Management Strategies For Fruit Flies in Fruitcrops – A Review

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Abstract- Fruit flies are one of the major threats to the world horticulture sector. They cause significant value losses to the horticultural crops. They have attained the status of worldwide quarantine insect pest. Across the world various studies have been conducted on their status, biology, damage and management. Due to the adaptability of fruit flies to various regions, high reproduction rate and polyphagous nature their management is so challenging. Fruit flies cannot be managed by using a single management tactic so more than one tactic is required to be combined for their management. Different methods of control like cultural control, physical control, behavioural control, mechanical control, biological control and chemical control etc. should be used in combination for managing them effectively. Different methods of management of fruit flies including SIT (sterile insect technique), MAT (male annihilation technique) etc. are discussed here in this paper which will be helpful in framing an effective fruit fly management programme.

Keywords– Quarantine, biology, polyphagous, sterile insect technique, behavioural control and male annihilation technique.

1. INTRODUCTION

Fruit flies are the economically important pests belonging to order Diptera: and family Tephritidae comprising of about 4000 species in 481 genera. Importance of horticultural crops is manifested by their high export potential, yield and monetary benefits per unit area (Ravichandra, 2014). But due to the adaptation of fruit flies to various regions, highly polyphagous nature and rapid reproduction some of their species, fruit flies have globally became the invasive pests of many horticultural crops (Baral *et al*., 2006; Muhammad *et al.*, 2004; Mumford, 2006 and Ndiaye *et al.*, 2008). Frequent climate change is also facilitating the frequent outbreaks of fruit flies in horticultural crops (Sultana *et al.*, 2017). Fruit flies are threatening the production and market potential of fruit crops by deteriorating their quality and quantity. They directly damage the important export crops which may lead to losses of about 40% to 80% or even more, depending on the crop, variety, growing region and growing season (Kibira *et al.*, 2010). They are transported very easily across borders without being detected. Because of this fruit flies have acquired the status of worldwide quarantine pest. European Union (EU) has imposed strict quarantine measures while importing fresh commodities. Detection of only one larva/maggot of fruit

fly at the entry point of an importing country will lead to the cancellation and destruction of the whole consignment of mango. Then EU imposes a ban for that particular exporting country. Female fruit flies directly damage the fruits by puncturing them for oviposition and the larvae develop inside the fruit (Aluja, 1994). It is very challenging to manage them because full grown third-instar larvae of fruit fly leave the rotting fruits and fall on to the ground for pupation in soil. Hence in this way, larvae and pupae both escape from the application of the insecticides on the surface of fruits (Heve *et al.,* 2016). Managing the menace of fruit flies with chemicals is becoming very difficult because in many countries formerly effective pesticides are being eliminated from the market and increasing global awareness among general public for pesticide residue free food. Hence, novel environment friendly methods of fruit fly management are being developed (Navarro-Llopis *et al.,* 2011 and Böckmann *et al.,* 2014). Fruit flies cannot be managed by a solo management tactic so more than one tactic is required for their effective management. Every tactics is having its own different pros and cons, and their adoption may or may not be possible (Suckling *et al.,* 2016). The objective of this paper is to establish a systematic review of the available management practices for fruit flies on horticultural crops.

1.1 Biology of fruit flies

Female fruit flies lay eggs on the surface of host fruits. After that eggs hatch into maggots/larvae. First instar larvae are very small and delicate. Second instar larvae are slight more robust and third instar larvae are quite stout and tough. After finishing feeding third instars leave the decaying host fruits, fall on the ground, and crawl into the soil for pupation. After that larval skin gets hard, become tanned brown and barrel-shaped which is called `as the puparium. Inside that puparium, true pupa will form, pupa turns into an adult fly. Adult fruit fly split open the anterior end of the puparium and escapes from the puparium by squeezing out. They may have multiple generations in a year depending on the host availability.

2. Management strategies for fruit flies

2.1 Cultural Control

Cultural methods of control generally rely upon orchard sanitation and crop hygiene which is focused at disrupting the normal life cycle of the target pests. For this purpose, it is very crucial to thoroughly understand the biology of fruit flies. It is important to ensure that the maggots present in fallen fruits don't get mature and pupate in the soil. Cultural control comprise the collection and destruction of all the infested fruits either they are present on the trees or fallen on the ground. Destruction of fruits can be done by crushing them in a grinder followed by burying them under the soil surface at least >50 cm depth. This can significantly reduce the fruit fly populations. Rwomushana (2008) observed that higher density of *B. invadens* was found in fallen mango fruits on the ground as compared to the fruits sampled from the tree which is highlighting the crucial role of farm/orchard sanitation in the management of fruit flies. Cultural control of fruit flies is very labour intensive but can be very effective if practised on regular basis. Collection and destruction of infested and fallen fruits is very strongly recommended to minimize the populations of fruit flies in farms/orchards. Another cultural control method against fruit

flies is collecting infested fruits in black plastic bags followed by tying that bag and exposing them to the sun for some days until the fruits are rotten and all the maggots in the bags are killed. Successful control of *B. zonata* has been attained in Egypt by using the killing bags (Mohamed and El-Wakkad, 2003).

2.2 Mechanical Control

Mechanical method of pest control includes wrapping/bagging/netting of fruits with either newspaper or paper bags. This is done to avoid the egg laying of adult female flies on the fruits to produce fruits which are free from the infestation of fruit fly. Wrapping of fruits should be done before the attack of fruit fly like at least one month prior to harvesting. Though this is a laborious practice but is an effective method to prevent the attack of fruit flies on fruits (Badii *et al.*, 2015).

2.3 Physical Control:

Physical methods of fruit fly management include the post-harvest quarantine treatments. These treatments are harmless to the fruits being treated, to the people treating the fruits and eating the treated fruits. These treatments are compulsory for the export commodities. Available post-harvest quarantine treatment which are being used as the substitute of the toxic chemicals fumigation include: i) heat treatment to increase the temperature of fruits above thermal limits of the fruit fly, ii) cold treatment to decrease the temperature of fruits below the thermal limits of the fruit fly, and iii) irradiation with gamma rays from a Cobalt-60 or Caesium-137 source to kill the developing flies (Robinson, 2005).

2.4 Behavioral Control

Behavioral methods of fruit fly management included two main tactics that is Sterile Insect Technique (SIT) and Male Anihilation Technique (MAT).

Sterile Insect Technique (SIT): In this technique artificially sterilized populations of the male fruit fly is used for mating with the fertile female in the wild population of fruit flies. This is done to interrupt the normal reproductive cycle of insects (Van der Vloedt and Klassen, 2006). Presently irradiation is commonly used method for the sterilization of the insects. Fruit flies are exposed to X-rays, electron beams and gamma rays from a Cobalt- 60 or Caesium-137 source to induce reproductive sterility (Robinson, 2005). This is one of the non destructive method pest controls. SIT is very advantageous because it is species-specific, relatively safer to the environment and is compatible with the other methods of pest control (Hendrich *et al.*, 2002 and IAEA, 2003).). SIT was successfully used for the management of Mediteranean fruit fly, *C. capitata* in Southern Mexico (Hendrich and Hendrichs, 1998). Application of SIT has successfully eradicated the *C. capitata* from Chile in 1995 (SAG, 1996). *B. dorsalis* (Hendel) was successfully eradicated from Okinawa and neighbouring islands in the Ryukyu Archipelago, Japan by using SIT (FFEPO, 1987).

Male Anihilation Technique (MAT): In this method parapheromones are used in controlling fruit flies. Aim of MAT is to reduce the population density of male fruit flies so that mating does not occur or mating gets reduced to very low levels. In market parapheromones are available in the form of liquid and polymeric plugs (a controlled-release formulation). Parapheromones are highly species specific and are highly efficient in attracting fruit flies from even long distances. Mainly types of attractants used

include Methyl eugenol (ME), Cuelure (CUE), Trimedlure (TML), Terpinyl acetate (TA) and Vertlure (VL). Methyl eugenol and Cuelure are used to attract several species of *Bactrocera*, Trimedlure and Terpinyl acetate are used to attract several species of *Ceratitis*, whereas several species of *Dacus* are attracted by using Vertlure (IAEA, 2003; Manrakhan, 2006). This kind of attractants are being used for the management of fruit flies in many countries (Ekesi and Billah, 2006; COLEACP-CIRAD, 2009). Use of traps and procedures of trapping fruit flies varies according to the type of attractant used and the area where traps need to be installed (IAEA, 2003).

2.5 Use of Foodbaits

Management of fruit flies mainly depends upon the use of food baits (hydrolyzed proteins or their ammonium mimics) mixed with an agent used for killing. This technique is known as the Bait Application Technique (BAT). These lures are used to attract both male and female fruit flies. Foodbaits are not specific to species and are less efficient in comparison to the male lures (White and Elson-Harris, 1992). In market foodbaits are procurable in both liquid and dry synthetic forms. Available liquid food baits include ammonium salts, proten hydrolysates, yeast products and the three component lure made up of ammonium acetate, putrescine and trimethylamine (Lux *et al.*, 2003; IAEA, 2003; Ekesi and Billah, 2006). GF-120 (Success® Apart), SolBait, Nulure and Buminal are some of the commercial baits which are presently available in the market, (Ekesi *et al.*, 2009; Vayssières *et al.*, 2009). Bait Application Technique has minimum effect on natural enemies and pollinators. This method is less time consuming and less laborious.

2.6 Soil inoculation

Soil inoculation with fungal pathogens is an important tactic of managing fruit fly by killing the mature maggots and pupae of fruit flies. In this method, only immature stages of the fruit flies are being targeted. Fungus *Metarhizium anisoplie* is the active ingredient in this method and is available in the form of granules which can be dispersed by hand. After that the granules are mixed with the soil where they can last for over the period of one year (Ouna, 2010). Other botanicals like neem cake and can also be used for the inoculation in the soil to kill the pupating larvae (Ekesi and Billah, 2006). Some other potent isolates have been identified against *B. invadens* for soil inoculation targeting both pupating larvae and adult using auto dissemination devices (Ekesi *et al.*, 2009 and Ouna, 2010). Overall effect of the soil inoculation on egg laying and fertility of the adult is very promising but this method cannot be recommended as sole technique for the management of fruit flies so this method can be combined with other management practices. This technique is eco-friendly, can be used in combination with the bait sprays and can be easily adopted by the farmers.

2.7 Early harvesting of fruits

Fruit fly infestation can be avoided by early harvesting of the fruits. Fruits should be harvested at such stage where they are not much vulnerable to the attack of fruit flies. Because of the preferences of color for oviposition by fruit flies some fruits are not considered as suitable host by them at the early maturity stage, so this method can be employed in such cases to avoid the attack of fruit flies; e.g. Green unripe fruits of mango are not suitable host of fruit flies for egg laying. Fruits like papaya, banana and sapodilla

are not attacked by fruit flies when they are 100% green; e.g. across the world bananas are exported at the mature green stage because at that stage banana fruits are not vulnerable to the attack of fruit flies (Badii *et al.*, 2015).

2.8 Biological control

Natural enemies of fruit flies can also contribute in their management hence their natural should be conserved in the farm/orchard (Stibick, 2004). Blanket spray of pesticides is hazardous to population of natural enemies. Minimum blanket spray applications and spot treatment of pesticides can help in conserving the important natural enemies. Use of natural enemies is relatively safer, sustainable and economic (Ekesi and Billah, 2006). *Opines* spp. is the most abundant group of parasitoids which is frequently used against the fruit flies. These larval parasitoids are parasitizing the young larvae of fruit flies which are feeding under the fruits skin. Larval-pupal parasitoids like *Terastichus* spp (Eulophids) can also be used to complement the activities of *Opines* spp. (Stibick, 2004*). Fopius (Opius) longicaudatus* var. *maliaensis* Fullaway, *Fopius (Opius) vandendoschi* Fullaway, and *Fopius (Opius) ariasanus* Fullaway are highly effective against the oriental and the Mediterranean fruit flies in and they have been established in Hawaii. About 80% less infestation of *B. dorsalis* was recorded in guava as a result of parasitism.

A study conducted in Benin revealed that number of fruits damaged by fruit flies was significantly reduced by the use of predator ants *Oecophylla longinoda*. Predation took place on adult fruit flies and ants disturbed them during oviposition which was the major causes of reduction in fruit fly damage. According to (Drew *et al.,* 2005) high larval mortality was observed by birds and rodents after the consumption of infested fruit by them. Nematodes, protozoan, bacteria and fungi are the other biocontrol agents which have been used against Tephritids. Larvae of *Anastrepha* spp. are reported to be susceptible to the entomopathogenic nematode, *Neoaplectana* spp (Rhabditida, Steinematidea) and *Heterorhabditis* spp. Pathogens attacking fruit fly was firstly observed in Hawaii by Fuji and Tamashiro (1972) as they observed the protozoa (*Nosema tephritidae*) infecting *B. dorsalis* and *C. capitata*. Efforts should be made to conserve the natural enemies by using such management practices which are safer to them.

2.9 Chemical control

From the starting of the 20th Century fruit flies have been managed by using the combination of baits with various pesticides. Across the world, hydrolyzed proteins and partially hydrolyzed yeast are used in a ratio of 4:1 with organophosphates like malathion have been aerially applied in ultra-low volume. Generally bait sprays are applied on bands or spots hence minimizing the area being treated. Research is being conducted on replacing malathion in bait spays with much specific, potent and environment friendly pesticides like spinosad. Male annihilation programme is successfully being used worldwide against *Bactrocera* spp. In this technique, wooden blocks which are impregnated with Methyl Eugenol and Malathion are spreaded and they attract male *Bactrocera* while feeding on the bait. (Ekesi and Billah, 2006; Mwatawala et al., 2009; COLEACP-CIRAD, 2008).

3. Conclusion

Attack of fruit flies is a major factor affecting the production of fruits crops. They are directly damaging the important export crops which may lead to losses of 40% to 80% or even more. It is very difficult to target their damaging stage which is larvae because larvae of fruit flies feed under the skin of the fruits. Due to the fruit fly infestation farmers are suffering from huge losses. They are deteriorating the quality and decreasing the yield potential of fruits crops. And it is quite impossible to manage fruit flies by using a single management strategy because every management strategy is having its own advantages & disadvantages. In addition to this fruit flies are polyphagous in nature and they may have multiple generations per year depending upon the availability of host. Hence, there is urgent need to combine all the available management practices like cultural, physical, mechanical, behavioral, biological, chemical control etc. to manage fruit flies, It is very important to create awareness among farmers about the importance of these pests and the techniques of managing these pests so that they can grow a crop which is free from the infestation of fruit flies and earn a handsome amount of money in exchange of their crops.

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