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EVALUATION OF EFFECTS OF TWO SPRING APPLICATIONS OF MICRONUTRIENTS ON THE POPULATION DENSITY OF COMMON PISTACHIO PSYLLA (*AGONOSCENA PISTACIAE*) IN PISTACHIO ORCHARDS

Mohammad Rouhani[1], Mohammad Amin Samih[1], Majid Esmaeilizadeh[2]*

[1] Department of Plant Protection, Faculty of Agriculture
Vali-e-Asr University, Kerman, Rafsanjan, P.O. Box 518, Iran
[2] Department of Plant Protection, Faculty of Agriculture
Vali-e-Asr University, Kerman, Rafsanjan, P.O. Box 518, Iran

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Abstract: The common pistachio psylla, *Agonoscena pistaciae* Burckhardt and Lauterer (Hemiptera: Aphalaridae) is one of the most detrimental pests to pistachio trees. This pest is distributed throughout all the pistachio producing regions of Iran. Nowadays various pesticides are used to control the common pistachio psylla, but extensive pesticide spraying against this pest over a period of several years has overpowered its natural enemies. Moreover, the overlapping of generations has resulted in an abundant presence of the pest. Many herbivorous insects can make qualitative distinctions between host plants, they can feed and oviposit preferentially on higher quality plants. Cultural methods such as crop fertilization can affect the susceptibility of plants to insect pests by altering a plant tissue's nutrient level. This study tested nitrogen (N), calcium (Ca) and zinc (Zn) fertilizers on *A. pistaciae* in pistachio orchards. The experiment was based on complete randomized blocks with three replications and nine treatments including once-applied Zn, Ca, N, NCa, ZnCa, ZnN, ZnCaN, pesticide (amitraz) and a control (distilled water), on common pistachio psylla fed on 20-year-old pistachio trees of Ahmadaghaei rootstock. The results demonstrated that the effect of nutritional solutions on nymph and egg populations showed a significant difference at a 5% level. The highest measure of control on eggs was related to amitraz, ZnCa and Zn while the least was related to NZn. The results also showed that the highest measure of pest control was related to Ca while the least was related to N and Zn. The results indicated that combinations of the elements mentioned had a stronger reducing effect on the concentration of pistachio psylla nymphs than the effect pesticide had.

Key words: *Agonoscena pistaciae*, amitraz, calcium, nitrogen, nutrition, zinc

INTRODUCTION

The pistachio, *Pistacia vera* L. (Sapindalis: Anacardiaceae), is one of the most important horticultural products in Iran. Pistachio is renown as the 'green gold tree' because of its high economic value. It is an edible nut cultivated in suitable microclimates at latitudes of 30°–458° in both northern and southern hemispheres (Ozden-Tokatli *et al*. 2005). The common pistachio psylla, *Agonoscena pistaciae* Burckhardt and Lauterer (Hem.: Aphalaridae) is one of the most significant pests of pistachio trees due to its widespread distribution in all pistachio producing regions of Iran (Samih *et al.* 2005). It also occurs in many pistachio growing regions around Iran's borders, including Armenia, Iraq, Turkmenia and Turkey, as well as Mediterranean regions such as Greece and Syria (Burkhardt and Lauterer 1989; Mart *et al*. 1995; Lauterer *et al*. 1998; Alizadeh *et al.* 2007). 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). Therefore, a suitable non-toxic approach needs to be developed to defend trees from the common pistachio psylla. Although the nature and extent of the evolutionary relationship between plants and herbivores is still debated (Edwards *et al.* 1992; Stout *et al*. 1998), there is little doubt that the natural products of plants serve to protect them against herbivores and that these metabolites are a major, if not the primary determinant of plant resistance to herbivores (Berenbaum 1995; Stout *et al*. 1998). Many researchers have suggested the increasing pressure on agro ecosystems from insect pests, and diseases is due to changes that have occurred in agricultural practices since World War II. For example, the use of fertilizers and pesticides has increased rapidly during this period. Evidence suggests that such excessive use of agrochemicals in conjunc-

*Corresponding address:
Rouhani_valiasr@yahoo.com

tion with expanding monocultures has exacerbated pest problems (Conway and Pretty 1991; Altieri and Nicholls *et al*. 2003). However, proponents of alternative agricultural methods contend that crop losses to insects and disease are reduced with organic farming (Merrill 1983; Oelhaf 1978; Altieri and Nicholls *et al*. 2003). Resource quality or abundance, influence many aspects of insect consumer behavior and physiology, including food selection or feeding rate (Stamp 2001), movement (Eubanks and Denno 1999), reproduction (Stamp 2001), and diapause (Hunter and McNeil 1997; Daugherty *et al*. 2007).

Nitrogen is one of the most critical chemical elements for plant and animal growth (Daugherty *et al*. 2007). Calcium is an important element for cell wall structure and various physiological processes in trees (Littke and Zabowski 2007) Zinc is essential for the normal healthy growth and reproduction of plants, animals and humans. When the supply of plant-available zinc is inadequate, crop yields are reduced and the quality of crop products is frequently impaired (Wang *et al*. 2006; Sarwar 2011).

In this experiment, we investigated the effect of micronutrient fertilization on the population abundance of *A. pistaciae* and compared it with the use of pesticides in pistachio orchards of Rafsanjan, Iran.

MATERIALS AND METHODS

Study site

This study was conducted in pistachio orchards in Rafsanjan, Iran during 2010 and 2011. Pistachios are the predominant tree variety in the study area. For this purpose, pistachio orchards of Ahmadaghaei rootstock with trees of similar ages and horticultural operations were selected. This test was applied on the basis of complete randomized blocks with three replications and nine treatments including two-applied Zn, Ca,N, ZnCa, NCa, NZn. NZnCa, pesticide (Amitraz) and a control (distilled water) on common pistachio psylla fed on 20-year-old pistachio trees of Ahmadaghaei rootstock in the first year. According to the results of the first year, the following fertilizer treatments were selected for the experiment in the second year; NZn, ZnCa, Ca, NZnCa, amitraz and the control. Two trees for each treatment were randomly assigned (18 treatments per block). The dates and concentrations were chosen based on the usual time recommended for spraying pistachio trees and the results of other research in the study area. Thus, concentrations of 0.5%, 0.3%, 0.05% and 1 lit/lit were selected for nitrogen, calcium, zinc and amitraz, respectively. Each of the required elements was prepared from Merck and Bayer, Germany and the spraying technique was used.

Sampling

Sampling began 72 hours after spraying and was continued at 4-day intervals until harvest. For this purpose, each sample was separated. Five leaves from each side of the tree (20 leaves) of each tree (treatment) were taken and transferred to the laboratory. Data were recorded for the number of eggs and nymphs on top of and under each leaf. Averages were calculated for the density of each developmental stage per treatment and months, and their replicates, to conclude averages per treatment per block.

Statistical analysis

The analysis of data was performed using Statistical Package for the Social Sciences (SPSS) 16 software and the comparison of means by Duncan's test. The diagrams were designed using Excel software.

RESULTS

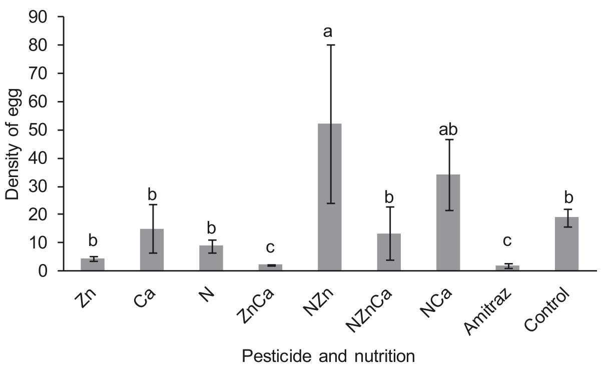
First year

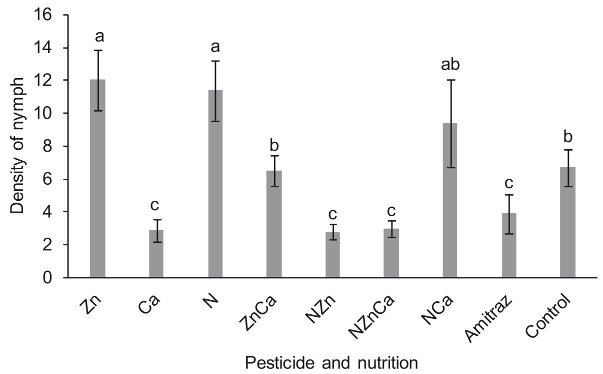
The analysis results of variance showed that the effect of the nutritional solution on 1st instar nymphs ($F_{8,261}$ = 5.40, p = 0.00), 2nd instar nymphs ($F_{8,261}$ = 2.57, p = 0.01), 4th instar nymphs ($F_{8,261}$ = 2.89, p = 0.00), 5th instar nymphs ($F_{8,261}$ = 2.49, p = 0.01) and the total amount of instar nymphs ($F_{8,261}$ = 5.99, p = 0.00) had a significant difference at a 1% level, and egg ($F_{8,261}$ = 5.40, p = 0.00) and developmental time ($F_{8,261}$ = 1.85, p = 0.05) at a 5% level. There was not a significant difference on 3rd instar nymphs. Using Duncan's test, the grouping and the similarity degree at a 5% level of the nymph's common pistachio psylla population were carried out (Table 1). As

Table 1. Means (±SE) effect of nutrition and pesticide on abundance of eggs and the total amount of instar nymphs of *A. pistaciae* in first year

Treatment	Egg Means (±SE)	Nymphal periods Means (±SE)					
		1th instar	2nd instar	3rd instar	4th instar	5th instar	Total
N	8.932.47± b	9.431.54± a	1.000.33± ab	0.460.16± a	0.030.11± a	0.20.08± abc	11.431.83± a
Ca	15.03±8.59 b	2.36±0.57 c	0.33±0.12 c	0.2±0.009 a	0.00±0.00 c	0.00±0.00 c	2.930.69 c
Zn	4.5±1.02 b	9.86±1.59 a	1.3±0.24 a	0.26±0.11 a	0.3±0.13 ab	0.3±0.18 ab	12.03±1.86 a
NCa	34.2612.5± ab	8.5±2.64 ab	0.73±0.2 abc	0.13±0.09 a	0.003±0.03 c	0.06±0.04 bc	9.46±2.68 ab
NZn	52.328.03± a	2.00±0.31 c	0.5±0.15 bc	0.2±0.11 a	0.06±0.04 c	0.03±0.03 bc	2.8±0.46 c
NZnCa	13.469.38± b	1.86±0.36 c	0.63±0.15 bc	0.36±0.12 a	0.1±0.05 bc	0.03±0.03 bc	3.00±0.51 c
ZnCa	2.20.66± c	5.06±0.87 bc	0.7±0.16 abc	0.46±0.11 a	0.13±0.07 abc	0.130.06 abc	6.5±0.95 bc
Amitraz	2.001.03± c	3.46±1.16 c	0.26±0.13 c	0.13±0.06 a	0.03±0.03 c	0.00±0.00 c	3.9±1.16 c
Control	19.114.16± b	0.63±0.16 bc	0.63±0.16 bc	0.3±0.1 a	0.1±0.05 bc	0.36±0.13 a	6.7±1.78 bc

The similar characters in column indicate the lack of significant difference at 5% level





a, b, c, ab – the grouping and the similarity degree in 5% level by Duncan's test

Fig. 1. Effect of nutrition and pesticide on abundance of eggs of *A. pistaciae* in the first year

Fig. 2. Effect of nutrition and pesticide on abundance of the total amount of instar nymphs of *A. pistaciae* in the first year

shown the highest measure of control on eggs was significantly related to the combination of amitraz and ZnCa and the least was related to NZn, compared to the control (Fig. 1, Table 1). An increase of abundance of 1st instar nymphs was caused by Zn and N and there was a significant difference between treatments and the control. The results also showed that NCaZn, NZn caused a decrease in the abundance of 1st instar nymphs and there was no significant difference between the treatments and the control. The treatment with Zn increased 2nd instar nymphs were significant compared to the control. Amitraz and Ca decreased the abundance of 2nd instar nymphs, but there was no significant difference between treatments and the control. Results for 3rd instar nymphs showed that N increased the abundance of nymphs and amitraz decreased the abundance of nymphs, but this difference was not significant. Also, N increased 4th instar nymphs significantly, compared to the control. The treatment with Ca caused a decrease in abundance of 4th instar nymphs and this had the most poisonous effect. The highest abundance of 5th instar nymphs was related to the control. Also, Ca and amitraz decreased the abundance of 5th instar nymphs significantly, compared to the control. The study of abundance of nymphs in this test showed that N and Zn increased their abundance significantly, compared to the control and Ca decreased the abundance of nymphs (Fig. 2, Table 1).

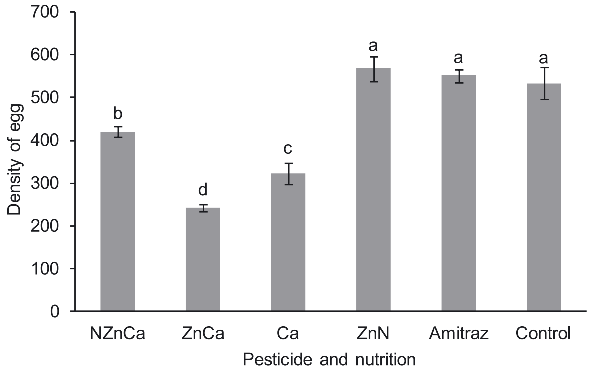
Second year

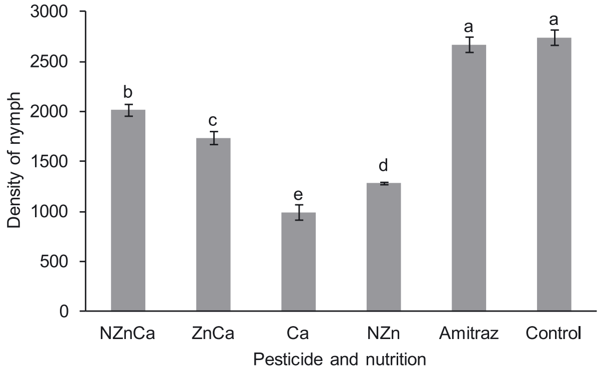
The results of the analysis of variance showed that the effect of the nutritional solution had a significant difference at a 1% level on eggs ($F_{5,24}$ = 32.29, p = 0.00), 1st instar nymphs ($F_{5,24}$ = 109.63, p = 0.00), 2nd instar nymphs ($F_{5,24}$ = 25.89, p = 0.00), 3rd instar nymphs ($F_{5,24}$ = 16.98, p = 0.00), 4th instar nymphs ($F_{5,24}$ = 69.93, p = 0.00), 5th instar nymphs ($F_{8,261}$ = 6.74, p = 0.00) and the total amount of instar nymphs ($F_{5,24}$ = 116.44, p = 0.00). The grouping and the similarity degree of nymphs of the common pistachio psylla population were carried out using Duncan's test (Table 2). The results were similar to those of the first year experiment: abundance of eggs decreased with ZnCa, and increased with NZn and amitraz (Fig. 3, Table 2). Results for nymph instars showed that all of the treatments were less than the control, and Ca decreased population density significantly (Fig. 4, Table 2). Also these results showed that Ca significantly decreased the population density of 1st, 2nd, 3rd, 4th and 5th nymph instars and there was not a significant difference between amitraz and the control.

Table 2. Means (±SE) effect of nutrition and pesticide on abundance of eggs and the total amount of instar nymphs of *A. pistaciae* in second year

Treatment	Egg Means (±SE)	Nymphal periods Means (±SE)					
		1th instar	2nd instar	3rd instar	4th instar	5th instar	Total
Ca	323.00±24.45 gh	328.00±25.29 f	200.2±14.48 a	83.00±1.014 k	86.6±6.95 j	295.2±78.99 g	993.2±78.38 g
NZn	567.229.77± abcd	431.00±24.48 e	305.8±11.00 ef	94.812.13 jk	138.8±8.54 g	312.2±12.44 g	1282.6±11.7 f
NZnCa	420.813.54± ef	660.8±35.78 c	436.00±34.55 d	187.2±15.55 efg	170.00±8.06 fgh	562.00±59.38 de	2016.13±57.96 d
ZnCa	242.88.91± h	568.4±26.21 d	375.8±29.06 def	128.6±15.4 hij	155.8±7.51 gh	507.8±68.67 de	1736.4±65.69 e
Amitraz	551.815.3± bcd	940.4±24.5 b	654.6±49.77 bc	206.6±16.27 cdef	248.6±8.69 ed	622.2±54.43 cde	2672.4±79.28 c
Control	533.837.13± bcd	986.4±26.51 b	660.6±56.86 bc	219.6±15.24 bcde	259.4±7.69 cde	618.00±41.68 cde	2744.00±77.62 dc

The similar characters in column indicate the lack of significant difference at 5% level





a, b, c, d – the grouping and the similarity degree in 5% level by Duncan's test

Fig. 3. Effect of nutrition and pesticide on abundance of eggs of *A. pistaciae* in the second year

Fig. 4. Effect of nutrition and pesticide on abundance of the total amount of instar nymphs of *A. pistaciae* in the second year

DISCUSSION

This study showed that use of nutrient elements could be applied to facilitate Integrated Pest Management (IPM) of *A. pistaciae*. But the abundance of these pests needs to be taken into consideration. According to our results, it appears that Ca decreased the abundance of *A. pistaciae* and Zn and N increased their density. This result shows that two sprayings of amitraz had the maximum effect on decreasing the abundance of eggs, but on nymphs, fertilization (Ca) decreased abundance. It can therefore be deduced, that the pesticide effect is temporary and organic fertilization can be applied as a replacement for traditional pesticide. An IPM strategy needs to be determined based on an economic injury level (EIL). This should be done whether the nutrient solution can act as a good method of control and bring common pistachio psylla populations under control following EIL or not. Many researchers have studied the effect of nutrient elements, especially that of nitrogen (Frangoyannis *et al*. 2001; Morales *et al*. 2001; Moon and Stiling 2005; Kagata and Katayama 2006; Zhong-xian *et al*. 2007; Sawar 2011). In this investigation, Ca decreased abundance of *A. pistaciae*, and N increased the density, which is consistent with other researchers' reports (Luna 1988; Brodbeck *et al.* 2001; Chau *et al*. 2005; Alasvand *et al.* 2010). A global literature review showed that no records were available that were related to *A. pistaciae*. Only the effects of nutritional elements on densities of other pests were mentioned. In most studies evaluating aphid and mite response to N fertilization, the increases in N rates dramatically increased aphid and mite numbers. Luna (1988) investigated the effects of Ca and N on *Heliothrips haemorrhoidalis* and *M. persicae*, and showed that nitrogen fertilizer increased abundance of aphid and mite but calcium fertilizer showed a decrease. Brodbeck *et al.* (2001) showed that populations of *Frankliniella occidentalis* were significantly higher on tomatoes that received higher rates of N fertilization. Chau *et al.* (2005) reported the population growth rate of *Aphis gossypii* on potted chrysanthemum *Dendranthema grandiflora* increased with fertilization of N. While studying nitrogen's effect on *Schizaphis graminum*, Alasvand *et al.* (2010) showed that N fertilization caused an increase in reproduction and this led to an increase in damage. Also in this investigation, Zn increased the abundance of *A. pistaciae*, which is not in agreement with the report by Sarwar (2011). According to Sarwar (2011), the population of rice borers (*Scirpophaga* species) was significantly affected by different treatments though the highest prevalence was found in control treatment. The prevalence of the borers tended to decrease with increasing doses of Zn.

CONCLUSION

In summary, nitrogen, calcium and zinc were tested on populations of *A. pistaciae* in pistachio orchards. The results of this study clearly demonstrated that Ca decreased the abundance of *A. pistaciae*, while Zn and N increased the density.

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