Population Parameters of *Tetranychus cinnabarinus* Boisduval (Prostigmata: Tetranychidae) on Eight Strawberry Cultivars

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Abstract: Development times, reproductive rates, and population growth parameters of *Tetranychus cinnabarinus* Boisd. on 8 strawberry (Fragaria × ananassa Duchesne) varieties were evaluated under laboratory conditions. Total development times of immature males and females were not significantly influenced by the strawberry varieties. *T. cinnabarinus* laid significantly more eggs per day on cultivar Muir (8.46) than on the other cultivars. Similarly, *T. cinnabarinus* on Muir had the highest net reproductive rate (R₀) (120.19 9/9), while R₀ was the lowest on cultivar Sweet Charlie (39.51 9/9). The generation time ranged from 18.96 to 22.32 days, but no significant varietal effect was seen. The intrinsic rate of increase (r m) showed a pattern similar to that of R₀; it was highest on Muir (0.253) and lowest on Sweet Charlie (0.208). The results indicate that Muir was the most favorable strawberry cultivar for *T. cinnabarinus* population growth, whereas Sweet Charlie was the least suitable, under controlled conditions.

Key Words: *Tetranychus cinnabarinus*, strawberry, life tables

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Introduction

The strawberry (*Fragaria × ananassa* Duchesne) (Rosaceae) is an important high-value crop with increasing importance in the Mediterranean and Marmara regions of Turkey, due to the favorable climatic conditions. In 2003 Turkey produced 150,000 t of strawberries on 10,400 ha, with 45% of this production occurring in the içel region and 21% in Bursa (Çakaryıldırım, 2004). New strawberry cultivars, such as Chandler, Camarosa, and Sweet Charlie, contributed much to this level of production.

Arthropods and diseases cause important crop losses wherever strawberries are commercially produced. The order Acarina is one of the most important groups of strawberry pests (Outman et al., 1967; Strand, 1994, Kazak et al., 2003). Among these pests, in addition to
Tetranychus urticae Koch is *T. cinnabarinus* Boisd., which occurs every year and damages nearly every strawberry field (Yi¤it and Erkılıç, 1992; Kazak et al., 2001; Çakmak and Demiral, 2007). It damages strawberries by first feeding on the leaves and later directly on the fruits. Heavy infestation causes leaves to turn brown and die, lowering yields and weakening plants (Van de Vrie et al., 1972; Regev, 1978; Wrensch and Young, 1978). Under appropriate conditions this spider mite can produce nearly 20 generations a year.

As in many other agricultural areas in the world, control of *T. cinnabarinus* in Turkey relies on acaricide application (Kazak et al., 2002). In 2001, the commercial formulations of 1200 kg dicofol, 750 kg azocyclotin, 700 kg bromopropylate, and 1350 kg tetradifon were used against *T. cinnabarinus* only in the strawberry growing areas of ‹çel (Mersin Bitki Koruma fiube Müdürlü¤ü, 2001). However, open field trials showed that strawberry production was possible without using chemical control measures against *T. cinnabarinus* on Camarosa, when compared to Chandler, because of its resistance to *T. cinnabarinus* (Kazak et al., 2001).

Recently, the rising awareness of environment issues, the side-effects of pesticide toxicity to human beings, and pesticide resistance has motivated researchers to find alternative control methods. The most important alternative control methods against the Acarina are integrated pest management (IPM) using biological control and the host plant’s genetically based resistance.

In this context, the predatory mite *Phytoseiulus persimilis* Athias-Henriot was successfully used for suppression of *T. cinnabarinus* populations, both in greenhouse and field conditions in different parts of Turkey (Kazak et al., 1992; Kısmalı et al., 1999; Kazak et al., 2001; Çakmak et al., 2005). Although many commercial strawberry cultivars were screened for susceptibility to *T. urticae*, the resistance of different strawberry types to *T. cinnabarinus* has not been studied in detail (Gimenez-Ferrer et al., 1993).

In this study, we recorded development time, fecundity, and sex ratio of *T. cinnabarinus* on 8 strawberry cultivars, using detached leaves under laboratory conditions. The objectives were to obtain a better understanding of the biology of this mite on these 8 strawberry cultivars in order to develop future IPM programs.

**Materials and Methods**

**Strawberry Cultivars and *Tetranychus cinnabarinus* Culture**

The commercial strawberry cultivars Camarosa, Chandler, Dorit, Muir, Seascape, Selva, Sweet Charlie, and Pajaro were chosen as hosts for comparing the biology of *T. cinnabarinus* on detached leaves under laboratory conditions. All the cultivars were obtained from the Department of Horticulture, Çukurova University, Adana, Turkey. The *T. cinnabarinus* mites originated from strawberries (*Fragaria × ananassa*) grown in a greenhouse at the Department of Plant Protection, Agricultural Faculty, Çukurova University.

**Development Time of Immature Male and Female *Tetranychus cinnabarinus***

The leaves of greenhouse-raised strawberry cultivars were cut and 20-mm diameter leaf disks were obtained from each cultivar with a cork borer. Fully developed leaflets were used to standardize leaf age. In total, 24 leaf disks from each variety were placed abaxial side up on a layer of blotting paper, which was placed on top of a thick water-saturated sponge. The leaves were then placed in a plastic tray (25 × 15 × 5 cm) filled with water to contain the mites on the individual disks. One gravid female was put on each leaf disk to obtain mite eggs for the experiment. Leaf disks were checked after 24 h. When there was more than one spider mite egg per leaf disk, excess eggs were removed, leaving one egg per leaf disk. Once a single egg was established on each leaf disk, female mites were removed. Spider mites on each leaf disk were observed twice daily (at 0800 and 1600) from egg to adult stage. The immature development time of each stage was evaluated for males and females.

**Tetranychus cinnabarinus Oviposition, Fecundity, and Life Tables**

When females reached adulthood, 2 male spider mites were introduced onto each leaf disk in order to mate with them and determine pre-oviposition periods. The number of eggs laid by the mated females was recorded on a daily basis. Each female was then transferred onto another clean leaf disk. The old leaf disks, which contained the eggs, were placed on freshly prepared leaf disk arenas. Eggs were kept on the same cultivar until adult emergence occurred; in this way the sex ratio was calculated for mites from each cultivar.
Oviposition and post-oviposition periods of females were calculated from the time the first egg was deposited to the time the last egg was deposited, and from the time the last egg was deposited to the time of death of the last female, respectively. These observations were continued until the last individual of the generation died. Average daily egg production was calculated from total egg production divided by the length of the oviposition period.

Life tables were constructed from the observed survival and fecundity rates. From the data in the life table, \( r_m \) was calculated by the equation e^{-\int_a^b l_x m_x dx} = 1 \) (Watson, 1964), where e is the base of the natural logarithm, \( x \) is the age interval of each female in days, \( l_x \) is the proportion of females alive at age \( x \) (as a proportion of one, or age-specific survival), and \( m_x \) is the mean number of offspring/female/day \( x \) (or age-specific fecundity). The other parameter obtained from the life table was the net reproduction rate (\( R_0 \)), which was calculated as the sum of the \( l_x m_x \) column in the life table. The mean generation time (\( T_o \)) was then calculated from the formula:

\[ T_o = \log_e R_0 / r_m \] (Laing, 1968).

After \( r_m \) was computed for the original data (\( r_{a11} \)), differences among \( r_m \) values were tested for significance by estimating the variances through the jackknife method, which facilitated calculation of the standard errors of \( r_m \) estimates. The jackknife pseudo-value \( r_j \) was calculated for the \( n \) samples using the following equation (Sokal and Rolf, 1981; Krebs, 1999): \( n \times r_{a11} - (n - 1) \times r_j \).

The mean values of \( n - 1 \) jackknife pseudo-values for the mean growth rate for each treatment were subjected to analysis of variance. The differences between the mean values of jackknife pseudo-values were analyzed by Duncan’s multiple range test (\( P \leq 0.05 \)). Statistical tests were performed using SPSS for Windows (version 10.0.1, SPSS Inc, Chicago, IL, USA).

One-way ANOVA was used to compare the effects of the strawberry cultivars on the immature stages, pre-oviposition, oviposition, and post-oviposition periods of \( T. cinnabarinus \). Means were compared at the \( P \leq 0.05 \) and Duncan’s multiple range test was used for separation of means (SPSS for Windows).

All experiments were conducted in a climate-controlled room in which temperature was set at 25 ± 2 °C and 65% ± 10 relative humidity, with a 14-h L:10-h D photo period.

Results

The Effect of Strawberry Cultivar on the Duration of Immature Stages and Oviposition Period

The development times of various stages of \( T. cinnabarinus \) on 8 strawberry cultivars are given in Table 1. The narrow range of total immature development time of females resulted in no significant differences among the cultivars. Total development time of \( T. cinnabarinus \) males ranged between 9.88 and 10.51 days, and were not significantly influenced by the strawberry varieties. In general, total development time of \( T. cinnabarinus \) males was shorter than for females, except on Muir; however, the total duration of immature stages was significantly longer for females than for males only on Chandler, Dorit, and Pajaro cultivars (t-test, \( P < 0.05 \)).

The pre-oviposition, oviposition, and post-oviposition times, and longevity of \( T. cinnabarinus \) females on the 8 strawberry cultivars are shown in Table 2. No significant host plant effects were observed on the pre-oviposition period of \( T. cinnabarinus \). The oviposition period of \( T. cinnabarinus \) was significantly influenced by the strawberry varieties (\( F = 5.35; P = 0.000 \)). Mites on Chandler (20.06) had the longest oviposition period, which was significantly different from those on Dorit, Selva, and Sweet Charlie. The longevity of \( T. cinnabarinus \) adults was significantly shorter on Sweet Charlie (18.03) than on Camarosa, Chandler, Muir, Pajaro, and Seascape (\( F = 3.84; P = 0.000 \)). In contrast, the longest (25.34) adult period was obtained on Chandler, which was significantly different only from Dorit and Sweet Charlie (Table 1).

The daily and total fecundity data of \( T. cinnabarinus \) are given in Table 2. \( T. cinnabarinus \) laid the highest daily number of eggs on Muir (8.46), which was significantly more than on the other cultivars (\( F = 13.4; P = 0.000 \)). This was followed by Selva, Chandler, Pajaro, Seascape, Camarosa, Dorit, and Sweet Charlie. In contrast to the highest mean, the lowest (Sweet Charlie) was significantly different only from Chandler, Muir, and Selva. Total fecundity of \( T. cinnabarinus \) was significantly different among the tested strawberry varieties and was highest on Muir (163.44), followed by Chandler, Seascape, Pajaro, Selva, Camarosa, Dorit, and Sweet Charlie (\( F = 16.6; P = 0.000 \) (Table 2).
Table 1. Duration (in days) of various stages of *Tetranychus cinnabarinus* on 8 strawberry cultivars at 25 ± 2 °C (Mean ± SEM).

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Stages</th>
<th>Camarosa</th>
<th>Chandler</th>
<th>Dorit</th>
<th>Muir</th>
<th>Pajaro</th>
<th>Seascape</th>
<th>Selva</th>
<th>Sweet Charlie</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>16</td>
<td>16</td>
<td>19</td>
<td>16</td>
<td>19</td>
<td>20</td>
<td>16</td>
<td>17</td>
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<td>16</td>
<td>16</td>
<td>19</td>
<td>16</td>
<td>19</td>
<td>20</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>E* ¶</td>
<td>4.81 ± 0.06 a</td>
<td>4.72 ± 0.06 ab</td>
<td>4.53 ± 0.07 bc</td>
<td>4.56 ± 0.09 bc</td>
<td>4.63 ± 0.07 abc</td>
<td>4.80 ± 0.05 a</td>
<td>4.73 ± 0.07 abc</td>
<td>4.41 ± 0.06 c</td>
<td></td>
</tr>
<tr>
<td>L ¶</td>
<td>2.00 ± 0.09</td>
<td>2.16 ± 0.06</td>
<td>2.14 ± 0.04</td>
<td>2.03 ± 0.06</td>
<td>2.05 ± 0.03</td>
<td>2.00 ± 0.05</td>
<td>2.00 ± 0.07</td>
<td>2.03 ± 0.08</td>
<td></td>
</tr>
<tr>
<td>P ¶</td>
<td>1.85 ± 0.09</td>
<td>1.78 ± 0.07</td>
<td>1.79 ± 0.05</td>
<td>1.62 ± 0.07</td>
<td>1.74 ± 0.06</td>
<td>1.80 ± 0.08</td>
<td>1.85 ± 0.10</td>
<td>1.85 ± 0.06</td>
<td></td>
</tr>
<tr>
<td>D ¶</td>
<td>2.18 ± 0.05</td>
<td>2.16 ± 0.06</td>
<td>2.08 ± 0.00</td>
<td>2.07 ± 0.05</td>
<td>2.19 ± 0.04</td>
<td>2.20 ± 0.05</td>
<td>2.25 ± 0.06</td>
<td>2.18 ± 0.07</td>
<td></td>
</tr>
<tr>
<td>T ¶</td>
<td>10.84 ± 0.20</td>
<td>10.81 ± 0.11**</td>
<td>10.53 ± 0.11**</td>
<td>10.28 ± 0.11</td>
<td>10.61 ± 0.11**</td>
<td>10.80 ± 0.15</td>
<td>10.72 ± 0.15</td>
<td>10.47 ± 0.18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.38 ± 0.08</td>
<td>9.88 ± 0.18</td>
<td>10.00 ± 0.22</td>
<td>10.51 ± 0.31</td>
<td>9.90 ± 0.24</td>
<td>10.38 ± 0.12</td>
<td>10.31 ± 0.13</td>
<td>10.29 ± 0.14</td>
<td></td>
</tr>
</tbody>
</table>

E: egg; L: larvae and quiescent stage; P: protonymph and quiescent stage; D: deutonymph and quiescent stage; T: total development time.

*Within rows, means followed by a common letter do not differ significantly (Duncan's MRT test, P = 0.05).

**Within columns, means between sexes differ significantly (t-test, P = 0.05).

n replicates

Table 2. Duration (in days) of pre-oviposition, oviposition, post-oviposition periods and reproduction rate of *Tetranychus cinnabarinus* on 8 strawberry cultivars at 25 ± 2 °C (Mean ± SEM).

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>n</th>
<th>Camarosa</th>
<th>Chandler</th>
<th>Dorit</th>
<th>Muir</th>
<th>Pajaro</th>
<th>Seascape</th>
<th>Selva</th>
<th>Sweet Charlie</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
<td>16</td>
<td>18</td>
<td>16</td>
<td>19</td>
<td>20</td>
<td>16</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Pre-Ov.</td>
<td>1.50 ± 0.06</td>
<td>1.28 ± 0.07</td>
<td>1.28 ± 0.10</td>
<td>1.19 ± 0.06</td>
<td>1.37 ± 0.12</td>
<td>1.30 ± 0.06</td>
<td>1.44 ± 0.07</td>
<td>1.44 ± 0.05</td>
<td></td>
</tr>
<tr>
<td>Ovip.</td>
<td>18.67 ± 1.14 ab</td>
<td>20.06 ± 1.08 a</td>
<td>13.22 ± 0.90 c</td>
<td>19.31 ± 1.4 ab</td>
<td>18.37 ± 1.22 ab</td>
<td>18.80 ± 1.04 ab</td>
<td>16.19 ± 1.36 bc</td>
<td>13.59 ± 1.10 c</td>
<td></td>
</tr>
<tr>
<td>Post-Ov.</td>
<td>4.53 ± 0.68</td>
<td>4.00 ± 0.46</td>
<td>3.88 ± 0.22</td>
<td>3.71 ± 0.48</td>
<td>2.94 ± 0.71</td>
<td>2.45 ± 0.63</td>
<td>3.64 ± 0.79</td>
<td>3.00 ± 0.61</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>24.70 ± 1.34 a</td>
<td>25.34 ± 1.49 a</td>
<td>18.38 ± 1.58 bc</td>
<td>24.21 ± 1.41 a</td>
<td>22.68 ± 1.31 ab</td>
<td>22.55 ± 0.94 ab</td>
<td>21.27 ± 1.76 bc</td>
<td>18.03 ± 1.28 c</td>
<td></td>
</tr>
</tbody>
</table>

Reproduction rate

<table>
<thead>
<tr>
<th>Reproduction rate</th>
<th>Daily Fec.</th>
<th>Total Fec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Fec.</td>
<td>5.45 ± 0.26 cd</td>
<td>99.40 ± 6.80 c</td>
</tr>
<tr>
<td>Total Fec.</td>
<td>6.33 ± 0.21 bc</td>
<td>126.25 ± 7.83 b</td>
</tr>
</tbody>
</table>

Pre-Ov.: pre-oviposition; Ovip.: oviposition; Post-Ov.: post-oviposition; Total: female longevity.

Daily Fec.: daily fecundity; Total Fec.: total fecundity.

*Within rows, means followed by a common letter do not differ significantly (Duncan's MRT test, P = 0.05).

n replicates
Life Tables

Daily egg production reached a peak on day 16 on Selva (9.41 eggs/day), day 17 on Sweet Charlie (4.92 eggs/day), day 17 on Dorit (5.62 eggs/day), day 17 on Pajaro (6.80 eggs/day), day 17 on Seascape (7.14 eggs/day), day 18 on Camarosa (6.55 eggs/day), day 18 on Chandler (7.79 eggs/day), and on day 18 on Muir (9.56 eggs/day); egg production decreased gradually thereafter (Figure). In general, there was no distinct m₀ peak, egg production was distributed over a relatively long time period on all tested cultivars, and survival declined gradually after an extended oviposition period (Figure).

Figure. Adult survival (lₓ - open circles) and age-specific fecundity rate (mₓ - solid diamonds) of *Tetranychus cinnabarinus* on 8 strawberry cultivars at 25 ± 2 °C.
The *T. cinnabarinus* net reproductive rate (*R₀*) was the highest on Muir (120.19 \(\frac{N}{N'})\) and lowest on Sweet Charlie (39.51 \(\frac{N}{N'}\)) (Table 2). The decreasing order of the remaining cultivars was Chandler, Selva, Seascape, Camarosa, Pajaro, and Dorit. The generation time ranged from 18.96 (Sweet Charlie) to 22.32 days (Chandler). The intrinsic rate of increase (\(r_m\)) showed a pattern similar to that of \(R₀\) in which it was highest on Muir and lowest on Sweet Charlie (\(F = 37.87; P = 0.000\)) (Table 3).

**Discussion**

In the present study the 8 strawberry cultivars did not significantly affect the immature development time of *T. cinnabarinus* females and males. Under greenhouse conditions (15-54 °C and 19%-58% relative humidity), the development time of *T. cinnabarinus* females was 9.00, 9.18, 9.25, 9.38, and 9.45 days on strawberry cultivars Selva, Pajaro, Sweet Charlie, Camarosa, and Chandler, respectively (Kazak et al., 2003). These results were shorter than our findings. It is obvious that hot and dry weather accelerates the life cycle of the genus *Tetranychus* (Haile and Higley, 2003); therefore, high temperature and low humidity inside the greenhouse could be a reason for the shorter development time of *T. cinnabarinus* on the same strawberry cultivars. However, the effect of the cultivars on the total development time of *T. cinnabarinus* females was not significant in the earlier study (Kazak et al., 2003). Kropczynska et al. (1995) studied the development time of *T. urticae* at 21 °C on 5 strawberry cultivars and found no significant influence of the variety or breeding line on the rate of development of that spider mite.

Development times of *Tetranychus* sp. from egg to adult on strawberries were also reported by Tanya and Clotting (1995), and the mean development times were 11.94-15.83 and 8.95-10.94 days for females and males, respectively. The differences encountered in that study were most probably due to the differences in cultivar and experimental conditions.

The net reproductive rate (*R₀*) and the intrinsic rate of increase (\(r_m\)) are important indicators of tetranychid population dynamics (Sabelis, 1985; Krisp et al., 1998). Comparisons of \(R₀\) and \(r_m\) often provide considerable insight beyond that available from the independent analysis of individual life-history parameters (Zhang et al., 2007). In the present study, strawberry cultivars greatly affected *T. cinnabarinus* fecundity and life-table parameters. *T. cinnabarinus* showed the fastest population development on Muir. This was mainly due to short development time, an early peak in reproduction, high daily egg production, and high total fecundity. On suitable host plants, spider mites have an \(r_m\) between 0.220 and 0.340/day (Sabelis, 1985). In this study \(r_m\) values ranged between 0.208 and 0.253. The reported \(r_m\) values of *T. cinnabarinus* on bean ranged between 0.197 and 0.440, while the same values of *T. urticae* were 0.282, 0.218, 0.182, and 0.143 on cucumber (susceptible line), strawberry, bean, and cucumber (resistant line), respectively, at 25 °C (Laing, 1969; 

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**Table 2. Net reproduction rate, intrinsic rate of increase, generation time, and sex ratio of *Tetranychus cinnabarinus* on 8 strawberry cultivars (± SEM).**

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Net reproduction rate (<em>R₀</em>) ((\frac{N}{N'}))</th>
<th>Intrinsic rate of increase ((r_m))*</th>
<th>Generation time ((T)) (days)</th>
<th>Sex ratio ((\frac{♀(♀+♂)}{♀}))*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camarosa</td>
<td>71.59</td>
<td>0.224 ± 0.0029 d</td>
<td>21.50</td>
<td>0.72 ± 0.04 abc</td>
</tr>
<tr>
<td>Chandler</td>
<td>96.50</td>
<td>0.237 ± 0.0007 b</td>
<td>22.32</td>
<td>0.78 ± 0.05 ab</td>
</tr>
<tr>
<td>Dorit</td>
<td>54.13</td>
<td>0.218 ± 0.0028 e</td>
<td>19.99</td>
<td>0.70 ± 0.01 abc</td>
</tr>
<tr>
<td>Muir</td>
<td>120.19</td>
<td>0.253 ± 0.0010 a</td>
<td>22.00</td>
<td>0.74 ± 0.03 abc</td>
</tr>
<tr>
<td>Pajaro</td>
<td>67.33</td>
<td>0.223 ± 0.0020 c</td>
<td>21.17</td>
<td>0.65 ± 0.01 bc</td>
</tr>
<tr>
<td>Seascape</td>
<td>81.72</td>
<td>0.230 ± 0.0012 bc</td>
<td>21.48</td>
<td>0.77 ± 0.06 ab</td>
</tr>
<tr>
<td>Selva</td>
<td>82.91</td>
<td>0.241 ± 0.0010 b</td>
<td>20.44</td>
<td>0.80 ± 0.05 a</td>
</tr>
<tr>
<td>Sweet Charlie</td>
<td>39.51</td>
<td>0.208 ± 0.0080 f</td>
<td>18.96</td>
<td>0.61 ± 0.03 c</td>
</tr>
</tbody>
</table>

*rm values and sex ratio followed by the same letter do not differ significantly (\(P < 0.05\))*. 

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Hazan et al., 1973; Gerson and Aronowitz, 1980; Düzgüneş and Çobanoğlu, 1983; Sabelis, 1985; Pietroisiuk et al., 2003). Large differences in rm values between host cultivars, probably due to different leaf nutrients and chemicals, were previously demonstrated in T. urticae (Van de Vrie et al., 1972; Leszcynski et al., 1988; Greco et al., 2006).

The use of jackknife techniques to estimate the variance of rm showed that the T. cinnabarinus reared on Muir had the highest rm values and on Sweet Charlie it had the lowest rm values. According to these results, Muir was the most favorable cultivar for population growth, followed by Selva, Chandler, Seascape, Pajaro, Camarosa, Dorit, and Sweet Charlie. In a greenhouse under natural conditions of temperature and relative humidity in Adana, Turkey, Pajaro was very susceptible to T. cinnabarinus, followed by Selva, Camarosa, Seascape, Muir, Dorit, Chandler, and Sweet Charlie (Kibritçi and Kazak, 2004). On the other hand, Sweet Charlie was reported to be moderately tolerant of T. urticae, while Pajaro appeared to be considerably less susceptible to T. urticae than Selva (Brinhurst and Voth 1989; Howard, 1994). Moreover, leaf disk bioassays based on oviposition rates (eggs/female/day) showed Muir and Selva to be moderately susceptible, while Chandler was moderately resistant and Pajaro was highly resistant to the two-spotted spider mite, under laboratory conditions (Gimenez-Ferrer et al., 1993).

Strawberry cultivars vary in susceptibility to spider mites. Short-day cultivars are generally more tolerant of mite feeding than day-neutral cultivars, particularly later in the fruit-production season (Zalom et al., 1991); therefore, an experiment comparing the resistance level of strawberry cultivars to T. urticae showed that the day-neutral cultivar Selva was more susceptible than the short-day cultivars Sweet Charlie and Pajaro (MacFarlane and Hepworth, 1994; Chandler et al., 1997). On the other hand, short-day cultivars Chandler and Selva demonstrated intermediate resistance patterns against T. urticae (Gimenez-Ferrer et al., 1994). The Muir, Selva, and Seascape strawberry cultivars evaluated in the present study were day-neutral cultivars with the highest rm values for T. cinnabarinus.

In Turkey, Camarosa is currently the most-planted strawberry cultivar (> 90%) due to its large, solid, and long shelf-life fruits, followed by Sweet Charlie, Chandler, and others (Nurgül Türemiş, personal communication). In the present study, according to jackknife estimation, Sweet Charlie was the least suitable cultivar for reproduction by T. cinnabarinus, followed by Camarosa and Dorit. Cultivation of these cultivars in large areas might facilitate setting up integrated mite management programs in which biological control agents are combined with other pest control techniques to accomplish these goals.

As stated above, this differential suitability of host plants to the mite is an important factor to consider while exploring IPM solutions for T. cinnabarinus and other mite species (Adango et al., 2006). Nonetheless, before reaching a final decision about the resistance level of strawberry cultivars to T. cinnabarinus, further studies will be necessary to clarify the consistency of resistance in a cultivar because it is known that local growing conditions can also greatly influence resistance (Shanks and Barritt, 1975; Kibritçi and Kazak, 2004). For this reason, the strawberry cultivars determined to be most tolerant to T. cinnabarius in the present study should be tested over several years at more than one location in order to confirm the promising cultivar performance that was measured under laboratory conditions.

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References


Population Parameters of *Tetranychus cinnabarinus* Boisduval (Prostigmata: Tetranychidae) on Eight Strawberry Cultivars


