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VEGETAL SYNERGISTS FOR TRAPPING THE ADULT OF *SCYPHOPHORUS ACUPUNCTATUS* GYLLENHAL, IN PHEROMONE BAITED TRAPS, IN *AGAVE ANGUSTIFOLIA* HAW., IN MORELOS, MEXICO

SINERGISTAS VEGETALES PARA LA CAPTURA DEL ADULTO DE *SCYPHOPHORUS ACUPUNCTATUS* GYLLENHAL, EN TRAMPAS CON FEROMONA, EN *AGAVE ANGUSTIFOLIA* HAW., EN MORELOS, MÉXICO

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ABSTRACT. The agave weevil *Scyphophorus acupunctatus* Gyllenhal (Coleoptera: Dryophthoridae) is the main insect pest of wild and cultivated agaves in Mexico and in other countries. The management of this pest is complicated because to its cryptic habits. Recently, it has been developed a trapping system based with synthetic pheromone and food bait for monitoring this insect. However, an important part of the any trapping system is to know if any can synergize the response of the insect to the synthetic pheromone. In this study, we evaluated several vegetal tissue and ripped fruits for determining its potential as synergist for the synthetic pheromone for trapping the agave weevil in "agave espadín mezcal", in Tlaltizapán, Morelos state. The vegetal evaluated were: "maguey espadín criollo" tissue, "maguey espadín oaxaqueño" tissue, "maguey papalote" tissue, sugarcane tissue, ripped pineapple fruit, ripped banana fruit, ripped guava fruit, ripped apple fruit, and tuberose flower. Our results showed that the best synergists were agave tissue, pineapple, banana submerged in soapy water.

Key words: agave weevil; vegetal synergist; pheromone; trapping; agave

Cruz-Faustino, J. J., Figueroa-Castro, P., Alcántara-Jiménez, J. A., López-Martínez, V., Silva-García, F. (2019) Sinergistas vegetales para la captura del adulto de *Scyphophorus acupunctatus* Gyllenhal, en trampas con feromona, en *Agave angustifolia* Haw., en Morelos, México. *Acta Zoológica Mexicana (nueva serie)*, 35, 1–9. https://doi.org/10.21829/azm.2019.3502187

RESUMEN. *Scyphophorus acupunctatus* Gyllenhal (Coleoptera: Dryophthoridae) es el insecto plaga más importante de diversas especies de agave silvestre y cultivadas en México y otros países. El manejo de este insecto se dificulta debido a los hábitos bio-ecológicos del insecto. Recientemente, se ha desarrollado un sistema de trampeo basado en feromona sintética y cebo alimenticio para monitorear a este insecto. Sin embargo, es importante conocer algunos vegetales que pueden sinergizar la respuesta de este picudo a la feromona sintética. En este estudio, se evaluaron diversos vegetales en trampas colocadas en una plantación de agave espadín, en Tlaltizapán, Morelos. Los sinergistas vegetales evaluados fueron: tejido vegetal de maguey mezcalero espadín criollo (*Agave angustifolia* Haw.), espadín oaxaqueño (*Agave angustifolia* Haw.) y maguey mezcalero papalote (*Agave cupreata* Trel.), tejido de caña de azúcar, fruta madura de piña, plátano, guayaba y manzana, y flor de nardo. Se encontró que los mejores sinergistas fueron tejido de agaves, piña y plátano sumergidos en el agua jabonosa de la trampa.

Palabras clave: picudo del agave; sinergistas vegetales; feromona; trampeo; agave

INTRODUCTION

The espadín maguey (*Agave vivipara* L. =*Agave angustifolia* Haw.), is essential for mezcal production in Mexico, and is a good source of employment and incomings for families of rural zones of Guerrero and Morelos (F. S. G. and P. F. C., unpublished data). The agave production is affected by several problems as diseases, weeds, and pest insects (Valenzuela, 2003; CRT, 2005), in the case of insect pests the most important species is the agave weevil (*Scyphophorus acupunctatus* Gyllenhal) (González *et al*., 2007) which attacks several *Agave* species including the henequen (*Agave fourcroydes* Lem.) (Halffter, 1957), blue agave (*Agave tequilana* Weber) (Solís-Aguilar *et al*., 2001) and mezcal maguey (A*gave angustifolia* Haw. and *Agave cupreata* Trel. & Berger) (Aquino *et al*., 2007; Figueroa-Castro *et al*., 2016). The weevil larvae drilled the periferic and central part of maguey, sometimes damaging leafs, this feeding habit cause damage the agave root (CRT, 2005; González *et al*., 2007).

Adults of *S. acupunctatus* frequently are found in the basal leaf or inside the "piña", in high infestations this weevil can be found also in the agave heart and in the "quiote". The adult is present and active during all the year, but is most abundant and active in the rainy season and with high temperatures (Ramírez-Choza, 1993; González *et al*., 2007; Figueroa-Castro *et al*., 2013).

In addition to the direct damage caused by larvae and adults (Solís-Aguilar *et al*., 2001; González *et al*., 2007; Aquino *et al*., 2007) this weevil is a transmitter of some pathogens that attack and can cause the died of the agave (Aquino *et al*., 2011).

The management of this pest is difficult because its cryptic habits, all biological cycle occurs inside the agave plant, when food resource ends, this pest emigrates searching new plantations for colonization, females and/or males (Figueroa-Castro *et al*., 2015) can start the infestation process also.

One basic tool in integrated pest management programs is the monitoring of pest population density (Rojas *et al*., 2008), in the case of *S. acupunctatus* a trapping system based in pheromone and food attractants baited traps has been developed (Ruiz-Montiel *et al*., 2008; Rodríguez-Rebollar *et al*., 2012; Figueroa-Castro *et al*., 2013). An important factor for optimizing the trapping system for monitoring or controlling insect pests is the use of ripped fruits or host tissue that works as synergists and increases insect captures (Figueroa-Castro *et al*., 2017). For different weevil species, researchers had tested several fruits as potential synergists, for example, sugarcane for the west Indian sugarcane weevil (Alpizar *et al*., 2002), guava fruits for the guava weevil (González *et al*., 2010). For agave weevil tuberose bulbs (García-Ramírez *et al*., 2014), agaves, pine apple, and banana (Figueroa-Castro *et al*., 2017) had been evaluated.

However, until now, the most common synergist source for agave weevil is fresh agave tissue (Figueroa-Castro *et al*., 2017; Figueroa-Castro *et al*., 2018), although it is important to know if other fruits and tissue can work as synergist for increasing the captures of this weevil in pheromone-baited traps. With the objective of found more options of synergists that increase the number of weevils trapped per trap, we evaluated several vegetal fruits and tissues as synergists in pheromone-baited in espadín agave.

MATERIALS AND METHODS

This research was performed in a "maguey espadín" (*Agave angustifolia* Haw.) plantation in Barranca Honda, Tlaltizapan, Morelos, Mexico (five hectares, five years-old). We conducted three consecutive field trials (December 2017 to February 2018), in each trial were evaluated different food attractants to determine the best alternative vegetal synergist to aggregation synthetic pheromone for trapping the agave weevil.

The trap design used was TOCCIA of 4 liters, white color (Figueroa-Castro *et al*., 2016). The killing agent for trapping weevils was 1 liter of soapy water at 5%. Traps were buried at trap holes (entry) level. Distance between traps was at least 50 m. Traps checking (collected trapped weevils), change of food attractant and killing agent application were biweekly. The synthetic pheromone used was Tequilur® (FeroComps, Mexico City, Mexico), pheromone dispensers were new at start of each experiment. The complete time of this research were three months, each experiment had a month duration.

First experiment. Were evaluated the following treatments: 1) empty trap (without attractants), 2) trap with pheromone without synergist, 3) trap with pheromone + 400 g of "maguey espadín criollo" (*Agave angustifolia* Haw.) tissue, 4) trap with pheromone + 400 g of "maguey espadín oaxaqueño" (*Agave angustifolia* Haw.) tissue, 5) trap with pheromone + 400 g of "maguey papalote" (*Agave cupreata* Trel.) tissue, 6) trap with pheromone + 400 g of ripped pineapple fruit (*Ananas comosus* L.), 7) trap with pheromone + 400 g of ripped banana (*Musa paradisiaca* L.) fruit, 8) trap with pheromone + 400 g of sugarcane (*Saccharum officinarum* L.) tissue, 9) trap with pheromone + 100 g of tuberose (*Polianthes tuberosa* L.) flower, and 10) trap with pheromone + 400 g ripped of guava (*Psidium guajava* L.) fruit. This experiment was establishment in a completely experimental design with four replications.

Second Experiment. Were evaluated the following treatments: 1) empty trap (without attractants), 2) trap with pheromone without synergist, 3) trap with pheromone + 400 g of "maguey espadín criollo" tissue, 4) trap with pheromone + 400 g of "maguey espadín oaxaqueño" tissue, 5) trap with pheromone + 400 g of "maguey papalote" tissue, 6) trap with pheromone + 400 g of ripped pineapple fruit, 7) trap with pheromone + 400 g of ripped banana fruit, 8) trap with pheromone + 400 g of sugarcane tissue, 9) trap with pheromone + 400 g of ripped apple (*Malus domestica* Borkh)fruit, 10) trap with pheromone + 400 g of ripped guava fruit. This experiment was establishment in a completely experimental design with four replications.

Third experiment. Were evaluated the following treatments: 1) trap with pheromone without synergist, 2) trap with pheromone + 400 g of ripped banana fruit hanged*, 3) trap with pheromone + 400 g of ripped banana fruit submerged**, 4) trap with pheromone + 400 g ripped pineapple fruit hanged, 5) trap with pheromone + 400 g of ripped pineapple fruit submerged, 6) trap with pheromone + 400 g of "maguey espadín oaxaqueño" tissue hanged, 7) trap with pheromone + 400 g of "maguey espadín oaxaqueño" tissue submerged, 8) trap with pheromone + 400 g of sugarcane tissue hanged, 9) trap with pheromone + 400 g of sugarcane tissue submerged, 10) trap with pheromone + 400 g ripped guava fruit hanged, 11) trap with pheromone + 400 g ripped guava fruit submerged. This experiment was establishment in a completely experimental design with factorial arrangement, with four replications. *hang means that the food bait do not have contact with the soapy water, the food bait was hung in a plastic container with 8 holes of 1 cm of diameter in the trap. ** Submerged means that the food bait or synergist is in the soapy water.

Captured weevils were placed in labeled plastic containers, and transported to laboratory for counting and sex classification, according to Ramírez-Choza (1993).

Collected data was checked for normality (Shapiro-Wilk test) and homogeneity of variances tests, an ANOVA tested treatment means with Tukey (α= 0.05). A Chi-squared test was applied to determine differences in the number of females and males caught by treatment.

RESULTS AND DISCUSSIONS

In the first experiment, we found significant statistical differences between treatments (F = 24.12; df = 9, 30; P= <0.0001), higher captures were obtained in traps baited with the synthetic pheromone plus any food bait "papalote" (18.50 ± 5.06), "criollo" (13.25 ± 0.85) and "oaxaqueño" maguey (16.0 ± 4.42), tuberose (8.5 ± 2.4), sugar cane tissue (23.0 ± 3.9), pineapple (28.3 ± 15.7), banana (22.3 ± 2.21) and guava fruit (21.8 ± 1.8) than traps baited only with pheromone (0.0). Empty traps did not captured weevils (Fig. 1).

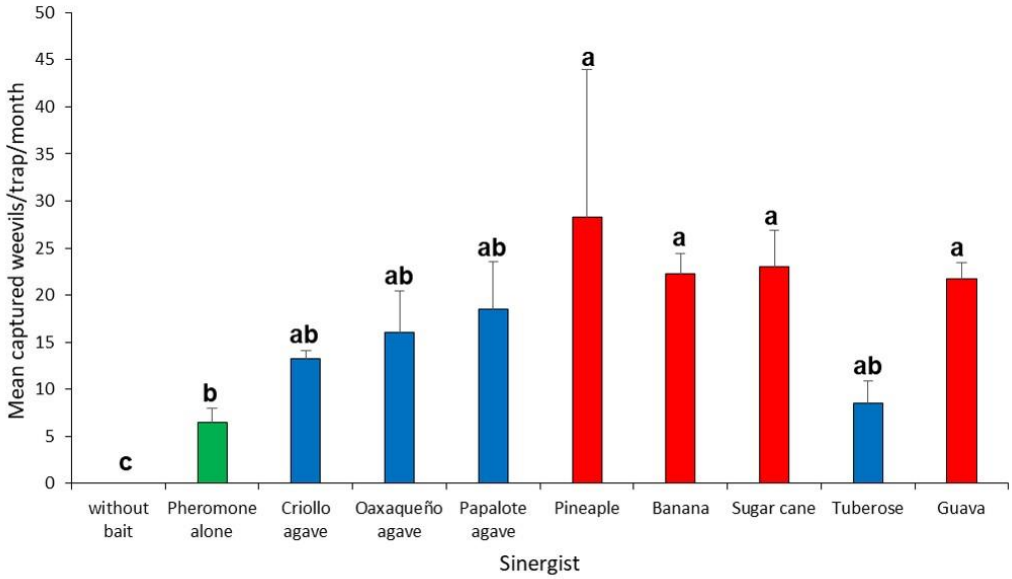

Figure 1. Mean number of captured weevils in pheromone-baited traps with different vegetal synergists in espadín maguey in Barranca Honda, Tlaltizapan, Morelos. Bars with similar letters are not significantly different (Tukey's test, α = 0.05). Means presented in this graph are an average of the four replications.

In the second experiment, significant statistical differences between treatments were detected (F = 3.40; df = 9, 30; P= 0.0055), higher captures were obtained in traps baited with the synthetic pheromone plus pineapple (10.75 ± 5.2) or banana (8.75 ± 1.4), than traps baited only with pheromone (0.8 ± 0.5) or baited with other food baits. Empty traps did not captured weevils (Fig. 2).

In the third experiment, treatments showed statistical differences (F = 2.75; df = 10, 33; P= <0.0139), higher captures were obtained in traps baited with the synthetic pheromone plus any food bait. Traps in which the food bait was placed submerged in the soapy water captured more weevils than traps baited with pheromone alone (Fig. 3).

The fact that some vegetal tissues and some fruits synergized the responses of agave weevils to the synthetic pheromone has been reported previously, Figueroa-Castro *et al*. (2017) recorded that tissue of

"papalote" maguey, and ripped fruits (banana and pineapple) worked as synergists increasing number of captured weevils in pheromone-baited traps. In addition, Ruiz-Montiel *et al*. (2017) evaluated tissue of "pulquero agave", blue agave and ornamental agave and tuberose bulbs, and found that tuberose bulbs were the most attractive for this weevil. Similar responses in other weevils with vegetal tissues or ripped fruits as synergists have been reported (Oehlschlager *et al*., 1993; Giblin-Davis *et al*., 1996; Tinzaara *et al*., 2007; Wibe *et al*., 2014).

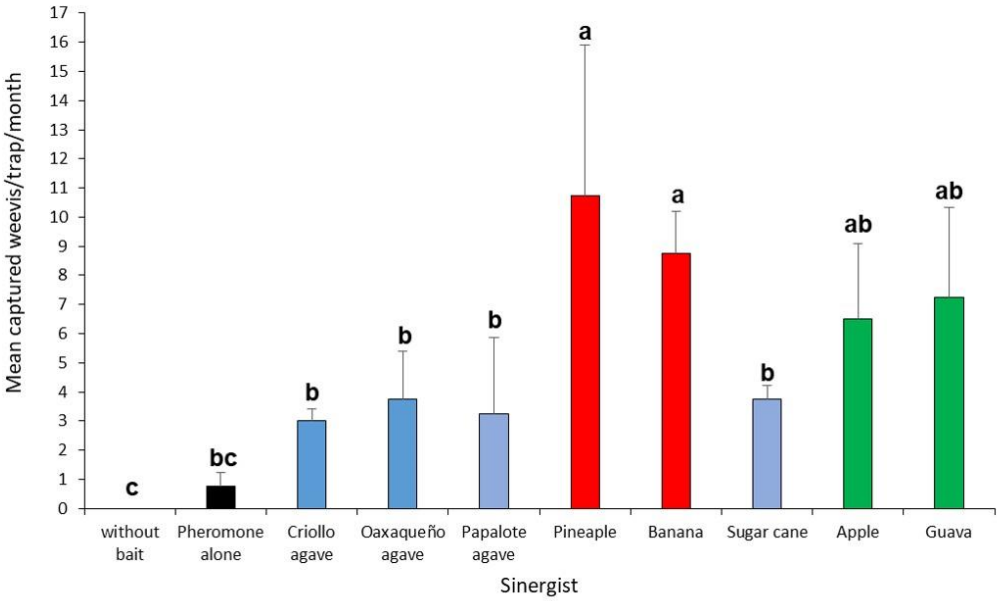

Figure 2. Mean number of captured weevils in pheromone-baited traps with different vegetal synergists in espadín maguey in Barranca Honda, Tlaltizapan, Morelos. Bars with similar letters are not significantly different (Tukey's test, $\alpha = 0.05$). Means presented in this graph are an average of the four replications.

Respect to the synergists, in our study the best food attractants were "papalote" maguey tissue, and banana and pineapple ripped fruits, these baits (banana and pineapple) have been reported previously as food attractants for trapping this and other weevil species. Pineapple was evaluated by García-Ramírez *et al*. (2014) for trapping this pest on tuberose plant [*Polianthes tuberosa* L. cv Perla (Asparagaceae)]. Figueroa-Castro *et al*. (2013) and Figueroa-Castro *et al*. (2016) used agaves tissue for collecting *S. acupunctatus* in blue agave and mezcal maguey, respectively. Agave tissue, ripped banana fruit and ripped pineapple fruit were reported as synergists for agave weevil by Figueroa-Castro *et al*. (2017). Banana was tested by Al-Saoud and Ajland (2013) for collecting *Rhynchophorus ferrugineus* Olivier, and by Sumano *et al*. (2012) for trapping *R. palmarum* L. Banana and pineapple fruits appears to be good synergists for agave weevil, with similar captures as reported for agave tissues, but with additional advantages: 1) cheaper, 2) abundant, 3) easy to buy, and 4) with no direct impacts for agave production when agave has high value.

Respect to sexual proportion of captured weevils in most of the traps were captured significantly more females than males (Table 1), data similar to previous reports (Figueroa-Castro *et al*., 2013; Figueroa-Castro *et al*., 2017; and Figueroa-Castro *et al*., 2018).

Based on our results, for trapping the agave weevil on cultivated agaves we suggest always to use as vegetable synergists 400 g of ripped fruit (banana or pineapple) or 400 gr of fresh agave tissue; whatever of these baits submerged in soapy water.

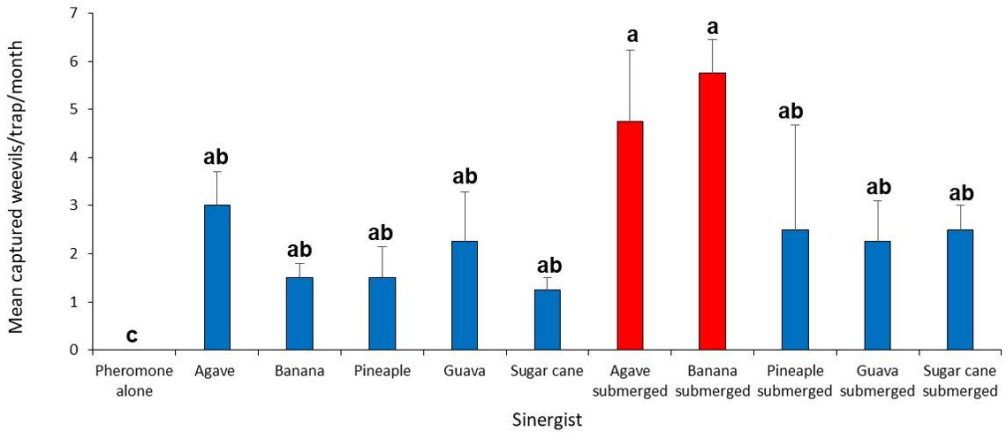

Figure 3. Mean number of captured weevils in pheromone-baited traps with different vegetal synergists in espadín maguey in Barranca Honda, Tlaltizapan, Morelos. Bars with similar letters are not significantly different (Tukey's test, $\alpha = 0.05$). Means presented in this graph are an average of the four replications.

Table 1. Percent of females and males captured in pheromone-baited traps with different vegetal synergists.

Experiment	Synergist	Females (%)	Males (%)	X^2	$Pr>X^2$
1	Without bait	0.00	0.00	NA	NA
	Pheromone alone	69.37	30.63	15.05	0.0001
	Criollo agave	48.88	51.12	0.0502	0.8228
	Oaxaqueño agave	73.33	26.67	21.7716	<.0001
	Papalote agave	67.03	32.97	11.6008	0.0007
	Pineapple	64.16	35.84	8.0202	0.0046
	Banana	59.67	40.33	3.7404	0.0531
	Sugarcane	58.59	41.41	2.9515	0.0858
	Tuberose	59.47	40.53	3.5872	0.0582
	Guava	60.45	39.55	4.3681	0.0366
2	Without bait	0.00	0.00	NA	NA
	Pheromone alone	66.66	33.34	11.1022	0.0009
	Criollo agave	82.86	17.14	43.1912	<.0001
	Oaxaqueño agave	50.00	50.00	0.000000	1.00000
	Papalote agave	77.50	22.50	30.25000	<.0001
	Pineapple	64.00	36.00	7.84000	0.0051
	Banana	66.25	33.75	10.5625	0.0012
	Sugarcane	72.22	27.78	19.7491	<.0001
	Apple	73.07	26.93	21.289	<.0001
	Guava	41.05	58.95	3.2041	0.0735
3	Pheromone alone	0.00	0.00	NA	NA
	Agave	50.00	50.00	0.000	1.000
	Banana	50.00	50.00	0.000	1.000
	Pineapple	66.67	33.33	11.116	0.001
	Guava	45.00	55.00	1.000	0.317
	Sugarcane	16.67	83.34	44.449	<.0001
	Agave submerged	57.22	42.78	2.085	0.149
	Banana submerged	61.89	38.11	5.655	0.017
	Pineapple submerged	70.00	30.00	16.000	<.0001
	Guava submerged	65.00	35.00	9.000	0.003
	Sugarcane submerged	35.72	64.28	8.157	0.004

CONCLUSIONS

In conclusion, the best synergists were agave tissue, pineapple and banana, all submerged in soapy water because reach the highest captures of agave weevils.

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