How?

Prior to treatment, it is important to decide on the application method, then select and properly adjust the most appropriate treatment equipment.
Use a pneumatic – knapsack, towed, or carried – sprayer with a centrifugal pump to ensure homogeneous distribution of the product on all parts of the tree. A preliminary test with water can be used to determine the number of trees that can be treated with a full tank. This information, together with information on the plant/ha density, is needed to calculate the volume of mixture to prepare and the product dilution rate that respects the required dose of active ingredient per hectare. The volume of the mixture generally varies between 400 and 700 l/ha for mature orchards.
Apply each product using good agricultural practices, in particular with regard to recommended doses and preharvest intervals (PHI) indicated on the label of the packages. This will make the treatment more effective, avoid problems of phytotoxicity, and ensure compliance with maximum residue limits (MRLs).

For further information contact:

COLEACP
Pesticides Initiative Programme (PIP)
98, rue du Trône, Bte 3
B-1050 Brussels, Belgium
Tel: +32 2 508 1090, Fax +32 2 514 0632
E-mail: pip@coleacp.org, Website: www.coleacp.org/pip

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Conference of West and Central African Ministers of Agriculture
Avenue Bourguiba, BP 15799, Dakar-Fann, Senegal
Tel: +221-8254711; Fax: +221-8254730; Email: cmaoc@cmaoc.org

CTA
partageons les connaissances au profit des communautés rurales
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The ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA)
P. O. Box 380, 6700 AJ Wageningen, The Netherlands
Tel: +31 317-467100, Fax: +31 317-460067
E-mail: cta@cta.int, Website: www.cta.int

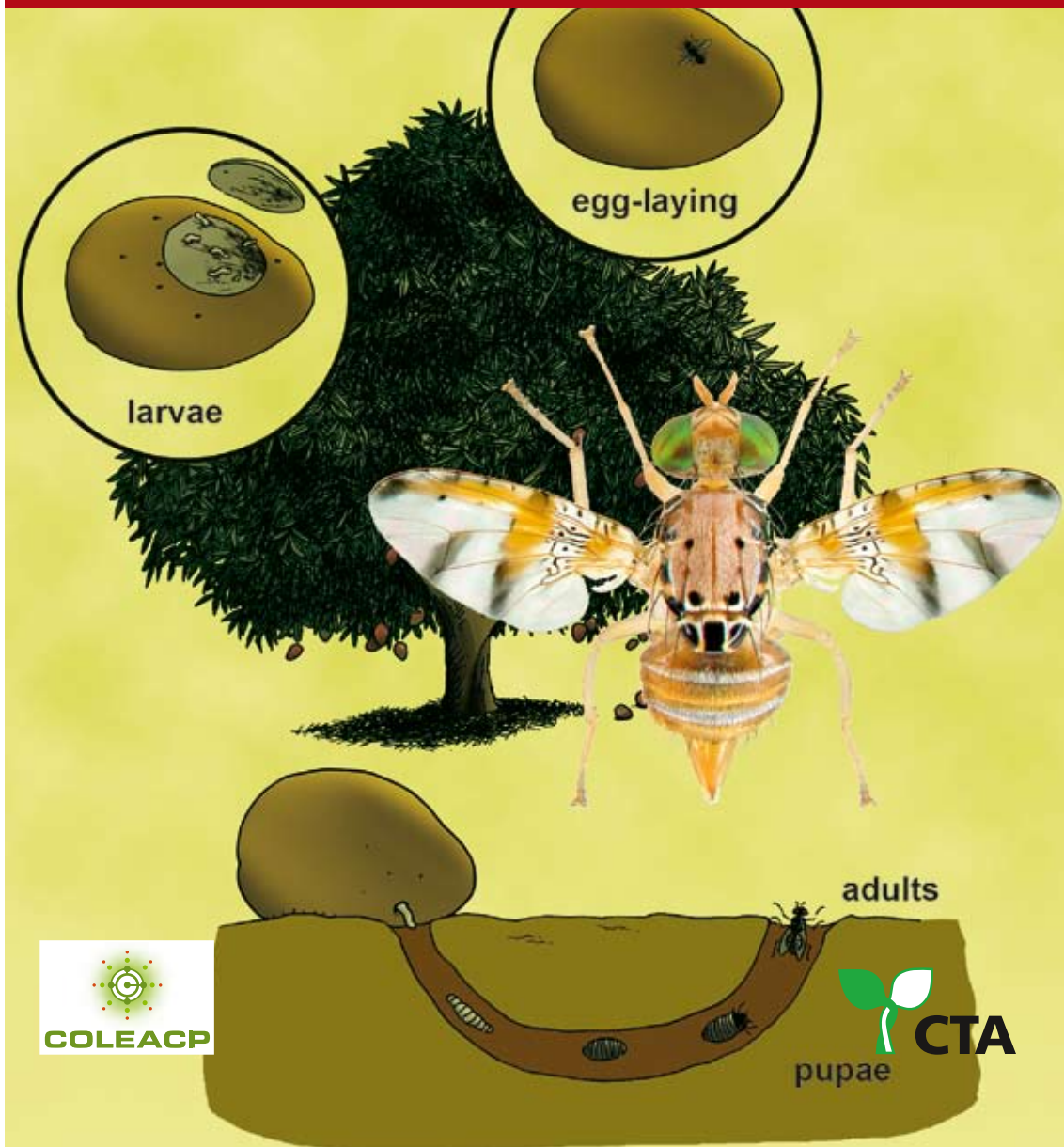
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How to Control the Mango Fruit Fly



Identifying the problem of the mango fruit fly

The mango tree suffers from numerous physiological, phytopathological and entomological problems. In West Africa, the economic importance of the damage caused by mango fruit flies (*Diptera tephritidae*) is growing in home garden mango trees as well as in small-scale and industrial mango orchards. The introduction and pan-African propagation of *Bactrocera invadens*, a fly species from Sri Lanka, first discovered in West Africa in 2004 by IITA in Benin, could jeopardise the recent commercial success of the whole mango sector.

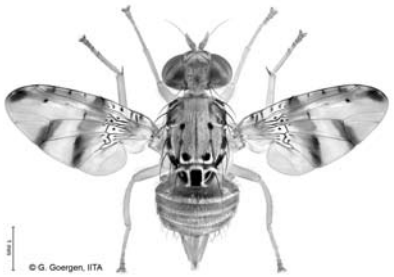
Since fruit flies are classified as "quarantine insects", if a consignment of mangoes containing even a single fruit infested with larvae is exported to Europe, the whole batch may be rejected and totally destroyed by the European phytosanitary services. Fruits showing the slightest trace of a fly bite must be identified, removed, and destroyed during harvesting and in-station sorting.

Each year whole containers of fruit from Africa are intercepted, confiscated and destroyed in incinerators in European harbours and airports because of these insects, thus causing major economic losses for the exporters.

The exporter who is unable to keep his business commitment runs the risk of losing the client and his reputation. The confiscation of a single batch can ruin the efforts of a whole campaign.

What are fruit flies and how do they proliferate in the fruit?

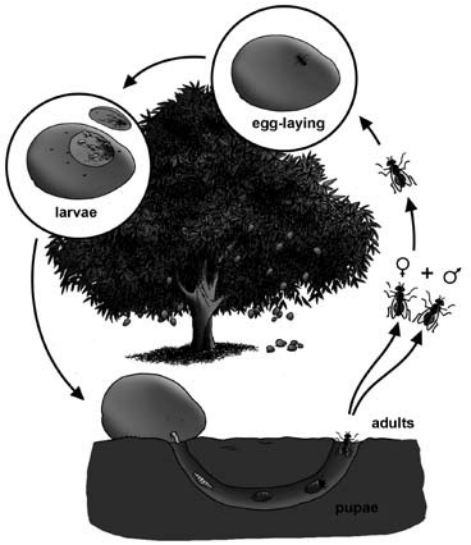
Out of 12 *Tephritidae* diptera species that attack mangoes, the two considered the most harmful are *Ceratitis cosyra* and *Bactrocera invadens* (even though three other *Ceratitis* species also cause economically significant damage).



Ceratitis cosyra



Bactrocera invadens



The life cycle of most *Tephritidae* species is similar. The female implants its eggs in the young fruit of the host plant, which become attractive as they reach maturity. The larvae or maggots develop in the flesh of untreated fruit by digging tunnels (which provide opportunities for secondary infections when the larvae emerge from the fruit). The growth of the larvae accelerates maturation of the fruit, which detaches and falls to the ground. The larvae leave the fruit and the pupae develop in the top layer (top few inches) of the soil. Upon emergence, the adult soon starts looking for the nourishment it needs to reach sexual maturity, couple, and lay eggs.

Methods for controlling the fruit fly

If the fly population becomes too large, there is no control method that will be genuinely effective and profitable. The only effective method for interrupting the fly's development cycle is to remove the dropped fruit every day and prevent the adults from implanting eggs in the fruit (baited traps, preventive insecticide treatments). Hence all preventive and prophylactic measures with demonstrable effects should be used in the orchards. To limit proliferation, it is essential to control the fly population at the beginning of the season.

❑ How to interrupt fly proliferation and bring down the infestation level in the production zones

Because of attacks by *Ceratitis cosyra* and *Bactrocera invadens*, harvest losses that are held down to 10% at the beginning of the growing season can reach 80% by the end of the season. In Guinea and Mali, losses for the main commercial cultivars such as Irwin, Amélie, Eldon, Kent, Smith and Keitt, can reach 40% in the middle of the season, and can exceed 50% for later maturing varieties such as Brooks.

The fruit fly can proliferate under the following conditions:	Actions to take:
Extended presence in orchard of larvae-infested fruit fallen from trees. Larvae will complete their growth cycle in the soil and create outbreak sites.	Pick up dropped fruit every day. Quickly remove the fruit from the orchard and destroy by: - burying fruit in a pit, (40-60 cm deep), covered once a week with earth or quicklime; - collecting fruit in a bag or under an impermeable plastic cover, exposed to the sun; - submerging fruit in a tank filled with water; - burning fruit in a ditch or a tank. Till the top soil (5-10 cm deep) in the orchard to expose the pupae to the sun, parasites and predators such as birds.
Presence of cultivated plants (which can be alternative hosts to the flies) in the orchard or in nearby orchards	Avoid growing certain plants such as pimento, bell peppers or cucumbers as intercrops. Avoid planting or keeping host plants nearby if their fruits attract the fly, e.g. citrus, guava, papaya, anona, melons, etc. A large number of host plants nearby may result in large populations of fruit flies at the start of the mango harvesting season. Manage orchards using the same rules as for mangoes (picking up, sorting, destroying) since flies are polyphagous.
Presence of abandoned, untended orchards or wild trees near the cultivated plot	Avoid leaving such trees nearby, since this is where infestations break out. Success in controlling fly populations in cropping zones requires information and collective responsibility.
Presence of weeds (which can be alternative hosts)	Weed carefully around the trees; weeding makes it easy to see and pick up fallen fruit. Till the top soil (5-10 cm deep) to clean the orchard.
Presence of several varieties (with successive harvesting dates) in the orchard	Avoid growing mango varieties with very different growth cycles in the same orchard; since fly populations grow during the production period, the late-maturing varieties are often infested the most. If market demand allows, produce the early-maturing varieties so that the fruit ripens when fly populations are low.

Presence of infested fruit in the plot or near the fruit-packaging station	Sort the fruit and quickly eliminate any fruit with traces of fly attack (consume or destroy immediately). Do not leave any rejected fruits, since they are ideal infestation sites, near the orchard or the packaging station. This includes ungraded, infested fruit and infested fruit eliminated during sorting.
Transport of infested fruit to local or regional markets	If possible, avoid selling infested fruit or fruit discarded during sorting; alternatively ensure immediate consumption, and proper destruction of unsold fruit (bury or incinerate the fruit; do not throw into a garbage bin). Avoid transporting punctured fruit from infested zones to less infested zones.

❑ How to decrease fly populations by capturing male *Bactrocera invadens* flies in the orchards

Parapheromone traps are generally used to capture male flies of certain species. At present they are the best tool for detecting the flies and, if used on a large scale and in large quantities, can hold down population growth early in the season.

The technique: at the beginning of the season, install a strip impregnated with a specific attractant and treated with a contact insecticide (malathion or deltamethrin).



The traps should be installed in the orchard at least one month before the fruit becomes appealing. It is advisable to install these traps in other orchards with fly-sensitive fruit trees, e.g. citrus orchards.

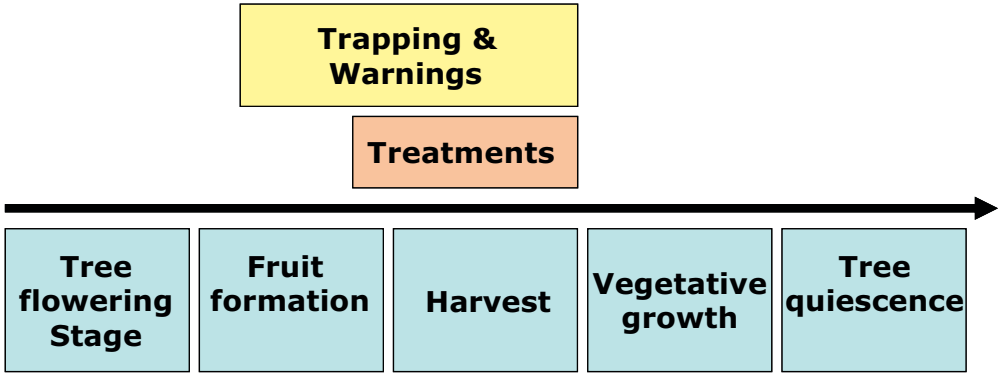
Small blocks of wood or strips are cut into pieces (Triplex-type chipboard) and soaked in a solution containing methyleugenol to attract the male *B. invadens*. A nail is driven through each strip and into the trunk of the mango tree. A concentrated solution (a malathion or deltamethrin emulsion prepared using an EC – emulsifiable concentrate – diluted in water) is then applied to the strip with a brush and left to dry. The strips (1 for 10 trees, or about 10 per hectare) are then hammered into the trees. To ensure easy replacement, the nail should not be totally driven in. The strip has to be renewed once a month.
A container, such as a water bottle cut in half, can be attached under the strip to collect the capture.

Intervention strategies

Population control strategies are based on infestation observation (trapping) and step-by-step interventions: localised treatment, and, under exceptional cases, throughout the orchard. Only locally registered products are to be used.

As an example, the following threshold values are applied in Réunion:

Level of infestation	Number of flies/foodstuff attractant trap (weekly reading)	Type of treatment
zero to low	fewer than 25	no treatment
medium	between 25 and 120	localised treatment
high	over 120	full treatment



❑ Localised treatment in orchards

When to treat?

Foodstuff attractant traps and insecticide strips (e.g. DDVP) are installed throughout the orchard (approx. 1 trap per 10 trees).
Treatment should be started either when the first flies (female *Bactrocera sp.* or *Ceratitis sp.*) have been found in the trap or when the fly-prone fruit are present (for *Ceratitis*, at the attack-prone ripening stage, sooner for the *Bactrocera*).
The first treatment must be applied on time since the product only has a preventive effect, not a curative effect (the larvae is protected while growing in the fruit).



What product?

SUCCESS APPAT® produced by DOW AGROSCIENCES (1 l/ha of CS – concentrated suspension – with a base of 0.24 g/l of Spinosad and an incorporated foodstuff attractant) can be used for a localised treatment in mango orchards (treat every third tree or every third line). The European Union authorises the use of Spinosad in organic production.
If fly captures in the trap continue, the treatment is to be renewed every 7 to 10 days, depending on the population intensity. Treatments should be repeated in the event of rainfall of over 10-25 mm (depending on rainfall intensity).
This type of treatment has very little effect on the orchard's natural enemies, and risks for the operator are low.

How?

The product should be applied by using a knapsack or towed sprayer equipped with a hose and a 1-2 mm (diameter) nozzle. The nozzle disc should be removed so that droplets are between 1 and 5 mm (do not use an atomiser, lower pressure as much as possible). The spray volume should be between 4 and 10 litres/ha. Apply the mixture to the top layer of leaves (about one m2), rotating around the tree (do not always treat the same leaf areas) and try to penetrate the foliage slightly. It is better not to treat the fruits. This type of localised application using a knapsack sprayer is acceptable just prior to harvest, and even during harvest since the operator can avoid spraying the fruit.

❑ Full treatment throughout the orchard

Under what conditions?

The decision to fully treat the whole orchard will depend on the results of the capture, i.e. if there are dense swarms of flies at the beginning of the growing season and when the fruit is becoming more sensitive (the tolerance threshold still needs to be thoroughly defined in the various agro-ecological zones).
Many bio-control agents (i.e. natural enemies) have been identified in the orchards and can be used to restrict pest development, e.g. mealy bugs and thrips. Full treatment is risky because of the potential destruction of a major part of the bio-control agents and could trigger an upsurge of certain pests that, until then, have been of lesser importance.
To protect the auxiliaries, it is preferable to limit the number of full treatments in the orchard, per season, to no more than two applications, with an interval of 10 days.

What product?

Products are selected on the basis of their spectrum, their effectiveness on the flies, the MRL (maximum residue limit) for mangoes, and the pre-harvest intervals (PHI). With a 7-day PHI, certain active ingredients (e.g. bifenthrin and lambda-cyhalothrin) can be used, even during the harvesting period, as long as the MRL is respected.
The following insecticides can be recommended: lambda-cyhalothrin at 25 g/ha (1 kg/ha of Karate Max 2.5 WG ® produced by Syngenta) or bifenthrin at a dose of 50 g/ha (0.5 m/ha of Talstar 100 EC ® produced by FMC).