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Coffee berry borer (*Hypothenemus hampei* Ferrari) trapping in coffee (*Coffea arabica* L.) with artisan traps at el Paraíso, Guerrero, Mexico

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ABSTRACT

Objective: To evaluate three proportions of alcohol in traps with one and three windows and two different colors to capture *Hypothenemus hampei* Ferrari in *Coffea arabica* L. plants.

Design/methodology/approach: The experiment followed a completely randomized design with a complete factorial arrangement and four replications. From March to July 2007, three mixtures of ethyl: methyl alcohol were evaluated in different proportions (1: 0, 0: 1 and 1: 1). In addition, green and transparent traps were used, designed with a single or three windows. The number of captured coffee berry borers, water loss, attractant evaporation and damaged fruits percentage was evaluated. The data were analyzed through an analysis of variance and a test of means differences (Tukey, $p \leq 0.05$).

Results: The mixture of ethyl: methyl alcohol 1: 1 was the best, with an average catch of 980 trapped - insects week^{-1}. The single window of transparent color traps was the most efficient to avoid water loss, with an average loss of 1,129.79 mL and 905 mL respectively.

Limitations on study/implications: The design and color of the traps did not influence the capture efficiency and the evaporation of the attractant during the evaluated months. Therefore, it should be further evaluated during other important phenological stages for the crop.

Findings/conclusions: Transparent color traps with a window and 1: 1 ethyl: methyl alcohol were efficient for capturing *H. hampei* and lowering their population.

Keywords: *Hypothenemus hampei* Ferrari, *Coffea arabica* L., attractant, capture and coffee berry borer.

INTRODUCTION

Coffee (*Coffea arabica* L.) is of great economic importance worldwide. In 2018 the average world production was 10,403,454 t. Brazil produced 3,556,638 t, followed by Vietnam 1,616,307 t,

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Indonesia 722,461 t, and Colombia 720,634 t. Mexico ranked eleventh with 158,325 t (FAO, 2020).

In 2018, Mexico registered a planted area of 21,163,051.24 ha, with an average production of 282,569 t and an estimated commercial value of the production of $ 641,026,369.00 (Mexican pesos). The state of Guerrero registered 45,839.05 ha distributed throughout the Costa Grande and Costa Chica regions (SIAP, 2018).

One of the serious phytosanitary problems that coffee presents is the attack of the coffee berry borer (CBB) (*Hypothenemus hampei* Ferrari), which causes losses of up to 80% of production (Benavides and Arévalo, 2002). This pest is endemic to central Africa and distributes in the coffee-growing regions of the world (Rosales *et al*., 1999). Most of the insect's life cycle is feeding on seeds or grains (Barrera, 2002; Barrera, 2013). Due to this, studies continue to develop technologies for its control and the insect´s biology has been studied for better management strategies (Giraldo-Jaramillo *et al*., 2018). Tests have been carried out with chlorantraniliprole, an ingestion insecticide against coleopteran larvae with a new mode of action and low impact with other insects, such as bees. Cyantraniliprole is another insecticide with a mortality effect that affects the behavior of *H. hampei* (Plata-Rueda *et al*., 2019A; Plata-Rueda *et al*., 2019B). In the field, the specimens are captured with attractant traps, where a single trap with methanol-ethanol can capture hundreds of insects per week (Barrera *et al*., 2008) and even with the use of terpenes as repellants (Góngora *et al*., 2020). Celestino *et al*. (2016) evaluated a wide variety of botanical oils, mineral oils and azadirachtin for the control of *H. hampei* but these were not effective.

The objective of this research was to evaluate the effect of three concentrations of alcohol in traps with one and three windows and two different colors to capture *H. hampei* at El Paraíso, municipality of Atoyac de Álvarez, Guerrero, Mexico.

MATERIALS AND METHODS

Experiment location

The research took place in a commercial coffee plantation at El Paraíso, Guerrero, Mexico, located between coordinates 17° 38' 91'' LN, 100° 19' 38'' LW, 1150 m above sea level. The region's climate is A(C)w2 semi-warm subhumid (INEGI, 2012; CESAVEGRO, 2013). The evaluation was carried out from March to July 2007, in a 3 ha area.

Establishment of the experiment and design

The plants under study were marked. The distance between traps was 20 m. A completely randomized design was used in a complete factorial arrangement with four repetitions. The experimental units were the different alcohol proportions in each trap. The traps were placed on a secondary branch at a 1.50 m height; they were marked with a treatment and repetition number to identify and locate it.

Traps crafting

The traps were made with 2 L capacity polyethylene terephthalate-polyester (PET) containers (Figure 1A). For the single window traps (5×5 cm; Figure 1B) a quadrangular cut was made in the middle of the containers. For the three-window trapS, quadrangular holes of the same size were made, distributed in such a way that each window had a barrier in front that would cause an effect of knocking down the insects when they entered the interior of the trap (Figure 1C). The traps were distributed in the orchard as described (Figure 1D). Inside the trap, a dropper with the attractant was installed in the middle of the windows and secured with A 35 cm wire at one end. The mixtures were previously prepared with the proportions of ethyl and methyl alcohol with the help of a syringe and the dropper was filled. With the other end of the wire, the trap was attached to the stem of the plant (Figure 1D).

Treatments

For the evaluation of the variable, three factors were considered: a) Trap design: with one and three windows, b) Trap color: green or transparent, and c) Proportions of ethyl and methyl alcohol: 1: 0, 0: 1 and 1: 1. The combination of these three factors generated 12 treatments shown in Table 1.

Captured CBBs by treatments

The number of captures per treatment was quantified to evaluate the effectiveness of the different treatments. The water from the traps was emptied into a container, separating the captured with a filter.

Water and attractant loss by trap

The water expenditure (mL per week) was quantified with a graduated cylinder when changing the attractant in each trap, to see which lost more water.

The attractant remaining amount per trap was also measured with a graduated cylinder to assess the

evaporation loss and calculate its periodicity for each design.

Infestation percentage

Four samples were taken per experimental unit, at a height of 1.5 m at each cardinal point, each with 25 coffee beans, of which the number of brocaded beans was recorded to calculate the percentage of infestation in each assessed plant.

Statistical analysis

A multivariate analysis of variance (MANOVA) was used with a factorial blocks design and the logarithmic transformation of the number of drilled seeds plus one to normalize the residuals. Subsequently, a means comparison was carried out using the Tukey test (α=0.05) to determine which factor levels were the best.

RESULTS AND DISCUSSION

Nineteen records were made of the number of borers captured per installed trap; the evaluations were weekly made.

Captured borers by treatment

The MANOVA results showed that the main effects of trap design, ethanol: methanol ratio and trap color were significant (p=0.002, p=0.002, p=0.001, respectively), but not the three interactions (Table 2).

Figure 1. Traps to capture of *H. hampei* in El Paraíso, Guerrero, Mexico. A) Materials used; B) Trap with one window; C) Trap with three windows; D) Identification and placement of traps.

Table 1. Treatments evaluated for the study of *H. hampei* in El Paraíso, Guerrero, Mexico.

No. Treatment	Trap design	Alcohol	Color of the trap
1	A window	1:0	green
2	A window	0:1	green
3	A window	1:1	green
4	A window	1:0	transparent
5	A window	0:1	transparent
6	A window	1:1	transparent
7	Three windows	1:0	green
8	Three windows	0:1	green
9	Three windows	1:1	green
10	Three windows	1:0	transparent
11	Three windows	0:1	transparent
12	Three windows	1:1	transparent

Regard the capture effectiveness for the coffee borer, it was observed that the ethanol: methanol 1: 1 ratio is the one that recorded the highest capture, an average of 980 trapped insects week 1, followed by 0: 1 and finally 1: 0 (Table 3). These results coincide with those observed by Fernández and Cordero (2005), where they evaluated different attractants and their methyl and ethyl alcohol treatment was superior to the others, with average 400 captured adults per week.

Regard the trap color, the transparent color captured a greater number than the green color. Finally, it is

Table 2. Analysis of variance of the variable number of coffee berry borer per trap.

Source of variation	Pr>F	Significance
Design* Attractive proportions	0.4506	ns
Design*Color	0.4272	ns
Attractant proportions *Color	0.6480	ns
Design*Attractive proportions *Color	0.9624	ns

* P≤0.05 ** P≤0.01 ns: not significant

observed that the design with three windows is better than the single window, which concurs with that reported by Barrera *et al*. (2008), who evaluated two types of traps (ETOTRAP® and ECOIAPAR®) with a mixture of methanol: ethanol in a 3: 1 ratio, respectively, concluded that the design of the trap influences the attraction efficiency.

The traps used in this study are an excellent tool to lower *H. hampei* populations weekly and can be part of an integrated management strategy with other different techniques or tools because insecticide tests with new action pathways against larvae have been carried and have shown to be friendly with parasitoid insects, predators and pollinators (Plata-Rueda *et al*., 2019A). Insecticides such as Ciantraniliprole have lethal and sublethal effects that affect their behavior (Plata-Rueda *et al*., 2019B); and terpenes, botanical and mineral essential oils with insecticidal and repellent effects (Celestino *et al*., 2016; Etztli *et al*., 2019; Góngora *et al*., 2020) or the use of *Bacillus thuringiensis* for first instar larvae (López-Pazos *et al*., 2009).

Table 3. Efficiency of the proportions of alcohol in the capture of *H. hampei*, in El Paraíso, Guerrero, Mexico.

Proportions ethanol:methanol	Number of coffee berry borer
1:1	980.00 a
0:1	473.60 b
1:0	143.6 c

Tukey's test ($p<0.05$), values with the same letter in the column are not significantly different.

Table 4. Water loss in mL per trap depending on the number of windows.

Design	Water loss (mL)
Three windows	1,997.38 a
A window	1,129.79 b

Tukey's test ($p<0.05$), values with the same letter in the column are not significantly different.

Water loss per trap

It was observed that the weekly water loss by evaporation presented differences according to the design ($Pr>F=0.0001$) and the color ($Pr>F=0.0415$) of the trap, as well as the interaction of these ($Pr>F=0.0121$).

The highest water loss occurred in the three window traps (1,997.38 mL per week) than in the traps with single window ones (1,129.79 mL per week) (Table 4).

The observed differences in water loss were according to the color and the design of the traps. The transparent color presented less evaporation or loss of water (1,501.63 mL per week), while the green traps lost 1,625.54 mL per week. This can be attributed to the conditions of the coffee plantation, since, in shaded coffee plantations, the relative humidity is higher than in those exposed to the sun (PROCAFE, 2013). Regard the water loss in traps due the number of windows, differences were observed between the treatments, where the three windows design is statistically the same and different from the treatments of one window. Noting that the three window traps had a greater water loss (1,919.5 to 2,090.5 mL per week), while the single window traps recorded lower water loss (905.0 to 1,3056.5 mL per week) (Table 5).

Loss of attractant by trap

This estimation was made with the amount of the mixture per dropper at the time of installation of the traps of each of the treatments and the difference in the second reading at the time of removing the dropper from the trap. No difference was observed in the ethanol-methanol ratios, design and color of the trap, as well as their interactions. Unlike other research, when evaluating alcoholic attractants in artisanal traps to capture adult female coffee borers (*H. hampei*), higher consumption of attractant was observed in the methanol: ethanol 1:1 treatment, the methanol-ethanol 3:1 treatment recorded higher captures than other treatments and a lower attractant consumption (Espinoza, 2013).

Table 5. Interactions of the design with the color of the trap in the loss of water.

No. treatment	Trap (No. Windows)	Color of the trap	Water loss (mL)
1	1	green	1,219.3 c
2	1	green	1,235.5 c
3	1	green	1,356.5 bc
4	1	transparent	1,106.0 c
5	1	transparent	905.0 c
6	1	transparent	959.5 c
7	3	green	2,047.0 a
8	3	green	1,970.0 a
9	3	green	1,928.0 a
10	3	Transparent	2,029.3 a
11	3	Transparent	2,090.5 a
12	3	Transparent	1,919.5 ab

Tukey's test ($p<0.05$), values with the same letter in the column are not significantly different.

Infestation percentage

The lowest infestation is observed in the 1:0 ethyl and methyl alcohol mixing ratio, with a mean of 0.9125. The highest infestation was recorded with the 1:1 ratio of ethyl and methyl alcohol of 1.4375, respectively (Table 6).

It should be noted that CBBs catch is not directly proportional to the infestation percentage, because the attractant attracts CBBs from neighboring properties with high infestations, usually those abandoned.

Table 6. Level of infestation by *H. hampei* according to the ethyl: methyl alcohol ratios and the percentage of damaged fruits.

Proportion (ethyl:methyl)	Infestation level (%)
1:1	1,4375 a
0:1	1,2500 ab
1:0	0.9125 b

Tukey's test ($p<0.05$), values with the same letter in the column are not significantly different.

CONCLUSIONS

The ratio of ethyl alcohol: methyl 1:1 presented the highest capture rate of the coffee berry borer (*H. hampei* Ferrari). The trap color does not influence the *H. hampei* capturing, the evaporation of the attractant and the level of infestation. The traps with a single-window and a transparent color were the ones that recorded the least water loss.

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REFERENCES

Barrera, J.F. (2002). La Broca del Café: Una plaga que llego para quedarse. Plagas del Café en Chiapas. Colegio de la Frontera Sur. 17-20.

Barrera, J.F., Herrera, J., Chiu, M., Gómez, J. y Valle, M.J. (2008). La trampa de una ventana (ECOIAPAR) captura más Broca del Café *Hypothenemus hampei*, que la trampa de tres ventanas (ATOTRAP). Entomología Mexicana. 7: 619-624.

Barrera, J.F. (2013). Ficha técnica Broca del Café *Hypothenemus hampei* SENASICA-Dirección General de Sanidad Vegetal.

Benavides, P. y Arévalo, M. (2002). Manejo Integrado: una estrategia para el control de la broca del café en Colombia. CENICAF. 53(1): 39-48

Celestino, F.N., Pratissoli, D., Machado, L.C., Santos, H.J., Queiroz, V.T. & Mardgan, L. (2016). Control of coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae: Scolytinae) with botanical insecticides and mineral oils. Acta Scientiarum. Agronomy, 38(1), 1-8. https://doi.org/10.4025/actasciagron.v38i1.27430

CESAVEGRO, Comité Estatal de Sanidad Vegetal de Guerrero. (2013). Sistema de Información de Campañas Fitosanitarias (SICAFI). Campaña contra Broca del Café. Consulta realizada en https://cesavegro.org.mx/plagas-del-cafeto/.

Espinoza, A.F. (2013). Evaluación de Atrayentes Alcohólicos en trampas artesanales para la captura de hembras adultas de broca del café *Hypothenemus hampei* (Ferrari) en la Estación Experimental de San Pedro de la loma-Coroico. Tesis de grado para obtener el título de: Licenciatura en Ingeniería Agronómica. La Paz-Bolivia.

Etztli, I.M., Reyes, S.F., Eliete, M.P., Claudinei, A.F., Plata, A.B., Picanço, M.C. & Barbosa, C.A. (2019). Eucalyptus resinifera essential oils have fumigant and repellent action against *Hypothenemus hampei*. Crop Protection 116: 49-55. https://doi.org/10.1016/j.cropro.2018.09.018.

FAO, Food and Agriculture Organization (2020). FAO: Estadísticas. http://www.fao.org/faostat/es/?#data/QC. Consultada el 08 de febrero del 2020.

Fernández, S. y Cordero, J. (2005). Evaluación de atrayentes alcohólicos en trampas artesanales para el monitoreo y control de la broca del café, *Hypothenemus hampei* (Ferrari). BIOAGRO. 17(3): 143-148.

Giraldo-Jaramillo, M., Garcia, G.A. & Parra, R.J. (2018). Biology, Thermal Requirements, and Estimation of the Number of Generations of *Hypothenemus hampei* (Ferrari, 1867) (Coleoptera: Curculionidae) in the State of São Paulo, Brazil, Journal of Economic Entomology, 111(5): 2192–2200. https://doi.org/10.1093/jee/toy162

Góngora, C.E., Tapias, J., Jaramillo, J., Medina, R., Gonzalez, S., Casanova, H., Ortiz, A. & Benavides, P. (2020). Evaluación de compuestos terpénicos volátiles repelentes al barrenador del café, *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae). J. Chem. Ecol. 46: 881–890. https://doi.org/10.1007/s10886-020-01202-5

INEGI (2012). Instituto Nacional de Estadística, Geografía e Informática. Gobierno del Estado de Guerrero, Anuario Estadístico del Estado de Guerrero. 601.

López-Pazos, S.A., Cortázar, J.A. & Cerón, S.A. (2009). Cry1B and Cry3A are active against *Hypothenemus hampei* Ferrari (Coleoptera: Scolytidae). Journal of Invertebrate Pathology 101(3): 242-245.

Plata-Rueda, A., Martínez, L.C., Rodrigues, N.C., Cola, J., Sena, M.E., Serrão, J.E., Carvalho, R.N. & Lemes, F. (2019A). Chlorantraniliprole–mediated effects on survival, walking abilities, and respiration in the coffee berry borer, *Hypothenemus hampei*, Ecotoxicology and Environmental Safety, 172: 53-58. https://doi.org/10.1016/j.ecoenv.2019.01.063.

Plata-Rueda, A., Martínez, L.C., Da Silva, B.K., Zanuncio, J.C., Fernandes, M.D., Guedes, R.N. & Fernandes, F.L. (2019B). Exposure to cyantraniliprole causes mortality and disturbs behavioral and respiratory responses in the coffee berry borer (*Hypothenemus hampei*). Pest Management Science. https://doi.org/10.1002/ps.5358

PROCAFE (2013). Fundación Salvadoreña para Investigaciones en Café. Consulta realizada en: http://www.procafe.com.sv/menu/Generalidades/CondicionesAgroecologicas.htm.

Rosales, M.M., Silva, A. y Rodríguez, G.G. (1999). Estrategia para el manejo integrado del minador de la hoja y la broca del fruto del café (en línea). FONAIAP.

SIAP, Servicio de Información Agroalimentaria y Pesquera. (2018). www.siap.gob.mx. Consultada el 25 de febrero, 2018.