Evaluation of Resistance in Seven Populations of the Two - Spotted Spider Mite (Tetranychus urticae Kosh) for Abamectin on Cucumber under Plastic Houses Conditions in Jordan

Tawfiq M. Al-Antary, Mohammad R. Al-lala and Marwan I. Abdelwali *

ABSTRACT

Laboratory bioassays were conducted during the period from June 2009 till August 2010 to evaluate the toxicities of abamectin against adult females of seven populations of the two- spotted spider mite, Tetranychus urticae (Kosh). Six out of the seven tested populations were collected from Al-Ramtha, Baqa, Zzyza, Krimeh, Deir-Alla and Karamah covering the main regions devoted to cucumber cultivation in Jordan. The seventh populations, was brought from Syria and considered as a susceptible strain (SSS).

All the seven populations except the Syrian susceptible strain were resistant to abamectin. The Karamah population was moderately resistant to abamectin (RF=11.6), while Al-Ramtha population was the least resistant one (RF= 4.05). These results indicated that most of the local T. urticae populations displayed different levels of resistance to abamectin. The study results recommend using registered acaricides in Jordan alternatively with abamectin to keep these pesticides effective to avoid or decrease the resistance of the two- spotted spider mite for these acaricides.

Keywords: Two Spotted Spider Mite, Tetranychus Urticae, Acaricide, Toxicity, Abamectin, Cucumber, Plastic Houses, Jordan.

INTRODUCTION

The two-spotted spider mite, Tetranychus urticae Kosh (Acari : Tetranychidae), is a polyphagous, parenchyma cell feeding spider mite with over 200 host plant species (Al-Mommany and Al-Antary 2008, Zhang 2003). It is a major pest on field crops, horticultural crops, ornamentals and fruit trees (Tsagkarakou et al. 1996, Van Den Boom et al. 2003). It has recently become a serious problem because of the extensive use of acaricides, resulting in resistance among the mite populations (Sokeli et al. 2007, Al-Antary et al. 2012). The development of the resistance is also known to be accelerated under confined environmental conditions such as plastic-houses (Zhang 2003). Since the mite has a very short and prolific life cycle, it's resistance to acaricides might develop more rapidly than resistance in other pests. In addition, mites resistance to certain acaricides has been shown to have cross resistance to other acaricides. Thus, most commercial acaricides have been often proved to be ineffective to control the field mite populations in several countries particularly Italy, Egypt and southern Korea (Ramasubramanian et al. 2005, El Kady et al. 2007, Koch et al. 2009).

From field surveillance in southern Korea and screening of various acaricides, it was speculated that T. urticae has developed resistance to the most conventional acaricides, but toxicological data were very scarce and poorly documented in Jordan (Al-Antary et al. 2012) and becoming huge globally (Lee et al. 2003, Choib et al. 2004, Sato et al. 2005, Price and Nagle 2009, Yorulmaz and Ay 2009). Susceptibility of T. urticae to acaricides might differ between locations of cucumber cultivation in Jordan. Therefore, it was important to monitor the acaricides susceptibilities of T.urtica populations that were collected from cucumber cultivation locations in Jordan and to evaluate the efficacy of acaricides.

The majority of the acaricides factories production in
Jordan is for export and the quantity of their product that goes to the local market is unknown. Although *T. urticae* represents a real threat to cucumber plantation under plastic-houses in Jordan, few toxicological studies on this pest have been conducted (Nazer 1985, Al-Antary *et al.* 2012) Therefore, this study aimed to achieve the following objectives: To evaluate the susceptibilities of TSSM collected from cucumber cultivation in Jordan to the studied abamectin acaricide and to find the resistance factors to the tested abamectin among the *T. urticae* populations.

**MATERIALS AND METHODS**

**Populations of *T. urticae***

Seven *T. urticae* populations collected from different areas were used in the current study. Six of these populations were collected from cucumber plants grown under plastic houses conditions in different regions of Jordan as shown in the map (Fig. 1). These geographical regions include Al-Ramtha (100 Km North West of Amman), Baq'a (20 Km North West of Amman), Zyzya (30 Km south of Amman), Krimeh (northern Jordan valley), Deir-Alla (central Jordan valley) and Karamah (southern Jordan valley). These regions are considered the main growing areas for cucumber in the country. Another *T. urticae* strain was obtained from Lattakia Center for Rearing and Production of Biological Agents (LCRPBA) in Syria. This strain was reared there for 5 years without acaricides applications.

**Production of Bean Plants**

Bean (*Phaseolus vulgaris* L. cv. Bronco, Asgrow, USA) was chosen for rearing and for the toxicological test of the *T. urticae*. Seeds of bean were directly sowed inside 10 cm.pots. Potting media used was Peat-moss and Perlite with 3:1 ratio. Plants were infested with SSS *T. urticae* when they reached the true leaf stage. These plants were irrigated and replaced as needed. No pesticides were applied on the plants during the rearing period. The infested plants were grown under greenhouse conditions at a temperature of 25-35°C, relative humidity of 45% to 60% and a photoperiod of L 16:D8. For use in the toxicological test, polystyrene trays of 84 cells were filled by Peat-moss and Perlite (3:1 ratio). Then, these trays were sown by 1-2 bean seeds for each cell, after complete germination, the cotyledon leaves were used in the toxicological tests.

Syrian *T. urticae* strain was separately reared and maintained on *Phaseolus vulgaris* at the faculty of Agriculture, University of Jordan, at temperature between 27°± 5°C and 57 ± 8% relative humidity and a photoperiod of L16:D8. Plants were irrigated and replaced as needed.

**Tested Acaricide**

Abamectin was produced in 1985. The recommended field application rate was 7.2 mg/L H₂O. Its Molecular formula is C₄₉H₇₄O₁₄ (Tomlin 2005). The acaricide...
was used as its commercial formulation (1.8 EC Vertimec®, Syngenta AG). For each test, fresh stock solution was prepared by dissolving a calculated quantity of the acaricide enough to run the whole concentrations needed. There were four replicates for each concentration and seven concentrations for each population as shown in Table (1). These concentrations were chosen based on preliminary studies and they were different for each *T. urticae* population.

<table>
<thead>
<tr>
<th>Used concentration (ppm)</th>
<th>Population of</th>
<th>Syriamh susc. Strain</th>
<th>Kriamah</th>
<th>Deir-Allah</th>
<th>Burhamah</th>
<th>Zyzya</th>
<th>Ba’q’a</th>
<th>Ramtha</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>0.5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>0.5</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>7</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>0.5</td>
<td>2</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>0.5</td>
<td>1</td>
<td>12</td>
<td>10</td>
<td>19</td>
<td>11</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>0.5</td>
<td>1</td>
<td>14</td>
<td>12</td>
<td>18</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>0.5</td>
<td>1</td>
<td>16</td>
<td>14</td>
<td>24</td>
<td>25</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>0.5</td>
<td>1</td>
<td>20</td>
<td>16</td>
<td>28</td>
<td>30</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

**Bioassay of the Acaricide Toxicity**

Toxicological bioassays were conducted according to the procedures described by IRAC (2004). Cotyledon leaves from untreated bean plants were placed, lower side up, in Petri-dishes lined with water-saturated cotton wool. Twenty five adult females of *T. urticae* were placed on each cotyledon leaf by using a fine paint brush under a binocular microscope. Twenty four hours after mite release, each Petri-dish was sprayed with a constant amount of the acaricide solutions for 2 seconds using a hand sprayer with a solid cone nozzle. The sprayed Petri-dishes were left to dry for 30 minutes, then they were kept under room temperature. Mite condition was assessed by gentle probing with a fine paint brush 48 hours post treatment. Mites were considered dead when they didn’t display movement. Mites which were able to move were considered alive. Tap water was sprayed as control. These experiments were carried out in the Pesticide Laboratory.

**Statistical Analysis**

Data were subject to probit analysis (Finney 1971) which incorporated Abbott’s correction for natural mortality (Abbott 1925). The SPSS (version 13 USA) (Robertson et al. 2007, van Pottelberge et al. 2009) computer program was used for data analysis to estimate LC$_{50}$ and LC$_{90}$ values, regression coefficient (slope) and its standard error, intercept and its standard error, Pearson goodness of fit Chi-square, expected mortality, and 95% confidence limits (95%CL) for effective level of concentrations. This program used normal equivalent deviate (NED) instead of probit numbers. However, NED numbers can be readily adjusted to probit by adding 5 to each NED number (Finney 1971). Y value for each line estimated by probit regression was equal to 0.0 and 1.28 when LC$_{50}$ and LC$_{90}$ (X) value was converted to log base 10, respectively.

LC$_{50}$ and LC$_{90}$ values were considered significant when (95% CL) did not overlap. To determine the resistance factor (RF) for each population, the LC$_{50}$ of the acaricide of the field population was divided by the corresponding LC$_{50}$ for the susceptible strain. The resistance factor was categorized according to Fukami et al (1983) as follows: low RF<10, moderate 10<RF≤40, high 40-60 and very high resistance >60. LC$_{90}$ values in ppm divided by the higher recommended field rate in ppm were calculated and tabulated for each TSSM strain (Ratio value). Goodness of line fitting was checked by Chi-square test $X^2$. According to Finney (1971), the value of $X^2$ at 0.05 level of probability equals to 14.1 at 5 degree of freedom (df).

**RESULTS**

Susceptibility of seven populations of *T. urticae* collected from different locations of cucumber production...
are illustrated in Table (2). Results showed that all the tested field populations were either of low resistance or moderate resistance to abamectin. Resistance factors of mite populations ranged from 4.0 to 11.7 depending on *T. urticae* origin. The highest resistance factor was found for Karamah population (RF=11.6) while Al-Ramtha population showed the least one (RF= 4.0). Results also indicated that Karamah and Baq'a populations showed the highest ratio value (over 3.03), while the lowest ratio value was measured for Al-Ramtha population (Ratio=1.88) (Fig 1). Values of LC$_{50}$ showed that Al-Ramtha population was significantly the most susceptible for abamectin (LC$_{50}$ = 3.89 ppm), and Karamah population was the highest resistant to abamectin toxicity (LC$_{50}$= 11.18 ppm). No significant differences were detected between the LC$_{50}$ s of Baq’a, Zzyza, and Deir-Alla populations, but both populations differed from the other tested populations Table (2). Al-Ramtha population had the lowest LC$_{50}$ of 13.56 ppm indicating that this population is the most susceptible to abamectin. Baq’a, Karamah and Deir-Alla populations were the highest resistant populations with LC$_{90}$ values of 21.95, 21.78 and 21.20, respectively. However, LC$_{90}$ values didn’t significantly differ among populations from Al-Ramtha, Zzyza and Krimeh. Furthermore there were no significant differences among LC$_{90}$ values of the populations from Baq’a, Deir-Alla and Karamah.

### Table 2. Susceptibility of field collected populations of *T. urticae* adult females to abamectin (higher recommended field rate = 7.2mg/L)

<table>
<thead>
<tr>
<th>Population name</th>
<th>LC$_{50}$ (mg/l)</th>
<th>LC$_{90}$ (mg/l)</th>
<th>L.E.P.R$^2$</th>
<th>Slope + S.E$^3$</th>
<th>RF$^4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Ramtha</td>
<td>3.89d$^3$</td>
<td>13.56b$^3$</td>
<td>Y=-1.39+2.36(X)</td>
<td>2.36+0.21</td>
<td>4.05</td>
</tr>
<tr>
<td>Baq’a</td>
<td>7.15b</td>
<td>21.95a</td>
<td>Y=-2.25+2.63(X)</td>
<td>2.63+0.22</td>
<td>7.45</td>
</tr>
<tr>
<td>Zzyza</td>
<td>7.94 b</td>
<td>15.43b</td>
<td>Y=-3.99+4.44(X)</td>
<td>4.44+0.35</td>
<td>8.30</td>
</tr>
<tr>
<td>Krimeh</td>
<td>5.53c</td>
<td>13.87b</td>
<td>Y=-2.38+3.21(X)</td>
<td>3.21+0.28</td>
<td>5.76</td>
</tr>
<tr>
<td>Deir-Alla</td>
<td>8.56b</td>
<td>21.20a</td>
<td>Y=-3.03+3.25(X)</td>
<td>3.25+0.29</td>
<td>8.92</td>
</tr>
<tr>
<td>Karamah</td>
<td>11.18a</td>
<td>21.78a</td>
<td>Y=-4.64+4.43(X)</td>
<td>4.43+0.34</td>
<td>11.65</td>
</tr>
<tr>
<td>Syrian susc. strain</td>
<td>0.96e</td>
<td>2.67c</td>
<td>Y=0.05+2.87(X)</td>
<td>2.87+0.23</td>
<td>-</td>
</tr>
</tbody>
</table>

1. 95% confidence limits for LC$_{50}$, or LC$_{90}$ in ppm
2. L.E.P.R = LINE Estimated by Probit Regression.
4. R.F. resistance factor = LC$_{50}$ of field population/LC$_{50}$ of susceptible population (SSS).
5. LC$_{50}$ or LC$_{90}$ values having different letters are significantly different (95%CL did not overlap).
DISCUSSION

Monitoring of local populations for susceptibility towards acaricides is the first step in resistance management of *T. urticae*. It is essential to carry out acaricide resistance tests regularly to evaluate resistance development in target mites. In addition, control tactics must depend on the use of acaricides with different modes of action to avoid or delay resistance, since resistance has become a serious problem globally (Ghough 1990, Sato et al. 2005, Yorulmaz and Ay 2009, Price and Nagle 2009) because of the extensive use of acaricides.

The toxicity of abamectin on one foreign susceptible mite strain obtained from Syria and six local populations collected from different locations revealed that all the local populations of *T. urticae* were resistance to abamectin whereas the foreign population was susceptible. Resistance to abamectin could be because of the frequent use of abamectin by Jordanian farmers in a large scale (Al-Ila 2010). Since Al Karamah region is mainly cultivated with eggplant throughout the year which is a favorite host for *T. urticae*, farmers use acaricides including abamectin in a large scale. Therefore, mite populations originated from this location exhibited the highest resistance to abamectin. In agreement with this result. However, Lee et al. (2003) pointed out that the resistance factors of abamectin varied between 0.3 to 19.5 towards eight populations of *T. urticae* collected from different locations in Korea. Stavrinides and Hadjiistylli (2008) achieved 100% mortality in two *T. urticae* populations collected from cucumber, 65% mortality in one rose population and 20% mortality in another rose population when they applied abamectin at a rate of 9 ppm. Nazer (1985) reported that farmers in Jordan valley and in some other parts in Jordan complained about unsatisfactory results in controlling the two spotted spider mite when using some organophosphate and carbamate acaricides due to the gaining of resistance. He tested some organophosphates and carbamate acaricides against the two spotted spider mite to find their toxicities and resistance under laboratory conditions in Jordan. AL-Antary et al. (2012) reported the response of seven populations of the two-spotted spider mite (*Tetranychus urticae* koch) for bifenzate acaricide on cucumber under plastic houses in Jordan. They found that moderate resistance of the different populations of the two spotted spider mite to bifenzate.

In conclusions, all the tested field populations were resistant to abamectin. The resistance factor ranged from 4.05 to 11.65. At its high recommended field rate; abamectin was ineffective in controlling *T. urticae*. However, In order to have safe and high quality and quantity of cucumber product and to manage resistance development by *T. urticae* to acaricides, regular monitoring should be carried out to detect the extent of resistance to the acaricides used, particularly abamectin and restricting the use of acaricides to which the magnitude of resistance is high. These results indicated that most of the local *T. urticae* populations displayed...
different level, of resistance to abamectin. The current study and related studies for one (AL-Lala 2010) of the same authors recommend using bifenazate, chlorfenapyr and spiromesifen or any registered acaricides in Jordan alternatively with abamectin, milbemectin and amitraz to keep these pesticides effective to avoid or decrease the resistance of the two-spotted spider mite for these acaricides.

REFERENCES

ACKNOWLEDGMENT
Thanks are extended to the dean ship of Research of University of Jordan and Agriculture material company administration for financial support. Thanks are also to the staff at the Lattakia Center for Rearing and Production of Biological Agents in Syria for providing us the sensitive strain of the spider mite.


---

**Tetranychus urticae** (Acari: Tetranychidae) تحت البيوت البلاستيكية في الأردن

ملخص


توصي نتائج الدراسة باستخدام مبيدات حشرية في الأردن بالتجارب مع مبيدات الأبيضات لمحافظة على فاعلية تلك المبيدات لتجنب أو التقليل من مقاومة الخيار الأحمر لهذه المبيدات.

المصطلحات الدالة: الخيار الأحمر ذو اللفتين، مبيد الحشرات، الأبيضات، الخيار، البيوت البلاستيكية، الأردن.