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Effects of liquid soap and dish washing detergent on the common pistachio psyllid, *Agonoscena pistaciae* (Hem., Aphalaridae) and the lady bug, *Oenopia conglobata*(Col., Coccinellidae)

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Abstract

The common pistachio psyllid, *Agonoscena pistaciae* Burckhardt and Lauterer (Hemiptera: Aphalaridae) is known as the key pest of pistachio trees in Iran. This study was carried out to test the effect of liquid soap (Jonobgan®) and dish washing detergent (Rika®) against this pest and their side effects on the lady bug, *Oenopia conglobata* L. (Col.: Coccinellidae). The field experiments was done with three treatments and three replications. The concentrations of treatments were applied as 3500 ppm for each treatment and control (water). The mean percent mortality of nymphs of the common pistachio psyllid for liquid soap on 3, 8, 14, and 21 days after treatment was 98.92, 60.74, 27.90 and 18.54 respectively, and for dish washing detergent, was 91.17, 82.46, 69.11 and 48.20, respectively. The results showed no significant difference between the percent mortality of common pistachio psyllid nymph between liquid soap and dish washing detergent after 8 and 21 days but significant after 3 and 14 days. The results also showed that the effect of treatments on the first and third instar larvae of *O. conglobata* was not significant 24, 48, and 72 hours after treatments. Therefore these treatments have no side effects on *O. conglobata*. It is concluded that the liquid soap and dish washing detergent can be used in IPM program to control the common pistachio psyllid.

Key words: *Agonoscena pistaciae*, *Oenopia conglobata*, mortality, liquid soap, detergent

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Introduction

Arthropod pests have been a serious problem for Iranian pistachio growers and numerous phytophagous insects and mites attack the pistachio trees since the last 70 years (Mehrnejad, 2001, 2010). The common pistachio psyllid, *Agonoscena pistaciae* Burckhardt & Lauterer (Hem.: Aphalaridae) is known as the major pest of pistachio trees and damages the pistachio trees and yeild in Iran every year. This pest has 6 to 7 generations per year in Rafsanjan (Hassani *et al*., 2009b,c). The pest severe outbreak, in addition to reducing the current year yield, results in abscission of next year flower buds, leaves abscission and tree weakness (Mehrnejad & Copland, 2006; Mehrnejad, 2003).

Soap might be an alternative to conventional pesticides for control of Asian citrus psyllid, *Diaphorina citri* Kuwayama (Hall & Richardson, 2012). M-Pede or Safer soaps at high concentrations (for example, 2% v/v in water) may be an effective alternative to conventional pesticides to manage adult and nymphal stages of *D. citri*, although multiple applications may be needed if a target population includes eggs. A 2% concentration of either soap applied as a direct spray was non-toxic to adult lady bug, *Cycloneda sanguinea* (L.) but acutely toxic to adult parasitoid *Tamarixia radiata* (Waterston). Therefore, Soaps may be compatible with biological control of *D. citri* and adult coccinellids, but not the parasitoid *T. radiate* (Hall & Richardson, 2012). Panahi (2012) showed that the dish washing detergent is harmless to parasitoid, *Psyllaephagus pistaciae* Ferrière (Hymenoptera: Encyrtidae).

Many efforts have been made to switch from chemical control to integrated pest management (IPM) in pistachio orchards. In this context, several so called natural and commercial products compatible with IPM often are considered to be effective and recommended in controlling aphids in young citrus plantations, without taking into account their side effects and selectivity on the natural enemies. This is the case with insecticidal soap which acts on foliar insects by contact, dissolving their outer cuticle and causing the insect to dry up and die (Smaili *et al*., 2014). In organic farming in many countries the insecticidal soap could be effectively applied for control of green apple aphid in apple growing areas (Raudonis *et al*., 2009). In a study that was done by Smaili *et al*. (2014) it was revealed that methomyl and imidacloprid foliar pulverization were very effective against aphids compared to insecticidal soap and kaolin application. Also Smaili et al. (2014) found that *Adalia decempunctata* L. adults as biological control agent were effective only in the first week after release. Applying insecticidal soap exhibited significant suppression of the rosy apple aphid, *Dysaphis plantaginea* (Passerini), green aphid, *Aphis pomi* De Geer and the spirea aphid, *Aphis spiraecola* Patch (Lawson & Weires, 1991). The insecticidal soap as a biorational insecticide could be suggested for the suppression of *Aphis gossypii* Glöver in cucumber greenhouse planting in an IPM program (Emami, 2016). The highest mortality for *Aphis gossypii* Glover by insecticidal soap, surfactant and antifeeding treatments occurred after 3 days, with 78.47, 67.16 and 60.48% mortality, respectively (Emami, 2016).

Soaps, surfactant and antifeedings are some biorational substances (Schuster and Stansly, 2009). Biorational insecticides are synthetic and/or natural materials that are more selective and environmentally friendly and proper to be combined in pest management programs founded on integration of biological and chemical control methods (Horowitz & Ishaaya, 2004). Insecticidal soaps are founded on potassium fatty acids and are applied to control many crop pests (Miller and Uetz, 1998; Trdan *et al*., 2006).

At least, 23 beneficial insect and mite species attack *A. pistaciae* (Mehrnejad, 2010, 2014). Predatory insects are the major cause of mortality to the spring population of *A. pistaciae* (Mehrnejad *et al*., 2011), particularly in wild pistachio where no chemicals are used (Mehrnejad and Copland, 2006). Twenty-five coccinellid species have been recorded in planted and wild pistachio plantations in southern Iran (Salehi *et al*., 2013). The coccinellid beetle, *Oenopia conglobata contaminata* Menetries is the dominant species and the most important coccinellid predator of the common pistachio psyllid in wild pistachio growing areas (Hassani *et al*., 2009a). Increased research on predaceous coccinellids and their use in the biological control of pests is at least partly due to the harmful side effects of pesticides (Michaud, 2012). The use of chemical pesticides in pistachio orchards over the last six decades has proved to be unsuccessful in controlling *A. pistaciae*, and efforts are now directed at developing an IPM program for pistachio pests (Mehrnejad, 2010).

Currently, chemical control is the most practical way for reducing the pest population density and preventing the related damage of pistachio psyllid. However, conventional insecticides cannot be used to control *A. pistaciae* in organic fields. Soaps might be an alternative to conventional pesticides for controling of this pest, but little is known about their efficiency. During the last years the pistachio growers use detergents for control the common pistachio psyllid in the pistachio orchards. The aim of present study was to assay the efficacy of detergent including liquid soap (Jonobegan®) and dish washing detergent (Rika®) as two detergents that use wildly for using in pistachio orchards in connection with their potential to control *A. pistaciae* in field condition and their side effects on the lady bird, *Oenopia conglobata* L. in laboratory condition.

Materials and methods

Site of the study

A pistachio orchard about 2500 m^2 with the high infestation was selected in Rafsanjan, Iran in 2016. The trees aged about 40 years and the pistachio cultivar was Fandoghi. The pistachio trees were planted in rows with seven meters space. The space between the trees in each row was about one meter and the number of trees in each row was about 50.

Treatments

Three different treatments were used in this study as below:

1. Liquid soap (Jonobgan®) (SL) at dose 3500 ppm
2. Dish washing detergent (Rika®) (SL) at dose 3500 ppm
3. Control (water)

Dose 3500 ppm for treatments (liquid soap and dish washing detergent) was chosen based on the research that has been done by Panahi *et al*. (2013).

Mortality rate of treatments on the nymph of pistachio psyllid

The treatments, liquid soap, dish washing detergent and control replicated 3 times in a randomized completely block design, and 5 trees selected as one replication. For each replication, 15 leaflets were chosen randomly and the number of nymphs on both sides of leaves was counted. In total, 45 terminal leaflets were selected for each treatment. The spraying was done using a tractor sprayer in cool and calm weather. After each application the sprayer was cleaned with water and prepared for the next application. In order to check the mortality of nymph of pistachio psyllid the population of psyllid nymphs was determined before treatments. After the treatment the population was checked 3, 8, 14 and 21 days. Leaf sampling was used to analyze the mortality rate of nymph of pistachio psyllid. The number of nymphs were counted in the laboratory using stereomicroscope. Then, based on Henderson-Tilton formula the mortality of nymph was corrected.

The mortality rate on the first and third instar larvae of *O. conglobata*

The lady bug, *O. conglobata* collected from pistachio orchards and transferred to the laboratory. The beating procedure was used to collect the lady bugs. A bed sheet and a stick were used to beat the shoots and collect the lady bugs. Afterwards the adult lady bugs separated considering their species and the larvae reared on the common pistachio psyllid until adult emergence. The *O. conglobata*, lady bugs were transferred into specific containers and some leaves infected with pistachio psyllid were used as the food source. The recommended concentration of each treatments were used on first and third stage of larva. reared in laboratory condition. For assessing the toxicity of liquid soap (Jonobgan®) and dish washing detergent (Rika®), one microliter of each solution applied on the thoraxic dorsaum of the first and third instar larvae using micropipette (Stanley & Preetha, 2016; Rahmani *et al*., 2013). This experiment was done for first instar larva with five replications, each contain ten larvae and for third instar larva with four replications, each replication contain ten larvae. Distilled water was used as control. The experiments were done in the growth chamber at 25 ± 5 °C, 60 ± 5% RH and 16:8 (L:D) h for all stages. To prevent cannibalism each larvae of coccinellid were put in separate petri dishes.

Statistical Analysis

The analyses of the field experiment data (mortality percentage of pistachio psyllid nymphs) was done by using independent student t-tests. Laboratory experiments were done in a completely randomized design. Analysis of data was done by SPSS (16.0) and the comparison of means was done by Tukey test at $\alpha = 0.05$.

Results and discussion

Effect on common pistachio psyllid

The mean percent mortality of nymphs of the common pistachio psyllid for liquid soap on 3, 8, 14, and 21 days after treatment was 98.92 ± 0.87, 60.74 ± 13.03, 27.90 ± 4.07 and 18.54 ± 9.20, respectively and for dish washing detergent, was 91.17 ± 2.40, 82.46 ± 4.73, 69.11 ± 6.37 and 48.20 ± 6.81, respectively (Table 1). There was no significant difference between the mean mortality rate of liquid soap and dish washing detergent 8 and 21 days after treatment. After 3 and 14 days of application significant differences were observed between liquid soap and dish washing detergent. At first the effect of liquid soap was more than dish washing detergent then the effect of dish washing detergent was more than liquid soap. In addition the effect of dish washing detergent was more than liquid soap (Table 1). The results of Panahi *et al*. (2013) showed that the percentage of mortality of dish washing detergent was lower than insecticide Amitraz. Direct sprays of M-Pede or safer insecticidal soap were acutely toxic to adults and nymphs of Asian citrus psyllid when applied in solutions of 0.8% or higher. Each of the two soaps was equally toxic to adult males and females (Hall & Richardson, 2012). Twenty-four hours after application at a concentration of 37.50 g/L, the soap caused 100% mortality in all aphid instars, and LC_{50} were 1.50, 3.25 and 5.50 g/L for first and second instars, third and fourth instars, and adults of green peach aphid, *Myzus persicae* (Sulzer), respectively (Tremblay *et al*., 2009).

Table 1- Efficiency of liquid soap and dish washing detergent on the common pistachio psyllid in field condition

	dish washing detergent	liquid soap	t	df	Sig. (2-tailed)
Day 3	91.17 ± 2.40[a]	98.92 ± 0.87[b]	3.033	4	0.039
Day 8	82.46 ± 4.73[a]	60.74 ± 13.03[a]	-1.567	4	0.192
Day 14	69.11 ± 6.37[a]	27.90 ± 4.07[b]	-5.452	4	0.006
Day 21	48.20 ± 6.81[a]	18.54 ± 9.20[a]	-2.592	4	0.061

* Means with same letter(s) in each row are not significantly different at P=0.05.

Effect on the first and third instar nymphs of *O. conglobata*

The data of mortality of first instar nymphs of *O. conglobata* at 24, 48 and 72 h after the application of treatments was given in (Table 2). The highest mortality after 24 h was recoded in dish washing detergent (8.00 %) ($F_{2, 14}$ = 33.89; p_{value}< 0.05). The highest mortality after 48 h was recoded at dish washing detergent (14.00 %) ($F_{2, 14}$ = 33.89; p_{value} < 0.05). After 72 h the highest mortality was recoded at dish washing detergent (18.00 %) ($F_{2, 14}$ = 33.89; p_{value} < 0.05). The data showed that there is not significant differences among treatments at 24, 48 and 72 h. Therefor liquid soap and dish washing detergent can be used for controling of the pistachio psyllid, without any negative effect on the bug.

Table 2. Percent mortality (Mean ± SE) of first instar nymphs of *O. conglobata* exposed to liquid soap, dish washing detergent and control after 24, 48 and 72 hours

Treatments	24	48	72
Liquid soap	4.00 ± 4.02[a]	10.00 ± 4.47[a]	12.00 ± 4.89[a]
Dish washing detergent	8.00 ± 3.74[a]	14.00 ± 5.09[a]	18.00 ± 5.83[a]
Control	6.00 ± 4.00[a]	6.00 ± 4.00[a]	8.00 ± 3.74[a]

* Means with same letter(s) in each column are not significantly different at α=0.05

The data on mortality of third instar nymphs of *O. conglobata* at 24, 48, and 72 h after the application of treatments was given in (Table 3). The highest mortality after 24 h was recoded at dish washing detergent (17.50 %) ($F_{2, 11}$ = 33.89; α < 0.05). After 48 h the highest mortality was obtained at dish washing detergent and liquid soap (14.00%) ($F_{2, 11}$= 33.89; aP= 33.89; α < 0.05). And 72 h after treatment the highest mortality was recoded at liquid soap (27.50 %) ($F_{2, 11}$ = 33.89; aP < 0.05). The data showed that there are not significant differences among treatments at 24, 48 and 72 h. Based on this results liquid soap and dish washing detergent are not toxic for *O. conglobate*.

A 2% concentration of liquid soap applied as a direct spray was non-toxic to adult lady bug, *C. sanguinea* (Coleoptera: Coccinellidae), but acutely toxic to adult *T. radiate* (Hym., Eulophidae) (Hall & Richardson, 2012). The side effect of dish washing detergent on the parasitoid *Psyllophagous* indicated that dish washing detergent on the susceptible and resistance stages of *Psyllaephagus* were evaluated as harmless and slightly harmful group, respectively. Both liquid soap and parasitoids could be used on a crop but, as the LC_{50} of the third and fourth instars and adult *M. persicae* are higher than that of the aphid parasitoid *Aphidius colemani* Viereck [Hym.: Aphidiidae] (2.75 g/L), it is essential to avoid treating aphids with liquid soap when adult parasitoids are present in the crop (Tremblay *et al*., 2009).

Table 3. Percent mortality (Mean ± SE) of third instar nymphs of *O. conglobata* exposed to liquid soap, dish washing detergent after 24, 48 and 72 hours

Treatment	24	48	72
Liquid soap	12.50 ± 7.50[a]	22.50 ± 4.78[a]	27.50 ± 6.29[a]
Dish washing detergent	17.50 ± 4.79[a]	22.50 ± 4.79[a]	22.50 ± 4.79[a]
Control	15.00 ± 2.89[a]	20.00 ± 0.00[a]	25.00 ± 2.89[a]

* Means with same letter(s) in each column are not significantly different at aP=0.05.

It is allowed to use liquid soap in organic farming in many countries and according to the trial data they could be effectively applied for controling the green apple aphid in apple growing area (Raudonis *et al*., 2009).

The results proved that the mortality effect of liquid soap, dish washing detergent and water on *O. conglobata* were not significantly and they did not toxic effect *O. conglobata* first and third instar larvae after 24, 48, and 72 hours of application. Also, the mortality effect of the treatments was not significant after 8 and 21 days. Therefore, liquid soap and dish washing detergent could be recommended as an alternative to chemical pesticides in integrated pest management (IPM) programs of *A. pistaciae*. Because the side effects of liquid soap and dish washing detergent is less than insecticides for natural enemies, human and environmental.

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تاثیر صابون مایع و مایع ظرفشویی روی پسیل معمولی پسته *Agonoscena pistaciae* و کفشدوزک *Oenopia conglobata*

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چکیده

پسیل معمولی پسته *Agonoscena pistaciae* Burckhardt and Lauterer (Hem., Aphalaridae) آفت کلیدی درختان پسته در ایران است. در این پژوهش تاثیر صابون مایع جنوبگان و مایع ظرفشویی ریکا روی این آفت و اثرات جانبی آن روی کفشدوزک *Oenopia conglobata* L. (Col.: Coccinellidae) بررسی شد. آزمایش‌های صحرایی در سه تیمار و سه تکرار انجام شد. تیمارها با غلظت ۳۵۰۰ پی‌پی‌ام و برای تیمار شاهد از آب استفاده شد. متوسط مرگ و میر پوره پسیل معمولی پسته بعد از گذشت ۳، ۸، ١٤ و ۲۱ روز برای صاون مایع به‌ترتیب ۲۷/۹۰،٦۰/۷٤،۹۸/۹۲ و ۱۸/٥٤ درصد و برای مایع ظرفشویی به‌ترتیب ۹۱/۱۷، ۸۲/٤٦، ٦۹/۱۱ و ٤۸/۲۰ درصد به‌دست آمد. نتایج نشان داد پس از ۸ و ١٤ روز بین درصد مرگ و میر پوره پسیل معمولی پسته در تیمار صابون مایع و مایع ظرفشویی تفاوت معنی‌داری وجود ندارد، اما پس از ۳ و ۲۱ روز تفاوت بین آن‌ها معنی‌دار بود. همچنین تاثیر تیمارها روی لارو سن یک و سن سه کفشدوزک *O. conglobata* پس از ۲٤، ٤۸ و ۷۲ ساعت معنی‌دار نبود. بنابراین این ترکیبات روی این کفشدوزک اثر نامطلوبی ندارند. بنابراین صابون مایع و مایع ظرفشویی می‌توانند در برنامه‌های مدیریت تلفیقی این آفت استفاده شوند.

واژه‌های کلیدی: پسیل معمولی پسته، صابون مایع، مایع ظرفشویی، *Oenopia conglobata*

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