Behavior and management of thrips population using biorational insecticides in avocado (*Persea americana* Mill.) trees

Figueroa-Gallardo, Josué E.[1]; Duran-Peralta, Elisa[1]; Aragón-Gutiérrez, Carlos[1]; Huerta-de la Peña, Arturo[1]; Morales-Galván, Oscar[2]; Gutiérrez-Rangel, Nicolás[1*]

[1] Colegio de Postgraduados – Campus Puebla. Maestría en Desarrollo e Innovación en Fruticultura Familiar, Buulevar Forjadores de Puebla Núm. 205. Santiago Momoxpan. Municipio de San Pedro Cholula. C.P. 72760, Puebla, México.

[2] Universidad Autónoma Chapingo. Departamento de Parasitología Agrícola, km 38.5 Carr. México-Texcoco, Chapingo, Edo. de México C.P. 56230.

* Correspondence: ngrangel@colpos.mx

ABSTRACT

Objective: To evaluate the effectiveness of biorational insecticides to control thrips and to provide alternatives that reduce the negative environmental impact of chemical pesticides on the management of avocado tree.

Design/Methodology/Approach: Using a randomized complete block design with four replicates, the following five treatments were evaluated: T1) control (water); T2) chicalote (*Argemone mexicana* L.) extract; T3) neem (*Azadirachta indica*) oil extract; T4) potassium soap (potassium salts); and T5) Spinosad (Spinosyn A and Spinosyn D). Each product was applied in its own row. Treatment rows were separated by a row of trees to which no treatment was applied. Samples were taken in different dates from plant and floral sprouts of four randomly selected avocado trees. Each tree was an experimental unit.

Results: The data obtained did not comply with the normality test and the homogeneity of variance; consequently, the data were subjected to a General Additive Model (GAM). The most efficient treatments were neem oil extract and Spinosad.

Study Limitations/Implications: Different orchards, with different initial pest populations, should be evaluated to determine the level of infestation in which the application of biorational products is still feasible for pest control.

Findings/Conclusions: Plant extracts have high potential to control thrips in open-air avocado plantations; consequently, they could be an alternative to the application of synthetic insecticides for pest management.

Keywords: Sustainable management, pesticides, pests, plant extracts.

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INTRODUCTION

Mexico supplies one third of the avocados (*Persea americana* Mill.) that reach the international markets (SADER, 2024); however, avocado production is impacted by multiple factors, including pests. Thrips (Thysanoptera: Thripidae) are a major pest of avocado trees: they feed on leaves, sprouts, flowers, and fruits, causing direct (sap sucking) and indirect (disease transmission) damage (Ávila-Quezada *et al.*, 2005). Thrips cause damages to up to 25% of the fruits; consequently, the fruit is rejected for exportation and

its price is reduced by half in the domestic market (Coria-Ávalos, 2003). Currently, the pest is mainly controlled with agrochemicals. Therefore, the selection of inputs to control pests should be improved and new alternatives to prevent environmental damage should be proposed (Torres and Capote, 2004). The application of plant extracts to control agricultural pests is an ancient practice used by different cultures and regions before the development of synthetic pesticides (FIDA-RUTA-CATIE-FAO, 2003). Plant extracts are liquid or powder preparations with active ingredients obtained with methods that concentrate substances from the root, leaves, flowers, and seeds of several species. The extracts are mainly rotenoids, pyrethroids, alkaloids, and terpenoids. These substances can have a severe and variable impact on the metabolism of insects, such as food aversion or reduction, consequently, preventing the development of pests (Do Nascimento *et al.*, 2008). Neem (*Azadirachta indica*; Meliaceae) has been the plant with the highest development in recent years. Its seeds have compounds that act against more than 200 insect species of the orders Coleoptera, Diptera, Homoptera, Himenoptera, Lepidoptera, and Thysanoptera. In addition, it impacts three mite species, five nematodes, and one crustacean species (Rodríguez, 2000). Furthermore, neem is not toxic for mammals and beneficial insects (Schmutterer, 1990). Currently, other plants, extracts, and compounds have been identified as potential pesticides for the control of thrips. Therefore, the objective of this study was to evaluate the effectiveness of biorational insecticides to control thrips and to provide alternatives to reduce the negative environmental impact of chemical insecticides used to manage avocado trees.

MATERIALS AND METHODS

The study took place from January to June 2023 in a 1-ha Hass avocado orchard, located in Tetela del Volcán, Morelos, at 18° 52' 45.8" N and 98° 42' 48.0" W, and 2,126 m.a.s.l. The area had a sprinkler irrigation system. The trees were arranged according to the topology (in a 5×4 m square planting) and were between four and eight years old.

Five treatments were evaluated: T1) control without pesticide (water); T2) 1 L of chicalote (*Argemone mexicana* L.; 90%) extract in 200 L of water; T3) 400 ml of neem (*Azadirachta indica*; 80 %) oil extract in 200 L of water; T4) 1 L of potassium soap (potassium salts; 35%) in 200 L of water; and T5) 40 ml Spinosad (Spinosyn A and Spinosyn D; 11.60%) in 200 L of water. The doses were based on previous trials (unpublished data) and technical recommendations for the commercial products. The products were applied thrice in each treatment. The tree foliage was sprayed in the morning (7:30-8:30 a.m.), when temperatures were lower and the wind speed reached 0-6 km h^{-1}. A Willy® motorized pump and a high-pressure hydra pistol (300 psi), calibrated at 200 L ha^{-1}, were used for this purpose.

A randomized complete block design with four replicates was used; the blocking factor was the age of the trees (4 and 8 years old). Each block was made up of ten contiguous trees in their plant growth and flowering stages. Four trees were randomly selected and marked as sampling specimens. The experimental unit was made up of a tree, from which four plant and floral sprouts were selected, based on their phenological development. Each sprout was selected from a different cardinal point. A row of trees without application was placed between the treatment rows to prevent derivative errors and contamination between treatments. The treatments were randomized within each block, using the design.ab procedure of the R statistical software (R Core Team, 2018).

The weather information (maximum, minimum, and mean temperatures) from 2023 were retrieved from: https://es.weatherspark.com/.

Treatment evaluation

In order to estimate the initial distribution of the pest, each plant or floral sprout from the marked trees were sampled at the beginning of the study. Subsequently, three evaluations were carried out at 7, 14, and 28 days after the first application. Evaluations were conducted from January to June to determine the natural population dynamic of thrips in the four T1 (control) trees. Four random inflorescence or plant sprout samples were taken from each marked tree at a height of 1.5-2.0 m. The sampling process covered the four cardinal points. Each tree was sprayed with a 9:1 water and fabric softener (Vel Rosita®) solution. The dripping of the trees was collected in a plastic tray and subsequently poured into a bottle with 70% ethanol. Afterwards, sieves were used to collect and count the captured specimens in the lab. The specimens were placed between a microscope slide and a slide cover with Canada balsam. They were then observed in a Master Olympus® compound microscope. The illustrated keys developed by Soto and Retana (2003) for the genus Thysanoptera were used for the taxonomic identification of the samples.

Statistical analysis

First, box-and-whisker plots were developed for the visual comparison of the evaluated treatments. Afterwards, a generalized additive model (GAM) was used to analyze the counting data in the R Core Team (2018) software. A mean comparison of the treatments (T) and the dates (D) was performed with the least significant difference (LSD) method.

RESULTS AND DISCUSSION

Population fluctuation in the control treatment

Figure 2 shows the natural behavior of thrips populations in the control trees (February-June); it also includes the two regression models employed to predict the said behavior. The thrips population started to increase on late February and early March, along with the increase of temperature; likewise, it started to diminish in June, at the beginning of the rainy season (Figure 1). These results match the findings of Ramírez Dávila *et al.* (2013), who pointed out that thrips populations in Morelos started to increase in March, reached their maximum peak in May, started to decrease in June, and finally reached their minimum point in September. Maximum and minimum temperatures in March reached 78 °F and 50 °F, respectively. According to Hoddle and Mound (2003), thrips can develop at a minimum temperature of 8 °C. Scarce precipitation favors the development of thrips populations in plant tissue (Díaz *et al.*, 2012).

Regarding the adjustment of population fluctuation models shown in Figure 2, the lineal model clearly was not the appropriate model to explain the data. However, the highest value of R^2 showed that the quadratic model had a better adjustment and, consequently, it achieved a better description of the natural dynamics of thrips populations. A quadratic

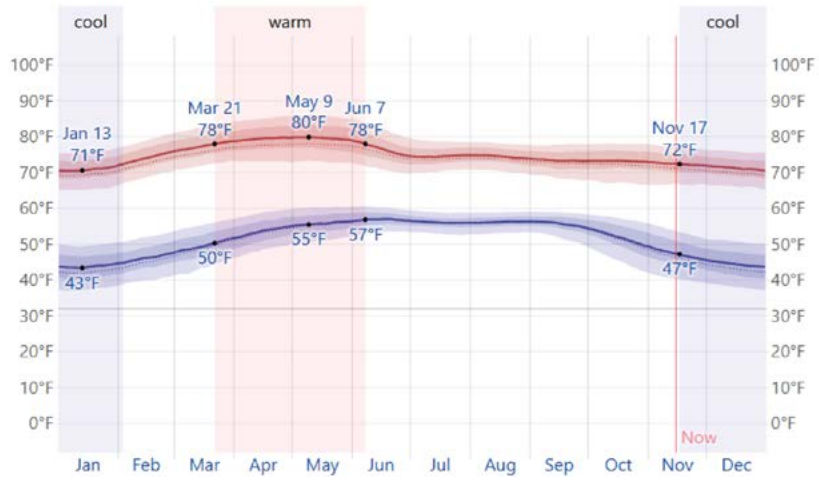


Figure 1. Maximum, minimum, and mean temperature in Tetela del Volcán, Morelos. Historical data retrieved from: https://es.weatherspark.com/.

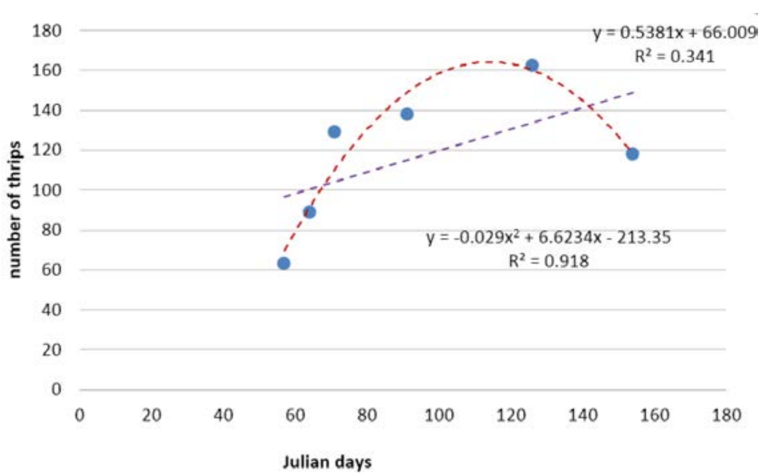


Figure 2. Natural fluctuation of the thrips populations in avocado trees in Tetela del Volcán, Morelos (2023).

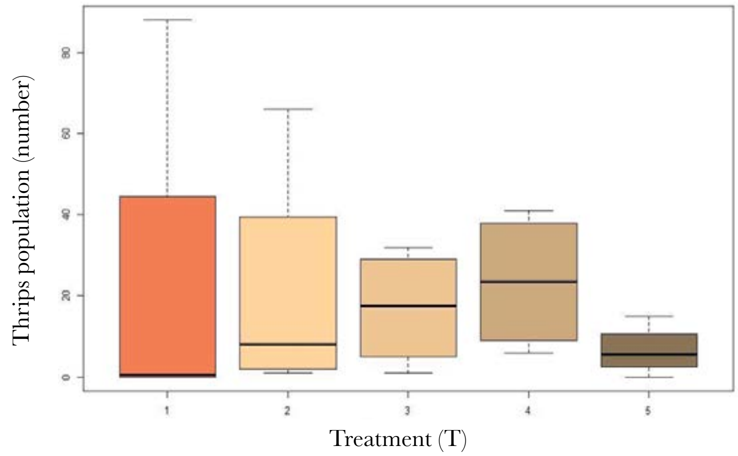
model can be used to study the response of population dynamics to environmental changes, to forecast the future of the population, and to evaluate the impact of the pest control on the said population.

The genera *Frankliniella* and *Scirtothrips* were found in the area. According to Urías-López *et al.* (2007), they are phytophagous species of the avocado plantations.

Efficiency of the treatments

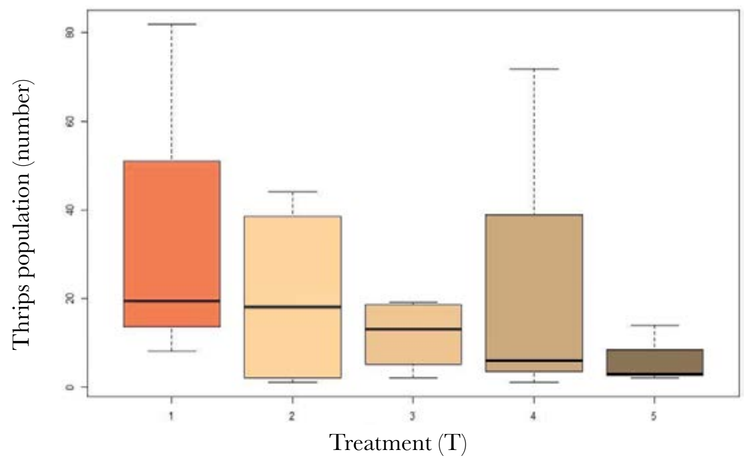
During the first sampling (seven days after the first application), all the plant extracts were able to control thrips populations. However, Spinosad recorded the best control, followed by neem (Figure 3). Control registered the highest data dispersion.

Based on the mean result of the treatments, Spinosad and neem were still the best treatments during the second sampling, while chicalote recorded a better control than potassium soap (Figure 4).



1=control, 2=chicalote, 3=neem, 4=potassium soap, 5=Spinosad.

Figure 3. Box-and-whisker plot of the five treatments during the first sampling date in Tetela del Volcán, Morelos (2023).



1=control, 2=chicalote, 3=neem, 4=potassium soap, 5=Spinosad.

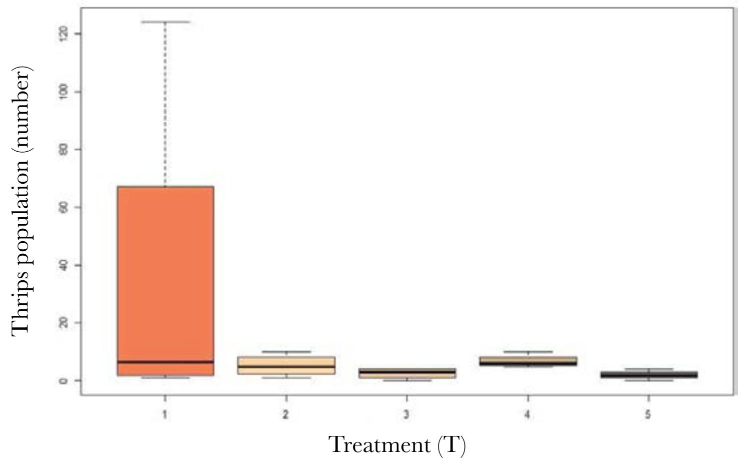
Figure 4. Box-and-whisker plot of the five treatments during the second sampling date in Tetela del Volcán, Morelos (March 12, 2023).

According to the statistical analysis, Spinosad and neem were still the best treatments during the third sampling date; in addition, no differences were recorded between chicalote and potassium soap (Figure 5).

Figure 6 shows that control recorded very diverse amounts of thrips during the experiment. This phenomenon contrasted with the results obtained from the other treatments which, as the sampling dates went by, recorded a significant interquartile range decrease.

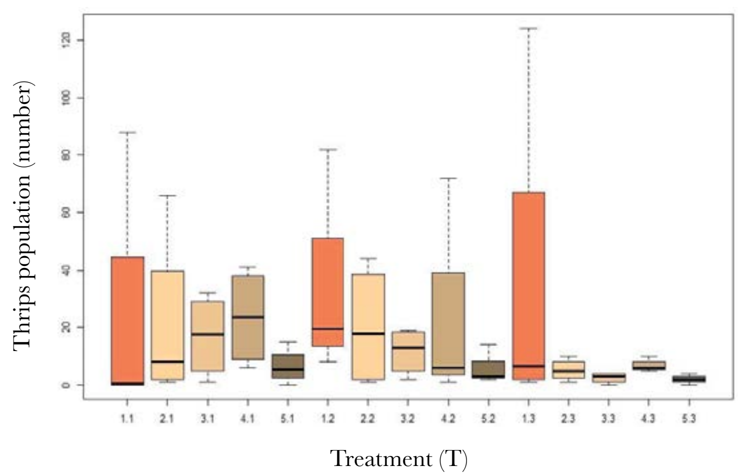
Differences were recorded based on the treatments and the sampling dates; in addition, an analysis of variance was conducted to determine the statistical difference between the effects of the different treatments.

Based on the analysis of variance of the GAM, a significant difference was verified between treatments and application dates.



1=control, 2=chicalote, 3=neem, 4=potassium soap, 5=Spinosad.

Figure 5. Box-and-whisker plot of the five treatments during the third sampling date in Tetela del Volcán, Morelos (April 01, 2023).



1=control, 2=chicalote, 3=neem, 4=potassium soap, 5=Spinosad.

Figure 6. Box-and-whisker plot of the five treatments during the three sampling dates. The first number indicates the sampling date, while the second indicates the treatment (Tetela del Volcán, 2023).

Analysis of variance of the GAM

According to the mean comparison test, the best treatment was Spinosad, followed by neem (Table 3). Spinosad is used in different crops to control thrips and mites (Grové *et al.*, 2002; IRAC, 2007). Its neurotoxicity activates nicotinic acetylcholine receptors.

A correlation analysis explained the positive or negative effect of the dates and treatments and the presence of thrips in the avocado trees (Figure 7). The results were negative for both treatments and dates. As a result of the application of the treatments, the presence of thrips decreased in time.

Table 1. Mean comparison parameters.

	Estimate	Std. Error	Z value	Pr(>|z|)	
(Intercept)	4.10120	0.10078	40.696	<2e-16	***
TREATMENT	−0.32609	0.02481	−13.142	<2e-16	***
DATE	−0.25488	0.04086	−6.238	4.43e-10	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
R-sq.(adj)=0.0518 Deviance explained=14.5%
UBRE=21.158 Scale est.=1 n=60

Table 2. Values obtained with the analysis of variance of the GAM.

MSerror	Df	Mean	CV	t.value	LSD
23.21912	57	15.46667	31.15488	2.002465	3.939238

LSD t Test for TRIP; Mean Square Error: 23.21912; TRA, means and individual (95 %) CI.

Table 3. Mean comparison of the last sampling date of the evaluation of biorational insecticides used to control thrips in avocado plantations in Morelos, Mexico (2023).

Treatment	Thryps (average)	Group
1: Control	29.66	a
4: Potassium soap	17.16	b
2: Chicalote	15.41	b
3: Neem	10.41	c
5: Spinosad	4.66	d

Alpha: 0.05; DF Error: 57; Critical Value of t: 2.002465; Least Significant; Difference: 3.939238; Treatments with the same letter are not significantly different.

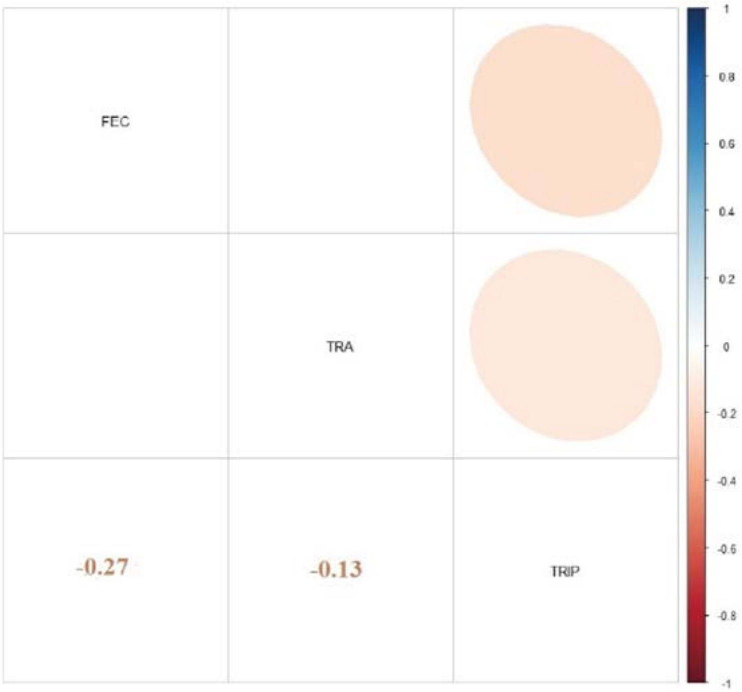


Figure 7. Correlation between the thrips presence and the dates and treatments.

CONCLUSIONS

The neem (*Azadirachta indica*) and chicalote extracts (*Argemone mexicana* L.) controlled and reduced thrips populations with greater efficiency than control. Although their action was slower than the effect of chemical products, they nevertheless controlled the pests. Consequently, they can be used in a comprehensive management program of avocado plantations.

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