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Article

Toxicity of spiromesifen on different developmental stages of two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae)

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ABSTRACT
Spiromesifen is a widely used pesticide (acaricide) for controlling the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) which is a severe pest on strawberries in Mersin region of Turkey. The experiment was carried out, under laboratory conditions (25 ± 1 °C, 60 ± 10% relative humidity and 16-h light) for the evaluation of responses of the spider mite against spiromesifen. The responses (mortality rate, sensitivity) of mite populations to pesticide were estimated by calculation of the mortality rate or effectiveness ratio (% Abbott), for three different concentrations (recommended, 1/2 and 1/4 of applied rate). According to effectiveness ratio, the mite species shows oversensitivity to eggs and immature stages for spiromesifen which were classified as harmful. Adults of *T. urticae* were found less susceptible to this acaricide. Spiromesifen was considered to be the most toxic to the eggs. Eggs hatching ratio has been reduced by almost 90–100% at the recommended and other applied concentrations at 36–72 h (0.5, 0.25 and 0.125 µL/mL). Spiromesifen was found to be highly toxic on eggs hatching ratio at 48 hours. The highest effectiveness ratios estimated for immature stages were 79, 89 and 98% for each concentration respectively (0.5, 0.25 and 0.125 µL/mL). Given the adult stage of the two-spotted spider mite, the highest response was carried out at the recommended concentration, which has the mortality rate reaching over 96 % after 60 hours.

KEY WORDS: Bioassay; effectiveness, sensitivity; spiromesifen, strawberry; *Tetranychus urticae*.

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INTRODUCTION

Tetranychidae has 70 genera, which contain 1302 identified species (Hoy 2011; Migeon and Dorkeld 2017). The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) is an invasive mite and has over 120 host plant species (Jeppson *et al*. 1975). *Tetranychus urticae* is an economically harmful pest due to its high rate of fecundity and short life cycle on various crops especially on vegetables and strawberry cultivation (Greco *et al*. 1999, 2005; Sato *et al*. 2007). The two-spotted spider mite populations develop easily in different environmental conditions (Jeppson *et al.* 1975), which has led to it being the most predominant species on vegetables like tomatoes, eggplants, peppers, and some ornamental plants in greenhouse and outdoor cultivation in the world and in Turkey (Can and Çobanoğlu 2010; Ferreira and Sousa 2011; Radonjic and Hrncic 2014; Çobanoğlu and Kumral 2014, 2016; Kumral and Çobanoğlu, 2015 a, b; 2016).

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The large-scale application of acaricides and insecticides against mites and insect pests can destroy the ecological balance, which enables the increase in economic damage and mite resistance problem in agroecosystems (Yu 2008).

Many insecticides and acaricides have been registered to control *T. urticae* in Turkey. A major problem for controlling this spider mite is their ability to rapidly develop resistance to acaricides after only a few applications. Their high reproductive potential and short life cycle, combined with several pesticide applications per season on vegetables in greenhouses, result in the development of resistance in spider mites (Ay 2005). Strawberry growers have difficulty, in controlling *T. urticae* populations, because of the very suitable climatic conditions for the mite population.

Pesticides have direct and indirect effects on natural enemies. So, the choice of less toxic pesticides is important for protecting natural enemies and controlling ecological balance. Ministry of Agriculture and Forestry in Turkey has licensed spiromesifen for controlling the two-spotted spider mite on strawberry plantations. However, Turkey has faced exportation problems due to insecticide/acaricide residues on strawberries. It is important to use less toxic acaricides in strawberry growing areas with minimum concentrations.

Spiromesifen is an effective acaricide on the eggs and young stages of the two-spotted spider mite. It acts as a lipid synthesis inhibitor and is commonly used by growers in strawberry fields in Mersin (Elbert *et al*. 2002; Dekeyser 2005; Nauen 2005; Marcic 2007).

Turkey is the 3rd biggest strawberry producer in the world with a cultivated area of 13.234 ha in 2014. Mersin, situated on the Southern Mediterranean Coast of Turkey, is the most important region with 45% of strawberry production and exportation (Çobanoğlu and Güldalı 2017).

The aim of this study was to determine the sensitivity ratio of different developmental stages of the two-spotted spider mite population collected from strawberry growing areas of Mersin against spiromesifen. Also, this study was done to evaluate the efficacy of sub-lethal doses of spiromesifen against *T. urticate* on strawberry. An important feature of this study was to assess the efficacy rates of sub-lethal concentrations against those recommended. We evaluated the efficacy of different rates of spiromesifen on spider mites on strawberry.

MATERIAL AND METHODS

Chemical

The spiromesifen was selected for testing studies which is licensed for strawberries as an acaricide. Spiromesifen is an acaricide (IUPAC: 3-mesityl-2-oxo-1-oxaspiro [4.4] non-3-en-4-yl 3, 3 dimethyl butyrate) (Lipid Synthesis Blocker), which is most commonly used as a chemical on strawberry cultivation area of Mersin, located the Mediterranean Sea Coast. The recommended field rate of spiromesifen (Oberon SC 240, Bayer) is 0.5 µL/mL in water (solvent). The pre-harvest interval (PHI) is 3 days and this characteristic has been an important feature for the consumption of strawberry plants.

The two-spotted spider mite population

Population of *T. urticae* was taken from the strawberry plantation of Silifke-Mersin and cultured in a greenhouse in the Faculty of Agricultural, Plant Protection Department-Ankara, Turkey since 2011. Spider mites were reared on strawberry plants, at 25 ± 1 °C and 60 ± 10% RH under a 16-h light duration.

Host plant

The strawberries (*Fragaria ananassa* Duch; Rosaceae) were taken from Silifke-Mersin as fryer frigo for use in the experiments when the strawberries were turning 6–8 leaves, the plants were used for breeding of the stock culture of the two-spotted spider mite population.

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Bioassay

Leaf disc method was used in this experiment which is accepted by the IOBC/WRPS Working Group on "Pesticides and Beneficial Arthropods" as a standard routine method (Helle and Overmeer 1985).

The effects of spiromesifen on different biological stages of *T. urticae* were carried out at three different concentrations [0.5, 0.25 and 0.125 µL/mL with water (solvent)]. Spray tower and Petri dish methods were used (Campos *et al*. 1997; Kabir and Chapman 1997).

For the experiments, different developmental stages of spider mites were placed on strawberry leaves which were placed on a wet cotton wool in a Petri dish (9 cm diameter) and were surrounded with Vaseline to prevent the escape of mites. This acaricide suspension was sprayed onto the leaf disc containing mites by a Potter spray tower (Auto-Load; Burcard® Scientific) at one bar pressure (2 µl/cm^2 suspension) (Bostanian *et al*. 2010; Kumari *et al*. 2017). The control groups were sprayed with pure water.

All of the experiments were carried out at 25 °C, 60 ± 10% relative humidity and 16 L: 8D photoperiod conditions with five replicates and each replicate with 10 individuals of the same age (eggs, immatures, and females). The number of the dead/live individuals and number of hatched eggs were recorded after 24, 36, 48 and 72 hours after application of the pesticide.

The effectiveness of spiromesifen on different stages of *T. urticae* was evaluated according to mortality rate for each concentration of spiromesifen. Live mites were counted after 24, 36, 48 and 72 h of pesticide application. Each individual exposed to different concentrations of spiromesifen was evaluated as either dead or alive. The mortality percentages were calculated using Abbott's formula which accounts for the mortality rate in registered concentration/control (Abbott 1925).

(1) $$\text{corrected } \% = \frac{X-Y}{X}$$

where corrected % is the corrected percent mortality, X is the survival percentage in the untreated controls, Y is the survival percentage in the treated applications.

All the trials were repeated two times by using the same methods at above-mentioned laboratory conditions (2011–2012).

Effects of spiromesifen on different biological stages of *T. urticae*

In this study, the effects of spiromesifen were evaluated depending on the eggs hatching ratio (%); mortality rate of the adult female and immatures (nymphs) of *T. urticae.* Each application unit was sprayed with pesticides at their recommended (0.5 µL/mL), ½ (0.25 µL/mL) and 1/4 (0.125 µL/mL) of registered concentration.

Eggs stage

In order to investigate the effects of the spiromesifen, for eggs, the adult individuals were gently transferred onto the leaf discs and allowed to lay eggs. After laying eggs, 10 two-spotted spider mite eggs at the same age were kept in each Petri dish and the others were killed by a needle. The chemicals were applied to the Petri dish with the help of the spray tower as (2 µl/cm^2 suspension) medicated liquid. The observations were made after 24, 36, 48, 60 and 72 hours of pesticide application and the number of hatched and unhatched eggs were recorded. In each experiment, 50 eggs were evaluated in 5 replicates.

The same procedure was applied for juvenile (nymphs) and adult stages (female). The mite individuals who survived after 24 hours of chemical application showed slow movement.

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Immature stages

In order to investigate the effects of the spiromesifen on immature stages of the two-spotted spider mite, each unit included 10 same aged nymphs and acaricide was applied in each Petri dish with the help of the spray tower as (2 µl/cm^2 suspension) medicated liquid. The observations were made after 24, 36, 48, 60 and 72 hours of chemical application and the number of dead/lived individuals were recorded. The effectiveness of the pesticide was evaluated in 5 replicates from 50 individuals.

Adults

The effects of the spiromesifen on adult female of the two-spotted spider mite were evaluated from newly emerged 10 same aged females and they medicated by liquid spray tower as 2 µl/cm^2 suspension. The observations were made after 24, 36, 48, 60 and 72 hours of chemcial application and the number of dead/lived individuals were examined. The evaluation was made from 50 individuals in 5 replicates.

Data analysis

Data were analyzed by using the SPSS 23.0 computer program and means were separated according to Duncan's Multiple Range Test (DMRT) at P = 0.05.

Data in the form of percentages were transformed to arcsine values for SPSS (2004). The homogeneity of the variances was controlled with ANOVA, and the non-homogeneous values were applied to arcsine square root.

Effects on the eggs were evaluated; through by the effectiveness of the egg hatching ratio (% Abbott). The same application and evaluation procedure were applied for immature stages and adults (female), with a 95% confidence.

RESULTS

Toxicity of spiromesifen on T. urticae *eggs*

The effects of spiromesifen on two-spotted spider mite eggs were evaluated out under laboratory conditions in two different times (2011–2012). Mortality rates in the control groups which got sprayed with water were less than 10%, hence were not used as comparison basis.

Spiromesifen has high effects on tetranychid eggs (Table 1, Fig. 1A, B).

The eggs hatching ratio was reduced by almost 100 % at the recommended concentration (0.5 µL/mL), likewise the sub-lethal doses (0.25 and 0.125 µL/mL) had high ovicidal effect and hatching ratio was reduced close to recommended concentration. Even the lowest concentration (0.125 µl/mL) of spiromesifen was found to have highly negative effects on eggs hatching ratio (Table 1, Fig. 1.A, B).

Table 1. The effect of spiromesifen on *Tetranychus urticae* eggs hatching ratio (%) in 2011 and 2012*.

Years	Concentration (µL/mL)	Eggs hatching (%) ± SE					
		N	24 h	36 h	48 h	60 h	72 h
2011	0.125	50	54 ± 0.10^{a}	90 ± 0.11^{bc}	100 ± 0.00^{c}	100 ± 0.00^{c}	100 ± 0.00^{c}
	0.25	50	81 ± 0.00^{ab}	85 ± 0.11^{ab}	98 ± 0.03^{c}	98 ± 0.06^{c}	98 ± 0.06^{c}
	0.50	50	86 ± 0.06^{bc}	100 ± 0.12^{c}	100 ± 0.00^{c}	100 ± 0.00^{c}	100 ± 0.00^{c}
2012	0.125	50	74 ± 0.06^{a}	94 ± 0.07b^{c}	100 ± 0.00^{c}	100 ± 0.00^{c}	100 ± 0.00^{c}
	0.25	50	88 ± 0.08^{ab}	90 ± 0.08^{ab}	98 ± 0.06^{bc}	98 ± 0.06^{bc}	98 ± 0.06^{bc}
	0.50	50	92 ± 0.09^{bc}	100 ± 0.00^{c}	100 ± 0.00^{c}	100 ± 0.00^{c}	100 ± 0.00^{c}

*: P < 0.05; means with different letters within a row were significantly different (Duncan's Test), SE = standard error.

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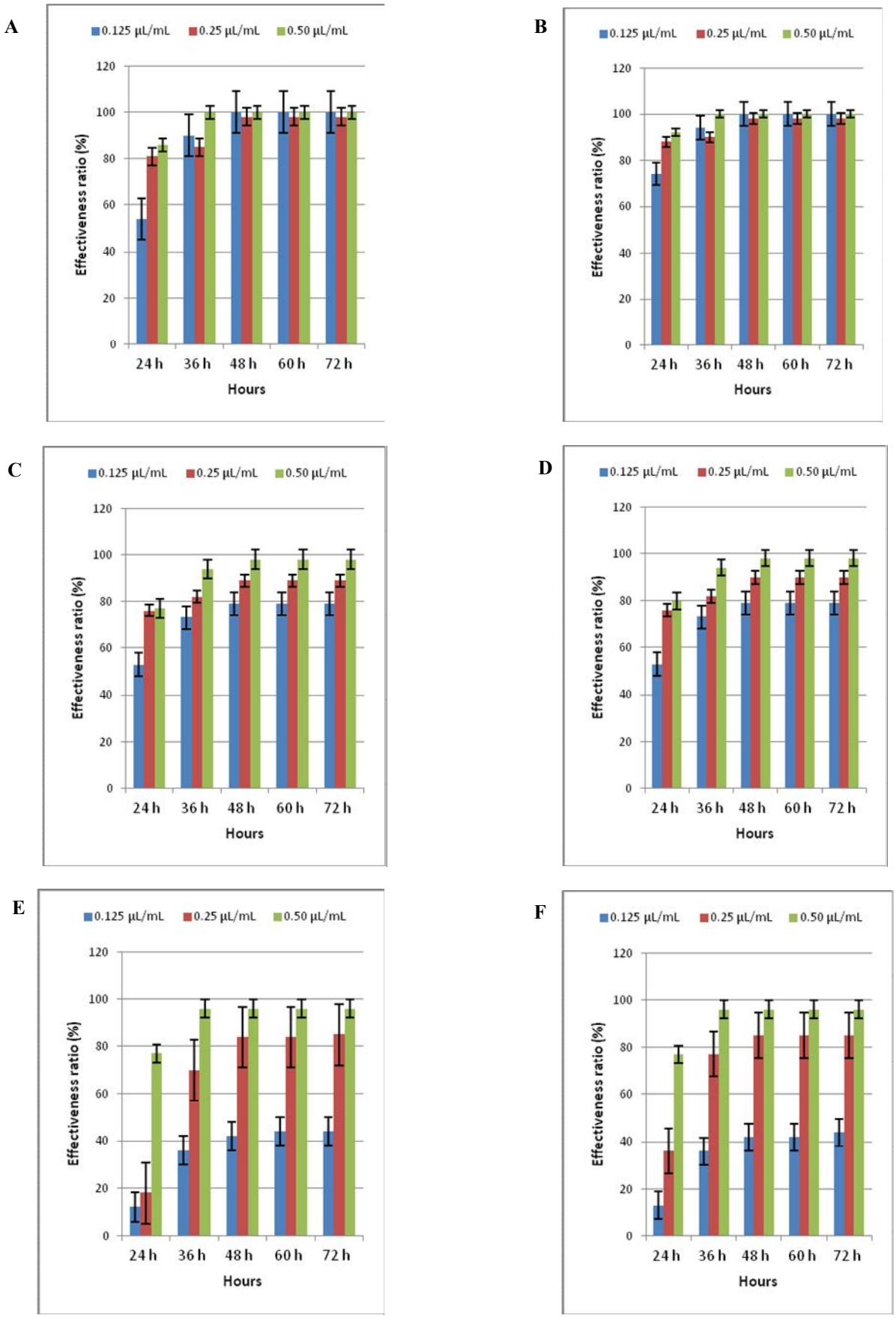

Figure 1. The effectiveness (%) of spiromesifen on different stages of *Tetranychus urticae* – A. Eggs hatching ratio (2011); B. Eggs hatching ratio (2012); C. Immature stages (2011); D. Immature stages (2012); E. Adult (females, 2011); F. Adult (females, 2012) (Mean ± SE; N = 50).

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After 24 hours of chemical application, the toxicity of spiromesifen at three different concentrations (0.5, 0.25 and 0.125 µL/mL) on two-spotted spider mite eggs was 86, 81 and 54% respectively. The highest effectiveness was obtained at the recommended concentration and considered statistically different from the other (0.25 µL/mL and 0.125 µL/mL) concentrations ($P < 0.05$).

After 36 hours of chemical application, the effect ratios were close in all three concentrations and were assessed, 100, 85 and 90% respectively (0.50, 0.25 and 0.125 µL/mL). The highest toxicity was observed at 0.5 µL/mL concentration at 36 hours ($P < 0.05$).

After 48 hours of chemical application, all concentrations reached up to 100% efficacy. The effects of spiromesifen were estimated as 100, 98 and 100% for eggs respectively (0.50, 0.25 and 0.125 µL/mL) ($P < 0.05$).

The results of the first and second application (2011–2012) of spiromesifen on *T. urticae* eggs were similar for each treated concentration. The effect of 0.25 µL/mL concentration on eggs was very close to the 0.5 µL/mL concentration (Table 1).

Toxicity of spiromesifen on T. urticae *immature stages*

The effects of spiromesifen on immature stages of *T. urticae* were carried out in 2011 and 2012 (Table 2, Fig. 1 C, D).

Table 2. The effect of spiromesifen on *Tetranychus urticae* immature stages (%) in 2011 and 2012*.

Years	Concentration (µL/mL)	Immature stages (%) ± SE					
		N	24 h	36 h	48 h	60 h	72 h
2011	0.125	50	53 ± 0.04^{a}	73 ± 0.07^{ab}	79 ± 0.07^{abc}	79 ± 0.07^{abc}	79 ± 0.07^{abc}
	0.25	50	76 ± 0.06^{abc}	82 ± 0.05^{abc}	89 ± 0.05^{bcd}	89 ± 0.08^{bcd}	89 ± 0.08^{bcd}
	0.50	50	77 ± 0.05^{abc}	94 ± 0.08^{cd}	98 ± 0.06^{d}	98 ± 0.06^{d}	98 ± 0.06^{d}
2012	0.125	50	53 ± 0.06^{a}	73 ± 0.07^{bc}	79 ± 0.00^{c}	79 ± 0.00^{c}	79 ± 0.00^{c}
	0.25	50	76 ± 0.08^{ab}	82 ± 0.08^{ab}	90 ± 0.06^{bc}	90 ± 0.06^{bc}	90 ± 0.06^{bc}
	0.50	50	80 ± 0.09^{bc}	94 ± 0.00^{c}	98 ± 0.00^{c}	98 ± 0.00^{c}	98 ± 0.00^{c}

* $P < 0.05$; means with different letters within a row were significantly different (Duncan's Test), SE = Standard error.

After 24 hours of chemical application, the toxicity of spiromesifen at three different concentrations (0.5, 0.25 and 0.125 µl/mL) on immature stages were estimated 77, 76 and 53% respectively. The highest response was obtained at 0.5µl/mL, while the lowest ratio was estimated at 0.125 µL/mL ($P < 0.05$).

After 36 hours of chemical application, the effectiveness ratios were 94, 82 and 73 for three concentrations respectively (0.5, 0.25 and 0.125 µl/mL). The toxicity of spiromesifen at immature stages had statistically different categories for 36 hours ($P < 0.05$).

After 48 hours of chemcial application, the highest effectiveness ratio (98) was obtained (0.50 µL/mL concentration), while these values were 89 and 79 for 0.25 and 0.125 µL/mL concentration respectively ($P < 0.05$).

After 72 hours of chemcial application, 100 % immature deaths were not detected at 0.125 and 0.25 µL/mL concentration whereas 98% deaths occurred after 48 hours (Table 2, Fig. 1C, D).

Generally, immature stages of *T. urticae* are more susceptible to this chemical. It has been observed that the effect of spiromesifen on immature stages changed according to the concentration and duration. The field concentration of acaricide was found to be very effective as compared to other concentrations.

The results of 2011 and 2012 treatment of spiromesifen on immature stages of *T. urticae* were similar in toxicity rates of 0.125 and 0.25 µL/mL concentrations. The effectiveness was also very

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high on immature stages at the recommended concentration (94 and 98%) (Table 2).

Toxicity of spiromesifen on T. urticae *adults*

The response of adults of *T. urticae* for spiromesifen lower than immatures and egg stage (Table 3, Fig. 1 E, F). The highest responses were carried out at the recommended rate, the mortality rate reached over 90% at the 0.5 µL/mL concentration.

Table 3. The effect of spiromesifen on *Tetranychus urticae* adult (females) in 2011 and 2012*.

Years	Concentration (µL/mL)	Adult (%) ± SE					
		N	24 h	36 h	48 h	60 h	72 h
2011	0.125	50	12 ± 0.03^{a}	36 ± 0.06^{ab}	42 ± 0.05^{abc}	44 ± 0.04^{abc}	44 ± 0.04^{abc}
	0.25	50	18 ± 0.07^{a}	70 ± 0.12b^{cd}	84 ± 0.13^{d}	84 ± 0.13^{d}	85 ± 0.13^{d}
	0.50	50	77 ± 0.08^{d}	96 ± 0.08^{d}	96 ± 0.08^{d}	96 ± 0.08d	96 ± 0.08d
2012	0.125	50	13 ± 0.03^{a}	36 ± 0.06^{a}	42 ± 0.04^{ab}	42 ± 0.04^{ab}	44 ± 0.04^{ab}
	0.25	50	36 ± 0.04^{a}	77 ± 0.02^{bc}	85 ± 0.06^{c}	85 ± 0.13^{c}	85 ± 0.13^{c}
	0.50	50	77 ± 0.12^{c}	96 ± 0.08^{c}	96 ± 0.08^{c}	96 ± 0.08^{c}	96 ± 0.08^{c}

*: $P < 0.05$; means with different letters within a line were significantly different (Duncan's Test), SE = Standard error, N = 50

After 24 hours of chemical application, the toxicity of spiromesifen on two-spotted spider mite females; 77, 18 and 12 at three different concentrations respectively (0.5, 0.25 and 0.125 µL/mL). The highest effectiveness was obtained at 0.50 µL/mL and this value is statistically different from the other concentration ($P < 0.05$).

After 36 hours of chemcial application, the toxicity of spiromesifen on two-spotted spider mite females; 96, 70 and 36 at three different concentrations, respectively (0.5, 0.25 and 0.125 µL/mL). The highest effectiveness rate was obtained at 0.50 µL/mL concentration. The effectiveness of 0.25 µL/mL and 0.125µL/mL concentrations evaluated statistically different categories ($P < 0.05$).

After 48 hours of chemical application, the toxicity of spiromesifen (0.5, 0.25 and 0.125 µL/mL) on two-spotted spider mite females were; 96, 84 and 42 respectively ($P < 0.05$). The response of the adults were similar at three different concentrations in two years.

After 72 hours of chemical application, the toxicity of spiromesifen on two-spotted spider mite females; 96, 85 and 44 % were determined respectively ($P < 0.05$).

The response of the adults was similar in two different concentrations (0.5 and 0.25 µL/mL). The ¼ concentration has the lowest rate of mortality as compared to the other concentrations. The mortality rate of the females generally occurred within the first 36 hours. Similar results were obtained in both years (2011, 2012) considering the effects of spiromesifen on females.

The adult mortality rate was not statistically different within the observation time at 0.125 µL/mL concentration. However statistical differences were observed depending on the duration at 0.25 µL/mL concentration. At 0.50 µL/mL, the response of the females was similar at different observation times (36, 48, 60 and 72 hours) which were very high mortality ratios, about 77–96 %. After 24 h, some replicates represented 100% percent mortality (at 0.50 µL/mL). At 0.25 µL/mL concentration, the mortality rate was lower by 20–30% after 24 hours of chemical application.

Spiromesifen has different mortality rates at different concentration levels and 0.50 µL/mL concentration statistically significant value as compared to the other two concentrations (Tables 1–3, Fig. 1A–F).

The mortality rate was lower at half of the recommended concentration after 24 h, and higher mortality rates were observed after 36 and 48 h of chemical application, but these values were still lower than the recommended concentration. In application of the lowest concentration (0.125 µL/mL), the mortality rates were the lowest as compared to the other two higher concentrations

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(0.50 and 0.25 µL/mL). The efficacy of spiromesifen on the adult stage of the two-spotted spider mite was lower than eggs and the immature stages.

DISCUSSION

In our experiments, spiromesifen demonstrated high toxicity on eggs and immature developmental stages of *T. urticae*, while females were less susceptible. It has been mentioned, Wachendorff *et al*. (2002), this chemical activity against females was slower, after direct treatment, it took several days to die, but fecundity and fertility of the treated individuals were significantly reduced (Marcic and Ogurlić 2006; Cheon *et al*. 2007).

Lethal and sub-lethal effects of spirotetramat, spiromesifen and spirodiclofen have also been assessed on *T. urticae* eggs and adults. Ovicidal activity was observed in all of the chemicals, but only spirodiclofen was considerably effective against adult stages of mites. The survival rate, the total number of laid eggs per female and egg-hatching rate were slightly lower in treated females as compared with controls (Saryazdi *et al*. 2013).

It is obvious that a relatively low concentration of spiromesifen would eliminate a considerable ratio of *T. urticae* population (Easterbrook 1992; Trumble and Morse 1993; Lilley and Campbell, 1999) as the most effective management strategy for this pest. Successful control can be achieved by releasing predators in conjunction with reduced rates of acaricides (Herron *et al*. 1993; Rhodes *et al*. 2006; Alzoubi and Çobanoğlu 2007; 2010 a, b).

Spiromesifen is highly toxic to all stages of *T. urticae*, which depends on the concentrations rate and duration of application. Spiromesifen has some negative effects on predatory mites, applied at recommended rates (De Maeyer *et al*. 2002; Wolf and Schnorbach 2002; Hardman *et al*. 2003; Reis *et al*. 2006; Cheon *et al*. 2007). The similar results were concurred with our study.

Kaplan *et al*. (2012) noted that spiromesifen had a lower effect on the adult stages of *Neoseiulus californicus* (Mc Gregor) (Acari: Phytoseiidae) as compared to its immature stages. The effect of three concentrations (field, doubles and half) of spiromesifen on immature stages of *N. californicus*, were varied by exposure time. All three concentrations of spiromesifen were found to be harmless to predatory mite *N. californicus* nymphs with an effective rate of less than 30% (Hassan 1992).

The survival rate of *T. urticae* females treated with the lowest concentration of spirodiclofen was significantly lower than the survival rate of untreated females. Total fecundity significantly decreased as concentrations of acaricides increased (Marcic 2007).

Spirodiclofen was found to provide good effects against *T.urticae* in several European countries (Elbert *et al*. 2002); even though it has some adverse effects on the survival and fecundity rates of some predatory mite species. The same results indicated that predatory mite, *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae), was more sensitive to insecticides when compared with *T. urticae*. (Reis *et al*. 2006; Alzoubi and Çobanoğlu 2007; 2010 a, b). Spirodiclofen was much less toxic to *Amblyseius womersleyi* Schicha (Acari: Phytoseiidae) than to *T. urticae*. Although the survival rate of adult females of *A. womersleyi* tended to decrease with increasing concentrations of spirodiclofen (Cheon *et al*. 2007).

The sub-lethal concentration of spirodiclofen has discriminative effects on eggs and immatures of *T. urticae*, and lower rates of the chemical could lead to bettercontrol of the pest population (Marcic 2007). The results represented, each concentration level of spiromesifen have a variable degrees of activity on different stages of the two-spotted spider mite. Eggs and immatures are more susceptible than adults. It is obvious that the spiromesifen has ovicid toxicity for the eggs of the two-spotted spider mite. The results of this study could be seen as a starting point for further research to improve the management of *T. urticae* populations.

This study focuses on sub-lethal effects of spiromesifen on the effect of different stages of the two-spotted spider mite with a ½ and ¼ recommended concentrations, beginning with the concentration discriminative on eggs, immatures and adults up to the recommended concentration.

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As well as being effective in bioassay studies, half and even ¼ concentrations have been successful in suppressing the populations of *T. urticae.* It is necessary to be confirm these results in field application by further studies.

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سمیت اسپیرومسیفن روی مراحل مختلف رشدی کنهٔ تارتن دو لکه‌ای، *Tetranychus urticae* Koch (Acari: Tetranychidae)

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چکیده

اسپیرومسیفن آفت‌کشی (کنه‌کش) است که برای کنترل کنهٔ تارتن دولکه‌ای، *Tetranychus urticae* Koch (Acari: Tetranychidae) که آفت مهم توت فرنگی در ناحیهٔ مرسین ترکیه است به طور گسترده استفاده می‌شود. بررسی در شرایط آزمایشگاهی (۲۵ ± ۱ درجهٔ سلسیوس، رطوبت نسبی ۶۰ ± ۱۰ درصد و دورهٔ نوری ۱۶ ساعتی) انجام شد. پاسخ‌های (میزان مرگ، حساسیت) جمعیت‌های کنه به آفت‌کش‌ها با محاسبه میزان مرگ یا میزان تأثیر (٪ ابوت)، برای سه غلظت مختلف (توصیه شده، ۱/۲ و ۱/٤ میزان مصرف) تخمین زده شد. بر اساس میزان تأثیر، تخم‌ها و مراحل جوان کنه حساسیت بسیار شدیدی به اسپیرومسیفن نشان دادند که اسپیرومسیفن در دسته‌بندی مضر قرار گرفت. کنه‌های کامل *T. urticae* حساسیت کمی به این کنه‌کش نشان دادند. اسپیرومسیفن به عنوان سمی‌ترین برای تخم‌ها در نظر گرفته شد. میزان تفریخ تخم حدود ۹۰–۱۰۰ درصد در غلظت توصیه شده و دیگر غلظت‌ها در فاصله ۳۶–۷۲ ساعت (۰/۵، ۰/۲۵ و ۰/۱۲۵ میکرولیتر/میلی لیتر) کاهش پیدا کرد. اسپیرومسیفن در فاصله ٤٨ ساعت روی میزان تفریخ تخم‌ها بسیار سمی بود. بیشترین میزان تأثیر برای مراحل جوان به ترتیب ۷۹، ۸۹ و ۹۸ درصد برای هر غلظت (۰/۵، ۰/۲۵ و ۰/۱۲۵ میکرولیتر/میلی لیتر) تخمین زده شد. برای مرحلهٔ کامل کنهٔ تارتن دولکه‌ای، بیشترین تأثیر در غلظت توصیه شده به دست آمد که میزان مرگ به بیش از ۹۶٪ پس از ۶۰ ساعت رسید.

واژگان کلیدی: زیست‌سنجی؛ تأثیر؛ حساسیت؛ توت‌فرنگی؛ *Tetranychus urticae* ؛ اسپیرومسیفن.

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