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Article

The efficacy of some chemical and botanical pesticides against *Tetranychus urticae* (Acari: Tetranychidae) on *Platanus orientalis* (Platanaceae) in urban areas

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ABSTRACT
The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), is a destructive pest causing significant damage to trees and shrubs in urban green spaces. Using pesticides is considered the most prevalent approach towards controlling this pest. In this research, the effects of pesticides abamectin, fenproxymate, Tondexir®, Sirinol®, and Palizin® on the mortality of *T. urticae* were investigated in the laboratory and urban green spaces. Laboratory bioassays were conducted with five concentrations of each pesticide between 0.72–3.60, 0.50–3.00, 1275–6800, 595–5950, and 325–3900 mg ai/L for abamectin, fenproxymate, Tondexir®, Sirinol®, and Palizin®, respectively in five replicates. Field experiments were conducted based on a complete randomized block design (CRBD) in the urban green space of Mashhad city on the oriental plane trees (*Platanus orientalis* L.) infested with *T. urticae*. Treatments included triplicate sprayings with commercial formulations of abamectin (250 mg/L) and fenproxymate (500 mg/L) as well as Tondexir® (2000 mg/L), Sirinol® (2000 mg/L), and Palizin® (2000 mg/L), and water (control). Abamectin and fenproxymate showed the highest toxicity for *T. urticae* adult females with LC_{50}s of 1.61 and 1.16 mg ai/L, respectively. Tondexir® showed a lower toxicity for *T. urticae* (LC_{50} = 2500.53 mg ai/L) compared to Sirinol® (LC_{50} = 1308.58 mg ai/L) and Palizin® (LC_{50} = 1494.73 mg ai/L). Abamectin and fenproxymate showed the highest population reduction in *T. urticae* adults on plane trees after 28 days (98.68 ± 0.64 and 99.70 ± 0.56%, respectively). For egg populations also, abamectin and fenproxymate showed a better reduction compared to other insecticides. Palizin® showed the least efficiency (32.60 ± 2.40%) in controlling *T. urticae* adults. *T. urticae* eggs were reduced better with Tondexir® (35.85 ± 2.24%) compared to Sirinol® (22.54 ± 0.69%) and Palizin® (20.85 ± 1.5%). Although abamectin and fenproxymate showed better control of *T. urticae* adults and eggs, spraying with more efficient botanical insecticides such as Tondexir® Sirinol® are suggested in urban areas due to health concerns for the residents.

KEY WORDS: Abamectin; fenproxymate; oriental plane tree; Palizin®; Sirinol®; Tondexir®.

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INTRODUCTION

The oriental plane tree (*Platanus orientalis* L.) is an ornamental species planted in parks and along

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streets in cities around the world due to having criteria of interest in terms of urban tree planning and management, including rapid growth, resistance to drought, and a wide crown providing shade (Vogt *et al.* 2017). In Iran, plane trees are planted extensively in the green spaces, streets, and avenues of different cities (Pourkhabbaz *et al.* 2010).

The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), is an invasive polyphagus mite species and has over 1000 host plant species over the world (Khanjani and Haddad Irani-Nejad 2006; Attia *et al.* 2013). *Tetranychus urticae* is an economically harmful pest due to its high rate of fecundity and short life cycle on various crops (Tirello *et al.* 2012). During summertime, this mite usually causes serious damage to plane trees in urban areas of cities resulting in decreasing the quality of urban green space (Mazaheri *et al.* 2006, 2007).

Many chemical-based insecticides and acaricides have been registered to control *T. urticae* in Iran, including abamectin and fenproxymate. To reduce the risk for environmental pollution and health of residents, demand for utilization of environmentally friendly pesticides has increased, among which botanical insecticides such as Tondexir®, Sirinol®, and Palizin® are of great popularity (Mirfakhraie and Mohammadian 2017; Kabiri Raeis Abad and Zaree 2017; Amiri-Besheli *et al.* 2020). Tondexir® and Sirinol® are botanical insecticides consisting of the extract of red pepper (*Capsicum annum* L.) and garlic (*Allium sativum* L.) extracts, respectively. The garlic extract has been reported to have repellency, antifeedant, bactericidal, fungicidal, and nematicidal activities (Fields *et al.* 2001; Loth *et al.* 2007; Londhe *et al.* 2011). Capsaicin is the main active ingredient in the red pepper extract, which has toxicity effects on invertebrates (Govindarajan and Sathyanarana 1991). Palizin® consists of the extracts from mint and eucalyptus and coconut (*Cocos nucifera* L.) oil (Nezhadverdy and Kavousi 2016). Palizin causes damage to the insect's respiratory system and exoskeleton (Kabiri and Amiri-Besheli 2012).

The efficacy of Tondexir®, Sirinol®, and Palizin® against various pests, including *T. urticae*, has been reported (Nezhadverdy and Kavousi 2016; Mirfakhraie and Mohammadian 2017; Kabiri Raeis Abad and Zaree 2017; Amiri-Besheli *et al.* 2020). However, environmental conditions and host plant characteristics are among the two important factors determining the toxicity of agrochemicals to pests (Auger *et al.* 2003; Bostanian *et al.* 2004). In this regard, no research has so far addressed the efficacy of these compounds in reducing the population of *T. urticae* on the plane trees in urban areas.

Controlling pests of plane trees, including *T. urticae*, is of great importance for maintaining the green spaces of urban areas. In this regard, applying effective and environmentally friendly pesticides is essential to ensure the health of the citizens. Therefore, we aimed to evaluate the efficacy of three botanical insecticides Tondexir®, Sirinol®, and Palizin®, in comparison with conventional insecticides fenproxymate and abamectin on *T. urticae* under laboratory and field (on plane trees in Mashhad city) conditions.

MATERIAL AND METHODS

Pesticides

Commercial formulations of pesticides abamectin (Vertimec®; 1.8% EC; Golsam Co.) and fenproxymate (Ortus®, 5% SC; Golsam Co.) along with botanical insecticides Tondexir® (85% EC; Sabzavar Co.) and Sirinol® (85% EC; Kimiasabzavar Co.), and also the insecticidal soap Palizin® (65% SL; Kimiasabzavar Co.) were obtained from local suppliers.

Mite collection and rearing for bioassay experiments

Mite populations for the bioassay tests were collected from infested plane trees without pesticide application history located in an urban area of Mashhad city, Iran. In the laboratory, mites were maintained and reared, for at least five generations, on plane stems with at least two leaves at 24 ± 1

°C, 60–70% relative humidity (RH), and 16L:8D h photoperiod. Stem tips were placed into a cork stopper placed in water to keep the moisture.

To obtain uniformly aged female *T. urticae*, 10 adults were randomly taken from separate mass rearing arenas and transferred to plane stems with at least two leaves, as described above. After 24 h, adults were removed, and the remaining eggs were kept at 24 ± 1 °C, 60–70% relative humidity (RH), and 16L: 8D h photoperiod. Differences in the sex-specific body size were used to determine their sex after reaching adulthood. 4 day-old adult females were used for the bioassay tests (Ullah and Lim 2017; Tahmina *et al*. 2020).

Laboratory bioassay experiments

To evaluate the lethal concentrations of 30, 50, and 70% (LC_{30}, LC_{50}, and LC_{70}, respectively) of each pesticide on the 4-day-old adult females of *T. urticae*, five concentrations of each pesticide were selected, causing 10–90% mortality based on the bracketing test (Robertson and Preisler 1991) and prepared in distilled water. These concentrations ranged between 0.72–3.60, 0.50–3.00, 1275–6800, 595–5950, and 325–3900 mg ai/L for abamectin, fenproxymate, Tondexir®, Sirinol®, and Palizin®, respectively. A round leaf disk (20 mm diameter) was prepared with plane tree leaves and was submerged for 15 s in aqueous solutions of each pesticide. After evaporation of water for 1 h, the disks were placed on the floor Petri dishes. In the control group, leaf disks were submerged into distilled water without any pesticide treatment. 16 adult females of *T. urticae* were transferred onto the leaf disks in each Petri dish. All Petri dishes were incubated at 24 ± 1 °C, 60–70% relative humidity (RH), and 16L:8D h photoperiod, and numbers of dead mites were counted after 24 h. Experiments were carried out with five replicates.

Field experiments

Field experiments were performed in an urban area located in a western region of the Mashhad City, Razavi Khorasan Province, Iran (longitude: 59° 36′ 0″ E; latitude: 36° 18′ 0″ N; altitude: 995 m). 40-year-old uniform oriental plane trees (*Platanus orientalis*) infested with the two-spotted spider mites were selected for the experiments. The experimental layout was a complete randomized block design (RCBD) in triplicates, with one tree in each block. Treatments consisted of sprayings with recommended dosages of commercial formulations of abamectin (250 mg/L) and fenproxymate (500 mg/L) as well as Tondexir® (2000 mg/L), Sirinol® (2000 mg/L), and Palizin® (2000 mg/L), and a water spray (control). The population of two-spotted spider mites was monitored regularly. Concurrently with the observation of the maximum population, sprayings were conducted (May 14, 2020) based on the common regional practice by using a calibrated sprayer. Between each plot, two trees were left unsprayed to avoid cross-contamination. Samplings were performed from different parts of the plane tree crown by collecting 20 leaves from each tree 1 day before pesticide application and 3, 7, 14, 21, and 28 days after spraying. Samples were transferred to the laboratory, and the numbers of adult mites and eggs were counted under a binocular microscope. For complementary counting, leaves were placed in a Berlese funnel, and after 48 h, numbers of mites escaped and trapped in a receptacle were also counted.

Data analysis

For field experiments, the percentage of mite population reduction (adults and eggs) were calculated for each treatment and each sampling day and corrected according to the control by using the Henderson-Tilton's formula (Henderson and Tilton 1955). One-way analysis of variance (ANOVA) was adopted for field data analysis, and means were compared using the least significant difference (LSD) method at $P = 0.05$ using the SAS software v. 9.4. LC values along with 95% confidence intervals (95% CI) were calculated using the PoloPlus v. 2 (LeOra Software).

RESULTS AND DISCUSSION

Laboratory bioassay

LC_{30}, LC_{50}, and LC_{70} values for pesticides on *T. urticae* adult females are shown in Table 1. According to the results, abamectin and fenproxymate showed the highest toxicities for *T. urticae* adult females with statistical different LC_{50}s from the botanical compounds. LC_{50}s of abamectin and fenproxymate were 1.61 (95% CI = 1.38–1.88) and 1.16 (95% CI = 0.92–1.43) mg ai/L, respectively. Among the other three compounds, Tondexir® showed a lower toxicity for *T. urticae* (LC_{50} = 2500.53 mg ai/L; 95% CI = 1984.96–3045.22) compared to Sirinol® (LC_{50} = 1308.58 mg ai/L; 95% CI = 959.19–1681.31) and Palizin® (LC_{50} = 1494.73 mg ai/L; 95% CI = 1200.61–1914.05). These results are in accordance with the estimated LC_{50} values for Tondexir® and Sirinol® as 1811.27 and 1509.51 mg ai/L, respectively by Mirfakhraie and Mohammadian (2017). Jafari *et al.* (2016) also evaluated an LC_{50} of 1898 mg/L for Tondexir® on *Panonychus citri* adults after 72 h. On the contrary, Kabiri Raeis Abad and Zaree (2017) reported considerable different LC_{50}s for Tondexir® (513.48 mg ai/L) and fenproxymate (19.36 mg ai/L) on *T. urticae*. These contrasts can be explained by the different bioassay methods used in the studies. Palizin® has also been shown to have repellency for various stored product pests, i.e., *Sitophilus oryzae*, *Tribolium castaneum*, *Rhizopertha dominica*, *Oryzaephilus surinamensis*, and *Lasioderma serricorne* (Sadeghi *et al.* 2014). Also, Palizin® at concentrations of 1.5, 2, and 2.5 ml/L resulted in 0.71, 1.64, and 1.55% mortalities, respectively on *T. urticae* after 24 h under laboratory conditions (Amiri-Besheli *et al.* 2020).

Table 1. Bioassay results of pesticides on adult females of *T. urticae*.

Pesticides	N[a]	LC_{30} (mg ai/L) (95% CI)	LC_{50} (mg ai/L) (95% CI)	LC_{70} (mg ai/L) (95% CI)	Slope (SE)	χ^2 (df)	H[b]
Abamectin	400	1.10 (0.87–1.29)	1.61 (1.38–1.88)	2.36 (2.00–2.95)	3.18 (0.48)	9.041 (13)	0.57
Fenproxymate	400	0.70 (0.48–0.89)	1.16 (0.92–1.43)	1.90 (1.52–2.68)	2.44 (0.43)	4.47 (13)	0.34
Sirinol®	400	724.72 (432.78–983.81)	1308.58 (959.19–1681.31)	2362.82 (1834.83–3329.19)	2.04 (0.35)	2.55 (13)	0.20
Tondexir®	400	1561.31 (1048.02–1969.71)	2500.53 (1984.96–3045.22)	4004.72 (3272.01–5409.45)	2.56 (0.46)	1.72 (13)	0.13
Palizin®	400	917.79 (693.86–1144.38)	1494.73 (1200.61–1914.05)	2434.35 (1902.57–3495.61)	2.48 (0.36)	6.40 (13)	0.49

[a] number of mites; [b] Heterogeneity.

Field sprayings

ANOVA results showed that the effect of pesticides on the population reduction of *T. urticae* adults and eggs were significant ($P < 0.01$) under field conditions (Table 2). Shapiro-Wilk and Levene's test results were insignificant ($P > 0.05$), showing the normality of the data and the homogeneity of variances, respectively (data not shown).

Based on the results, for all pesticides, the mortality percentages of *T. urticae* adults and eggs increased with time and reached a maximum after almost 21–28 days (Tables 3, 4). This result shows that all pesticides had acceptable persistence overtime under field conditions and could affect the pest population up to 21-28 days after application.

Table 2. ANOVA for population reduction percentages of *T. urticae* adults and eggs on plane trees treated with different pesticides.

Life stage	Sources of Variation	df	Mean square (MS) at different sampling days after spray				
			3	7	14	21	28
Adults	Block	3	22.95^{ns}	23.46^{ns}	9.72^{ns}	19.32^{ns}	10.97^{ns}
	Treatment	14	1544.05^{**}	1736.10^{**}	3049.57^{**}	3084.30^{**}	3052.40^{**}
	Error	12	13.61	8.43	9.23	5.60	3.86
Eggs	Block	3	3.27^{ns}	1.71^{ns}	9.50^{ns}	6.60^{ns}	2.95^{ns}
	Treatment	14	371.84^{**}	1623.22^{**}	1424.99^{**}	1826.07^{**}	1858.26^{**}
	Error	12	1.13	2.99	4.65	7.53	2.93

^{ns} and ** are not significant and significant ($P < 0.01$), respectively.

Abamectin and fenproxymate showed the highest population reduction in *T. urticae* adults on plane trees after 28 days (98.68 ± 0.64 and 99.70 ± 0.56%, respectively) (Table 3). For egg populations also, abamectin and fenproxymate showed a better reduction compared to Tondexir®, Sirinol®, and Palizin® and After 28 days, abamectin was significantly more efficient (66.23 ± 2.29%) compared to fenproxymate (62.21 ± 0.56%) (Table 4). Fenproxymate and abamectin are both considered broad-spectrum acaricides and are effective against different growth stages of spider mites, i.e., larvae, nymph, and adults. Although fenproxymate and abamectin showed higher toxicities for adults and eggs of *T. urticae* in both laboratory and field trials, the environmental contamination and health risks of these two agrochemicals, especially in urban areas, should be considered. Long-term application of chemical pesticides can also adversely affect the ecosystem balance through the elimination of the natural enemies (Gonzalez-Zamora *et al.* 2004; Mones *et al.* 2011; Pekár 2012). For instance, it has been shown that the application of fenproxymate diminished the populations of *Phytoseiulus persimilis*, a common predator of *T. urticae* (Kabiri Raeis Abad and Zaree 2017). Therefore, shifting towards the application of more environmentally friendly pesticides, i.e., Sirinol®, Tondexir®, and Palizin®, especially in urban and residential areas, is suggested.

Table 3. Mean comparisons for population reduction percentages of *T. urticae* adults on plane trees treated with different pesticides.

Treatments	Average for population reduction (%) of *T. urticae* adults ± SD in days after spraying				
	3	7	14	21	28
Abamectin	69.28 ± 4.06^{a}	77.71 ± 2.39^{a}	98.41 ± 1.22^{a}	98.71 ± 1.06^{a}	98.68 ± 0.64^{a}
Fenproxymate	66.90 ± 3.90^{a}	76.07 ± 4.06^{a}	98.73 ± 1.80^{a}	98.64 ± 1.21^{a}	99.70 ± 0.56^{a}
Sirinol®	43.25 ± 3.35^{b}	59.30 ± 2.30^{b}	72.32 ± 2.89^{b}	70.45 ± 3.49^{b}	70.64 ± 3.30^{b}
Tondexir®	42.86 ± 5.16^{b}	58.09 ± 2.97^{b}	68.19 ± 4.31^{b}	69.89 ± 3.80^{b}	70.74 ± 2.92^{b}
Palizin®	21.81 ± 2.87^{c}	25.91 ± 4.56^{c}	31.51 ± 3.88^{c}	31.17 ± 3.58^{c}	32.60 ± 2.40^{c}

SD: standard deviation. Means followed by the same letters in each column do not differ significantly (LSD, $P = 0.05$).

Table 4. Mean comparisons for population reduction percentages of *T. urticae* eggs on plane trees treated with different pesticides.

Treatments	Average for population reduction (%) of *T. urticae* eggs ± SD in days after spraying				
	3	7	14	21	28
Abamectin	23.13 ± 1.86^{a}	49.31 ± 2.53^{a}	56.07 ± 3.64^{a}	65.31 ± 2.52^{a}	66.23 ± 2.29^{a}
Fenproxymate	23.01 ± 1.81^{a}	42.24 ± 1.93^{b}	51.56 ± 2.22^{b}	59.63 ± 3.85^{b}	62.21 ± 0.56^{b}
Sirinol®	4.89 ± 0.27^{c}	7.14 ± 0.65^{d}	19.29 ± 1.41^{d}	21.87 ± 1.23^{d}	22.54 ± 0.69^{d}
Tondexir®	8.00 ± 0.55^{b}	16.22 ± 1.57^{c}	23.99 ± 1.77^{c}	33.29 ± 3.63^{c}	35.85 ± 2.24^{c}
Palizin®	4.10 ± 0.82^{c}	6.52 ± 0.81^{d}	16.37 ± 2.19^{d}	19.35 ± 0.95^{d}	20.85 ± 1.50^{d}

SD: standard deviation. Means followed by the same letters in each column do not differ significantly (LSD, $P = 0.05$).

Tondexir® and Sirinol® are botanical insecticides consisting of the extract of red pepper (*C. annum* L.) and garlic (*A. sativum* L.) extracts, respectively. Palizin® consists of extracts from mint, eucalyptus, and coconut oil (Nezhadverdy and Kavousi 2016). The diallyl and disulfide present in Sirinol® produce a sharp odor and act as a powerful insecticide (Kaufman *et al.* 2006). Huang *et al.* (2000) showed that diallyl trisulphide is the dominant constituent of garlic extract. Other constituents such as sulfur-containing amino acids also have toxicity against mites (Dąbrowski and Seredyńska 2007; Hincapié *et al.* 2008). Our results showed that after 28 days, Tondexir® and Sirinol® resulted in significantly less reduction in the populations of *T. urticae* adults (70.74 ± 2.90% and 70.46 ± 3.30%, respectively) compared to abamectin and fenproxymate (Table 3). Palizin® showed the least efficiency (32.60 ± 2.40%) in controlling *T. urticae* adults (Table 3), despite its higher efficiency in laboratory bioassay tests. *Tetranychus urticae* eggs were reduced better with Tondexir® (35.85 ± 2.24%) compared to Sirinol® (22.54 ± 0.69%) and Palizin® (20.85 ± 1.5%) (Table 4). Kabiri Raeis Abad and Zaree (2017) showed Tondexir® (2000 mg/L) resulted in 93 and 89% reduction of *T. urticae* eggs and adults, respectively after 21 days in a field trial on bean (*Phaseolus vulgaris* L.) plants. Also, Mirfakhraie and Mohammadian (2017) reported that Tondexir® and Sirinol® have appropriate efficiencies in reducing *T. urticae* populations. Amiri-Besheli and Kabiri-Res Abad (2018) showed that Sirinol® at 2000 mg/L reduced the adult and egg populations of *T. urticae* by 92.11 and 91.75%, respectively under field conditions after 21 days on bean plants. Palizin® at concentrations of 1.5, 2, and 2.5 ml/L resulted in 0.71, 1.64, and 1.55% mortalities, respectively, on *T. urticae* after 24 h under laboratory conditions (Amiri-Besheli *et al.* 2020). Erdoğan *et al.* (2012) showed that Sirinol® at 5700 mg/L resulted in 77.77% mortality in *T. urticae* populations. Also, Erdoğan *et al.* (2010) reported that the 12% ethanolic extract of the red pepper caused 97, 84, and 95% mortality for *T. urticae* larvae, nymphs, and adults, respectively. The efficacy of other botanical insecticides, e.g. the garlic extract, on the two-spotted spider mites have also been reported (Aslan *et al.* 2004; Pontes *et al.* 2007; Attia *et al.* 2011; Shakarami *et al.* 2014). The toxicity of pesticides for mites depends on various factors, e.g. the toxicity of the active ingredient, the applied dose, climatic conditions, the life stage of the mites, and the host plant (Auger *et al.* 2003; Bostanian *et al.* 2004).The difference in climatic conditions and host plant characteristics might have resulted in contrasts observed between our study and the previously conducted ones. Plane trees have a wide crown and a dense canopy, and therefore, it is supposed that the lower control efficacy of the botanical pesticides might be due to a lack of balanced distribution of the sprayed solutions to all parts of the crown. Also, various allelochemicals and secondary metabolites present in different host plants can influence the susceptibility of herbivorous arthropods, including *T. urticae*, to pesticides (Yang *et al.* 2001; Wang *et al.* 2002; Homayoonzadeh *et al.* 2020).

On the other positive side, a research has reported low toxicity of Tondexir®, Sirinol®, and Palizin® for beneficial insects. i.e., parasitoids and predators. Kabiri Raeis Abad and Zaree (2017) reported significantly lower toxicity of Tondexir® to *P. persimilis* compared to fenproxymate. The toxicity of Tondexir®, Sirinol®, and Palizin® for *Oenopia conglobata* L., a major predator of the common pistachio psyllid, is also reported to be low (Kabiri Raeis Abad 2012).

The efficacies of the pesticide in reducing egg populations of *T. urticae* were generally lower compared to the adults (Tables 4 and 5). It has been suggested previously that adults of *T. urticae* are more susceptible to pesticides than eggs (Kabiri Raeis Abad and Zaree 2017; Amiri-Besheli and Kabiri-Res Abad 2018). Therefore, sprayings are suggested after the emergence of adults.

CONCLUSION

Our results suggested that under both laboratory and field conditions, abamectin and fenproxymate had higher toxicities for *T. urticae* adults and eggs compared to Tondexir®, Sirinol®, and Palizin®. According to laboratory LC_{50} values derived from bioassay experiments, Sirinol® and Palizin®

showed toxicities 1.9 and 1.7 times, respectively higher than Tondexir® for *T. urticae* adult females. When sprayed on plane trees in urban areas, however, Tondexir® resulted in a more efficient reduction in the populations of adults and eggs compared to Sirinol® and Palizin®, and Palizin showed the least efficiency. Also, all pesticides were more efficient in reducing adult populations of *T. urticae* compared to the eggs, probably due to more susceptibility of the adult stage of this pest. The application of pesticides in urban areas should be handled with care, and selecting environmentally friendly compounds with the least risk for the health of residents is crucial. In this regard, our results suggest that although abamectin and fenproxymate controlled *T. urticae* adults and eggs with higher efficacy, using efficient botanical insecticides such as Tondexir® Sirinol® are recommend-ed for controlling *T. urticae* populations on plane trees in urban areas.

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REFERENCES

Amiri-Besheli, B. & Kabiri-Res Abad, M. (2018) The survey effects of garlic extract Sirinol® and chemical acaricide spirodiclofen Envidor® on two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae) under laboratory and field conditions. *Journal of Plant Protection*, 32(2): 205–213.
DOI: 10.22067/JPP.V32I2.63951

Amiri-Besheli, B., Toorani, A.H. & Abbasipour, H. (2020) The effect of different bio-rational and chemical pesticides on *Panonychus citri* and *Tetranychus urticae* mites under laboratory conditions. *Fresenius Environmental Bulletin*, 29(12A): 11089–11095.

Aslan, İ., Özbek, H., Çalmaşur, Ö. & Şahin, F. (2004) Toxicity of essential oil vapours to two greenhouse pests, *Tetranychus urticae* Koch and *Bemisia tabaci* Genn. *Industrial Crops and Products*, 19(2): 167–173.
DOI: 10.1016/j.indcrop.2003.09.003

Attia, S., Grissa, K.L., Lognay, G., Bitume, E., Hance, T. & Mailleux, A.C. (2013) A review of the major biological approaches to control the worldwide pest *Tetranychus urticae* (Acari: Tetranychidae) with special reference to natural pesticides. *Journal of Pest Science*, 86(3): 361–386.
DOI: 10.1007/s10340-013-0503-0

Attia, S., Grissa, K.L., Mailleux, A.C., Lognay, G., Heuskin, S., Mayoufi, S. & Hance, T. (2012) Effective concentrations of garlic distillate (*Allium sativum*) for the control of *Tetranychus urticae* (Tetranychidae). *Journal of Applied Entomology*, 136(4): 302–312.
DOI: 10.1111/j.1439-0418.2011.01640.x

Auger, P., Guichou, S. & Kreiter, S. (2003) Variations in acaricidal effect of wettable sulfur on *Tetranychus urticae* (Acari: Tetranychidae): effect of temperature, humidity and life stage. *Pest Management Science*, 59(5): 559–565.
DOI: 10.1002/ps.665

Bostanian, N.J., Vincent, C., Hardman, J.M. & Larocque, N. (2004) Toxicity of indoxacarb to two species of predacious mites and a predacious mirid. *Pest Management Science*, 60(5): 483–486.
DOI: 10.1002/ps.817

Dąbrowski, Z.T. & Seredyńska, U. (2007) Characterization of the two-spotted spider mite (*Tetranychus urticae* Koch, Acari: Tetranychidae) response to aqueous extracts from selected

plant species. *Journal of Plant Protection Research*, 47(2): 113–124.
Erdoğan, P., Saltan, G. & Sever, B. (2010) Acaricidal effect of *Capsicum annum* L. extracts on two-spotted spider mite *Tetranychus urticae* Koch (Arachnida: Tetranychidae). *Bitki Koruma Bülteni*, 50(1): 35–43.
Erdoğan, P., Yildirim, A. & Sever, B. (2012) Investigations on the effects of five different plant extracts on the two-spotted mite *Tetranychus urticae* Koch (Arachnida: Tetranychidae). *Psyche*, 2012: 125284.
DOI: 10.1155/2012/125284
Fields, P.G., Xie, Y.S. & Hou, X. (2001) Repellent effect of pea (*Pisum sativum*) fractions against stored-product insects. *Journal of Stored Products Research*, 37(4): 359–370.
DOI: 10.1016/S0022-474X(00)00038-2
Gonzalez-Zamora, J.E., Leira, D., Bellido, M.J. & Avilla, C. (2004) Evaluation of the effect of different insecticides on the survival and capacity of *Eretmocerus mundus* Mercet to control *Bemisia tabaci* (Gennadius) populations. *Crop Protection*, 23(7): 611–618.
DOI: 10.1016/j.cropro.2003.11.011
Govindarajan, V.S. & Sathyanarayana, M.N. (1991) Capsicum—production, technology, chemistry, and quality. Part V. Impact on physiology, pharmacology, nutrition, and metabolism; structure, pungency, pain, and desensitization sequences. *Critical Reviews in Food Science & Nutrition*, 29(6): 435–474.
DOI: 10.1080/10408399109527536
Henderson, C.F. & Tilton, E.W. (1955) Tests with acaricides against the brown wheat mite. *Journal of Economic Entomology*, 48(2): 157–161.
Hincapié, C.A.L., López, G.E.P. & Torres, R.C. (2008) Comparison and characterization of garlic (*Allium sativum* L.) bulbs extracts and their effect on mortality and repellency of *Tetranychus urticae* Koch (Acari: Tetranychidae). *Chilean Journal of Agricultural Research*, 68(4): 317–327.
Homayoonzadeh, M., Moeini, P., Talebi, K., Allahyari, H., Torabi, E. & Michaud, J.P. (2020) Physiological responses of plants and mites to salicylic acid improve the efficacy of spirodiclofen for controlling *Tetranychus urticae* (Acari: Tetranychidae) on greenhouse tomatoes. *Experimental and Applied Acarology*, 82(3): 319–333.
DOI: 10.1007/s10493-020-00559-2
Huang, Y., Chen, S.X. & Ho, S.H. (2000) Bioactivities of methyl allyl disulfide and diallyl trisulfide from essential oil of garlic to two species of stored-product pests, *Sitophilus zeamais* (Coleoptera: Curculionidae) and *Tribolium castaneum* (Coleoptera: Tenebrionidae). *Journal of Economic Entomology*, 93(2): 537–543.
DOI: 10.1603/0022-0493-93.2.537
Jafari, I., Amiri-Besheli, B. & Mohammadi Sharif, M. (2016) Comparison ability of three plant pesticides, two chemical acaricides and conventional mineral oil against citrus red mite *Panonychus citri* (McGregor) (Acarina: Tetranychidae). *Journal of Plant Protection*, 30(2): 304–312.
DOI: 10.22067/jpp.v30i2.46028
Kabiri, M. & Amiri-Besheli, B. (2012) Toxicity of Palizin, Mospilan and Consult on *Agonoscena pistaciae* Burckhardt and Lauterer (Hemiptera: Psyllidae), *Oenopia conglobata* L. (Coleoptera: Coccinellidae) and *Psyllaephagus pistaciae* Ferrière (Hymenoptera: Encyrtidae). *Academic Journal of Entomology*, 5(2): 99–107.
DOI: 10.5829/idosi.aje.2012.5.2.63215
Kabiri Raeis Abad, M. (2012) *The effect of three botanical insecticides Palizin, Sirinol and Tondexir on the common pistachio psylla Agonoscena pistaciae and their two natural enemies*. M. Sc. Thesis, Sari Agricultural Science and Natural Resources University, Sari, 110 pp.

Kabiri Raeis Abad, M. & Zaree, E. (2017) Comparison toxicity of plant pesticides, Tondexir® and chemichal acaricides, Ortus® on two spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae) and its natural enemies *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae). *Plant Protection*, 40(3): 53-70.
DOI: 10.22055/PPR.2017.19096.1272

Kaufman, P.B., Kirakosayan, A., Mckenzie, M., Dayanadan, P., Hoyt, S.E. & Li, C. (2006) The uses of plant natural products by human and risks associated with their use. *In*: Cseke, L.J., Kirakosyan, A., Kaufman, P.B., Warber, S.L., Dukes, J.A. & Brielman, H.L. (Eds.), *Natural products from plants*. CRC Press, New York, pp. 441–473

Khanjani, M. & Haddad Irani-Nejad, K. (2006) *Injurious mites of agricultural crops in Iran*. Bu-Ali Sina University Press, 526 pp. (In Persian).

Londhe, V.P., Gavasane, A.T., Nipate, S.S., Bandawane, D.D. & Chaudhari, P.D. (2011) Role of garlic (*Allium sativum*) in various diseases: an overview. *Journal of Pharmaceutical Research and Opinion*, 1(4): 129–134.

Loth, S.M., Elice, N. L., Shazia, O.W.M.R. & Robert, N.M. (2007) Effectiveness of local botanicals as protectants of stored beans (*Phaseolus vulgaris* L.) against bean bruchid (*Zabrotes subfaciatus* Boh) (Genera: Zabrotes. Family: Bruchidae). *Journal of Entomology*, 4: 210–217.

Mazaheri, A., Hatami, B., Khajehali, J. & Sadeghi, S.E. (2007) Reproductive parameters of *Aeolesthes sarta* Solsky (Col., Cerambycidae) on *Ulmus carpinifolia* Borkh. under laboratory conditions. *Journal of Science and Technology of Agriculture and Natural Resources*, 11: 333–342.

Mazaheri, A., Hatami, B., Khajehali, J., Sadeghi, S. & Namazi, Y. (2006) Determination of infestation rate and intensity of *Aeolesthes sarta* on different tree species in Isfahan landscape. *Iranian Journal of Forest and Range Protection Research*, 4(2): 47–60.

Mirfakhraie, S. & Mohammadian, P. (2017) Effects of botanical insectides Sirinol, Tondexir and repellency of Palizin on two spotted spider mite (*Tetranychus urticae* Koch) in the laboratory conditions. *Plant Protection*, 40(3): 1–12.

Moens, J., De Clercq, P. & Tirry, L. (2011) Side effects of pesticides on the larvae of the hoverfly *Episyrphus balteatus* in the laboratory. *Phytoparasitica*, 39(1): 1–9.

Nezhadverdy, M. & Kavousi, A. (2016) Side-effects of Palizin® and Tondexir® as environmentally safe pesticides on the predatory mite, *Phytoseiulus persimilis. Abstract book of the 22nd Iranian Plant Protection Congress, College of Agriculture and Natural Resources, Karaj, Iran*, p. 752.

Pekár, S. (2012) Spiders (Araneae) in the pesticide world: an ecotoxicological review. *Pest Management Science*, 68(11): 1438–1446.
DOI: 10.1002/ps.3397

Pontes, W.J., De Oliveira, J.C., Da Camara, C.A., Lopes, A.C., Gondim, M.G.C., De Oliveira, J.V., & Schwartz, M.O. (2007) Composition and acaricidal activity of the resin's essential oil of *Protium bahianum* Daly against two spotted spider mite (*Tetranychus urticae*). *Journal of Essential Oil Research*, 19(4): 379–383.
DOI: 10.1080/10412905.2007.9699310

Pourkhabbaz, A., Rastin, N., Olbrich, A., Langenfeld-Heyser, R. & Polle, A. (2010) Influence of environmental pollution on leaf properties of urban plane trees, *Platanus orientalis* L. *Bulletin of Environmental Contamination and Toxicology*, 85(3): 251–255.
DOI: 10.1007/s00128-010-0047-4

Robertson, J.L. & Preisler. H.K. (1991) *Pesticide Biomethod with Arthropods*. CRC Press, Boca Raton, 224 pp.

Sadeghi, R., Jokar, M., Jamshidnia, A. & Ebadollahi, A. (2014) Repellency of Palizin® (Coconut Soap) with three laboratory techniques against five stored-product insect pests. *Archives of Phytopathology and Plant Protection*, 47(14): 1686–1695.

Shakarami, S., Heidari, A. & Arbabi, M. (2014) Efficacy of the EC 1.28% formulation of Neem, *Azadirachta indica*, on two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae), in laboratory and field conditions. *Journal of Entomological Society of Iran*, 34(1): 85–93.

Tahmina, M., Basak, R., Arafat, Y., Sharmin, D., Jahan, M. & Ullah, M.S. (2020) Comparative efficacy of chemicals, entomopathogenic fungus and botanical for the management of Red Spider mite *Tetranychus macfarlanei*. *Journal of South Pacific Agriculture*, 23: 1–7.

Tirello, P., Pozzebon, A., Cassanelli, S., Van Leeuwen, T. & Duso, C. (2012) Resistance to acaricides in Italian strains of *Tetranychus urticae*: toxicological and enzymatic assays. *Experimental and Applied Acarology*, 57(1): 53–64.

Ullah, M.S. & Lim, U.T. (2017) Laboratory evaluation of the effect of *Beauveria bassiana* on the predatory mite *Phytoseiulus persimilis* (Acari: Phytoseiidae). *Journal of Invertebrate Pathology*, 148: 102–109.
DOI: 10.1016/j.jip.2017.06.006

Vogt, J., Gillner, S., Hofmann, M., Tharang, A., Dettmann, S., Gerstenberg, T., Schmidt, C., Gebauer, H., Van de Riet, K., Berger, U. & Roloff, A. (2017) Citree: A database supporting tree selection for urban areas in temperate climate. *Landscape and Urban Planning*, 157: 14–25.
DOI: 0.1016/j.landurbplan.2016.06.005

Wang, K.Y., Liu, T.X., Yu, C.H., Jiang, X.Y. & Yi, M.Q. (2002) Resistance of *Aphis gossypii* (Homoptera: Aphididae) to fenvalerate and imidacloprid and activities of detoxification enzymes on cotton and cucumber. *Journal of Economic Entomology*, 95(2): 407–413.
DOI: 10.1603/0022-0493-95.2.407

Yang, X., Margolies, D.C., Zhu, K.Y. & Buschman, L.L. (2001) Host plant-induced changes in detoxification enzymes and susceptibility to pesticides in the two-spotted spider mite (Acari: Tetranychidae). *Journal of Economic Entomology*, 94(2): 381–387.
DOI: 10.1603/0022-0493-94.2.381

اثربخشی برخی از آفت‌کش‌های شیمیایی و گیاهی علیه *Tetranychus urticae* (Acari: Tetranychidae) روی *Platanus orientalis* (Platanaceae) در نواحی شهری

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چکیده

کنهٔ تارتن دولکه‌ای، *Tetranychus urticae* Koch (Acari: Tetranychidae) یکی از آفات مخرب است که باعث ایجاد خسارات زیادی به درختان و درختچه‌های فضاهای سبز شهری می‌شود. استفاده از آفت‌کش‌ها یکی از متداول‌ترین راه‌های کنترل این آفت محسوب می‌شود. در این پژوهش، اثر آفت‌کش‌های آبامکتین، فن‌پروکسی‌میت، تنداکسیر®، سیرینول® و پالیزین® بر مرگ‌ومیر *T. urticae* در شرایط آزمایشگاه و فضاهای سبز شهری بررسی شد. زیست‌سنجی‌های آزمایشگاهی با استفاده از پنج غلظت بین ۰/۷۲–۳/۶۰، ۰/۵۰–۳/۰۰، ۱۲۷۵–۶۸۰۰، ۵۹۵–۵۹۵۰ و ۳۲۵–۳۹۰۰ میلی‌گرم ماده مؤثر بر لیتر به ترتیب برای آبامکتین، فن‌پروکسی‌میت، تنداکسیر®، سیرینول® و پالیزین® و در پنج تکرار انجام شدند. آزمایش‌های مزرعه‌ای بر پایه طرح بلوک‌های کامل تصادفی (CRBD) در فضای سبز شهری شهرستان مشهد روی درختان چنار (*Platanus orientalis* L.) آلوده به *T. urticae* انجام شدند. تیمارها شامل محلول‌پاشی با فرمولاسیون‌های تجاری آبامکتین (۲۵۰ میلی‌گرم بر لیتر) و فن‌پروکسی‌میت (۵۰۰ میلی‌گرم بر لیتر) و همچنین تنداکسیر® (۲۰۰۰ میلی‌گرم بر لیتر)، سیرینول® (۲۰۰۰ میلی‌گرم بر لیتر)، پالیزین® (۲۰۰۰ میلی‌گرم بر لیتر) و آب (شاهد) بودند. آبامکتین و فن‌پروکسی‌میت بیشترین سمیت را برای ماده‌های بالغ *T. urticae* با مقادیر LC_{50} به ترتیب ۱/۶۱ و ۱/۱۶ میلی‌گرم ماده مؤثر بر لیتر نشان دادند. تنداکسیر® سمیت کمتری برای *T. urticae* (LC_{50} معادل ۲۵۰۰/۵۳ میلی‌گرم ماده مؤثر بر لیتر) در مقایسه با سیرینول® (LC_{50} معادل ۱۳۰۸/۵۸ میلی‌گرم ماده مؤثره بر لیتر) و پالیزین® (LC_{50} معادل ۱۴۹۴/۷۳ میلی‌گرم ماده مؤثر بر لیتر) داشت. آبامکتین و فن‌پروکسی‌میت بیشترین کاهش جمعیت *T. urticae* را روی درختان چنار پس از ۲۸ روز داشتند (به ترتیب ۰/۶۴ ± ۹۸/۶۸ و ۰/۵۶ ± ۹۹/۷۰ درصد). در مورد جمعیت تخم نیز، آبامکتین و فن‌پروکسی‌میت کاهش بهتری را در مقایسه با سایر حشره‌کش‌ها نشان دادند. پالیزین® در کنترل افراد بالغ *T. urticae* کمترین اثربخشی را داشت (۲/۴۰ ± ۳۲/۶۰ درصد). کاهش تخم‌های *T. urticae* با تنداکسیر® (۲/۲۴ ± ۳۸/۸۵ درصد) بیشتر از سیرینول® (۰/۶۹ ± ۲۲/۵۴ درصد) و پالیزین® (۱/۵۰ ± ۲۰/۸۵ درصد) بود. با اینکه آبامکتین و فن‌پروکسی‌میت باعث کنترل بهتر تخم و افراد بالغ *T. urticae* شدند، در مناطق شهری و به دلیل نگرانی در خصوص سلامت ساکنین، محلول‌پاشی با استفاده از حشره‌کش‌های گیاهی با کارایی بیشتر مانند تنداکسیر® و سیرینول® توصیه می‌شود.

واژگان کلیدی: آبامکتین؛ فن‌پروکسی‌میت؛ درخت چنار؛ پالیزین®؛ سیرینول®؛ تنداکسیر®.

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