Organic-Based Attractant For The Control Of Fruit Flies (Diptera: Tephritidae)Infesting Ampalaya (*Momordicacharantia*l.)

Roberto B. Barba Jr., Ruben P. Tablizo

ABSTRACT: One of the major constraints in obtaining good quality fruits and better harvest in bittergourd production is the infestation caused by fruit flies (Diptera: Tephritidae) known to inflict damages in cucurbits, thus, rendering the crop unfit for human consumption. Field experiment on the bio-efficacy of different coco-based organic attractants was carried out to determine the behavioural preferences of fruit flies among food sources designed in a trap-and-killed approach. As revealed by the body coloration and distinct marking patterns on the dorsal (i.e. back) part of the thorax and the forewings (i.e. presence of infuscation); three (3) discrete species were identified under genus *Bactrocera,* including melon fruitfly (*Bactroceracucurbitae*Coq.) which was predominant than the oriental fruitfly (*Bactroceradorsalis*Hendel) and *Bactrocera tau* Walker observed in the study site. The cocosugar solution (1:1v/v) exhibited a significant fruitfly population count, number of species attracted and is generally preferred by both female and male fruitfly but relatively selective to non-target organisms. The bio-efficacy of the cocosugar solution was observed until 2-3 weeks compared to the other coco-based attractants and the control treatment (i.e. plain water). More female fruitflies were observed than male across cocobased attractants. Behavioural preference of the female fruitflies is outright directed to a sucrose-enriched diet (i.e. cocosugar; 1:1v/v) but sustained preference over the cocobased treatments might be implicated to a coconut toddy as a natural complete food affecting behavioural choices of fruitfly among food sources. However, the use of cocosugar solution obtained 30% better harvests than plain coconut toddy. Similarly, the marketable yield is enhanced up to two-fold relative to the control treatment. Yield reduction due to fruitfly infestation had reached 42% when no control measures were employed, of which only 26.18% and 50% of the totallosses (i.e. relative to without control measures) due to incurred damage are accounted by cocosugar and plain coconut toddy, respectively. Hence, infusion of sugar into the treatment has rendered the solution to twice as effective as plain coconut toddy in abating fruitfly infestation. Results were discussed in reference to its significance of obtaining a simple, low-cost yet effective organic-based control of tephritid fruit flies.

Keywords: Diptera, tephritidae, bio-efficacy, coco-based attractants, Bactrocera, BactroceracucurbitaeCoq., BactroceradorsalisHendel, Bactrocera tau Walker, coconut toddy

Introduction:

Ampalaya, *amargoso* or bitter gourd (*Momordicacharantia* L.) is one of the most important commercial and backyard vegetables widely grown for its edible fruits in the Philippines. It is popular for its bitter taste, as the name literally suggests (i.e. bitter gourd or bitter melon), due to the presence of *momordicin.* It belongs to the Cucurbitaceae family. The fruits, young shoot and flowers are consumed as vegetables and are nutritionally rich in vitamins and an excellent source of iron and calcium. Potential health benefits include cure to diabetes, arthritis, rheumatism, asthma, warts, abscesses and ulcers. The fruit of bitter gourd is known to be infested by different insect pests. It is susceptible to the attack by wide-array of fruiflies (order: Diptera) species, which is categorized underTephritidaefamily.Sexually mature female adults deposit its eggs preferably into young fruits which hatched into larvae that feed inside the fruit cavity. The affected fruit will in turn show one or more of the following symptoms: fruits with holes and rots inside; fruit discoloration into orange or yellow prematurely, and; deformed fruits which would render them unmarketable. The degree of fruit infestation by (melon) fruit fly in bitter gourd has been reported to vary from 41 to 89% (Lall and Sinha, 1959; Narayanan and Batra, 1960; Kushwaha et al., 1973; Gupta and Verma, 1978; Rabindranath and Pillai, 1986). Because of the difficulties and/or consequences associated with the control of this pest using chemical insecticides, farmers most likely apply methods such as individually bagging of fruits and removal of affected fruits which are labor-intensive (Philrice and Jica, 2007). Furthermore, the use of chemical-based fruitfly attractant seemed effective control measure but a costly approach. Nevertheless, alternative control measures such as the use of naturally-derived fruitfly attractant, specifically coconut-based materials which require relatively less cost can offer an untapped potential in the control of fruitfly in bittergourd production. Likewise, these traps are organic-based and accordingly harmless to the environment and posed no health hazard to the farmer-applicator in comparison with the use of chemical insecticides. Hence, this study aims to evaluate the bio-efficacy of different organic-based attractants in controlling fruit flies (Diptera:Tephritidae) in ampalaya (*Momordicacharantia*).

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Materials and Methods:

Experimental set-up location and crop variety:

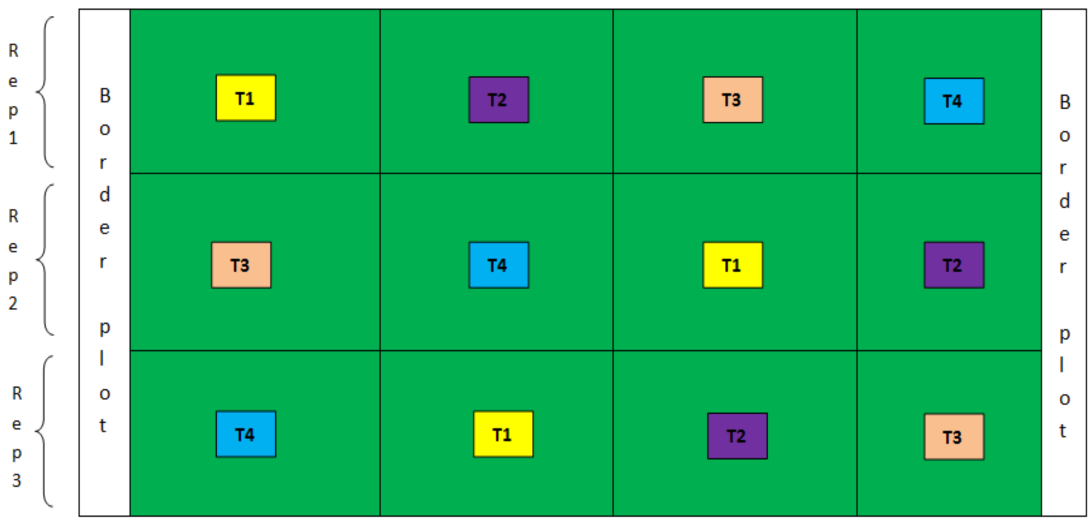
Field trial was conducted at the College of Agriculture and Fisheries Experimental Station in 2013 to evaluate the bio-efficacy of cocobased organic attractants in controlling fruit flies infestation in bitter gourd. The experimental area measures a total span of 580 m^2 (20mx29m) inclusive of replicated trials for every treatments and the border plot at each side. Locally available cultivar Galaxy (F1 hybrid) ampalaya, which matures in 65 to 75 days after planting

(DAP), obtained through Eas-west Seed Company was utilized in the study.

Cultural Management:
Uniform cultural management was employed across all treatment based from the standard recommendation of the Bureau of Plant Industry (BPI-Ampalaya production guide). Some provisions, however, were modified to suit particular need of the test trial. After land preparation, furrows were constructed 2 meters apart. A combination of 2 tbsp/hill (i.e. 20 grams/hill) and 1 kg of vermicast was applied as basal fertilizer. Seeds were direct-seeded at a rate of 2 seeds per hill line at 4 inches apart following a modified planting distance of 2.0 m x 1.0 m between furrows and between hills, respectively. Thinning was done at 7 to 10 days after germination (DAG), maintaining only 1 seedling per hill. *Balag*type trellis was constructed at 2 weeks after germination utilizing 2 ft. wooden posts reinforced by G.I. wire as main frame while nylon twine was interspersed as lateral support. To obtain the standard 6-inch mesh size of the trellis, sewer's thread (locally known as, *sinulid*) was installed in-between the nylon twine. Further, the thread was used as horizontal support as the vine crawls sideways to the top.

Experimental design and plot lay-out:

Figure 1: Experimental lay-out using 4 treatments with three replications arranged in a Completely Randomized Design (CRD).



Total area: 580 m^2 (20mx29m)
Distance of furrows: 2 m
Area per individual treatment assigned to every replications: 30m^2 (5mX6m)
Seeding rate: 2 seeds/hill
Distance between Replication: 1.5 m; border plot (all sides): 1 m
Planting distance: 2 meters between furrows X 1 meter between hills

Treatment Application:
Recycled plastic drinking bottles were perforated around the body using heated 5" nail spaced at 3 to 5 inches from the base and 1 to 2 inches circumferential. About 12 circular perforations/holes per bottle will serve as an entry point for fruitflies. Cocobased attractants and plain water treatment were prepared as indicated below:

T1: Plain coconut toddy
T2: Coco-mol solution (2 parts coconut toddy: 1 part liquid molasses)
T3: Coconut toddy-sugar solution (1:1v/v)
T4: control treatment (i.e. plain water)

Individual treatment with 40ml solution (i.e. amount of attractant prepared) per bottle was allocated to each replication and placed at the center of each designated treatment.

Data collection:
Data collections were observed in four (4) weeks observation period when bittergourd is at reproductive/fruit-bearing stage. Fruitflies parameters (e.g. fruitfly population count, number of fruitfly species attracted, female: male sexual preference) were recorded at the termination of the study while data on the marketable and fruitfly-damaged/non-marketable fruits were taken/observed twice every week. The effect of cocobased organic attractants was also evaluated relative to its effect on non-target organisms. Fruitflies species identification observed in every respective treatment was based on the morphological descriptors given byPrabhakar, C. S. et. al., 2012.

Statistical analysis:
Data collected from the field trial were analyzed through one way ANOVA technique, by using SPSS 17.0 software to determine the degree of significance between treatments. For post hoc analysis, mean separation was done using LSD pairwise comparison at P≤0.05.

Results and Discussion:

Table 1: Effects of Organic-based attractant on the number, species, and sexual preferences of fruit fly and the non-target organisms populations.

TREATMENT [CODE]*	PARAMETERS					
	Number of fruitfly attracted/killed	Fruitfly species identified/ trapped	Sexual preference (female/male count)		Non-target organisms	
			Female	Male	Non-target organisms count	Non-target organisms type
Coconut wine ('tuba') **[1]**	7^{B}	2.33^{A}	5.67^{B}	1.33^{B}	21.67^{A}	Housefly>*drosophila* fruitfly>*buyungaw*> moths>beetles>bee
Coco-mol solution (2:1 v/v) **[2]**	1.33^{BC}	1.33^{B}	1^{B}	0.33^{B}	11.67^{AB}	
Coconut wine-sugar solution (1:1v/v) **[3]**	25^{A}	2.67^{A}	20.67^{A}	4.33^{A}	11.33^{B}	
Water (Control) **[4]**	0^{C}	0^{C}	0^{B}	0^{B}	0.67^{C}	Caterpillar, ant

* Mean(s) for treatment or code with the same letter(s) designation across parameters is/are not significant at 5% level of probability (i.e. separation of means thru LSD pairwise comparison).

Coconut wine-based attractant offers a good alternative for fruitfly control in *ampalaya*. Coco-sugar solution (Treatment 3) had resulted to a significant count of fruitfly killed/trapped, relative number of species identified, and is generally preferred by both sexes (i.e. female/male fruitlfy). The use of plain coconut wine (treatment 1) exhibited an intermediate efficacy in terms of fruitfly count, but relatively non-selective to non-target organisms. Infusion of liquid molasses into a coco-based organic attractant had rendered the solution to become less effective and less palatable to fruitfly. Results indicate that the overpowering scent and bitter taste of molasses may have been the cause of the lesser number of fruitfly killed, the fruitfly species count, and its negative effect on sexual preferences. On the other hand, the addition of sugar synergistically influences the bio-efficacy of coconut-based attractant across parameters while relatively being selective to non-target organisms compared to plain coconut toddy treatment. At most, there are three fruitfly species under genus *Bactrocera*that were identified (see: figures 4 and 5) in both plain coconut toddy (treatment 1) and coco-sugar (treatment 3) treatments as revealed by the body coloration and distinct marking patterns in the thoracic and abdominal regions of the target insect.Amongst these, *Bactroceracucurbitae*(Coq.) occur in relatively greater number than*Bactroceradorsalis*(Hendel) and *Bactrocera tau* (Walker) (see: figure 2). Thegreater preference of melon fruit fly (i.e. *Bactroceracucurbitae* Coq.) reflects that bittergourd, indeed, serves as its primary host(Manjunathan, 1997; GC and Mandal, 2000; Dhillon MK, et. al., 2005), hence, posed a major limiting factor in obtaining good quality fruits and better harvests (Srinivasan, 1959; Mote, 1975; Rabindranath and Pillai, 1986). Notably, the forewing segments of *Bactroceracucurbitae* Coq. ischaracterized with aninfuscation(i.e. darkened) on *dm-cu*crossveins in addition to cubital streak and costal band with a distinct large spot in its wing apex. Additionally, the thorax region has a reddish-brown scutum base. On the other hand, the oriental fruitfly (i.e. *Bactroceradorsalis*Hendel), which is known in infesting wide range fruit crops (e.g. mangoes, bananas, tomatoes, etc.) was also observed, though to a lesser extent, in the study site. Forewing has a costal band confluent with R_{2+3} and not extending into a distinct spot in wing apex. The dorsal (i.e. back) region of the thorax has a darkened scutum with lateral postsutural yellow vittae and absent of medial postsutural yellow vittae(Prabhakar, C. S et. al, 2012). Lastly, *Bactrocera tau* Walker, also commonly observed to infest cucurbits (Allwood etal., 1999), has a similarly darkened scutum but infused with both lateral and medial postsuturalvittae on the dorsal sclerites (i.e. nota or back portion). Furthermore, its forewing marking patterns include a cubital streak and costal band ending into a distinct large spot in wing apex (see: figures 3, 4, 5). While there are only three discrete species that were identified, observations suggest that fruitfly with an intermediate phenotype could have been resulted from any crosses between these three species noted. From the three species mentioned, the female fruitfly can be distinguished from its male counterpart by the presence of an exerted needle-like ovipositor located in the abdomen while the latter is characterized by having a blunt-end abdomen (see: figure

5). Generally, the female population is much more attracted to a coco-sugar solution (1:1v/v) in a 5:1 observed ratio over the males. Across the coco-based attractants, more females are attracted than the males compared to the control treatment (i.e. plain water). Food preference of female fruitfly is outright directed to a sucrose-enriched diet (coco-sugar solution, 1:1v/v) needed in foraging ability (Jacob, undated). The sustained preference of female fruitfly to plain coconut toddy and coco-sugar solution explains that the coco-based attractants exhibit fair amount of nutrients especially protein needed for increased fecundity. Substances like sugar, protein, ethanol, and an enhanced natural yeast cell count are packaged in both fresh and stored coconut toddy (Singaravadivel, K. et. al., 2012), hence, a natural complete food affecting behavioural choices of fruitfly among food sources.

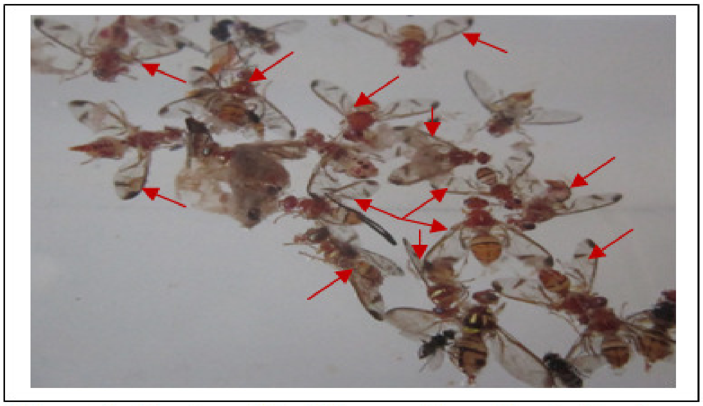


Figure 2: Cluster of fruitfly species attracted using coco-based attractants. *B. Cucurbitae* Coq. occur in greater number than other species identified (see red arrows).

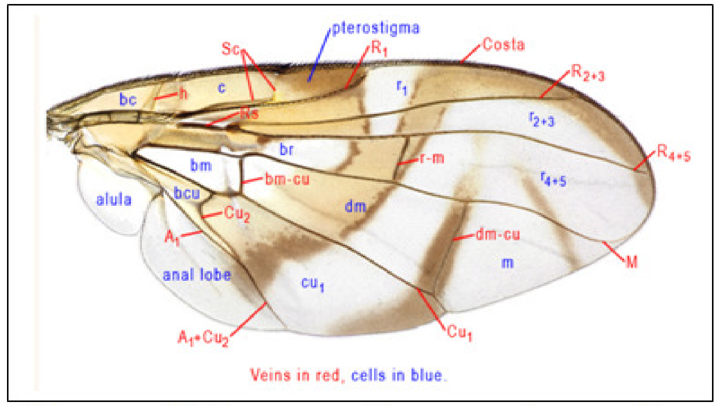
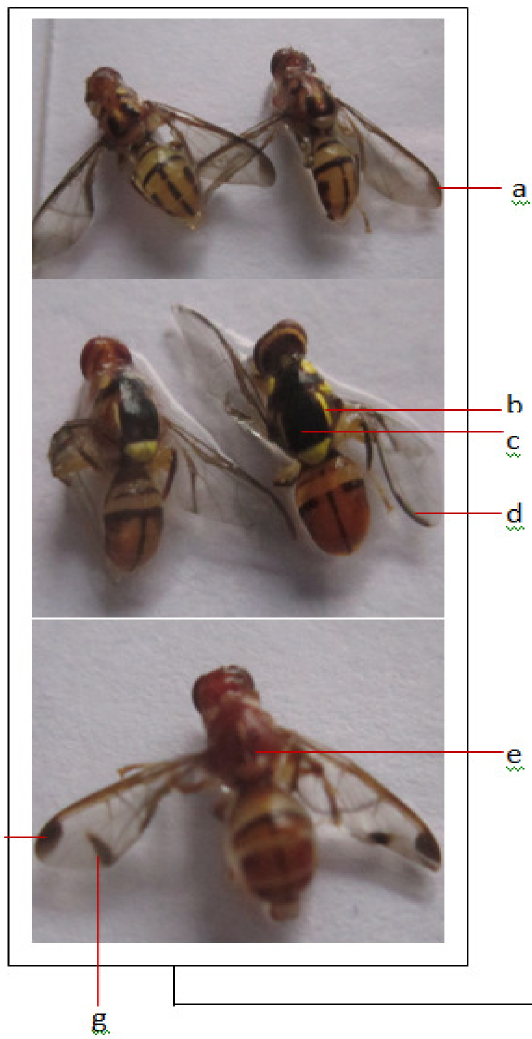


Figure 3:Wing venation and marking patterns(Illustration adapted from: http://delta-intkey.com/anatox/l/media/html/_c094.htm)



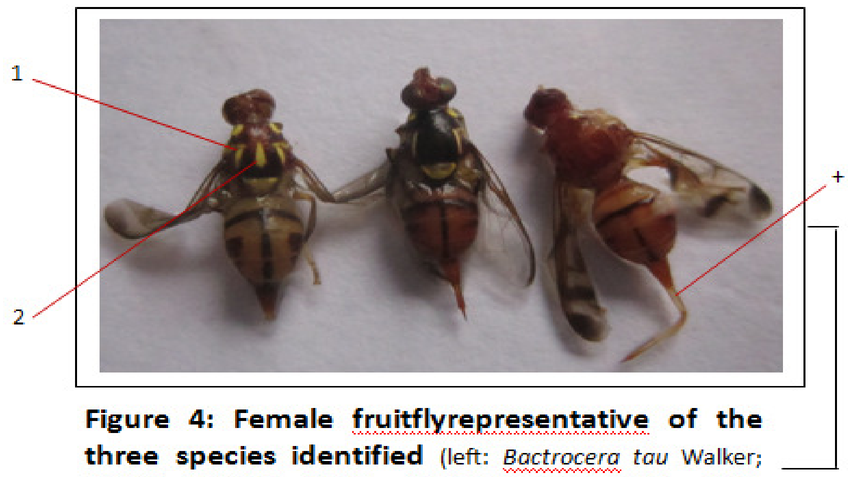
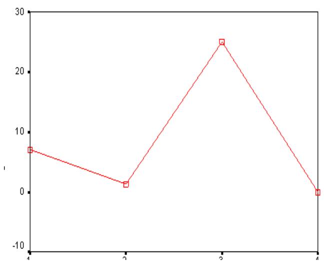
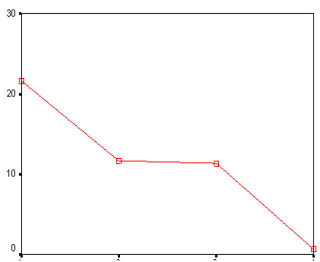


Figure 4: Female fruitflyrepresentative of the three species identified (left: *Bactrocera tau* Walker; center: Oriental fruitfly, *BactroceradorsalisHendel*; right: melon fruitfly, *Bactorceracucurbitae*Coquilllett. Notice the posterior-end ovipositor(+) for egg-laying. 1. Lateral postsutural yellow vittae. 2.Medialpostsutural yellow vittae).

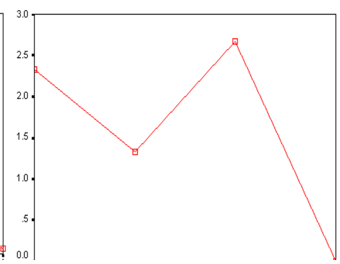
Figure 5: Male fruitfly of the three species identified (topmost: *Bactrocera tau* Walker; center: Oriental fruitfly, *Bactroceradorsalis*Hendel; lowermost: melon fruitfly, *Bactroceracucurbitae*Coquilllett.It is characterized by having a blunt-end abdomen. (a) forewing pattern: cubital streak and distinct large spot in wing apex. (b) presence of only Lateral postsutural yellow vittae in *B. dorsalis*. (c) darkened/infuscatedscutum. (d) forewing marking pattern: costal band confluent with R_{2+3} and not extending into a distinct spot in wing apex. (e) reddish-brown scutum base. (f) distinct forewing pattern of *B. cucurbitae*: cubital streak and costal band with a distinct large spot in its wing apex. (g) infuscation (i.e. darkened) on *dm-cu*crossveins.



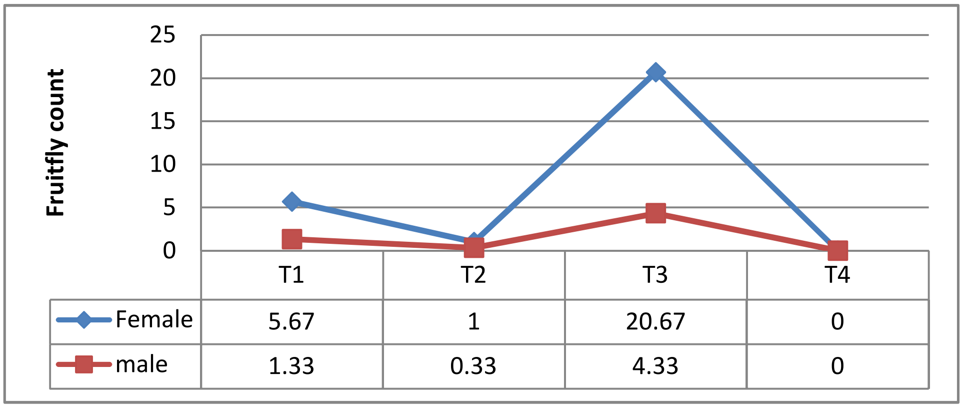
a. #fruitfly attracted

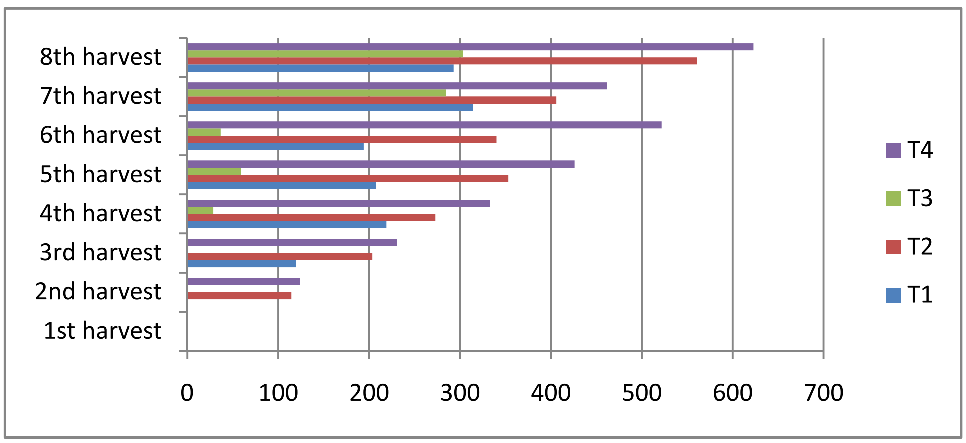


b. non-target organisms



c. # fruitfly species identified





e. Non-marketable fruitfly-damaged fruit

The figures 6(a-e) showed the dynamics of fruitfly-crop damage-non-target organism responses to coconut-based attractants. Treatment 3 (coco-sugar solution; 1:1v/v) exhibited three separate peak points in terms of the fruitfly population count (see: figure 6a), the number of species identified (see: figure 6c) and generally preferred by both male and female fruitfly (see: figure 6d). It is relatively selective in its effect and less likely affecting non-target organisms (figure 6b). The efficacy of each treatment can be viewed as a direct function of the total fruitfly count and the degree of incurred damage in every harvest period (figure 6e).

Table 2*: Harvested fruits (i.e. grams) at every harvest interval: average marketable fruits and bulk of non-marketable fruitfly-damaged fruits

Week/ Harvest frequency		TREATMENT							
		Coconut wine ('tuba')		Coco-mol solution (2:1 v/v)		Coconut wine-sugar solution (1:1v/v)		Water (Control)	
		Marketable fruits	Non-marketable fruitfly-damaged	Marketable fruits	Non-marketable fruitfly-damaged	Marketable fruits	Non-marketable fruitfly-damaged	Marketable fruits	Non-marketable fruitfly-damaged
Wk1	1st harvest	420^{AB}	0^{A}	385^{C}	0^{A}	448^{AB}	0^{A}	404^{BC}	0^{A}
	2nd harvest	654^{B}	0^{A}	408^{D}	114.33^{B}	828^{A}	0^{A}	450^{CD}	124^{B}
Wk2	3rd harvest	627^{B}	119.67^{B}	503^{D}	203.67^{C}	1218^{A}	0^{A}	520^{CD}	230.67^{D}
	4th harvest	671^{BC}	219^{B}	570^{C}	273^{BC}	1023^{A}	28.67^{A}	786^{B}	333^{C}
Wk3	5th harvest	731^{B}	207.67^{B}	688^{B}	353^{C}	950^{A}	59^{A}	651^{B}	426^{D}
	6th harvest	923^{B}	194^{B}	809^{BC}	340^{C}	1229^{A}	36.67^{A}	612^{C}	522^{D}

Wk4	7th harvest	1019^{B}	314^{A}	927^{B}	406^{B}	1264^{A}	285^{A}	751^{C}	462^{B}
	8th harvest	938^{B}	293^{A}	779^{B}	561^{B}	1548^{A}	303^{A}	756^{B}	623^{C}

* Mean(s) for treatment or with the same letter(s) designation across parameters is/are not significant at 5% level of probability (i.e. separation of means thru LSD pairwise comparison).

Data shown above reflected a month-long harvests of ampalaya fruits, both marketable yield and fruitfly-damaged, regularly done twice a week. It is clearly noted that any incremental change in the yield (i.e. marketable fruits) of ampalaya could be due to significantly less damage to fruits throughout the observation period for the ampalaya treated with coco-sugar solution (T3). The bio-efficacy in abating fruit damages due to fruitfly infestation using a coco-sugar solution (1:1v/v) is manifested within 2-3 weeks duration compared to the other organic-based attractant and the control treatment. The marketable yield, based on using the coco-sugar solution, is 30% better than plain coconut wine treatment but is significantly reduced to 42% when there is no control measures employed (i.e. plain water treatment), whereas infusion of molasses into the solution offers no benefits in the harvested marketable fruits. This clearly indicates that significant fruit-damages incurred in the early weeks of fruit formation greatly impact not only the current marketable yield but also the yield for the succeeding harvests. Symptoms of fruit damage due to fruitfly infestation include deformed fruits, fruits with holes that prematurely discolorate into orange or yellow (PhilRice and Jica, 2007; http://bpi.da.gov.ph/guide_ampalaya.php,), rendering the crop unfit for human consumption. Significant reduction in yield (i.e. 41-89%) conforms with the findings of Lall and Sinha, 1959; Narayanan and Batra, 1960; Kushwaha et al., 1973; Gupta and Verma, 1978Rabindranath and Pillai, 1986. Reduction in yield due to incurred damage on fruits are accounted to 26.18% and 50% for coco-sugar solution (1:1v/v) and plain coconut toddy treatment, respectively. This suggests that the bio-efficacy of using coco-sugar solution is twice as effective as plain coconut toddy treatment in abating fruit damages due to fruitfly infestation. Consequently, fruit yield is two-fold enhanced by employing treatment 3 (1 part coconut toddy: 1 part of sugar; v/v) than the control treatment (i.e. plain water treatment).

Conclusion:

A sucrose-enriched diet highly influences immediate behavioural choice of fruit flies (Diptera:Tephritidae) among food sources. The bio-efficacy of cocobased organic attractants manifested within 2-3 weeks duration; of whichcoconut-sugar solution attracted significant fruitfly population count while relatively selective to non-target organisms. There are more females fruitflies observed in a cocobased attractants over the males. Reference is given to the three species identified under genus *Bactrocera* based on morphological differences.The prevalence of*Bactroceracucurbitae*Coq.among species generally indicates specificity for bitter gourd as its major host. Relative to the losses due to fruitfly infestation, cocosugar solution is twice effective than plain coconut toddy while enhancing fruit yield to two-fold than the control treatment.

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