia	57.24 $\pm$ 3.65ab	43.25 $\pm$ 2.94ab	0.229 $\pm$ 0.002bc	1.257 $\pm$ 0.003bc	16.43 $\pm$ 0.18bc	3.02 $\pm$ 0.03bcd
Orange Juice	66.01 $\pm$ 5.04ab	47.50 $\pm$ 3.50ab	0.248 $\pm$ 0.003ab	1.281 $\pm$ 0.004ab	15.58 $\pm$ 0.21cd	2.79 $\pm$ 0.03d
Pinkpromise	75.15 $\pm$ 7.59a	53.70 $\pm$ 6.51a	0.232 $\pm$ 0.004bc	1.261 $\pm$ 0.005bc	17.44 $\pm$ 0.32b	2.98 $\pm$ 0.05bcd
Roulette	50.41 $\pm$ 5.04b	36.20 $\pm$ 3.41b	0.169 $\pm$ 0.004d	1.184 $\pm$ 0.005d	21.20 $\pm$ 0.28a	4.08 $\pm$ 0.11a
Tea	49.68 $\pm$ 2.99b	35.12 $\pm$ 2.07b	0.233 $\pm$ 0.002bc	1.261 $\pm$ 0.002b	15.31 $\pm$ 0.21cd	2.98 $\pm$ 0.03bcd
Valentine	52.21 $\pm$ 5.87b	34.05 $\pm$ 2.96b	0.213 $\pm$ 0.004c	1.237 $\pm$ 0.005c	16.58 $\pm$ 0.22bc	3.25 $\pm$ 0.07b
Persianyellow	56.07 $\pm$ 5.10ab	38.30 $\pm$ 4.00ab	0.244 $\pm$ 0.003ab	1.276 $\pm$ 0.004ab	16.64 $\pm$ 0.33bc	2.84 $\pm$ 0.04cd

Mean values in a column followed by different lowercase letters are significantly different on the basis of ANOVA with Student-Newman-Keuls procedure (SNK) ($P < 0.05$) (Sample sizes on all cultivars were 20)

reflect lower female fecundity on a plant (Verkerk and Wright, 1996; Sarfraz *et al.*, 2007). The differences between findings of multiple researches may be due to the differences in quantity and quality of nutrients and secondary compounds in host plants, rearing techniques, conditions of experiments, hairiness and structure of leaf epidermis, as well as the source of *T. urticae* population.

The life table parameters, especially intrinsic rate of increase (r_m), have been used as indicators of pest population performance to assess the level of plant resistance to herbivorous pests (Sabelis, 1985; Sedaratian *et al.*, 2010; Golizadeh *et al.*, 2016). Several factors, such as development time, survivorship, and fecundity rate can affect the intrinsic rate of increase, so this parameter adequately summarizes the physiological qualities of an insect in relation to its capacity to increase. Hence, r_m would be the most appropriate index to evaluate the performance of an insect on different host plants, as well as their susceptibility (Kocourek *et al.*, 1994; Southwood and Henderson, 2000). The significant differences in our r_m values showed extensive variation among rose cultivars in terms of suitability for spider mites. The estimated r_m values of *T. urticae* on all rose cultivars (except for Roulette cultivar) in current research obviously fell in the range of r_m value (0.212 to 0.480 day⁻¹) reported in literature (Sabelis, 1985; Bounfour and Tanigoshi, 2001; Kafil *et al.*, 2007; Razmjou *et al.*, 2009; Sedaratian *et al.*, 2010). In our

study, r_m value on Roulette (as the least suitable cultivar) was 0.169 day⁻¹. Susceptibility of rose cultivar for *T. urticae* is indicated by both net reproduction rate and mean generation time, which are summarized in intrinsic rate of increase (r_m). The relatively lower net reproductive rate on Roulette is a major factor affecting r_m value on this cultivar. In addition, the longest mean generation time was calculated on this host plant (21.20 $\pm$ 0.28 days), which can effectively result in a lower intrinsic rate of increase on Roulette cultivar. The relatively longer generation time on Pink Promise had caused r_m value not to be the highest on this cultivar despite the highest fecundity and reproductive rate on this host plant. The variations in life table parameters were probably a function of different food sources (host plants) taken up by the adults during larval and nymphal stages. The lower performance of some host cultivars may be due to the absence of primary essential nutrients for the growth and development of this mite or the presence of secondary metabolites that directly affect potential herbivore development and fecundity (Potter and Anderson, 1982; Sabelis, 1985; Awmack and Leather, 2002; Pietrosiuk *et al.*, 2003; Razmjou *et al.*, 2009; Sedaratian *et al.*, 2010; Khanamani *et al.*, 2012).

In conclusion, three rose cultivars, i.e. Cool Water, Orange Juice, and Persian yellow, were the most susceptible host plants and the Roulette cultivar showed relatively positive characteristics com-

pared with others and was a relatively resistant cultivar. Other cultivars showed intermediate susceptibility. Host plant resistance is in many ways an efficient pest management strategy and it has been one of the most important elements of integrated pest management programs (Zehnder *et al.*, 2007). It is easy to use, economical to the producer, cumulative in effects, and mostly compatible with other strategies, especially biological control methods (Wiseman, 1994, Desneux *et al.*, 2007). Our findings provide some basic information describing resistance of ten rose cultivars to spider mite. Thus, the use of partially resistant cultivars can enhance biological and chemical control methods. When this information is used in association with additional ecological characteristics (such as temperature, humidity and other environmental conditions), it could be useful in developing and planning spider mite integrated pest management programs on rose shrubs in urbanized areas, as well as in commercial rose breeding. Additional studies to determine the type and quantity of nutrients, as well as insect growth deterrent compounds of each cultivar are needed for a comprehensive discussion.

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