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Identification and biorrational management of thrips (Thysanoptera) on blueberry (*Vaccinium corymbosum* L.) in Nayarit, Mexico.

Identificación y manejo biorracional de trips (Thysanoptera) en arándano (*Vaccinium corymbosum* L.) en Nayarit, México.

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ABSTRACT

This research aimed to morphologically identify the thrips associated with blueberry cultivation in the municipalities of Xalisco and Tepic, Nayarit; Also, biorational insecticides were evaluated for their management. During 2022, thrips were captured directly in the crop with the knockdown technique. Insecticides were applied with 5 L manual sprayers, 8-lb pressure, and a full cone nozzle extension. Five applications were made at 15 days intervals. In Xalisco, eight species of thrips were recorded, while in Tepic only *Scirtothrips dorsalis* was registered, which predominated in both properties. Formulated products based on cinnamon extract, garlic, azadirachtin, mustard, a regional control Spintor® (Spinosad), and an absolute control (water) were evaluated individually. The cinnamon extract was the most effective biorational with 73.5 % control, while the mustard extract obtained 32.44 % being the least effective. The previous results show that the thrips fauna in the blueberry crop is diverse and is mostly represented by *S. dorsalis*, which is a pest species of this crop in other producing states, in addition, biorational products were found with the potential to be incorporated in an integrated thrips management program.

KEY WORDS: Biorational control, Macrotunnel, *Scirtothrips dorsalis*, Thrips, Thysanoptera.

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Revista Bio ciencias ISSN 2007-3380

RESUMEN

El objetivo de la investigación fue identificar morfológicamente los trips asociados al cultivo de arándanos en los municipios de Xalisco y Tepic, Nayarit; además de evaluar insecticidas biorracionales para su manejo. Durante el año 2022, se capturaron trips con la técnica de derribo directamente en el cultivo. Los insecticidas se aplicaron con aspersores manuales de 5 L, de 8 lb de presión y extensión con boquilla de cono lleno. Se realizaron cinco aplicaciones con intervalos de 15 días. En Xalisco se registraron ocho especies de trips, mientras que en Tepic se registró a *Scirtothrips dorsalis,* misma que predominó en ambos municipios. Se evaluaron individualmente productos formulados a base de extracto de canela, ajo, azadiractina, mostaza, un testigo regional Spintor® (Spinosad) y un testigo absoluto (agua). El extracto de canela fue el biorracional más efectivo con 73.5 % de control, mientras que el extracto de mostaza obtuvo un 32.44 % siendo el menos efectivo. Los resultados demuestran que la fauna de trips en el cultivo de arándano es diversa, mayormente representada por *S. dorsalis* la cual es una especie plaga de este cultivo en otros estados productores, además, se encontraron productos biorracionales con potencial para ser incorporados en un programa de manejo integrado de trips. Estos resultados sientan las bases para tener más herramientas para el manejo de estas especies plaga en el cultivo de arándano.

PALABRAS CLAVE: Control biorracional, Macrotunel, *Scirtothrips dorsalis*, Trips, Thysanoptera.

Introduction

The blueberry *Vaccinium corymbosum* L. (Ericaceae) has a wide market, as it is a very versatile crop since it is consumed fresh, as processed food and oil (Ehlenfeldt & Prior, 2001; Romero, 2016); it is also a fruit with great health benefits by containing fiber, vitamins, antioxidant capacity, and secondary metabolites, the latter, used to treat cardiovascular diseases (Neri *et al.,* 2009; Romero, 2016).

FAOSTAT (2021) reports a worldwide production of 850,886 t, and in Mexico, 48,998 t are produced in 4,908 ha planted, with the varieties Biloxi, Misty, Ventura, and Victoria. Mexican production is distributed in 10 states, highlighting Jalisco as the main producer with 29,471 t, Nayarit state is the 10th producer with 44 t since it is a recent introduction (SIAP, 2019).

Pests and diseases are the most relevant causes of production loss in blueberries. In Mexico, damage is associated with different diseases (Santiago *et al.,* 2019), and insect pests such as the strawberry whitefly *Trialeurodes packardi* Morill (Hemiptera: Aleyrodidae), spotted wing drosophila *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) and gall midge *Dasineura*

Revista Bio ciencias
ISSN 2007-3380

oxycoccana Johnson (Diptera: Cecidomyiidae) (Cisternas, 2007; Restrepo *et al.,* 2011; Hahn, 2011). Thrips (Thysanoptera: Thripidae) are considered primary pests and cause damage by feeding, and oviposition on flowers and vegetative shoots, resulting in necrotic spots and leaf rolling (Goldarazena, 2015; Zamora *et al.,* 2020). In Mexico, there are records of thrips species such as *Scirtothrips dorsalis* (Hood), *Thrips palmi* (Karny), *Frankliniella fortissima* (Priesner), *F. bruneri (*Watson) associated with the blueberry crop (*V. corymbosum*) in Michoacán, Mexico (Ortiz *et al.,* 2020; Zamora *et al.,* 2020).

Thrips management is complicated due to the lack of knowledge about species, habits, and behavior associated with damage, together with the reduced amount of chemical molecules that can be used in this crop; As a consequence, a mosaic of active ingredients is applied, where the ones registered for its management are Pyriproxyfen, Zeta-Cipermethrin+Novaluron, Spinosad, Spinoteram, Thiamethoxam among others, being one of the main problems the residual in fruits, as well as the development of resistance by pest organisms (Santaeufemia *et al.,* 2006; Devine *et al.,* 2008; Aneberries, 2021).

Based on the above, and with the need to identify sustainable alternatives for the thrips management in blueberry, this research aimed to taxonomically identify the thrips species associated with the blueberry crops and evaluate the biological effects of biorational insecticides for their control in Nayarit, Mexico.

Material and Methods

Study area

The experiment was carried out at the "Los Compadres" farm of Agroconcordia S.P.R. de C.V. group, in Xalisco, Nayarit (21° 25' 36'' N and 104° 54' 20.6'' W at 1,001 masl) with the blueberry varieties Biloxi, Victoria, and Ventura. It was also carried out at the "Agrícola Frutane" ranch in Tepic, Nayarit (21° 30'04.54.54'' N and 104° 52'10.35'' W at 949 masl), with 2 ha of the Biloxi variety.

Thrips capture

Thrips sampling was carried out weekly during 2020 in the "Los compadres" and "Agrícola Frutane" farms; 30 plants per block were randomly selected for capture, one inflorescence per plant was shaken on a white plastic tray of 25 cm × 25 cm, the samples were collected in the direction of the four cardinal points and with the support of a triple "0" camel hair brush were preserved in 2 mL Eppendorf tubes with 70 % alcohol for later mounting and identification (Castañeda *et al.,* 2003).

Thrips were collected on the weeds present within the crop and the peripheries using the roundup technique. It consisted of giving 100 blows in five representative points of each farm with an entomological net of 30 cm diameter (Cambero *et al.,* 2009); the collected insects were deposited in a 2 L plastic bag. All collected specimens were transferred to the Agricultural Parasitology Laboratory CEMIC 03 at the Universidad Autónoma de Nayarit for processing and identification.

Assembly and taxonomic identification

Adult thrips were mounted with the technique suggested by Johansen & Mojica (1997), which consisted of progressive dehydration with 80, 90 and 100 % alcohol; were placed in Petri dishes for 15 min in each concentration; later, for clarification, the specimens were placed in xylene for 3 min. Finally, with the aid of a stereoscopic microscope (Motic® SMZ-143), thrips were mounted on slides and coverslips and left on a plate (IKA®, Model: C-IMAG) at 30°C for 24 h for drying.

For specimen identification, a compound microscope (Labomed®, Model: C x L), and the taxonomic keys of Mound & Marullo, (1996); Soto & Retana, (2003); Hoddle & Mound, (2012) were used. Species confirmation was performed by M.C Jesús Alexander Rodríguez Arrieta of the Centro de Investigación en Estructuras Microscópicas (CIEMIC) at the Universidad de Costa Rica.

Evaluation of biorational insecticides

The evaluation was carried out at Los Compadres farm with the Biloxi variety. Treatments were applied during the flowering stage (June-August 2020) since this coincides with the highest incidence of the pest. Treatments were applied with manual sprinklers (KAWASHIMA AK5L) of five liters, with application schedules that ranged between 7:00 and 8:00 hours. Five applications were made at 15 d intervals (Table 1). Thrips mortality was recorded 72 h after application. The response variable was the number of thrips per plant.

Table 1. Insecticides evaluated on thrips in the blueberry crop.

Treatment	Trade name	Active ingredient	Formulation	Dosage 200 L/Ha
T1	Spintor ®	Spinosad (22.14 %)	CS	0.6 L
T2	Mix protective C ®	Excerpt from cinnamon (20 %)	CS	2 L
T3	Azanim ®	Azadirachtin (20 %)	EC	2 L
T4	Mix protectivee A ®	Garlic extract (20 %)	CS	2 L
T5	Mix protectivee M ®	Excerpt from mustard (20 %)	CS	2 L
T6	Control	Water	------------------	2 L

CS= Concentrated suspension; EC= Emulsifiable concentrate.

Experimental design and statistical analysis

A randomized complete block design was used, with six treatments and three replicates. The experimental unit (E.U.) was a 10 m plantation of the Biloxi variety, with an average of 14 plants; seven plants were quantified as a useful plot. An analysis of variance (ANOVA) was applied

Revista Bio ciencias
ISSN 2007-3380

to the obtained data to determine differences in biological effectiveness between insecticides, as well as between applications, using the statistical package IBM SPSS Statistics® Version 25 for Windows®. A comparison of means was performed with Tukey's test (α ≤ 0.05).

Resultados y Discusión

Thrips capture

31 samples obtained at Los Compadres, Xalisco, and 16 at Agrícola Frutane, Tepic (Table 2) were analyzed. A total of 3,077 thrips were captured with both techniques; in Agrícola Frutane, the largest number of individuals collected was obtained.

Table 2. Number of thrips specimens collected by two sampling methods, in two blueberry farms in Nayarit state.

	Knockdown						Roundup	
Site	**Larvae**			**Adults**			**Larvae**	**Adults**
Variety	**Bi**	**Ve**	**Vi**	**Bi**	**Ve**	**Vi**	**-**	**-**
Xalisco	215	97	72	726	421	285	28	281
Tepic	131	0	0	703	0	0	31	87
Subtotal	346	97	72	4,429	421	285	-	-
Total		515			2,135		59	368

Bi= Biloxi; Ve= Ventura; Vi= Victoria.

Taxonomic identification

Of the total number of individuals captured, 702 (22.8 %) adult specimens were mounted in good condition, of which 343 corresponded to Xalisco municipality and 164 to Tepic municipality. Two suborders were found, Terebrantia (99.93 %) and Tubulifera (0.06 %). In Terebrantia, thrips were identified: *Scolothrips sexmaculatus* (Pergande), *Caliothrips phaseoli* (Hood), *F. gardeniae* (Moulton), *F. bruneri* (Watson), *F. occidentalis* (Pergande), and *Scirtothrips dorsalis* (Hood), the latter being the most dominant species with 321 individuals. In Tubulifera, *Leptothrips* sp. was identified (2) (Table 3).

In this regard, Cambero *et al*. (2010) and Cambero *et al*. (2011a), recorded a thrips complex in the avocado crop *Persea americana* Mill (Lauraceae) in Nayarit, where they coincide with the species presented in this study, such as *F. occidentalis*, *F. gardeniae*, *F. orizabensis*, *S. sexmaculatus, and specimens of the genus Leptothrips sp. sexmaculatus* and specimens of the genus *Leptothrips* sp. On the other hand, Ortiz *et al*. (2020) recorded damage by thrips of the species *S. dorsalis*, *F. occidentalis,* and *F. cephalica* in the crop of *V. corymbosum* L. and raspberry *Rubus idaeus* L. in Michoacán state, Mexico. While Zamora *et al*. (2020) recorded damage by thrips of the species *F. fortissima*, *F. bruneri*, and *Thrips palmi* on blueberries in Michoacán, Mexico. Highlighting that the species *F. orizabensis* is considered a predator and is used in a biological control context, as a predator of thrips eggs, larvae, and pupae (Hoddle, 2003), while, Johansen & Mojica, (2006) and, Hoddle *et al*. (2008), reported the species *S. sexmaculatus* as a predator of *Tetranychus* spp. mites and thrips of the genus *Scirtothrips*. Both *F. orizabensis* and *S. sexmaculatus* were previously recorded for Nayarit by Cambero *et al*. (2011b).

Table 3. Number of thrips specimens collected in the blueberry crop in Xalisco and Tepic, Nayarit, Mexico.

	Municipality			
Suborder Family Species	Xalisco		Tepic	
	Knockdown	Sweep netting	Knockdown	Sweep netting
	343	136	164	59
Terebrantia Thripidae				
Scirtothrips dorsalis Hood, 1919	322	136	164	59
Scolothrips sexmaculatus Pergande, 1890	3	-	-	-
Caliothrips phaseoli Hood, 1912	3			
Frankliniella gardenia Moulton, 1948	6	-	-	-
Frankliniella bruneri Watson, 1926	5	-	-	-
Frankliniella occidentalis Pergande, 1895	1	-	-	-
Terebrantia Aeolothripidae		-	-	-
Franklinothrips orizabensis Johansen, 1974	1	-	-	-
Tubulifera Phlaeothripidae		-	-	-
Leptothrips sp. Hood, 1909	2	-	-	-

Evaluation of biorational insecticides

In the insecticides analysis, among applications only treatment 1 (Spintor®) showed significant differences between the 4th and 5th applications with an increase in thrips per plant (Figure 1).

Revista Bio ciencias
ISSN 2007-3380

Insecticides reached a percentage of higher effectiveness ranging from 32.4 to 73.5 % with respect to the control, on the other hand, Mix Protectivee C®, obtained higher effectiveness (73.5 %) than Spinosad, while the treatment with Mix Protectivee M®, obtained 32.44 % effectiveness. These results are similar to those reported by Lemus *et al*. (2017) when registering 91 and 93 % of effectiveness in the control of thrips of the Thripidae family, in cv. Hass avocado, using botanical insecticides based on Neem and Cinnamon.

Similarly, Zamora (2019), reported for the cultivation of blueberry and blackberry 92 % biological effectiveness on *Thrips* sp., *Frankliniella bruneri,* and *F. fortissima*, with the products FLY-NOT® (quilaya plant extract), Grandevo® (*Chromobacterium subtsugae*), Venerate® (*Burkholderia rinojensis*) and BIODie® (Argemonine, Berberine, Ricinine, and a- Terthienyl). In five applications, there were no significant differences between treatments (Table 4), with < 12 individuals per plant.

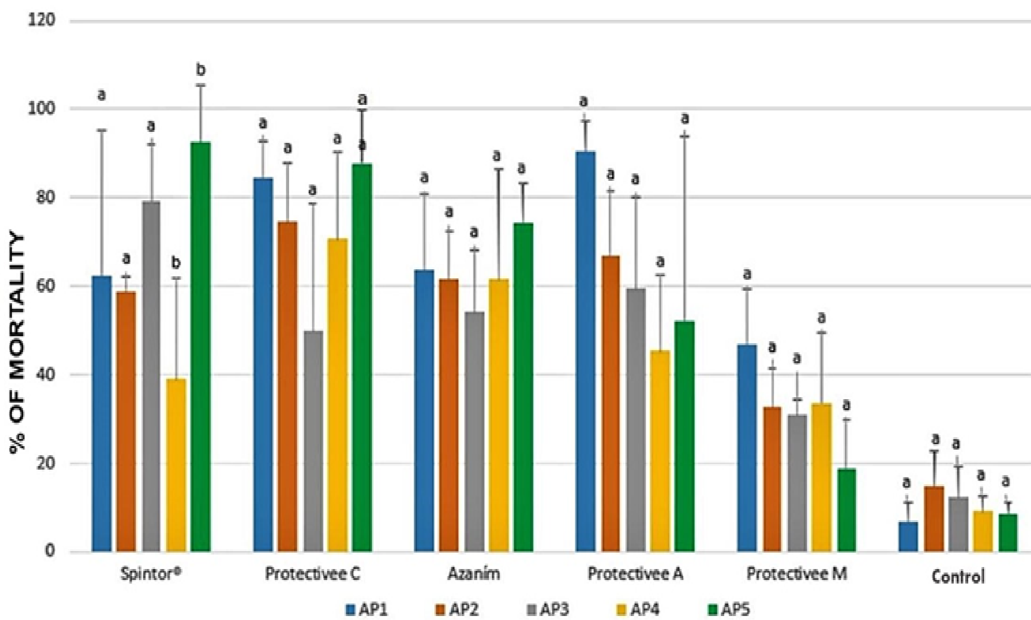

Figure 1. Thrips mortality percentage.

* Means with the same letter are statistically equal according to Tukey (p = 0.05). *AP: application.

Revista Bio ciencias
ISSN 2007-3380

Table 4. Number of thrips/plant in blueberry after applications of treatments in Xalisco and Tepic Nayarit, Mexico.

Treatment	DAA1	DAA2	DAA3	DAA4	DAA5
Control®	*23.3±2.7[a]	*35±2.5[a]	*34±3[a]	*32.6±4[a]	26.2±2.2[a]
Spintor®	4.8±3.6[a]	3.7±1[a]	1.3±9[a]	2.4±0.5[b]	0.3±0.5[a]
Mix Protectivee C®	3.7±1.5[a]	2.9±1[a]	3.2±2[a]	2.1±1.3[a]	0.5±0.5[a]
Azanim®	8±1.9[a]	5.1±2[a]	4.1±2[a]	2.8±2[a]	1.2±1.1[a]
Mix Protectivee A®	1.4±1[a]	2.5±2.3[a]	1.5±0.3[a]	2.6±2[a]	2.7±2.5[a]
Mix Protectivee M®	12.1±1.4[a]	11.2±2[a]	9.9±2[a]	8.2±2[a]	8.2±2.2[a]

*For each day of application, means between columns are statistically different (p < 0.05, Tukey).
*Days After Application.

Conclusions

Two suborders were identified, Terebrantia (99.9 %) and Tubulifera (0.06 %). In Terebrantia, *Scirtothrips dorsalis* (681 individuals), *Scolothrips sexmaculatus* (3), *Caliothrips phaseoli* (3), and *Frankliniella gardeniae* (6), *F. bruneri* (5), *F. occidentalis* (1), and *F. orizabensis* were identified. In Tubulifera, *Leptothrips* sp. was identified (2). On the other hand, the evaluation of the biorational insecticides showed that the product with the highest biological effectiveness was Mix Protectivee C® with 73.5 %, while Mix Protectivee M® was the one with the lowest value with 32.44 %.

Contribution of the authors

B.C.G.S. Development of the methodology; **Z.L.A.I.** Development of the methodology; **E.V.M.O.** Experimental validation; **L.S.B.** Work conceptualization; **R.B.A.** Experimental validation; **I.A.N.** Analysis of results; **C.A.C.B.** Data management; **C.C.O.J.** Fundraising, project manager.

"All authors of this manuscript have read and accepted the published version of it."

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Interest conflict

The authors declare no conflict of interest.

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