Entomol Gener	34 (4): 279–286	Stuttgart: 2013-11	ISSN: 0171-8177

EGT-Nr **1.462** V

Evaluation of Kaolin Application on Oviposition Control of the Vine Cicada, Psalmocharias alhageos in Vineyards [Homoptera: Cicadidae]

HYDAR VALIZADEH, HABIB ABBASIPOUR, HOSSEIN FARAZMAND & ALIREZA ASKARIANZADEH

Received: 2012-12-22 Accepted: 2013-02-12

VALIZADEH H [Agric Nat Sci Res C, Qom/Iran], ABBASIPOUR H [Dep Plant Prot, Shahed Univ, Tehran/Iran], FARAZMAND H [Pestic Sect, plant prot Res inst, Tehran/Iran] & ASKARIANZADEH A [Dep Plant Prot, Shahed Univ, Tehran/Iran]: **Evaluation of Kaolin Application on Oviposition Control of the Vine Cicada, Psalmocharias alhageos in Vineyards [Homoptera: Cicadidae]**. – Entomol Gener **34** (4): 279–286; Stuttgart 2013-11. [Note]

The vine cicada, *Psalmocharias alhageos* (Kolenati 1857) (Homoptera: Cicadidae), is an important pest of vineyards. The nymphs of cicada damage the trees by feeding on roots, adult insects on young buds and by oviposition under branch barks. Nourishing roots by nymphs leads to the weakness of the tree and hinder its growth. The high density oviposition of adult insects inside young barks causes withering of branches. The efficacy of a kaolin-based formulation (Sepidan®) along with diatomaceous earth (Sayan®) and essential oil to control field infestations of the vine cicada, *P alhageos* was investigated in Qom province of Iran. The results indicate that kaolin plus diatom suppresses the vine cicada egg laying activity (50% reduction in comparison to untreated control). Also the number of healthy shoots in treated trees was increased, and conversely number of infected shoots was decreased. The highest product yield was obtained in treated trees. In overall, Kaolin and diatom particles successfully suppressed *P alhageos* oviposition and provided season-long insect control. Consistent with previous findings, the Sepidan® kaolin particles proved to be a promising alternative method to synthetic insecticides and could be used to control *P alhageos* in vine groves.

Keywords: *Psalmocharias alhageos* (Kolenati 1857) – diatomaceous earth – essential oil – kaolin – vineyard

1 Introduction

Powdered suspensions of processed kaolin have a barrier or repellent effect against insects [GLENN, PUTERKA, VENDERZWET et al 1999, PUTERKA, GLENN, SEKUTOWSKI et al 2000]. The processed-kaolin particle film technology, hereafter referred to as kaolin, was originally used in agriculture to protect fruit from solar injury by forming a film of reflecting particles on the fruit surface [GLENN, PRADO, EREZ et al 2002]. However, kaolin sprayed on crops was found to be effective against a range of pest insects such as aphids [COTTRELL, WOOD & REILLY 2002, WYSS & DANIEL 2004, HALL, LAPOINTE & WENNINGER 2007, RAWORTH, MATHUR, BERNARDY et al 2007], psyllids including *Cacopsylla* spp and *Bactericera cockerelli* [GLENN et al 1999, PUTERKA et al 2000, PASQUALINI, CIVOLANI & GRAPPADELLI 2002, 2004, SAOUR 2005, DANIEL, PFAMMATTER, KEHRLI et al 2005, DANIEL & WYSS 2006, ERLER & CETIN 2007, PENG, TRUMBLE, MUNYANEZA et al 2010], thrips

0171–8177/13/0034-0279 $ 2.00

[LARENTZAKI, SHELTON & PLATE 2008, REITZ, MAIORINO, OLSON et al 2008], fruit flies [MAZOR & EREZ 2004, SAOUR & MAKEE 2004, MARK'O, BLOMMERS, BOGYA et al 2008], whiteflies [LIANG & LIU 2002], Lepidoptera [KNIGHT, UNRUH, CHRISTIANSON et al 2000, UNRUH, KNIGHT, UPTON et al 2000, SHOWLER 2003, BARKER, FULTON, EVANS et al 2006, CADOGAN & SCHARBACH 2005] and Coleoptera [LAPOINTE 2000, LAPOINTE, MCKENZIE & HALL 2006, SHOWLER 2002a]. With kaolin particles clinging to the body, pest insects struggle with moving over particle treated surfaces, which leads to reduced feeding and oviposition [GLENN & PUTERKA 2005]. Especially the tarsal segments are covered with kaolin particles [GLENN et al 1999]. COTTRELL et al [2002] noted that black pecan aphids were unable to stay on the underside of kaolin treated leaves; their dusty tarsi reduced their mobility. Moreover, plants coated with the kaolin may become visually or tactilely unrecognizable as a host [PUTERKA et al 2000, SHOWLER 2002b, WYSS & DANIEL 2004]. Since the kaolin powder does not kill insects but acts as a repellent or barrier, the side effects on beneficial arthropods are low [LAPOINTE 2000, SHOWLER & SE'TAMOU 2004, GLENN & PUTERKA 2005]. The Environmental Protection Agency in America considers kaolin as not harmful to non-target organisms and to the environment: studies indicate no adverse effects either on spiders and honeybees or on aquatic organisms [EPA 1999]. In addition, SHOWLER & SE'TAMOU [2004] stated that populations of dipterans, *Orius* spp, and wasps were reduced in the kaolin treatments only on one of 10 sampling dates over two seasons (2000, 2001). Foliar kaolin sprays had no effect on other arthropod groups identified in this study (Silver leaf whitefly, *Bemisia argentifolii* Bellows and Perring, herbivorous hemipterans and coleopterans, thrips, lepidopteran larvae, *Geocoris* spp, *Nabis* spp, reduviids, coccinellids, *Collops* spp, neuropterans and spiders). This type of technology fits with the goals of organic and integrated pest management (IPM) strategies, particularly for the vine cicada, because the products currently used in organic and IPM vine orchards for this major pest have side effects on beneficial arthropods.

The vine cicada, *Psalmocharias alhageos* (Kolenati 1857) (Homoptera: Cicadidae) is an important pest of vineyards in most parts of Iran, Afghanistan, Pakistan, southern areas of Russia, Turkey and Iraq. This cicada is spread in most provinces in Iran such as Esfahan, Hamedan, Qazvin, Markazi, Lorestan, Qom, Kerman, Tehran and Kordestan. In addition to grapevine, this insect damages some other fruit trees, such as apple, sour cherry, quince, peach, pomegranate and pear trees and some non-fruit trees, namely white poplar, ash, elm, eglantine, silk and black poplar trees [BABAEI 1967, ZAMANIAN et al 2008]. *P alhageos* appears with one generation in four years in Iran [ESMAEILI 1991]. The nymphs of cicada damage the trees by feeding on roots, adult insects on young buds and by oviposition under branch barks. Nourishing root by nymph leads to the weakness of the tree and hinder its growth. The high density oviposition of adult insects inside young barks causes withering of branches. The resulted damage on vine products is 40% which is one of the most important factors in product reduction in vineyards [SHEKARYAN & REZVANI 2000, VALIZADEH & FARAZMAND 2009]. Different nymphal instars of *P alhageos* spent the winter under the soil on the grapevine roots and in sandy soils, nymphs could penetrate the soil to a depth of 1 m. Adults appear from mid June to early of September in the vineyards. Females immediately after emergence mate and lay their eggs under branch bark on the young shoots of grapevines. Currently, the control of the *P alhageos* is attained by using different insecticides against different nymphal instars in the soil [VALIZADEH & FARAZMAND 2009]. The broad-spectrum oral and contact insecticide Carbaryl (Sevin®) for terrestrial pests, Imidacloprid (Confidor®) is used in IPM treated orchards [NYOMAN et al 2001, TOLLERUP et al 2004]. These insecticides are toxic to a broad range of beneficial insects, particularly to *Centrodora* sp (Aphelinidae) and *Eupelmus cicadae* (Eupelmidae) which are important egg parasitoids of *P alhageos* [BABAEI 1967, OILB 1971, POLASZEK 1991]. Kaolin and other inert dusts have potential as an environmental-friendly alternative to the traditional insecticides. Previous studies on kaolin reported a reduction of *Cacopsylla* spp in spring but not in summer when the population reaches damaging levels [GLENN et al 1999, PUTERKA et al 2000, PASQUALINI et al 2002].

The aims of the present study were to confirm the deterrence effect of kaolin, diatomaceous earth (DE) and other repellents against *P alhageos*, and to compare these compounds with traditional control approaches in order to develop an alternative control strategy against *P alhageos* in organic and IPM grape orchards.

2 Material and methods

The trials were carried out in a 14-year-old cv. Mahdikhani commercial vineyard during 2011 year in Qom Province of Iran. The treatments were untreated control, essential oil (Menthol and *Eucalyptus* essential oil), DE 5%, DE 10%, kaolin (Sepidan WP) 5%, mixture 5% of kaolin and DE, kaolin 10% and mixture 10% of kaolin and DE. The treatments were applied prior to egg laying and repeated for three times including 15 June, 15 July and 15 August. The essential oil was used because it has anti-ovipositional action for several pests, although it is not commonly used to control the vine cicada adults. The treatments were delivered using a motorized one-hundred liters sprayer calibrated to deliver 15hl/ha (standard spray volume) on the both leaf surfaces and branches until run-off. The trial was arranged in a completely randomized block design in the centre of the orchard with four replications (each plot consisted of two trees, and in total 64 trees were tested in this experiment). Before running the experiment to eliminate the impact of cicada nymphs, *P alhageos* on the tree roots, 20^{cc} confidor® (Sc 35%) dissolved in 20 liters of water was applied per each tree in treated plots.

At each stage of counting operation for 64 trees and for each tree about 500 branches and in total 32,000 branches were sampled. Traits measured included product yield per each tree (kg), healthy number of shoots, number of infected shoots and total number of cicada eggs per branch.

2.1 Statistical Analysis

Data were analyzed by a one-way ANOVA using SAS (Version 9.3). Means of the different control approaches were compared by Duncan's Multiple Range Test (DMRT).

3 Results

The resulting data of the field trials (2011) showed a significant difference at 1% level between treatments in the product yield, number of healthy and infected shoots and eggs number of the vine cicada (**Tab 1**), but the effect of replication for studied traits was not significant at 5% level. Coefficient of variation, were 20.8%, 1.92%, 7.27% and 7.27%, respectively, and they were acceptable.

Tab 1: Analysis variance of different traits measured by application of different treatments on the vine cicada, *Psalmocharias alhageos* (Kolenati 1857) in the vineyards [Homoptera: Cicadidae].

Resources of Variance	df	Product yield	No of healthy shoots	No of infec-ted shoots	No of eggs
Block	3	1.61^{ns}	0.71^{ns}	8.22^{ns}	7.7**
Treatment	7	4.78**	53.83**	48.65**	52.42**

^{ns} non significant

** significant at 1%

Analysis of variance and comparison of grape product yield means showed that there was no significant difference between blocks (df = 3, F = 1.61, P < 0.01), but differences between treatments were significant (df = 7, F = 4.78, P < 0.01) (**Tab 1**). In this study, a mixture of 10% kaolin and DE treatment with 61 kg yield per each tree was in group A and the highest yield was obtained. Control, essential oil and DE 5% had the lowest yield among treatments (**Tab 2**).

Also, data analysis of results and comparison of means of number of healthy shoots stated that there was no significant difference between blocks (df = 3, F = 0.71, P < 0.01), but differences between treatments were significant (df = 7, F = 53.83, P < 0.01) (**Tab 1**). In this study, a mixture of 10% kaolin and DE treatment with 115.29 healthy shoots was in group A with highest category. Control and essential oil treatments had the lowest number of healthy shoots among treatments (**Tab 2**).

In addition, results of number of infected shoots and comparison of means indicated that there was no significant difference between blocks (df = 3, F = 8.22, P < 0.01), but differences between treatments were significant (df = 7, F = 48.65, P < 0.01) (**Tab 1**). In this study mixture 10% of kaolin and DE treatment with 2.13 infected shoots was in group D with lowest category. Control and essential oil treatments had the highest number of infected shoots among treatments (**Tab 2**).

Furthermore, analysis of variance and the mean number of *P. alhageos* eggs on the shoots demonstrated that there was significant difference between blocks (df = 3, F = 7.7, P < 0.01), and differences between treatments were significant (df = 7, F = 52.42, P < 0.01) (**Tab 1**). The lowest number of eggs on the shoots treated with 10% kaolin clay mixed 10% diatoms, with the average of eggs, 25.81 per shoot, set in the Group E. Most eggs have been laid in control and essential oil treatments (**Tab 2**).

Tab 2: Comparison of different traits measured (Mean ± SE) by application of different treatments on the vine cicada, *Psalmocharias alhageos* (Kolenati 1857) in the vineyards [Homoptera: Cicadidae].

Treatment	Product yield	Healthy shoots	Infected shoots	No. of eggs
Control (water)	32 ± 1.47 c	95.33 ± 1.24 e	4.67 ± 0.15 a	58.30 ± 1.34 a
Essential oil	34 ± 1.29 c	97.38 ± 1.52 de	4.17 ± 0.12 b	53.15 ± 1.32 b
DE (5%)	36 ± 2.58 c	99.21 ± 1.23 d	4.06 ± 0.08 b	50.20 ± 0.89 bc
DE (10%)	40 ± 2.04 bc	99.62 ± 0.46 d	3.83 ± 0.25 b	47.24 ± 2.87 c
Kaolin (5%)	45 ± 1.47 bc	108.15 ± 0.28 c	3.03 ± 0.25 c	37.34 ± 2.88 d
Kaolin (5%) + DE (5%)	46 ± 3.87 bc	108.52 ± 0.49 c	2.91 ± 0.16 c	35.67 ± 2.2 d
Kaolin (10%)	52 ± 3.58 ab	111.87 ± 1.06 b	2.68 ± 0.13 c	33.77 ± 1.93 d
Kaolin (10%) + DE (10%)	61 ± 11.38 a	115.29 ± 0.87 a	2.13 ± 0.16 d	25.81 ± 2.69 e

Means within a column followed by the same letter are not significantly different ($P < 0.05$; Duncan Multiple Range Test).

These results indicate that kaolin plus diatom suppresses the vine cicada egg laying activity (50% reduction in comparison to untreated control) and thus the density of nymphs at next stage (50% reduction in comparison to untreated control). Lower, yet interesting, non-effectiveness was found with essential oil (menthol and *Eucalyptus*), which is normally used as repellent for prevention of egg laying in many cases. The presence of the vine cicada feeding activity on the roots was only observed in the untreated control plots. This result should be important for several grape varieties (e.g Mahdikhani) that are frequently damaged by the cicada in that period. There were no phytotoxic effects to vine leaves or fruits during the season and between the fruit set observed in the treatment plots in comparison to that of the untreated ones.

4 Discussion

This study demonstrated that kaolin protects grapevines against infestations of the vine cicada, *P alhageos*. The information obtained from this study is characterized by a mixture 10% of kaolin and DE treated with the highest production and control and essential oil treatment had the lowest yield. Kaolin (Sepidan WP) as a chemically inert, has been developed in recent years as a physical barrier to repel insects, prevent disease spread and reduce the incidence of fruit sunburn on the trees [Wünsche, Lombardini & Greer 2004]. As previous studies have shown the kaolin mineral powder could prevent damages of insect pests on fruit trees and makes them unable to find a suitable place for oviposition [Showler 2002b]. The range of effects of kaolin we observed with *P alhageos* is similar to the results reported by Glenn et al [1999] for several important leaf feeding apple and pear pests. For example, they found that pear psylla adults in choice tests did not settle on or oviposit on kaolin-treated surfaces. Similarly, potato leafhopper populations did not develop in a greenhouse on treated apple seedlings, whereas populations on untreated seedlings caused severe plant damage. In fact, as an inhibiting substance (Deterent), it sticks to the insect ovipositor during egg laying and prevent of the oviposition. Presence of the dried particle film on leaves interfered with the ability of adults to grasp and walk on citrus leaves [Hall et al 2007]. Also Kaolin had no effect on *P alhageos* eggs, but it was quite effective on 1st nymphal instars as it was previously reported on the neonate larvae of the colding moth [Knight et al 2000]. Our field trials showed that kaolin clay mixed diatoms can be effective in controlling nymphal populations of *P alhageos*. A single spray applied before the initiation of oviposition in the spring reduced the number of laid eggs and subsequently nymphs feeding on the roots by more than 50%. Although further studies should be conducted on the effects of kaolin on the nymphal instars. The here reported findings are supported by Pasqualini et al [2002] who showed that two applications of kaolin in February and March caused a 99–100% reduction of *Cacopsylla pyri* (L) eggs and nymphs. Glenn et al [1999] noted that the adult *Cacopsylla pyricola* Foerster became heavily coated with kaolin particles within 24 h and appeared pre-occupied by attempts to remove these particles from their body, unable to feed or to oviposit. In particular, tarsal segments became covered with kaolin particles. However, these studies focused on the short-term effects of kaolin. There is still need to evaluate the long-term effects of kaolin on *P alhageos*. Since kaolin is not toxic for beneficials [Epa 1999, Showler & Se'Tamou 2004] this product might be an alternative to the insecticides commonly used to control the vine cicada, *P alhageos* in organic and IPM grape orchards.

In conclusion, kaolin (Sepidan WP) affects egg laying of the vine cicada, *P alhageos*, by hindering their anchorage on the shoot surface and inhibiting host plant acceptance (kaolin's mineral barrier).

It was also found that the body and wings of some adults become soiled, rendering them less mobile and preventing them reaching the laying site (host location) on plants; indeed, the kaolin-treated plot was practically free from nymph instars. Further investigations will be carried out on a large scale to better define key aspects regarding the *P alhageos* spring and summer populations, any side-effects on *Centrodora* sp (Aphelinidae) and *Eupelmus cicadae* (Eupelmidae) which are important egg parasitoids of *P alhageos* in vineyards. Our overall results, like those reported in other studies, show that non-chemical kaolin is an effective insecticide without such side-effects on treated plants as fruit set and phytotoxicity.

5 References

BARKER J E, FULTON A, EVANS K A & POWELL G [2006]: The effects of kaolin particle film on Plutella xylostella behaviour and development. – Pest Manag Sci **62:** 498–504; Hoboken/USA.

BABAEI H [1967]: Vine cicada, Cicadatra ochreata Melichar. – Appl Entomol Phytopathol **27:** 69–97; Tehran/Iran.

CADOGAN B L & SCHARBACH R D [2005]: Effects of a kaolin-based particle film on oviposition and feeding of gypsy moth (Lep: Lymantriidae) and forest tent caterpillar (Lep: Lasiocampidae) in the laboratory. – J Appl Entomol **129:** 498–504; Hoboken/USA.

COTTRELL T E, WOOD B W & REILLY C C [2002]: Particle film affects black pecan aphid (Homoptera: Aphididae) on pecan.- J Econ Entomol **95**: 782–788; Lanham/ USA.

DANIEL C & WYSS E [2006]: Pre-flowering kaolin treatments against the European pear sucker, Cacopsylla pyri (L). – Mitt Dtsch Ges allg angew Entomol **15:** 263–267; Deutschland.

DANIEL C, PFAMMATTER W, KEHRLI P & WYSS E [2005]: Processed kaolin as an alternative insecticide against the European pear sucker, Cacopsylla pyri (L). – J Appl Entomol **129** (7): 363–367; Hoboken/USA.

EPA [1999]: Kaolin (100104) Fact Sheet. – URLhttp://www.epa.gov/pesticides/biopesticides/ ingredients/ factsheets/factsheet_100104.htm

ERLER F & CETIN H [2007]: Effect of kaolin particle film treatment on winter form oviposition of the pear psylla, Cacopsylla pyri. – Phytoparasitica **35:** 466–473; Dordrecht/Nederland.

ESMAEILI M [1991]: Fruit Trees Important Pests. – Sepehr Press, 578 pp.; Tehran/Iran.

GLENN D M, PUTERKA G, VENDERZWET T, BYERS R E & FELDHAKE C [1999]: Hydrophobic particle films: a new paradigm for suppression of arthropod pests and plant diseases. – J Econ Entomol **92:** 759–771; Lanham/USA.

GLENN D M, PRADO E, EREZ A & PUTERKA G J [2002]: A reflective, processed-kaolin particle film affects fruit temperature, radiation reflection, and solar injury in apple. – J Am Soc Hortic Sci **127:** 188–193; Alexandria/USA.

GLENN D M & PUTERKA G J [2005]: Particle films: a new technology for agriculture. – Hortic Rev **31:** 1–44; Prague/Czech Republic.

HALL D G, LAPOINTE S L & WENNINGER E J [2007]: Effects of a particle film on biology and behavior of Diaphorina citri (Hemiptera: Psyllidae) and its infestations in citrus. – J Econ Entomol **100:** 847–854; Lanham/USA.

KNIGHT A L, UNRUH T R, CHRISTIANSON B A, PUTERKA G J & GLENN D M [2000]: Effects of a kaolin-based particle film on the obliquebanded leafroller (Lepidoptera: Tortricidae). – J Econ Entomol **93:** 744–749 Lanham/USA.

LAPOINTE S L [2000]: Particle film deters oviposition by Diaprepes abbreviatus (Coleoptera: Curculionidae). – J Econ Entomol **93:** 1459–1463 Lanham/USA.

LAPOINTE S L, MCKENZIE C L & HALL D G [2006]: Reduced oviposition by Diaprepes abbreviatus (Coleoptera: Curculionidae) and growth enhancement of citrus by surround particle film. – J Econ Entomol **99:** 109–116 Lanham/USA.

LARENTZAKI E, SHELTON A M & PLATE J [2008]: Effect of kaolin particle film on Thrips tabaci (Thysanoptera: Thripidae), oviposition, feeding and development on onions: a lab and field case study. – Crop Prot **27:** 727–734; Oxford/Great Britain.

Liang G M & Liu T X [2002]: Repellency of a kaolin particle film, Surround, and a mineral oil, sunspray oil, to silverleaf whitefly (Homoptera: Aleyrodidae) on melon in the laboratory. – J Econ Entomol **95:** 317–324; Lanham/USA.

Mark'O V, Blommers L H M, Bogya S & Helsen H [2008]: Kaolin particle films suppress many apple pests, disrupt natural enemies and promote woolly apple aphid. – J Appl Entomol **132:** 26–35; Hoboken/USA.

Mazor M & Erez A [2004]: Processed kaolin protects fruit from Mediterranean fruit fly infestations. – Crop Prot **23:** 47–51; Oxford/Great Britain.

Nyoman W, Taylor A G, Urwiler M, Suzuki Y & Nakasuji F [2001]: Effects of sublethal doses of Imidacloprid on the fecundity of green leafhoppers, Nephoteeix spp (Hem: Cicadellidae) and their natural enemies. – Appl Entomol Zool **36** (4): 501–507; Tokyo/Nippon.

OILB [1971]: Liste d'identification des entomophages **8:** pp. 6 ; OILB, Genève/Swiss.

Pasqualini E, Civolani S & Grappadelli L C [2002]: Particle film technology: approach for a bio-rational control of Cacopsylla pyri (Rynchota: Psyllidae) in Northern Italy. – B Insectol **55:** 39–42; Bologna/Italia.

Pasqualini E, Civolani S & Grappadelli L C [2004]: Control of pear psyllid with a kaolin film. – Inform Agric Supp **60:** 85–86; Italia.

Peng L, Trumble J T, Munyanezae J E & Liua T X [2010]: Repellency of a kaolin particle film to potato psyllid, Bactericera cockerelli (Hemiptera: Psyllidae), on tomato under laboratory and field conditions. – Pest Manag Sci **67** (7): 815–824; Hoboken/USA.

Polaszek A [1991]: Egg parasitism in Aphelinidae (Hymenoptera: Chalcidoidea) with special reference to Centrodora and Encarsia species. – B Entomol Res **81** (1): 100; Cambridge/Great Britain.

Puterka G, Glenn D M, Sekutowski D G, Unruh T R & Jones S K [2000]: Progress toward liquid formulations of particle films for insect and disease control in pear. – Environ Entomol **29:** 329–339; Lanham/USA.

Raworth D A, Mathur S, Bernardy M G, French C J, Chatterton M & Chan C K [2007]: Effect of kaolin clay on migrant alate aphids (Hemiptera: Aphididae) in blueberry fields in the context of Blueberry scorch virus. – J Entomol Soc BC **104:** 65–72; Britsh Columbia/Canada.

Reitz S R, Maiorino G, Olson S, Sprenkel R, Crescenzi A & Momol M T [2008]: Integrating plant essential oils and kaolin for the sustainable management of thrips and tomato spotted wilt on tomato. – Plant Dis **92:** 878–886; St Paul/USA.

Saour G & Makee H [2004]: A kaolin-based particle film for suppression of the olive fruit fly Bactrocera oleae Gmelin (Dip, Tephritidae) in olive groves. – J Appl Entomol **128:** 28–31; Hoboken/USA.

Saour G [2005]: Efficacy of kaolin particle film and selected synthetic insecticides against pistachio psyllid, Agonoscena targionii (Homoptera: Psyllidae) infestation. – Crop Prot **24:** 711–717; Oxford/Great Britain.

SAS Institute [1997]: SAS/STAT Guide for Personal Computers, version 6.12. – SAS Institute: North Carolina/USA.

Shekaryan B & Rezvani A [2000]: The study of vine cicada, Psalmocharias alhageos Kol Bioecology in Lorestan province. – Final report of research project, Iranian Research Institute of Plant Protection, 25 pp; Tehran/Iran.

Showler A T [2002a]: Effects of kaolin-based particle film application on boll weevil (Coleoptera: Curculionidae) injury in cotton. – J Econ Entomol **95:** 754–762 Lanham/USA.

Showler A T [2002b]: Effects of water deficit stress, shade, weed competition, and kaolin particle film on selected foliar free amino acid accumulations in cotton, Gossypium hirsutum (L). – J Chem Ecol **28:** 631–651; Dordrecht/Nederland.

Showler A T [2003]: Effects of kaolin particle film on beet armyworm, Spodoptera exigua (Hübner) (Lepidoptera: Noctuidae), oviposition, larval feeding and development on cotton, Gossypium hirsutum L. - Agr Ecosyst Environ **95:** 265–271; Amsterdam/Nederland.

Showler A T & Se Tamou M [2004]: Effects of kaolin particle film on selected arthropod populations in cotton in the lower Rio Grande Valley of Texas. – Southwest Entomol **29:** 137–146; Dallas/USA.

Tollerup K E, Rust M K, Dorschner K W & Klotz J H [2004]: Low-toxicity baits control ants in citrus orchards and grape vineyards. - Calif Agr **58** (4): 213–217; California/USA.

It was also found that the body and wings of some adults become soiled, rendering them less mobile and preventing them reaching the laying site (host location) on plants; indeed, the kaolin-treated plot was practically free from nymph instars. Further investigations will be carried out on a large scale to better define key aspects regarding the *P alhageos* spring and summer populations, any side-effects on *Centrodora* sp (Aphelinidae) and *Eupelmus cicadae* (Eupelmidae) which are important egg parasitoids of *P alhageos* in vineyards. Our overall results, like those reported in other studies, show that non-chemical kaolin is an effective insecticide without such side-effects on treated plants as fruit set and phytotoxicity.

5 References

BARKER J E, FULTON A, EVANS K A & POWELL G [2006]: The effects of kaolin particle film on Plutella xylostella behaviour and development. – Pest Manag Sci **62:** 498–504; Hoboken/USA.

BABAEI H [1967]: Vine cicada, Cicadatra ochreata Melichar. – Appl Entomol Phytopathol **27:** 69–97; Tehran/Iran.

CADOGAN B L & SCHARBACH R D [2005]: Effects of a kaolin-based particle film on oviposition and feeding of gypsy moth (Lep: Lymantriidae) and forest tent caterpillar (Lep: Lasiocampidae) in the laboratory. – J Appl Entomol **129:** 498–504; Hoboken/USA.

COTTRELL T E, WOOD B W & REILLY C C [2002]: Particle film affects black pecan aphid (Homoptera: Aphididae) on pecan.- J Econ Entomol **95**: 782–788; Lanham/ USA.

DANIEL C & WYSS E [2006]: Pre-flowering kaolin treatments against the European pear sucker, Cacopsylla pyri (L). – Mitt Dtsch Ges allg angew Entomol **15:** 263–267; Deutschland.

DANIEL C, PFAMMATTER W, KEHRLI P & WYSS E [2005]: Processed kaolin as an alternative insecticide against the European pear sucker, Cacopsylla pyri (L). – J Appl Entomol **129** (7): 363–367; Hoboken/USA.

EPA [1999]: Kaolin (100104) Fact Sheet. – URLhttp://www.epa.gov/pesticides/biopesticides/ ingredients/ factsheets/factsheet_100104.htm

ERLER F & CETIN H [2007]: Effect of kaolin particle film treatment on winter form oviposition of the pear psylla, Cacopsylla pyri. – Phytoparasitica **35:** 466–473; Dordrecht/Nederland.

ESMAEILI M [1991]: Fruit Trees Important Pests. – Sepehr Press, 578 pp.; Tehran/Iran.

GLENN D M, PUTERKA G, VENDERZWET T, BYERS R E & FELDHAKE C [1999]: Hydrophobic particle films: a new paradigm for suppression of arthropod pests and plant diseases. – J Econ Entomol **92:** 759–771; Lanham/USA.

GLENN D M, PRADO E, EREZ A & PUTERKA G J [2002]: A reflective, processed-kaolin particle film affects fruit temperature, radiation reflection, and solar injury in apple. – J Am Soc Hortic Sci **127:** 188–193; Alexandria/USA.

GLENN D M & PUTERKA G J [2005]: Particle films: a new technology for agriculture. – Hortic Rev **31:** 1–44; Prague/Czech Republic.

HALL D G, LAPOINTE S L & WENNINGER E J [2007]: Effects of a particle film on biology and behavior of Diaphorina citri (Hemiptera: Psyllidae) and its infestations in citrus. – J Econ Entomol **100:** 847–854; Lanham/USA.

KNIGHT A L, UNRUH T R, CHRISTIANSON B A, PUTERKA G J & GLENN D M [2000]: Effects of a kaolin-based particle film on the obliquebanded leafroller (Lepidoptera: Tortricidae). – J Econ Entomol **93:** 744–749 Lanham/USA.

LAPOINTE S L [2000]: Particle film deters oviposition by Diaprepes abbreviatus (Coleoptera: Curculionidae). – J Econ Entomol **93:** 1459–1463 Lanham/USA.

LAPOINTE S L, MCKENZIE C L & HALL D G [2006]: Reduced oviposition by Diaprepes abbreviatus (Coleoptera: Curculionidae) and growth enhancement of citrus by surround particle film. – J Econ Entomol **99:** 109–116 Lanham/USA.

LARENTZAKI E, SHELTON A M & PLATE J [2008]: Effect of kaolin particle film on Thrips tabaci (Thysanoptera: Thripidae), oviposition, feeding and development on onions: a lab and field case study. – Crop Prot **27:** 727–734; Oxford/Great Britain.