

Effectiveness of Selected Parapheromones for Mass Trapping of Mango Fruit Fly, *Ceratitis cosyra* Walker and Oriental Fruit Fly, *Bactrocera dorsalis* Hendel (Diptera: Tephritidae) on Mango

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Abstract

Mango (*Mangifera indica* L.) is an important fruit crop in Nigeria. It is a source of essential vitamins and is also cultivated for its nutritional, medicinal and industrial uses. Fruit flies infest various commercial fruit crops and cause economic damage. Mass trapping and male annihilation technique (MAT) has been the most useful and common means of controlling fruit flies with special focus on *Bactrocera dorsalis* Hendel (Diptera: Tephritidae) on mangoes. The study evaluated the effectiveness of four types of parapheromones namely, methyl eugenol (liquid and solid forms), cuelure, terpinyl acetate and trimedlure for mass trapping of fruit flies on Mango. Modified Lynfield traps containing the parapheromones were randomly set on the mango orchards in three replicates in Nigeria Horticultural Research Institute (NIHORT) orchard, Okigwe, Imo state, Southeast Nigeria. This study was conducted during the mango fruiting period of 2019 season, when the density of fruit flies peaked. Effect of parapheromones on mean number of damaged dropped fruits was also evaluated. The mean population of *B. dorsalis* and *Ceratitis cosyra* was significantly higher ($P > 0.05$) in liquid methyl eugenol traps when compared to other parapheromones. *Bactrocera dorsalis* recorded more than 90% of the fruit flies that were trapped especially in the first 3 weeks of trapping. In orchard I, Liquid methyl eugenol significantly ($P < 0.05$) trapped highest number of *B. dorsalis* (270.20) in week I and similar trends were observed in orchard II. There was steady decline in damaged dropped mango fruits as the study progressed (Fig. 1 and 2). Use of liquid methyl eugenol was most effective in trapping *B. dorsalis* and *C. cosyra*, and it can be incorporated in Integrated Pest Management (IPM) programmes for the control of fruit flies.

Keywords: *Mangifera indica*, *Ceratitis cosyra*, *Bactrocera dorsalis*, mass trapping, Parapheromones, Lynfield trap

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INTRODUCTION

Mango (*Mangifera indica* L.) is a member of the Anacardiaceae family (CIRAD, 2015). The crop is cultivated in over 90 countries worldwide and about 63 countries producing more than 1000 metric tonnes per year. Developing countries account for about 98% of total production and that includes Nigeria (FAOSTAT, 2017). Notwithstanding lack of motivation for large scale mango production in the country, Nigeria still occupies the 8th position in the world ranking of mango producing countries (FAOSTAT, 2017).

Mango is traded and consumed as fresh or in processed form. A number of products from mango like mango juice, mango pulp, fruit salad, puree or jams canned sliced frozen mango, mango flavours, mango kernel oil, mango pickles and powder have been well introduced and accepted in different market segments (GEPC, 2005). The kernel contains 8-10% good quality fat which is used for making soap and as substitute for cola in confectionery. The wood is used for furniture and boat making (GEPC, 2005). The fruit pulp which makes up 60-75% of fresh fruit weight contains 15% carbohydrates, little protein, high amounts of vitamin A and some quantities of vitamins B and C. It also contains minerals like calcium, iron, zinc, copper, magnesium, potassium, phosphorus, sodium, manganese and selenium (Hussain *et al.*, 2002).

According to the European Union Strategic Marketing Guide (EUSMG, 2001), favourable climatic conditions and low labour cost leading to the low production cost give the South American and African countries a strong position on the European markets. The report further stated that west African countries are closer to Europe and thus gives it an edge in terms of market opportunities due to lower logistics cost and shorter delivery times. Despite these oppor-

tunities, Nigeria is yet to take advantage of the uncompetitive state of the industry (Ajayi and Nyishir, 2006).

Among various insect pests of mangoes, fruitflies are of economic importance because they drastically reduce yield and affect local and export markets. Oriental fruit fly, *Bactrocera dorsalis* (Hendel) and *Ceratitis* sp are the most recognized and notorious pests of mango and other horticultural crops in Sub-Saharan Africa. These species affect fresh fruit production, regional and international trade of mangoes, due to their high fecundity rate and strict quarantine regulations (CABI, 2014).

Parapheromones are chemicals that are not naturally used in intraspecific communication but which do elicit responses similar to true pheromones. The parapheromone, methyl eugenol (ME) has been reported to attract high number of the genus *Bactrocera* (including *B. dorsalis*, *B. zonata*, *B. carambolae*, *B. philippinensis* and *B. musae*) (IAEA, 2003) and is used for Male Annihilation Technique (MAT). Suppression or elimination is a control measure of fruit flies population. They are of extreme significance for the economy of growing countries whose income is greatly dependent on agriculture.

Various management strategies, such as the use of food baits, parasitoids, pathogens, field sanitation, fruit bagging, sterile insect technique (SIT), bait application techniques (BAT) and MAT are presently used for the control and management of many species of fruit flies (Ekesi and Billah, 2007). There are different control measures against *B. dorsalis* and *C. capitata*. Asawalam *et al.* (2009) reported that the use of Methyl eugenol and nulture placed in Lynfield trap was effective for the control of *Bactrocera dorsalis*. The authors reported improvement in the taste and quality of the citrus, after trapping the fruit fly. Since parapheromones are common

and are widely used, their efficacy and cost effectiveness evaluation is required. The objectives of this study were to evaluate the use of Parapheromones for mass trapping of *B. dorsalis* and *C. cosyra* populations on mango and to assess their damage on mango fruits.

MATERIALS AND METHODS

Experimental Location

The study was conducted in National Horticultural Research Institute (NIHORT) Okigwe, South East Nigeria during the mango fruiting period of May to June, 2019. The study area, which is a humid rainforest lies on latitude 05° 33'N and longitude 7° 23'E with annual rainfall of 2048mm and relative humidity of 78%. The area is located at an altitude of 130 metres above sea levels (NIMET, 2017; Google maps, 2019).

Experimental Materials

The parapheromones used in this study were cuelure, liquid methyl eugenol, solid methyl eugenol, terpinyl acetate and trimedlure and Lynfield traps.

Experimental Design

Randomized Complete Block Design (RCBD) was used for the study. Two orchards in the area of study, having different mango varieties (Peach or kerosene mango for orchard 1 and Julie for orchard 2) were selected for the experiment. The two orchards were located at reasonable distance from each other. Six traps were hung on each tree at 10m above the ground within the tree canopy. Three trees were selected per orchard and a distance of 25m separates each tree to obtain three independent replicates within each orchard. The treatments were replicated three times.

Placement of Traps

Four (4) of the parapheromones (in solid form) were dropped in the Lynfield traps with a DDVP cube for each parapheromones to kill the insects that are attracted. For the liquid treatment of methyl eugenol, 2 mls of the liquid methyl eugenol was soaked in cotton wool prior to placing in the Lynfield trap, which were attached to a hook to which the food bait dispenser is fitted. This treatment for liquid methyl eugenol was replaced in the traps every two weeks as compared to the solid attractants that were replaced weekly. This is because of increase in the rate of diffusion of the parapheromones. After one week, the rate of diffusion decreases; implying a reduction in the efficiency of the parapheromones.

In each mango orchard, Lynfield traps were positioned randomly at 25m apart from each other. The methyl eugenol was taken with the aid of syringe and carefully dropped on 0.5gm of absorbent cotton wool and placed at bottom of the trap. Baits were removed and replaced weekly and fruit flies collected from the traps using small vials, were preserved in 70% ethanol in the laboratory where they were identified and weekly capture rate recorded. Control traps were empty with no attractants or lures.

DATA COLLECTION

Catches of *B. dorsalis* and *C. cosyra* in the traps were counted every week for 6 weeks consecutively. Number of dropped fruits and total number of mangoes dropped were assessed. Damaged dropped fruits were also assessed.

Mean number of trapped fruit flies: The number of flies per trap per week was used to compute daily capture rate as:

$$FTD = \frac{F}{TXD}$$

Where F = total number of flies
 T = number of serviced traps
 D = Trapping duration in weeks.

Significant Difference (FLSD) at 5% level of probability.

RESULTS

The collections were preserved on small vials containing 70% ethanol (IAEA 2003).

Mean Number of Damaged Fruits

Mean number of damaged fruits in treated and untreated plots:

$$R = \frac{D}{U} \times 100$$

Where U is the number of uninfested fruits, D is number of observed damaged dropped fruits and R is Number of trees per replicates

Statistical Analysis

The number of fruit flies trapped was transformed using square root transformation to normalize the data. Data obtained was also subjected to analysis of variance (ANOVA) procedure and significant means were separated by using Fishers' Protected Least

In orchard 1, the number (270.20) of *B. dorsalis* trapped in liquid methyl eugenol for week1 was highly significant when compared to other parapheromones. Similar trend was recorded in week 2 (Table 1). In week 3, Mean population of *B. dorsalis* (50.50) trapped for liquid methyl eugenol dropped, although it was still highly significant in comparison to other parapheromones that recorded lower populations as compared to week 1 and 2. Mean population of *B. dorsalis* (103.8) trapped using liquid methyl eugenol for week 4 increased significantly in orchard 1. Other parapheromones had low numbers of *B. dorsalis* from week 4-6. The numbers (89.40 and 86.10 respectively) caught for week 5 and 6 were almost similar and were highly significant. Control trapped the least number (0.10 and 0.20) of *B. dorsalis* for week 1 and 2 respectively.

Table 1: Mean population of *B. dorsalis* trapped with different parapheromones in orchard I in NIHORT, Okigwe

Parapheromones	Mean population of <i>B. dorsalis</i>					
	1WAT	2WAT	3WAT	4WAT	5WAT	6WAT
Cuelure	3.70(1.98)	2.60(1.76)	0.91(0.81)	0.20(0.81)	1.60(1.41)	1.70(1.41)
Liquid methyl euge	270.20(16.32)	190.80(13.77)	50.50(7.14)	103.80(10.16)	89.40(9.25)	86.10(8.92)
Solid methyl eugenol	27.10(5.25)	8.60(2.99)	2.81(1.69)	2.10(1.45)	1.20(1.29)	0.50(0.98)
Terpinyl acetate	13.40(3.62)	0.40(0.93)	0.31(0.86)	0.10(0.75)	0.00(0.71)	0.00(0.71)
Trimedlure	4.20(2.16)	0.90(1.19)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.10(0.78)
Control	0.00(0.79)	0.20(0.81)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)
Mean	53.10(5.02)	33.92(3.58)	9.08(1.99)	17.70(2.43)	15..37(2.35)	14.73(2.25)
LSD (0.05)	47.82	25.22	3.38	14.20	25.80	29.57
CV %	24.40	20.10	4.20	24.70	46.60	55.30

*WAT = weeks after treatment, *CV = Coefficient of variation
 Values in Parentheses are transformed values

In orchard 1, numbers of *C. cosyra* trapped in week 2 were significantly different for liquid methyl eugenol (10.75). However, in

week 1, liquid and solid methyl eugenol showed no significant difference (P=0.05) in numbers (5.69 and 5.12 respectively) of *B.*

dorsalis trapped. Observations on *C. cosyra* Traps not baited with parapheromones did followed similar trend with *B. dorsalis*. not trap *C. cosyra* (Table 2).

Table 2: Mean population of *C. cosyra* trapped with different parapheromones in orchard I in NIHORT, Okigwe

Parapheromones	Mean population of <i>C. cosyra</i>					
	1WAT	2WAT	3WAT	4WAT	5WAT	6WAT
Cuelure	0.88(1.15)	1.06(1.23)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.06(0.75)
Liquid methyl eugenol	5.69(2.40)	10.75(3.23)	9.62(3.10)	10.00(2.97)	9.44(2.93)	7.31(2.47)
Solid methyl eugenol	5.12(2.36)	3.19(1.92)	0.94(1.15)	0.13(0.79)	0.75(1.11)	0.25(0.86)
Terpinyl acetate	0.13(0.79)	0.12(0.78)	0.00(0.71)	0.06(0.75)	0.06(0.75)	0.00(0.71)
trimedlure	0.50(0.99)	0.50(0.96)	0.00(0.71)	0.00(0.71)	0.00(0.75)	0.00(0.71)
Control	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)
Mean	2.05(1.40)	2.60(1.47)	1.76(1.18)	1.70(1.10)	1.71(1.16)	1.27(1.04)
LSD (0.05)	2.59	4.09	3.30	6.18	4.77	4.58
CV %	24.20	44.60	58.80	99.70	78.60	98.50

*WAT = weeks after treatment. *CV = Coefficient of variation

Values in Parentheses are transformed values

In orchard 2, numbers of *B. dorsalis* trapped followed similar trends as compared to orchard 1. In week 3, *B. dorsalis* recorded (Table 3) the lowest number (36.20) using liquid methyl eugenol in comparison to other weeks, but was also highly significant when compared to other parapheromones. Control recorded the least number (0.10) of *B. dorsalis* trapped in week 1 and did not trap any fruit fly in subsequent weeks for orchard 2.

Table 3: Mean population of *B. dorsalis* trapped with different parapheromones in orchard II in NIHORT, Okigwe

Parapheromones	Mean population of <i>B. dorsalis</i>					
	1WAT	2WAT	3WAT	4WAT	5WAT	6WAT
Cuelure	2.20(1.60)	2.30(1.65)	0.20(0.86)	0.00(0.71)	1.60(1.45)	1.60(1.41)
Liquid methyl eugenol	233.80(15.10)	229(15.17)	36.20(5.92)	95.10(9.62)	76.20(8.68)	88.20(9.38)
Solid methyl eugenol	24.30(4.78)	5.20(2.36)	2.10(1.51)	1.80(1.51)	1.90(1.49)	1.80(1.45)
Terpinyl acetate	12.60(3.55)	0.40(0.92)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)
trimedlure	3.70(2.04)	1.00(1.20)	0.00(0.71)	0.10(0.78)	0.00(0.71)	0.00(0.71)
Control	0.10(0.79)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)
Mean	46.12(4.64)	39.65(3.67)	6.42(1.74)	16.17(2.34)	13.28(2.29)	15.27(2.40)
LSD (0.05)	53.88	9.42	10.44	23.15	14.61	12.06
CV %	26.80	6.00	46.50	38.80	31.60	22.70

*WAT = weeks after treatment, *CV = Coefficient of variation

Values in Parentheses are transformed values

In orchard 2, significantly higher number (9.94) of *C. cosyra* (Table 4) was recorded in week 1 in liquid methyl eugenol baited traps, while solid methyl eugenol had 3.94. Other weeks, recorded low number of *C. cosyra* trapped with week 4 recording the lowest

across all parapheromones. The *C. cosyra* trapped for cuelure was only recorded in week 2 (1.31). Terpinyl acetate recorded the lowest number (0.12) for *C. cosyra* throughout the study. Control did not trap *C. cosyra* in this orchard.

Table 4: Mean population of *C. cosyra* trapped with different parapheromones in orchard II in NIHORT, Okigwe

Parapheromones	Mean population of <i>C. cosyra</i>					
	1WAT	2WAT	3WAT	4WAT	5WAT	6WAT
Cuelure	0.00(1.29)	1.31(1.33)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)
Liquid methyl eugenol	9.94(3.19)	12.38(3.48)	10.56(3.26)	5.06(2.32)	10.31(3.22)	0.94(3.20)
Solid methyl eugenol	3.94(2.08)	3.00(1.87)	0.88(1.13)	0.25(0.86)	0.50(0.98)	0.12(0.79)
Terpinyl acetate	0.19(0.83)	0.12(0.79)	0.00(0.71)	0.00(0.71)	0.19(0.83)	0.00(0.71)
Trimedlure	0.37(0.93)	0.50(0.98)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)
Control	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.00(0.71)
Mean	2.41(1.51)	2.89(1.53)	1.91(1.00)	0.89(1.00)	1.83(1.19)	0.18(1.14)
LSD (0.05)	2.54	4.45	1.29	1.37	2.96	2.08
CV %	29.70	38.40	43.80	37.70	42.50	33.30

*WAT = weeks after treatment, *CV = Coefficient of variation
 Values in Parentheses are transformed values

Number of Dropping Infested Mango Fruits

Number of infested damaged mango dropping per week after treatment reduced drastically during the period of the study (Figures 1 and 2). Damage done by fruit flies was lower on peach mango fruits in orchard 1 compared to Julie mango in orchard 2 in both treated and untreated sections of both orchards. In orchard 1, mean number (31.33)

of damaged fruits for untreated section of the orchard was higher than that of treated (20.50). There was a steady decline of damaged fruits in both treated and untreated sections of orchard 1, as the fruiting season progressed. But, treated section had lower number of damaged fruit during the period of study. Same trend was also recorded on orchard 2, although mean number of damaged fruits were higher.

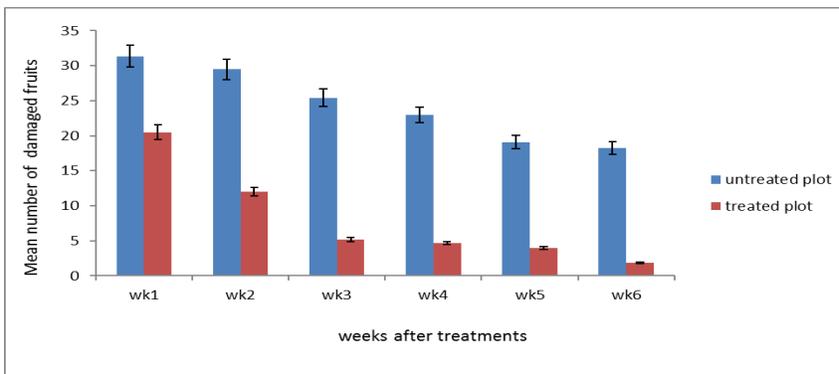


Figure 1: Mean number of damaged mango fruits in untreated and treated plots of orchard 1 (Standard error of the mean as error bar)

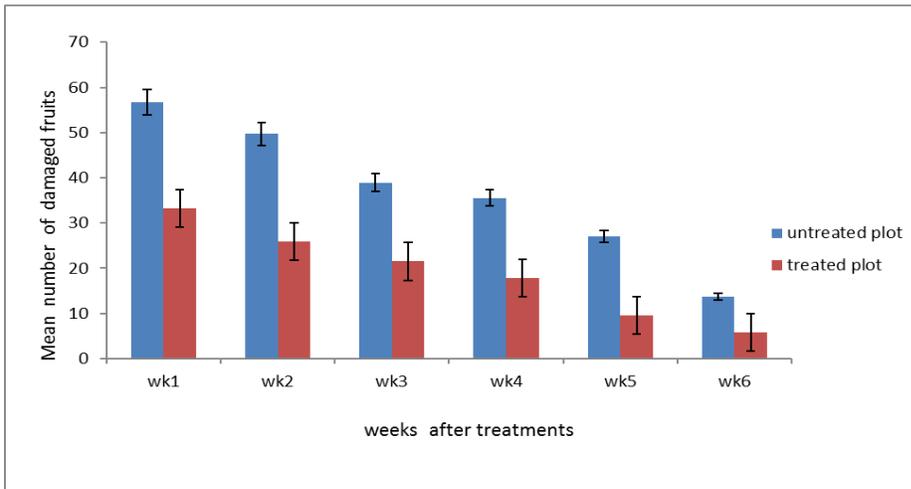


Figure 2: Mean number of damaged mango fruits in untreated and treated plots of orchard 2 (Standard error of the mean as error bar)

The population of *B. dorsalis* trapped by different parapheromones in orchard 1 is shown in Figure 3. Liquid methyl eugenol significantly ($P < 0.05$) trapped highest number of *B. dorsalis* throughout the study period. Catches of *B. dorsalis* by liquid methyl eugenol traps recorded mean population density of 131.80 (92.57%) in 6 weeks, followed by solid methyl eugenol with mean value of 7.05 (4.95%).

There were no significant difference ($P > 0.05$) for the population densities of *B. dorsalis* caught by other parapheromones used in the study. Control also trapped negligible number of *B. dorsalis* in orchard 1. *B. dorsalis* population densities were similar in orchard from 4th– 6th week, although higher values were recorded for week 1 and week 2 (Table 1).

In orchard 2 (Figure 3), similar trend was observed for the population of *B. dorsalis* caught by the various parapheromones. *B. dorsalis* trapped by Liquid methyl eugenol had highest population density 126.55 (92.35%) at 6 weeks which was followed by solid methyl eugenol with mean value of

6.18 (4.51%). Although, catches for Terpinyl acetate showed no significance ($P > 0.05$) in week 1, it outperformed cuelure and trimedlure in orchard 2 (Table 3), and control also recorded similar trend as seen in orchard 1.

The result showed that liquid methyl eugenol was the most effective in trapping *C. cosyra* in orchard 1 and orchard 2. For orchard 1 (Figure 4), it recorded mean population of 8.80 (79.28%) of adult *C. cosyra* per trap after 6 weeks. This was followed by solid methyl eugenol with mean population of 1.73 (15.59%). Although in week 1, liquid and solid methyl eugenol significantly ($P < 0.05$) trapped high numbers of *C. cosyra*, catches for week 2–6 for solid methyl eugenol were not significant in orchard 1 (Table 2), when compared to liquid methyl eugenol that had significant catches. Other parapheromones in orchard 1, recorded very low population density of *C. cosyra* in their traps throughout the study. Control recorded zero catches for *C. cosyra* in orchard 1.

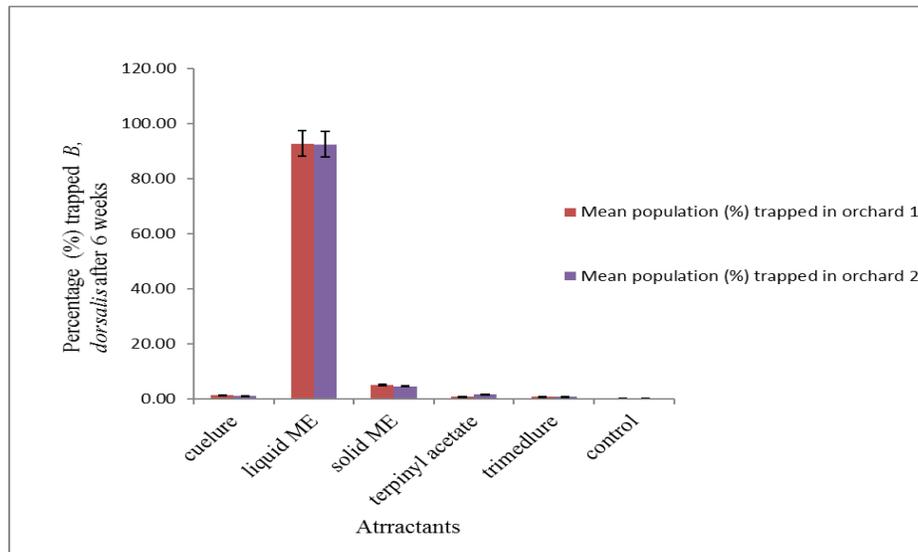


Figure 3: Mean population (%) of *B. dorsalis* trapped with different parapheromones in both orchards in NIHORT, Okigwe
 ME = methyl eugenol. (Standard error of the mean as error bar)

In orchard 2 (Figure 4), similar trends were recorded, except for week 6 (Table 4), recording low density of *C. cosyra* for liquid methyl eugenol. However, mean population recorded for *C. cosyra* for liquid methyl

eugenol was 8.20 (81.19%), followed by solid methyl eugenol with mean population of 1.45 (14.36%). Control also trapped zero *C. cosyra* in orchard 2.

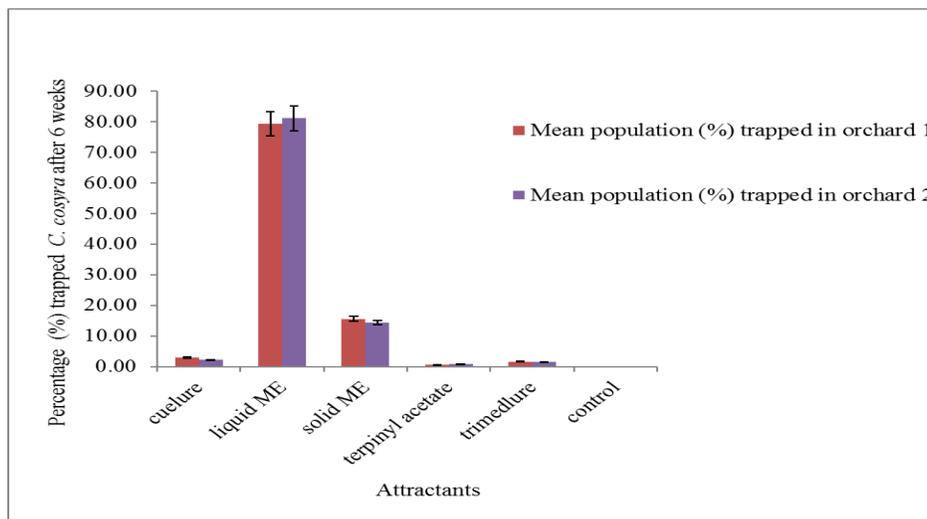


Figure 4: Mean population (%) of *C. cosyra* trapped with different parapheromones in both orchards in NIHORT, Okigwe
 ME = methyl eugenol. (Standard error of the mean as error bar)

B. dorsalis were trapped in all parapheromones at the selected area for the study. There were no significant differences ($P < 0.05$) in the population density of *B. dorsalis* trapped in both orchards. However, trapping of *B. dorsalis* in orchard 1 performed better when compared to that of orchard 2. Figure 5 revealed that mean popul

ation
of *B. dorsalis*
trapped for

orchard 1 (142.38) were higher than in orchard 2 (137.04). This revealed higher levels of fruit flies population in orchard 1. There were no significant ($P < 0.05$) differences in the population density of *C. cosyra* trapped in both orchards. Orchard 1 recorded 11.1 while orchard 2 recorded 10.1.

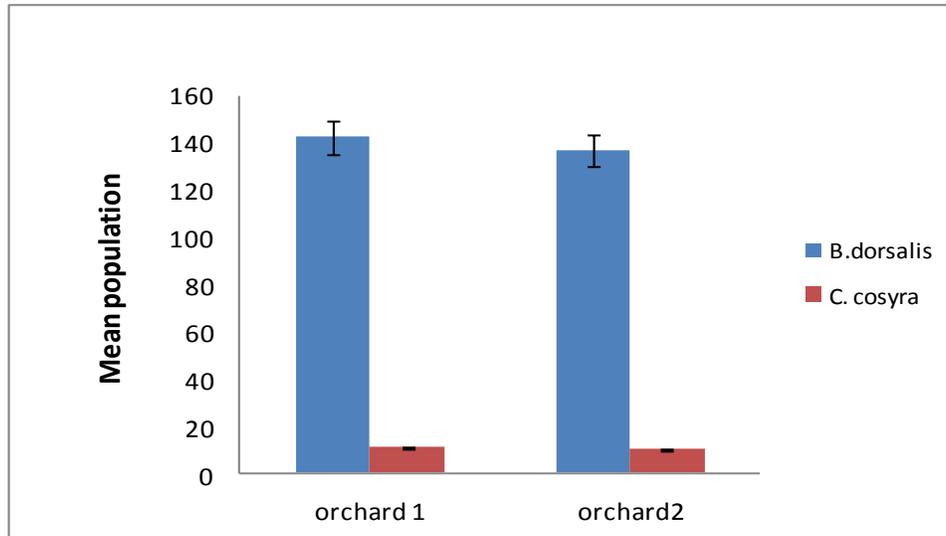


Figure 5: Mean population of *B. dorsalis* and *C. cosyra* trapped in NIHORT, Okigwe (Standard error of the mean as error bar)

DISCUSSION

The study revealed that all the parapheromones tested attracted adult *B. dorsalis* and *C. corysa*. However, the level of attraction varied with the different parapheromones. This corroborates the earlier reports by Ekesi *et al.* 2014 who reported that various food attractants tested in his experiment were able

to attract the *B. invadens* in mango but the level of attraction varied with the different protein baits. Methyl eugenol had high efficacy in trapping *B. dorsalis* compared to other parapheromones evaluated; it was also similar for *C. cosyra* trapping on mango. Asawalam and Ezioha (2016); Ugwu *et al.* (2018) reported the effectiveness of methyl

eugenol on mango, guava and bush mango fruits that were infested with *B. dorsalis*.

Bactrocera captured in methyl eugenol (solid and liquid) traps were in abundance compared to any other treatments. Mwatawala *et al.*, (2006); Asawalam and Nwachukwu. (2011) reported similar results which indicated the sensitivity of *B. dorsalis* to Methyl eugenol. Fruit flies were trapped in mass at the height of the fruiting period during the study. This result is similar to the report of Lutap *et al.* (2009) which indicated peak population of fruit flies during the May-June period of ripening and harvest, using the ME traps to monitor fruit flies.

Cuelure recorded minimal capture of *B. dorsalis* and *C. cosyra*. Similar results were obtained in the works of Vayssières *et al.*, (2010); Ndayizeye *et al.*, (2017) which reported that Methyl eugenol attracted 90.97% of tephritidae in Burundi while cuelure recorded 5 % of the fruit flies captured, this is an abnormal occurrence because males of economically important tephritidae fruit flies may be attracted to either cuelure or methyl eugenol, but never to both (Dhillon *et al.*, 2005). This may be due to possible contamination or coincidental attraction to the yellow traps.

Terpinyl acetate and trimedlure (developed for *C. capitata*) (Ekesi and Billah, 2007), captured very low numbers of *B. dorsalis* and negligible numbers of *C. cosyra*. This agrees with the works of Vayssières *et al.*, (2010) that observed attraction of the genera *Ceratitis* and *Bactrocera* to the above parapheromones. The capture rate declined from week 1 to week 6.

CONCLUSION

Methyl eugenol in liquid form proved highly effective for field suppression of *B. dorsalis* and *C. cosyra* on mango orchard during the

fruiting season at NIHORT, Okigwe, Imo State when compared to the other parapheromones. There was reduction as time went on in the number of fruit flies captured. Therefore methyl eugenol is promising attractants of *B. dorsalis* and *C. corysa* on mango orchards. Suitable choice of attractants enhances the mass trapping results.

The activities of these fruit flies can be controlled by the use of parapheromones especially methyl eugenol which trapped the fruit flies longer in comparison to other parapheromones used in the field. There is urgent need to enlighten fruit growers on the invasiveness of *B. dorsalis* and the use of methyl eugenol for lure and kill in order to improve fruit production to meet with the daily recommended fruit intake and quarantine standard required on local and export markets There is also need for federal government to make these Parapheromones available for small holder farmers so as to achieve food security and alleviate poverty.

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