The Effects of Several Minerals on Pistachio Psylla *Agonoscena pistaciae* Burckhardt & Lauterer (Hemiptera: Psyllidae) Control in Orchard Conditions

Hamid Porkhosravani (MSc)[1], Najmeh Azimizadeh (PhD)[2]*, Kamal Ahmadi (PhD)[3]

[1] *Graduate of Masters Entomology, Department of Plant Protection, Rafsanjan Branch, Islamic Azad University, Rafsanjan, Iran*
[2] *Department of Plant Protection, Rafsanjan Branch, Islamic Azad University, Rafsanjan, Iran*
[3] *Department of Plant Protection, Faculty of Agriculture, Shahid Bahonar University of Kerman, Kerman, Iran*

Information

Article Type:

Original Article

Article History:

Received: 15.01.2020
Accepted: 01.06.2020

DOI: 10.22123/phj.2021.266645.1075

Keywords:

Common Pistachio Psylla
Lime Sulfur
Boric Acid
Kaolin
Nonionic Surfactant (NIS)

Corresponding Author:

Najmeh Azimizadeh

Email: n.azimizadeh613@gmail.com

Tel: +98- 9132496128

Abstract

Common pistachio psylla (*Agonoscena pistaciae*) is the key pest of pistachio orchards in Iran. To control this pest, the Iranian gardeners are thus forced to use large amounts of chemical pesticides; this results in environmental pollution, the destruction of natural enemies of the pests, and the outbreak of pistachio pests. Given the low risk of mineral insecticides for both humans and the environment as well as the superiority of mineral substances to chemical compounds in terms of the pest's resistance to insecticides, the present study has investigated the insecticide effects of some mineral compounds including lime sulfur (4000 ppm), boric acid (1000 ppm), kaolin + nonionic surfactant (NIS) (10000 ppm+ 1000 ppm) and potassium silicate+ nonionic surfactant (3000 ppm+ 1000ppm) on pistachio psylla nymphs. This study was conducted in a completely randomized block design in orchard conditions. Based on the results of the present study, in comparison to the other treatments, the compound of potassium silicate+ non-ionic surfactant reduced the population of nymphs in 5, 10, and 25 days for 854.14± 78.32, 804.23± 70.05, and 554.23± 57.75 percent respectively; it had the greatest effect on the controlling the population of pistachio psylla nymphs. Thus, these mineral compounds can be used to control pistachio psylla in pistachio orchards.

►Please cite this article as follows:

Porkhosravani H, Azimizadeh N, Ahmadi K. The effects of several minerals on pistachio psylla *Agonoscena pistaciae* Burckhardt & Lauterer (Hemiptera: Psyllidae) control in orchard conditions. Pistachio and Health Journal. 2020; 3 (2): 66-79.

1. Introduction

Pistachio (*Pistacia vera* L.), as one of the most important horticultural products and the third most important Iranian export product, is of significant economic importance among agricultural products. Given its special quality, Iranian pistachio has an excellent quality among the pistachio-producing countries [1]. Pests have always been one of the most important problems for pistachio producers across in Iran over the recent years. Depending on the weather conditions, a small number of pests are likely to bring about economic damages to pistachios. One of the most important pistachio pests is common pistachio psylla (*Agonoscena pistaciae* Burckhardt & Lauterer (Hemiptera: Psyllidae)); it is also known as dry sap. This insect is currently a key harmful pest to Iranian pistachio orchards. The pest spends the winter as a fully-grown insect. The mature females usually oviposit in late April. The psylla nymphs feed on the sap by dipping the stylets into the leaf surfaces, absorbing the protein material of the sap, and excreting the extra sugar as a sap. These sugary substances dry when exposed to air and are called the sugars. These sticky substances absorb dust and make tree branches and leaves look unpleasant and awful. Moreover, loss of plant sap will result in general weakness of pistachio trees and fall of their leaves and buds. In addition, the lost sap will bring about smaller fruits as well as increased hollow pistachios and closed-shell ones [2]. This pest is controlled in various ways, including the use of yellow sticky cards, field operations, the use of natural enemies of the pest, and chemical control. Artificial insecticides are widely used as well. Their extensive use results in environmental destruction, pest resistance, harmful effects on non-target organisms, and toxic effects on fruit consumers. Given the increased sensitivity to dangerous pesticides and pesticide residues in agricultural crops, a group of common pesticides have been banned over the past few years; they are no longer available to users. Given the environmental risks and natural resources protection, especially in terms of managing water and soil systems, it is highly essential to apply alternative compounds for controlling pests. Mineral compounds can be investigated as alternatives for pesticides. Mineral insecticides are compounds lacking carbon atoms in their molecules; they are commonly made up of white crystals. These compounds are stable and do not evaporate. Moreover, they can solved be in water [3]. The use of mineral compounds and their derivatives is one of the common strategies applied to prevent pest damages [4]. Few studies have been conducted on the effects of mineral compounds on pests. The studies have shown that kaolin is used to protect plants against insects, pathogens, sunburns, and thermal stresses [5, 6, 7, 8]. Moreover, the use of kaolin in laboratory and farm conditions has led to the removal of potato psylla (*Paratrioza cockerelli*

(Sulc) (Hemiptera: Triozidae)); it has resulted in the reduction of its oviposition and feeding [9]. Nano-silicate has been introduced as a new biological pesticide. Silicate can be widely found on earth [10, 11]. Moreover, in the studies conducted, the lime sulfur compound has been introduced as a herbicide, insecticide, and fungicide [12]. In another study, it has been attempted to investigate the effects of borate formulations as wood preservatives for controlling subterranean termites in Australia. The results of the aforementioned study showed that borates turned out to be toxic to termites eight weeks after starting the bioassay [13].

The present study aims to investigate the lethal properties of mineral compounds including kaolin, talcum powder, boric acid, lime sulfur, potassium silicate and NIS (non-ionic surfactant) on pistachio psyalla nymphs. These compounds were either used alone or in combination at predetermined concentrations.

2. Materials and Methods

2.1- The location and conditions of the experimenting area

The present study was conducted out in desert conditions in a pistachio orchard with an area of 2500 square meters with round (Fandoghi) pistachio in Qotbiyeh of Sirjan. The city is geographically located at 55 degrees and 34 minutes east longitude and 29 degrees and 28 minutes north latitude. Its altitude is 1743 meters above sea level. The garden designed for conducting the experiment had ten rows of gutters each of which was about 50 meters long, and the row were four meters apart.

The irrigation frequency was 36 days by using a submerged method. The trees were 18 years old. No pesticide had been sprayed on the selected garden at least from the late March to late June; the population of common pistachio psylla was thus high.

2.2- Preparation of mineral compounds used in the experiment

The mineral compounds used in the present study i.e. kaolin powder, talcum powder, boric acid, potassium silicate, and non-ionic surfactant (NIS) have been prepared from different shops. For preparing lime sulfur, one kilogram of sulfur, a half a kilogram of lime, and five liters of water were gently heated; the final outcome formed an orange substance called lime sulfur. This compound was then stored in a glass container with an aluminum foil [14].

2.3- The required treatments for conducting the preliminary experiment

The experiments have been conducted in two phases; preliminary and final. The tested treatments and their concentrations in the preliminary experiment are as follows (Table 1) (The control was the water used).

Table 1- The mineral compounds used in the preliminary experiment

Mineral compound	Company	Concentration (ppm)	Reference
Non-ionic Surfactant (NIS)	Karmania Pak Azma Kesht	2000	Maximum recommended rate
Talcum powder	Tehran Kimia Acid	5000	Slavica and Brankica, 2013
Kaolin powder	Tehran Kimia Acid	5000	Silva and Ramalho, 2013
Talcum powder + NIS		5000+ 1000	
Kaolin powder + NIS		5000+ 1000	
Potassium Silicate	Karmania Pak Azma Kesht	2000	Maximum recommended rate
Potassium Silicate + NIS		2000+ 1000	
Boric Acid	Tehran Kimia Acid	1000	Fathollahi, 2011
Lime Sulfur	Prepared at the laboratory	2000	Paulo et al, 1999

2.4- The method of conducting the experiment and sampling

As many as ten treatments and ten rows have been designed for conducting the preliminary experiment. In the first year, rows of each treatment were sampled one day before spraying the pesticides. Sampling was conducted randomly from the terminal leaflets. For each replication, as many as 20 leaflets were removed from the trees, and they were then placed in a paper bag related to the row number and related treatment. Psylla nymphs on both upper and lower surfaces of the terminal leaflets were counted by stereomicroscope and recorded in the related replication and treatment. Then, one day after conducting the sampling and recording the number of live nymphs related to each treatment, the spraying operations related to each treatment were conducted in their respective rows. Water was used as control. All treatments were sprayed randomly in one day. Five days after the spraying operations, sampling of the rows related to each treatment was separately conducted. As many as twenty leaves were selected from each row and the number of nymphs was recounted and recorded in the related table.

After reviewing the results of experiments related to the ten treatments mentioned in the first year and observing the effect of each tested treatment on pistachio psylla, the following treatments were selected in the supplementary experiments in the second year the (Table 2). Water was once more used as the control.

Table 2- The mineral compounds used in the supplementary experiments

Mineral Compound	Concentration (ppm)
Kaolin Powder+ NIS	10000+ 1000
Potassium Silicate+ NIS	3000+ 1000
Boric Acid	500
Lime Sulfur	4000

Each of the above treatments was used in two rows out of the total ten rows experimented. First, as in the first year's experiments, samples were taken one day before conducting the experiment. Then, spraying was conducted on the above treatments from both rows of each treatment. At intervals of five, 10 and 25 days after spraying, random sampling was conducted like the previous year, and the number of live psylla nymphs related to each treatment and repetition was separately recorded.

2.5- Statistical analysis

The present study was considered in a completely randomized block design with four replications. As many as 20 leaflets have been designed for each replication. The data obtained were first entered into Excel. In these experiments, the formula used for measuring the percentage of population growth at intervals of five, 10 and 25 days is as follows:

$$\text{percentage of population growth} = \frac{n_i - n_{i-1}}{n_{i-1}} \times 100 \qquad i = 2, 3, 4, \ldots$$

n_i is the mean of population at i^{th} phase

Then they were statistically analyzed using StatPlus2009. One-way ANOVA was used to analyze the data. For comparing the means, Fisher LSD test was applied with a 5% probability.

3. Results

3.1- The effect of mineral compounds on increasing the population of pistachio psylla nymphs in the first year

Based on the results obtained, from among the mineral compounds used in the first year, the control treatment (water) with the mean nymph population growth of -0.02± 0.01, and the non-ionic surfactant treatment (NIS) with the mean nymph population growth of -685.78± 75.29 had the highest and lowest percentages, respectively; they were significantly different at the level of one percent. Moreover, the results indicated that there is a significant difference between the control treatment and the treatments of nonionic surfactant, talcum, kaolin, nonionic surfactant+ talcum, nonionic surfactant+ kaolin, potassium silicate, and potassium silicate+ nonionic surfactant at the level of one percent ($P \leq 0.00001$). However, the control treatment was not significantly different from boric acid and lime sulfur treatments (Fig. 1).

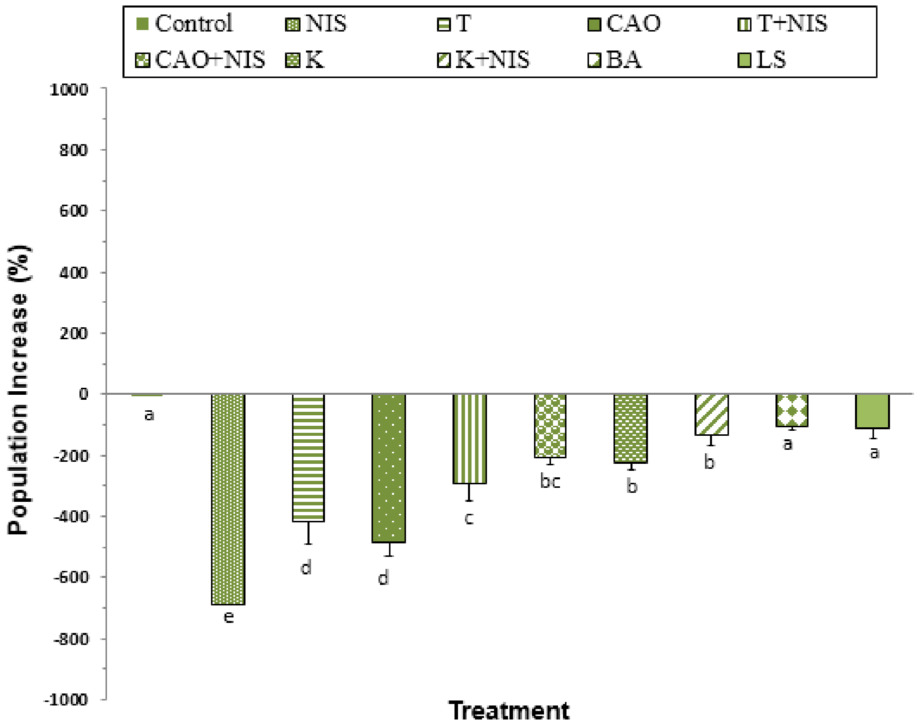

Fig. 1- Mean population growth of pistachio psylla, treated with mineral compounds after five days in the first year

3.2- The effect of five mineral compounds on the percentage increase of pistachio psylla nymph population in the second year

According to the results of experiments in the first year as well as an improved performance to some treatments, as many as five treatments (including water (control), kaolin+ non-ionic surfactant, boric acid, potassium silicate+ non-ionic surfactant, and lime sulfur) were selected and used for the second stage (supplementary) experiments in the summer of the second year. The results are as follows.

3.2.1- The effect of five mineral compounds on the population increase of pistachio psylla nymph; five days after spraying

According to the results, after five days, from among different mineral compounds used, potassium silicate+ non-ionic surfactant treatment and control treatment accounted for the lowest and highest percentage of nymph population growth mean with -854.14± 78.32 and -83.00± 8.74 respectively. This indicated a significant difference at the level of one percent. Moreover, the results have indicated that there is a significant difference between the control treatment and boric acid, potassium silicate+ non-ionic surfactant, and lime sulfur treatments (P≤ 0.02). However, no significant difference was observed between the control treatment and kaolin+ non-ionic surfactant treatment.

In addition, there was a significant difference between potassium silicate+ non-ionic surfactant treatment and the boric acid, lime sulfur, kaolin+ non-ionic surfactant and control treatments (P≤ 0.02) (Fig. 2).

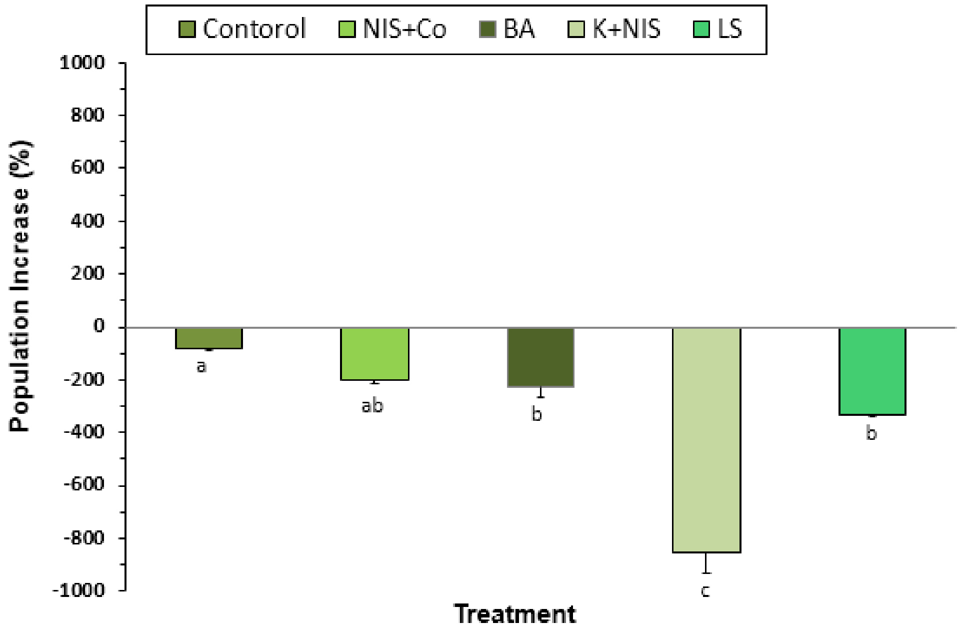

Fig. 2- The mean percentage increase in the pistachio psylla nymph population; treated with five mineral compounds after five days

3.2.2- The effect of five mineral compounds on the percentage increase of pistachio psylla nymph population; 10 days after spraying

Based on the results, after 10 days, from among different mineral compounds applied, the control treatment and the potassium silicate+ non-ion surfactant treatment accounted for the highest and lowest percentages of pistachio psylla nymph population with 1.38± 4.27 and -804.23± 70.05 respectively.

This indicated a significant difference at the level of one percent. Moreover, the results indicated that there was a significant difference between the control treatment and the kaolin+ nonionic surfactant, boric acid, potassium silicate+ nonionic surfactant, and lime sulfur treatments (P≤ 0.00001). In addition, no significant difference was observed between kaolin+ non-ionic surfactant, boric acid, and lime sulfur treatments (Fig. 3).

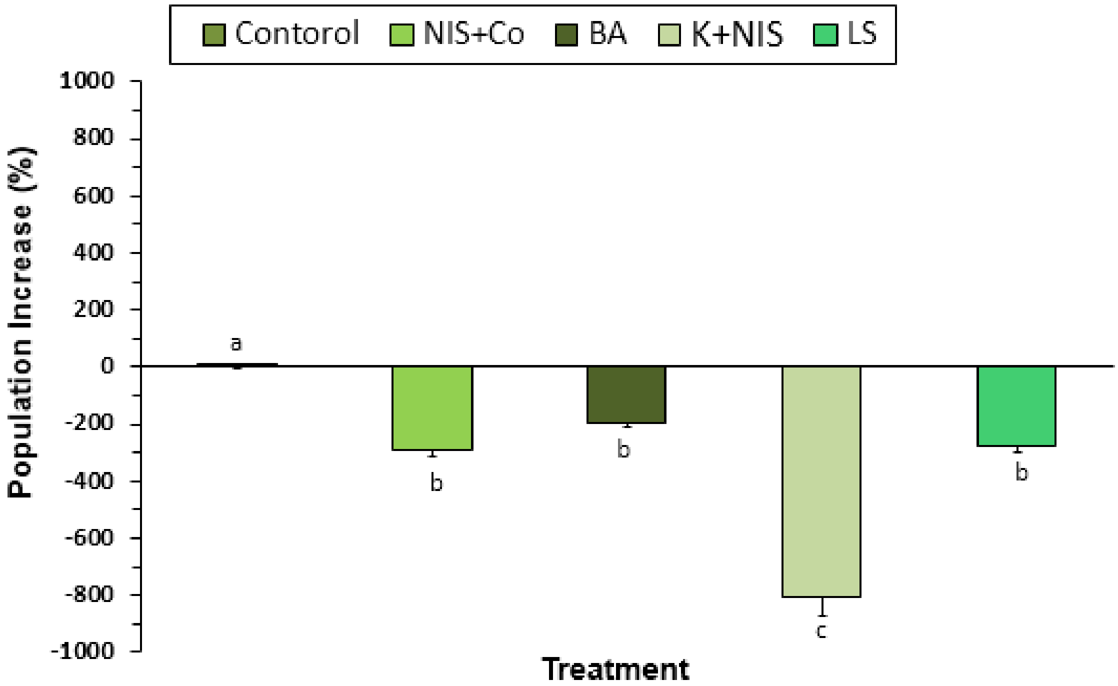

Fig. 3- The mean percentage increase in the pistachio psylla nymph population; treated with five mineral compounds after 10 days

3.2.3- The effect of five mineral compounds on the percentage increase of pistachio psylla nymph population; 25 days after spraying

Based on the results, after 25 days, from among different mineral compounds applied, the control treatment and potassium silicate+ nonionic surfactant accounted for the highest and lowest percentages of pistachio psylla nymph population with -7.69± 5.58 and -554.57± 23.75. This indicated a significant difference at the level of one percent. Moreover, the results indicated that there was a significant difference between the control treatment and kaolin+ nonionic surfactant, boric acid, potassium silicate+ nonionic surfactant, and lime sulfur treatments ($P \leq 0.00001$). In addition, there is a significant difference between kaolin+ nonionic surfactant treatment and potassium silicate+ nonionic surfactant, lime sulfur, and control treatments ($P \leq 0.00001$). However, kaolin + nonionic surfactant treatment was not significantly different from boric acid treatment (Fig. 4).

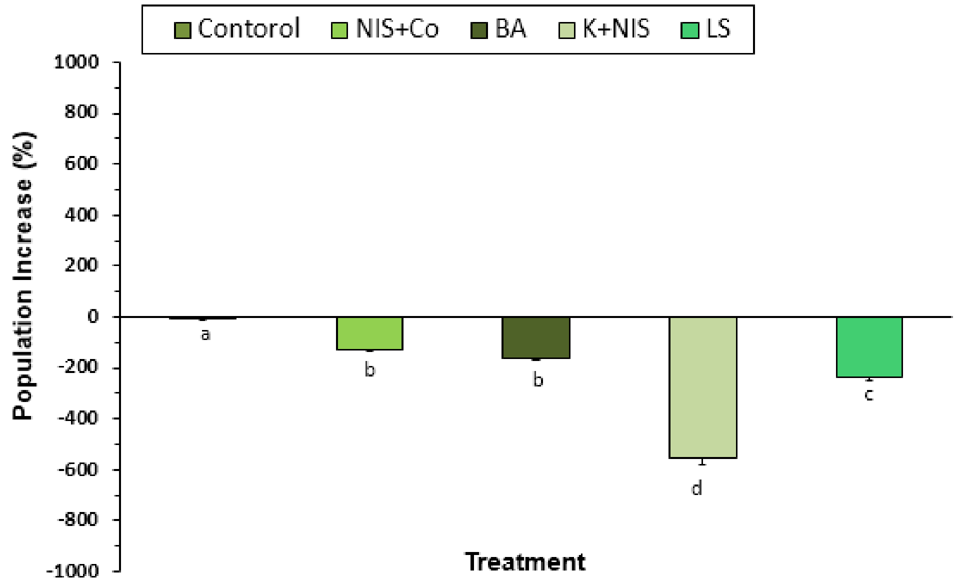

Fig. 4- The mean percentage increase in the pistachio psylla nymph population; treated with five mineral compounds after 25 days

4. Discussion

The results of the present study indicated that in garden conditions, these compounds are different in terms of their effects on increasing the population of pistachio psylla nymphs after 5, 10 and 25 days of spraying. The results indicate that from among these mineral compounds, potassium silicate+ non-ionic surfactant treatment accounted for the highest percentage of nymph population reduction. Moreover, non-ionic surfactant+ kaolin, boric acid, and lime sulfur treatments showed similar results after 5, 10, and 25 days; these compounds were significantly different from non-ionic surfactant+ potassium silicate. After non-ionic surfactant+ potassium silicate treatment, lime sulfur treatment was accounted for the second highest percentage of nymph population reduction.

Surfactants are surface-active agents that are basically used to reduce the surface tension of water-based pesticides. As the surface tension decreases, the coverage of the pesticide used increases; the surface of the plant or soil becomes more wet. Surfactants are commonly referred to as moisturizers [15].

The studies conducted by different researchers have indicated that the surfactant compounds are effective on pesticides; they increase their effectiveness. For example, according to the studies conducted, the effect of surfactant on the activity of insecticides on lettuce and melon has been investigated. The results indicated that the adding surfactants resulted in the significant mortality increase of *Liriomyza trifolii* larvae [16].

In addition, the studies conducted indicate that kaolin has been proved to be effective in controlling some insects. In the study conducted by different researchers, the effect of kaolin on second instar larvae of tomato leaf miner (*Tuta absoluta*) in greenhouse conditions was investigated. Based on the results of the aforementioned study, different concentrations of kaolin are effective on the parameters of repulsion and mortality of larvae; they have increased mortality [17].

Moreover, in another study, it was attempted to investigate the effect of kaolin on common pistachio psylla. In this study, it was found that kaolin was effective on normal pistachio psylla nymphs and was more effective in controlling pistachio psylla than the Acetamiprid. Moreover, it was proved to be more durable than the aforementioned insecticide; it resulted in the control of this pest [18].

In addition, another study has investigated the effect of kaolin on controlling Mediterranean fruit flies (medflies) on pomegranate. The results of this study indicated that spraying of pomegranate trees with kaolin (once in two weeks) can successfully control the damages caused by Mediterranean fruit flies [19]. In addition, the vitro and field application of kaolin has been proved in removing the potato psylla of *P. cockerelli*; it resulted in the reduced oviposition and feeding rate of this pest [20]. One of the effect mechanisms of kaolin is that the kaolin sprayed particles stick to the legs tarsus of the insects and reduce the possibility of their movements; thus, the process of their feeding and oviposition is disrupted. This disruption process continues until they are completely exterminated. Another reason for the effect of kaolin is related to the physical repellent effect of kaolin; the placement of a thin layer of kaolin on the plant tissue and the creation of a white color and light reflection reduce the pest's attractiveness to the tree [21]. This effect mechanism of kaolin has been also observed in pistachio trees on psyllas; the inhibition rates of psylla oviposition in pistachio trees sprayed with 3-percent and five-percent kaolin were 82 and 93%, respectively [22].

Moreover, in the studies conducted, the lethal and sub-lethal effects of talcum powder, Diatomaceous earth and kaolin on two-spotted spider mites were investigated in laboratory conditions. The results indicated that these compounds have increased the mortality of adult female two-spotted spider mites. In this study, the effect of Diatomaceous earth has been investigated on the daily oviposition rate of adult females; the results indicated that Diatomaceous earth has reduced the oviposition rate of adult females [23].

5. Conclusion

According to the results of this study, in comparison to other treatments, the compounds of non-ionic surfactant+ potassium silicate in all three sections of 5, 10 and 25 days reduced the population increase of psylla. Moreover, given the similarity of results in all three sections, it can be concluded that this compound had the largest effect on controlling the population of pistachio psylla. These results confirm that potassium silicate absorbs the wax on the surface of the insect's body, causing the insect's body water to evaporate. Thus, it results in the insect death. Moreover, surfactants are used as an additive in most insecticides. Therefore, their effect can be increased by adding surfactants to mineral compounds. In general, toxins derived from mineral compounds have little effect on mammals and are rapidly degraded in the environment. However, nowadays, there is a growing desire around the world to find new mineral compounds having insecticidal properties. This action is an effective step towards maintaining and keeping the health of the environment [24]. Thus, given the results of the present study, the investigated mineral compounds can be widely recommended for controlling pistachio psylla.

Conflict of Interest

The authors of present researches declare that there is no conflict of interest.

Acknowledgments

The present study has been extracted from a master's thesis. The sincere efforts of the supervisor and advisor are highly appreciated.

References

1- Amirghasemi T, Sozani J. Pistachio or green gold of Iran: with the latest scientific and practical findings related to planting, holding, harvesting and processing techniques of pistachio in Iran. Publication of the Agricultural Engineering and Natural Resources Organization of the country. **2009**; *172 p.*

2- Samih MA, Alizadeh A, Saberi Riseh R. Pistachio pests and diseases in Iran and their IPM, Jahad Daneshgahi Press. Tehran. **2005**.

3- Talebi Jahromi Kh. Toxicology of pesticides: Insecticides, acaricides and rodenticides, University of Tehran Press. **2007**; *492.*

4- Arthur FH. Grain protectants: Current status and prospects for the future. J Stored Prod Res. **1996**; 32: *293-302*.

5- Farazmand H. Effect of Kaolin clay on pomegranate fruits sunburn. Appl. Entomol. Phytopathol. **2013**; 80 (2): *173-83*.

6- Glenn DM, Puterka GJ, Vanderzwet T, Byers RE, Feldhake C. Hydrophobic particle films:

A new paradigm for suppression of arthropod pests and plant diseases. J Econ Entom. **1999**; 92: *759-71*.

7- Puterka G, Reinke M, Luvisi D, Ciomperik MA, Bartels D, Wendel L, Glenn DM. Particle film, Surround WP, effects on glassy-winged sharpshooter behavior and its utility as a barrier to sharpshooter infestations in grape, Plant Health Progress. **2003**; doi: 10.1094/PHP-2003-0321-01-RS.

8- Wand SJ, Theron KI, Ackerman J, Marais SJ. Harvest and post-harvest apple fruit quality following applications of kaolin particle film in South African orchards. Scientiahorticulturae. **2006**; 107(3): *271-76*.

9- Peng L, Trumble JT, Munyaneza JE, Liu TX. Repellency of a kaolin particle film to potato psyllid, *Bactericera cockerelli* (Hemiptera: Psyllidae), on tomato under laboratory and field conditions. Pest Manag Sci. **2011**; 67(7): *815-24*.

10- Barik T, Sahu B, Swain V. Nanosilica-from medicine to pest control. Parasitol. Res. **2008**; 103(2): *253-58*.

11- Bhattacharyya A, Bhaumik A, Usha-Rani P, Mandal S, Timothy T. Nano-particles-A recent approach to insect pest control. Afr J Biotechnol. **2010**; 9(24): *3489-93*.

12- Tomlin C. Pesticide Manual 10th edition. British Crop Protection Council. Cambridge, U.K.: The Royal 671 Society of Chemistry. **1994**.

13- Ahmed BM, French JR, Vinden P. Evaluation of Borate formulations as wood preservatives to control subterranean termites in Australia. Holzforschung. **2004**; 20: *1-9*.

14- Shabani Brojeni F. Booklet of natural and plant pesticides training course, Chaharmahal and Bakhtiari Province Agricultural Jihad Organization, Agricultural Research and Training Center and Natural Resources. **2017**; *39*.

15- Somervailla A, Betts G, Gordon B, Green V, Burgis M, Henderson R. Adjuvants- iols, surfactant and other additives for farm chemicals, Grain research and Development Corporation. Australian Government. **2012**; *1-48*.

16- Palumbo J. The effect of spray adjuvants on the insecticidal activity of success (spinosad) on Lettuce and Melons, Vegetable Report, College of Agriculture and Life Sciences. University of Arizona (Tucson, AZ). **2002**.

17- Abdollahi M, Minaii K, Alichi M, Atashi H, Eshghi S. The effect of kaolin on second instar larvae of *Tuta absoluta* (Lep.: Gelechiidae) in greenhouse conditions. Plant Pest Res. **2017**; 6 (2): *29-38*. (In Persian).

18- Faeazmand H, Hasanzadeh H, Sirjani M, Mohammadpour K, Moshiri A, Valizadeh SH, Jafare Nadoshan A. The effect of processed kaolin on ordinary pistachio nymphs of *Agonoscena pistaciae*. Appl. Entomol. Phytopathol. **2015**; 82 (2): *1137-46*. (In Persian).

19- Khezri A, Soleymannejad A, Goldaste SH, Farazmand H. Application of kaolin in the control of Mediterranean fruit flies, *Ceratitis capitata* (Wiedemann) (Dip: Tephritidae) on pomegranate. J. Entomol. Res. **2018**; 9 (1): *27-34*.

20- Moshiri A, Farazmand H, Vafaeishoushtari R. The preliminary study of kaolin on damage reduction of pomegranate fruit moth, *Ectomyelois ceratoniae* (Lep.: Pyralidae) in Garmsar region. J. Entomol. Res. **2011**; 3(2): *163-71*.

21- Puterka GJ, Glenn DM, Pluta RC. Action of particle films on the biology and behavior of pear psylla (Homoptera: Psyllidae), J Econ Entom. **2005**; 98(6): *2079-88*.

22- Hassanzadeh H, Farazmand H, Oliaeitorshiz A, Sirjani M. Effect of kaolin clay (WP 95%) on oviposition deterrency of pistachio psylla (*Agonoscena pistaciae* Burckharat & Lauterer). J Pestic Plant Prot Sci. **2014**; 1(2): *76-85*. (In Persian).

23- Khodayari M. Investigation of the effect of mineral compounds, linear alcohols and plant extracts on mortality and oviposition of adult females of *Tetranychus urticae* Koch (Acari: Tetranychidae). Master Thesis in Agricultural Entomology. Shahid Bahonar University of Kerman. **2017**.

24- Heydarabadipour M. The effect of ethanolic extract of ten plant species on the nymph reproduction rate of *Brevicoryne brassicae* cabbage aphid. Master Thesis in Agricultural Entomology. Shahid Bahonar University of Kerman. **2017**.