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Effects of Liquid Soap and Dishwashing Detergent on Pistachio Trees

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A R T I C L E I N F O

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A B S T R A C T

The common pistachio psyllid, *Agonoscena pistaciae* Burckhardt and Lauterer (Hemiptera: Aphalaridae) is the key pest of pistachio trees in Iran. Nowadays, pistachio growers use detergents widely to control this pest in pistachio orchards. Consequently, the study was carried out to investigate the effects of applying liquid soap (Jonobgan®) 3500 ppm, dishwashing detergent (Rika®) 3500 ppm, and conventional insecticides (spirotetramat (Movento®) 300 ppm and phosalon (Zolon®) 2500 ppm, periodically on some characteristics of "Fandoghi" pistachio trees, including sodium and potassium contents of leaves and bud abscission rate over three years. The field experiments were done in a randomized complete block design with three treatments and three replications in Rafsanjan. The results showed that the application of liquid soap and dishwashing detergent caused no significant variation in sodium and potassium contents of leaves and bud abscission compared to other conventional insecticides. Therefore, detergents can be used safely to control pistachio psyllid.

Introduction

Pistachio (*Pistacia vera* L.) is an important nut crop that widely grown commercially in arid and semi-arid areas of Iran (Eslami et al., 2019; Norozi et al., 2019; Sharifkhah et al., 2020). Arthropod pests are one of the most problems for pistachio growers in Iran for more than 70 years (Mehrnejad 2001, 2010). The common pistachio psyllid, *Agonoscena pistaciae* Burckhardt and Lauterer (Hemiptera: Aphalaridae) is the major pest of pistachio in Iran. Both nymphs and adults suck sap from leaves and reduce plant vigor and yield, increase the number of blank, causes half growth kernel, unsplit nuts,defoliation and buds drop (Sheibani & Hassani, 2014). It is difficult to control the pest using the conventional insecticides because of its high rate of reproduction, multiple generations, and resistance to pesticide. The outbreak of this pest usually causes

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abscission of buds and leaves, leading to weakness of pistachio trees (Mehrnejad, 2003; Mehrnejad & Copland, 2006).

The chemical control is the most practical method to control the pest population (Mehrnejad, 2010). Soaps are possible alternative compounds to conventional pesticides, but little is known about their efficiency. Insecticidal soaps are formulated on the basis of potassium fatty acids and applied to control many crop pests (Miller & Uetz, 1998; Trdan *et al*., 2006). As Curkovic (2016) stated, the soap and detergents are used for controlling agricultural pests mainly sucking insect pest. Furthermore, Curkovic (2016) argues that the knowledge of the pests' biology and ecology must be used to improve the performance of the detergents and soaps. In addition, it is found that the application of insecticidal soaps causes a significant suppression of rosy apple aphid, *Dysaphis plantaginea* (Passerini), green aphid, *Aphis pomi* De Geer, and *Aphis spiraecola* Patch (Lawson & Weires, 1991). Moreover, Emmami (2016) stated that insecticidal soaps as biorational insecticides can be suggested for suppression of *Aphis gossypii* Glöver in cucumber greenhouse planting in integrated pest management (IPM) programs.

In addition, Hall & Richardson (2013) noted that insecticidal soaps might be a substitution to conventional pesticides to control Asian citrus psyllid, *Diaphorina citri* Kuwayama. The researchers mentioned that M-Pede or safer soap at high concentrations (for example, 2% v/v in water) might be an effective alternative to conventional pesticides to manage the adult and nymphal instars of *D. citri*. However, it was mentioned that multiple applications may be needed if the target population includes eggs of pest. Direct spray of 2% concentration of either soaps was non-toxic to adult ladybug, *Cycloneda sanguinea* (L.), but acutely toxic to adult parasitoid *Tamarixia radiata* (Waterston). They concluded that insecticide soaps might be compatible with biological control of *D. citri* by adult coccinellids, but not the parasitoid (Hall & Richardson (2013)).

The side effect of detergents on Na and Fe level of pistachio leaves has revealed that applying detergents increases the Na level and decreases the Fe level of the leaves. However, the differences were non-significant among dishwashing detergent at 3500 and 2000 ppm concentrations, and dishwashing detergent 1000 ppm + pesticide (amitraz) 500 ppm, pesticide (amitraz) 1500 ppm and control (Panahi *et al*., 2013). They found that, the use of liquid detergent led to decrease the amount of gas exchanges, photosynthesis, and was non-hazardous to parasitoids. So far, several researchers have tried to shift the focus from using chemical control to IPM. It was stated that, soap acts through dissolving the epicuticle of the foliar insects and causes the insect to dry up and die (Smaili *et al*., 2014). In another study, Raudonis *et al*., (2009) proved that the insecticidal soap could be effectively applied to control the green apple aphid in an organic farming. Furthermore, they found that, foliar application of methomyl and imidacloprid against aphids was very effective. According to the study done by Emami (2016), it was revealed that the highest mortality was found in insecticidal soap, surfactant, and antifeeding treatments, respectively.

Given that organic fruit industries are not able to tolerate the risk caused high outbreak of pests and lack of effective tools for pest control, increases the importance of exploring the effects of soaps. consequently, it causes the industry not to be able to show a high growth rate (1–5 % market share) compared to the other approaches (Tamm *et al*., 2004). The other problem attracting the attention to the use of soaps is that the use of chemical pesticides in pistachio orchards has not been successful in controlling *A. pistaciae* over the last six decades, and researchers have tried to develop an IPM program for pistachio pests (Mehrnejad, 2010). During the recent years, the pistachio growers have used detergents as a nonchemical insecticide to control the common pistachio psyllid in pistachio orchards. Vahabzadeh *et al*. (2017) determined the effect of insecticidal soap (Jonobgan®), dishwashing detergent on the common pistachio psyllid, coccinellid beetle, and *Oenopia conglobata* L.

As laundry detergents are used in houses and industries, their wastewater usually contains detergent contaminations in variable amounts. As a result, some studies have been done on detergent contaminations and it was consequently found that detergents presented in irrigation water at high concentrations could affect maize by impairing light-harvesting pigments and cell viability (Uzma *et al*., 2018). In another study, some significant changes were observed in the bean plants irrigated with water contaminated by detergent . The study shows that,chlorophyll concentration dropped by 12% and the activity of photosynthesis apparatus in leaves decreased by around 45% (Jovanić *et al*., 2010). Furthermore, the insecticidal and phytotoxic effects of household detergents were evaluated in field studies on fresh-market tomato (*Lycopersicon esculentum* Mill.). A once-a-week application of 0.25% to 0.5% detergent was initially applied two weeks after transplanting alleviated phytotoxicity and caused yield reduction problems (Vavrina *et al*., 1995).

Considering the needs and the controversies, the current study seeks to evaluate the side effects of insecticidal soaps (Jonobegan®) and dishwashing detergents (Rika®) and make a comparison between them and the conventional insecticides namely spirotetramat (Movento®) and phosalone (Zolon®). The study evaluates and compares the sodium and potassium level of the leaves and examines bud abscission rate as the cause of applying detergents and pesticides.

Materials and Methods

Site of the study

A pistachio orchard about 2500 m^2 with high infestation of psyllid was selected in Rafsanjan, Iran in 2015 (on year), 2016 (off year), and 2017 (on year). The age of trees was about 40 years and the cultivar was Fandoghi. The pistachio trees were planted in rows with seven meters space between the rows and the space between trees in each row was about one meter. The flood irrigation was applied every 65 days. Each row was selected as one block, and all treatments were randomly done in each block. For each replicate, five trees were selected. Three rows were selected as three blocks.

Treatments

Three different treatments were used in this study as below: Liquid soap (Jonobgan®) (SL) 3500 ppm, dishwashing detergent (Rika®) (SL) 3500 ppm, and conventional insecticides (spirotetramat (Movento®) 300 ppm and phosalon (Zolon®) 2500 ppm. Liquid soap and dishwashing detergent treatments applied from the beginning of infestation until at the end of season. At treatment current insecticides, in the early season, the pistachio psyllid controlled by phosalone insecticide, and at the mid-season was done by insecticide spirotetramat and at the end of season was done by phosalone. Because the insecticide spirotetramat were recommended to be used just one time per season, concentrations of liquid soap and dishwashing detergent were applied based on the research by Panahi *et al*. (2013) and Vahabzadeh *et al*. (2017). In this research, the liquid soap (Jonobgan®) and dishwashing detergent (Rika®) were compared with the spirotetramat (Movento®) and phosalone, periodically.

Spraying procedure

In this study, the spraying was done using a 1000 L sprayer tank and full-cone nozzle. The spraying was done in the morning in a calm, cold, and clear weather from four to seven am. The first time of the treatment was applied on mid June 2015. In this year, the second and third treatment application was done in an interval of three to four weeks. In 2016 and 2017, the spraying was repeated three times like 2015.

Effect of treatments on sodium and potassium content of pistachio leaves

In this study, pistachio trees were randomly selected and marked based on the randomized complete block design and then, different treatments (liquid soap, dishwashing detergent and current insecticides) were sprayed on them. The amount of leaves' potassium and sodium were determined. Each treatment replicated three times. In each treatment, the sampling procedure was done by randomly collecting 30 leaves from the selected trees. Ten trees were selected and three leaves were randomly picked up from each tree, from fruitless branches at 150 cm height. Only the apical leaflets were selected. The samples were put in plastic bag and transferred to the laboratory. The sampling was done at the end of July after two times of application of treatments (Sedaghati, 2007). The amount of sodium and potassium was analyzed in the laboratory using the flame photometer (Jenway PFP7 Models) (Fattahi *et al*., 2017). After starting the apparatus, flame was adjusted to the desired degree and it started soaking distilled water. The blank was adjusted to zero and the apparatus was adjusted considering potassium and sodium analysis standards. The calibration curve was depicted and the sample was feed into the apparatus and the absorption level was noted. Afterwards, the solution was analyzed and the density number was multiplied with the reversed density of the solution. Then, the results against the standard or calibrated curve were checked (Bagherifard & Hamidoghli, 2015).

Effects of treatments on bud abscission in 2015 and 2016

Ten pistachio trees were randomly selected and marked. Ten shoots from each tree were randomly selected and marked. Altogether, 300 shoots were selected as the sample of the study and the buds on the selected 300 shoots was counted. The buds were counted before the treatment and after the harvest. The experiments were done based on the randomized complete block design.

Effects of treatments on bud abscission after three years of application of treatments

The number of buds on shoots treated by liquid soap, dishwashing detergent and current insecticides for three subsequent years was counted. Each treatment was replicated three times and each replication was applied on ten shoots for three years. After controlling the common pistachio psyllid by liquid soap and dishwashing detergent and comparing it with current insecticides in the third year, the buds on each shoot was counted and recorded. The results were compared with common insecticides treatments. In the third year, the pistachio psyllid was controlled based on years 2015 and 2016 and the bud abscission after three years of application of treatments was determined.

Statistical analysis

The field experiment was done in a randomized complete block design with three replications. Data analysis was done by SPSS (16.0) and the means were compared by Tukey test ($P < 0.05$). The normality test was done before analysis of variance (ANOVA).

Results

The sodium and potassium rate of pistachio leaves in 2015

Based on the results, the mean value of sodium in liquid soap, dishwashing detergent, and current insecticides treatments was 0.093 ± 0.02, 0.083 ± 0.008 and 0.062 ± 0.010%, respectively. The amount of sodium in current insecticides treatment was lower than liquid soap and dishwashing detergent; but there was not significant difference among treatments (F = 2.549; df = 2, 8; Sig = 0.193). The mean amount of potassium was 1.56 ± 0.40, 1.11 ± 0.11 and 1.23 ± 0.40%, respectively (Table 1). There was no significant difference in potassium rate of leaves among treatments (F = 0.166; df = 2, 8; Sig = 0.408) (Table 1).

The pistachio leaves rate of sodium and potassium in 2016

The mean value of sodium in liquid soap, dishwashing detergent, and current insecticides treatments were 0.115 ± 0.027, 0.095 ± 0.016 and 0.08 ± 0.021%, respectively and the mean value of potassium were 1.31 ± 0.18, 1.13 ± 0.115 and 1.15 ± 0.20%, respectively (Table 1). According to the ANOVA, there was no significant difference among the pistachio leaves' sodium rate (F = 1.388; df = 2, 8; Sig = 0.348) and potassium rate (F = 0.705; df = 2, 8; Sig = 0.547) treated by liquid soap, dishwashing detergent, or common insecticide.

Table 1. Mean (± SE) contents of sodium and potassium in pistachio leaves after treatment in 2015 and 2016

		Liquid soap	Dishwashing detergent	Current insecticides
2015	Sodium (%)	0.093 ± 0.02[a]	0.083 ± 0.008[a]	0.062 ± 0.010[a]
	Potassium (%)	1.56 ± 0.40[a]	1.11 ± 0.11[a]	1.23 ± 0.40[a]
2016	Sodium (%)	0.115 ± 0.027[a]	0.095 ± 0.016[a]	0.08 ± 0.021[a]
	Potassium (%)	1.31 ± 0.18[a]	1.13 ± 0.115[a]	1.15 ± 0.20[a]

The same letters in the same row indicate no significant differences (P < 0.05).

The mean percentage of bud abscission on pistachio trees in years 2015 and 2016

The mean percentage of bud abscission of pistachio trees in year 2015 after controlling pistachio psyllid by liquid soap, dishwashing detergent, and current insecticides was determined to be 15.19 ± 2.24, 9.94 ± 1.94, and 9.47 ± 2.19, respectively (Table 2). The mean percentage of bud abscission of pistachio trees in year 2016 after controlling pistachio psyllid by liquid soap, dishwashing detergent, and current insecticides was determined to be 23.93 ± 4.53, 42.06 ± 7.10 and 32.44 ± 4.01 respectively (Table 2). There was no significant difference between the mean percentage of bud abscission in 2015 (F = 2.583; df = 2, 26; Sig = 0.107) and in 2016 (F = 2.844; df = 2, 26; Sig = 0.088). The results showed that using liquid soap and dishwashing detergent did not have any negative effect on the mean percentage of bud abscission compared to current insecticides.

Table 2. Mean percentage (± SE) of bud abscission of pistachio trees after treatment in 2015 and 2016

	Liquid soap	Dishwashing detergent	Current insecticides
2015	15.19 ± 2.24[a]	9.94 ± 1.94[a]	9.47 ± 2.19[a]
2016	23.93 ± 4.53[a]	42.06 ± 7.10[a]	32.44 ± 4.01[a]

The same letters in the same row indicate no significant differences (P < 0.05).

Effect of liquid soap, dishwashing detergent, and current insecticides on bud abscission at the third year of the experiment

After applying the treatments for controlling pistachio psyllid for three years, bud abscission was checked at the third year of the experiment. At the third year of the experiment, unlike the first two years, the buds before and after applying the treatments were not counted and only the buds on shoots was counted after applying the treatments. The results revealed that the average number of bud abscission in liquid soap, dishwashing detergent, and current insecticides was 5.30 ± 0.42, 5.20 ± 0.29 and 4.20 ± 0.63, respectively (Table 3). Based on ANOVA, there was not a significant difference among treatments (F = 1.563; df = 2, 29; Sig = 0.237).

Table 3. Mean (± SE) of bud abscission after treatment during three years

Treatment	Liquid soap	Dishwashing detergent	Current insecticides
Bud abscission	5.30 ± 0.42[a]	5.20 ± 0.29[a]	4.20 ± 0.63[a]

The same letters in the same row indicate no significant differences (P < 0.05).

Discussion

Detergents and soaps are used as co-adjuvants for conventional pesticides. These compounds can be applied to debilitate insects and mites, spraying after insecticides and miticides. In both cases, a rate reduction (for conventional and more expensive and restricted products) is possible (Curkovic, 2016). The dishwashing detergent have good potential for controlling pistachio psyllid, *A. pistaciae* (Vahabzadeh *et al*., 2018) and silverleaf whitefly, *Bemisia argentifolii* Bellows & Perring (Liu & Stansly, 2000). The results showed that, there is no significant difference between liquid soap (Jonobgan®), dishwashing detergent (Rika®) compared to the current insecticide treatment in sodium and potassium contents of leaves and bud abscission.

The application of dishwashing detergent at 3500 ppm concentration can lead to a relative increase in sodium and relative decrease in iron in leaf, and continuous and long-term use of these detergents may have more adverse effect on these elements. Since iron is an essential element in photosynthesis and chlorophyll production in leaf, foliar application of detergent has probably led to relative reduction of photosynthesis in leaf followed by reduction of iron concentration. Nevertheless, there was no difference between potassium of leaf among dishwashing detergent and other treatments (Panahi *et al*., 2013). The results of Panahi *et al*. (2013) indicate that none of the treatments (3500 ppm dishwashing detergent, 2000 ppm dishwashing detergent, 1000 ppm dishwashing detergent + 500 ppm pesticide (amitraz) , 1500 ppm pesticide (amitraz) and water (control) had a significant effect on concentration of leaf nutrients including phosphorous, potassium, calcium, magnesium, iron, zinc, manganese and copper at 5% level during the three-year period of the experiment. Concerning sodium, although no significant difference was observed, sodium concentration was higher (0.35%) in treatment of 3500 ppm dishwashing detergent compared to other treatments. After treatment of 3500 ppm dishwashing detergent, 2000 ppm dishwashing detergent comes treatment in this regard. The use of water with high concentrations of detergent is not suitable for application in agricultural irrigation, since they have a very alkaline pH and high electrical conductivity (Sawadogo *et al*., 2014). Exposure to high concentration of detergents in irrigation water caused an increased accumulation of Na^{+}, K^{+}, and Ca^{2+} in maize seedlings (Uzma *et al*., 2018). The effects of 3500 ppm dishwashing detergent, 2000 ppm dishwashing detergent, 1000 ppm dishwashing detergent + 500 ppm pesticide amitraz, 1500 ppm pesticide amitraz and water (control) on soil and pistachio plant indicated were not significant on EC and pH of soil, mineral elements of leaf and different parts of fruit, relative water content, and leaf chlorophyll (Panahi *et al*., 2013). The effect of laundry detergent including anionic surfactants tested on plant growth (Lettuce and Okra) by irrigation water. The pH of soil significantly increased, after irrigation. However, the EC increases with increasing detergent content which can increase soil salinity and make it unfavorable for the growth of crops in long term (Sawadogo *et al*., 2014).

Vavrina *et al*. (1995) found that a negative correlation between detergent rates, frequency of application, plant dry weight accumulation, fruit yield and fruit maturity. In the study, different concentrations of detergent were applied on tomatoes ranging from zero to 1%, 2%, 4%, and 8%. The results were tested against a slighter increase in concentrations from 0% to 0.025%, 0.5%, 1%, and 2%. In both cases, it was revealed that as the detergent rate, frequency of application, or both increased, plant's dry weight accumulation and fruit yield decreased. However, the side effects were minimized by doing some modifications in the application strategy. A two-week delay in detergent application resulted in reduction of phytotoxicity. Moreover, the delay led to higher tomato yields compared to samples sprayed with just plain water (Vavrina *et al*., 1995). Even the detergent existing in irrigation water may have some negative effects on the plant. For example, significant changes were observed in the chlorophyll concentration of bean plants irrigated with detergent contaminated water. In that case, the chlorophyll concentration dropped by 12% and the activity of photosynthesis apparatus in leaves decreased by around 45% (Jovanić *et al*., 2010).

Heidari (2012) stated that the laundry detergent in a concentration up to 2.5 g L^{-1} did not affect the leaf number in *Amaranthus hybridus* and *Solanum lycopersicon* (Ehilen *et al*., 2017). However, laundry detergents used in concentrations up to 500 mg L^{-1} can reduce leaf number and leaf size in maize. At 2 and 20 g L^{-1} of a detergent, a reduction in leaf number and leaf area was observed, respectively. Detergents presented in irrigation water at higher concentrations may adversely affect maize by impairing light-harvesting pigments and cell viability (Uzma *et al*., 2018).

Based on the results of the study, using detergents on pistachio trees to control pistachio psyllid, has no negative effect on pistachio trees; since when detergents are used as spreader, the concentration is very low, and the uptake of leaves is less than that of roots by irrigation. By irrigation, the rate and the amounts of uptake are more than leaves. Furthermore, the detergents on the leaves evaporates. Detergents can be used for pest control on trees and crops, applying for IPM, or organic products, and production of foods free of insecticide residues and replacing conventional insecticides (Curkovic, 2016).

The results suggested that the application of liquid soap (Jonobgan®) and dishwashing detergent (Rika®) do not have significant difference on pistachio tress (sodium and potassium contents of leaves, bud abscission and leaves defoliation) compared to current insecticides. Therefore, soap and liquid detergent could be recommended as alternatives to chemical pesticides in IPM programs of *A. pistaciae*.

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