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The Toxicity Investigation of the Botanical Insecticides on the Common Pistachio Psyllid, *Agonoscena pistaciae* Burckhardt and Lauterer (Hemiptera: Psyllidae)

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Abstract

The common pistachio psyllid, *Agonoscena pistaciae*, is the key pest of pistachio trees in Iran. Both nymphs and adults suck sap from leaves and reduce plant vigor and yield, increase the number of blank, half growth kernel and unsplit nuts and also cause defoliation and buds drop. Detrimental effects of chemical synthetic insecticides and the resistance of common psyllid pistachio to them and the effect of three botanical insecticides, Sirinol (garlic extract), Tondexir (pepper extract) and Palizin (eucalyptus extract), were investigated as a randomized complete block design experiments in field conditions. The sampling was done 2, 7, 14, 21 and 28 days after treatment. The results showed that the highest mortality in Palizin treatment occurred after 2 and 7 days. The sampling of 14, 21 and 28 days post-treatment were showed the highest and lowest mortality in Sirinol and Tondexir treatments, respectively. Generally, there were no significant differences between Sirinol and Palizin 28 days post-treatment, but these compounds showed significant differences with Tondexir. As a result, these botanical insecticides are suitable in integrated pest management of common pistachio psyllid.

Keywords: Botanical insecticides, Common pistachio psyllid, Palizin, Sirinol, Tondexir.

Introduction

The pistachio, *Pistacia vera* L. (Sapindalis: Anacardiaceae), is one of the most important horticultural products in Iran (Hassani 2009). The common pistachio psylla, *Agonoscena pistaciae* Burckhardt and Lauterer (Hemiptera: Psyllidae) is a key pest of pistachio trees throughout the pistachio producing regions of Iran. Both nymphs and adults suck sap from leaves (Hassani 2009). This causes defoliation, falling flower buds and eventually stops tree growth and leads to the loss of crops and produces large amounts of honeydew (Samih *et al*., 2005). High reproduction rates and multi generation (multivoltine) of this pest lead to outbreaks, high levels of damage and extraordinary losses of the crops that even influence the next year yields (Mehrnejad 2001). There is an acknowledgement of the growing resistance of common pistachio psylla to pesticides and the subsequent and repetitive invasion of other pests after spraying. There is also an intensification of pests as a reaction to compensate for population loss after spraying. It seems that chemical control is not an appropriate method for controlling populations of this pest (Alizadeh *et al.*, 2007). The extensive use of these pesticides can promote negative impacts on human health and on ecosystems. It can also reduce the number of species and density of natural enemies, which results in resistance and increasing production costs (Ahmadi *et al*., 2012; Leite *et al*., 2006). With the public perception that synthetic pesticides leave harmful residues in crop produce for human consumption, there has been increased interest in using natural products for pest control (Antonious *et al*., 2007). Plant extracts were used as an alternative to chemical insecticides (Ahmadi *et al*., 2012; Weathersbee and McKenzie 2005) and can reduce environmental pollution, preservation of non-target organisms, and avert insecticide-induced pest resurgence (Weathersbee and McKenzie 2005). Botanical insecticides pose less risk to humans and animals, have a selective mode of action, avoid the emergence of resistant races of pest species, and as a result, they can be safely used in integrated pest management (Ntalli and Menkissoglu-Spiroudi 2011). Also, botanical insecticides are more efficacious, safe, ecologically acceptable, nature friendly (Senthil Nathan *et al.*, 2007) and biodegradable. Their use in crop protection is a practical sustainable alternative (Sohail *et al.*, 2012). Furthermore, they may be suitable and be used as products of choice for organic food production (Ntalli and Menkissoglu-Spiroudi 2011). Extracts from plant origin containing insecticidal properties are indigenously available. It has been reported that over 2,000 plant species belonging to about 170 natural families are known to have insecticidal properties (Sohail *et al.*, 2012). The chemicals extracted from plants include approximately more than 6,000 alkaloids, 3,000 terpenoids, several thousands of phenylterpenoids, 1,000 flavanoids, 500 quinones, 650 polyacetylenes and 4,000 amino acids. Many of these chemicals serve to protect plants from insect pests and disease pathogens (Kianmatee and Ranamukhaarachchi 2007).

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Secondary metabolites were used in plant protection from the end of 19th century until the beginning of the Second World War, when synthetic organic pesticides took over (Ntalli and Menkissoglu-Spiroudi 2011). Botanical extracts induce insecticidal activity, repellence to pests, antifeedant effects and insect growth regulation and toxicity to nematodes, mites and other pests (Khater 2012; Singh and Saratchandra 2005; Mureithi 2005). Many studies have indicated the potential ecological damage due to the widespread use of synthetic pesticides. Therefore, basic and applied research to provide alternative pesticides with low impact on human health and environmental quality is needed (Antonious *et al.*, 2007). Therefore, the objective of this study to investigate the effects of botanical insecticides Palizin, Sirinol and Tondexir on *A. pistaciae* in field conditions.

Materials and Methods

Botanical insecticides

In this study, the botanical insecticides of Sirinol (garlic extract), Tondexir (pepper extract) and Palizin (eucalyptus extract) were used (Kimia Sabzavar Co., Iran) to control of common pistachio psyllid nymphs. These insecticides are considered nontoxic to mammals (rat oral acute LD_{50} is >5000 mg kg^{-1}). 2500cc/1000 L water was used for each insecticide.

Study site

This study was carried out in a pistachio orchard with high density of common pistachio psyllid in Rafsanjan. The trees were approximately 15 years old. This test was applied on the basis of complete randomized blocks with three replications and four treatments including Palizin, Sirinol and Tondexir; each one with 2500 ml in 1000L water and control (water) on common pistachio psylla fed on pistachio trees of Akbari cultivar.

Sampling

The sampling was carried out a day before test and 2, 7, 14, 21 and 28 days post-treatment. For sampling of each treatment, four trees in the center rows were randomly selected and from each one, five leaves were picked (twenty leaves for each treatment). The leaves were picked in different geographical directions and the top and bottom of each tree randomly. The nymphs of common pistachio psyllid on upper and lower sides of each leaf were counted and recorded. The mean of mortalities were obtained and data corrected by Henderson-Tilton formula (Henderson and Tilton, 1955).

Statistical analysis

The analysis of data was performed using SPSS 16 software and the comparison of means by Tukey's test (P<0.05).

Results

The results showed that there were significant differences among treatments (Tondexir, Sirinol and Palizin) (p<5%) at 2, 7, 14 and 28 days post-treatment (Table 2, 3).

Table 2. Variance analysis of different treatments on common pistachio psyllid nymphs at 2 and 7days post-treatment.

S.V	2 days post-treatment				7 days post-treatment			
	df	Mean square	F	Sig.	df	Mean square	F	Sig.
Replicate	2	6.959	53.701	0.001**	2	3.953	13.759	0.016*
Treatment	2	22.603	174.412	0.000**	2	35.051	121.953	0.000**
Error	4	0.13			4	0.287		

n.s P is not significant; * p is significant at 0.05 level; ** p is significant at 0.01 level.

Table 3. Variance analysis of different treatments on common pistachio psyllid nymphs at 14, 21 and 28 days post-treatment.

S.V	14 days post-treatment				21 days post-treatment				28 days post-treatment			
	df	Mean square	F	Sig.	df	Mean square	F	Sig.	df	Mean square	F	Sig.
Replicate	2	6.568	4.204	0.104 ns	2	2.901	0.4	0.695ns	2	18.633	5.018	0.081 ns
Treatment	2	17.995	11.519	0.022*	2	45.627	6.289	0.058 ns	2	59.163	15.933	0.012*
Error	4	1.562			4	7.255			4	3.713		

n.s P is not significant; * p is significant at 0.05 level; ** p is significant at 0.01 level.

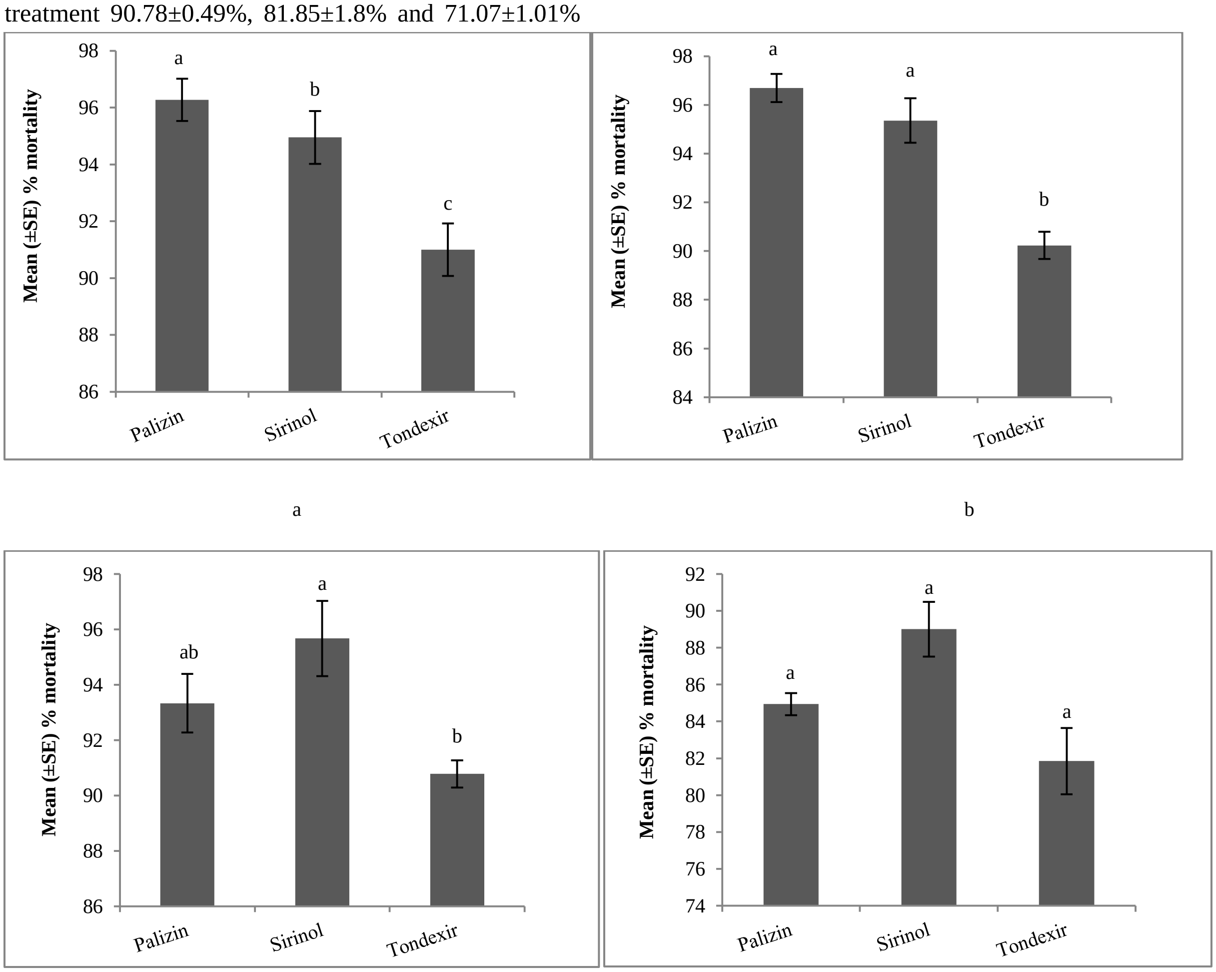
The comparison of means percentage of mortality of botanical insecticides on common pistachio psyllid nymphs showed that at 2 and 7 days post-treatment, the highest mortality was obtained with Palizin, %96.27±0.74 and %96.7±0.58, respectively (Tables 4, Fig. 1a,b). Also, there were significant differences between treatments at 2 days post-treatment and therefore, were categorized into different groups, consistent with a Tucky's test. Seven days after treatment, Palizin and Sirinol showed a significant difference with Tondexir and were categorized into two different groups. Also, there were significant differences between Sirinol and Tondexir treatments 14 days post-treatment, but Palizin had no significant differences with the two other treatments (Table 4, Fig. 1 a, b and c).

Table 4. Means (±SE) percentage* of the effect of botanical insecticides on common pistachio psyllidnymphsat different times.

Botanical insecticides	Doses in 1000L water	Days post-treatment				
		2	7	14	21	28
Palizin	2500cc	96.27±0.74 [a**]	96.7±0.58 [a]	93.33±1.06 [ab]	84.94±0.6 [a]	77.22±1.7a
Sirinol	2500cc	94.95±0.93 [b]	95.36±0.91 [a]	95.67±1.36 [a]	89±1.48 [a]	79.69±2.18a
Tondexir	2500cc	91±0.92 [c]	90.23±0.56 [b]	90.78±0.49 [b]	81.85±1.8 [a]	71.69±1.01b

*means comparison consistent with a Tukey's test ($p<5\%$)
** Different letters indicate significant differences ($p<5\%$)
The means in the same column followed by the same letters do not differ significantly ($p > 0.05$) as determined by Tukey's test.

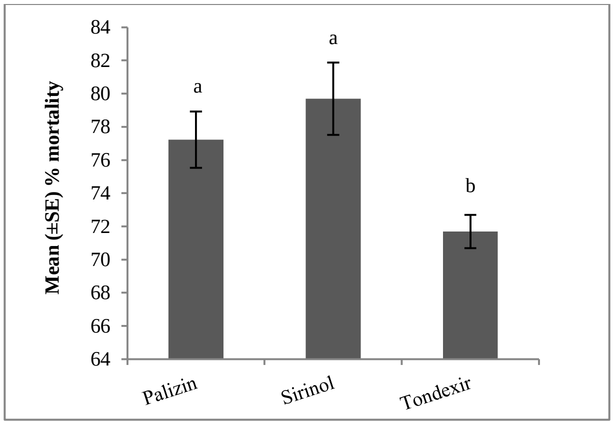
The comparison of means in sampling 14, 21 and 28 days post-treatment showed that the highest and least mortality was obtained with Sirinol and Tondexir, respectively (Table 4, Fig. 1 c, d, and e). The Sirinol treatment recorded 95.67±1.36%, 89.6±1.48% and 79.69±2.18% mortality, respectively. The Tondexir treatment 90.78±0.49%, 81.85±1.8% and 71.07±1.01% mortality, respectively. In sampling 21 days post-treatment, there were no significant differences between the treatment groups (Table 4, Fig. 1 d). However, there were significant differences between treatments at 28 days post-treatment and therefore, were categorized into two different groups (Table 4, Fig. 1 e).



a b

c d

Fig 1. Means (±SE) percentage of mortalities of common pistachio psyllid nymphs at different times post-treatment, a) 2 days, b) 7 days, c) 14 days, d) 21 days.



e

Continue of Fig 1. e.28 days.

Discussion

Botanical pesticides can control pests more effectively and are less harmful for the environment, people and also for non-target organisms (Kabiri and Amiri-Besheli 2012). They also have a selective mode of action, avoid the emergence of resistant races of pest species, and as a result, they can be safely used in Integrated Pest Management (IPM). Furthermore, they may be proved suitable and be used as products of choice for organic food production (Ntalli and Menkissoglu-Spiroudi 2011).

The results of this study showed that 2 and 7 days post-treatment the highest mortalities were recorded in Palizin treatment with %96.27±0.74 and %96.7±0.58 respectively (Table 4). Kabiri and Amiri-Besheli (2012) indicated Palizin (2500 ppm) caused 84.93±0.65% mortalities on the pistachio psyllid nymphs in laboratory conditions that is in agreement with this study. Also, Kabiri and Amiri-Besheli (2012) reported Palizin provides a physical and chemical barrier against insect pests and shows considerable potential for effective control of insect pests in certain agricultural crops. Other advantages of Palizin are that pests are unlikely to develop resistance to it, it has no phytotoxic effects, it lasts longer than most insecticides on plants when it does not rain or there is no excessive dew, is nontoxic to humans and is relatively harmless to natural enemies. Additionally, it is dissolvable, forming a suspension in water, thereby making it easy to apply using conventional spray equipment. It may eventually reduce the number of applications of conventional insecticides (Kabiri and Amiri-Besheli 2012). The highest mortality 14, 21 and 28 days post-treatment were recorded in Sirinol treatment with 95.67±1.36%, 89.6±1.48% and 79.69±2.18% mortalities, respectively (Table 4). Also, there were significant differences between treatments 28 days ($p<5\%$) post-treatment and mortality obtained 79.69±2.18, 77.22±1.7 and 71.69±1.01 in Sirinol, Palizin and Tondexir treatments, respectively. Conclusively, the results showed the mortality of all of the botanical insecticides were high in the field, which may be due to insecticides. Amiri-Besheli (2009) reported that the effect of Palizin, Tondexir and Sirinol on *Phylocnistis citrella* Stainton caused 76.25±3.4%, 81±7.29% and 71±11.42% mortalities after 96 hours in laboratory conditions, respectively. Also, the results of Ahmadi *et al.*, (2012) showed that Palizin, Tondexir and Sirinol treatments on *Planococcus citri* (Risso) caused 86.16%, 90.6% and 87.11% mortalities, respectively. The results of these researchers are consistent with this study. The effects of garlic and pepper extracts have been investigated in other studies. Garlic produces a variety of volatile sulfur based compounds, which are effective as insect repellents and insecticides (Kazem and El-Shereif 2010). Sohail *et al.*, (2012) investigated the effect garlic extract on *Toxoptera aurantii* and concluded that this extract caused 66% mortality. Osipitan and Mohammed (2008) indicated the insecticidal, repellence, antifeedant, and fumigative effects of garlic. Extracts from pepper fruits may provide an opportunity for use in crop protection as an alternative to synthetic pesticides. Hot pepper also contains a significant amount of tannins that break down and behave as toxins and deterrents, particularly for insects that do not typically feed on diets rich in tannins (Antonious *et al.*, 2007). Capsaicin, obtained from the genus *Capsicum* such as chili peppers (*Capsicum frutescens*, Mill.), is characterized by nematicidal, insecticidal and insect repellent properties (Neves *et al.*, 2009). Kiani *et al.* (2012) reported garlic, pepper and onion extracts significantly control *Frankliniella occidentalis* (Pergande). Also, Antonious *et al.*, (2007) investigated the effect pepper extract on cabbage looper, *Trichopulsia ni* (Hubner) and spider mite, *Tetranychus urticae* (Koch) and reported that this extract caused 94% mortality in *T. ni* and showed repellency effect on *T. urticae.* Kazem and El-Shereif (2010) concluded that garlic and pepper extracts have a lethal effect on *Aphis gosspii* and *T. urticae.* Also, Buba *et al.*, (2007) showed that garlic extracts control *Bemisia tabaci* Gennadius and *Megalurothrips sjostedti* Trybom. In this study, Palizin, sirinol and tondexir were very promising botanical pesticides against the pistachio psyllid. Therefore, these extracts, as botanical pesticides, could become an important and promising tool in integrated pest management program of *A. pistaciae.*

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