

Toxicity of Selected Insecticides to Green Peach Aphid, *Myzus persicae* (Hom.: Aphididae) and its Parasitoid, *Aphidius matricariae* (Hym.: Aphidiidae)

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Abstract: The estimated LC₅₀ and LC₉₀ to the green peach aphid, *Myzus persicae* Sulzer for the pesticides: Imidacloprid, Deltamethrin, Oxydemeton methyl, Pirimicarb and Abamectin were 2.22 and 19.79, 6.62 and 44.76, 261.92 and 545.61, 207.25 and 513.50 and 1.5 and 7.77 ppm, respectively. The ratio between estimated LC₉₀ and recommended field rate for the above pesticides in arrangement were 0.4, 2.39, 2.18, 2.05 and 1.73 folds. Accordingly, Imidacloprid was the most toxic and control failure was expected by using other pesticides at recommended field rate. A Resistance Factor (RF) of 10.5 x for Oxydemeton methyl and 18.8 x for Pirimicarb was estimated. A green house experiment integrating biological and chemical controls revealed that Imidacloprid toxicity to the aphid when applied directly to the infested plants was higher than toxicity estimated by treating plants prior to infestation. Rapid decay of available residue after Pirimicarb treatment is expected. According to the results obtained from the present study, all pesticides tested at the estimated LC₅₀ value did not affect the efficiency of *Aphidius matricariae* (Haliday) adults emerging from treated mummies and exposed to pesticides residues on treated plants.

Key words: *Myzus persicae* · *Aphidius matricariae* · LC₅₀ · LC₉₀ · resistance factor

INTRODUCTION

The green peach aphid, *Myzus persicae* Sulzer (Homoptera: Aphididae) is highly polyphagous pest attacking a wide range of economically important plants. The aphid was recorded attacking many important crops in Jordan [1-3]. Substantial crop losses are also caused by the transmission of viral diseases by *M. persicae*. Viral diseases transmitted by the aphid resulted in major losses to peppers [4], potatoes [5] and cucurbits [6] in Jordan and other parts of the world. Chemicals continue to play a major role in pest control in many parts of the developing countries. Insecticides are widely used by farmers for the control of green peach aphid [7]. The impact of several insecticides on mixtures of resistant clones of *M. persicae* infesting sugar-beet plants was evaluated in a field caged studies [8]. Pirimicarb gave the best control of resistant aphids, while deltamethrin plus heptenophos, ethiofencarb and demeton-S-methyl gave reasonable control. However, multiple mechanism insecticide resistance was detected in populations of *M. persicae* in the UK [9] and other parts of the world

[10]. Growers in Jordan have reported frequent failure of various organophosphate, carbamate and pyrethroid insecticides in providing adequate protection against aphid infestations. On the basis of the reported failure of control, we speculated that resistance to some insecticides may have developed in populations of the *M. persicae* in Jordan.

Knowledge of the impact of chemicals applied for the control of *M. persicae* on its natural enemies is essential for the integration of chemical and biological control tactics. Usually, the late larval and pupal stages of a parasitoid within the mummified bodies of their host aphid seem to be less susceptible to pesticides [11-13]. Such tolerance to chemicals offers an opportunity for selective application of pesticides while minimizing the impact on the biological control agent.

The aim of the current study was to evaluate the aphicidal potency of five pesticides to *M. persicae* and to study the possibility of integrating chemical and biological control measures with *Aphidius matricariae* (Haliday) against *M. persicae* under greenhouse conditions.

MATERIALS AND METHODS

Pesticides: Commercial formulations of five pesticides were evaluated for their toxicity to the green peach aphid. The pesticides were: Imidacloprid (Confidor® SL 200 g L⁻¹, Bayer, Germany), Deltamethrin (Decis® EC 25 g L⁻¹, AgrEvo, Germany), Oxydemeton methyl (Metasystox® EC 250 g L⁻¹, Bayer, Germany), Pirimicarb (Pirimor® WP 500 g Kg⁻¹, Jiagying Pesticides Fac., China) and Abamectin (Vertimec® EC 18 g L⁻¹ Novartis, USA). A fresh stock solution of each pesticide was prepared in tap water on each test day. All further dilutions were prepared from the stock solution. Tap water was used as control.

Insects culture: *M. persicae* was cultured on potted sweet pepper plants (variety Marvillo) grown under green house conditions at Al-baqā' area (15 Km North Amman). The culture was established from infested leaves of pepper plants grown in Madaba area (30 Km South Amman). *A. matricariae* culture was established from mummified *M. persicae* collected from the previous region. The parasitoid was maintained on potted pepper plants (variety Marvillo) infested with green peach aphids. The pepper plants were kept in wooden cages in a greenhouse in Al-baqā' area.

Pesticides toxicity to *M. persicae*: A preliminary test with each chemical was conducted to determine the range of appropriate concentrations for the main bioassay test. The main bioassay was conducted on potted sweet pepper plants (variety Marvillo). The plants were grown in 1:1 mixture of sand and peatmoss in 20cm pots for 8 weeks. Pepper plants were sprayed individually with one of the tested pesticides with a manual hand sprayer until run-off. Five to six concentrations of each pesticide were used. Tap water was used as the control. The treated plants were left to dry for one hour. Infested pepper leaves from the aphid culture were collected and then placed in a white plastic dish under a source of light. The treated plants were individually placed in cylindrical transparent plastic cages with muslin top covers (40cm diameter, 80 cm height). The cages were kept under lab conditions (Temp. 24±3°C, R.H 60±10 % and L: D 14:10). The plants were examined after 24 h and numbers of living aphids were recorded. Five replicates were conducted for each pesticide concentration.

Integration of biological and chemical control: An experiment was conducted in a greenhouse to evaluate the combined effect of the above tested pesticides and the

parasitoid *A. matricariae* on *M. persicae*. The experiment was arranged in a randomized complete block design with 6 treatments (the above tested pesticides+a water control) and 4 replicates. Three potted pepper plants, 8 weeks old, infested with a total of 120 aphids were placed in a wooden cage. Each cage was assigned randomly to one of the tested pesticides. The pesticides were applied to the cages at the estimated LC₅₀ value from the previous bioassay. Tap water was used as a control. On the same day, 8 mummified *M. persicae*, 2-4 days before parasitoid emergence, were dipped in a pesticide solution at the recommended field rate for 5 seconds. The treated mummified aphids were introduced to each cage. Number of aphids and mummified aphids were recorded weekly for 5 weeks. Average daily temperature and relative humidity were recorded during the experiment.

Statistical analysis: Data were subjected to probit analysis [14] after correction for natural mortality using Abbotts formula [15]. The SPSS computer program was used for data analysis. This program uses Normal Equivalent Deviate (NED) instead of probit numbers. However, NED numbers can be readily adjusted to probit by adding 5 to each NED number [14]. LC₅₀ and LC₉₀ values were considered significant when 95% Confidence Limits (CL) did not overlap.

RESULTS

Pesticides toxicity to the green peach aphid: By Comparing the LC₅₀ values of the tested pesticides, Abamectin (1.5) was significantly the lowest, followed by Imidacloprid (2.22), Deltamethrin (6.62), Pirimicarb (207.25) and Oxydemeton methyl (261.92). The ratio between the calculated LC₅₀ and the recommended field application rate (Table 1) showed that Imidacloprid was the most toxic (0.044) to *M. persicae* followed by Abamectin (0.33) and Deltamethrin (0.35). The least toxic pesticides were Oxydemeton methyl (1.05) and Pirimicarb (0.83). Similarly, the LC₉₀ values comparisons (Table 2) showed that Abamectin (7.77) was significantly the lowest followed by Imidacloprid (19.79), Deltamethrin (44.76), Pirimicarb (513.50) and finally Oxydemeton methyl (545.61). The LC₉₀ values for Oxydemeton methyl and Pirimicarb were not significantly different as indicated by overlapping 95% CL. The ratio between LC₉₀ and recommended field rate showed that Imidacloprid was the most toxic (0.4) followed by Abamectin (1.73). The least toxic pesticides were Deltamethrin (2.39), followed by Oxydemeton methyl (2.18) and Pirimicarb (2.05).

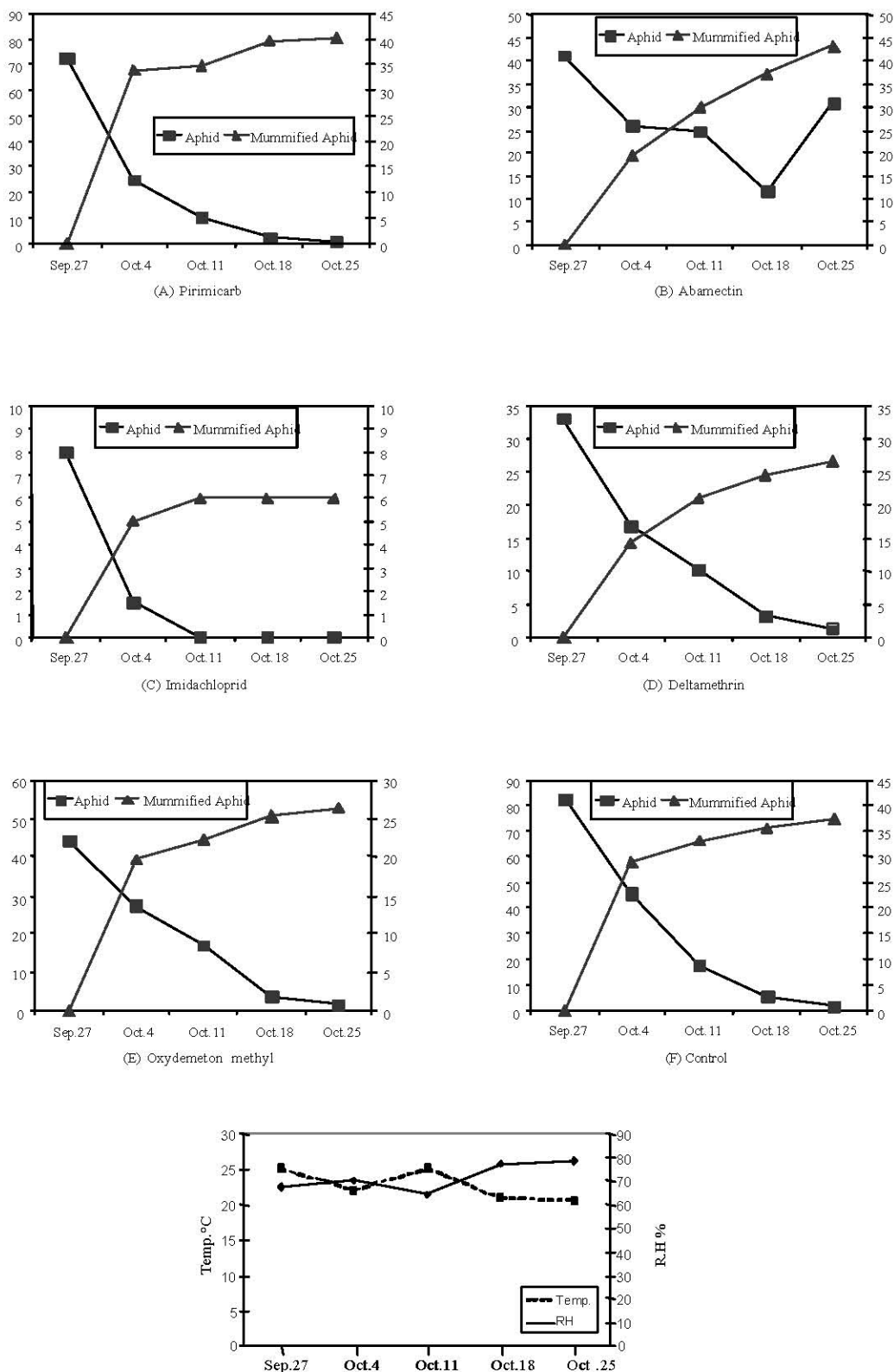


Fig. 1: Weekly mean number of aphids and mummified aphids treated with different pesticides during the period from Sep 27 to Oct. 25, 2000 under greenhouse conditions

Table 1: Toxicity (LC₅₀) of various pesticides tested against *M. persicae* in the laboratory

Pesticide	LC ₅₀ * ppm	95% CL ¹	Equation	Slope±SE	R.F.R ² ppm	Ratio **
Imidacloprid	2.2 ^d	1.9-2.5	Y=-0.47+1.35 x	1.35±0.08	50	0.044
Deltamethrin	6.6 ^c	5.9-7.4	Y=-1.27+1.54 x	1.54±0.10	18.8	0.35
Oxydemeton methyl-R	261.9 ^a	250.8-274.0	Y=-9.72+4.02 x	4.02±0.25	250	1.05
Pirimicarb	207.3 ^b	196.2-219.6	Y=-7.53+3.25 x	3.25±0.20	250	0.83
Abamectin	1.5 ^e	1.3-1.7	Y=-0.32+1.80 x	1.80±0.11	4.5	0.33

¹95% confidence limits for LC₅₀ in ppm²R.F.R. Recommended field rate*LC₅₀ values having different letters are significantly different (95% CL did not overlap)**LC₅₀ values in ppm divided by recommended field rate in ppm. Lower ratio indicates that the pesticides are more toxic at the LC₅₀ valueTable 2: Toxicity (LC₉₀) of various pesticides tested against *M. persicae* in the laboratory

Pesticide	LC ₉₀ * ppm	95% CL ¹	Equation	Slope±SE	R.F.R ² (ppm)	Ratio **
Imidacloprid	19.8 ^c	16.1-25.3	Y=-0.47+1.35 x	1.35±0.08	50.0	0.40
Deltamethrin	44.8 ^b	36.5-58.0	Y=-1.27+1.54 x	1.54±0.10	18.8	2.39
Oxydemeton methyl-R	545.6 ^a	496.0-615.6	Y=-9.72+4.02 x	4.02±0.25	250.0	2.18
Pirimicarb	513.5 ^a	456.1-595.0	Y=-7.53+3.25 x	3.25±0.20	250.0	2.05
Abamectin	7.8 ^d	6.8-9.1	Y=-0.32+1.80 x	1.80±0.11	4.5	1.73

¹95% confidence limits for LC₉₀ in ppm²R.F.R. Recommended field rate*LC₉₀ values having different letters are significantly different (95% CL did not overlap)**LC₉₀ values in ppm divided by recommended field rate in ppm. Lower ratio indicates that the pesticides are more toxic at the LC₉₀ value

Integration of biological and chemical controls: Numbers of aphids one week post treatment were 8, 33, 44, 72, 41 and 83 aphids per wooden cage treated with Imidacloprid, Deltamethrin, Oxydemeton methyl, Pirimicarb, Abamectin and water, respectively. Whereas the numbers of mummified aphids were zero for all the treated wooden cages (Fig. 1). A sharp decrease in aphids numbers and an increase in mummified aphids were recorded in the subsequent weeks. In week 4 post treatment, numbers of aphids reached 0, 3, 4, 3, 12 and 5 aphids per wooden cage for the Imidacloprid, Deltamethrin, Oxydemeton methyl, Pirimicarb, Abamectin and water treatments, respectively. While the number of mummified aphid during the same period were 6, 25, 25, 40, 37 and 36 mummies for the same treatments, respectively (Fig. 1). An increase in aphid numbers was noticed during the fifth week for Abamectin treatment only, but it was still lower than mummified aphid numbers. The experiment was carried out during the period between Sep. 20 to Oct. 25, 2000 under green house conditions. Average temperatures and relative humidities during the period were 20.6-25.2°C and 64-79%, respectively (Fig. 1).

DISCUSSION

Comparing pesticides based on LC₅₀ values indicates that Abamectin was 1.47, 4.41, 174.6 and 138.17 times more toxic to *M. persicae* than Imidacloprid, Deltamethrin,

Oxydemeton methyl and Pirimicarb, respectively. On the other hand, the ratio between LC₅₀ and recommended field rate showed that Imidacloprid outperformed the other tested pesticides. The least toxic pesticides were Oxydemeton methyl and Pirimicarb.

Pesticides failure to provide control at concentrations that were formerly effective, indicate a case of suspected resistance [16]. During the past few years Jordanian farmers noticed frequent failure of various organophosphate, carbamate and pyrethroid insecticides against aphids infestations in many crops. The prolonged use of these groups of insecticides might be responsible for increasing the degree of tolerance in aphid populations. It was reported that the LC₅₀ for *Aphis gossypii* was positively correlated with the use of insecticides of the same chemical class [17]. The LC₅₀ for oxydemeton methyl and methomyl were significantly correlated with the use of organophosphate and carbamate insecticides [17]. In the present study, the ratio between LC₉₀ and recommended field rate for Deltamethrin (2.4), Oxydemeton methyl (2.2), Pirimicarb (2.1) and Abamectin (1.7) supported the previously mentioned failure of some insecticides noticed by Jordanian farmers.

Imidacloprid was effective in controlling *M. persicae* in many countries [8, 18, 19]. The LC₅₀ for imidacloprid, pirimicarb and oxydemeton methyl to a susceptible reference strain of *M. persicae* were 0.47, 11 and 25 ppm,

respectively. Whereas it was 3.4, >300 and >300 ppm to a Japanese (JR) strain, with resistant factor (RF) of 7.2 x, >27 x and >12 x, respectively [18]. In spite of the slightly reduced susceptibility to Imidacloprid, this chemical pesticide was 100 times more effective against the JR resistant strain than other compounds [18]. In agreement with these results, Imidacloprid was 119 and 94 times more effective than Oxydemeton methyl and Pirimicarb against *M. persicae*. Moreover, RF values of 4.7, 10.5 and 18.8 were estimated for Imidacloprid, Oxydemeton methyl and Pirimicarb in comparison with the reference susceptible strain. These results highlight the occurrence of resistance to organophosphate and carbamate groups but not neonicotinoids insecticides in the current study. These results coincide with finding of Nauen and Denholm (2005) that indicate the resilience of neonicotinoids insecticides to develop resistance, especially when considering aphids such as *M. persicae* [10].

Avermectin have been tested against 84 species of insects in 10 orders. It was found toxic to almost all insects examined [20]. Excellent control was obtained against *M. persicae* and *Thrips tabaci* Lindeman using abamectin at 2.25-9.00 ppm. The current study emphasized those previous finding as the LC₅₀ and LC₉₀ of the present study for Abamectin were 1.5 and 7.77 ppm respectively.

The relatively high percentage reduction in aphid population one week post Imidacloprid treatment in the cage experiment demonstrated that Imidacloprid application directly to the aphids is more effective than applying the insecticide to the plants and then placing the aphids on the plant. On the other hand and in agreement with the previous reports [21], the relatively small percentage reduction in aphid population one week after Pirimicarb treatment might be attributed to the rapid decay of the pesticide residues which enabled *M. persicae* to survive on the treated plants. This conclusion is supported by average temperatures (25°C) prevailig during the first week of the experiment that encouraged volatilization of the insecticide Pirimicarb (Fig. 1).

The current study shows that the tested pesticides did not affect the efficiency of *A. matricariae* adults emerging from treated mummies and exposed to pesticides applied to the treated plants. These findings are crucial for selecting appropriate pesticides that should be used in conjunctions with biological control as well as for the frequency of application to minimize resistant build-up and to maximize the role of natural enemies in *M. persicae* management.

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