ASSESSING THE IMPACT OF INTEGRATED PEST MANAGEMENT PROGRAMME FOR MANAGEMENT OF FRUIT FLIES (DIPTERA: TEPHRITIDAE) ON MANGO ORCHARDS IN TANZANIA

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ABSTRACT: Fruit flies (Diptera: Tephritidae) are a major threat to the vegetables and mango industry in the world. The female flies prick and lay eggs under the skin of the fruits. The eggs hatch and release the larvae which present three immature stages before reaching adult stages. The first two larval stages occur in plant tissues and cause the premature fall of the fruits. The invasive fruit fly Bactrocera invadens was first detected in Tanzania in 2004. Direct damage due to B. invadens attack in African countries varies between 30-80%. Therefore, the objective of this study was to assess the impact different Integrated Pest Management (IPM) techniques on suppression of mango fruit flies in Muheza district. Improvised twenty traps baited with methyl eugenol hanged 2m above the soil surface was used to trap the flies. Traps were inspected every after 7days and were recharged every after 60 days. Traps were left on the same position throughout the entire period of this study. Furthermore, application of Mazoferm bait spray every after two weeks followed by regular fruit collection on weekly basis were considered as full IPM African Weaver Ant (AWA) enhancement was considered as biological control agent. Fruits from different treatment were collected during development stage, green stage and at fully ripening stage. Fruits samples were randomly collected within mango orchards except from weaver ant where by fruits collected were those observed foraged with weaver ants. A total of 2,848 fruit flies belonging to the genera Bactrocera were captured during the study period. B. invadens was the dominant species recorded in all traps during the main fruiting periods of September to December 2013. The effect of Different IPM showed significant differences between sampling dates. Similarly comparison of fruits damage from different treatments showed significant differences (P=0.05). These findings demonstrate that fruits from weaver ants showed AWA significantly reduces B.invadens and needs to be conserved. Fruit fly IPM in the study area should be targeted at different stages of fruit development using singly or combined IPM technologies.

Key words: Full IPM, Mango orchard, population, Sanitation, AWA, B. invadens

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INTRODUCTION

The effect of seasonality on fluctuation of fruit flies (Diptera: Tephritidae) in mango orchard is one of the main factors that can help smallholder mango growers on determining the correct time to develop sustainable control measures [1]. Fruit flies have several peaks depending on the availability of plant host and season. The higher abundance of fruit flies is high during the crop season than during the off season in vegetable and fruit growing areas [2, 3]. In other studies showed that fruit fly population tends to increase with an increase of temperature and moisture [3, 4, 5].

Invasive species *B. invadens* was reported in the country since 2004 after delimiting survey carried out during the same period [6]. Losses resulted from indigenous species was estimated at 20-30% but losses resulted by *B. invadens* is 50-80% depending on the location [7,8]. Despite of the direct damage to fruits it associated with quarantine restriction imposed by fruits importers.

The female flies prick and lay eggs under the skin of the fruits. The eggs hatch and release the larvae which present three immature stages before reaching adult stages. The first two larval stages occur in plant tissues and cause the premature fall of the fruits [9]. In the third stage, the larva eject out of the fruit, to ensure they pupate in the soil from which the adult emerges and the cycle begins again [7].

Regular monitoring of fruit flies population using Pheromone lure traps is necessary to determine the presence or absence of the species and to assess their fluctuations, because the species and their populations change frequently depending on abiotic factors. This information will ensure sustainable control measures of target fruit flies from the selected study area. Therefore, this study was initiated to assess the effect of different IPM technologies on fruit flies species management as an important of poorly documented fruit feeder in Muheza district.

MATERIALS AND METHODS

The district covers an area of 1,497.96Km² characterized with different ground cover. The study area lies between 5° 17’ and 38° 79’. The district has bimodal rainfall pattern the long rain season commence from March to June and the short between October and December. The district receives an average rainfall of about 1,400mm/year and temperatures ranges from 20°C to 32°C. Criteria of the site selection were large area under mango growing were expected to provide good data than the small mango orchard area.

Different IPM techniques were tested including Full IPM, sanitation, biological control and untreated control. (Full IPM includes Male annihilation, bait spray and cultural control).

Fruit fly population was monitored from the selected mango orchard using Methyl Eugenol liquid form, for *B. invadens* population studies was carried out between 2012 to 2013 on the mango orchard. Twenty traps of Methyl eugenol were locally made from used water bottles 0.5L with three holes 10cm diameter evenly spaced. Methyl eugenol traps were prepared by baiting each trap with 3ml of methyl eugenol and Dichlorvos at a ratio of 1:10 in a cotton wick (4 cm long and 1cm diameter); each trap was serviced every after 7 days and was replaced on the same position during the study period. The traps were hanged using a thread 2meter from the ground level preferably shaded area to reduce quick dry up. The hanging threads or wires material were covered with a solid layer of grease to avoid the predatory activity of the ants on the captured flies [10]. Specimens were collected from the bottles using a fine brush and preserved in insect vial containing 70% alcohol for the laboratory studies.

Application of Field Sanitation (Cultural method)

This activity was carried out by picking, weekly or at shorter intervals, of all fallen fruits and burying them in pits 90 cm deep or more. Alternatively the fallen fruits were collected in large black polythene bags which were then tightly closed and exposed to the open sun to scorch developing larval forms with the heat that would be generated. In addition to these methods, in this orchard a special structure, the augmentorium, was erected in which fallen mangoes were also disposed of. The augmentorium ensures that fruit flies emerging from infested mangoes remained within the structure whereas beneficial, especially parasitoids, could escape through fine pores of the netting material composing the top. The sanitation practices were conducted from the start to the end of the mango season i.e. from the time when the mangoes were fruit lets until the time of harvesting [11].

Application of Toxic Food Bait

This was achieved by using Mazoferm food bait + Dichlorvos 50% EC preparation which was sprayed onto 1m² spots/patches on the crown of mango trees, using a shoulder-carried knapsack sprayer as course droplets 4mm in diameter and directed on undersides of leaves to prevent rapid loss of toxic bait due to intense sun.
The toxic bait was prepared by mixing the ingredients in the following ratio: 1 litre of water + 50 ml Mazoferm+5 ml Dichlorvos 50% EC. Spraying was repeated on all trees at 10-12 days intervals throughout the mango season. Application of toxic bait was as far as possible done in early hours of the day from 6-10 AM in the morning or late in the evening from 5-6 PM to minimize drift. Initial bait application was done by MARI staff as demonstration but subsequent routine bait sprayings were done by a trained farm worker of farm owner who was supervised by a village based extension staff.

**Application of Methyl eugenol-(Male annihilation)**
This was achieved by installing 20 methyl eugenol pheromone-baited traps made from discarded 500ml mineral water bottles. The methyl eugenol, prepared by mixing its pure form with Dichlorvos 50% EC at the ratio of 10 parts of methyl eugenol to 1 part of Dichlorvos, was impregnated onto 5-6cm x 1.5-2cm cylindrical compacted cotton wool dental rolls at the rate of 3-4 ml per dental roll. The methyl eugenol-impregnated cotton rolls were hung into the bottles with a thin string and they are attractive for two months, after which methyl eugenol was replenished on the same cotton rolls. Traps were installed 10 meters apart around the corners and in the middle of the orchard hung on trees at 3m above the ground to attract and kill male fruit flies immigrating into the orchard from neighboring areas. Fruit flies entered the trap through three perforations around the bottle 1.5cm wide. Captured fruit flies were counted and recorded weekly. Trapping was done throughout the mango season. Fruit flies population were computed using the following formula F=F/F x D [12].

Where F= Total number of flies captured

T= Total number of traps (For this case traps was =20)

D= Number of days traps were exposed in the field

**Weaver ant Sampling**
Weaver ants abundance were enumerated directly by counting leaf nests per tree and individuals foraging on tree branches [13, 14]. One hundred and fifty mango trees were selected randomly per site for AWA abundance assessment as follows:-

(i) % trees occupied with AWA.

**Untreated (control) orchard**
The mango orchard was planted with different varieties including Apple, Kent, Tommy Atkins and other local varieties. Only collection of mangoes for dissection was done in this orchard in order to compare the effect of the different treatments

**Fruit Sample Collection**
Fruits samples were randomly handpicked except from weaver ant whereby fruits picked were those found foraged with weaver ants during early development stage, greening stage and finally at the ripening stage. Fruits were stored in jute bags well secured with sisal rope and transported to the laboratory. Collected samples were incubated at room temperature into rearing containers 5l filled with sterilized sand at 60oC. At the top the rearing containers were covered with muslin cloth to protect any entry or exit of flies. Fruits were dissected after 12-14 days to examine presence or absence of fruit fly larva.

**Fruit Fly Identification**
The collected insect samples were counted and identification was made based on their morphological characteristics using taxonomic keys developed by the African Fruit Fly Initiative (AFFI) [5].

**Data Analysis**
Data on fruit fly catches from flowering, development or green and maturity stages were converted into fly abundance per trap per day [12]. Similarly one –way Analysis of variance (ANOVA) were used to compare mean differences over the entire period of the study. Linear regression and correlation analyses were used to determine the effect of IPM technologies used in relation to fruits damage.

**RESULTS**

**Fruit Fly Population**
A total of 2,848 fruit flies were captured during the entire period of this study. Lower catches were during March and August. The highest number of *B. invadens* male catches were during the early, mid to the maturity stage of the crop November to January. The sampling dates differ significantly (P= 0.0001) (Figure 1).
Figure 1: Mean number of *B. invadens* males per trap per day (F/T/D) of fruit fly species from February 2012 to January 2013.

**Fruit Fly catches in Muheza Mango Orchard**

The mean fruit fly population /trap/week/ showed significance differences (P=0.0001). Table 1

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**Mean catches per trap**

8 3 2 3 2 4 5 2 2 5 6 7

Key WK= week (F= F/TXD)

**Fruits Damage From Full IPM (ME, bait spray and sanitation)**

Fruits damage from full IPM were 1% followed by fruits from weaver ant 2%, sanitation represent 23% and the least was control represent high fruits damage 32% of the total fruits sampled Linear regression analyses were used to correlate clean fruits from Full IPM (ME traps, field sanitation and Mazoferm spray) and AWA showed there was no significant differences (P>0.05). Comparison between full IPM fruits damage and fruits damage from field sanitation showed significant differences (P=0.05). Fruits from AWA showed significant differences when correlated with fruits from sanitation and control (P=0.05) (Fig. 2).

Figure 2: Fruits damage collected from different treatments n=300
RESULT DISCUSSION

Fruit Fly Catches

During wet season in March an average of 2 insects/traps of *B. invadens* males were recorded. The high trap catches of *B. invadens* males during the wet season resulted from other fruits apart from mango in contrast with Vayssierres et al. 10,15], where he observed an increase of *B. invadens* after onset of long rain season (Table 1). There was a decline of fruit fly population in July followed by gradual increase towards the mango season. Mango season starts from month of September to December and it extends to January for the late maturity cultivars include Kent and Keit in contrast with Lux et al. [16]. Abundance of *B. invadens* males was found to be related to the environmental weather condition and presence of plant hosts. The results from this study showed that *B. invadens* male population has two peaks, the first one was between July after the long rain season and the second one was in January during the maturity stage of different mango varieties including late maturity.

Comparison of Fruit Fly Population during wet and Dry Season

The correlation analysis showed fruit fly catches during wet season showed significant catches with Methly eugenol (Table 1). It suggests that during wet season farmers should pay extra attention to their mango orchards. Similar result was reported by Mahmood et al. [17] who showed a positive correlation between rainfall and *Dacus zonatus* trapping in peach orchards in Pakistan. All weather factors, when computed together, contributed maximum towards population fluctuation [18, 19] and Shukla and Prasad [20]. The highest population of *B. invadens* was high in December which represents the end of the ripening stage of mango season. This can be explained that during ripening stage the population of fruit fly was high compared to the development and green stages. Mango fruits were observed to be more susceptible and attractive to fruit flies near to maturity to ripening stage.

Fruits Damage

Combination of different IPM technologies was highly effective in the management of *B.invadens* in mango growing areas. Male annihilation for example relies on using high density of trapping stations consisting male lure combined with Dichlorvos as a killing agent, was used to reduce population of *B.invades* significantly. Bait sprays applied on a small area of the tree canopy attract both sexes thus reduces fruit flies population. Similarly AWA was effective to protect mangoes from fruit flies infestation as ants were actively foraging on tree branches and deter wide range of pests in contrast with other findings carried out in citrus growing areas [21]. Furthermore, cultural control which involves collection and burial of all fallen fruits, damaged and over ripe was an important activity to reduce fruit flies population, if this technology is widely applied through Farmer Field Schools as a learning process it builds farmers confidence on planning and execution of IPM programs.

CONCLUSION

The results from this study showed that *B. invadens* was recorded from mango orchards throughout the year. The populations peaks coincide with the rainfall and crop phenology as crop matures number of captures were also observed to increase. This suggested that the control measures of the target pest to start early after onset of long rain season to reduce population build up. Use of different IPM technologies is highly encouraged to reduce fruit flies population if applied alone or in combination with other control measures. Farmers who cultivate late maturing variety are advised to undertake strategies that are targeting reduction of *B. invadens* population build up throughout the crop season. Enhancement of weaver ant showed its potential as a biological control of invasive fruit flies and considered as an alternative option for poor mango growers. This observation is similar to other findings reported in citrus growing areas [22].

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REFERENCES


