Fruit fly management practices on tropical fruit in Africa

Prepared by

Prof. Dr. Talal S. El-Abbassi

Plant Protection Research Institute
Cairo, EGYPT
INTRODUCTION

Fruit flies belonging to Family Tephritidae are considered the most important insect pests that cause enormous damage for a wide host range of horticultures allover the world. More than 950 species are of economic significance in Africa. Some of these species are accidentally introduced from other regions, in particular from Asia. So far, four Asian species belonging to the genus Bactrocera invaded Africa, two of these were introduced in recent years and the risk for other introductions is great.
Fruit flies of major importance in Africa

Indigenous Species

- Ceratitis (Capitata) capitata
- Ceratitis (Pardalaspis) ditissima
- Ceratitis (Pardalaspis) punctata
- Ceratitis (Pardalaspis) bremi
- Ceratitis (Pardalaspis) rosa
- Ceratitis (Pardalaspis) fasciventris
- Ceratitis (Pardalaspis) colae
- Ceratitis (Ceratolaspis) cosyra
- Ceratitis (Ceratolaspis) quinaria
- Ceratitis (Ceratoplaspis) silvestrii

Mediterranean fruit fly
Cocoa fruit fly
Natal fruit fly
Marula fruit fly
Five spotted fruit fly
<table>
<thead>
<tr>
<th>Invasive Species</th>
<th>Melon fly</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Bactrocera</em> (<em>Zeugodacus</em>) <em>cucurbitae</em></td>
<td><em>Malaysian fruit fly</em></td>
</tr>
<tr>
<td><em>Bactrocera</em> (<em>Bactrocera</em>) <em>invadens</em></td>
<td><em>Peach fruit fly</em></td>
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<tr>
<td><em>Bactrocera</em> (<em>Bactrocera</em>) <em>latifrons</em></td>
<td></td>
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<tr>
<td><em>Bactrocera</em> (<em>Bactrocera</em>) <em>zonata</em></td>
<td></td>
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<tr>
<td><em>Dacus</em> (<em>Dacus</em>) <em>bivittatus</em></td>
<td>Pumpkin fruit fly</td>
</tr>
<tr>
<td><em>Dacus</em> (<em>Dacus</em>) <em>punctatifrons</em></td>
<td>Lesser pumpkin fruit fly</td>
</tr>
<tr>
<td><em>Dacus</em> (<em>Didacus</em>) <em>ciliates</em></td>
<td>Jointed pumpkin fly</td>
</tr>
<tr>
<td><em>Dacus</em> (<em>Didacus</em>) <em>vertebratus</em></td>
<td></td>
</tr>
<tr>
<td><em>Dacus</em> (<em>Dedacus</em>) <em>frontalis</em></td>
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<td><em>Dacus</em> (<em>Dedacus</em>) <em>lounsburyii</em></td>
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<tr>
<td><em>Trithithrum nigerrimum</em></td>
<td></td>
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<tr>
<td><em>Trithithrum coffeae</em></td>
<td></td>
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<tr>
<td><em>Bactrocera</em> (<em>Daculus</em>) <em>oleae</em></td>
<td>Coffee fly</td>
</tr>
<tr>
<td><em>Bactrocera</em> (<em>Daculus</em>) <em>oleae</em></td>
<td>Olive fruit fly</td>
</tr>
</tbody>
</table>
The Geographical distribution and presence of these four invasive Bactrocera species in Africa have been studied and illustrated in the following figs.
Distribution of *B. cucurbitae* (Melon Fly)

**West Africa**
- Benin
- Burkina Faso
- Cameroon
- Gambia
- Guinea
- Ivory Coast
- Mali
- Niger
- Nigeria
- Senegal
- Togo

**East Africa**
- Sudan
- Kenya
- Tanzania
- Uganda
- Congo
- Mauritius
- Réunion
- Seychelles
Distribution of *B. invadens*

Senegal  
Mali  
Guinea  
Liberia  
Cote D'Ivoire  
Ghana  
Togo  
Benin  
Burkina Faso  
Niger  
Nigeria  
Cameroon  
Rep.Of Congo  
Chad  

Sudan  
Kenya  
Tanzania  
Loanda  
Burundi  
Ethiopia  
Comoro Islands  
Mozambique  
Zambia  
Namibia
Distribution of B. latifrons (Malaysian Fruit Fly)

Kenya

Tanzania
Distribution of *B. zonata* (Peach Fruit Fly)

Libya

Egypt

Saudi Arabia

Oman

UAE

Yemen

Mauritius

Réunion
C. Capitata Distribution Map
In Africa horticulture is recognized to become a major source of income for smallholders and various national development. However, the expansion of fruit production and export is greatly increasing the risk of transferring African fruit flies both within Africa and to other regions of the world; heavy fruit fly infestation seriously reduces the quantity of marketable fruit and increases production costs.
Many fruit fly species are serious pests of agriculture throughout Africa and represent a threat to the agriculture and ecology of many countries.

Because of the threats the pests would constitute to the agricultural systems of foreign countries, certain countries would restrict or prohibit the entry of host produce from the African countries, thereby eliminating many current (and potential future) African export markets.
In the absence of government efforts to control exotic fruit fly pests, losses and damage to private and commercial crops would provoke independent control efforts. Lacking the resources or capability to use sophisticated program techniques, such as detection trapping, sterile insect technique, and regulatory controls, the growers or homeowners could be expected to rely predominantly on chemical pesticides. Those efforts could result in continually increasing, uncoordinated, and less controlled use of pesticides.
A proposal of an international program (a broad strategy) among African countries should be prepared to respond to the threat of these invasive pest species.

Such program must include a range of alternatives (exclusion, detection, and prevention, and control...
Bactrocera invadens and Ceratitis cosyra are of the major constraints that in general limit tropical fruit production in Africa and mango fruits in particular. They cause up to 40–80% direct damage to mango fruits and also restrict export to large lucrative markets in Europe, the Middle East, Japan and USA.
Chemical pesticides have been extensively used for controlling these insect pests for a long time which caused many environmental problems like (high pesticide residues in edible fruits – developing resistant strains of pests against pesticides – disturbing the natural balance and the environmental pollution).
Developing and implementing an integrated pest management (IPM) programmes is highly requested to minimize the use of chemical pesticides to overcome these abovementioned problems and produce fruit fly-free and residue-free fruits to facilitate compliance with standards required for export markets.
To achieve these goals

Understanding and extensive studies on the biology and ecology of any insect pest is considered the corner stone to establish effective control measures that might enable us to win the battle against such pest.
A- The biological studies include the following points

- Knowledge of population cycles

- Studies on various developmental stages of subjected insect species

- The length of time required for the Tephritidae fruit flies to complete their life cycles in relation to weather conditions

- Distinguishing between the different fruit fly species in larval stage
B- Ecological Studies include the following points:

1) Geographical distribution of economic fruit flies allover the country through :
   - Finding the relationship between weather factors represented in ( Maximum and minimum day temp. and daily relative humidity .
   - Survey for all favorite, wild and alternative hosts.

2) Diagnosing symptoms of infestation by fruit flies at various plant hosts.
B- Ecological Studies include the following points:
(continued)

C) Detecting and monitoring system:
   1-Trap catch for fruit flies:
      - Selecting appropriate and effective trap for catching flies
      - Using effective attractants (sex attractants, food attractants, lures and dispensers).
   2-Collecting infested fruits from various locations and hosts to be incubated under laboratory conditions
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Parapheromone Traps

- Jackson trap
- Steiner Trap
- Champ trap
- Cook & Cunningham

Food Bait Traps

- Yellow Panel
- McPhail trap
- Adhesive sheet
- Oben bottom dry
- Plastic McPhail
- Tephri trap
- Multilure trap
B- Ecological Studies include the following points: (continued)

3- Identification of captured flies into traps or flies emerging from infested fruits.

N.B. identification of various fruit fly species by inspecting larvae in infested fruit needs well trained and experienced staff.

D) Determination of hot spots, seasonal peaks and No. of generations per year.
Cephalopharyngeal Skeleton

Anterior Spiracles

Posterior Spiracle

C. capitata

B. cucurbitae

B. Oleae

B. zonata

B. latifrons
Developmental Goal

To increase the level of production and quality of fresh fruit and fleshy vegetables, leading to enhanced availability for local consumption, increased exports and higher farmer's incomes.

To upgrade the technical knowledge and understanding of the impact of fruit flies on production and export of fresh fruits and fleshy vegetables by plant protection, quarantine, extension services staff and the private sector.
The program should focuses on effects of both chemical and nonchemical control methods on the physical environment, human health and safety, socioeconomics, cultural and visual resources, and biological resources.

An integrated program would offer the greatest flexibility for responding to fruit fly pest outbreaks.
It would be characterized by cooperative integrated efforts to control (suppress, eradicate, or otherwise manage) invasive exotic fruit fly pests. It would utilize principles of integrated pest management (IPM).

The integrated program appears to offer the best combination of short-term risk and long-term benefit to agricultural resources and the environment, when compared to no action or a nonchemical program.
IPM STRATEGY

The strategy of IPM programme is based on usage of all means of control procedures in a complementary way (legislative control, physical control, cultural control, biological control, Biotechnological Control, sterile insect technique, wise use of pesticides and postharvest treatments)
1- Legislative control

- Apply restricted quarantine laws at all country borders to avoid entrance of fruits infested with fruit flies into territories.
- Avoid transfer of infested fruits from area to another within the country (internal quarantine procedures) especially free areas.
- Issuance of pronouncements to growers to apply proper sanitary procedures which safe the environment and protect fruit hosts from insect infestation like getting rid of infested, cracked and fallen fruits.
1- Legislative control (continued)

- Prohibit total coverage spray using chemical pesticides
- Prohibit usage of pesticides not recommended by Ministry of Agriculture.
- Growers are committed to participate in conducting collective control at the level of a province or a district in case of pest outbreak.
2. Physical Control

Physical control involves physical actions taken to eliminate fruit fly hosts or host produce. **Fruit stripping and host elimination** are two principal physical control methods. Fruit stripping is employed when fruit fly larvae are found. The physical elimination of fruit fly hosts, when possible and appropriate, may be especially helpful in the elimination of small, isolated infestations.

Except in very limited circumstances, host elimination is unacceptable because of environmental considerations, time and resource constraints.
Fruits can be easily protected against fruit flies by bagging them in paper bags. The bag provides a physical protection to the fruit by preventing adult female flies from laying eggs.

This technique has been successfully practiced in Malaysia for exporting Carambola and also widely practiced to protect mangoes in Thailand and Philippines.

Bagging is inexpensive and easy to apply and guarantees nearly complete protection from fruit flies. It is ideal for small scale growers who do not use pesticides.
3. Cultural Control

Cultural control reduces pest populations through manipulation of agricultural practices. In general, agricultural practices are modified to make the crop environment as unfavorable as possible for the insect pest.

Cultural control methods frequently include: clean culture, special timing, trap cropping, use of resistant varieties, crop rotation, varying plant locations, and manipulation of alternate hosts.

Collecting and burying host fruit left after harvest, destroying damaged fruit, and removing unwanted or wild alternate hosts in and around fields are often recommended for suppressing fruit fly infestations.
Getting rid of infested, cracked and fallen fruits
- Over flooding soil after harvesting may kill larvae and pupae by suffocation and prevent invasion of newly emerged flies to successive fruit hosts

- Avoiding cultivating many fruit fly hosts in the same field (mixed host orchards are severely infested).

- Good and balanced nourishing regimes result in strong trees more tolerable to infestation
Harvesting the fruit before it reaches a stage of ripeness highly susceptible to fruit fly attack. Although this technique theoretically could reduce fruit fly populations, it is not likely to do so for a variety of reasons.

First, some fruits lose flavor when harvested too early, as they will not ripen fully.

Second, the development of most fruit flies generally coincides with the development (growth) of their host crops.

Third, it is doubtful that enough control could be exercised over commercial agricultural practices to make the technique effective or worthwhile.
Finally, the presence of multiple hosts in many areas that are susceptible to fruit fly infestations limits the applicability of this method. Trap cropping involves the planting of a crop that is favored by the pest in order to attract and concentrate the pest in a limited area where the pest can be destroyed by chemical or cultural methods.

It is unlikely that this method could be applicable to most fruit fly programs because of the perennial nature of many host species, the availability of multiple host species in the program areas, and the lack of data on effectiveness of trap crops in attracting fruit flies from distant areas.
Reduce populations:

If fruit flies are present in your field prior to crop ripening, you can try to reduce their population by attracting the adults to a poisoned bait.

This can be done by spraying a protein-bait–insecticide mixture onto nearby non-crop plants, windbreaks, or a border of corn plants.
4. Biological Control

Biological control (or biocontrol) is a pest control strategy making use of living natural enemies, antagonists or competitors, and other self-replicating biotic entities.

In spite of its advantages, biological control has major limitations which influence its suitability for control programs, including: lack of immediate results; potential lack of effectiveness; logistical difficulties; and incomplete or unavailable information about rearing techniques.
5. Biotechnological Control

Biotechnological control would involve the use of genetic engineering techniques to control fruit fly pests. Currently, there are four primary areas of genetic engineering that show promise for control of insect pests:

1. bio-engineering of crop plants (insertion of specific genes into the plants to improve plant characteristics such as pest resistance),
2. improvement of insect-infecting viruses,
3. production of genetic mutations of the pest (thereby affecting its reproductive capabilities) by radiation or other means, and
4. gene probe techniques to screen for insecticidal properties in microorganisms.
Biotechnology is being developed for use against fruit flies, but has not been used extensively because of a number of constraints:

(1) the technology is still relatively undeveloped;
(2) some control mechanisms have not been developed.
(3) Insect-infecting viruses have not been proven effective, nor are they available commercially for fruit fly control;
(4) screening done for new strains of bacteria against fruit flies is only the first step in basic research and development of insect-infecting microorganisms; and
(5) the information relative to the environmental impacts of bioengineered organisms is incomplete and unavailable.
6. Sterile Insect Technique

Sterile insect technique (SIT) involves the release of sterilized fruit flies into infested areas where they mate with the feral fruit flies, producing only infertile eggs. SIT has been used successfully and/or developed as a control method for the Medfly, Mexican fruit fly, Caribbean fruit fly (Carib fly), and the melon fly. SIT may be used as a component of an overall detection and prevention strategy, or it may be used as a component of suppression or eradication programs.
7. Chemical Control Methods

A- Male Annihilation Technique (MAT)

This technique is being used successfully for suppressing population of the peach fruit fly in Egypt (National area wide program for extermination of peach fruit fly in Egypt)

1- This technique is used to reduce the No. of males to the least level.
Fiber blocks (5 × 5 × 0.5 cm) are saturated with a mixture of the male sex attractant (Methyl eugenol) and a technical insecticide (fenetrothion) at a rate of 4:1. Each block is loaded with 10 ml of this mixture.

Blocks are distributed at a rate of 1 block per acre (i.e. the distance between each two successive blocks is Ca. 65 meters.)
Fiber blocks
Fiber blocks Saturation room
Fiber blocks Saturation room
B-Bait spray Application Technique (BAT)

1-This technique is currently used for controlling most species of fruit flies.

b- In this technique, a food attractant material is mixed with an insecticide. Concentration of the attractant material depends on the type of this material. For instance, in case of Buminal (a protein hydrolysate), the efficient concentration is 10%.
Several materials with insecticidal properties in conjunction with an improved bait attractant have been tested against several species of economic tephritid fruit flies.

Phloxine B is a photoactive dye which is toxic to certain insect species added to an attractant bait evoked a high degree of mortality in Medfly and other fruit fly species.
Recently new safer insecticides (Spinosad) has been developed for area-wide control of fruit flies.

These latter treatments offer environmentally friendly alternatives to present organophosphate formulations for eradication or suppression of fruit flies without adverse effect on non-target organisms (honey bees, predators and parasites).
Partial Bait Spray
Trees are sprayed with a quantity 100-150 ml of bait mixture. Only trunks near from trees canopy are sprayed. Be sure that the spray solution will not contact fruits. Trees are treated by spraying a tree row and leaving a row without treatment, or spraying a row and leaving two rows without treatment depending on level of infestation.
C. Soil Treatments

- Soil treatment with certain chemical insecticides (such as Diazinon, Chlorpyrifos, and Fenthion) directly to the soil within the drip line of host plants immediately after fruit fly larval detection induces significant control against fruit flies.

- Because of the nature of the chemicals and/or the method of delivery, there is no potential for drift, runoff, or leaching.

- Generally, no more than three applications are made
D- Mass trapping

*Ceratitis spp.* can not be controlled using MAT due to many technical and scientific concerns. Therefore Mass trapping is being used in some areas. This technique depends on distributing traps loaded with female attractant lure mounted in sachets in fruit orchards at a rate of 21 traps per acre. These traps are supposed to be effective for a period of approximately 4 months.
<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Item Of Comparison</th>
<th>Medfly</th>
<th>Peach Fruit Fly</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Mean Larval duration</td>
<td>6-8 Days</td>
<td>9-10 Days</td>
</tr>
<tr>
<td>2</td>
<td>Flight Range</td>
<td>Up to five Mile</td>
<td>Up to 20 Miles</td>
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<tr>
<td>3</td>
<td>Pre- Oviposition period</td>
<td>4-7 days</td>
<td>16-23 days</td>
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<tr>
<td>4</td>
<td>Range of required temperatures</td>
<td>15-30 C</td>
<td>25-35 C</td>
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<tr>
<td>5</td>
<td>Mean Adult longevity</td>
<td>55.2 days (Males) 61.8 days (Females)</td>
<td>41.0 days (Males) 48.0 days (Females)</td>
</tr>
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<td>No</td>
<td>Item</td>
<td>Item 1</td>
<td>Item 2</td>
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<td>--------</td>
</tr>
<tr>
<td>1</td>
<td>Name</td>
<td>Melon fly</td>
<td>--------</td>
</tr>
<tr>
<td>2</td>
<td>Distrib.</td>
<td>West Africa Some East Africa (19 countries)</td>
<td>Most west, East &amp; few south (27 countries)</td>
</tr>
<tr>
<td>3</td>
<td>Hosts</td>
<td>&gt;100 hosts</td>
<td>46 hosts</td>
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<tr>
<td>4</td>
<td>Life cycle: Duration</td>
<td>14-27 days</td>
<td>31 days</td>
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<td></td>
<td>Larval duration</td>
<td>6-11 days</td>
<td>11.1 days</td>
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<td></td>
<td>Pupal duration</td>
<td>6-9 days</td>
<td>12.4 days</td>
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<tr>
<td></td>
<td>Pre-ovp. period</td>
<td>10-16 days</td>
<td>--------</td>
</tr>
<tr>
<td>5</td>
<td>Flight Range</td>
<td>2 Km</td>
<td>Not studied</td>
</tr>
<tr>
<td>6</td>
<td>Sex Attractant</td>
<td>Cuelure</td>
<td>Methyl Eugenol</td>
</tr>
</tbody>
</table>
8. postharvest treatments

Export of fresh fruits and vegetables to various countries require conducting certain post harvest treatment to ensure that the consignments are free from infestation. More attention has been paid to apply natural control techniques for controlling insect pests and diseases in fruits and vegetables as safe alternatives to chemical treatments. Type of applicable natural method technique and time of application is dependant on host and pest. These natural techniques could be summarized as follows:-
A- **Immersion of fruits in warm water path** at a temperature 46-48 °C for an hour. This technique is recommended for mango fruits and sufficient to kill all immature stage of *Bactrocera zonata* inside fruits of present.

B- **Expose fruits to hot water vapor** until temperature of fruit pulp reaches 46.2°C, then keeping temperature at this level for 30 minutes. This method is recommended for treating mango and guava fruits against *Bactrocera zonata*. 
Warm water Immersion
Hot water vapor chamber

Water boiler
Hot water vapour control room
C- Cold treatment: This technique is recommended for treating citrus and pomegranate fruits. Fruits should be kept at constant temperature at 1.7°C for continuously 14 days. This technique is sufficient to kill all immature stage of *Bactrocera zonata* inside treated fruits.
Cold treatment Champer
THANK YOU