ALTERNATIVE APHID CONTROL METHODS FOR PEACH PRODUCTION

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ABSTRACT

One of the major pests in peach orchards is the aphid *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). Unfortunately, this aphid has developed multiple mechanisms of insecticide resistance. Furthermore, none of the agents which have been used to control *M. persicae* is environmentally friendly and harmless to non-target organisms. Therefore, new, environmentally friendly agents with different modes of actions need to be evaluated. One promising agent is kaolin, a white, nonabrasive, fine-grained aluminum-silicate mineral. The aim of this study was to evaluate imidacloprid and alternative products such as insecticidal soap, light mineral oil and processed kaolin for use in organic farming in terms of their ability to control *M. persicae* and in terms of their effects on aphid predators. The experiment was carried out at a peach orchard at the Experimental Farm in Velestino, which belongs to the University of Thessaly, in May and June, 2004. The experimental orchard consisted of fifty trees planted in five rows of ten trees each. The treatments evaluated were: Confidor 200 SL (imidacloprid); Savona (insecticidal soap); Sun Oil 7E (light mineral oil); and Surround WP (kaolin, PFT). Efficacy was evaluated by grading the level of aphid infestation on a scale from 0 to 5. Aphids and beneficial insects were counted on the seven apical leaves of selected shoots the day before the treatments were applied, and then once a week for six weeks until almost all of the aphids had left the orchard and migrated to their secondary hosts. The treatments were applied once on May 13, 2004, at the concentrations recommended by the manufacturers. Imidacloprid proved to be the most effective of the four products tested and reduced the aphid population by 53.1% compared to the control. Kaolin reduced the

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aphid population by 26.8%. Insecticidal soap reduced the aphid population by 19.1%. Light mineral oil reduced the aphid population by 6.7%. None of the products tested seemed to have an adverse effect on coccinellid populations except for imidacloprid. Among the beneficial insect species found in the orchard, the most abundant were coccinellids such as *Coccinella septempunctata* (L.), *Adalia bipunctata* (L.) and *Hippodamia variegata* (Goeze). Kaolin promises to be a useful agent for controlling aphids in peach orchards.

Key words: *Myzus persicae*, Coccinellidae, peach, kaolin, imidacloprid.

INTRODUCTION

One of the major pests in peach orchards is the aphid *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). The primary host of this aphid is the peach. *M. persicae* reproduces by parthenogenesis in the spring and early summer, and sexually in the autumn.

Different classes of insecticides have been extensively used to control *M. persicae* in many countries. Unfortunately, this aphid has developed multiple mechanisms of insecticide resistance, including:

- increased synthesis of the esterase enzyme E4/FE4, which detoxifies organophosphates and pyrethroids (Devonshire and Moores, 1982); and
- reduced sensitivity of target proteins. For example, reduced sensitivity of acetylcholinesterase confers resistance to pirimicard and triazamate, and reduced sensitivity of the voltage driven sodium channel (*kdr*) confers resistance to pyrethroids (Moores et al., 1994; Martinez-Torrez et al., 1997).

An individual aphid population may exhibit more than one resistance mechanism (Foster and Devonshire, 1999).

Neonicotinoids are another class of insecticides against *M. persicae*. Until now, *M. persicae* has been reported to have a low level of tolerance to neonicotinoids (Foster et al., 2003). However, neonicotinoids have been extensively used for more than ten years.

Furthermore, none of the agents mentioned above is environmentally friendly and harmless to non-target organisms. Therefore, new, environmentally friendly agents with different modes of actions need to be evaluated.

One promising agent is kaolin, a white, nonabrasive, fine-grained aluminium-silicate mineral ($Al_4SiO_{10}[OH]_8$) (Puterka et al., 2000). It has been used with the particle film technique (PFT), a new method for controlling agricultural pests and diseases (Glenn et al., 1999). The processed kaolin film technique (Surround™ WP) has also been studied as a way to prevent solar injury to fruit crops by forming a film of reflecting particles on their surface (Kerns and Wright, 2001; Glenn et al., 2002; Melgarejo et al., 2004).

Kaolin has been found to be effective against various aphid species, including:

- *Aphis spiraecola* (Patch) (Hemiptera: Aphididae) (Glenn et al., 1999);
- *Melanocallis caryafoliae* (Davis) (Hemiptera: Aphididae) (Cottrell et al., 2002); and
- *Dysaphis plantaginea* (Pass.) (Hemiptera: Aphididae) (Bürgel et al., 2005).

Kaolin is also effective against other insects (Glenn and Puterka, 2005). Furthermore, processed kaolin can be used in integrated pest management programs (Glenn et al., 1999). It does not harm beneficial organisms such as predators and earthworms (Liang and Liu, 2002).

The processed kaolin particle film technique does not directly kill insects. Instead, it prevents damage to crops by repelling insects or by forming a protective barrier. The inert particle film creates a hostile environment for insects by forming a physical barrier which interferes with movement, feeding and egg laying (Glenn and Puterka, 2005). Pests may also be unable to recognize host plants coated with kaolin by sight or touch (Glenn et al., 1999; Wyss and Daniel, 2004).

The aim of this study was to evaluate imidacloprid and alternative products such as insecticidal soap, light mineral oil and processed kaolin for use in organic farming in terms of their ability to control *M. persicae* and in terms of their effects on aphid predators.

MATERIAL AND METHODS

The experiment was carried out at a peach orchard at the Experimental Farm in Velestino, which belongs to the University of Thessaly, in May and June, 2004. The experimental orchard consisted of fifty trees planted in five rows of ten trees each. The experiment was carried out in a random block design with five blocks of two trees each.

The treatments evaluated were:

- Confidor 200 SL (imidacloprid);
- Savona (insecticidal soap);
- Sun Oil 7E (light mineral oil); and
- Surround WP (kaolin, PFT).

Untreated trees served as the control.

The treatments were applied once on May 13, 2004, at the concentrations recommended by the manufacturers. The aphid population was already dense at this time.

Surround WP was applied at a concentration of 60 grams per liter on the advice of Dr. G. Puterka, a research entomologist with the Agricultural Research Service in Kearneysville, West Virginia, USA. The same

concentration had also been used by Cottrell et al. (2002) to control *M. caryafoliae* in pecan cultivars, and by Bürgel et al. (2005) to control the rosy apple aphid (*D. plantaginea*).

All treatments were applied with a portable CP3 knapsack sprayer using a cone nozzle at a pressure of 30 kg cm^2. No other insecticides were applied except for the experimental treatments.

Efficacy was evaluated on the basis of aphid infestation. All nymphal stages and adults were counted on the seven apical leaves of selected marked shoots the day before the treatments were applied, and then once a week after treatment. Infestation was graded from 0 to 5 as follows:

0: no aphids;
1: 1 to 10 aphids per leaf;
2: 10 to 20 aphids per leaf;
3: 20 to 30 aphids per leaf;
4: 30 to 40 aphids per leaf; and
5: more than 40 aphids per leaf.

Aphids were counted a total of six times before almost all of the aphids had left the orchard and migrated to their secondary hosts. The last measurement was not taken into account during data analysis because of the low number of aphids remaining.

Eggs, larvae and adults of coccinellid species were also counted on the same marked shoots. Adults were transported to the laboratory for species identification.

Data were statistically elaborated using analysis of variance (ANOVA) followed by Tukey's test at $P \leq 0.05$ (STATISTICA 6.0). The $\sqrt{x+1}$ transformation was used to stabilize the variance (Snedecor and Cochran, 1989). The data was also recalculated and expressed using Abbott's correction (Abbott, 1925).

RESULTS

Imidacloprid proved to be the most effective of the four products tested and reduced the aphid population by 53.1% compared to the control. Kaolin reduced the aphid population by 26.8%. Insecticidal soap reduced the aphid population by 19.1%. Light mineral oil reduced the aphid population by 6.7% (Tab. 1).

Imidacloprid remained highly effective for up to three weeks after application (Tab. 1). After four weeks, the aphid population in trees treated with imidacloprid was higher than in the control. The manufacturer states that imidacloprid remains active for about three or four weeks after application.

The insecticidal soap started to lose its efficacy two weeks after application, and had completely lost its efficacy three weeks after application (Tab. 1). Light mineral oil followed a similar pattern.

Table 1. Mean aphid infestation scores per shoot before and after product application (May 13, 2004) and Abbot's efficacy for the four samplings after product application

Treatment		Sampling dates					Mean[4]
		May 12	May 19	May 26	June 2	June 8	
Imidacloprid	M.I.[1]	2.08	0.76	1.07	1.15	0.93	0.98a
	S.E.[2]	0.58	0.32	0.49	0.48	0.31	0.43
	A.C.[3]		73.1%	64.5%	45.8%	- 116.3%	53.1%
Insecticidal soap	M.I.[1]	1.47	1.60	2.02	2.19	0.96	1.69bc
	S.E.[2]	0.44	0.47	0.40	0.36	0.25	0.38
	A.C.[3]		43.3%	32.9%	- 3.3%	- 123.3%	19.1%
Light mineral oil	M.I.[1]	2.21	2.05	2.57	2.55	0.62	1.95c
	S.E.[2]	0.48	0.29	0.23	0.09	0.09	0.23
	A.C.[3]		27.3%	14.6%	- 20.3%	- 44.2%	6.7%
Kaolin	M.I.[1]	2.46	1.90	1.92	1.69	0.61	1.53ab
	S.E.[2]	0.50	0.44	0.32	0.28	0.32	0.37
	A.C.[3]		32.6%	36.2%	20.3%	- 41.9%	26.8%
Control	M.I.[1]	2.16	2.82	3.01	2.12	0.43	2.09c

Means in the same column followed by a different letter are significantly different according to Tukey's test at $P \leq 0.05$ [1] Mean infestation [2] Standard Error of Mean infestations [3] Abbot's efficacy
[4] Mean for the sampling dates after product application

Table 2. Mean coccinellid scores per shoot before and after product application (May 13, 2004) and Abbot's efficacy for the four sampling dates after product application

Treatment		Sampling dates					Mean[4]
		May 12	May 19	May 26	June 2	June 8	
Imidaclo-prid	M.V.[1]	6.1	2.20	14.40	19.80	33.40	17.45a
	S.E.[2]	4.01	0.80	4.82	8.21	7.78	0.43
	A.C.[3]		89.9%	53.9%	62.2%	20.5%	43.0%
Insecticidal soap	M.V.[1]	14.20	20.60	22.80	34.60	49.70	1.69bc
	S.E.[2]	12.37	15.23	9.61	6.42	9.45	0.38
	A.C.[3]		5.5%	26.9%	34.0%	- 17.6%	- 4.1%
Light mineral oil	M.V.[1]	8.40	5.00	35.60	46.40	38.80	1.95c
	S.E.[2]	4.88	2.59	10.55	7.27	4.10	0.23
	A.C.[3]		77.1%	- 14.1%	11. 5%	7.6%	- 2.8%
Kaolin	M.V.[1]	13.51	28.14	32.91	26.41	22.56	1.53ab
	S.E.[2]	7.99	14.40	14.03	7.68	8.72	0.37
	A.C.[3]		- 29.1%	- 5.4%	49.6%	46.3%	10.1%
Control	M.V.[1]	8.60	21.80	31.20	52.40	42.00	2.09c
	S.E.[2]	6.28	0.19	0.41	0.25	0.10	0.24

Means in the same column followed by a different letter are significantly different according to Tukey's test at $P \leq 0.05$ [1] Mean infestation [2] Standard Error of Mean infestations [3] Abbot's efficacy
[4] Mean for the sampling dates after product application

Kaolin had a high initial efficacy and retained it for three weeks, longer than the other organically approved products tested.

The effects of the four products tested on beneficial coccinellids are summarized for each counting date in Table 2. Only trees treated with imidacloprid had lower numbers of coccinellids compared to untreated trees, especially three weeks after application. The insecticidal soap had no apparent effect on the coccinellid populations. Mineral oil was lethal to coccinellids one week after application, but had no residual effect. Kaolin did not affect coccinellid populations at first, but reduced them three weeks after treatment, probably because of its insect repellent action.

Among the beneficial insect species found in the orchard, the most abundant were coccinellids such as *Coccinella septempunctata* (L.), *Adalia bipunctata* (L.) and *Hippodamia variegata* (Goeze) (Fig. 1).

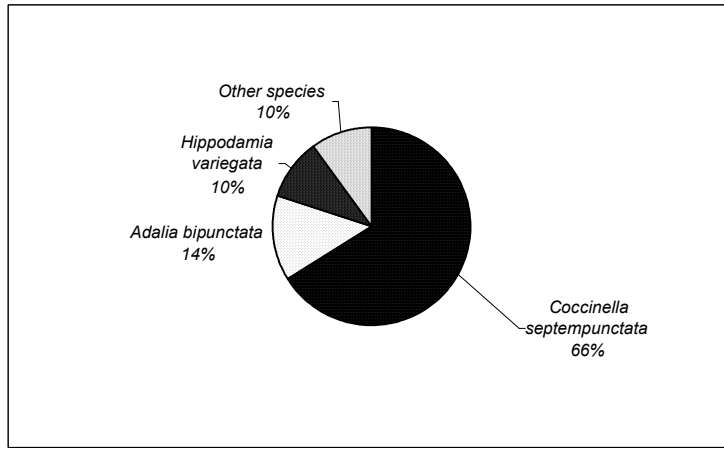

Figure 1. Frequency of the coccinellid species in the experimental orchard

DISCUSSION

The most effective of the products tested in controlling aphids was imidacloprid, followed by kaolin, light mineral oil, and insecticidal soap. Efficacy varied depending on how much time had passed since application.

Products such as kaolin are most effective when used as preventative measures rather than curative agents (Glenn et al., 1999).

The leaf curling caused by aphid infestation reduced the efficacy of all of the products tested except for imidacloprid, which is a systemic agent.

To ensure maximum efficacy, the products tested need to be applied so that they cover the entire tree canopy.

For the insecticidal soap tested (Savona), the manufacturer recommends repeated applications in the early stages of aphid infestation to ensure satisfactory results.

Products such as kaolin may also have to be repeatedly applied because they can be washed off by frequent rainfalls. Kaolin is thus best suited for use in dry regions (Mazor and Erez, 2003). Kaolin also needs to be repeatedly applied in order to ensure coverage of new growth (Showler, 2003; Puterka et al., 2000).

None of the products tested seems to have an adverse affect on coccinellid populations except for imidacloprid. In a recent study, kaolin did not harm beneficial organisms such as predators and earthworms (Liang and Liu, 2002).

Kaolin promises to be a useful agent for controlling aphids in peach orchards. Further study is needed on applying kaolin in the early stages of infestation and on the effects of kaolin on beneficial insects. Insecticidal soap and light mineral oil were not effective in controlling aphids when applied only once, even in the dry climate of central Greece.

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ALTERNATYWNE METODY ZWALCZANIA MSZYC W UPRAWIE BRZOSKWIŃ

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STRERSZCZENIE

Celem badań było zbadanie efektywności czterech insektycydów w zwalczaniu mszycy brzoskwiniowej *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) oraz określenie wpływu tych insektycydów na owady pożyteczne występujące na brzoskwini.

Wśród testowanych preparatów znalazły się: imidakloprył, sól potasowa kwasu tłuszczowego, olej parafinowy oraz glinka kaolinowa. Poletko eksperymentalne obejmowało 50 drzew brzoskwiń uprawionych w gospodarstwie Uniwersytetu Thessaly w Velestino, w centalno-wschodniej części Grecji. Skuteczność stosowanych insektycydów określana była na podstawie liczebności mszyc na siedmiu liściach wierzchołkowych 25 pędów każdego drzewa według pięciostopniowej skali. Ocena liczebności mszyc oraz owadów pożytecznych przeprowadzana było sześciokrotnie, w odstępach siedmiodniowych. Insektycydy zastosowano 13 maja, jeden dzień po wstępnej ocenie liczebności szkodnika.

Wśród testowanych preparatów najwyższą efektywność wykazał imidakloprył, którego zastosowanie pozwoliło zredukować liczebność mszyc w stosunku do kontroli o 53.1%. Gorszą efektywność wykazały kolejno – glinka kaolinowa, sól potasowa kwasu tłuszczowego oraz olej parafinowy, gdzie redukcja liczebności mszyc wyniosła odpowiednio – 26,8; 19,1 oraz 6,7%. Obniżoną liczebność owadów pożytecznych w stosunku do kontroli obserwowano tylko na poletkach opryskiwanych preparatem imidakloprył. Owady pożyteczne najliczniej reprezentowane były przez biedronki Coccinellidae, wśród których dominowały *Coccinella septempunctata* (L.), *Adalia bipunctata* (L.) oraz *Hippodamia variegata* (Goeze).

Słowa kluczowe: mszyce, *Myzus persicae,* brzoskwinia, imidakloprył, sól potasowa kwasu tłuszczowego, olej parafinowy, glinka kaolinowa, *Coccinella septempunctata*, *Adalia bipunctata, Hippodamia variegata*

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