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Mechanical Control Prospectus to Aid in Management of Fruit Flies and Correlated Tephritid (Diptera: Tephritidae) Pests

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Abstract

Fruit flies (Diptera: Tephritidae) pose a severe economic threat for the fruit or vegetable growers and in areas of the world where this pest is well established has been responsible for 100% losses of some commercial plantings. The feeding damage of fruit fly maggots (larvae) destroys the pulp, allowing the entry of secondary bacteria and fungi, and cause premature fruit drop and degrade the quality of production. Many farmers at the moment are trying to find sustainable ways to remove pests without harming the ecosystem. The key for controlling fruit fly infestations is to locate and eliminate their breeding sources and the first obvious place to check is where large numbers of rotting fruits or vegetables accumulate. Mechanical pest control is the management and control of pests using substantial means such as fences, barriers, handpicking, insect vacuums, water pressure sprays or electronic devices. It also includes weeding, breeding sources reduction and sanitary measures to tackle pest control. Mechanical methods of controlling the fruit fly further include the use of protective coverings on the fruit and the destruction of adults by use of traps. Shrubs within about hundred meters of larval hosts may be used advantageously in placing traps in target locality. The use of protective coverings is more effective and somewhat costly than the use of traps. This includes the simple fly swat, fly screen and nets, exclusion methods and the use of temperature regimes against storage of produce. Ultra violet insect light traps may be of little help because fruit flies are more attracted to host's odor than to the ultra violet light. However, mechanical measures may include use of attractants and other types of traps that can be helpful for attracting flies. The widespread and rapid establishments of the fruit fly in the world require immediate changes in integrated pest management (IPM) programs and mechanical methods of controlling may be a part of this program. It makes the present invention a well suited option for pest management in a variety of plantings. This aspect, however, requires a further good deal of study so as to determine the more critical procedure of mechanical controlling and the influence on the quality of the final produce.

Keywords

Tephritids, Fruit Files, Fruit, Vegetable, Traps, Mechanical Control

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1. Introduction

Fruit flies are one of the most destructive fruit and vegetable pests in the Asia as well as the Pacific, and attack certain cultivated and wild plants. The damage caused by fruit flies to crops results from oviposition of adults in fruit and soft tissues of vegetative parts of plant, feeding by the larvae, and decomposition of plant tissue by invading secondary microorganisms. The larval feeding in fruits is the most damaging and damage usually consists of breakdown of tissues and internal rotting associated with maggots infestation, which varies with the type of host attacked. Infested young fruits become distorted, hardened and usually drop, while mature attacked fruits develop a water soaked appearance. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot. When only a few

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larvae develop, damage consists of an unsightly appearance and reduced marketability because of the egg laying punctures or tissue break down associated with maggot's infestation and due to the decay. Likewise, the quarantine regulations to prevent establishment of fruit flies in areas where these do not occur are vigorously enforced. The government of certain states has implemented strict laws regulating the movement of certain commodities to prevent the establishment of fruit flies and restrict the entry of untreated hosts of these pests into their country (Sarwar et al., 2013; 2014 a; 2014 b; 2014 c).

During these days there is emphasis on environmental and health issues, and gardeners and growers are searching for ways to grow healthy crops to protect the fragile ecosystems in their own gardens. But, this goal may seem to conflict when insects or other pests invade the gardens. There is time; the gardeners may resort to pesticides to control insect pest invasions, because there are many nonchemical alternatives. Some of these alternatives are in a category known as mechanical control. The economic importance of the fruit fly cannot be evaluated entirely from the standpoint of the actual damage to the various crops affected. It must also be considered from the standpoint of quarantine causing of export reduction of fruits and vegetables because of serious concern of the importing countries. Moreover, repeated use of toxic insecticides has created a hazardous situation for the environment as well as health of the farmers and consumers. Therefore, it is desirable to explore alternative methods of control, and develop a control strategy for effective, cheap and environment friendly management of fruit flies. Environment friendly management of fruit flies involving mechanical pest control is useful in reducing the undesirable pest populations responsible for decreasing the yield and the crop quality (Sarwar, 2014 a; 2014 b; Shah et al., 2014; Sarwar et al., 2015).

The pest management practices throughout the world are increasingly leaning toward more environment friendly agriculture without disturbing the balance of the eco-system (Tilman et al., 2002). Thus, the evolution of modern organic agriculture depends on biological control agents to disrupt and control pest attacks which impart serious adverse effects on the agricultural economy (Copping and Menn, 2000). The researchers have performed the field trials, thus a simple, practical and low cost green chemical approach is developed that has a significant potential for crop protection, long lasting residual activity, excellent efficacy and favorable safety profiles. This makes the present invention well-suited for pest management in a variety of crops (Deepa et al., 2013). Mechanical control involves the use of hands-on techniques, simple equipments, devices as well as natural ingredients that provide a protective barrier between plants and insects. Mechanical control is usually more practical for small or commercial gardens and these can be effectively used singly or in combinations.

2. Identification and Detection

The order Diptera is composed of the "true flies" and is one of the largest groups of insects. Diptera means "two wings" and true flies have only two wings (one pair), instead of four wings (two pair) found in most other types of winged insects. Fruit flies are smaller with delicate bodies and legs, and there are over several known fruit fly species across the globe. The head, thorax and abdomen are brown with darker markings, and several white or yellow patches on the top and sides of the thorax. Their wings are positioned horizontally and are held away from the body. Like other fly species, fruit flies experience a four-stage life cycle, beginning as eggs, and these undergo larval and pupal stages before emerging as adults. The span of early life stages is approximately a few days and fruit flies can complete their development in as little as week in ideal temperature conditions. The adult fruit flies can live up to 30 days under normal conditions.

Fruit flies can be monitored by traps baited with male lures, and the lure is usually placed on a cotton wool wick suspended in the middle of a plastic trap that has small openings at both ends. Lure can either be mixed with an insecticide or a piece of paper dipped in insecticide can be placed in the trap. Traps are usually placed in fruit trees at a height of about 2 m above ground and should be emptied regularly as it is possible to catch hundreds of flies in a single trap left for just a few days, although the lure may remain effective for a few weeks.

3. Means of Movement and Dispersal

Adult flight and the transport of infested fruits are the major means of movement and dispersal to previously uninfested areas. There is evidence that *Ceratitis capitata* (Wiedemann) can fly at least 20 km (Fletcher, 1989). Some host fruits are only infested when ripe, and this has been the basis for an "infestation-free quarantine procedure", which is recently called into question when fruits still on the tree are found to be infested (Liquido et al., 1995).

4. Methods of Mechanical Pest Control

By developing a better understanding of fruit fly's population dynamics (i.e., when and how many) in gardens, researchers

hope to better manage this pest in commercial fruit grower's fields. Sometimes the most efficient way to kill insects is to stomp on them, literally or figuratively. Mechanical control methods can be as simple as hand-picking from tree or using of screens to keep plants free of flying adult insects. At the other end of the technology spectrum are the electronic insect killers and these high-tech fly swatters producing an ultraviolet glow that attracts flying insects to an untimely death on an electrified grid or on the grill. Simple entrapment devices work quite well to control some types of insects. For example, fruit and shade trees can be protected from various pests by using fly paper and sticky boards. In the previous times, it remained a common practice for a farmer to hitch a bale of chicken wire behind a team of horses or a tractor and drive it through his fields to stir up dust. When the dust settled, it gave the insect pests an abrasive coating that gradually rubbed away their cuticular waxes and caused them to die from dehydration. Although this is certainly not the most reliable method of pest control, but it does explain why crops planted near the edge of a well-travelled dirt road often have less insect injury than those on the opposite side of the same field.

The following paragraphs describe key mechanical controls for many fruit fly species across the globe.

4.1. Handpicking

The use of human hands to remove harmful insects or other toxic material including infested hosts is often the most common action by gardeners. It is also classified as the most direct and the quickest way to remove clearly visible pests or hosts. However, it also has equal disadvantages as it must be performed before damage to the plant has been done and before the key development of insects. Hand destruction or removal of insects and infested hosts ensures quick and positive control. Excluding labor, handpicking is the least expensive of all organic or natural control practices. However, handpicking also has disadvantages in that it must be performed long before insect damage is noticeable and at the key stage of development of the insect. Gardeners must actively monitor their crops, and watch for the first sign of damage before fruit fly populations get too high.

4.2. Mechanical Traps

Mechanical traps and attractants often appeal to an insect's needs for food, shelter and reproduction. Mechanical traps or physical attractants are used in three main ways, to efficiently trap adult flies to lower crop damage, to kill them, and to monitor how many and what species of flies are in the garden or to estimate how much adult flies are there in the total landmass using sampling method. However, some traps are expensive to produce and can end up benefiting insects rather than harming them. One type of mechanical trap is a sticky barrier, which can be placed on the trunks of trees and woody shrubs to prevent flying and crawling stages pest from causing damage. Another example of a mechanical trap consists of sticky paper on stakes. The paper attracts insects because of its color or because of a sex pheromone in the sticky substance that attracts the pests. Most sticky traps are yellow, a color which seems to attract more insects and destroy. A disadvantage of traps or attractants is that these may trap beneficial insects. Also, some traps may be homemade using simple, inexpensive materials, while others are expensive and must be cleaned or replaced periodically. Many traps and attractants are available in the market to trap or capture the adults fruit fly (Vossen and Devarenne, 2006; Burrack et al., 2008).

4.3. Insect Vacuums

The use of vacuums to remove insects from plants is growing in popularity, especially among commercial producers. These tools may contain a disposable cartridge lined with a non-toxic, sticky gel to trap insects sucked up by the machine. Commercial producers have large vacuum equipment attached to and powered by tractors. On a smaller scale, hand-held, battery powered vacuums are available, some of which have a small pipe attachment to use when reaching across a row or bed. In home garden or for indoor use, a plant can be shaken to dislodge insects that are in a flying stage of growth. When the plant is shaken and the fruit flies begin to fly, these can be sucked into the vacuum hose held in the air near the plant. Vacuums may also remove crawling insects such as larvae. The vacuum nozzle may be placed directly on plants with strong or thick leaves, but caution is needed on plants with tender foliage. It may be safer to those plants to shake them and vacuum underneath to catch any insects that fall.

4.4. Water Pressure Sprays

A forceful stream of water can sometimes dislodge insects such as adult flies from fruit, foliage and plant stems. This practice must be repeated since many of the adult flies are likely to return to hosts. However, water pressure should be used only on sturdy plants to avoid plant damage. This method may also be a problem since frequent applications of water could increase diseases or cause root problems if the soil is already too wet. Therefore, use water sprays in the morning, so that plants can dry out during the day time.

4.5. Mechanical Control Trapping

In addition to fly swatting, mechanical fly control includes other trapping systems. Sticky fly paper is one type of fly trap. Ultraviolet light traps are other tools, often used to

supplement fly control in commercial localities. To be effective the traps must be properly placed in target areas. This type of trap should be placed where it cannot be seen from outside the farms, no more than 5 m above the floor (where most flies fly), and away from competing trap sources and food preparation areas. Such trapping system should be changed at least once per year. However, ultra violet insect light traps may be of little help because fruit flies are more attracted to host's odor than to the ultra violet light.

4.6. Use of Diatomaceous Earth

Diatomaceous earth is a dusty product that looks similar to flour and is composed of finely ground skeletons of fossil diatoms. Sharp edges of the ground diatoms scratch the waxy or oily outer layer of soft-bodied insects, which reportedly die eventually from dehydration. Because, it functions to scratch the insect's outer body covering, diatomaceous earth is categorized as a mechanical pest control. However, it may also be considered a mechanical barrier or repellent because some insects will not crawl on or feed upon plant foliage sprinkled with it. Before buying or applying diatomaceous earth, gardeners should read the label and look for the insect control formulation, since some brands are not labelled for fruits or vegetables. It is considered a pesticide, but it is non-toxic to birds and mammals (David and Pat, 1990).

5. Post-Harvest Quarantine Control

Temperature extremes can be used to kill insects or prevent their injury in horticultural products to establish cold or hot quarantine approach for the fruits and vegetables treatments. The research work on effect of heat and cold treatments on post harvest quality of sweet orange Cv Blood Red found that both heat and cold treatments and storage durations have significant effects on various parameters of citrus fruit (Gohar et al., 2007). This generally utilizes the mechanical refrigeration to reduce storage temperature. Recommended temperature and relative humidity should be maintained to safely store produce (Hassan, 2010).

5.1. Cold Treatment

Cold storage of agricultural products prolongs their shelf life and retards the development of insect pests. In a work, survival of the Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) on artificially infested clementine mandarins (*Citrus reticulata* Blanco) has been assessed on fruit subjected to integrated quarantine treatments consisting of irradiation with X-rays at doses of 0 (control), 30, 54 and 164 Gy followed by exposure to 1°C for 0 (control), 3, 6, 9 or 12 days. Complete insect mortality with no negative effects on fruit quality after 7 days at 20°C has been obtained on clementines firstly X-irradiated at 30 Gy and subsequently exposed to 1°C for 2 days. This combination of treatments considerably reduced quarantine time if compared to standard cold quarantine treatments (1.1-2.2°C for 14-18 days) and therefore showed promise as a potential commercial treatment for citrus exports. The integration of treatments would provide clear technological benefits for the citrus industry because it would be a non-polluting approach that would substantially reduce quarantine time and allow the treatment of citrus cultivars susceptible to either irradiation or chilling injury while maintaining the reliability of the standard cold quarantine protocols **(**Palou et al., 2007).

5.2. Heat Treatment

Heat treatments are sometimes used in place of fumigation to kill insect larvae in certain types of produce. Mangoes, for example, are submersed in hot water baths (115°F for 68 minutes) to kill the eggs and larvae of fruit flies (Tephritidae) prior to export. The current quarantine treatment for few produces grown for distribution to other lands requires careful fruit selection and a two stage hot water immersion treatment called the "double dip" method. The double dip method involves the treatment of less than quarter ripe fruits for an initial immersion for 30 minutes in 107.6°F (42°C) water followed immediately by a second hot water immersion at 120.2°F (49°C) for 20 minutes (Liquido and Cunningham, 1990).

6. Differences from Integrated Pest Control

Integrated Pest Management (IPM) is a combination of pest management techniques to reduce the need for pesticides and it relies on monitoring insect pests and pest damage. Suggested untreated strategies are increase habitats for predators, such as ants, ground beetles, spiders and birds, and clean up all infected fruits as soon as possible. To destroy the maggots, immerse fruit in water or even it is better to place in a pot, bring to the boil and then feed it to poultry or try placing fruit in a sealed, black plastic bag in the sun. Traps baited with food lures can be used to reduce adult fly densities by mass trapping. Traps are hung in the shade, and flies are attracted to the trap, crawling inside and dying there.

Before harvest, an on-going effort to pick up and destroy fallen fruit can help to reduce fruit fly populations. Remove fruit as soon as possible once it is ripe to prevent the maggots from leaving the fruit and entering the soil to pupate. After harvest, fruit left on trees or on the ground can result in continuing development of the fruit fly. Knock down remaining fruit from trees with a wooden or fiberglass pole to

break the cycle of infection. Using exclusion products such as plant guard and net, or exclusion bags and sleeves like pest guard bags, paper exclusion bags, fruit protection bags, cloth fruit bags, along with mesh sleeves and mesh bags, are a great idea to protect fruit from fruit fly and offer protection from birds as well as prevent sunburn of fruit and are re-useable. Covering the fruit with these products does not interfere with ripening as it is the leaves that are primarily responsible for photosynthesis. Using a combination of these methods can certainly help to keep numbers of fruit fly down and public should be able to enjoy pesticides free grown fruits (Vargus et al., 2001; Heuskin et al., 2011; Sarwar, 2012; 2013; Beatus et al., 2015; Hood et al., 2015).

7. Conclusion

Fruit flies have become a major nuisance in horticultural products, these prefer fruits and vegetables, and their heavy populations can develop from a single source. In summary, mechanical control of flies is a simple and straight forward method where the use of hands-on techniques, simple equipments, devices as well as natural ingredients that provide a protective barrier between plants and pests is prepared as a control system to fruit fly that remains active over a sustained period in an environmentally safe manner. In view of the demonstrated efficiency of this method in a fruit orchard or a vegetable farm, in rainy season and also in humid, sunny peak summer months, this approach should be useful in pest control in most parts of the world. The other techniques include maintaining healthy plants, which resist insects and diseases better, encourage of natural predators of pests to stay in backyard, using non-chemical means to remove insects when possible such as handpicking, and when using pesticides, choosing the one that is environmentally safer. A regional fruit fly program which includes research, extension and quarantine to back up national fruit fly programs should be operational, and quarantine procedures can also be harmonized so as to minimize risks of entry of exotic pests.

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