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Cultural Measures as Management Option Against Fruit Flies Pest (Tephritidae: Diptera) in Garden or Farm and Territories

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Abstract

This article provides and recommends cultural practices to control common fruit flies (Tephritidae: Diptera) insect pests of fruit trees and vegetables in the home and commercial gardens or farms, and territories. Fruit flies of Family Tephritidae are one of the most serious insect pests of horticultural produces throughout the tropics and subtropics world. Feeding by fruit fly larvae may cause complete destruction of fruits, rather than cosmetic damage as is caused by many other insect pests. Infested fruits quickly become rotten and inedible or may drop to the ground prematurely, thus causing considerable losses in production. The damages on crops consist of oviposition stings on the fruit surface, the fruit drops early, also causing destruction of the inside of the fruits and these results in an unmarketable crop. Poorly managed vegetations are a source of infection and infestation for nearby home and commercial orchards. The farmers spray their fields very frequently during a growing period until approximately one week before harvest and the spraying is carried out in a big degree during the cool hours of the day. Therefore, implementation of control measures that do not imply an added burden to the environment and the farmers is urgent. Cultural control includes practices that may be regarded as part of the normal production system and do not involve the application of insecticides. Initially, the use of crops hygiene, sanitation, removal of fallen fruits or old crops, collection and destruction of infested fruits and buried deep in soil can achieve good success in reducing population of fruit flies. Other cultural management strategies to complement crop hygiene or sanitation include, production during periods of relatively low fruit fly activity, growing of less susceptible varieties, early harvesting of fruits and fruit bagging practices that can be effectively employed to manage fruit fly infestations in fruit and vegetable crops. Be aware that local laws and legislations in the interior and exterior fruit-growing regions require that certain insect pests on fruit trees in gardens or farms be controlled instantly.

Keywords

Fruit Fly, Fruit, Vegetable, Cultural Control, Diptera, Tephritidae

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1. Introduction

The productions of fruits and vegetables in Islamic Republic of Pakistan generate an important source of income and represent a significant part of the home economics for peoples. A constantly growing interest of population, rising of incomes and urbanization levels increase the demand of fresh fruits and vegetables (Sarwar, 2014 a; 2014 b). Fruit flies belonging to the family Tephritidae of Order Diptera are considered a very destructive group of insects that cause enormous economic losses in agriculture, especially in a wide variety of fruits, vegetables and flowers (Diamantidis et

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al., 2008). Approximately 10% of these are serious pests distributed around the world in temperate, subtropical and tropical areas (Weems and Heppner, 1999). The situation about the control of these pests is unsustainable, and the need for further and more intensive studies on this topic is urgent to carry out. But first of all the priority is to work together with farmers on the issue of the use of environmental friendly control methods such as crop hygiene or sanitation to go away from the dependence on insecticides.

2. Fruit Fly Damage and Crop Losses

Worldwide, the sub-regions East, Southeast, and South in Asian region are among the major producers of a range of economically important fruits and vegetables for domestic consumption, and regional and international trade. However, several factors constrain fruit and vegetable productions such as tephritid fruit flies that cause direct damage to hosts which can lead up to 100% yield loss depending on fruit fly's population, locality, variety and season. In addition, to the direct losses, fruit fly's infestation can result in serious losses in trade value and export opportunity due to strict quarantine regulations enforced by most importing countries. A number of economically important and widely prevalent species of genus Bactrocera such as peach fruit fly *Bactrocera zonata* (Saunders), oriental fruit fly *B. dorsalis* (Hendel) and melon fly *B. cucurbitae* (Coquillett) and possibly others (Diptera: Tephritidae) are commonly found in Asia. The first named both species are causing enormous losses of fruits, and last mentioned pest represents a serious threat to the most of popular vegetables from the cucurbit family in this region.

3. Seasonal Activity of Fruit Fly

Fruit fly's activity and population vary throughout the year, and their populations increase as temperature warms up and suitable hosts become available. Within spring season (September to November), the late winter and early spring overwintering adult flies become active and females sting and lay eggs in maturing fruit, maggots develop in infested fruit, then emerge from contaminated fruit to pupate in the ground and adults emerge from the ground. If control is not started at this time, fruit fly populations can increase and cause more problems later in spring, summer and autumn. Inside winter (December to February), fruit flies usually do not infest host fruits, some fruit flies can overwinter as adults in sheltered locations or as pupae in mummified fruit or in the ground or as eggs and maggots in fallen fruits if temperature is not too severe, and overwintering adult flies may become active on warmer days. In autumn (March to April), fruit flies are active if suitable host fruit is available, fruit fly numbers generally decrease in cooler weather and the time taken for life cycle development lengthens. For summer (May to August), fruit flies are usually most active from late spring to early autumn, adult flies search for fruit suitable for feeding and breeding, and populations build up in successions as suitable hosts fruit become infested. The combination of low fruit fly's activity and effective field control in the exporting country during cooler months, and the low risk of establishment of fruit flies in winter months in the importing country may open up new markets for low risk of fruit fly host commodities.

The results from the fruit flies collected study suggest that the melon fly and the oriental fruit fly are active in the morning starting at dawn. Furthermore, there are differences between the species in number of flies caught in traps and how long these remain active in the morning. Oriental fruit fly seems to be more active for short time and for melon fly the activity time is longer, but in both cases activity declines shortly before noon. The morning activity is due to the search for food after a long period of inactivity during the night. Flies visit host and non-host plants when searching for food and the temperature seems to be a regulatory element of this behavior, since major activity is observed during early hours. Previous studies demonstrate that temperature, humidity and rainfall are very strong factors that regulate development rates and other population processes in fruit flies. A preliminary suggestion regarding an appropriate time of day to control fruit flies in fields may be during the first hours in morning suggesting that this is the time when flies are most active. Nevertheless, if temperature is the main regulatory factor of its activity, late afternoon time would also be possible and this is something that should be looked into further studies (Victor, 2009).

There are several actions that can be taken to control fruit fly, but it is still disappointing to discover eggs or maggots in the ripening fruit. Whether the crop can be saved from some of pests is dependent on factors such as the level of infestation and the development stage of the fruit. After picking or cutting a few fruits to inspect for maggots, when the crop may have just been attacked by fruit fly or some are infested with maggots or current fruiting crop is infested but other crops in the garden are in the early stages of fruit development, at that moment consider to protect crop from further fruit fly attack, and to control any eggs and maggots in fruit, then decide on a control strategy to protect other crops for the rest of the season. Most fruit flies are facultative breeders that lay eggs whenever their host fruits are available, and so these may have many generations per year. The damage starts when the female fruit fly punctures the fruit with its long and sharp ovipositor. Dissect one fruit vertically

through the oviposition marks and observe the eggs inside the fruit's flesh within the oviposition marks (Sarwar et al., 2014 a; 2014 b; 2014 c).

When the fruit's skin is breached by fruit fly females, then bacteria enter to host and the fruits start to decay. It is also thought that some or may be all fruit fly females carry bacteria with them that these inject into the fruit at oviposition time, so that the fruit decays faster. The larvae that hatch from the eggs feed on the decaying fruit tissue, and on the yeasts and bacteria that multiply in it, thus making it more nutritious for the larvae. Fruits with fruit fly larvae in them decay quickly. The larvae leave the host on completion of third instar for pupation, larval skin becomes barrel-shaped, turns tanned brown and hard, it is known as the puparium, and the true pupa is formed inside this puparium shell‖. The pupa turns into an adult fly, which escapes from the puparium by splitting open the anterior end and squeezing out side. Fly's infested fruits are generally unsalable and certainly cannot be exported (Shah et al., 2014; Sarwar et al., 2013; 2015).

4. Basic Obligations for Controlling of Fruit Fly

A range of fruit fly control and prevention methods can be used by gardeners and strategies for the control of pest flies include physical control, cultural control, biological control, behavioural control, genetic control, chemical control and combinations of some or all of these into an Integrated Pest Management (IPM) approach. Most of these techniques are appropriate for the various countries and territories, but genetic control is probably too expensive or too sophisticated to use under normal conditions. Cultural control includes practices, such as production during periods of relatively low fruit fly's activity, sound crop sanitation and early harvesting that may be regarded as part of the normal production system and do not involve the application of insecticides (Allwood et al., 2001). Some of basic obligations for controlling of fruit fly are as given below:-

4.1. Identification of Pests

There are many kinds of fruit flies that can attack fruit or vegetable and the loses from fruit flies can be caused by single species of fruit flies or as result of several species which attack the same plant at the same time. Proper identification of insect pests is an important step before attempting to control the fruit flies. Not all plant problems are caused by pests; some are caused by cultural, nutritional or environmental conditions. Always consult to local nurseries, garden centers and gardeners, for more detailed information on fruit tree pests and management practices to prevent fruit flies problems and improve fruit quality and quantity. Information on tree fruit pests, including pictures of pests and their damage can also be found on these stations. Morphological characteristics of adult fruit flies can be observed from their presence or absence under binocular microscope. The simple identification can be made by examining the face mark, thorax and abdominal band and marks on the wing.

4.2. Early Detection

Early detection of an outbreak of any invasive species is very important, as it increases the odds of a successful eradication, before the pest becomes established. In areas where horticulture crops are grown there should be an 'early warning system' of traps to detect outbreaks of adult flies.

4.3. Trapping

Traps are used as a monitoring device to monitor for fruit fly activity rather as well as a control way to reduce pest's invasion. Generally, traps use synthetic attractants (sometimes sex-specific) to attract adult fruit flies into a container. Brightly colored traps emulating colors of host fruit (e.g., orange, yellow and green) have been found to be most attractive to fruit flies. The attractants can be pheromones, food scents or visual cues to draw flies in traps. Once captured the trapped flies are unable to escape and are either killed by an insecticide or drowned in a liquid. Traps can be used to help reduce in fruit fly numbers, but these are generally not recommended as a long term control method because trapping only captures some of the adult male flies while leaving others to infest the crop.

5. Cultural Management Measures for Fruit Fly

Cultural management involves encourage and use of gardening practices that discourage or prevent development of fly pest problems, and not by using insecticides unless needed.

5.1. Production during Periods of Relatively Low Fruit Fly Activity

Trapping data show that the fruit fly's activity and population are low during the cooler months, thus, growing crops during the cooler months reduces pressure on the effectiveness of field control systems, such as protein bait sprays.

5.2. Sound Crop Sanitation

The collection and destruction of fallen, damaged and overripe fruits is strongly recommended to reduce the resident population of fruit flies. Evidence shows that hosts

left on the ground act as a major breeding site for fruit flies. Thus, to eliminate or reduce this reservoir of the resident population, crop sanitation should be an essential component of melon fly and oriental fruit fly control programs in orchards. Crop residues such as fallen, over-ripe or damaged fruits may be destroyed by deep-burying (> 50 cm) or by burning or by feeding them to animals. Alternatively, these may be sealed inside plastic bags and exposed to direct sunlight for several hours. Putting fruit or vegetable residues into compost heaps or rubbish dumps are not recommended. Under quality assurance schemes being adopted for production of commodities for export, sound crop sanitation is essential and a prerequisite for any farm that is registered for export production.

5.3. Early Harvesting

Early harvesting of fruits may avoid infestations, i.e., before fruit fly attacks the fruits is a good option, however this is for fruit fly species that infest almost-ripe fruits but not for species that attack small, green and un-harvestable fruits. Avoidance of fruit fly infestation is possible by harvesting crops at a stage of maturity when the fruit or vegetable is not susceptible to fruit fly attack. For example, banana and mongo are exported around the world because these are not susceptible to fruit flies at the mature green stage. Early harvests can also be achieved by planting early fruiting varieties which crop before fruit fly populations build up. On that basis, remove all fruit from the trees at harvest and destroy any insect-infested or disease-infected fruit to reduce the risk of problems the following year.

5.4. Fruit Type Selection

The worst attacks of fruit flies often occur in late summer and autumn. Fruit losses can be minimized if fruit growers chose to grow varieties of fruits which mature before or after this period of maximum impact. Removing less valuable host plants will reduce the amount of control needed, and reduce the likelihood of flies escaping control actions.

5.5. Tree Pruning

Trees which are well pruned, and not too tall, are much easier to adequately spray with insecticides. It is also easier to make sure that all ripped fruit is picked, if trees are kept at a manageable height. Pruning of fruit trees to a manageable size makes it easier to harvest fruit and implement fruit fly control methods such as netting and cover spraying. Other cultural management options which can be employed include that the healthy trees are more resistant to many pests, so, maintain trees in a healthy state with balanced fertilizer, adequate water and judicious pruning. Prune trees in dormant season or summer to open up canopy to improve exposure of fruit to sun, air circulation and spray coverage

5.6. Picking up Ripe Fruit

Fruit should be picked off from the trees as it ripens; this stops the flies from laying eggs inside it, and prevents any larvae surviving. This fruit should either be eaten immediately, or put in the refrigerator to preserve. It is recommended that all mature fruits should be stripped from trees prior to beginning of winter to prevent fruit flies overwintering inside the host.

5.7. Picking up Fallen Fruit

Fallen fruits should be removed, to stop larvae from getting into the soil and continuing their life cycle (pupating).

5.8. Disposal

Suitable disposal of infested fruits is required to prevent outbreaks of fly. A recommended way of safely disposing of unwanted fruit is, place any unwanted fruit in a black plastic bag, tie the top of the bag to shut, leave the bag in the sun for three to five days to kill the larvae and adults, and bury the bag. Or else do not bury the bag in soil and dispose of the bag through the garbage system.

5.9. Sanitation

Garden hygiene is essential because fruit trees with fallen and rotting fruit around them are a major source of uncontrolled fruit fly infestations. Sanitation may help to prevent fruit fly eggs and maggots from developing in infested fruit. All fallen and unwanted fruits should be collected and destroyed. Destroying the fruit ensures that maggots do not survive to pupate in the ground to later emerge as adult flies. Fallen and unwanted fruit should not be left in a waste heap or added to manure. Infested fruit can be collected into plastic bags and can be deep buried by covering with more than 30 cm of compacted soil. Small amounts of infested fruit can be micro waved to kill the maggots.

5.10. Host Plant Removal

The physical removal of unwanted fruit fly host plants and trees from garden can help to prevent the build-up of fruit flies. Encouraging the local council to remove neglected fruit trees such as those on vacant blocks or growing beside public roads can add to the level of fruit fly control across the district.

5.11. Alternative Plants

Replacing fruit fly host fruit trees with ornamental trees and shrubs is an alternative control strategy to manage pest fly.

5.12. Solarizing

Solarization uses heat from the sun to kill fly pests by placing infested and potentially infested fruit on the ground in a sunny location away from fruit-bearing plants. Place clear plastic sheeting (preferably 1 to 2 mm thick) over the pile, and tightly secure the edges of the tarpaulin to hold in the heat. Remove any visible air pockets as these may result in a poor seal and can compromise the effectiveness of this pest control method. Patch all holes or tears with clear packing tape or duct tape. Adjust the solarization time according to local weather conditions. To kill fly larvae in fruit, the temperature beneath the tarp should remain at 120°F for at least a couple of days; but heavy rains or overcast skies can slow the process.

5.13. Crushing

Place infested and potentially infested fruit on the ground in a sunny location away from fruit-bearing plants. Crush of fruits by stepping on them (for berries), rolling something over them (tire, PVC pipe, or rolling pin), or cutting and crushing them with a shovel or other garden tool (for larger fruits) are advantageous. The sun helps to desiccate crushed fruit and killing the larvae inside. In preliminary trials, fly larvae do not survive in flattened, dried and crushed fruit. However, precipitation from rain or sprinklers, uncrushed fruit and fruit placed in shady areas increased chance of fly larvae survival.

5.14. Fly Control for Each Season

Control strategies that gardeners can apply in particular seasons of the year and at different plant growth stages can give very high reductions of fly's infestation. Seasonal control strategies include monitoring, preventing attack, reducing numbers and control of fruit fly numbers during spring, summer, autumn and winter seasons. Control strategies at vegetative, flowering, fruit formation, harvest and end of season plant growth stages include monitoring, preventing attack, reducing numbers and control of fruit fly numbers. Some control methods can be on-going, depending on crop growth, fruiting and fruit fly numbers.

6. Quality Control of Materials Used in the Phytosanitary Procedures

The materials used in the phytosanitary procedures should perform effectively and reliably at an acceptable level for a prescribed period of time. The devices and equipments should maintain their integrity for the entire duration that these are anticipated to remain in the field. The attractants and chemicals should be certified or bio-assayed for an acceptable level of performance.

7. Verification of Integrated Strategies and Phytosanitary Procedures for Fruit Fly Management

The effectiveness of the relevant chosen phytosanitary procedures and integrated pest management (IPM) strategies (suppression, containment, eradication and exclusion) should be verified. The main phytosanitary procedure used for verification is adult and larval surveillance, and the normal production system without the application of insecticides.

8. Combined Management Approaches

As with the control of many pest species, a single control method by itself is often not sufficient to eradicate or even effectively control the fruit fly from an area. The best results are gained from a combination of the methods found in this section as given subsequently. For example, bait spraying, male annihilation and good hygiene have been used in combination in attempts to eradicate fly. Nevertheless, the practice of IPM should be something to strive for because of its effectiveness and gains for the environment and health. Training farmers to become "IPM experts" is the only way to reach a sustainable production of fruits and vegetables; otherwise the use of pesticides will keep increasing (Ketelaar and Kumat, 2002). According to Verghese et al., (2004; 2006), the practice of IPM to control *B. dorsalis* can give very high reductions of infestation in mango fields. Level of reductions between 75% and 100% are possible if sanitary measures such as the removing of fallen fruit are applied. Fruit left on the ground serve as important breeding sources (Liquido, 1991). Furthermore, the use of a single control measure such as insecticides can hardly give a total reduction of fruit flies infestation since the damage done by larvae in fruits and vegetables is internal, and therefore difficult to control (Dhillon et al., 2005).

A field experiment has been conducted to assess the efficacy of different methods of fruit fly control on ber (*Zizyphus mauritiana*). Five different methods namely insecticides, baiting, cultural, integrated management and no treatment have been compared for percentage fruit damage and yield per plant. Damage percentage and yield per plant varied significantly in different control methods. Integrated Management (IM) and insecticide control showed excellent results with yield potential of 35 and 34 kg per plant with

minimum damage of 2% and 2.5%, respectively. The lowest yield (24 kg per plant) and the highest damage (16.5%) have been recorded in plants where no treatment applied. Bait method produced a yield of 30 kg per plant along with damage of 4.5% (Bashir et al., 2005). Based upon the findings of the present study, it can be fairly concluded that the Integrated Management (IM) method for control of fruit fly has a significant effect over other methods on the fruit fly infestation and a visible reduction in the yield losses generally occurs due to this option.

The effectiveness of orchard sanitation increases when the collection of fruit and the disposal of fallen fruit are focused on the primary hosts of the pests and are done continuously on an area-wide basis. For good results, collection and disposal should be done before, during and after fruit harvest. Fruit that remains on the trees after harvest, fruit rejected because of poor quality during harvest and packing, and fruit on hosts present in the surrounding area should be collected and disposed off. The pupae of many fruit flies can be targeted by disturbing the soil medium in which these pupate. This can be done by ground swamping (causing pupae anoxia) and ploughing (causing pupae desiccation).

9. Conclusion

Extremely high fly populations can occur in fruited varieties of landscape trees and in unmaintained ornamental situations. These can be significant sources for invasion of commercial groves. The traps have a potential to obtain information on the abundance and species composition of fruit flies in the field, that is an information needed to determine whether a control measure is needed or not, but traps also have a potential as a tool in the control of the pest by mass trapping or disruption in mating process. Field sanitation is important in reducing overall fly densities. Remove old fruit remaining on trees following harvest and destroy all fruits on the ground by either burying these at least 30 cm deep or taking to the landfill. Prevent fruiting on landscape trees in the spring by using a chemical like "Fruit Stop" or destroy fruit on the ground in the fall to reduce this invasion pathway. An area wide approach is needed to reduce fly densities where commercial plantings are near to ornamental or unmaintained trees. This is often difficult to implement, however, fruitless varieties should be used for landscaping purposes. These have the additional advantage of producing less pollen that may aggravate people's allergies. Despite this, a lot of knowledge is still lacking and it is indispensable to the understanding of these pests until this knowledge gap be filled. Fruit fly adults feed on honeydew of insects, so, reducing black scale populations may decrease a food source needed during high summer temperature. It is urgent to find more effective and environmental friendly control strategies that guarantee a sustainable production of fruits and vegetables. Furthermore, it is urgent to train farmers in the use of sustainable control measures to approach integrated pest management.

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