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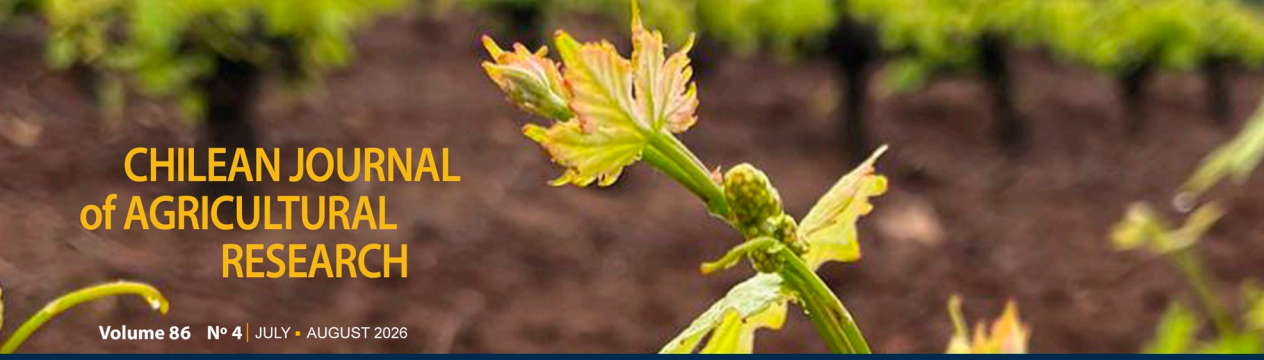

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RESEARCH

REVIEW

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RESEARCH ARTICLE

Pest-specific chemical strategies for the management of *Aleurocanthus spiniferus* (Quaintance, 1903) in mandarin orchard supported by on-site chlorophyll assessment

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ABSTRACT

In southern Montenegro, *Aleurocanthus spiniferus* (Hemiptera: Aleyrodidae) is an important *Citrus* pest. A field experiment was conducted in a Satsuma mandarin (*Citrus unshiu* Marcow.) orchard to evaluate the efficacy of chemical treatments for *A. spiniferus* control and to assess impact induced by this pest in plant leaves using portable chlorophyll meter-SPAD. Two insecticide applications were carried out, the first in June and the second in August in 2024 and 2025. During the first treatment in each season among all tested insecticides, deltamethrin, spirotetramat, pyriproxyfen and acetamiprid, the last mentioned showed the highest efficacy 7 d after treatment for larvae. During 2024, in the second treatment, pyriproxyfen showed highest efficacy of more than 91% 7 and 14 d after treatment, while acetamiprid showed the highest efficacy of more than 95% during the second trial in the second year. Spirotetramat showed high efficacy towards eggs in all except the first assessment during the first season. After both assessments in 2025, SPAD value was measured representing the chlorophyll content in mandarin leaves. In comparison to the control variant (49.9 SPAD units), the increase in chlorophyll content ranged from 38.2% to 48.6% (69.1-74.2 SPAD units) across all tested variants. The greatest positive impact was observed in the variant with spirotetramat (48.6%). Acetamiprid (45.6%) and pyriproxyfen (47.6%) values were also highly positive, while the smallest effect was recorded for deltamethrin (38.2%). The obtained results are consistent with high insecticide efficacy, i.e., the decreased chlorophyll levels within the control variant were caused by the higher pest infestation.

Key words: *Citrus unshiu*, insecticides, mandarin, SPAD, whitefly.

INTRODUCTION

Since its first record in southeast Italy in 2008 (Porcelli, 2008), *Aleurocanthus spiniferus* (Quaintance, 1903) (Hemiptera: Aleyrodidae) has continued to spread throughout the Mediterranean, invading new areas and host plants (Nugnes et al., 2020). The genus *Aleurocanthus* comprises species predominantly found in tropical and temperate climate, with a total of 91 species currently recognized within this genus (Ouvrard and Martin, 2021). There are as many as 10 species of this genus that choose *Citrus* species as their host. Among them, *A. spiniferus*, *A. citriperdus* and *A. woglumi* are considered the most invasive and harmful to *Citrus* plants (EPPO, 2022). These insects pose a particular threat to *Citrus* fruits as primary target, but also are known to infest a variety of plants including stone and pome fruits and weeds (Uesugi et al., 2016; Aruna et al., 2017; Nugnes et

al., 2020). In Europe, after first record in Italy, *A. spiniferus* was also detected in several other Mediterranean countries, including Croatia (Šimala and Milek, 2013), Montenegro (Radonjić et al., 2014), Greece (Kapantaidaki et al., 2019), Albania (Nugnes et al., 2020) and France (Streito et al., 2023). According to European and Mediterranean Plant Protection Organization (EPPO), *A. spiniferus* is listed among the species for which quarantine measures are recommended. It is currently included on the EPPO A2 List of quarantine pests, file A2/186 (EPPO, 2025a). In Montenegro, the presence of *A. spiniferus* was observed in the southwestern part of the country, near Herceg Novi in 2013 (Radonjić et al., 2014). In the following years, it appeared along the coast to the south (Radonjić and Hrnčić, 2021). Besides *A. spiniferus*, whiteflies *Dialeurodes citri* and *Aleurothrixus floccosus* have been found on *Citrus* plants in the coastal area. In the categorization of harmfulness for *Citrus* for species *D. citri* and *A. spiniferus* it has been assessed that their occurrence happens every year, that they are widespread, but their abundance is variable (Radonjić and Hrnčić, 2020).

Direct damage on *Citrus* trees caused by feeding behaviour of *A. spiniferus* on plant juices generates weak plants which cannot develop further, while indirect damage occurs as a result of the appearance of honeydew on which the soot (*Capnodium* spp.) develops. Due to the development of soot on plants photosynthesis is significantly reduced, which leads to plant defoliation. Also, it causes qualitative deterioration in fruit production (EPPO, 2020; da Silva et al., 2024). In Montenegro, Satsuma mandarin (*Citrus unshiu* Marcow.) is the most cultivated *Citrus* and the areas under mandarin plantations are increasing continuously (Monstat, 2020); which makes *A. spiniferus* a significant threat to these plantations. In terms of control, the use of yellow sticky traps did not achieve the efficiency that meets the need of intensive production, nor did it lead to a reduction in the population of *A. spiniferus* below the economic damage threshold (Wang et al., 2015). The control with insecticidal preparations of natural origin (mineral oil, extract of the plant *Clitoria ternatea*, pyrethrin, azadirachtin, sweet orange oil) has not yielded favourable results. However, changes in the behaviour of *A. spiniferus* towards the treated plants were observed, suggesting that these substances may have repellent features (Mokrane et al., 2020). Chemical control of whiteflies on *Citrus* using commercially produced insecticides has been successfully carried out on the species *A. floccosus* (Kerns, 2007; Beyene et al., 2019; Kulava et al., 2022) as well as on *D. citri* (Meena et al., 2022). According to Šimala and Milek (2013), chemical control of *A. spiniferus* can be achieved using one of the active substances: Pyriproxyfen, acetamiprid or flonicamid when the first larvae appear from the eggs. According to the list of the database of registered pesticide products in the EPPO region, in order to control whitefly pests in *Citrus* orchard in Greece, the use of products based on the active substances spirotetramat, acetamiprid, sulfoxaflor and Ksalts is allowed. In Italy, acetamiprid-based preparations are used for *A. spiniferus* control, while for the citrus whiteflies control paraffinic oil and deltamethrin are approved. For *A. spiniferus* control in Croatia, pyriproxyfen, orange oil, azadirachtin, and Ksalts are permitted, while sulfoxaflor application is approved only for indoor *Citrus* production (EPPO, 2025b).

The principal objectives of this study were to compare the efficacy of four insecticides (deltamethrin, spirotetramat, pyriproxyfen and acetamiprid) against larval and egg stages of *A. spiniferus* in mandarin orchard across two consecutive growing seasons (2024-2025), supported by on-site chlorophyll assessment of both pest infestation and chemical treatments on host plants with a portable SPAD meter.

MATERIALS AND METHODS

During 2024 and 2025, a field experiment was conducted in southern Montenegro, under the agro-ecological conditions of the Bar region, in a Satsuma mandarin (*Citrus unshiu* Marcow.) 'Owari' plantation (42°08'68.78'' N. 19°10'30.641'' E). Inter and intra-row spacing between the trees is 3×3 m. The plantation is well maintained, in good health and of moderate age. The aim of the study was to monitor the population dynamics of *Aleurocanthus spiniferus* and to evaluate the efficacy of four active substances used in a chemical control experiment. The identification of the species *A. spiniferus* was carried out according to the protocol EPPO PM 7/007(2) (EPPO, 2022).

Population dynamics

To assess the flight dynamics of *A. spiniferus*, two yellow sticky traps were deployed at the plantation starting on 15 April 2024, and were replaced every 2wk for two seasons. To determine the abundance of immature stages (eggs and larvae) 100 randomly selected leaves were sampled according to the EPPO protocol. Trap inspections and leaf sampling were done every 2wk from April to November.

Insecticide efficacy experiment

The efficacy experiments were conducted during 2024 and 2025 according to the modified EPPO standard PP 1/310 (1) (EPPO, 2019). Foliar application was conducted using a motorized atomizer (SR 420, STIHL, Waiblingen, Germany). The following active substances were used: Deltamethrin ((*S*)-α-cyano-3-phenoxybenzyl-(1*R*,3*R*)-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane-1-carboxylate; Decis 2.5 EC, Bayer, Monheim am Rhein, North Rhine-Westphalia, Germany) dose 5 mL 10 L^{-1}, spirotetramat (*cis*-3-(2,5-dimethylphenyl)-4-(ethoxycarbonyloxy)-8-methoxy-1-azaspiro[4.5]dec-3-en-2-one; Movento 100 SC, Bayer) dose 15 mL 10 L^{-1}, acetamiprid ((*E*)-*N*-[(6-chloro-3-pyridyl)methyl]-*N*'-cyano-*N*-methylacetamidine; Asset, Sharda Cropchem Espana AD, Murcia, Spain) dose 2.5 mL 10 L^{-1}; and pyriproxyfen (4-phenoxyphenyl-(*RS*)-2-(2-pyridyloxy)propylether, Harpun EC, Galenika-Fitofarmacija, Belgrade, Serbia) dose 7 mL 10 L^{-1}. The experiment was arranged according to the randomized block design and was carried out in 4 replicates per treatment. Each replicate consisted of 4 trees with the control group comprising of untreated trees.

Treatment was applied 10 d following the peak of adult flight, as recorded on yellow sticky traps. In the first year the first treatment was carried out on 4 June 2024 and the second on 2 August 2024 and in the second year on 1 June 2025 and 3 August 2025.

The day (up to 36 h) before the treatment, a sampling of 100 leaves randomly selected was carried out. According to the standard, due to the uniform distribution of the whitefly, leaves were taken from 25 unmarked shoots per replicate. In order to determine the effectiveness of the applied active substances, 400 leaves per treatment (100 per replicate) were sampled. The samples were examined under a stereomicroscope (Bio-Optica XTL, Milano, Italy) to determine the number of viable eggs, larvae and pupae. Differences in the efficacy of the applied active substances were determined based on the least significant difference at 95% confidence level. The efficacy (E) of the applied insecticides was determined 7 and 14 d after treatment according to the Henderson-Tilton formula based on live pest stages:

$$\mathrm{E}(\%) = \left(1 - \frac{\text{n in Co before treatment} \times \text{n in T after treatment}}{\text{n in Co after treatment} \times \text{n in T before treatment}}\right) \times 100$$

where n is insect population, T is treated, Co is control.

On-site chlorophyll monitoring

On-site chlorophyll monitoring was conducted by using portable chlorophyll meter-SPAD (502 Plus, Konica Minolta, Tokyo, Japan) for the stress assessment in plant leaves. The experiment was arranged at the same site in Bar during 2025 in treated mandarin plots. After both assessments of insecticide efficacy, baseline chlorophyll measurements were taken using a SPAD chlorophyll meter on 100 leaves per treatment (25 per replicate). The data obtained during the research were processed using the statistical program Statistica version 12 (TIBCO Software, Palo Alto, California, USA).

RESULTS AND DISCUSSION

Dynamics of *Aleurocanthus spiniferus* population for 2024 and 2025 are presented in Figures 1 and 2. The presence of the fourth stage of the whitefly was recorded in early April. The first adult captured on yellow sticky trap was recorded on 30 April 2024. Adult presence was observed until November, with the maximum recorded in late May, late July, late August and late October. First eggs were noticed on young leaves on 30 April 2024. Maximum egg laying activity was observed in early June, late July and late September. The appearance of the first instar larvae was recorded in mid-May while the maximum of L1-L3 larvae was recorded in early Jun, early August and late October. First appearance of the fourth stage (new pupa) was observed in mid-June. The maximum of the fourth stage was recorded in early April, mid-July, end of August and early November (Figure 1). In the second season, the fourth stage was observed during winter. The first adult captured on yellow sticky

trap was recorded on 3 April 2025. The activity of adults was recorded from April to November with the maximum recorded in late May, late July, early August and mid-October. First eggs were noticed on young leaves on 20 April 2025. Maximum egg laying activity was observed in late May, late July, mid-August, mid-September and mid-October. The appearance of the first instar larvae was recorded in late May while the maximum of L1-L3 larvae was recorded in mid-June, mid-August, mid-September and mid-October. First appearance of the fourth stage (new pupa) was observed in mid-June. The maximum of the fourth stage was recorded in early March, early July, early August and early October and was on that level until November. In Croatia, *A. spiniferus* completes three generations per year. Slightly higher temperature and higher humidity are positively affecting *A. spiniferus* development. The appearance of eggs is associated with the growth of new shoots (Paladin-Soče, 2023). This aligns with our findings.

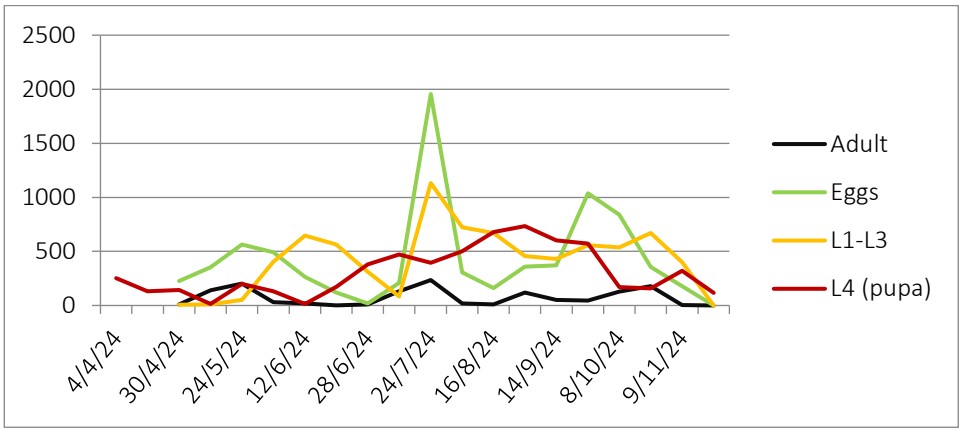

Figure 1. Population dynamics of *Aleurocanthus spiniferus* on mandarin plantation in Bar region, southern Montenegro (2024).

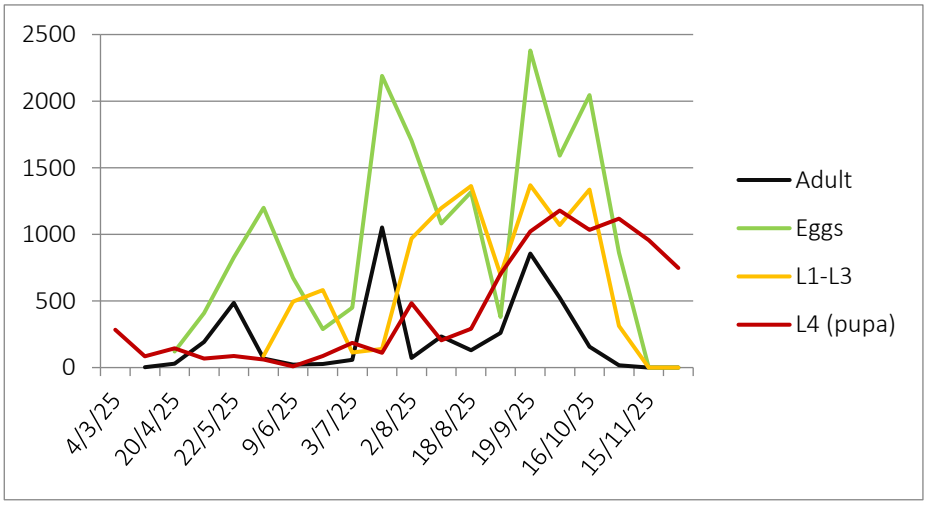

Figure 2. Population dynamics of *Aleurocanthus spiniferus* on mandarin plantation in Bar region, southern Montenegro (2025).

Current published research offers limited insight into the chemical control of this harmful species using insecticides for commercial application. The results of the insecticide efficacy based on the active substances deltamethrin, acetamiprid, spirotetramat and pyriproxyfen applied in two treatments are presented in Tables 1 to 4.

For all trials, in the pre-treatment sampling the abundance of eggs and larvae L1-L4 was recorded and there were nonsignificant differences within the groups. In the first trial in 2024, among all tested substances, acetamiprid showed highest efficacy of 84% for larvae 7 d after treatment. Acetamiprid, spirotetramat and pyriproxyfen did not differ significantly 7 d after treatment, while deltamethrin was at a lower level. The acetamiprid efficacy 14 d after treatment was 91%. Fourteen days after treatment, all applied substances did not differ significantly and showed efficacy towards eggs ranging from 87% for acetamiprid to 93% for pyriproxyfen (Table 1). In the second treatment, no preparation based on the active substance deltamethrin was applied. Seven days after treatment, pyriproxyfen showed highest efficacy of 91% for larvae followed by spirotetramat (88%) and acetamiprid (85%). Seven and 14 d after treatment all applied substances did not differ significantly. Compared to the previous assessment, 14 d after treatment efficacy does not change notably. All applied substances did not differ significantly and demonstrated efficacy towards eggs ranging from 63% for acetamiprid to 84% for spirotetramat 14 d after treatment (Table 2).

Table 1. Efficacy of selected insecticides against *Aleurocanthus spiniferus* (4 June 2024). Different letters mean significant differences between groups. $\bar{x}$ ± SD: Average number of eggs per larvae ± standard deviation; E: efficacy; LSD: Fisher least significant difference test.

		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD		$\bar{x}$ ± SD	
36 h BT	Deltamethrin	362.5 ± 61.6^{a}		413.2 ± 93.9^{a}	
	Acetamiprid	334.7 ± 144.4^{a}		394.5 ± 142.4^{a}	
	Spirotetramat	299.0 ± 21.4^{a}		356.5 ± 191.8^{a}	
	Pyriproxyfen	388.7 ± 95.6^{a}		311.7 ± 169.5^{a}	
	Control	353.0 ± 73.8^{a}		355.0 ± 104.7^{a}	
	LSD	198.7		335.7	
		F = 0.61 P = 0.66		F = 0.29 P = 0.88	
		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD	E (%)	$\bar{x}$ ± SD	E (%)
7 DAT	Deltamethrin	51.2 ± 4.5^{b}	71.3	321.2 ± 59.7^{b}	65.0
	Acetamiprid	50.0 ± 22.8^{b}	71.3	135.0 ± 57.6^{c}	84.6
	Spirotetramat	46.7 ± 3.8^{b}	66.9	171.0 ± 53.3^{c}	78.4
	Pyriproxyfen	36.2 ± 10.8^{b}	75.2	178.2 ± 78.9^{c}	74.3
	Control	106.0 ± 27.8^{a}	/	787.5 ± 209.3^{a}	/
	LSD	39.5		88.3	
		F = 10.39 P < 0.01		F = 75.69 P < 0.01	
		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD	E (%)	$\bar{x}$ ± SD	E (%)
14 DAT	Deltamethrin	11.2 ± 6.7^{b}	87.8	170.0 ± 51.0^{b}	82.3
	Acetamiprid	13.7 ± 11.2^{b}	87.3	77.0 ± 47.7^{c}	91.6
	Spirotetramat	6.5 ± 5.5^{b}	91.1	150.7 ± 36.5^{b}	81.8
	Pyriproxyfen	6.7 ± 5.7^{b}	93.0	132.0 ± 45.6^{b}	82.0
	Control	84.7 ± 17.0^{a}	/	825.5 ± 74.1^{a}	/
	LSD	16.8		80.8	
		F = 43.35 P < 0.01		F = 172.1 P < 0.01	

Table 2. Efficacy of selected insecticides against *Aleurocanthus spiniferus* (2 August 2024). Different letters mean significant differences between groups. $\bar{x}$ ± SD: Average number of eggs per larvae ± standard deviation; E: efficacy; LSD: Fisher least significant difference test.

		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD		$\bar{x}$ ± SD	
36 h BT	Acetamiprid	235.0 ± 76.8^{a}		424.0 ± 158.5^{b}	
	Spirotetramat	202.0 ± 82.2^{a}		656.0 ± 481.2^{a}	
	Pyriproxyfen	281.0 ± 140.7^{a}		1012.0 ± 494.5^{a}	
	Control	292.0 ± 39.6^{a}		383.0 ± 175.3^{b}	
	LSD	205.6		463.4	
		F = 0.82 P = 0.51		F = 8.05 P < 0.01	
		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD	E (%)	$\bar{x}$ ± SD	E (%)
7 DAT	Acetamiprid	58.7 ± 27.7^{bc}	68.9	101.5 ± 78.0^{b}	85.3
	Spirotetramat	34.7 ± 17.0^{c}	78.6	120.0 ± 26.9^{b}	88.7
	Pyriproxyfen	100.5 ± 24.0^{b}	55.6	136.8 ± 53.0^{b}	91.7
	Control	235.2 ± 39.8^{a}	/	622.3 ± 100.5^{a}	/
	LSD	63.3		119.7	
		F = 39.74 P < 0.01		F = 91.91 P < 0.01	
		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD	E (%)	$\bar{x}$ ± SD	E (%)
14 DAT	Acetamiprid	30.7 ± 12.2^{b}	63.7	81.0 ± 32.9^{b}	85.7
	Spirotetramat	11.2 ± 10.5^{b}	84.5	90.7 ± 9.0^{b}	89.6
	Pyriproxyfen	35.5 ± 17.8^{b}	65.0	95.7 ± 66.5^{b}	92.9
	Control	105.5 ± 47.5^{a}	/	511.2 ± 116.2^{a}	/
	LSD	59.3		108.9	
		F = 9.57 P < 0.01		F = 86.95 P < 0.01	

In the first trial in 2025, acetamiprid showed highest efficacy of more than 91% for larvae 7 d after treatment. All substances did not differ significantly 7 d after treatment. Pyriproxyfen showed the lowest efficacy 14 d after treatment and it was 70% for larvae. Fourteen days after treatment, all applied substances showed high efficacy of more than 94% towards eggs (Table 3). In the second treatment of the second year acetamiprid showed highest efficacy of 96% for larvae followed by pyriproxyfen (86%) and spirotetramat (81%) 7 d after treatment and they did not differ significantly. Deltamethrin showed 73% efficacy. All applied substances demonstrated high efficacy towards eggs, more than 78% for pyriproxyfen to 91% for spirotetramat 7 and 14 d after treatment (Table 4). Deltamethrin proved highly effective in controlling *A. floccosus* on oranges, where efficiency of 89% and 85% was achieved at two sites in Ethiopia (Beyene et al., 2019). According to Kulava et al. (2022), acetamiprid demonstrated high efficacy of 85% for the management of *A. floccosus*. In another study, the pyriproxyfen-based preparation showed to be reliable in prolonged period and effectiveness can be observed 19, 26, 33, 40 and 47 d after foliar treatment, when it continuously shows significantly lower number of live young and older larvae and pupae compared to the untreated control (Kerns, 2007). Researchers in India achieved approximately 70% efficacy against *D. citri* in *Citrus* orchards using spirotetramat (Meena et al., 2022). Compared to the findings of this study, efficacy of deltamethrin was similar to the one reported by Beyene et al. (2019). Acetamiprid efficacy was similar to the results reported by Kulava et al. (2022). Compared to the results reported by Kerns (2007), pyriproxyfen demonstrated an efficiency that can be observed sooner. Spirotetramat has shown greater efficacy of around 80% and more than 85% in both seasons compared to the findings reported by Meena et al. (2022). After both assessments, chlorophyll content in mandarin leaves was determined (Figure 3). In comparison to the control variant (49.9 SPAD units), the increase in chlorophyll content ranged from 38.2% to 48.6% (69.1-74.2 SPAD) across all tested variants. The greatest positive impact was observed in the variant with spirotetramat (48.6%). Acetamiprid (45.6%) and pyriproxyfen (47.6%) values

were also highly positive, while the smallest effect was recorded for deltamethrin (38.2%). Significant differences were observed between the control variant and all tested variants ($F = 29.17$; $p < 0.01$). It can be assumed that obtained results are consistent with high insecticide efficacy. The decreased chlorophyll levels within the control variant were caused by the higher pest infestation. This is in accordance with the latest research from Mantzoukas et al. (2025), where they concluded that the citrus spiny whitefly *A. spiniferus* causes severe damage to the leaves and fruits of tree crops, which leads to intense damage of *Citrus* orchards.

Table 3. Efficacy of selected insecticides against *Aleurocanthus spiniferus* (1st Jun 2025). Different letters mean significant differences between groups. $\bar{x}$ ± SD: Average number of eggs per larvae ± standard deviation; E: efficacy; LSD: Fisher least significant difference test.

		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD		$\bar{x}$ ± SD	
36 h BT	Deltamethrin	691.0 ± 90.24^{b}		88.0 ± 20.40^{ab}	
	Acetamiprid	1005.0 ± 289.02^{ab}		100.0 ± 21.17^{a}	
	Spirotetramat	1278.0 ± 103.41^{a}		134.0 ± 41.63^{a}	
	Pyriproxyfen	1115.0 ± 138.81^{a}		100.0 ± 40.40^{a}	
	Control	1298.0 ± 202.78^{a}		108.0 ± 32.50^{a}	
	LSD	312.8		54.9	
		$F = 4.62$ $P < 0.01$		$F = 2.9$ $P < 0.05$	
		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD	E (%)	$\bar{x}$ ± SD	E (%)
7 DAT	Deltamethrin	76.5 ± 39.61^{c}	91.3	59.5 ± 29.05^{b}	89.6
	Acetamiprid	304.0 ± 26.93^{b}	77.2	48.0 ± 14.70^{b}	91.8
	Spirotetramat	157.0 ± 51.34^{c}	94.5	74.5 ± 35.30^{b}	89.6
	Pyriproxyfen	272.5 ± 33.52^{b}	88.4	99.5 ± 34.23^{b}	83.3
	Control	643.5 ± 52.09^{a}	/	537.5 ± 57.14^{a}	/
	LSD	94.8		142.9	
		$F = 17.66$ $P < 0.01$		$F = 35.21$ $P < 0.01$	
		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD	E (%)	$\bar{x}$ ± SD	E (%)
14 DAT	Deltamethrin	87.5 ± 8.23^{c}	96.5	77.0 ± 25.42^{c}	86.5
	Acetamiprid	149.5 ± 18.79^{b}	94.6	94.5 ± 19.55^{c}	85.4
	Spirotetramat	106.0 ± 40.82^{bc}	97.9	143.5 ± 11.93^{b}	83.4
	Pyriproxyfen	127.0 ± 6.00^{b}	96.6	191.5 ± 45.11^{b}	70.4
	Control	263.5 ± 49.70^{a}	/	699.0 ± 132. 26^{a}	/
	LSD	57.24		77.8	
		$F = 11.9$ $P < 0.01$		$F = 49.2$ $P < 0.01$	

Table 4. Ef1ficacy of selected insecticides against *Aleurocanthus spiniferus* (03 August 2025). Different letters mean significant differences between groups; $\bar{x}$ ± SD: average number of eggs/larvae ± standard deviation; E: efficacy; LSD: Fisher least significant difference test.

		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD		$\bar{x}$ ± SD	
36 h BT	Deltamethrin	1636.0 ± 261.48^{a}		1304.0 ± 289.27^{a}	
	Acetamiprid	1666.0 ± 392.43^{a}		853.0 ± 243.07^{b}	
	Spirotetramat	1161.0 ± 240.07^{b}		648.0 ± 113.65^{bc}	
	Pyriproxyfen	1537.0 ± 243.08^{a}		917.0 ± 224.50^{b}	
	Control	1826.0 ± 390.58^{a}		1302.0 ± 172.77^{a}	
	LSD	474.11		327.1	
		$F = 7.88$ $P < 0.05$		$F = 5.43$ $P < 0.01$	
		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD	E (%)	$\bar{x}$ ± SD	E (%)
7 DAT	Deltamethrin	280.0 ± 79.75^{c}	87.4	400.0 ± 91.22^{b}	73.7
	Acetamiprid	223.5 ± 96.06^{c}	90.4	38.5 ± 40.01^{c}	96.1
	Spirotetramat	194.5 ± 50.58^{c}	91.4	137.5 ± 54.16^{c}	81.8
	Pyriproxyfen	457.5 ± 32.55^{b}	78.9	148.5 ± 63.10^{c}	86.1
	Control	1229.5 ± 157.88^{a}	/	1516.0 ± 228.78^{a}	/
	LSD	145.1		183.1	
		$F = 74.4$ $P < 0.01$		$F = 107.7$ $P < 0.01$	
		Eggs		L1-L4	
	Active substance	$\bar{x}$ ± SD	E (%)	$\bar{x}$ ± SD	E (%)
14 DAT	Deltamethrin	241.5 ± 48.45^{c}	89.7	253.5 ± 67.27^{b}	85.3
	Acetamiprid	272.5 ± 64.59^{c}	89.4	46.0 ± 13.75^{c}	95.9
	Spirotetramat	210.5 ± 71.54^{c}	91.3	188.0 ± 64.93^{b}	78.1
	Pyriproxyfen	490.0 ± 39.53^{b}	79.6	188.0 ± 79.41^{b}	84.5
	Control	1286.5 ± 180.87^{a}	/	1724.5 ± 262.42^{a}	/
	LSD	144.5		160.8	
		$F = 89.56$ $P < 0.01$		$F = 122.6$ $P < 0.01$	

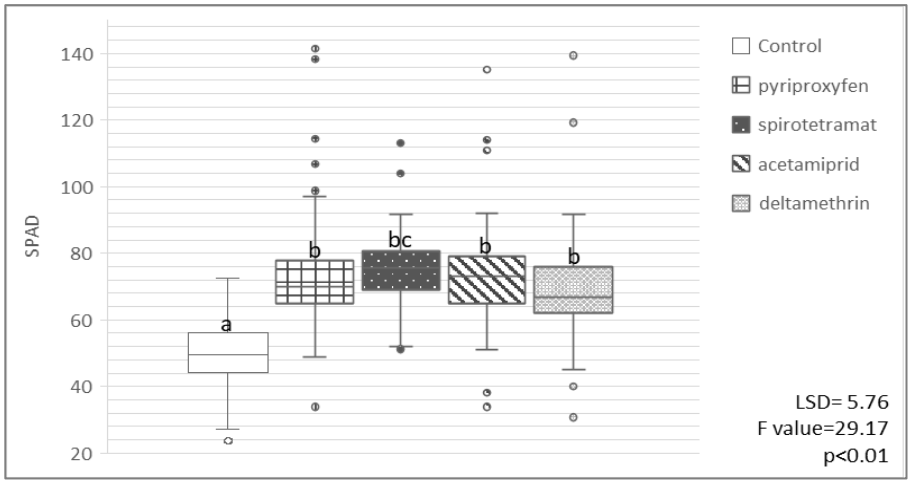

Figure 3. SPAD values of mandarin leaves, Bar, southern Montenegro, 2025. Different letters mean significant differences between groups. LSD: Fisher least significant difference test.

CONCLUSIONS

Whitefly *Aleurocanthus spiniferus* has successfully adapted to the agro-ecological conditions of the Montenegrin coast and currently represents a serious threat to the Satsuma mandarin (*Citrus unshiu*), the predominant host species under cultivation. Obtained results for photosynthetic pigments monitoring are consistent with high insecticide efficacy, i.e., decreased chlorophyll levels within the control variant were caused by the higher pest infestation.

Optimal *A. spiniferus* control can be achieved with two applications per season with preparations based on the active substances deltamethrin, acetamiprid, spirotetramat or pyriproxyfen 10 d following the peak of adult flight.

Author contribution

Conceptualization: T.P., D.M., M.Đ. Methodology: T.P., D.M., A.Ž. Software: A.Ž., M.Đ. Validation: S.T., V.B., N.M., T.P. Formal analysis: A.Ž. Investigation: M.Đ. Data curation: A.Ž., T.P., S.T., M.Đ. Writing-original draft: M.Đ. Writing-review & editing: T.P., A.Ž., V.B., S.T., B.M., M.B. Supervision: T.P., D.M., V.B., N.M. All co-authors reviewed the final version and approved the manuscript before submission.

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