Article

Toxicity of insecticides against (*Optatus palmaris* Pascoe) in soursop

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Abstract

Originally from tropical America, the soursop (*Annona muricata*) has great potential and production expectations in Mexico. However, it presents pest problems that limit its cultivation. One of these is the fruit weevil (*Optatus palmaris*), whose damage detracts from quality and yield. Insecticides and repellants were evaluated: spinosad, spinoteram, azadirachtin, lambda-cyhalothrin, chlorpyrifos, imidacloprid and etofenprox. The percentage of mortality, fruit consumption was evaluated and the CL_{50} and TL_{50} were determined. One hour after application, 89.2% and 85.7% ($\alpha < 0.05$) mortality were observed with lambda-cyhalothrin and chlorpyrifos at a concentration of 0.025 g ai L^{-1} and 2.4 g ai L^{-1}, respectively. Spinosad and azadirachtin had no mortality effect at concentrations of 0.6 g ai L^{-1} and 32 g ai L^{-1}, respectively ($\alpha < 0.05$). At 12 h after the application spinosad (0.6 g ai L^{-1}), lambda-cyhalothrin (0.0012 g ai L^{-1}) and chlorpyrifos (0.24 g ai L^{-1}) exerted more than 95% mortality ($\alpha < 0.05$). Fruit consumption was lower with the application of lambda-cyhalothrin, 24.9% of consumed fruit ($\alpha < 0.05$). The insecticide with the highest toxicity was imidacloprid with an CL_{50} of 0.06 g ai L^{-1} and TL_{50} of 0.3 h, followed by spinoteram with an CL_{50} of 0.96 g ai L^{-1} and a TL_{50} of 0.36 h. Azadirachtin did not cause mortality or decrease fruit consumption compared to the absolute control at concentrations of 0.32, 3.2 and 32 g ai L^{-1} ($\alpha < 0.05$) therefore the use of this product is not recommended for the control of *O. palmaris*.

Keywords: anonaceae, borer, control.

Reception date: November 2020
Acceptance date: February 2021

Introduction

Soursop (*Annona muricata* L.) is a fruit native to Tropical America (Geurts, 1981), distributed in various countries in Asia, Africa, America and Oceania (CABI, 2018) and with great expectations in the export market to countries in America, Caribbean, Asia and Australia. The cultivated area in Mexico is 3 700 ha, a production of 29 220 t whose value amounts to more than 300 million pesos.

The surface area and the value of production increased 200% and 365%, respectively, in the last 10 years. The production of this fruit tree faces important challenges, mainly in pest management. The main pests are the seed borer (*Bephratelloides cubensis* Ashmead), fruit borer moth (*Cerconota anonella* Sepp.), Fruit borer (*Oenomaus ortygnus* Cramer), pink hibiscus mealybug (*Maconellicoccus hirsutus* Green), mealybug (*Plano citricus* green) Risso), striped worm (*Gonodonta pyrgo* Cramer) and fruit weevil (*Optatus palmaris* Pascoe), among others (Hernández *et al*., 2012; 2013; Maldonado *et al*., 2014; Pinzón *et al*., 2016; Cham *et al*., 2019).

O. palmaris is distributed in the main producing areas of custard apple fruit in Mexico (Salas *et al*., 2001; Vildozola *et al*., 2009; Maldonado *et al*., 2014). As an adult, it feeds on developing fruits, it damages the peel and the pulp in a superficial way, the insect lays its eggs under the epidermis and the larva when emerging enters the fruit, damaging the pulp and seeds, thereby derating its quality and it seriously affects the yield, it chooses the fruits close to harvest to feed, mate and oviposit, although they also damage flowers and tender shoots very sporadically and in a solitary way.

The life cycle is completed in 215 days, of which five are incubation days, 73 in the larval stage, 25 pupae in the ground under the leaf litter and 112 in the adult stage (Castañeda, 2009; Maldonado *et al*., 2014). *O. palmaris* was reported for the first time in Nayarit by Castañeda *et al*. (2009) and its importance as a soursop pest was established by Castañeda (2011).

For their part, Maldonado *et al*. (2014) when conducting more detailed studies of biology and feeding habits of the weevil in soursop in Nayarit, Mexico, observed up to 30 adults per fruit, with an incidence of 7 to 13.3% and average severity of 19 to 49% with 4.7 to 6.6 larvae per fruit, the adult is active during most of the day and the greatest damage occurs in the months of August to November.

Due to its recent detection in soursop de Nayarit and based on population fluctuation and distribution studies, these authors concluded that the weevil is in the process of adaptation and dispersal towards the producing areas of this crop. Despite the regional importance of soursop currently in Mexico, there are no pesticides registered for its use in this crop by the federal commission for protection against sanitary risks (COFEPRIS, 2020).

For its part, BC Global Pesticides (https://bcglobal.bryantchristie.com/db#pesticides/query), indicates that for the soursop export market to the United States of America, there are maximum residue limits established for 21 ingredients active ingredients (ai), among which are: etofenprox, imidacloprid, spinoteram and spinosad. In addition to this, the main method of combat is the use of insecticides, with few studies of toxicity and biological effectiveness.

Bioassays with pesticides are experiments carried out to estimate the probability that a pest population will respond in a desired way in terms of biological effect (Robertson *et al*., 2017), in addition to the result, be it death or repellency of the pest insect, safety and the least environmental impact are sought.

Given the pest problems present in the soursop crop, it is necessary for the producer to have options for insecticides and other compounds, evaluated in order to determine the optimal concentration that can cause the greatest effect for the control of the main pests of the crop and manage to reduce damages and losses in production. Therefore, different insecticides and food repellants were evaluated against the adults of *O. palmaris*.

Materials and methods

Collecting insects. Adults of *O. palmaris* were collected during August to November, in the period of greatest emergence of July-September (Maldonado *et al*., 2014), in a soursop orchard with the following geographic coordinates: 21° 06’ 15’’ latitude north and -105° 09’ 50’’ west longitude located in the AltaVista production area, Compostela, Nayarit. An orchard was chosen under conditions of low agronomic management where only weed and harvest control is carried out, with no application of insecticides.

To reduce the experimental error in insecticide tests attributed to the age, nutrition and genotype of the insects from the field according to what was indicated by Matsumura (1985); Robertson *et al*. (2017), insect collections were made daily for eight days and were transferred to the Laboratory of Agricultural Entomology of the Santiago Ixcuintla Experimental Agricultural Field of the National Institute of Forestry, Agricultural and Livestock Research (INIFAP).

Once in the laboratory, the insects were mixed and placed in 900 cm^3 cages. They were fed with soursop fruits, which were changed daily following the methodology of Maldonado *et al*. (2014). To evaluate the biological effectiveness of insecticides and repellants, ingestion, contact and residual exposure methods were used (Matsumura, 1985; Robertson *et al*., 2017). The evaluations were carried out under laboratory conditions of 25 ±2 °C and relative humidity of 65 ±5%. Groups of 10 insects chosen at random from the field collections were used as an experimental unit.

Insecticidal effect and repellency by ingestion. The treatments were established with five repetitions and in each repetition 10 adults (five males and five females) were introduced with a 24-hour fast. A 100 mm x 15 mm Pyrex glass Petri dish was used as a repetition. A fruit fragment with known weight (Shimadzu UX4200H Cap. 42 000 g, precision 0.01 g) was introduced in each repetition and previously immersed in the insecticide solution. Before introducing it, it was allowed to dry for two hours.

Distilled water was used as solvent in all treatments. To determine the doses to be evaluated, the technical recommendations were considered, the recommended average dose was taken as a reference and in a 1:10 dilution a higher and a lower concentration were evaluated. The treatments were the following: spinosad in concentration of 0.006, 0.06 and 0.6 g ai L^{-1}; azadirachtin in concentrations of 0.32, 3.2 and 32 g ai L^{-1}; lambda-cyhalothrin in concentrations of 0.0013, 0.0025 and 0.025 g ai L^{-1} and chlorpyrifos in concentrations of 0.024, 0.24 and 2.4 g ai L^{-1}, in addition to an absolute control only with distilled water according to those indicated by Robertson *et al*. (2017).

The variables evaluated were: percentage of mortality according to the Abbott formula (1925) at 1, 2, 4, 12 and 24 h after treatment, in addition to the % of the weight of fruit consumed at 24 h, obtained by the equation: % consumption $=\left(\frac{a-b}{a}\right) * 100$. Where: a= initial weight; b= final weight. Analysis of variance was performed and the comparison of means of treatments of the variables evaluated with the Tukey test ($\alpha \leq 0.05$), the statistical program SAS version 9.3 was used for this.

Determination of the concentration and mean lethal time. This method was evaluated in the laboratory according to Matsumura (1985); Lagunes *et al*. (2009); Robertson *et al*. (2017); Paramasivam and Selvi (2017). To determine the concentrations, the recommended average dose was taken as a reference and from this, two higher and two lower concentrations were evaluated, doubling the concentrations with respect to the lowest dose.

The following treatments and doses were evaluated: imidacloprid 30.2% in doses of 0, 0.2, 0.4, 0.8, 1.6 and 3.2 ml L^{-1}; chlorpyrifos 48% in doses of 0, 0.5, 1, 2, 4 and 8 ml L^{-1}; etofenprox 10% in doses of 0, 0.1, 0.2, 0.4, 0.8 and 1.6 ml L^{-1} and spinoteram 8.8% in doses of 0, 0.4, 0.8, 1.6, 3.2 and 6.4 ml L^{-1}. Distilled water was used for the dilutions.

Each treatment was established with six repetitions, which consisted of a 50 mm Petri dish and 16 mm in height. 10 insects (five males and five females) were introduced per repetition. The application was made with a micro-sprinkler as suggested by Paramasivam and Selvi (2017) with an expenditure of 0.25 mL of the mixture in each repetition. It was applied directly on the body of the insects and the contact surface inside the Petri dish, simulating the field conditions in which the insect would be exposed after application, where the insecticide is deposited directly on the body and comes into contact when moving across the surface of the applied foliage, branches or fruit.

The variable evaluated was percentage of mortality according to the Abbott formula (1925) at 1, 2, 3, 4, 5 and 24 h after the application. The concentrations evaluated were transformed with the logarithm function and by means of Probit analysis the Lethal Concentration 50 (CL_{50}) and the Lethal Time 50 (TL_{50}) were estimated. (Matsumura, 1985; Lagunes *et al*., 2009; Robertson *et al*., 2017), a goodness of fit test of the model was performed with the observed and expected values using the Chi-square test (p= 0.05) (Robertson *et al*., 2017). To calculate the TL_{50}, a serial sampling design was used, which consisted of applying treatments in various doses and observing the response in time series after application (Robertson *et al*., 2017).

Results and discussion

Insecticidal effect and repellency by ingestion

Significant differences were observed between treatments and the absolute control in the mortality of *O*. *palmaris* adults. With the exception of azadirachtin (Az), in the rest of the treatments mortality of the weevil was observed at the different evaluation moments after application. In the first hour after application, in the treatments with spinosad (Sp), Az and the lowest concentration of chlorpyrifos (Cl) (0.024 g ai L^{-1}), there was no mortality of the weevil and instead if it fed during this time (Table 1).

Table 1. Consumption of fruit treated with repellents and insecticides.

Active ingredient (ai)	(g ai L^{-1})	(%) of consumption*	Fruit consumed (g) *
Spinosad	0.006	54.8 a	0.3 ab
	0.06	45.1 abc	0.27 abc
	0.6	49.6 abc	0.26 abc
Azadirachtin	0.32	58.3 a	0.29 ab
	3.2	60.3 a	0.32 a
	32	51.9 ab	0.28 ab
Lambda-cyhalothrin	0.0013	26.6 bc	0.15 cd
	0.0025	24.9 c	0.14 d
	0.025	41 abc	0.21 abcd
Chlorpyrifos	0.024	39.5 abc	0.23 abcd
	0.24	40.6 abc	0.22 abcd
	2.4	38.8 abc	0.2 bcd
Control	Distilled water	50.6 ab	0.29 ab

*= means with different letters differ statistically (Tukey, $\alpha \leq 0.05$).

Chlorpyrifos exerted mortality of 32.1% and 85.7% in this first observation with concentrations of 0.24 and 2.4 g ai L^{-1}, respectively. According to Ujvary (2010), spinosad acts by contact and ingestion with a similar speed to most neurotoxic insecticides. However, it is not until 4 h after application that mortality of *O. palmaris* occurs with the highest concentration of spinosad (0.6 g ai L^{-1}).

The treatments with lambda-cyhalothrin (LC) (0.025 and 0.25 g ai L^{-1}) exercised the greatest control with 74.9% and 89.2%, respectively. In the evaluation 2 h after the application, mortality only occurred in the treatments with LC and Cl in all the doses evaluated; however, the concentrations of LC (0.0025 and 0.025 g ai L^{-1}) and Cl (2.4 g ai L^{-1}), caused the highest mortality with statistical equality between these and a mortality of 92.8%, 96.4% and 100%, respectively (Table 2).

Table 2. Corrected mortality of *Optatus palmaris* with different insecticide treatments.

Active ingredient (ai)	(g ai L^{-1})	*(%) corrected mortality (Abbott, 1925)				
		1 h	2 h	4 h	12 h	24 h
Spinosad	0.006	0 c	0 c	0 d	0 c	1 d
	0.06	0 c	0 c	0 d	10.6 bc	53.5 b
	0.6	0 c	0 c	78.5 ab	100 a	100 a
Azadirachtin	0.32	0 c	0 c	0 d	0 c	0 d
	3.2	0 c	0 c	0 d	0 c	0 d
	32	0 c	0 c	0 d	0 c	0 d

Active ingredient (ai)	(g ai L^{-1})	*(%) corrected mortality (Abbott, 1925)				
		1 h	2 h	4 h	12 h	24 h
Lambda-cyhalothrin	0.0013	3.5 bc	7.1 c	17.8 cd	25 b	24.9 c
	0.0025	74.9 a	92.8 a	96.4 a	100 a	100 a
	0.025	89.2 a	96.4 a	100 a	100 a	100 a
Chlorpyrifos	0.024	0 c	3.5 c	49.9 bc	82.1a	92.8 a
	0.24	32.1 b	46.4 b	85.7 a	96.4 a	100 a
	2.4	85.7 a	100 a	100 a	100 a	100 a
Control	Distilled water	0 c	0 c	0 d	0 c	0 d

***=** time after application. Means with different letters differ statistically (Tukey, α≤ 0.05).

In the evaluation of 4 h after the application, it is observed that the Sp concentration of 0.6 g ai L^{-1} exerted a mortality of *O. palmaris* of 78.5%, as in the previous evaluation, LC in its concentrations of 0.0025 and 0.025 g ai L^{-1} and Cl with 2.4 g ai L^{-1}, exercised the greatest control with statistical equality. In this evaluation, the mean concentration of Cl (0.24 g ai L^{-1}) obtained an efficiency of 85.7%, being statistically the same as the highest concentrations.

In the penultimate evaluation, 12 h after application, significant differences occurred between treatments (Tukey, α≤ 0.05) (Table 2). For this evaluation, Sp and Cl in its highest concentration and LC in its medium and high concentration with statistical equality, caused 100% mortality of *O. palmaris*.

Finally, at 24 h after application, the results are very similar to those observed in the 12 h evaluation in the aforementioned concentrations, with the exception of the low concentration of Cl (0.024 g ai L^{-1}) that passed 82.1% to 92.8% control efficiency. Spinosad is a natural product obtained from the bacterium *Saccharopolyspora spinosa* Mertz and Yao, with biological effect mainly against Lepidoptera, Orthoptera, Hemiptera (bed bugs), Diptera, Coleoptera and Thysanoptera (Pedigo and Rice, 2009). It shows variable toxicity depending on the concentration and time of exposure (Ujvary, 2010). The extract of *Azadirachta indica* A. Juss, mainly azadirachtin, is attributed insecticidal, repellent and growth regulating properties (Koul, 1990), with mortality effects, especially in soft-bodied insects and immature states such as larvae and nymphs (Rana *et al*. al., 2008). In this regard, Esparza *et al*. (2010) in contact application of azadirachtin 0.2 mg 5 cm^{-2} observed 100% mortality of *Aphis gossypi* Glover after 48 h of application.

However, in the present study with *O. palmaris*, no mortality or repellent effect was observed (Tables 1 and 2) during the observation period at the concentrations evaluated. On the other hand, the LC insecticide, belonging to the pyrethroid chemical group, is characterized by being toxic against insects at extremely low doses (Pedigo and Rice, 2009), and by its high efficacy against a wide variety of species of Hemiptera, Diptera, Coleoptera and Lepidotera (Anadon *et al*., 2006). Although there are no maximum residue limits allowed for soursop in the United States of America (EPA, 2012), in other fruit trees such as apple, avocado or fresh vegetables, its maximum allowed limit ranges from 0.2 to 2.5 ppm. Lambda-cyhalothrin does not show cross-resistance with Cl in insects (Chaverra *et al*., 2012), so it could be an option to design a rotation program for the control of *O. palmaris* and use the lowest doses evaluated.

Cl is an organophosphate insecticide, with a broad spectrum and rapid degradation in the environment, commonly used in agriculture Pedigo and Rice (2009). This frequency of use is likely to decrease in the near future, due to stricter legislation and the search for substances with less impact on the environment. In the case of *O. palmaris* management, these chemical molecules should remain as an option with proper use and effective concentration. When observing the high efficacy in low concentrations (0.024 g ai L^{-1}) against *O. palmatis*, it is considered that its use may be feasible under an insecticide rotation scheme by following the recommendations for the safe handling of pesticides.

Regarding the effect on fruit consumption, significant differences were observed between treatments (Table 1). In the absolute control, the insects consumed 0.29 g in 24 h, 50.6% of the weight of fruit provided. In this period, in the treatments with Sp, a slight inhibitory effect of feeding was observed. The insect consumed more than 0.25 g, which represents more than 45%, slightly less than 5% compared to the absolute control.

In the treatments with Az, the insect consumed 28 g, which is equivalent to just over 50%. It is worth mentioning that although the evaluated doses of Az are equivalent to a field application with formulated product of 0.15 to 16 L ha^{-1}, they did not affect feeding during the observation time. Treatments with LC in their concentrations of 0.0013 and 0.0025 g ai L^{-1}, exercised greater inhibition of consumption, since only 0.15 and 0.14 g were ingested, which represents 26.6% and 24.9%, respectively (Table 1).

This coincides with a higher mortality (Table 2) in the mean concentration (0.0025 g ai L^{-1}), which contrasts with the mortality of less than 25% obtained in the concentration of 0.0013 g L^{-1}. In other words, a repellent effect occurred and the insect consumed less fruit. Finally, Cl, presented a low inhibitory effect on feeding, since the concentration with the greatest effect produced an intake of 0.2 g of fruit, which is equivalent to 38.8% of the fruit, only 11.8% lower than the absolute control. Although the statistical differences with respect to the absolute control were significant, the insect causes damage when feeding on the fruit during the first hours after the application of insecticides.

With these results, it is recommended to integrate the insecticides at the doses that best control exercised, within a rotational management scheme; however, it should be taken into account that applications should be made in the first weevil detections. The emergence of the adults of this insect is related to the onset of rains, as indicated by Maldonado *et al*. (2014), so that in the places where soursop is grown and the presence of the insect is registered, samplings must be carried out to detect the first adults and make the decision to implement a control measure before they damage the fruits.

Determination of concentration and mean lethal time

When comparing the CL_{50} of each contact insecticide and residual exposure, a greater toxicity is observed with the insecticide imidacloprid and spinoteram against the red-black weevil *O. palmaris* (Table 3), it is worth mentioning that both insecticides are on the list allowed for the market from the USA, with a maximum residue limit of 0.3 ppm for soursop (EPA, 2012; DataBase LMR, 2020). The goodness of fit test (Chi-square, p= 0.05) indicates that there are no differences between observed mortality (OM) and estimated mortality (EM) (Chi-tables= 0.71) (Table 3) (Figure 1).

Table 3. Estimates of CL_{50} and TL_{50} of insecticides against *Optatus palmaris* adults.

Active ingredient (ai)	CL_{50} (g ai L^{-1})	TL_{50} (h)	Chi-calculated	Ji-Tables
Etofenprox	1.83 ±0.6	3.8 ±0.18	0.045	0.71
Spinoteram	0.96 ±0.8	1.76 ±0.58	0.524	
Chlorpyrifos	3.6 ±1.4	0.36 ±0.05	0.61	
Imidacloprid	0.06 ±0.01	0.3 ±0.09	0.011	

±= standard error.

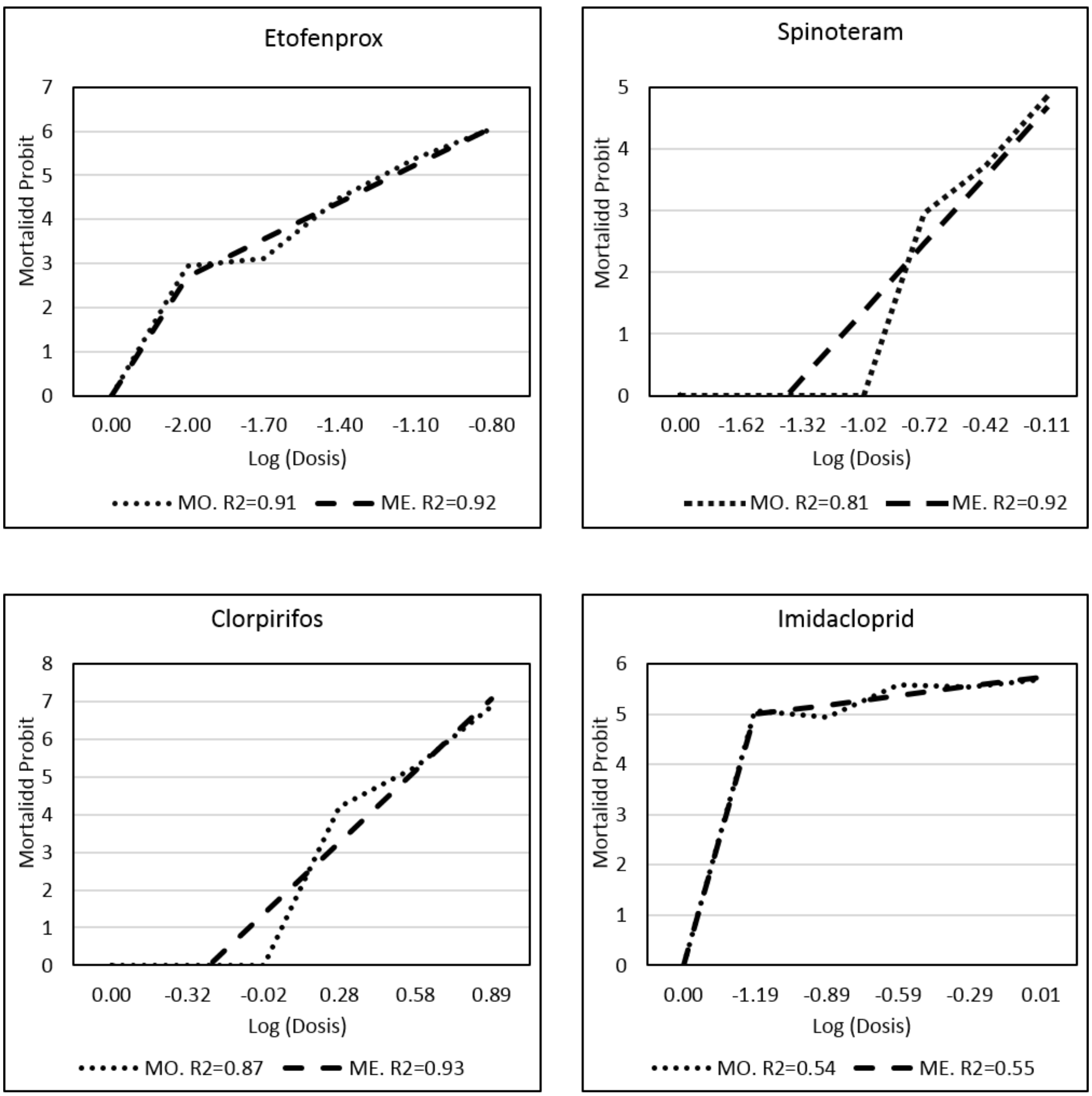

Figure 1. Toxicity of insecticides against the red-black weevil *Optatus palmaris*. OM= observed mortality; EM= expected mortality; R^2= log (dose)/mortality probit regression coefficient.

The CL_{50} of imidacloprid was the lowest as was the TL_{50}, 0.06 g ai L^{-1} and 0.3 h, respectively; that is, it presented the highest toxicity against *O. palmaris*, with systemic and contact activity. This insecticide has shown high toxicity for different groups of pest insects (Pedigo and Rice, 2009); however, it shows less selectivity for some predatory species such as *Chrysoperla carnea* Stephens (Huerta *et al*., 2004; Estay *et al*., 2005; Cerna *et al*., 2012), so its application in soursop could be in a rotation scheme, only as a last option, in conditions and times when it has the least impact on beneficial insects.

Imidacloprid, in second place and with greater toxicity, was followed by spinoteram with an CL_{50} and TL_{50} of 0.6 g of ai L^{-1} and 1.76 h, respectively. The spinoteram product is of recent formulation and belongs to the group of spynosins (IRAC, 2020), the same group to which spinosad belongs and with a maximum residue limit in soursop of 0.3 ppm for the United States of America market.

With contact activity, it has shown toxicity towards different groups of insects, mainly for coleopterans and lepidopterans (Pedigo and Rice, 2009) and thrips (Hernández *et al*., 2018; Walter *et al*., 2018) and low toxicity towards beneficial insects (Morales *et al*., 2020); therefore, it can be an important alternative for the control of *O. palmaris* in soursop cultivation.

In third place, the insecticide etofenprox was located with less toxicity with a CL_{50} of 1.83 g ai L^{-1} and a TL_{50} of 3.8 h, a recently synthesized insecticide belonging to the pyrethroid group, with a maximum residue limit in the United States of America, for soursop of 5 ppm (EPA, 2013; DataBase LMR, 2020) and considered low risk for birds and mammals by the European food safety authorities (EFSA, 2008).

It presents toxicity to several pest insects (Trisyono *et al*., 2017) and could be an important option for the management of *O. palmaris* in an insecticide and repellent rotation scheme. Finally, chlorpyrifos presented less toxicity against *O. palmaris*, although it presented a lower TL_{50} than etofenprox and spinoteram, its CL_{50} was 3.6 g ai L^{-1}, in field concentration with commercial product already formulated, that amount represents 7.5 ml L^{-1}, with an estimated output of 200 L ha^{-1} that volume would be equivalent to approximately 1.5 L ha^{-1}.

Being insecticides that act by contact, the mortality effect is high in the first 12 h after application; The CL_{50} (0.06 g ai L^{-1}) was higher in the insecticide imidacloprid and a lower TL_{50} (0.3 h), as this also has a systemic action, its evaluation against larvae of *O. palmaris* is convenient. According to Maldonado *et al*. (2014) the weevil damages fruits in development and in physiological maturity, at a time when the presence of pollinating insects is lower and it is expected that with proper use the collateral effect will be less; however, due to the possible effects against other insects, it is necessary to evaluate their impact on them, mainly on coleopterans, since they have important activity as pollinators in custard apple (Peña *et al*., 2002).

Conclusions

Significant differences were observed in the mortality of *O. palmaris* between treatments in application by contact, residual exposure and by ingestion. It is possible to achieve a management of the weevil with the rotation of the insecticides and doses that showed greater toxicity spinosad, lambda-cyhalothrin, etofenprox, imidacloprid and spinoteram. Being compounds that act by contact, with the exception of imidacloprid, the mortality effect is high in the first 12 hours after application.

The CL_{50} (0.06 g ai L^{-1}), as this also has a systemic action, it is convenient to evaluate it against the larval state of the weevil and that damages fruits in development and emerges in fruits close to harvest, which detracts from quality and favors damage by pathogens, at this stage, the presence of flowers is lower, as is the density of pollinating insects, so it would be expected that the proper use of these products would have less collateral effects; however, due to the possible effects of this and the other compounds against other insects, it is necessary to observe their impact, mainly in coleopteran insects that are associated with custard apple flowers.

Chlorpyrifos had a contact mortality effect greater than 85% after the first hour of observation with a concentration of 2.4 g ai L^{-1} and at 4 h with the concentration of 0.24 g of ai L^{-1}; however, the fruit consumption was slightly lower (11.8%) than the absolute control; in other words, the insect continued with its feeding, which represents significant damage to the fruit and detracts from its quality, in addition to damaging flowers and leaves.

Therefore, the use of this insecticide for the control of *O. palmaris* is not recommended. Likewise, the application of azadirachtin is not recommended as it did not show mortality or repellency efficacy during the time and doses evaluated. Due to the distribution of *O. palmaris* and recent establishment in the main soursop producing area in Mexico; it is necessary to continue with control studies evaluating other products and repellents and integrating other methods to achieve a more efficient sanitary management with the least environmental impact.

Acknowledgments

The soursop producers in Nayarit are thanked for the facilities granted to access their orchards. To INIFAP for the financial support to carry out this research.

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