Evaluation of fruit fly attractants in the State of Ceará – Brazil[1]

Avaliação de atraentes de moscas-das-frutas no Estado do Ceará - Brasil

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ABSTRACT

Studies were conducted to find the most effective combination of attractants and lures using Plastic McPhail Traps (PMT). The surveillance system using PMT was baited with the following attractants and lures: Nulure (NL), Ammonium Acetate (AA), Putrescine (PT), Trimethylamine (TMA), Propylene Glycol (PG), Ammonium Bicarbonate (AB), Torula (T), Brazilian Hydrolyzed Protein (BHP) plus Borax and the surfactant Triton. The experiments consisted of two independent tests in guava and mango orchards in 2001. The working area called "Median Jaguaribe Valley" is located between 5° and 7° southern latitude and 46° and 47° western longitude. The highest captures of female adults of *Ceratitis capitata* in mango and guava orchards were obtained from combinations of AA + PT + TMA + H_2O and AA + PT + TMA + PG. The highest adult captures (5,397 males and 5,962 females) of *Anastrepha* spp. in guava orchards came from traps baited with NL + H_2O. The best trap efficiencies for female adults of *C. capitata* were obtained by the combinations of NL + H_2O, AA + PT + TMA + Triton and AA + PT + TMA + PG. However, for *Anastrepha* spp. the best efficiencies came with NL. In mango orchards the best combination for *C. capitata* was AA + PT + TMA, and for *Anastrepha* spp. was AA + PT + TMA + PG. The treatment NL + H_2O allowed the highest fly per trap per day (FTD) indices for both fruit fly genera.

Index terms: *Anastrepha* spp., *Ceratitis capitata*, Fly Trap Day (FTD).

RESUMO

Este trabalho foi realizado com o objetivo de encontrar a mais eficiente combinação de atraentes usando a armadilha de plástico modelo McPhail para a captura de moscas-das-frutas. Foram usados nas armadilhas os seguintes atraentes: Nulure (NL), Acetato de Amônia (AA), Putrescina (PT), Trimetilamina (TMA), Propileno Glicol (PG), Bicarbonato de Amônia (AB), Torula (T), Proteína Hidrolizada Brasileira (PHB) mais Borax e Triton. O trabalho consistiu de dois experimentos independentes em pomares de goiabeira e mangueira no ano de 2001. A área experimental está localizada entre 5º e 7º de latitude Sul e 46º e 47º de longitude Oeste. As maiores capturas de fêmeas adultas de *C. capitata* em manga foram obtidas usando as combinações AA + PT + TMA + H_2O e AA +PT + TMA + PG. As maiores capturas de adultos (5.397 machos e 5.962 fêmeas) de *Anastrepha* spp. em pomar de goiabeira foram obtidas com o atraente NL + H_2O. As mais eficientes capturas de *C. capitata* foram obtidas com os atraentes NL + H_2O, AA + PT + TMA + Triton e AA + PT + TMA + PG. Entretanto, para *Anastrepha* spp. os melhores índices de eficiência foram obtidos com o atraente NL. Em pomar de manga a melhor combinação para a espécie *C. capitata* foi AA + PT + TMA e para *Anastrepha* foi AA + PT + TMA + PG. O tratamento NL + H_2O resultou no melhor índice de mosca-armadilha-dia (MAD) para os dois gêneros de moscas-das- frutas.

Termos para indexação: *Anastrepha* spp., *Ceratitis capitata*, mosca-armadilha-dia.

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Introduction

The family Tephritidae comprises economically important fruit fly pests, which infest over 100 plant species from northern to southern Brazil. Some important species such as *Anastrepha fraterculus* (Wiedemann, 1830), *Anastrepha obliqua* (Macquart, 1835), *Anastrepha grandis* (Macquart, 1846) and the worldwide species *Ceratitis capitata* (Wiedemann, 1824) are highly destructive pests of tropical and temperate fruits (Norrbon and Kim, 1988; Zucchi, 2000).

McPhail (1937) documented the use of food attractants for capture fruit flies. He found that protein lures were attractive to *Anastrepha* species, especially guava fruit fly, *A. striata* Schiner. In the 1950s, the use of hydrolyzed protein and partially hydrolyzed yeast in combination with organophosphate insecticides to control fruit flies were used in Hawaii for the control of Oriental fruit fly, *Bactrocera dorsalis* Hendel (Backer et al., 1944). Plastic McPhail traps containing grape juice at 25% as attractant was more efficient than hydrolyzed protein, vinegar and sugar cane molasses (Kovaleski et al., 1995).

The South America fruit fly, *A. fraterculus*, is the best-studied fruit pests in Brazil, regarding its biology and ecology. Kovaleski et al. (1999) demonstrated that adults are able to move 600 - 1,000 m from area of native forest into apple orchards.

The Mediterranean fruit fly, *C. capitata* is one of the most serious fruit pests in the world infesting more than three hundred plant species (Liquido et al., 1991). Several studies on population dynamic of *C. capitata* have been conducted in the tropics (Vargas and Carey, 1989; Nishida et al., 1985; Harris et al., 1993; Souza and Nascimento, 1999).

The objective of this study was to test new synthetic fruit fly attractants and lures and to determine their efficiency compared to proteinaceous baits under different weather, host plants and population densities.

Material and Methods

The experiments consisted of two independent phases in guava (*Psdium guajava* L.) and mango (*Mangifera indica* L.) orchards that lasted eight weeks each. The total field work covered a period of sixteen weeks (from March 13 to May 8 and August 08 to October 11). The working area called "Median Jaguaribe Valley" is located between 5° and 7° southern latitude and 46° and 47° western longitude. The guava field located at Limoeiro do Norte county. The mango orchard located at Jaguaruana county, both in the State of Ceará, Brazil. The climate of both orchards is a semi-arid tropical with an average, minimum and maximum temperatures of 26°C, 21°C and 34°C, respectively. Most rainfall occurs from January to June with a historical average around 600 mm per year. Winds are predominantly from north-northeast with a 90% of frequency and they are more intense from July to December with a maximum speed of 13.6 km/h.

Both fields guava and mango consisted of a complete randomized block design, with 5 blocks and 7 treatments. Traps used in this study were the standard Plastic McPhail Traps (PMT). Traps within a block were rotated sequentially after each week sampling. Each test was running for 8 weeks and trap data collected twice a week. At each week the liquid and ingredients were replaced. For each of the 8-week standard protocol, Ammonium Acetate (AA), Putrescine (PT) and Trimethylamine (TMA) were replaced by new lures in the fourth week. Both orchards were free from any insecticide application during the tests. All traps were installed into the plot area in plants as uniform as possible Traps were hung in the upper two thirds of the southeastern part of the host tree canopy. Trap was installed in a relatively open space with no canopy touching the trap. In the same block, trees with traps had similar canopy size, density and fruiting condition. All the old liquid and baits or other attractant were collected and discharged away from the trial area during the renewal. All traps were checked on the same day.

The treatments used for each orchard were: A – Nulure (NL); B - Ammonium Acetate (AA) + Putrescine (PT) + Trimethylamine (TMA) + Water/Triton; C - (AA) + (PT) + (TMA) + Propylene Glycol (PG); D - Ammonium Bicarbonate (AB) + (PT) + Water/Triton; E - (AA) + (PT) + Water/Triton; F - Torula (T); and G - Brazilian Hydrolyzed Protein (BHP).

In the guava orchard the assessment started in March and finished in May. During this period 7 treatments with 5 traps each were maintained during 8 weeks. During the year 2001 the total precipitation reached 566.9 mm and the peak occurred during the three months with a total of 391.6 mm distributed as 119.4 mm, 203.6 mm and 68.6 mm for March, April and May, respectively. Mean temperatures varied from 26.7°C with a minimum and maximum of 21.0°C and 34.0°C, respectively. Relative humidity medium was 68.6% with a minimum of 41.5% and maximum

of 91.4%. Wind speed in the period was the lowest with an average of 5.1 km/h for the three-month experiment.

The mango trial was performed from August to October. It had the same number of treatments, replications and also lasted 8 weeks. During this period the temperature and relative humidity were similar to the first period, except for precipitation that was zero, and the wind speed that varied from 7.2 to 7.8 km/h during the three- month period.

The guava field was an orchard with seven years old located at Flores district belonging to the Limoeiro do Norte county. This field has been used for production of guava for fruit processing. The total plot had an area of 4 hectares. The space between plants and rows was 7 m by 7 m with a population of 204 plants per hectare. Traps were placed at 28 meters a part from each other. A four-year old mango orchard (Tommy Atkins) located at Jaguaruana county was used for the second experiment. The total plot had an area over 3 hectares. The space between plants and rows was 9 m by 9 m with a population of 124 plants per hectare. Traps were located at least with 36 meters apart from each other. Three rows and four plants in all sides were left free. All the area was under supplementary micro irrigation with water control and measurement.

In the surrounding plot areas there is a village where there were many common fruit fly host trees in backyards and streets. The most common hosts are mango (*M. indica*), *Citrus* spp., banana (*Musa* spp.), *Spondias* spp., star fruits (*Averrhoa carambola* L.), cassava (*Manihot esculenta*), papaya (*Carica papaya*), grape (*Vitis* spp.) melon (*Cucumis melo*), guava (*P. guajava*) and a shade tree known as tropical almond (*Terminalia catappa*). Most the village houses are spread out, and the closest and the furthest fruit fly host trees may vary from 150 m to 1,000 m, respectively, from each research plot.

Fruit flies captured are reported as mean number of males, females and total flies per trap per day; relative trap efficiency (i.e., percentage) of males, females and total flies captured among treatments; and as percentage of females in the total number of flies captured in each trap. The number of fly per trap per day (FTD) was calculated based on the number of fruit flies captured divided by the product of number of traps multiplied by the number of days. Statistical analysis was performed with Analysis of Variance (ANOVA) and pair wise comparison of means (Tukey's test, 95% confidence).

Results

The treatment Nulure showed a capture of 5,962 females, 5,397 males, and 966 females, 991 males, respectively, for *Anastrepha* spp. and *C. capitata*. The detailed results of capture for both fruit fly genera (*Ceratitis*, *Anastrepha*) from guava and mango trials are presented Tables 1-4.

The treatment Nulure in guava allowed the best Fly Trap Day (FTD) index, the best Relative Trap Efficiency for *C. capitata* and *Anastrepha* spp. females plus males (Table 3) with values of 6.99, 40.57 and 19.20, 24.90, respectively. The combinations AA + PT + TMA + H_2OTriton and AA + PT + PMA + PG allowed the best percentage of female per trap for *Anastrepha* spp. For Mediterranean fruit fly, the treatments Brazilian Hydrolyzed Protein and AB + PT + H_2O/Triton gave the best percentage of female capture.

In the mango orchard the population of *Anastrepha* spp. was almost zero. The *C. capitata* population in this place was low, but it was possible to make inferences about population density. The treatment AA + PT + TMA + H_2O/Triton gave the best Fly Trap Day (FTD) index and the best Relative Trap Efficiency. The best percentage of female per trap was observed for treatment Torula.

Discussion

The total number of adults of male and female of *Anastrepha* spp. in guava orchard was clearly higher than the number of *C .capitata* captured. Historically, the fruit fly monitoring program in this region has shown that the population of *Anastrepha* spp. in guava is always higher when compared with *C. capitata* (Braga Sobrinho et al., 2002). The mango orchard presented an extremely low population of *Anastrepha* and a fairly low population of Medfly, which has also been verified in the regular fruit fly monitoring program in the region (Braga Sobrinho et al., 2002).

Based on ANOVA followed by multiple mean comparisons, there were significant differences between treatments for fruit fly captures in guava orchard. The food attractant Nulure presented significantly higher number of total captures (female + male) of both fruit fly genera. It is clear that Nulure is the best food attractant to capture males and females of *Anastrepha* from guava orchards using the standard PMT. The treatment that presented the

Table 1 - Total number of individuals of fruit fly male and female captured in traps with different food and lure attractants in guava and mango orchards in Limoeiro do Norte county, State of Ceará, Brazil, in 2001.

Treatments*	*Ceratitis capitata***				*Anastrepha* spp**			
	Guava		Mango		Guava		Mango	
	Male	Female	Male	Female	Male	Female	Male	Female
Nulure + H2O	991	996	2	5	5,397	5,962	0	0
AA+PT+TMA+ H_2O/Triton	753	1,074	6	16	1,315	2,130	1	0
AA+PT+TMA+PG	724	1,058	1	12	2,574	3,994	1	1
AB+PT+ H_2O/Triton	266	459	2	3	1,865	2,186	0	0
AA+PT+ H_2O/Triton	955	696	5	11	3,224	4,142	0	0
Torula+ H_2O	531	659	0	5	3,567	3,903	1	0
Hydrolyzed Protein+ H_2O	578	727	2	1	2,289	3,069	1	0

* AA - Ammonium Acetate; PT - Putrescine; TMA - Trimethylamine; PG - Propylene Glycol; AB - Amonium Bicarbonate.
** Number of captured individuals.

Table 2 - Mean number of male and female fruit flies captured per treatment in guava orchards in Limoeiro do Norte county, State of Ceará, Brazil, in 2001.

Treatment	*Anastrepha* spp			*Ceratitis capitata*		
	Male	Female	Total	Male	Female	Total
Nulure + H_2O	134.9 a	149.0 a	283.9 a	24.8 a	24.1 ab	48.9 a
AA+PT+TMA+H_2O/Triton	32.9 d	53.2 c	86.1 c	18.8 ab	26.2 a	45.0 a
AA+PT+TMA+PG	65.1 bcd	99.3 b	164.4 bc	18.1 ab	26.4 a	44.5 a
AB+PT+ H_2O/Triton	46.6 cd	54.6 c	101.3 c	6.6 b	11.5 b	18.1 b
AA+PT+ H_2O/Triton	80.6 abc	103.5 b	184.1 b	17.4 ab	23.9 ab	41.3 ab
Torula+ H_2O	89.0 b	99.4 b	188.4 b	13.3 ab	16.5 ab	29.8 ab
Hydrolyzed Protein+ H_2O	57.2 bcd	76.7 bc	133.9 bc	14.4 ab	18.1 ab	32.6 ab

Mean values within a column followed by similar letters are not significantly different ($P \leq 0.05$).

Table 3 - Fly trap day (FTD) and relative trap efficiency for male and females of *Ceratitis capitata* and *Anastrepha* spp. adults captured in traps in guava orchards in Limoeiro do Norte county, State of Ceará, Brazil, in 2001.

Treatments	Avg. Flies Trap per Day (FTD)				Relative Trap Efficiency			
	Males		Females		% Males		% Females	
	Ceratitis	*Anastrepha*	*Ceratitis*	*Anastrepha*	*Ceratitis*	*Anastrepha*	*Ceratitis*	*Anastrepha*
Nulure + H_2O	3.54	19.28	3.45	21.29	22.90	26.68	16.45	23.49
AA+PT+TMA+ H_2O/Triton	2.69	4.70	3.74	7.61	17.40	6.50	17.84	8.39
AA+PT+TMA+PG	2.59	9.19	3.78	14.26	16.75	12.72	18.02	15.73
AB+PT+ H_2O/Triton	0.95	6.66	1.64	7.81	6.14	9.22	7.82	8.61
AA+PT+ H_2O/Triton	2.49	11.51	3.41	14.79	16.11	15.94	16.26	16.31
Torula+ H_2O	1.90	12.74	2.35	13.94	12.29	17.63	11.21	15.38
Hydrolyzed Protein+ H_2O	1.30	8.18	2.60	10.96	8.41	11.32	12.40	12.09
Total	15.46	72.26	20.97	90.66	100.00	100.00	100.00	100.00

Table 4 - Fly trap day (FTD) and relative trap efficiency for male and females of *Ceratitis capitata* and *Anastrepha* spp. adults captured in traps in mango orchards in Limoeiro do Norte county, State of Ceará, Brazil, in 2001.

Treatments	Avg. Flies Trap per Day (FTD)				Relative Trap Efficiency			
	Males		Females		% Males		% Females	
	Ceratitis	*Anastrepha*	*Ceratitis*	*Anastrepha*	*Ceratitis*	*Anastrepha*	*Ceratitis*	*Anastrepha*
Nulure + H_2O	0.0071	0.0000	0.0179	0.0000	11.06	0.00	9.45	0.00
AA+PT+TMA+ H_2O/Triton	0.0214	0.0036	0.0571	0.0000	33.33	25.00	30.15	0.00
AA+PT+TMA+PG	0.0036	0.0036	0.0429	0.0071	5.61	25.00	22.65	100.00
AB+PT+ H_2O/Triton	0.0071	0.0000	0.0107	0.0000	11.06	0.00	5.65	0.00
AA+PT+ H_2O/Triton	0.0179	0.0000	0.0393	0.0000	27.88	0.00	20.65	0.00
Torula+ H_2O	0.0000	0.0036	0.0179	0.0000	0.00	25.00	9.45	0.00
Hydrolyzed Protein+ H_2O	0.0071	0.0036	0.0036	0.0000	11.06	25.00	1.90	0.00
Total	0.0642	0.0144	0.1894	0.0071	100.00	100.00	100.00	100.00

poorest performance for *C. capitata* was AB + PT + H_2O/Triton. If the capture of *Anastrepha* spp. and *C. capitata* is considered separately, Nulure is the best food attractant for *Anastrepha*, and there were no statistical differences in the number of Medfly for treatments **A**, **B**, **C**, **E** and **F**. The poorest food attractant for *C. capitata* was the treatment **D**. All treatments captured more fruit fly females. The predominant genus was *Anastrepha*.

The combination of AA + PT +TMA + H_2O/ Triton resulted in the second best attractant for *C. capitata* followed by the combination of AA + PT + PMA + PG. All these combinations caught more females. The best combination for male *C. capitata* was AA + PT + H_2O/Triton. The treatment Torula and the combination of AA + PT + H_2O/Triton followed by AA + PT + PMA + PG caught the second, the third and the fourth highest numbers of *Anastrepha* spp. adults, respectively.

Since the peak of the rain season was concentrated during the three-month experiment catches were always high, especially for *Anastrepha* spp., suggesting that population density is highly influenced by period of rain. The wind speed in the whole region is always low. In 2001 the mean annual wind speed was around 5.1 km/hour.

Each week in both trials natural enemies and other insects were collected in traps. In guava orchard the treatments AA + PT + TMA + PG and AA + PT +H_2O/Triton attracted more natural enemies than the other treatments. The most common natural enemies captured belonged to family Chrysopidae. The predominant species of the genus *Anastrepha* identified was *A. zenildae*.

Conclusions

Plastic McPhail Traps baited with the food attractant Nulure constitutes the most effective trapping system for monitoring fruit fly populations in guava orchards. The high population of *Ceratitis capitata* in guava represents a serious threat to the expansion and production of fruits for export in the State of Ceará. Most attractants and lures captured more females. The overall results of this study present a capture of 20.3% and 13.8% more females of *Anastrepha* species and *Ceratitis capitata*, respectively. The lowest number of C. *Capitata* captured in guava was obtained by combination of two synthetic lures, Ammonium Bicarbonate and Putrescine. Due to low population of *C. Capitata* in mango the availability of a potent synthetic attractant like 3 component synthetic lures (AA + PT + TMA) may provide a new dimension to the detection, survey and possibly suppression of this species by using mass trapping. The highest captures of *A. fraterculus* and *C. capitata* were obtained by Nulure + H_2O.

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