# COST-EFFECTIVE MASS REARING OF THE ORIENTAL FRUIT FLY, BACTROCERA DORSALIS (HENDEL) ROUND THE YEAR

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## ABSTRACT

*Essential developmental and reproductive attributes of the Oriental fruit fly, Bactrocera dorsalis (Hendel) were studied on five host fruits viz., mango (Mangifera indica), papaya (Carica papaya), guava (Psidium gaujava), sapota (Achras zapota) and banana (Musa acuminate) at 27±1 °C and 65% RH. These studies were carried out to develop economical mass rearing technique for B. dorsalis, which fulfill the supply of good quality fruit flies of specific life stage round the year for various studies. All test host fruits supported the development of B. dorsalis properly from egg to adult emergence. The fecundity of adult flies of $F_1$ generation emerging from different hosts was at par based on incubation period and fecundity rate. Although all test fruits sustained the full development of B. dorsalis, host fruit played a major role in differential adult emergence, and has positive correlation with fiber content ($R^2$=0.87) of the fruit. The cost-effective host fruit for rearing of B. dorsalis is banana followed by guava, sapota, papaya and mango, on the basis of fruit cost and adult emergence per unit weight of fruit.*

**Key words:** *Bactrocera dorsalis*, developmental attributes, reproductive attributes, Mango, Papaya, Banana, Guava, sapota

## Introduction

The true fruit flies (Diptera: Tephritidae) comprises of over 4,000 species are distributed globally. Fruit flies in the genus *Bactrocera* infest fruit of numerous hosts in tropical and semitropical areas of Southeast Asia (CPC, 2005) and include about 500 species. Several species complexes are present in this family, of which the Oriental fruit fly *Bactrocera dorsalis* (Hendel) species complex is of great importance. *B. dorsalis* is widely distributed in the oriental region from Australia and Hawaii to Pakistan (White and Harris, 1992). Waterhouse, (1993) identified *B. dorsalis* as one of the five most important agricultural pests in Southeast Asia. In India, *B. dorsalis* is the most destructive fruit fly of mango, followed by *B. zonata* and *B. correcta* (Abbas *et al.,* 2000).

India is the second largest producer of fruits and vegetables in the world and holds first position in production of fruits like mango, banana, sapota, pomegranate, aonla and vegetables like okra as well as peas. The diverse agro-climatic condition allows production of large variety of tropical, sub-tropical and temperate fruits and vegetables. The area under fruit and vegetable crops during 2012-13 was 7.0 and 9.2 m ha respectively with a total production of 81.3 m MT of fruits and 162 m MT of vegetables(agricoop.nic.in/Annualreport2013-14/artp13-14ENG.pdf).Productivity was found to be lower in fruits (11.3 MT/ha) as compared to vegetables (17.5 MT/ha).However, its share in world trade in fruit and vegetables has remained dismal at 1.7 per cent and 0.5 per cent, respectively due to quarantine regulatory, sanitary and phytosanitary measure associated with host plants. Many countries prohibit imports from India owing to the presence of quarantine pests, particularly commodities that are host plants of fruit fly. Fruit fly status determination lies at the heart of strategic decisions on national and international trade of fruits and vegetables (Aluja and Mangan 2008).

Japan, Australia, New Zealand and USA had imposed ban on import of Indian fresh fruits especially, mangoes and vegetables due to infestation of fruit flies. Moreover, European and Mediterranean Plant Protection Organization (EPPO) lists *B. dorsalis* as an A1 quarantine pest within the broad category of non-European tephrtid(OEPP/EPPO 1983). It has also quarantine significance of Asia and Pacific Plant Protection Commission (APPPC), Comite'de Sanidad Vegetal del conoSur est (COSAVE), Caribbean Plant Protection Commission (CPPC), Inter-African Phytosanitary Council (IAPSC), and Junta del Acuerdo de Cartagena (JUNAC) and Organismo Internacional Regional De Sandad Agropecuaria (OIRSA).

Post harvest technologies for disinfestation of fruits especially for fruit fly include Vapour Heat Treatment (VHT), hot water treatment, cold treatment and irradiation. To standardize the disinfestation protocols, a prerequisite is the supply of good quality fruit flies of specific life stages. So this requires studies on the developmental as well as reproductive attributes of fruit flies for mass rearing. Besides, the emphasis is also on low cost of rearing, simplicity and the availability of fruits. Biology of fruit fly has been extensively studied by many researchers with respect to host effect (Doharey, 1983; Kalia, 1992; Gupta and Verma, 1995). The present paper deals with host fruit influence on the biology of *B. dorsalis*, and describes economical mass rearing on continual basis.

## Materials and methods

The original colony of *B. dorsalis* was established from the infested mango fruits purchased from market of Delhi region. The insects were reared in the VHT laboratory at Division of Entomology, Indian Agricultural Research Institute, New Delhi at 27±1 °C and 65% RH. The infested fruits were kept in plastic container containing sterilized sand. The maggots on completion of larval period hop from the fruits and pupated in the sand. Pupae were collected after two-three days by gently sieving the sand and were stored in moist sand for emergence. Emerging adults were identified (RRS No. 505-511/08) stored in National Pusa Collection at this Division. The adult flies were transferred to rearing cages (about 30x30x30 cm). In the rearing cages, water was supplied in glass bottles with cotton wick, Yeast hydrolysate and sugar cubes were kept in Petri dish to meet the dietary requirement of adult fruit flies.

Five commonly available fruits namely mango (*Mangifera indica*), papaya (*Carica papaya*), guava (*Psidium gaujava*), sapota (*Achras zapota*) and banana (*Musa acuminate*) were chosen to determine the suitability of host fruit for mass rearing of *B. dorsalis* round the year economically. Mango was used as standard fruit for comparison.

### *Developmental attributes of B. dorsalis on different hosts*

All these studies were carried out under controlled condition at 27±1 °C, 65% RH and 12:12 photo-scoto phase. Fresh slices of fruits were kept for two hours in cages having 200-225 pairs of sexually matured fruit flies. Samples of eggs collected were counted under a dissecting microscope, and then immediately divided into five replicates of fifty each and placed on two cm squares of black-moist filter paper for hatching to determine incubation period. Incubation period was duration between egg laying and hatching. First instar maggots upon hatching were transferred into the fruits viz., banana, sapota, papaya, guava, and mango by making cavity to determine larval period on different host fruits. These fruits were kept in the plastic jars (15 cm high and 10 cm diameter) having sterile sand up to the height of 4 cm. Non-feeding/jumping third instar maggot leave the fruit and pupate in the sand. Test fruits were checked by opening fruits to make sure that all larvae have left the fruit and by sieving the sand with a strainer, the pupae were separated from sand. Larval period was the duration between hatching and pupation. Pupae from each test fruit were placed in a separate Petri plates having a piece of blotting paper lining the bottom of the dish and covered with lid. Pupal period was defined by the time between pupation and adult emergence. Date of adult emergence was recorded to determine the pupal period.

***Host preference***

Hundred grams each of different fruits (whole/part) was placed in five adult rearing cages having 200-225 sexually mature flies, which are considered as five replicates. After 24 hrs, the fruits were removed from the cages and transferred to the plastic jars (15 cm high and 10 cm diameter) having sterile sand up to the height of 4 cm. Non-feeding/jumping third instar maggot left the fruit and pupated in the sand. Sand was sieved after 2-3 days after the pupation and pupae were kept in plastic container till emergence. The weight of pupae and size of adult flies emerging from each host fruit were recorded. A number of adult flies emerging per 100 gm of fruits showed the suitability of host for rearing of *B. dorsalis*.

***Reproductive attributes on different hosts***

Ten pairs of newly emerged adults were placed in separate cages having water in glass bottles with cotton wick, yeast hydrolysate and sugar cubes to meet the requirement of adult fruit flies to assess pre-oviposition period and fecundity. For this assessment three replicates were kept. Thin slices of host fruits were placed inside cages for egg laying on $7^{th}$ day onwards to assess pre-oviposition period. When egg laying started, fruits were removed from the cages and counted daily till seven days to assess the effect of test fruit on fecundity of flies.

**Statistical Analysis**

The analysis of variance was carried out for different biological parameters without any transformations by using the least square difference at 5% level of probability using SAS Enterprise 4. Probability less than or equal to 5% (p value, 0.05) was accepted as statistically significant. Correlation between the parameters viz., fiber content of the fruits and number of adults emerged per 100 gm of fruits was determined by regression analysis.

**Results and discussion**

***Developmental attribute of B. dorsalis on different hosts***

The incubation period was varied from 3.5 days (maximum) in sapota to 1.7 days (minimum) in mango (Table 1). However, incubation period was found to be at par among papaya, guava and banana. Similarly, variation was reported in *B. cucurbitae* reared on different cucurbitaceous hosts *viz.,* pumpkin, bitter gourd, squash gourd, cucumber and sponge gourd (Doharey, 1983, Koul and Bhagat, 1994, Gupta and Verma, 1995). An incubation period of *B. dorsalis* varied from 2.0 to 3.25 days on different cultivars of mango whereas on different cultivars of guava, incubation period ranged from 2.25 to 3.50 days (Kalia, 1992). The larval period was maximum in case of guava (9.7 day) and minimum in banana (6.0 day). In papaya and mango, larval period was at par while in guava, sapota and banana larval period was significantly different (Table 1). High fiber content of these fruits may afford an optimum medium for larval development. In earlier studies, the larval period varies from 3 to 21 days (Renjhan, 1949; Narayanan and Batra, 1960; Hollingsworth *et al.*, 1997), depending on temperature and the host. On different cucurbit species, the larval period varies from 3 to 6 days (Chawla, 1966; Doharey, 1983; Koul and Bhagat, 1994; Gupta and Verma, 1995). Kalia (1992) reported range of larval period from 6.0 to 7.75 days of *B. dorsalis* on different cultivars of mango whereas on guava, larval period varied from 7.5 to 9.0 days. In present study, pupal period ranged from 8.5-11.7 days. The maximum pupal period of 11.7 days was recorded on banana followed by papaya. Whereas, pupal period in case of guava, sapota and mango was at par. Similarly Jayanthi and Verghese, (2002) reported 8-11 days pupal period on banana but contrary to present study longest pupal period (12 day) was observed on mango. Likewise, Shehata *et al.,* (2008) reported pupal period of peach fruit fly, *B. zonata.*

Table1.Effect of different hosts on developmental attributes and life cycle of *B. dorsalis*

| Host | Incubation period (days± SE) | Larval period (days± SE) | Pupal period (days± SE) | Total life cycle (days± SE) | Sex ratio ♂ : ♀ |
|---|---|---|---|---|---|
| Mango | 1.7±0.21[c] | 7.5±0.16[c] | 8.8±0.46[a] | 18.00±0.80 [a] | 1:1 |
| Papaya | 2.9±0.23[a] | 6.9±0.27[c] | 10.4±0.30[b] | 20.2±0.77[a] | 1:1.12 |
| Guava | 3.0±0.23[ab] | 9.7±0.30[a] | 8.9±0.40[a] | 21.6±0.88[a] | 1:1.25 |
| Sapota | 3.5±0.16[b] | 8.4±0.33[b] | 8.5±0.16[a] | 20.4±0.63[a] | 1:1.11 |
| Banana | 2.6±0.16[a] | 6.0±0.21[d] | 11.7±0.15[c] | 20.3±0.44[a] | 1:1.22 |

* The figures followed by the same letter in the column do not show any significant difference

at 5% level of probability.

Perusal of data in Table 1 indicates that there was no significant difference in overall mean total life cycle i.e., from egg to adult emergence in all the test fruits. This could be due to shorter larval period of fruit fly *i.e.,* 6.0 and 6.9 days on banana and papaya respectively and longer pupal period (11.7 and 10.4 days, respectively), whereas in sapota larval period as well as pupal period was almost same (8.4 and 8.5 days, respectively) but incubation period was relatively longer *i.e.* 3.5 days. In guava and mango, there was no significance difference in pupal period. However, larvae took longer duration on guava due to higher dietary fiber content as compared to mango. Though, life cycle was completed in shortest duration on mango (18 day). Correspondingly Doharey (1983) reported shorter life cycle on mango (19.8 days) than on guava and sapota (20.4 and 21.8 days, respectively). Contrary to the present studies Jayanthi and Verghese (2002) reported longest life cycle on mango (25.0 day) followed by guava (22.7 day). Sex ratio (♂ : ♀), among all the tested fruits, banana, guava, papaya and sapota favors females i.e., 1:1.22, 1:1.1 and 1:1.06, respectively, whereas in mango, sex ratio was 1:1. Similar findings that all the fruits either favors females or at par with males were reported by Shimada *et al.,* (1981), Batra, (1960), Doharey, (1983), Kalia, (1992), Jayanthi and Verghese, (2002).

The colour of pupa varied with the host fruits and ranged from white (guava) to dark brown (papaya). It is evident from Table 2 that in mango, larger pupae with mean maximum width of 2.1 mm were produced. Pupal width in guava, papaya and sapota was same (1.8 mm). Length of pupa was maximum in mango (4.9 mm), followed by banana (4.7 mm). No significant difference was observed among pupal length in papaya, guava and sapota. Pupal weight was maximum (12.5 mg) in mango followed by guava (8.1 mg), papaya (7.1 mg) and sapota (6.1 mg). Minimum pupal weight was in banana (4.5 mg).

Table 2. Effect of different hosts on pupal size, pupal weight, pupal colour and adult size of *Bactrocera dorsalis.*

| Host | Pupal colour | Pupal weight (mg± SE) | Pupal size | | Adult size | | Number of Adult emerged/ 100gm |
|---|---|---|---|---|---|---|---|
| | | | Width (mm± SE) | Length (mm± SE) | Length (mm± SE) | Wing span (mm± SE) | |
| Mango | Honey brown | $12.5\pm0.72^{d}$ | $2.1\pm0.14^{a}$ | $4.9\pm0.10^{c}$ | $8.16\pm0.09^{b}$ | $14.42\pm0.08^{c}$ | 200 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Papaya | Dark brown | 7.1±0.33[ab] | 1.8±0.02[b] | 4.3±0.14[ab] | 6.0±0.14[a] | 11.7±0.28[a] | 240 |
| Guava | Off white | 8.1±0.21[a] | 1.8±0.03[b] | 4.2±0.06[b] | 6.2±0.15[a] | 12.0±0.29[ab] | 345 |
| Sapota | Light brown | 6.1±0.18[bc] | 1.8±0.02[b] | 4.5±0.07[a] | 6.3±0.13[a] | 11.9±0.22[ab] | 325 |
| Banana | Brown | 4.5±0.65[c] | 2.0±0.02[a] | 4.8±0.02[c] | 6.4±0.13[a] | 12.5±0.27[b] | 303 |

*The figures followed by the same letter in the column do not show any significant difference at 5% level of probability.

Similarly, Kalia (1992) reported that size of pupa varied not only between different fruits like guava and mango but also among cultivars of mango as well as guava. Likewise, Duyck *et al.* (2004) also reported the influence of host fruits (guava, *P. guajava*, strawberry guava, *P. cattleianum*, mango, *M. indica* and Indian almond, *Terminalia catappa*), on larval development, pupal weight and fecundity of four species of fruit flies *viz., Ceratitis catoirii* (Guérin Mèneville), *C. capitata* (Wiedemann), *C. rosa* Karsch and *B. zonata* (Saunders). However in earlier reports, pupal weight was considered as indicator of the quality of the colony as well as of adult performance, since high pupal weight is associated with high fecundity (Krainacker *et al.,* 1989, Vargas *et al.,* 1994). But in the present study, perusal of Fig.1 showed that weight of pupa had not affected the fecundity of females so could not be considered as quality or viability parameter of the colony. Adult size was maximum in mango (length 8.1 mm and wing span 14.2 mm) and minimum in papaya (6.0 mm and wing span of 11.7 mm). There was no significant difference in size of adult was observed among guava, sapota and banana (Table 2). Wing span of 11.5 to 13.8 mm and length of 5.2 to 8.15 mm of *B. dorsalis* adult on different cultivars of mango was reported by Kalia, (1992).

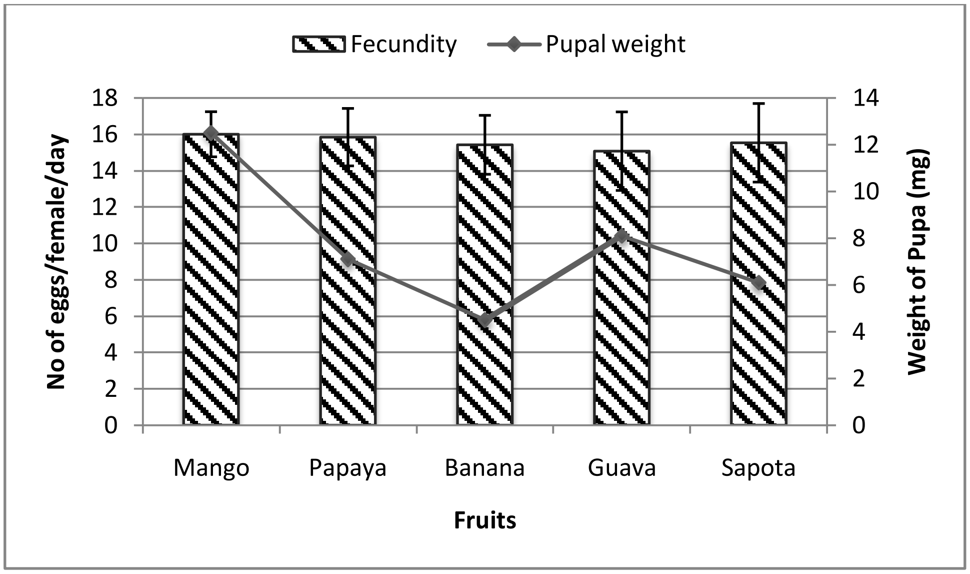


Fig. 1. Effect on fecundity of *Bactrocera doraslis* adult females emerged from pupa formed from the maggots reared on five different host fruits.

***Host preference***

Although all test fruits can sustain the full development of *B. dorsalis*, host fruit plays a major role in differential adult emergence. Of all the fruits, guava had the highest number of adult emergence (345) per 100 gm of fruit followed by sapota (325), banana (303), papaya (240) and minimum of 200 adults from mango (Table 2). This variation in number of adults emerged could be due to the difference in dietary fiber and water content of various fruits. To confirm this hypothesis, dietary fiber content and water content was procured from http://www.nal.usda.gov/fnic/foodcomp/cgi-bin/ site and correlated with number of adults emerged from different test fruits. Dietary fiber was found to be positively correlated ($R^2$=0.928) while water content was found to be negatively correlated (-0.633) with number of adults emerged per 100 gm of fruits (Fig. 2). Hence, the fruits having more dietary fibers favours the development of more larvae than fruits having more water content like mango and papaya (. Thus less number of adult emerged from mango and papaya indicating that guava, sapota and banana were better host for mass rearing of *B. dorsalis*.

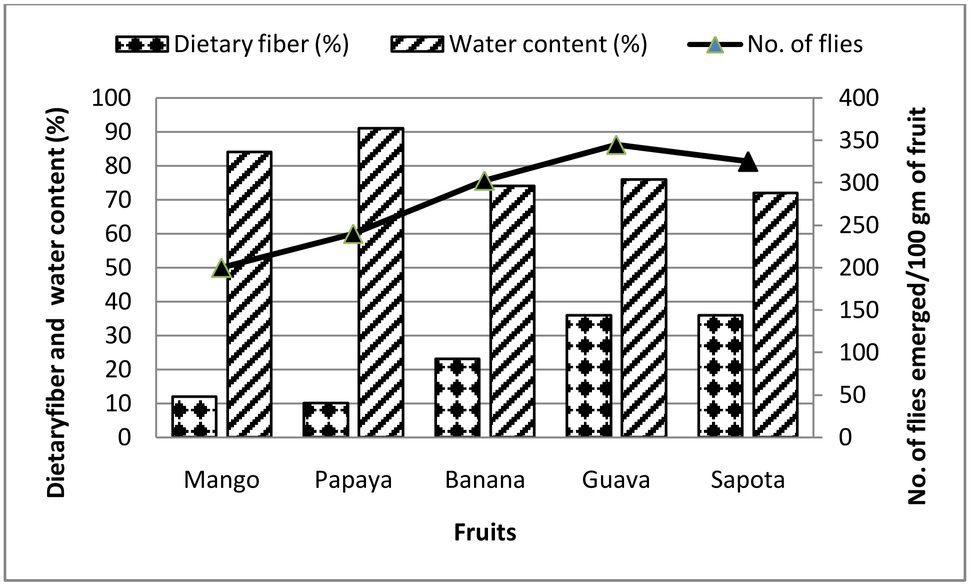


Fig. 2. Correlation between dietary fiber as well as water content of different test fruits with number of flies emerged per 100 gm of fruit

***Reproductive parameters on different hosts***

The results presented in Table 3 clearly indicated that there was no significant difference among pre-oviposition period of $F_1$ adult flies of *B. dorsalis* emerging from different host fruits. Depending upon the pre-oviposition period (18-22 days), *B. dorsalis* could complete 9-10 generation/year. This observation agreed with the previous studies on some fruit flies (Meats, 1980; Saeki *et al.*, 1980; Qureshi *et al.*, 1993; Shehata, 2008). Fecundity rate (15.0-16.0 eggs/female/day) was found to be at par among $F_1$ adult flies emerging from different host fruits (Table 3). Thus all host fruits supported the development of *B. dorsalis* properly from egg to adult emergence. As discussed earlier, pupal weight had no effect on the fecundity rate (Fig.2). The sustainability of different hosts for $F_1$ generation was at par based on incubation period and fecundity rate.

Table 3. Reproductive parameters of *Bactrocera dorsalis* reared on different host fruits

| Parameters | Test Fruit | | | | |
|---|---|---|---|---|---|
| | Mango | Papaya | Guava | Sapota | Banana |
| Pre-oviposition period (days ± SE) | 19.33 ± 2.08 | 18.00 ±2.00 | 21.00 ±1.00 | 21.00 ±2.64 | 22.66 ±2.08 |
| Fecundity*/♀/day (No. ± SE) | 16.00 ± 1.24 | 15.84 ± 1.58 | 15.07 ± 2.16 | 15.53 ± 2.16 | 15.42 ± 1.62 |

*Fecundity data based upon the observation taken every day on egg laying till seven days after pre-oviposition period was over.

The cost per 100 gm of fruit was highest for mango (₹5.0) and least for banana (₹3.0) followed by papaya (₹3.0), Guava (₹4.0) and sapota (₹4.0) (Fig. 3). On the basis of fruit cost and adult emergence per unit weight of fruit, It is clear that cost-effective host fruit for rearing of *B. dorsalis* is banana (101/₹) followed by guava (86.25/₹), sapota (81.25/₹), Papaya (80/₹) and mango (40/₹). Banana and papaya were found to be most suitable host fruit based on their availability throughout the year.

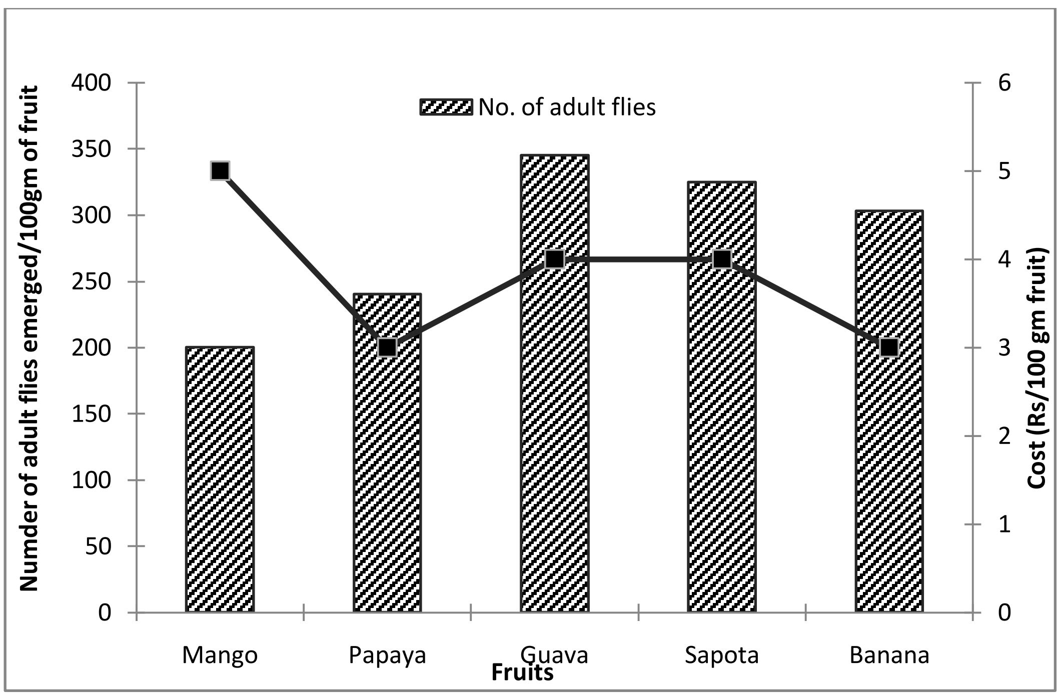


Figure 3. Number of adult fruit flies emerged and cost involved per 100g of fruit

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