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Comparative efficacy of two fruit juice products as attractants for trapping oriental fruit fly, *Bactrocera dorsalis* (Diptera: Tephritidae)

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ABSTRACT

Adult Female tephritid fruit flies require a protein food source for the development of reproductive organ and egg production. Catches of *Bactrocera dorsalis* (Hendel) in Lynfied trap bated with locally made orange juice and pineapple juice were compared in two different bush mango plantations in Nigeria for two years. Methyl eugenol a commercial parapheromone was used as a standard adult fruit fly attractant. Orange juice was a more effective attractant than pineapple juice in trapping adult *B.dorsalis* for the two years of study at both sites. However, there was no significant difference ($p<0.05$) in the number of trapped flies by orange and pineapple juices. Orange juice captured 10.69 % - 20.82 % of total adult flies for 2016 and 2017 respectively while Pineapple juice trapped 6.37% - 16.29% of total adult flies for 2016 and 2017 respectively. Methyl eugenol caught the highest numbers of flies ranging 63.67% to 84.17% for 2017 and 2017 respectively at both sites. Methyl eugenol trapped only male adult flies while fruit juices trapped both male and female adult flies. Orange juice and pineapple juices significantly ($p<0.05$) captured a higher number of flies than the control for the two years at both locations. The density of flies trapped by all the attractants in 2016 was higher than that of 2017 at both locations.

INTRODUCTION

Fruit flies in the family Tephritidae are amid the insect pests of high economic importance that possess severe threat to the production and export of agricultural crops across the globe. (Papadopoulos 2014; Vargas et al. 2016). The phytophagous insects are important phytosanitary insect pests of many fruits and vegetable crops with several species having cases of successful biological invasions (Liu,et al. 2019). Most of these fruit flies were introduced outside their region of origin and consequently resulted to be invasive pests in their new areas (Duyck et al. 2004). *Bactrocera dorsalis, Bactrocera zonata* and *Bactrocera cucurbitae* have been successfully introduced to Africa (White et al. 2000; Price et al. 2000; De Meyer et al. 2015). *Bactrosalis dorsalis* was introduced in Africa in 2003, first detected in Kenya and has spread to all most parts of Africa including Nigeria (Goergen et al. 2011). The economic damage caused by fruit flies of the family Tephritidae has been recognized across the globe. They are categorized as key -pests because they reach economic damage at low population densities, thus necessitating adequate control measures in fruit farms producing for exports in order meet up with quarantine requirements on exportation of fresh fruits (Water 2012). Monitoring of fruit fly population using traps is an important management procedure validate population status and discover the presence of exotic or quarantine species in the region (Santos 2009).

The use of proteinbaits in mixture insecticides is a common and effective attract and kill approach to fruit fly management targeting female populations (Roessler 1989; Mangan 2014). The baiting approach has minimize the pesticide use in fruit fly management and it has been successfully incorporated into Integrated pest management(IPM) programs for many fruit fly species including *B. dorsalis* and *B.cucurbitae* (Piñero et al. 2009, Vargas et al. 2010). The use of food-based attractants made from proteins and fermenting sugars has been intensely utilized in

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fruit fly detection, monitoring, and eradication approaches (Roessler 1989; IAEA 2003). The main targets of food-based lures is usually female flies but they capture both male and female of several fruit fly species (Ekesi,et al. 2014). The standard commercial lures for detection, monitoring and suppression of female fruit flies in many countries is Nulure (Moreno and Mangan 1995; IAEA 2003). A recent report recorded that Biolure a synthetic lure based on ammonium acetate, trimethylamine and putrescine has high efficacy as Nulure in trapping female fruit flies (Epsky et al. 1999, Heath et al. 2007, Navarro-Llopis et al. 2013). However, these commercial protein bait and lures are not often affordable and accessible to farmers due to high cost and importation problems in many developing countries of the world (Sookar et al. 2002). Assessment and development of the effective locally produced baits might offer substitutes for fruit fly management and enhance crop protection for the medium and small scale fruit and vegetable farmers and consequently mitigate the problems of cost and availability of commercial lures (Epsky et al. 2014). Owing to the high cost of commercial fruit fly attractants and their associated importation constraints for the local farmers, the search for alternative fruit fly attractants that are readily available and affordable becomes a necessity. Thus, using comparative approach in the field condition, the study compared the efficiency of locally produced pineapple juice baits and orange juice baits as attractants for *B. dorsalis* in bush mango plantation for two years in Nigeria.

MATERIALS AND METHODS

Experimental Site

The study was carried out in Ibadan, Oyo state South west Nigeria during the bush mango maturity to ripening periods of May- July 2016 and 2017. Ibadan is located within latitude 70 and 90 N longitude 30 and 580E of green meridian (GMT) with annual rainfall of about 1300 mm to 1500 mm and average relative humidity of about 80 to 85 % (FRIN 2014). Two villages from two different local governments of Oyo state were selected for the study. The study sites were Idishin in Ibadan North West Government and Eniosa in Akinyele local government area. At Idishin village, the bush mango plantation of Forestry Research Institute of Nigeria was used as experimental site while at Eniosa, the area is concentrated with bush mango trees.

Preparation of Fruit juices

The pineapple and orange baits were prepared by peeling 1kg of each the ripe fruit and blending them into a smooth slurry paste using an electric kitchen blender. The juices were extracted separately with 1litre of water and sieved with muslin cloths to obtain a homogenous solution as described by Ugwu et al. (2018).

Experimental Set-Up

Modified Lynfield traps were used made from a recycled transparent 500mL cylindrical plastic bottle with two equidistant holes created opposite each other in the uppermost part, a lid and a small metal string which was used as a hanger of the attractants. The treatments were orange juice, Pineapple juice, methyl eugenol (standard check) and water (control). Three trees were selected from each location, the tree within each location were separated by 10 m to obtain three independent replications within each location. Five hundred (500mL) of each prepared juice was baited with 2 ml of cypermethrin to knock down the trapped flies and mixed solution was then used to set the trap. Forty milliliters (40mL) of baited fruit juice was dispensed with aid of syringe and carefully dropped on a 0.5 gm of cotton wool and placed at bottom of the trap, the trap was later hung at 1.8m above ground level and within the tree canopy and four traps were randomly hung on each tree. For the methyl eugenol 10mL was used following the same procedure while water served as was used as control. Each treatment was replicated three times per each location. The experiment was set up during the Maturity to ripening stage of bush mango during the two years when the environmental temperature varied within 27-30°C for nine weeks.

Data collection and Analysis

Data were collected on the number of fruit flies trapped per trap at weekly intervals at both locations for 9 weeks consecutively and traps were washed and replenished with fresh lure mixture at weekly intervals until the end of the study. The trapped flies were taken to the laboratory for counting, identification and sexing. Data collected were subjected to Analysis of Variance (ANOVA) and significant means were separated at 5% level using Tukey's Honestly Significant Difference (HSD). Analysis was done with ASSISTAT 7.7en 2016 version.

RESULTS AND DISCUSSION

The density of trapped *B.dorsalis* on Bush mango at FRIN site in 20 16

The results showed that locally made fruit juices evaluated has potential as attractants *for B. dorsalis.* Both fruit juices and methyl eugenol attracted and caught adult*B.dorslis* at this location in bush mango plantation (Figure1). Methyl eugenol significantly (<0.05) trapped the higher density of adult fruit flies with about 80% of the total trapped flies during the study. The efficacy

Table 1. Mean density of trapped *B.dorsalis* after nine weeks at both location for two years.

Treatments	Mean number of trapped flies at FRIN in 2016	Mean number of trapped flies at FRIN /2017	Mean number of trapped flies at Eniosa in 2016	Mean number of trapped flies at Eniosa in /2017
Orange juice	116b	11.51b	93.66b	13.9b
Pineapple juice	96.01b	10.53b	65.34b	10.36b
Methyl eugenol	869.99a	41.54a	863.31a	42.5a
Control	2.99c	0c	3.33c	0c

Means with same letters within the same column are not significantly different

of orange juice was slightly higher than pineapple juice in attracting adult *B.dorsalis* in this study site, however, there was no significant difference on the density of adult *B. dorsalis* flies by both atractants. Orange and pineapple juice trapped 10.69% and 8.85% respectively for the total flies trapped during the study. Control trapped only 0.3 % of the flies during the study period. The results of our study demonstrate that, locally made orange and pineapple juices tested attracted *B. dorsalis at* varied proportion. This corroborates the earlier report that the type of protein in a food-based bait can influence the attractiveness of fruit flies to the bait Vargas et al. (2003). Orange juice bait outperformed pineapple juice in terms of attractiveness to *B. dorsalis* at both sites for the two years. This result supports the report by Ugwu et al. (2018) that orange juice was more effective than pineapple juice in trapping *B. dorsalis.* Food base attractants have been used extensively in the management program of fruit flies of Tephritidae family (Epsky et al. 2014)

The population of *B.dorslis* trapped floctuated with time during the study period. The peak of the trapped flies was at the first week of the study, a decreasing trend on the population of trapped flies was observed from the second week until the 4th week and slightly increase from 5th week till the end of the study. The lowest population of flies was trapped at the 8th week of the study. Methyl eugenol persistently attracted only male *B. dorsalis* flies throughout our study. Several authors have reported that methyl eugenol is a male annihilation lures for many *Bactrocera species* (Cunningham,1989; White 2006, Tan et al. 2014, Ekesi et al. 2014).

The density of trapped *B.dorsalis* on Bush mango at Eniosa site in 20 16

The results revealed a significant difference in the mean number of adult *B. dorsalis* captured weekly per trap between methyl eugenol and fruit juices. Both fruit juices attracted and caught adult *B.dorslis* at this location in bush mango plantation at varied proportion.(Figure2). Methyl eugenol significantly (<0.05) trapped the higher density of adult fruit flies with about 84% of the total trapped flies during the study. The efficacy of orange juice was slightly higher than pineapple juice in attracting adult *B.dorsalis* in this study site, however, there was no significant difference on the density of adult *B. dorsalis* flies by both atractants. Orange and pineapple juice trapped 9.13% and 6.37% respectively for the total flies trapped during the study. Control trapped only 0.32 % of the flies during the study period.

The population of *B.dorslis* trapped floctuated with time during the study period. The peak of the trapped flies was at the second week of the study, a deccreasing trend on the population of trapped flies was observesd at 7th week and slightly increase from 8th week till the end of the study. This results support findings by Montes et al. (2011) who reported that Fruit fly population fluctuates due to a succession of primary or alternative hosts, environmental complexity, and abiotic factor

Density of trapped *B. dorsalis* at FRIN site in 2017

Similar trend was observed at FRIN site in 2017. Both fruit juces attracted and caught adult B. dorsalis on bush mango, though in a smaller number (Figure 3)

Methyl eugenol significantly (<0.05) trapped

Table 2. Variance Table for the combined analysis of trapped flies at the two study sites for two years.

V.S.	D.F.	S.S.	S.A .	F
Treatments	3	133485.0855	44495.02852	1909.7202**
Blocks(Locations)	1	61274.19506	61274.19506	2629.8797**
Treatment X Block	3	112084.72403	37361.57468	1603.5534**
Error	8	186.39391	23.29924	
Total	15	307030.39856		

V.S. = Variation source , D.F. = Degree of freedom , S.S. = Square sum, S.A. = Square average , F = Statistics of the test , **= Significant at a level of 1% of probability (p < .01) by Turkey Test

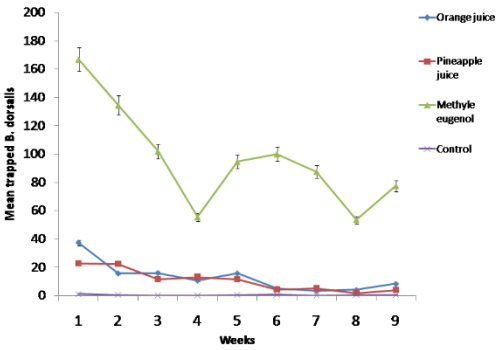

Figure 1. The weekly trapped B. dorsalis flies at FRIN site in 2016

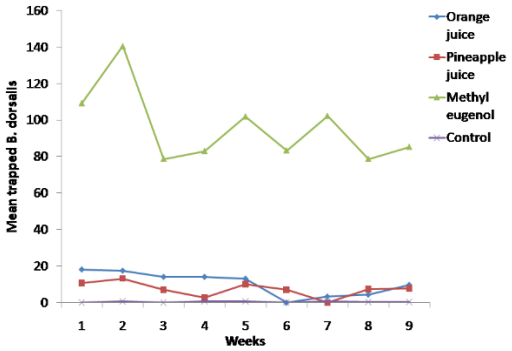

Figure 2. The weekly trapped *B.dorsalis* at Eniosa in 2016

the higher density of adult fruit flies with about 65. 34% % of the total trapped flies during the study. The efficacy of orange juice was slightly higher than pineapple juice in attracting adult *B.dorsalis* in this study site but the difference is not significant with number of flies trapped by Pineapple juice. Orange and pineapple juice trapped 18.1 % and 16.23 % respectively for the total flies trapped during the study. The peak of the trapped flies was at the first week of the study, the population of the *B. dorsalis* fluctuated until the end ot the study. Methl eugenol trapped higher density of flies from first week to the end of the experiment while control trapped no flies.

Density of trapped *B. dorsalis* at FRIN site in 2017

Orange and pineapple juices also attracted and caught adult *B.dorslis* at this site on bush mango at varied proportion in 2017 though in smaller number compared to 2016.(Figure4). A significant difference was recorded in the mean number of adult *B. dorsalis* captured weekly per trap between methyl eugenol and fruit juices

Methyl eugenol significantly (<0.05) trapped the higher density of adult fruit flies with about 64% of the total trapped flies during the study. The efficacy of orange juice was also slightly higher than pineapple juice in attracting adult *B.dorsalis* in this study site, however, there was no significant difference on the density of adult *B. dorsalis* flies by both attractants. Orange and pineapple juice trapped 20.82% and 15.52% respectively for the total flies trapped during the study. A similar trend on the *B. dorsalis* population was observed as seen in 2016 in this study site. The population of *B.dorslis* trapped floctuated with time during the study period. The peak of the trapped flies was on the 5th week and decreasing trend continues from 6th week to the end of the study. Methyl eugenol trapped higher density of flies from first week to the end of the experiment while control trapped no flies in this site in 2017.

Mean density of trapped *B.dorsalis* after nine weeks at both location for two years.

The density of trapped *B.dorsalis* flies was significantly ($p<0.05$) higher in 2016 than 2017 at both study sites(Table 1)

Above eighty percent (80%) and 63% of *B. dorsalis* were trapped by methyl eugenol for 2016 and 2017 respectively. Orange juice trapped higher number of flies at both locations than pineapple juice for the two years. However, there was no

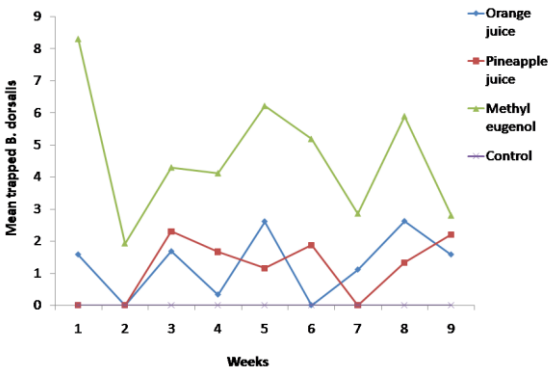

Figure 3. The weekly trapped *B.dorsalis* at FRIN in 2017

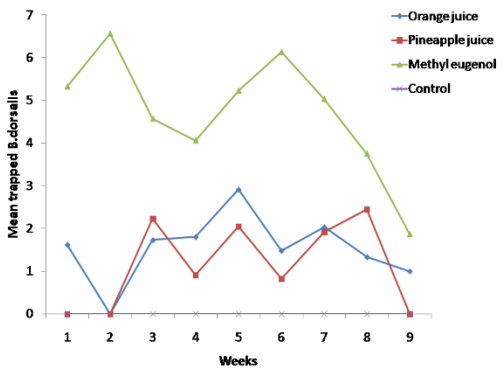

Figure 4. The weekly Trapped *B. dorsalis* at Eniosa in 2017

significant difference on the density of trapped flies between them for the two years. Both fruit juices significantly ($p<0.05$) caught higher number of flies than control for the two years at both locations.

Combined analysis of variance for the mean densities of flies trapped by different attractants for the two years.

The analysis of variance for the combined mean densities of flies trapped by different attractants from the two locations for the years of study showed significant differences among the treatments and the locations (Table 2). The interactions between the treatments and the two locations were also significantly different

Percentage male and female *B. dorsalis* trapped at both locations in two years

The two fruit juices trapped both male and female adult *B.dorsalis* at the two study sites for two year (Fig 5). Methyl eugenol trapped only adult male fruit flies and the number of trapped male is significantly higher that both fruit juices and control. Orange and pineapple juice significantly ($p<0.05$) trapped higher number of female flies than male at both locations in 2016 and at Eniosa in 2017. There was no significant difference on the number of trapped male and female by pineapple juice at FRIN site in 2017.

The results of our study corroborate the earlier report of Ekesi et al. (2014) who reported that various food attractants tested in their study attracted both sexes of *B. dorsalis* at varying level of attraction with different attractants. Both fruit juices (orange and pineapple) caught more females than male *B. dorsalis* at both locations in two years of our study. This results support the report of Ekesi, et al. (2014) that all protein baits tested caught more females than males in their two year experiments. According to Drew and Yuval (2000) the effectiveness of food- based protein baits relies on need of protein food by juvenile female develop mature eggs. Biolure a commercial food - based attractant used in multi-lure traps captured twice more females *C. capitata* than males in citrus orchards in Israel (Gazit et al. 1998). In a similar report, Biolure trapped up to five time more females of *C.capitata* than males in Citrus orchard in Greece (Katsoyannos et al. 1999). In corroboration to the results of our study, several reports from earlier studi7ues have been recorded on the use of local formulated attractants in trapping various fruit fly species. Protein based food bait from brewery waste was reported effective in mass trapping Ceratitis *species* in sweet orange in Nigeria (Umeh and Garcia, 2008). Similarly, Ekesi and Tanga, (2016) reported that locally developed protein baits made from waste brewer's yeast (WBY) was effective in mass trapping *Bacrocera dorsalis* in Uganda and Kenya and was comparable to imported food baits for suppression of tephritid fruit flies in Africa. Mixtures of corn- steep liquor with ammonia compound was reported to be effective attractant for female *Ceratitis species* in Spain (Casaña-Gineretal., 2001). Local fermented corn products known as chicha was reported more effective than commercial food lures in trapping *Ceratitis capitata* in peach orchards in Bolivia(Candia et al. 2019).

Moreover, Mwatawala et al. (2015) reported that application mixture of liquid waste brewer's yeast and extracts of *Derris elliptica* Benth reduced infestation of fruit flies on mango orchards compared with Success ® bait spray and cover spray of dimethoate in Tanzania. Application of Waste brewer's yeast modified with slurry papain (0.8 %), raw pawpaw and pineapple juice (4 % v/v) was found effective in reducing of *Zeugodacus. cucurbitae* infestation on ridged gourd, Luffa *acutangulata* (L) to 1%, 2% and 6% with modified WBY products of Papain, pawpaw and pineapple respectively (Sookar et al. 2002). Ortega and Cabrera (1996) reported that pineapple juice, fermented pineapple, molasses, cow milk serum, and extracts of mango, *Mangifera indica* L and jobo, *Spondias mombin* attracted west Indian fruit fly, *Anastrepha obliqua* but were less attractive less than torula yeast and several chemical hydrolyzed proteins. Grape juice was also reported to have potential in trapping A. *ludens* in citrus crops and mango orchards (Herrera et al. 2016).

CONCLUSIONS

The study revealed that orange and pineapple juices are prospective attractants for oriental fruit fly and could be used to trap *B. dorsalis* in fruit orchards. Orange juice was more effective than pineapple juice in trapping *B. dorsalis* on bush mango at both study sites. *B.dorsalis* were trapped at the two study sites by both tested attractants for the two years of study. The study has provided small and medium scale farmer with baseline information to embrace the low-technology, low cost and low environmental impact approach in the management of fruit flies' problems in their orchards.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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