



Pesticides in honey and beeswax and toxicity to honey bees (*Apis mellifera*) from hives kept in avocado (*Persea americana*) orchards managed with different cultural systems in Jalisco, Mexico



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INTRODUCTION

Honey bee colonies are commonly used to provide pollination services to avocado orchards in Mexico. However, it is not known if the pesticides used in these orchards affect bee health and leave residues in hive products

OBJECTIVE

To detect pesticides in honey and beeswax and to document the damage from lethal and sublethal exposure of pesticides to honey bees from colonies placed in avocado orchards that follow certified, organic and conventional cultural systems in Southern Jalisco, Mexico

MATERIALS AND METHODS

Pesticide residues in honey and beeswax
Method: QuEChERS (165 pesticides)
Chromatographic analysis

Study sites
Cultural system: Organic, Certified and Conventional
In Zapotlan, el Grande.

Toxicity tests with bees in cages exposed to:
Acetamiprid, Hexazinone
Thiabendazole at recommended and empirical doses (twice the recommended dose)



RESULTS

In the experiments with live bees, significant differences between recommended and empirical doses were found for all the variables measured ($p < 0.05$; Table 1).

Table 1. Mean $\pm$ S.D. for number of dead bees or showing abnormal behaviors after applying recommended and empirical doses of acetamiprid on avocado trees kept in cages

Dose	No flying	No walking	Walking in circles	Flying in circles	Immobile on the wall	Dead
Recommended	45.5 $\pm$ 6.6 a	37.2 $\pm$ 6.3 a	2.5 $\pm$ 2.3 a	0.0 $\pm$ 0.0 a	33.4 $\pm$ 17.0 a	236.1 $\pm$ 54.1 a
Empirical	55.9 $\pm$ 9.4 b	45.6 $\pm$ 8.3 b	16.6 $\pm$ 13.1 b	9.4 $\pm$ 4.5 b	62.8 $\pm$ 5.9 b	385.1 $\pm$ 12.5 b

* Different literals indicate significant differences ($P < 0.05$)



RESULTS

There were significant differences in the concentration of pesticides in honey and beeswax from honey bee colonies located in the tree types of avocado cultural systems, with acetamiprid having the highest concentrations ($p < 0.05$; Table 2)

Table 2. Mean $\pm$ S.D. for residues of pesticides in honey and beeswax samples

Treatments	Pesticides	Residues in honey (mg/kg)	Residues in wax (mg/kg)
Organic system	Acetamiprid	0.320 $\pm$ 0.121 a	0.190 $\pm$ 0.530 a
	Hexazinone	0.029 $\pm$ 0.008 b	0.070 $\pm$ 0.052 b
	Thiabendazole	0.005 $\pm$ 0.002 c	0.020 $\pm$ 0.010 c
Certified system	Acetamiprid	0.460 $\pm$ 0.212 a	0.250 $\pm$ 0.106 a
	Hexazinone	0.030 $\pm$ 0.018 b	0.070 $\pm$ 0.052 b
	Thiabendazole	0.010 $\pm$ 0.003 b	0.007 $\pm$ 0.001 c
Conventional system	Acetamiprid	0.340 $\pm$ 0.082 a	0.250 $\pm$ 0.045 a
	Hexazinone	0.007 $\pm$ 0.002 b	0.040 $\pm$ 0.029 b
	Thiabendazole	0.005 $\pm$ 0.001 b	0.020 $\pm$ 0.006 c

* Diferente literals between pesticides in every treatment indicate significant differences ($P < 0.05$)



CONCLUSIONS

- Of the three most common pesticides detected in honey and beeswax of colonies placed in all avocado cultural systems, acetamiprid predominated and had the highest concentrations
- The concentration of most pesticides in the samples were above the EU MRL.
- High mortality and behavioral abnormalities were observed in bees exposed to the recommended dose and even higher for empirical doses.
- Acetamiprid was more lethal than hexazinone and thiabendazole with both doses.

LITERATURE

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Honey bee colonies are commonly used to provide pollination services to avocado orchards in Mexico. However, it is not known if the pesticides used in these orchards affect bee health and leave residues in hive products. Samples of honey and beeswax were collected from hives placed in three types of avocado orchards differing in management practices: organic (pesticides not used), certified (pesticides used under regulations), and conventional (pesticides used without regulations). A chemical analysis of the samples revealed residues of pesticides, mainly acetamiprid, hexazinone, and thiamethoxam. In honey samples, acetamiprid exceeded the European Commission's MRL, and there were no differences in acetamiprid concentration between the three orchard types ($P=0.0963$). In beeswax samples, acetamiprid concentration was significantly lower in organic orchards ($P<0.001$) and varied compared for the other two pesticides ($P<0.001$). Additional pesticides detected at lower concentrations included coumaphos and cyhalothrin in honey, and methidathion, coumaphos, mefenoxam, cyhalothrin, pentachlorophenol, chlorpyrifos, and permethrin in beeswax. Based on these results, experiments were conducted to determine the toxicity and behavioral effects on bees of the three main pesticides found in hive products. Avocado plants inside meshed cages were sprayed with the pesticides using either of two doses, the doses recommended by the manufacturers, and the doses used in conventional orchards, which are twice higher. Then, bees were introduced into each cage and observed for mortality and inability to fly and walk. In the cages with plants treated with the recommended doses, bee mortality rates were 47%, 7% and 6%, for the acetamiprid, hexazinone, and thiamethoxam treatments, respectively, and a significantly higher number of bees showing behavioral changes were observed for the acetamiprid treatment ($P<0.001$). Also, mortality and behavioral changes of the exposed bees were higher with the conventional treatments ($P<0.001$). We conclude that acetamiprid may reach concentrations above MRL in honey, irrespective of the type of orchard management. The pesticides tested at doses used in the orchards have detrimental effects on honey bee health and behavior, particularly acetamiprid. Alternative methods of pest control should be implemented in avocado orchards to reduce the use of pesticides that affect honey bee health and pollute hive products