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Control de mosca de la fruta del género *Anastrepha* mediante estaciones cebo en huertos comerciales de mango

TESIS
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Maestría en Ciencias en Recursos Naturales y Desarrollo Rural

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Jorge Villalobos Cruz

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A mi esposa Doris

y mis hijos Mateo y Andrés

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Contenido

I. Introducción

El mango (*Mangifera indica* L) es uno de los frutos de mayor preferencia para su consumo en fresco. Esta especie se cultiva en todos los países de Latinoamérica, siendo México, junto con la India, el principal país exportador a nivel mundial (SIAP 2013). Entre los principales problemas fitosanitarios que afectan al cultivo de mango, destacan las moscas del género *Anastrepha* (Diptera: Tephritidae) (Hernández-Ortiz y Aluja 1993), particularmente *Anastrepha ludens* (Loew) y *A. obliqua* (Macquart) (Aluja et al. 1996).

Las moscas de la fruta del género *Anastrepha* afectan la fruticultura, ya que las larvas se alimentan de la pulpa de los frutos, incrementando el costo de control fitosanitario y la imposición de medidas cuarentenarias por parte de los países donde la plaga no está presenta (Reyes et al. 2000, Montoya et al. 2007). Estudios realizados en la región del Soconusco, Chiapas, señalan que las especies predominantes en el cultivo del mango son *A. lud*ens y *A. obliqua* (Aluja et al. 1996).

Para la supresión y/o erradicación de estas plagas, desde 1992, el gobierno mexicano implementó la Campaña Nacional contra Mosca de la Fruta (NOM-023-FITO-1995). Esta campaña establece los lineamientos básicos para el manejo integrado de esta plaga que incluyen acciones de combate mecánico, control químico, control biológico aumentativo, el uso de la técnica del insecto estéril (TIE) y el control legal (Gutiérrez 2010). La aplicación de estos métodos genera gastos, por lo que es necesario explorar otras alternativas que sean eficientes y a la vez permitan abaratar los costos. Por ejemplo, el trampeo masivo mediante el uso de estaciones cebo, representa una alternativa eficiente y económica para el control de *A. ludens* en huertos de cítricos (Lasa et al*.* 2014). La técnica se basa en la colocación de trampas a una densidad suficiente que capturen el mayor número de moscas con el fin de reducir la cantidad de fruta infestada en el huerto (Delpoux y Deguine 2015). Esta estrategia puede aumentar su eficiencia y reducir costos de manejo al combinar un atrayente eficiente y rentable (Lasa et al. 2015). Además, las estaciones cebo tienen la ventaja que pueden ser combinadas con otros métodos de control (Putruele y Segade 2008).

Estudios realizados en laboratorio y en jaulas de campo sugieren que las estaciones cebo pueden suprimir las poblaciones de *A. suspensa* (Loew) siempre y cuando su uso sea constante (Heath et al. 2009). Flores et al (2010) reportaron que las estaciones cebo son tan eficaces como las aspersiones terrestres de GF-120 para reducir la población de moscas de *A. ludens* y *A. obliqua*, con la ventaja de que las estaciones cebo son específicas para moscas de la fruta y las aspersiones terrestres pueden afectar organismos no blancos. Recientemente se reportó que las estaciones cebo elaboradas de manera artesanal usadas de forma masiva pueden ser tan efectivas y a un menor costo que las trampas comerciales para el control de *A. ludens* en huertos citrícolas de Veracruz, México (Lasa et al. 2013, 2014).

Por lo anterior, el presente estudio fue realizado en tres etapas con el fin de evaluar la efectividad de las estaciones cebo PET con tres ventanas (patente en trámite) y las aspersiones de GF-120 NF Naturalyte® (Dow AgroSciences, Indianapolis, IN) en el control de moscas de la fruta *Anastrepha* en huertos comerciales de mango cv Ataulfo. El primer experimento tuvo como objetivo determinar el mejor atrayente, comparando el CeraTrap® (Bioiberica, SA, Barcelona, Spain), el BioLure® (Kenogard, Spain) y la proteína hidrolizada Captor 300® (Lucava®, México) en pruebas en jaulas de campo con adultos estériles de *A. ludens*. Basado en estos resultados se decidió utilizar el Ceratrap en las siguientes fases de la investigación. En el segundo experimento, se evaluó el efecto de la estación cebo PET cebadas con Ceratrap y las aspersiones terrestres de GF-120 con poblaciones de moscas estériles de *A. obliqua* y *A. ludens* en huertos comerciales de mango Ataulfo. Finalmente, en la tercera fase se evaluó el efecto de las estaciones cebo PET de tres ventanas cebadas con Ceratrap y las aspersiones terrestres de GF-120 sobre las poblaciones silvestres de *A. obliqua* y *A. ludens,* así como el grado de fruta infestada al momento de la cosecha en huertos comerciales de mango cv Ataulfo.

El siguiente capítulo es el manuscrito que fue sometido a publicación a la revista *Pest Management Science* en donde se presentan y discuten los resultados obtenidos.

II. Bait stations are as effective as ground bait sprays for the control of *Anastrepha* (Diptera: Tephritidae) fruit flies in mango orchards

Sometido a Pest Management Science

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Villalobos-Cruz et al. Control of *Anastrepha* fruit flies comparing bait station and GF-120

Correspondence to: Edi A. Malo
Grupo de Ecología y Manejo de Artrópodos. El Colegio de la Frontera Sur (ECOSUR). Carretera Antiguo Aeropuerto km 2.5, Apartado Postal 36 C. P. 30700, Tapachula, Chiapas, México.
Email: emr@ecosur.mx

Bait stations are as effective as ground bait sprays for the control of *Anastrepha* (Diptera: Tephritidae) fruit flies in mango orchards

Jorge Villalobos[1], Salvador Flores[2], Pablo Liedo[1], Edi A. Malo[1*]

[1]El Colegio de la Frontera Sur (ECOSUR). Carretera Antiguo Aeropuerto km 2.5, Tapachula, Chiapas, México 30700.

[2]Programa Moscafrut SAGARPA-IICA, Camino a los Cacaotales S/N Metapa de Domínguez, Chiapas, CP 30860, México

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*: Corresponding author at: emr@ecosur.mx

Abstract

BACKGROUND: *Anastrepha* fruit flies are considered one of the main phytosanitary problems for the fresh fruit industry in the USA, Caribbean Islands and Latin America. Since 1994, the Mexican government implemented the National Fruit Fly Program using an area-wide integrated pest management approach. In this paper, we evaluated the effectiveness of bait stations and compared them with ground GF-120 spraying against *Anastrepha obliqua* and *Anastrepha ludens* populations in mango cv Ataulfo orchards.

RESULTS: Multilure® traps baited with Ceratrap® or Biolure® captured significantly more fruit flies than Captor 300 in field cages. Bait stations with Ceratrap and ground GF-120 spray significantly suppressed fruit fly populations compared with the untreated areas. In Multilure traps placed in untreated areas, we captured significantly more fruit flies than in treated areas with bait stations or GF-120 sprays. Plots treated with either bait stations or GF-120 sprays reduced significantly the percentage of infested fruit compared with untreated areas. There was no difference between bait stations and GF-120 ground bait spraying.

CONCLUSION: Our results demonstrate that bait stations were as effective as GF-120 ground spraying for the control of fruit flies in mango cv Ataulfo orchards.

Key Words: Mango cv Ataulfo, Ceratrap, GF-120, Area-wide IPM, *Anastrepha ludens*, *Anastrepha obliqua*

1 INTRODUCTION

The *Anastrepha* Schiner genus (Diptera: Tephritidae) has a wide geographical distribution in South, Central America, Caribbean islands and part of the United States of America.[1] Some species of this genus are pest fruit flies in many countries. In Mexico, *Anastrepha ludens* (Loew) and *A. obliqua* (Macquart) are the most important pests of mango.[2, 3] To reduce the risk of introduction into areas free of fruit flies, quarantine restrictions are imposed by importers countries.[4]

Since 1994, the Mexican government implemented the National Fruit Fly Program for suppression or eradication of fruit flies of economic importance. This program is based on the area-wide integrated pest management approach, including the use of the sterile insect technique (SIT) and augmentative biological control.[3] These control methods are complemented with other alternatives, such as the use of bait stations or mass trapping. In both approaches the insects are attracted and killed. Results obtained with *A. suspensa* (Loew) in Florida suggest that bait stations can suppress fly populations and are as effective as ground bait spraying.[5]

One important benefit of bait stations is that they are more specific than bait-sprays, reducing the effects on non-target organisms. [6] The successful use of bait stations depends on placing an adequate density of traps to reduce the level of infested fruits.[7]

Inexpensive and effective bait station have been tested for control of *A. ludens* in citrus orchards in Veracruz, Mexico.[8,9,10] Our aim in this study was to evaluate the effect of bait stations and bait sprays for the control of *Anastrepha* fruit flies in mango cv Ataulfo orchards. First, we compared three commercially available lures (Ceratrap, Biolure and Captor 300 protein hydrolyzed) under field cage conditions to determine which one was the most effective in attracting sterile *A. ludens* flies. In a second experiment, we evaluated the effect of bait stations, and GF-120 sprays by release and recapture tests using sterile *A. obliqua* and *A. ludens* flies under mango Ataulfo orchards conditions. Finally, we compared the effect of bait stations and GF-120 sprays against wild *A. obliqua* and *A. ludens* populations by recording trap captures and fruit infestation in mango Ataulfo orchards. These last two experiments were performed to determine whether the bait station and GF-120 sprays gave the same results in release and recapture tests with sterile *A. obliqua* and *A. ludens* compared with wild *A. obliqua* and *A. ludens* populations.

2 MATERIALS AND METHODS

2.1 Study area

The tests were carried out in commercial mango orchards with the Ataulfo cv from December 2015 to July 2016. This period covered from the start of flowering to end of harvest. Six 1-ha plots were located in the municipality of Huehuetán (15° 02' N, 92° 39' W) and the other six 1-ha plots in the municipality of Tuzantán (15° 12' N, 92° 42' W), Chiapas. All plots consist of 15 years old trees approximately 12 m tall, planted at 15 m distance between trees and canopy covering of approximately 70%. These orchards were selected because of historical fruit fly records. Trap captures during the last two years (2014, 2015) ranged from 0.200 to 0.400 flies per trap per day (FTD), according to the Fruit Fly National Campaign Treatments were randomly distributed in these 12 1 ha plots with four replicates for each treatment.

2.2 Biological material

Mass-reared sterile *A. ludens* and *A. obliqua* flies were obtained as pupae from the MOSCAFRUT (SAGARPA-IICA) facility. The pupae were marked with pink fluorescent dye (Aurora Pink, DayGlo Color, Cleveland, OH) and irradiated at 80 Gy with a Co 60 Gamma beam 127. For the evaluation of lures, emerged adults were placed in 30 x 30 x 30 cm glass cages and fed with water and hydrolyzed yeast (MP Biomedicals LLC, Santa Ana, CA) and maintained for 8 d at 25 °C and 12:12 h light: dark. For evaluations in the mango orchards, pupae were placed in kraft paper bags No. 20, with a strip of kraft paper impregnated with a 24:1 mixture of sugar and hydrolyzed yeast. The bags were kept 8 d in the emergency room at 23-25 ° C and 55 - 65% relative humidity.

2.3 Evaluation of lures

Lures were evaluated in 3 m diameter x 2 m height field cages with two small mango trees inside, placed in a mango orchard in Metapa (14° 49' N, 92° 11' W), Chiapas. The treatments were: 1) 250 ml of enzymatic hydrolyzed protein Ceratrap® 100% (Bioiberica, SA, Barcelona, Spain), 2) 10 ml of Captor 300® (Lucava®, Mexico) hydrolyzed protein, plus 5 g of borax and 235 ml of water; and 3) Biolure® two components (ammonium acetate and putrescine) synthetic attractant (Kenogard, Spain) and 250 ml of 20% propylene glycol. Three Multilure (Better World Manufacturing Inc., Fresno, CA) traps were randomly hung on a tree inside a a field cage. Each trap was baited with one of the treatments. Two hundred sterile *A. ludens* flies were released in the center of each cage. After seven days, the traps were inspected, rotated clockwise and the lures were renewed. This was done during 4 weeks, so the three traps were in the 3 locations. The number of captured flies was recorded by sex. The experiment was replicated in three field cages and during four time periods. In addition, the three lures were evaluated without renewal the during 6 weeks. The experiment was replicated in three field cages during two 6 week periods.

2.4 Field evaluation by release and recapture of sterile flies

The control methods used against *A. obliqua* and *A. ludens* populations were evaluated through release and recapture of sterile fly tests in twelve 1-ha mango plots with three treatments and four replicates. The treatments were: 1) Ceratrap bait stations at density of 20 per ha uniformly distributed; 2) Ground spray of GF-120 bait (Naturalyte® Fruit Fly Bait) 40% applying 4 L per hectare in alternate tree rows; and 3) Untreated area without pest management activities. The bait stations employed were recycled soft drink (soda) plastic / PET bottles (600 ml) with three 1 cm^2 openings in the upper part, baited with 200 ml of Ceratrap. Bait station placement and GF-120 ground sprays were done one day after the release of 9,000 sterile *A. ludens* and 9,000 sterile *A. obliqua* in the central point of each plot. Bait stations were removed four days after release, and four Multilure traps baited with Captor 300 protein hydrolyzed (NOM-023-FITO-1995) were evenly placed in each plot.[11] The traps were inspected 6 days after release. The experiment was repeated three times with one day left between replicates. The captured flies were identified according to the taxonomic keys[12,13] and quantified by sex. Sorting of sterile from wild flies was based on the color marking observed under an epifluorescent microscope (Carl Zeiss model SMZ1500, Germany).

2.5 Field evaluation based on wild flies trap captures and fruit infestation

The effect of Ceratrap bait stations and GF-120 ground spray on wild *A. obliqua* and *A. ludens* populations was tested using the twelve 1-ha plots of mango orchards from previous experiment. Bait stations, GF-120 sprays and untreated area were applied in the plots as described above. Six days after treatments, four Multilure traps baited with Captor 300 were placed in each plot. Traps were inspected every week and the bait was renewed. The captured flies were identified and the number and sex recorded. Fly captures were monitored during 16 weeks. GF-120 was sprayed every week in alternate rows. Bait stations were rebaited monthly.

2.6 Fruit infestation

The total mango production of each plot was recorded. Per each harvesting date, the total weight of fruit per plot was recorded and a sample was taken according to the preclearance program to export mangoes from Mexico to the U.S.A.[14] (**Table 1**)

The sampled fruits were cut into slices and when larvae were found, they were identified to species based on anal lobes and anterior spiracles.[13,15] When a fruit was found infested, the whole batch was considered as a damaged batch that could not go to the market, as stated in the export protocol.[14] The percentage of damaged fruit was estimated by dividing the weight of damage batches by the total weight of harvested fruit, multiplied by 100.

2.7 Data analysis

Data were analyzed using the R (R Development Core Team, 2016) statistical package software.[16] In the field cage evaluation of lures, data were first checked to see if they met the assumptions of normality and homogeneity of variance. Then, they were analyzed by one-way ANOVA, where the treatments were Ceratrap, Captor 300 and Biolure. Means were separated by the Tukey multiple range test ($\alpha = 0.05$). In the field tests, the number of flies captured in traps for each treatment was analyzed by one-way ANOVA, where the treatments were the bait stations, GF-120 spray and the untreated area. To compare fruit infestation among treatments, the weight of damaged and undamaged batches was analyzed by logistic regression analysis and differences between means by orthogonal contrasts ($\alpha = 0.05$).

3 RESULTS

3.1 Evaluation of lures

The mean number of sterile *A. ludens* flies captured in Multilure traps in field cages was significantly different for the lures tested when these were renewed every week ($F = 20.22$; df = 2, 16; $P < 0.001$). The traps baited with Ceratrap and those baited with Biolure captured significantly more flies than those baited with Captor 300 (**Fig. 1**). When the lures were left for six weeks, no significant differences were observed among the three lures ($F = 0.48$; df= 2, 106; $P = 0.620$) (**Fig. 2**).

3.2 Field evaluation by release and recapture of sterile flies

A total of 293 sterile adults were captured in Multilure traps, 62.45% were *A. obliqua* and 37.54% *A. ludens*. The mean number of *A. obliqua* (F = 6.23; df = 2, 141; *P* = 0.003) and *A. ludens* (F = 5.49; df = 2, 141; *P* = 0.005) captured were significantly different among treatments. Bait stations and GF-120 spray treatments captured lower numbers of flies of both species than those in the untreated area (**Fig. 3**). The bait stations captured a total of 2,651 sterile flies, being 62.24% *A. ludens* and 37.75% *A. obliqua*. The percentage of recaptured flies increased after every release. The female: male ratio for *A. obliqua* was 2:1 and for *A. ludens* was 1:1.

3.3 Field evaluation based on wild flies trap captures

A total of 425 fruit flies were captured in the Multilure traps during the experiment, 213 were females and 212 males. A higher number of *A. obliqua* were captured (60.47%), followed by *A. ludens* (30.82%), and *A. serpentina* (8.70%). The statistical analysis showed significant differences among treatments for *A. obliqua* (*F* = 6.84, df = 2, 765; *P* = 0.001) and *A. ludens* (*F* = 3.78, df = 2,765; *P* = 0.02). Traps in the untreated control area captured more wild fruit flies. The difference with the GF-120 spray treatment was not significant, but the difference with the bait stations treatments was significant (**Fig. 4**). In bait stations, a total of 709 wild flies were captured, 68.41% *A. obliqua*, 26.67% *A. ludens*, 3.66% *A. serpentina* and 1.26% *A. striata*. Overall female: male ratio was 2:1.

3.4 Level of fruit infestation

Total mango production in the four plots for each treatment is shown in **Table 2**. The production in the bait stations plots was lower and this could be attributed to natural differences among the sites. Sampling was proportional to the amount of fruit harvested. Fruit infestation rates were significantly different among treatments. The highest infestation rate was observed in untreated areas. No infestation was observed in the bait station plots. The number of larvae present in mango sampled from bait station and untreated plots was significant different ($\chi^2 = 9.71$; df = 2, $P < 0.001$), without statistical differences between GF-120 and baits station (**Table 2**). Untreated areas had significantly lower percentage of undamaged fruit (57.6%), compared with GF-120spray (88%) and bait station (100%) (**Table 2**). The highest fruit infestation rate found in the untreated area is coincident with the highest adult capture in Multilure traps (**Table 2**).

4 DISCUSSION

Bait stations were as effective as GF-120 bait sprays in suppressing *A. obliqua* and *A. ludens* populations and both significantly reduced fruit damage. Ceratrap and Biolure were more attractive lures than Captor 300 hydrolyzed protein in one-week periods. However, when traps were left for six weeks, no difference was found among the three lures.

These results were consistent with other studies where these lures have been evaluated under different habitats. For example, in experiments carried out in citrus orchard (grapefruit, *Citrus* × *paradisi* Macfad. and orange, *Citrus sinensis* [L.]), there were significantly more fruit flies captured with Ceratrap than with Biolure and Captor 300 baits.[8,9] In sapodilla (*Manilkara zapota* (L.) P. Royen) and mango commercial orchards significantly higher captures of *A. ludens* and *A. serpentina* were reported with Ceratrap than with Captor 300 baits.[17] With *Ceratitis capitata* (Wiedmann) and *Bactrocera zonata* (Saunders), Ceratrap was a better attractant than the hydrolyzed proteins tested.[18] When traps baited with Ceratrap were compared with the standard Captor 300 hydrolyzed protein, for monitoring fruit fly populations in citrus orchards, a greater number of flies were captured in Ceratrap baited traps.[10] These and our results confirmed that Ceratrap is an effective lure that can be used in bait stations for control purpose. The different results obtained when the traps were left six weeks without renewing the lure could be attributed to Captor 300 hydrolyzed protein bait decomposition or fermentation as was reported previously.[19,20]

Our results with sterile and wild *A. obliqua* and *A. ludens* flies under field conditions demonstrated that bait stations at the density tested and GF-120 sprays have similar effects on suppressing adult populations. The use of sterile flies allowed us to have similar populations in all experimental plots, and avoid the bias that the distribution of wild flies could produce. We found similar and consistent results using sterile flies and the wild populations (**Fig. 3**, **Fig. 4**). In the release and recapture experiment with sterile *A. obliqua* and *A. ludens* flies, bait stations were removed from the plots to avoid competition with the Multilure traps. In the experiments with wild flies, bait stations stay in the plot and compete with the Multilure traps and the results of capture of both flies were similar. This means that bait stations and Multilure traps do no compete.

The constant use of bait stations has been shown to suppress *A. suspensa* (Loew) populations effectively.[5] Ceratrap bait stations improved the control of *C. capitata* in citrus orchards in Spain, when compared with the use of Multilure traps baited with hydrolyzed protein.[21] GF-120 applied either as a foliar sprayor with bait stations was demonstrated to reduce female oriental fruit fly *Bactrocera dorsalis* (Hendel) populations in papaya orchards in Hawaii.[22] In Veracruz, Mexico, a bait station called MS2 baited with Ceratrap captured significantly more female fruit flies than GF-120 and Malathion hydrolyzed protein baited traps in grapefruit orchards.[23]

Bait stations were similar or better than GF-120 spraying in suppressing adult populations. This result was unexpected and highly desirable, since bait stations minimize the effect on non-target organisms, and with Ceratrap, no insecticide was used. The advantages of bait stations were reported for *Bactorcera olea* and *C. capitata* control.[24,25] These authors concluded that under high pest density, bait stations alone could not achieve sufficient control, and bait sprays were necessary to reduce populations.[26]

Weather conditions could affect the efficacy of GF-120 sprays. During spray applications, we observed that the droplets of GF-120 were getting dry, possibly because of high temperatures in the area (17°C min; 39°C max, HR 86.6%). Rainfall could also affect the effectiveness of GF-120 sprays. When applied to control *B. cucurbitae*, the effectiveness of GF-120 applications was reduced by 50% when the bait was exposed to rain.[27] These authors suggest frequent applications of GF-120 to obtain the maximum benefits in tropical climates. The bait station with recycled PET bottles were an alternative to reduce the effect of whether on the bait, avoiding the washing in the rainy season or the drying in the dry season.[22]

Our data obtained with 20 bait stations per hectare in commercial mango Ataulfo orchards suggest that to protect 1 hectare during the mango season, the estimated cost for Ceratrap bait stations will be $107.48 USD, whereas the cost of GF-120 spray will be $152 USD (**Table 3**). The estimated income per hectare, considering the production of non-infested fruit (Table 2) will be $6373 and $5031 for bait stations and bait sprays, respectively. This makes the Ceratrap bait stations control strategy highly competitive.

In Valencia, Spain, the cost for control *C. capitata* in clementine (*Citrus reticulata* Blanco, var. Marisol) orchards, using 50 Ceratrap bait stations per ha, was estimated between $110 and $165 USD per ha, compared with $ 266 USD per ha for mass-trapping. [28] In the control of the oriental fruit fly, *B. dorsalis* in papaya orchards in Hawaii, the use of bait station represents 42% cost-saving compared with the insecticidal foliar application of GF-120.[22] The use of bait stations as an IPM tool to control fruit fly populations by farmers and government agencies depended upon several factors: the level of crop protection, the availability of an effective and cheap attractant, ease of use, the cost of the bait station and the area to be protected.[9,29]

In summary, results from this work demonstrate that Ceratrap bait station and GF-120 spray can be used to control *Anastrepha* fruit flies in mango cv. Ataulfo orchards with high levels of suppression and reduction of fruit damage due to fruit fly infestation. The use of Ceratrap bait stations built from recycled PET bottles can be considered an unexpressive and environmental friendly control method to be incorporated within the integrated pest management approach. This approach has the potential to minimize or avoid the use of insecticides.

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Table 1. Number of fruits to sample according to the preclearance program to export mangoes from Mexico to the U.S.A. [16]

No of boxes	Fruit sampled*
01 to 100	1 of every 3 boxes**
101 to 200	1 of every 4 boxes
201 to500	1 of every 5 boxes
>501	1 of every 6 boxes

*Without exceeding 200 fruits per lot

**1 field box weighs approximately 30 kg fruit

Table 2. Fruit infestation determined at harvest, including sample size in weight and number of fruits, number of infested fruits, and number of larvae detected. Total fruit production in the 4 plots for each treatment and estimation of undamaged fruit.

	Sample					Total Production	
Treatments	Sample (Kg)	N° sampled fruits	N° infested fruits	N° larvae	% infested fruit	(kg)	% fruit without damage
GF-120	182.5	226	3	12	1.33 **ab**	25,680	88.0 **b**
BS	164.5	203	0	0	0.00 **a**	15,420	100.0 **b**
Untreated	214.7	291	13	38	4.47 **b**	26,580	57.6 **a**

Table 3. Cost of pest control application per hectare per season comparing two control methods, Ceratrap bait stations and GF-120 bait sprays.

Treatments	Number of applications	cost (USD $)			
		Chemical product	Labor	Total cost	Incomes
Bait station	4	81.98	25.5	107.58	6,373
Spray GF-120	4	60.47	91.53	152	5,032

Figure legends

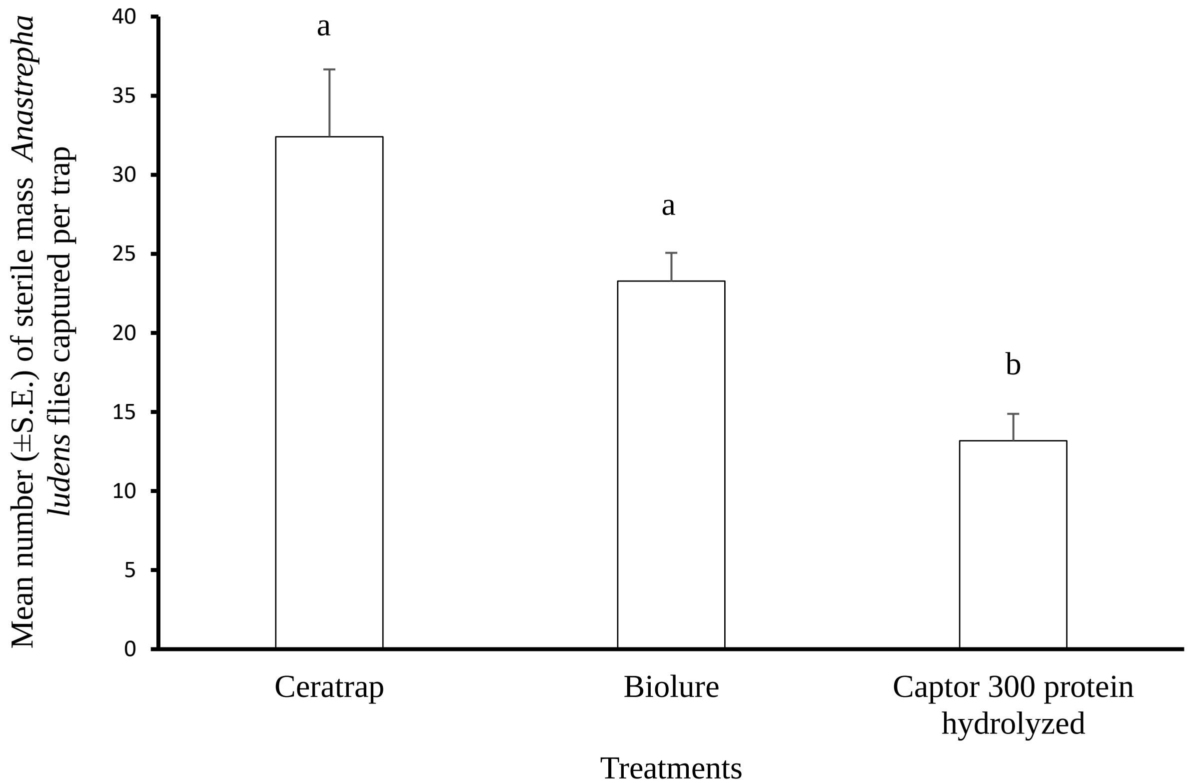
Figure 1. Mean number (±S.E.) of sterile mass reared *Anastrepha ludens* flies captured per trap per week under field cage conditions. Lures were renewed every week. Bars with the same letter were not significantly different.

Figure 2. Mean number (±S.E.) of sterile mass reared *Anastrepha ludens* flies captured per trap during six weeks under field cage conditions. Bars with the same letter are not significantly different.

Figure 3. Mean number (±S.E.) of sterile mass reared *Anastrepha ludens* and *Anastrepha obliqua* flies captured per trap per week in each treatment tested in mango Ataulfo orchards. Bars with the same letter for each species are not significantly different.

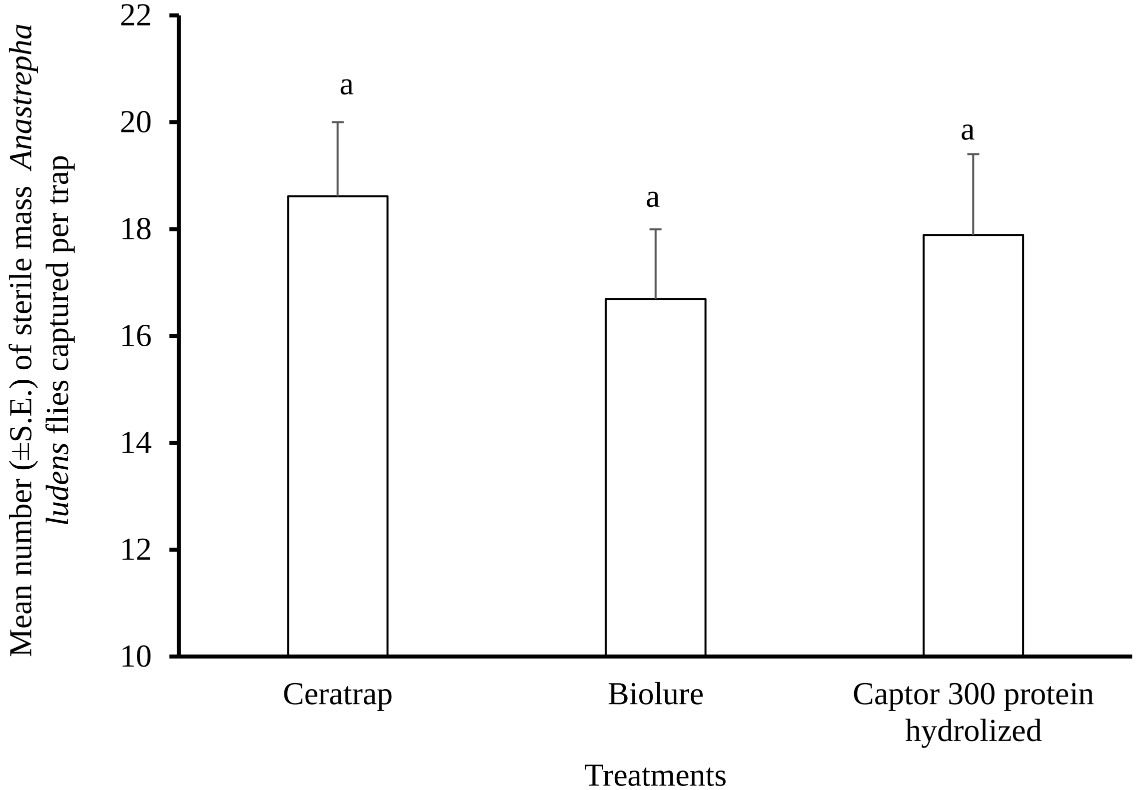
Figure 4. Mean number (±S.E.) of wild *Anastrepha* fruit flies captured per trap per week in each treatment tested in mango Ataulfo orchards. Bars with the same letter are not significantly different.

Figure 1



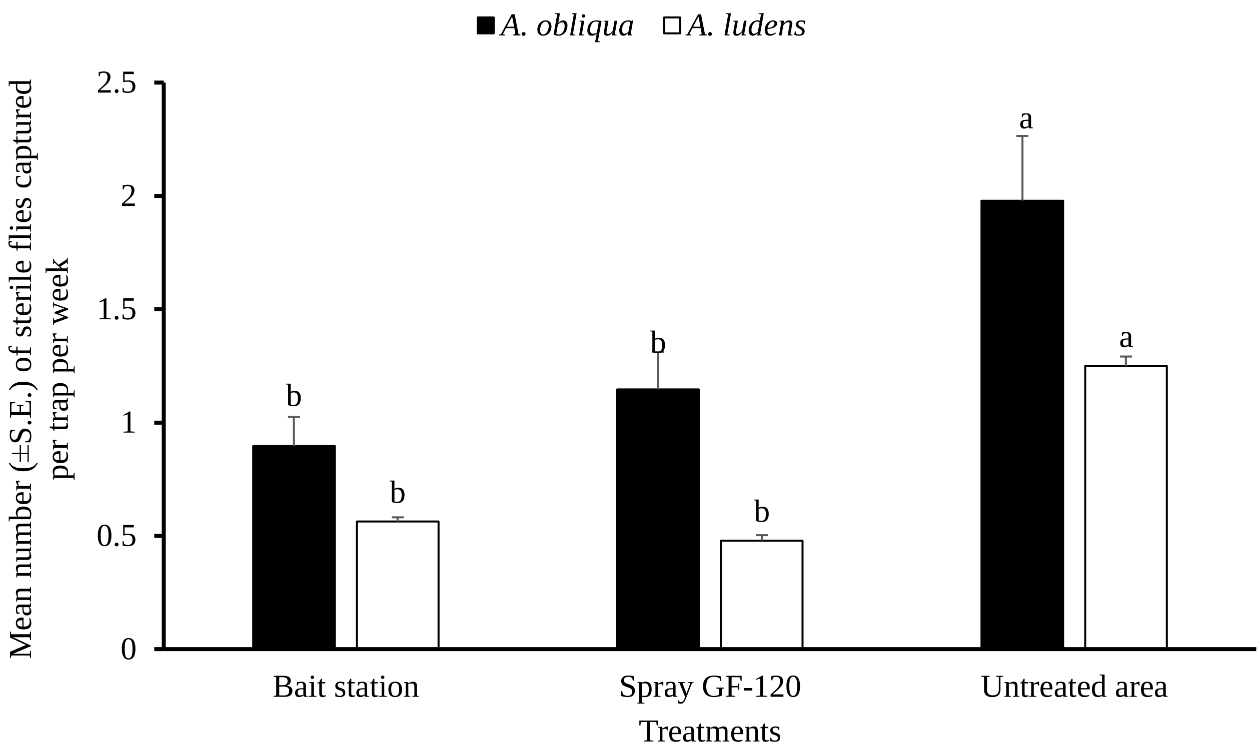
Mean number (±S.E.) of sterile mass *Anastrepha ludens* flies captured per trap
40
35
30
25
20
15
10
5
0
a
a
b
Ceratrap
Biolure
Captor 300 protein hydrolyzed
Treatments

Figure 2



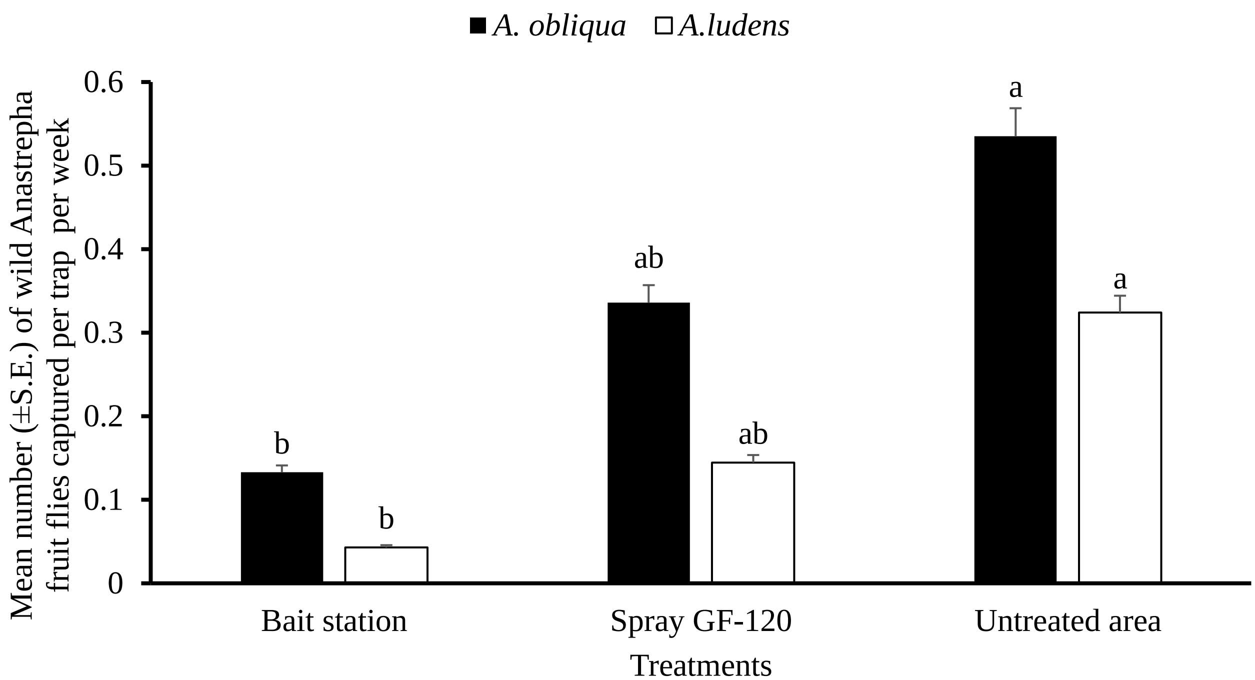
Mean number (±S.E.) of sterile mass *Anastrepha ludens* flies captured per trap
22
20
18
16
14
12
10
a
a
a
Ceratrap
Biolure
Captor 300 protein hydrolized
Treatments

Figure 3



■ A. obliqua □ A. ludens
Mean number (±S.E.) of sterile flies captured per trap per week
2.5
2
1.5
1
0.5
0
a
b
a
b
b
b
Bait station
Spray GF-120
Untreated area
Treatments

Figure 4



■ A. obliqua □ A.ludens
Mean number (±S.E.) of wild Anastrepha fruit flies captured per trap per week
0.6
0.5
0.4
0.3
0.2
0.1
0
b
b
ab
ab
a
a
Bait station
Spray GF-120
Untreated area
Treatments

III. Conclusiones

Las conclusiones de esta investigación fueron:

1) De los 3 atrayentes alimenticios evaluados, el que presentó mayor atracción fue el Ceratrap. Por ello se utilizó con las estaciones cebo PET de 3 ventanas y es el que se recomienda.

2) Hubo una menor captura de *Anastrepha obliqua* y *A. ludens* estériles en las trampas Multilure colocadas en las parcelas donde se instalaron las estaciones cebo o se asperjó el cebo tóxico GF-120 que en las parcelas donde no se aplicó ningún tratamiento, lo que demuestra la efectividad de ambos métodos en reducir las poblaciones de adultos.

3) Las estaciones cebos redujeron las poblaciones silvestres de moscas de la fruta en un nivel similar al obtenido por las aspersiones terrestres de GF-120.

4) Los datos de infestación de fruto fueron acordes a lo encontrado mediante el trampeo y demostraron que las estaciones cebo y las aspersiones de GF-120 redujeron la infestación de fruta. Este efecto resultó significativo en caso de las estaciones cebo.

5) Con respecto a la producción de mango, se observó, que sin acciones de control (tratamiento testigo) solamente el 57.6% de la fruta cosechada estuvo libre de daño y con posibilidad de ser comercializada al mercado de exportación. En el caso de las aspersiones de GF-120 el porcentaje de fruta libre de daño fue del 88%, y en el caso de las estaciones cebo el 100%. Sin embargo, entre estos dos tratamientos la diferencia no fue significativa.

Sin acciones de control en huertos de mango, las moscas de la fruta ocasionaron que 42.4% de la producción fuera rechazada como fruta para exportación a EU. Realizando las aspersiones de GF-120, la perdida se redujo a 22%, mientras que con el uso de estaciones cebo se logró la comercialización para exportación a EU del 100% de la fruta producida.

6) La fruta que no pudo exportarse a los mercados de EU y Canadá por la presencia de larvas vivas (lotes larvados), fue comercializada en el mercado nacional sin tratamiento hidrotérmico pero aún a menor precio.

7) Considerando que las estaciones cebo tienen un menor efecto sobre organismos no blanco, que tienen una mayor duración y un menor costo, resultan una alternativa efectiva y eficiente muy recomendable.

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