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How to Manage Fruit Fly (Family Tephritidae) Pests Damage on Different Plant Host Species by Take up of Physical Control Measures

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Abstract

This article analyses different fruit fly's management approaches and offers some solutions and options to deal with this most common pest issues in fruits and vegetables production. Today, gardeners and growers have the ability to control fruit flies successfully as a result of the development of biologically based sustainable pest management strategies that use environmentally friendly methods to suppress fruit flies to economically manageable levels. Specific control measures may be applied to reduce fruit fly populations to or below the specified level of low pest prevalence. Physical controls rely on good horticultural practices to prevent or reduce the probability of fruit fly infestations, and in the absence of that option, the incidence of pest is likely to increase and infestation can be difficult to manage. For this purpose the decision includes creating of barriers and placing of traps for removal of insect pests, and these methods should be considered the first line of defense. Sampling and monitoring are critical to assess the presence and level of prevalence of the target fruit fly species. Parameters used to determine the level of fruit fly prevalence is flies per trap per day that is the result of dividing the total number of captured flies by the product obtained from multiplying the total number of inspected traps by the average number of days the traps have been exposed. Physical controls create a barrier between the pest and the fruit to decrease the probability of fruit flies infestation. Covering of individual fruits (for peaches and other larger fruits), fruiting clusters or entire fruiting plants (for berries) with a fine netting (0.98 mm mesh), nylon stocking or paint strainer bag are promising options. Taking up of Integrated Pest Management (IPM) is knowledge intensive and ecologically based decision making process that uses a variety of management tools and methodologies to suppress fly pest populations to acceptable levels but relies primarily on natural mortality factors.

Keywords

Tephritidae, Diptera, Fruit Fly, Vegetable, Fruit, Physical Control

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1. Introduction

Fruit flies (Family Tephritidae) insect pests attack sound and damaged fruits and vegetables by laying eggs under the skin. The eggs hatch into larvae that feed in the decaying flesh of the fruits and vegetables. At maturity, larvae drop to the ground and after burrowing in the ground, their skins harden to form hard shells called puparia, inside which the larvae transform themselves into adults fly. As well as these direct losses, other most important losses result from quarantine restrictions that are enforced by trading countries to avoid the entrance or establishment of unwanted fruit fly species. Substantial monetary burdens are forced on governments, farmers and exporters, who have to implement quarantine surveillance systems, quality assurance schemes and acceptable post-harvest quarantine treatments if they wish to export fruit fly host products. The cost of losses due to

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infestation of fruit flies can be surprisingly very high (Allwood et al., 2001). There are examples where losses have been up to 100% in cucurbit species, caused by melon fly (*Bactrocera cucurbitae* Coquillett) (Dhillon et al., 2005; Sarwar et al., 2013). The bitter gourd is found as most preferred host, brinjal observed as moderately preferred, while, muskmelon and pumpkin sorted out as least preferred hosts by *B. cucurbitae*. Crop losses in guava *Psidium guajava* L., (9.05-7.45%), *Citrus reticulata* Blanco (3.33-3.70%) and mango *Mangifera indica* L., (8.05-18.59%) have also been recorded by Sarwar et al., (2014 a; 2014 b; 2014 c) by peach fruit fly *Bactrocera zonata* (Saunders) and oriental fruit fly *B. dorsalis* (Hendel). The frequent use of insecticides in controlling fruit flies in fruits and vegetables has not resulted in sustainable management of the pest. Problems associated with this complete reliance on chemical control are many residues of insecticides in crops, health problems for farmers, contamination of water and soil, insecticide resistance development and decrease in natural enemy populations (Victor, 2009). Also neuro-toxic effects are believed to be a result of a high level insecticide exposure (organophosphate, organochlorine and carbamate) on humans (Kamel and Hoppin, 2004). Despite this, a lot of knowledge is still lacking and it is indispensable to the understanding of these pests that this knowledge gap be filled. It is urgent to find more effective and environmental friendly control strategies that guarantee a sustainable production of fruits and vegetables (Shah et al., 2014; Sarwar et al., 2015).

Suppression of fruit fly populations may involve the use of more than one control option; some of these available methods may include use of beneficial natural enemies, cultural control, chemical control and physical control. The use of insecticides as the only way to control pests in fruits and vegetables causes environmental pollution and hygienic problems that represent a risk for peoples and animals (Gallo, 2007). In the last four decades the use of synthetic pesticides such as organophosphate and carbamate in an extensive way has led to the development of insecticide resistance in a number of pest species (Hsu et al., 2004) and residues of organophosphate and organochloride and other compounds have been detected in soil, water and crops (Thapinta and Hudak, 1998). Insecticides in the form of pyrethroids, and thriazopos have been used on cucurbits crops but the results have not been satisfactory. Resistance problems due to the overuse of such insecticides and high residues in the sprayed vegetables are some of the concerns that necessitate some form of other management strategy. Other approaches to pests fruit fly management, such as use of protein baits have been more or less ineffective because of our limited knowledge of the ecology of the fruit flies. Now, there are concerns about how to control fruit flies in the most efficient way (Sarwar, 2014 a; 2014 b).

The most effective organic solution for the home gardeners is the exclusion method. This simply involves covering either the individual piece of fruit, fruit clusters or the whole tree. It sounds time consuming but can be surprisingly easy and fast compared to the process of donning protective gear and spraying a chemical control several times through the fruiting season. Commercial fruit fly exclusion bags are available in either waxed paper or cloth. These paper fruit bags come in two sizes, the smaller size is suitable for nectarines, peaches and persimmons, while the larger size is for mangoes or apples. Excluding fruit fly from the entire tree is also possible by using a light weight fabric such as mosquito netting, shade cloth or nylon fly screen material. These materials are generally needed to be supported by a frame. Early in the season, thin the fruit, then simply twist a bag over each remaining cluster of fruit, using the built-in twist-tie. Only leave these covers in place for the period that fruit is ripening to avoid damage to the tree. A big advantage to exclusion is that it usually helps to deal with bird problems as well. With this organic solution for the gardeners, it is possible to enjoy unsprayed fruit fly free fruits (Ketelaar and Kumar, 2002; Johnson et al., 2006).

2. Physical Control of Fruit Fly

The principle of physical control involves providing a barrier between the host fruits and the egg-laying female fruit fly.

2.1. Surveillance Activities of Fruit Fly Prior to Establishment Using Traps

In addition to removing the food sources of fruit flies and preventing them from getting in crop area, the best way to get rid of pest is to use a trap. Prior to the establishment of a fruit fly, surveillance to assess the presence and level of prevalence of the target fruit fly species should be undertaken for a period determined by its biology, behavior, climatic characteristics of the area, host availability and appropriate technical considerations. This surveillance should continue for at least 12 consecutive months. One of the mainly significant things to manage flies is analytically monitoring for adults and larvae. For best results, combine the information so gained through monitoring with multiple pest control methods i.e., cultural, physical, biological, and chemical (International Atomic Energy Agency, 2003; 2011; Mwatawala et al., 2006). Monitor the levels of fruit fly damage to crop and determine if there is an economic injury level. Evaluate the pest's situation on crop and use recommended strategies if damages warrant to fruit fly control. Fruit sampling as a routine surveillance method is not widely used for monitoring fruit flies in low prevalence

areas except in areas where it may be a major tool.

The most widely used parameter to determine the level of fruit fly prevalence is defined by the flies per trap per day (FTD). More precise spatial data may be presented on the basis of trap density (FTD per unit area) or temporally for each trap present in an area over time. The FTD is an index used to estimate the population by averaging the number of flies captured by one trap in one day. This parameter estimates the relative number of fruit fly adults in a given time and space. It provides baseline information to compare fruit fly populations among different places and time. The FTD is the result of dividing the total number of captured flies by the product obtained from multiplying the total number of inspected traps by the average number of days the traps are exposed. The formula is as given: $FTD = F/ T \times D$

Where F = total number of flies captured, T = number of inspected traps, D = number of days traps are exposed in the field. In areas of the world where the fruit flies are established and not controlled, the damage threshold may be 1%.

The information may complement trapping for adults with fruit sampling for larvae. Fruit sampling may be especially useful for surveillance for fruit flies when no traps are available. If larvae are detected in fruit sampling, it may be necessary to rear the larvae to adults in order to identify them. This is the case particularly if multiple species of fruit flies may be present. However, fruit sampling alone cannot provide sufficient accuracy for describing the size of the population and should not be solely relied on to validate or verify status. Surveillance procedures on fruit sampling for infestation may include remove of any fruit from the tree with dimples or weeping clear sap and tiny punctures that leak juice when the fruit is squeezed indicate infestation. A magnifying glass may helpful to look for damage and cut open fruit to look for larvae inside of host.

2.2. Exclusion of Fruit Fly

Exclusion is a preventative method that uses physical barriers to stop female adult fruit flies from reaching the fruits and vegetables. This method forces female flies looking to lay eggs in crop to search elsewhere for a suitable host. Typical barriers that can be used around the gardens are nets, bags and sleeves. Exclusion benefits completely to protect crop so that it can be harvested larvae (maggot) free, allows produce to ripen as normal on the tree or plant, requires a once only application of exclusion products over crop, and can help to protect crop from other insect pests as well as birds. Some exclusion products can be reused from year to year, have relatively low cost and easy to use when compared to chemical spraying.

Exclusion method is right for personally owned or renting areas, in a fruit fly prone area particularly in highly infested areas, an effective, organic method without the use of chemicals, desires produce to ripen on the plant as it is unsuited to being picked green, and have only limited success with other control methods such as cover spraying and baiting. Factors affecting success of exclusion barriers include, well secured for fruits and vegetables and free from tears and gaps, timing of the placement of barriers over crop, usage in combination with other control methods such as sanitation and pruning, removal of any infested fruit if barriers are placed on plants late in the season, and integrity of exclusion products may be damaged if are not removed at the end of the season.

2.2.1. Some Ideas for Making Physical Exclusion Products

If someone is able and willing to make one's own exclusion products, it is possible because some home-made exclusion products, such as cloth or paper bags and sleeves, can be made relatively easy from items that may be found from around the household. Ideally, the materials used for exclusion products should be relatively durable to outdoor conditions. Some ideas for making one's own physical exclusion products are provided below:-

(i) Nets

The nets can be made from materials such as mozzie (mosquito) nets and gauze curtain material (1.6 mm good for fruit flies and most other pests). But, the gauze curtain material may deteriorate quicker when exposed to weather or lace curtain material may be unsuitable as it eventually deteriorates and become unusable. The nets can be made from mozzie nets, cut or sewn to desired shape and size which may have zipper on side for easy access. The frames for nets can be made from materials such as electrical conduit or Polypipe (2 inch in diameter) that does not lose its shape in the sun. The frames can be constructed by crossing over and securing (tie with wire) together two lengths of pipes over the tree. The frames can be secured in the ground by slipping end of polypipe over pickets in the ground.

(ii) Bags and Sleeves

The bags and sleeves are generally a little more easily made because of the size required and materials used to make these. For exclusion products such as bags, some gardeners have been known to use brown paper lunch bags (which may get soggy when it rains), wax paper bags that are used for keeping mushrooms in, and mozzie netting cut and sewn according to size. The sleeves can be made from materials such as mozzie netting, fly screen and gauze curtain material, also cut and sewn to desired size. Both bags and sleeves can

be secured to the tree or plant with string, clothes pegs or tie wire.

2.2.2. Placement of Barriers on Crops

For installing exclusion, select barriers that are best suited to crop needs, for instance, nets are suited for whole trees or whole branches and even whole rows of crops. Bags tend to be better for individual fruit with little or no stems, and sleeves are better suited for covering clumps of fruit, such as plums. It is needed to try different barriers to see which ones best suits to crop situation and may not be labor-intensive and time-consuming.

(i) Nets

Try to place nets either directly on plants, on a frame of PVC tubes staked in the ground, or over individual tree branches, secure nets well to the frame or the base of the tree to prevent tearing by strong winds and wildlife such as birds becoming entangled. Use a sturdy frame if possible as this will help the net to last longer from rips and tears caused by branches, secure nets at ground levels with heavy object such as bricks or logs, or use stakes or pegs to prevent fruit fly from getting inside the net, prune trees to a smaller size so that nets can more easily be placed and removed from the tree, or consider planting dwarfed varieties of fruit trees, and practice sanitation within the net. Sometimes, it is also possible to use insecticides-treated nets on plants for protecting crop as well to kill fruit flies.

(ii) Bags and Sleeves

Try to place bags and sleeves over the fruit desired to keep inside, thin (remove) any flowers or developing fruit that are not covered by a barrier from the plant, and secure bags and sleeves to the plant with tie wire, clothes pegs or string.

2.2.3. Preparation and Placement of Paper Bags on Crop

Typical barriers that can be used around the gardens are paper bags and the most common method is to bag or wrap fruit before the fruits reach a stage of maturity at which these are susceptible to infestation. Normally, bags made from double layers of newspaper or brown paper are used. Fruit bagging or wrapping has been widely used in tropical Asia for nearly a century ago, and it is a common practice for the protection of crops, particularly those grown for export. The damage levels may be reduced from nearly 100% to 15-25% by bagging. Correspondingly, this technique is used to protect mangoes from fruit fly attack and to protect melons from melon fly. Generally, this technique is applicable where relatively small areas of production are involved (e.g., village or subsistence production); where the costs of labor is cheap; where high quality, high value, unblemished produce is necessary; and where no alternative practical methods of control are available. This technique is appropriate for fruits and vegetables production systems and should be encouraged especially for backyard and village production.

To prepare a bag use a double layer of newspaper as a double layer of newspaper is needed to make a bag and a single layer breaks easily. Fold and sew or staple the sides and bottom of the sheets to form a rectangular bag. To bag fruits, blow in the bag to inflate it, place the fruit in the bag and firmly tie top end of bag with string or tie wire. Generally, bag immature fruits not yet infested with fly larvae. Push the bottom of bag upwards to make it “V” shaped, as this prevents damage by rain and keeps the bag inflated, and also keeps the fruit away from the sides of the bag. Near to harvest time, the bag may be carefully opened to check if the fruit inside is ripe. Bagging produces very high quality fruits at harvest and it is best suited to protect guavas, mangoes and carambolas. Plastic bags may be used but are not ideal, because its inside gets hot and moisture favors fungus growth. Alternatively, bags made of natural leaves may be used. Leaves of Pandanus, betel nut tree, sago palm or swamp taro are recommended. Leaves can be softened to increase pliability by heating them over a fire. To protect bananas, the whole bunch may be bagged inside banana leaves, as is frequently done to protect bananas against banana fruit fly (*Bactrocera musae*) and to improve market appearance of bananas.

2.2.4. Monitoring of Crop for Ripeness

It is needed to check the crop for ripeness on a regular basis through doing this by opening the barrier and looking inside. This needs to be done since many of the materials used for barriers are not transparent to see through. Also, remember to practice good garden sanitation by collecting and destroying any rotting or unwanted fruit that is fond.

2.2.5. Application of Physical Exclusion Products

Exclusion barriers should be applied as early as possible during the growing season. This can mean as early as petals drop, indicating that pollination has been occurred or as fruit are just developing. Placing exclusion products on the plant at this time can protect the produce, since fruit flies tend to target fruits and vegetables that are maturing or ripe. When there is suspect that the produce has already been stung, and then remove it before netting or bagging. Make a note of those self-pollinated crops that can be covered any time before fruit matures or ripens. Note down that if there is unsure whether there are fruit fly pupae in the ground under fruit trees, then it is desirable to secure the bottom of the net to the trunk base. This can prevent any adult fruit flies emerging from the ground from infesting the new season crop.

Physical controls create a barrier between the pest and the fruit to decrease the probability of fruit flies infestation. Cover individual fruits (for peaches and other larger fruits), fruiting clusters, or entire fruiting plants (for berries) with a fine netting (0.98 mm mesh), nylon stocking, or paint strainer bag. Organza fabric is useful for this purpose. Make sure the fruit is completely covered and the netting is secured such that fruit flies cannot sneak in under the bottom of the net. Generally, determine when to cover plants can be tricky, if the plants are covered too early, it can exclude pollinators from flowering plants and this will reduce yield. When the plant is covered too late, fruit fly can be trapped with the fruit and this may increase, rather than decrease the pest problems. For best results, cover plants at the first sign of fruit fly adults captured in traps but after plants have finished flowering.

3. Remove of Barriers

At the end of the fruits and vegetables growing season, remove any barriers from the garden that have been used and store away for next season. Repair or discard any barriers that have been damaged.

4. Conclusion

For many countries on the planet, fruit flies are a very important group of pests on account of their potential to cause damage to fruits and vegetables, and these restrict national and international trades for plant products that are hosts of fruit flies. The high probability of introduction of fruit flies associated with a wide range of hosts results in restrictions forced by several bring in countries and the need for phytohygienic measures to be applied in exporting countries related to movement of host material to ensure that the risk of introduction is appropriately mitigated. Fruit sampling can be used as a complementary surveillance method for trapping to assess the profile of the fruit fly population levels and fruit sampling should be done on known hosts. Fruit sampling may include by fruit cutting to visually detect larvae and rearing of larvae to identify the fruit fly species involved. Exclusion is a preventative method that uses physical barriers to stop female fruit flies from reaching the fruits and vegetables. Typical barriers that can be used around the gardens are nets, insect gauze, bags and sleeves. Fruit bagging, on the other hand, is the practice of covering the fruits with some sort of protective layer that prevents fruit flies from laying eggs in the fruits. Various kinds of cheap bagging materials may be used and can be very effective when applied at a stage of fruit development before the fruits or vegetables have become attractive to fruit flies. Oftentimes, fruit bagging increases fruit quality and consequently also increases its selling price. An area wide fruit fly pest management program is a collaborative mission between the department of agriculture, agricultural research service and growers. Commercial farmers should contact their local agriculture extension office, and using a combination of prevention and a good trapping there is no reason to suffer annoying due to fruit flies anymore in orchards.

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