FRUIT FLY

Ceratitis (Ceratitis) capitata (Wied.)
Ceratitis (Pterandrus) rosa Karsch
Bactrocera (*Bactrocera*) *dorsalis* (Hendel)

1 PEST PROFILE

1.1 Distribution and status

Three fruit fly species pose a serious threat to citrus in southern Africa and are of quarantine importance. Two of the fruit fly pests, Mediterranean fruit fly (Medfly), *Ceratitis (Ceratitis) capitata* (Wied.), and Natal fly, *C. (Pterandrus) rosa* Karsch, are indigenous and widely distributed across South Africa. The third fruit fly pest – Oriental fruit fly, *Bactrocera* (*Bactrocera*) *dorsalis* (Hendel), is an exotic species which is currently restricted in the north and north eastern areas of South Africa. The pest is still considered absent in the Eastern Cape, Western Cape, Northern Cape and the Free State Provinces.
Ceratitis rosa was split into two species in 2016: *Ceratitis rosa* sensu stricto (Natal fly) and *Ceratitis quilicii* De Meyer, Mwatawala & Virgilio (Cape fly). Both the Natal fly and the Cape fly are present in South Africa and occur in sympatry in some of the northern areas of South Africa. Females of the two species cannot be distinguished morphologically while males differ in the coloration patterns on the mid tibia. The plants from which the Cape fly was reared and confirmed do not include citrus. As such, Cape fly is not listed as a pest of citrus.

1.2 Description

Adults of Medfly and Natal fly have characteristic features of which the swept-back wings with their smoky yellow and brown markings and bright, blue-green eyes are the most readily noted. The Medfly is generally smaller than the Natal fly which has a body length of 5 to 6 mm. The colouration of Natal flies tends towards brown and is generally darker than that of Medflies. The upper thorax of the latter has a readily visible pattern of black and silver-white markings.

The adult of the Oriental fruit fly has a wasp like appearance. The wing of the fly has a dark band running along the front edge of the wing. The fly has two vertical yellow stripes on the thorax and there is a characteristic dark T-shaped marking on the abdomen. The Oriental fruit fly adult is bigger than the adults of Medfly and Natal fly, with a body length of about 8 mm.

Females of all three pest species have an ovipositor protruding from the tip of the abdomen. This is used to pierce the fruit skin and lay banana-shaped eggs in small pockets below the surface. Females frequently make trial punctures, the so-called “abortive stings”, before selecting a spot for oviposition. Hatched larvae are cream-coloured, legless and can reach a length of 6 to 8 mm. The body tapers to a point at the mouthparts and is truncated at the posterior. The larvae burrow into the fruit tissue. Mature larvae leave the fruit and pupate in the soil from where the adults emerge in due course.

1.3 Infestation sites on the tree

Fruit fly pest species attack only the fruit stage. However, it is important to remember that throughout the year the canopy of evergreen citrus is favoured as a source of shelter and food by adults. The latter comprises natural food sources such as droplets of water, honeydew and animal faeces (e.g. birds and lizards within orchards).

The larval developmental cycle is not always as readily completed in some citrus cultivars as in crops such as subtropical and deciduous fruits. Citrus rind oils that can be released during the oviposition process frequently kill the eggs. In addition, many larvae are unable to burrow through the albedo to get to the underlying juice segments.

1.4 Damage

1.4.1 Symptoms

The skin around oviposition punctures and abortive stings usually becomes discoloured with time. When the fruit has a greenish hue, the punctured area will first become yellow before the decaying surface tissue turns brown. On well-coloured fruit, browning of the tissue is usually the first sign of damage. These colour changes become progressively more visible, but generally can be seen unaided about eight days

after the skin has been punctured.

The puncture can be exploited by secondary insects such as vinegar flies, Lonchaeidae (*Silba* sp.) and various small beetles. Immature stages of these insects must not be confused with fruit fly larvae. Vinegar flies and Silba sp. can be distinguished from fruit fly larvae using characteristics on their posterior spiracles. For both vinegar flies and *Silba* sp. their posterior spiracles are on a raised prominence. The posterior spiracles of *Silba* sp. are also dark and have angled slits when viewed under a stereo-microscope. The vinegar flies are about half the length of fruit fly larvae. Beetle larvae, are different to fruit fly larvae in that the former have well-defined heads and legs while the latter do not.

Export regulations require that, if a single live immature fruit fly (egg or larva) is found in a consignment of fruit during inspection, then the entire consignment must be rejected. Such rejection leads to delay and extra costs as a result of the need to re-sort, repack and re-route the fruit. The oviposition puncture also acts as an entry point for fungi which can cause post-harvest fruit decay. This hazard must be avoided.

1.4.2 Seasonal occurrence

Citrus is primarily subject to attack by fly populations that originate in hosts outside the orchard environs. There are two annual peaks of fly activity that citrus growers need to control and they are as follows:

1.4.2.1 Late summer/autumn

During this period, flies which have developed in a succession of summer hosts, migrate into citrus orchards where they can reach high density levels. These populations will commence attacking early maturing citrus cultivars as they break colour.

1.4.2.2 Early spring

The cold weather of winter will variably reduce populations present in the orchards and also other sites where adults shelter. However, the surviving flies pose a severe threat to late-hanging citrus cultivars in early spring. These fruit are fully coloured and ripe and this facilitates the development of larvae. The hazard of rejections of such fruit is increased and every effort should be made to maintain control quality during their harvest period.

1.4.3 Association between birds and fruit flies

High numbers of fruit-eating birds in orchards, particularly in easy-peeler orchards, can result in high fruit fly infestation. Birds inflict wounds on fruit which then provide good feeding and egg-laying sites for fruit flies. Moreover, bird faeces are natural sources of protein for fruit flies and can compete with artificial proteinaceous baits used for fruit fly control. Options to reduce incidence of birds in the orchards include the use of loud noises, reflected lights and exclusion nets. If birds are not controlled, routine fruit fly control measures might not be adequate and would have to be increased.

2 MANAGEMENT ASPECTS

2.1 Infestation

2.1.1 Non-bearing trees

Fruit flies are not a threat to non-bearing trees. However, non-bearing trees which surround unharvested trees can harbour fruit flies in search of shelter or food.

2.1.2 Bearing trees

2.1.2.1 Monitoring of adult fly populations

Adult fly activity can only be monitored with traps and lures. Full details of traps for monitoring flies are presented below.

Monitoring for the Oriental fruit fly should be carried out throughout the year. For the other fruit fly pests, it is essential that monitoring activities be initiated before the peak activity periods (usually between January and May). In regions under historically high fruit fly populations, such as the Western Cape and Eastern Cape regions, monitoring of Medfly and Natal fly should be initiated from October. In other regions, monitoring of Medfly and Natal fly

should be initiated between December and January. Because the production of fly-free crops for export is of critical importance it is recommended that, in general, growers make liberal use of traps to monitor until the completion of harvest. Fruit fly activity in citrus orchards would continue throughout the season and a second peak of activity is usually experienced at the end of the harvest season, particularly in the northern regions.

One of the pre-requisites for conformance to GLOBALGAP standards is the monitoring of insect pests. By reacting to pest populations based on monitoring, the grower will be applying good agricultural practices in that pesticides will not be applied unnecessarily. In the case of fruit flies, the number of individuals trapped should be kept as far as possible under specified threshold levels set for registered trapping systems (2.1.2.2).

There are five trap attractant combinations that can be used for fruit fly monitoring in citrus: (1) Sensus trap baited with Capilure, (2) Sensus trap baited with Questlure, (3) Chempac Bucket trap baited with Biolure® Fruit Fly, (4) Chempac Yellow Delta trap baited with Chempac fruit fly lure (Trimedlure**)** and (5) Traps baited with Methyl Eugenol (ME).

Both males and females of all pest species should be monitored. Males of Medfly and Natal fly should be monitored using either Sensus trap baited with Capilure or Chempac Yellow Delta trap baited with Chempac fruit fly lure (Trimedlure**)**. Females of fruit fly pests should be monitored using either Sensus trap baited with Questlure or Chempac Bucket trap baited with Biolure® Fruit fly. The ME baited trap is used for monitoring of males of the Oriental fruit fly.

Monitoring of the Oriental fruit fly is a requirement for phytosanitary registration of citrus for export to special markets (USA, Japan, South Korea, China and the European Union – EU). It is therefore essential that ME baited traps are used in all commercial citrus orchards, even in areas where the pest is considered absent.

All traps should preferably be examined at weekly intervals. It is highly recommended to make use of the fruit fly identification sheet for proper identification of males and females of the targeted fruit fly pests in citrus orchards.

2.1.2.1.1 Trap placement

Traps should be hung within the foliage on the shadier side of the tree and in the middle of the canopy (usually about 1.5 m above ground). Traps should not be exposed to direct sunlight, strong wind and dust. Specific details on the trap placement within the tree are provided on the labels of the attractant. Within the canopy the trap must be able to hang freely so that it does not become entangled with leaves or fruit. Trap entrances should be cleared of leaves to allow access to flies and prevent entry of ants. The wire hanging the trap should be coated with a sticky ant barrier, grease or Vaseline for further protection against ants.

Traps should preferably be placed in the outer two to four rows of orchards. Traps with different attractants should not be placed in close proximity in order to avoid trap interference. A distance of at least 30 m should be kept between traps with different attractants. Traps should preferably be deployed in a grid system and be uniformly distributed.

2.1.2.1.2 Sensus trap

The Sensus trap is recommended for monitoring populations of Medfly and Natal fly. The trap consists of a blue lid and a transparent receptacle in which the dead flies collect (Figure 1). Two types of attractants can be used with the Sensus trap; Capilure and Questlure.

DO NOT USE TWO DIFFERENT LURES TOGETHER IN THE SAME TRAP

It is recommended that some polybutene adhesive or grease be placed on the piece of wire from which the Sensus trap is suspended to prevent ants from entering the trap and removing the flies.

Figure 1. The Sensus fruit fly trap

Use of Capilure in the Sensus trap

A Capilure capsule (red) is attached to the Sensus trap lid. A DDVP block is added to kill the attracted flies. Capilure attracts males of Medfly and Natal fly only.

Use of Questlure in Sensus trap

The Questlure capsule (green) is applied in the same way as the Capilure capsule. Again a DDVP block is added. Questlure attracts mostly female fruit flies.

One trap of either Capilure or Questlure is required every 2 - 5 ha. The total trap numbers on a farm must be 50% Capilure and 50% Questlure.

Capilure, Questlure and DDVP must be replaced every 6-8 weeks.

2.1.2.1.3 Chempac Bucket trap and Biolure® Fruit fly

The Chempac Bucket trap consists of a transparent lid and a yellow bucket in which flies collect (Figure 2). The yellow bucket contains three lateral holes close to the top and an inverted hole at the bottom of the trap for entrance of flies. Three plastic pipes are supplied with each trap and these must be fitted into the three lateral holes, with the pipes protruding on the inside of the trap, to prevent entering flies from flying out of the trap. The food-based attractant Biolure® Fruit Fly can be used with this trap.

Figure 2. Chempac Bucket trap

The Biolure® Fruit Fly is available as one sachet containing ammonium acetate, trimethylamine hydrochloride and 1,4-diaminobutane (Putrescine). The sachet must be removed from the sealed plastic bag for release of attractant. The Biolure® Fruit fly sachet must then be placed inside the trap. A DDVP block must be placed at the bottom of the trap to kill fruit flies entering the trap. The density for traps baited with Biolure® Fruit Fly is one trap per four hectares.

Attractants and DDVP must be replaced every 6 weeks.

2.1.2.1.4 Chempac Yellow Delta trap and Chempac fruit fly lure (Trimedlure)

The Chempac fruit fly lure (Trimedlure) is registered and commercially available for monitoring of male fruit flies and targets both Medfly and Natal fly. The Chempac fruit fly lure is recommended for use in the Chempac Yellow Delta trap (Figure 3). A sticky pad (Chempac Sticky pad) can be inserted on the floor of the Delta trap to catch any attracted flies. The Chempac fruit fly lure should be placed in the middle of the sticky pad. The density for traps baited with Chempac fruit fly lure is one trap per four hectares. The attractant must be replaced every 6 weeks.

Figure 3. Chempac yellow Delta trap

2.1.2.1.5 ME traps

Three types of traps: Lynfield, Chempac Bucket and McPhail, are recommended for use with the attractant ME which is fairly specific to males of some *Bactrocera* species including the Oriental fruit fly.

The Lynfield trap is a bucket type trap composed of a cylindrical plastic container with four equidistant holes on the upper third. The lid of the trap contains a hook to which an ME dispenser such as Invader Lure must be fitted.

The Chempac Bucket trap is a yellow cylindrical container with a transparent lid (as described in 2.1.2.1.3). A plastic basket can be fitted in the lid of the trap to contain an ME dispenser.

The McPhail trap consists of two parts, a clear lid and a yellow bottom section with an inverted funnel entrance underneath. The ME dispenser is suspended inside a plastic basket at the top of the trap**.**

Various ME dispensers are commercially available in South Africa. ME is available as slow release dispensers in the form of a plug, a wafer or a fibre-board block (Invader Lure). ME should be used in bucket type traps such as Lynfield trap, Chempac Bucket trap and McPhail trap. Only one ME dispenser must be placed per trap. Maximum precaution is required while handling ME in order to avoid contamination of the outside of the trap. When using ME with other fruit fly attractants (e.g. Questlure, Capilure, BioLure®, preferably designate different persons to handle the different attractants in order to avoid cross contamination of traps.

An insecticide such as DDVP must also be placed in all bucket type traps to kill any attracted flies. One small piece of DDVP (1 cm x 1 cm) should be used per trap.

For monitoring of the Oriental fruit fly, at least one ME baited trap is required per Production Unit Code (PUC). On farms, ME baited traps should be spaced at least 400 m apart. The density of ME baited traps varies according to the status of the pest in the area:

- For areas where the pest is considered absent, 1 ME trap should be used per 100 ha.
- For areas where the pest is transient (under eradication), 3-5 ME traps should be used per 100 ha.
- For areas where the pest is considered present, 2-4 ME traps should be used per 100 ha.

ME and DDVP should be replaced every 6-8 weeks depending on lure dispensers used.

2.1.2.1.6 Traps at packhouses

Either a Questlure baited Sensus trap or a Biolure baited Chempac Bucket trap should be placed where fruit arrives before entering the packhouse. If numbers of flies caught per week exceed the threshold (provided in 2.1.2.2), extra care should be taken to keep fruit in trailers and bins covered at all times. If numbers of flies are consistently high, bait stations should be hung in shade trees near the packhouse.

2.1.2.1.7 Trapping records

Trapping information should be properly recorded. For each trapping system, the details of the trap that can be recorded are as follows: Province, Farm name, PUC, fruit type (where trap is placed), Orchard block number, attractant (e.g Capilure, Questlure, Trimedlure, Biolure, ME), trap type (Sensus, Chempac bucket, Chempac Delta, Lynfield), trap number, date trap set and GPS co-ordinates.

For the regular/weekly trap service records, the following can be recorded: date serviced, PUC number, trap number, number of target fruit flies

(fruit fly groups targeted by specific trapping systems). For the Oriental fruit fly, a trapping sheet template is available on the Citrus Research International (CRI) website.

Every week, records of trapping of a target fly group (e.g. Medfly male) in a specified trapping system (e.g. Capilure baited Sensus trap) for an area (e.g. either entire farm, PUC or preferably orchard block number) should be summarised as flies per trap per week. If traps of a specified trapping system are all read on the same day every week, this can be calculated by dividing the total number of target flies (F) captured by the total number of traps (T) in the area (e.g. either entire farm or preferably orchard block number): F/T. If the total number of days between trap services vary, the trapping data for the area should be adjusted by dividing the F/T over average number of trapping days and multiplied by seven so that flies per trap per week can be obtained.

Trapping records should be kept for at least two seasons.

2.1.2.2 Treatment thresholds

Treatment thresholds indicate the need for additional control measures for fruit fly pests in orchards, such that these pests remain at levels that pose little or no risk of infestation of fruit destined for export.

Treatment thresholds for the *Ceratitis* pests of citrus were previously developed for Capilure and Queslure baited Sensus traps. These have long been applicable in the citrus industry. Treatment thresholds for the Trimedlure (Chempac) baited Chempac Yellow Delta trap and Biolure baited Chempac bucket trap, which are equivalent to those established for the Capilure baited Sensus trap and Questlure baited Sensus trap respectively, can now also be applied.

When using a **Capilure baited Sensus trap**, the threshold for **Medfly** is **four flies** per trap per week, whilst the threshold for **Natal fly** is **two flies** per trap per week.

When using a **Chempac fruit fly lure (Trimedlure) baited Chempac Yellow Delta trap**, the threshold for **Medfly** is **eight flies** per trap per week, whilst the threshold for **Natal fly** is **four flies** per trap per week.

When using **Questlure in a Sensus trap**, the threshold is **one female** fly per trap per week for both Medfly and Natal fly.

When using a **Biolure baited Chempac Bucket trap,** the threshold is **two females** per trap per week for all fruit fly pests of citrus.

In an area where the Oriental fruit fly is present, there is a threshold range of **between 10 and 12 flies per ME trap per month (equivalent to between 2.5 and 3 flies per trap per week).**

Higher numbers of flies per trap per week than the above thresholds indicate that control is inadequate and intervention is required.

For the Oriental fruit fly additionally, exceedance of the threshold range would have consequences on removal permits which are required for movement of fruit from areas infested with Oriental fruit fly to areas free of the pest in South Africa. PUCs with catches of Oriental fruit fly averaging 10 or less flies per ME trap per month would be considered safe for removal of fruit out of these units. If catches of Oriental fruit fly exceed 10 flies per ME trap per month in a PUC, (equivalent to over 2.5 flies per ME trap per week), control measures must be intensified. Removal permits will not be granted or will be withdrawn for PUCs with catches of Oriental fruit fly averaging more than 12 flies per ME trap per month (equivalent to over 3 flies per trap per week).

<u>Maintaining fly populations below thresholds</u>

The objective of any fruit fly control programme is to prevent fly oviposition during the period that fruit are susceptible to attack. Fly populations in orchards should be reduced to minimal levels by the time that fruit are susceptible to attack. When fruit become susceptible to attack which is from colour break onwards, fly populations should be maintained below threshold levels until harvest. Fruit fly populations can be maintained below threshold levels by implementation of diligent control measures and adjustment of control

measures when necessary (e.g. increasing frequency of control, adding other control options).

Growers who have problems in reducing fly numbers or maintaining the recommended low counts, should call for assistance from a consultant to help them check their control programme.

2.2 Control

2.2.1 Timing of control

Fruit fly control should be initiated in middle to late summer (either January or February depending on regions) before fly numbers peak. Fly catches should be brought down to below the threshold levels (2.1.2.2) as soon as possible. In fruit production regions where citrus is grown in proximity to crops susceptible to fruit fly infestation such as deciduous fruit or mango, fruit fly control should be initiated by December.

Fruit fly control should be carried out regularly throughout the season and should be adjusted based on trap catches (catches staying below thresholds).

Co-ordinated area-wide control is recommended in citrus production areas since fruit flies are highly mobile, migrating between different environments (for example untreated areas to treated areas, backyard gardens with host fruit to commercial orchards).

2.2.2. Control options

2.2.2.1 Biological

Biological control is not practical within commercial orchards for the control of fruit flies. There are natural enemies that attack certain of the immature stages of some of the pest fruit flies, particularly in fruit of smaller sizes in natural and non-commercial environments, and these, together with climatic factors, can cause variations in annual fly density. However, these variations do not reduce the annual threat posed by the pest fruit fly species to the citrus crop.

2.2.2.2 Cultural

During the harvest period, fallen fruit should be regularly removed from orchards. In addition, fruit left on the tree after harvest or damaged by birds should be removed from the orchard. This orchard sanitation serves a threefold purpose by removing fruit possibly infested with fruit fly and false codling moth while, at the same time, reducing the spore load on sound fruit which can arise from decaying fruit on the orchard floor. The latter issue is of vital importance in reducing post-harvest decay. See the section on FALSE CODLING MOTH in this chapter for procedures to conduct effective orchard sanitation.

2.2.2.3 Plant protection products

Cover sprays have been developed for fruit fly control in other fruit crops. However, they have not been regarded as feasible propositions for use on citrus with available materials for reasons of efficacy, cost, pest repercussions and residues.

To date, the “Attract and Kill” approach, relying on the use of bait sprays or bait stations or Male Annihilation Technique (MAT), has been the most appropriate method for controlling fruit flies in citrus orchards.

Bait sprays and bait stations comprise a mixture of an attractant (mostly protein based) and toxicant. Both sexes of each fly species are attracted by the protein-based bait, although the latter is generally more attractive to females. Application of poisoned protein baits either as sprays or as stations is required to control populations of all pest fruit fly species in citrus orchards. In case bait stations are used and fly catches increase above threshold levels, bait sprays (either aerial or ground) would have to be applied.

In areas where the Oriental fruit fly is either transient (under eradication) or present (under suppression), MAT is required.The objective of MAT is to achieve a high number of male kills in order to reduce the number of matings, which will subsequently lead to population control through reduced production of fertile offspring. For the Oriental fruit fly, MAT is an essential component in the control of the pest. The males of the Oriental fruit fly are targeted using ME and killed by an insecticide incorporated with ME.

MAT can be applied by hand, spatula or applicator depending on products being used.

2.2.2.3.1 Baiting

Baiting should start in middle to late summer (either January or February depending on regions) as mentioned in 2.2.1. Different baiting techniques: ground-based sprays, aerial sprays and bait stations can be used, at times in combinations depending on trap catches.

2.2.2.3.1.1 Ground-based baiting

Baiting machinery

Three different types of ground-based machinery are used to apply the bait mixtures:

- *Tractor-drawn applicator for dilute bait*: This either consists of a 500 litre tank with pump and specialised spray equipment on the three-point, or a small modified mistblower. Bait is applied simultaneously from both sides of the machine by way of a single spray nozzle mounted on each of the dual arms of an adjustable "Y"-shaped rig. **No whirler plates are used and no wind is used in the case of mistblowers**. Ideally the spray disks should contain more than one hole. As a result the bait mixture is applied in jets of liquid directed upwards into the top half of the tree as coarse droplets.

- *Tractor-drawn applicator for concentrated bait (Mantis or Ladybird):* CRI and Quest Developments (now Green Trading) designed an applicator for concentrated bait which is available in two models. The Mantis is PTO driven and mounted on the tractor three-point and the Ladybird is self-propelled and mounted on a small trailer. Both designs use a blower to deposit large droplets of concentrated bait on the tree foliage.

- *Knapsack sprayer for dilute bait:* This usually consists of a 15-20 litre back-pack tank with accessory spray gun. The bait is manually applied either under tank pressure or with the aid of a spray gun operating like a bicycle pump. Either way care should be taken to ensure that sufficient bait is applied per tree. The spray nozzle should be adjusted to deliver bait in the form of coarse droplets.

Bait application

Weekly bait sprays may be required to maintain fruit fly populations at or below threshold levels. The frequency of bait sprays can be adjusted according to trap catches. In cases where catches remain above the threshold, bait sprays may have to be applied twice a week. In case of rain, bait sprays would have to be reapplied after the rain within the same week if possible..

Baits must be delivered in large droplets over the major part of the tree canopy. The recommended volumes of protein and toxicant are presented in the following tables. The volume of bait per tree should be as per recommendation on the label. Bait volumes can be adjusted according to tree size. Young trees would require lower bait volumes than mature trees. The diligent use of traps to monitor fly activity in individual situations may permit variable reductions in the recommended bait quantities applied per tree. A 2X concentration (of protein only) is commonly-used at half the above volumes.

When using the Mantis or Ladybird mistblower, concentrated bait sprays should be applied whereby the amount of protein used is increased by 15 fold. However the insecticide concentration should remain unchanged. The volume of bait applied per tree should not be less than 45 ml.

Dilute bait mixtures

One of the following dilute bait spray options comprising a mixture of a protein attractant and toxicant can be used:

Products to mix	Dosage/100 ℓ water
Proteins: Hym-Lure ready for use	400 ml
or Lok-Lure	400 ml
or Buminal	250 ml

Products to mix	Dosage/100 ℓ water
Plus toxicant: Trichlorfon/ Dipterex or Malathion EC or Malathion WP	 50 g 175 ml 300 g
Bait mixture	**Dosage/ha**
Hym-Lure plus Cyantraniliprole/ Exirel™ SE	400-1000 ml plus 100 ml in 50-100 L of water
Ready to use protein and toxicant mixture	**Dosage/ha**
GF-120	1 – 1.2 L in 4-29 L of water
FF240	1 – 1.2 L in 9-29 L of water
CURA FLY	1 – 1.2 L in 9-29 L of water

NOTES

- The dilute bait mixtures must be applied as soon as possible after mixing. They must not be kept overnight and longer.

- Where a bulk quantity of bait is prepared to supply a squad of operators using knapsack sprayers, the mixture must be well stirred before each filling.

- GF-120, FF240 and CURA FLY do not dissolve easily and must be pre-mixed thoroughly in a bucket of water before being added to the tank.

- There are warnings of potential phytotoxicity of GF-120 and CURA FLY on certain citrus cultivars such as mandarin. The risk of phytotoxicity has been previously found when fruit is either at the green or colour break stage. Phytotoxicity of baits were not previously recorded when fruit was in full colour.

- Bait formulations should not be kept from one season to the next.

The protein baits exert most attraction on the day of application. As a result the larger the area that can be treated **during the morning**, the bigger the overall bait impact will be. When using manually operated knapsack sprayers for application purposes, best results will be obtained if workers operate as a team to treat specific areas quickly.

Concentrated bait mixture

The bait mixture for use with the Mantis or Ladybird applicator is made as follows:

Products to mix	Dosage/100 ℓ water
Hym-Lure or Lok-Lure or Buminal	6 L 6 L 3.8 L
Plus: Trichlorfon/Dipterex or Malathion EC or Malathion WP	 50 g 175 ml 300 g
Ready to use protein and toxicant mixture:	**Dosage/ha**
GF-120	1-1.2 L in 4-29 L
FF240	1 – 1.2 L in 9-29 L of water
CURA FLY	1 – 1.2 L in 9-29 L of water

2.2.2.3.1.2 Aerial baiting

Aerial baits should be applied as specified in the labels of the registered products. Wind speed should not exceed 15 km/h during application. Baiting should be restricted to orchards.

The swath width during aerial baiting should be determined for each type of bait, aircraft and atomizing equipment used. The no-spray area during an aerial bait application should preferably be no more than 20 m in width. This is based on the knowledge that protein baits

most effectively attract flies up to a distance of 10 m.

Aerial baiting is most frequently used to augment ground-baiting programmes if difficulty is being experienced in reducing fly numbers. As a result, its use is based on trap data to support both the need for aerial treatment and its resulting efficacy.

For aerial application, four bait mixtures are registered. These are as follows:

Products to mix	Dosage/ha
Hym-Lure or Lok-Lure **Plus:** Malathion UL	750 ml 750 ml 250 ml
GF-120 **Plus:** Water	1 L 1-3 L
Hym-Lure **Plus:** Exirel® 100 SE **Plus:** Water	900 ml 100 ml 1 L
CURA FLY **Plus:** Water	1 L 1-3 L

2.2.2.3.1.3 Bait stations and mass trapping

This approach to fruit fly control avoids the non-target effects caused by bait sprays. No pre-harvest interval is associated with bait stations and mass trapping.

M3 bait station

The M3 bait station was developed by CRI and Quest Developments. It has been used since 1999 and has the advantage that no insecticides are applied to the tree canopy. The bait station comprises a rigid holder that can be clipped onto a branch and an absorbent material containing protein hydrolysate (bait) and alpha-cypermethrin (insecticide) that is held in place by a plastic grid. Current recommendations are for 300 bait stations to be used per hectare in Valencias and grapefruit, 350/ha in navel oranges and 400/ha in easy-peeling cultivars. When using the M3 bait station for fruit fly control it is essential to hang the bait stations before the fruit become susceptible to fruit fly **(before colour break),** in order to lower the numbers in time. The label recommends a product longevity of four months. However, the attractiveness of the station was found to be significantly reduced after eight weeks. When using the M3 for fruit fly control, there may be a shutdown of Questlure baited Sensus traps since the same attractant is used in both M3 and Questlure. It is essential to hang the bait stations correctly so that the holder stays horizontal with the bait facing the ground in order to prevent the bait from leaching out.

Magnet™ Med

Magnet Med is a bait station which consists of a laminated folded cardboard which is coated with deltamethrin for killing targeted fruit fly pests. A Biolure® dispenser is fitted inside the folded cardboard as an attractant. The device is suspended from a branch using a hook provided. The number of devices recommended per ha varies between 50 and 75 depending on cultivar and pest pressure. Devices must be hung as high as possible on the north-facing side of the tree. The field longevity of the product is set at six months.

CeraTrap®

CeraTrap® is a mass trapping system for fruit fly pests of citrus. The CeraTrap® consists of a plastic container with lateral holes, which function as a fruit fly trap (CeraTrap® trap). The trap is filled with 600 ml of an enzymatically hydrolysed protein bait (CeraTrap® bait). The CeraTrap® bait does not contain insecticide. Flies attracted to the bait would enter the trap and drown in the bait. In citrus, CeraTrap® is registered at 100 traps per ha. The traps should be refilled every 8-10 weeks. Each trap should be refilled with CeraTrap® bait up to a maximum of 600 ml. Once total evaporation has occurred,

the trap must be refilled. Refilling interval is dependent on prevailing temperature, relative humidity and direct sunlight.

Beta P1 Fruit Fly Attractant

Beta P1 is a bait station that consists of a yellow plastic trap (Beta P1 trap), which is folded open into a delta shape and contains a bait (Beta P1 fruit fly attractant) inside a tray at the bottom of the trap. The Beta P1 fruit fly attractant contains a mixture of protein hydrolysate, imidacloprid and alpha-cypermethrin. Beta P1 traps are applied at 400 units per ha. The traps should be replaced every season.

2.2.2.3.2 Male Annihilation Technique (MAT)

Last Call FF

For Medfly and Natal fly, Last Call FF is available as a control product targeting males. Last call FF is produced by Insect Science SA and requires the application of droplets containing the attractant and insecticide to the tree. The product contains enriched ginger oil (EGO), a male attractant for a number of *Ceratitis* species including Medfly and Natal fly and a contact insecticide (permethrin) in a protective, slow-release, paste-like matrix. Small droplets are applied to a few leaves on each tree using a special applicator. The droplets are attractive to males of Medfly and Natal fly. When these flies come in contact with the droplet, they pick up enough of the insecticide to kill them. The dosage rate is 3000 droplets per hectare but care should be taken to avoid any contact with the fruit because permethrin residues are not permitted on citrus.

ME-based MAT

In areas where Oriental fruit fly is present, ME-based MAT should be applied in middle to late summer (either January or February depending on regions) as mentioned in 2.2.1.

For the Oriental fruit fly, a number of methods of MAT such as wooden fiber blocks impregnated with ME and malathion (e.g. Invader-b-Lok, blocks impregnated with Chempac ME liquid and malathion) and SPLAT technology containing ME and spinosad such as STATIC Spinosad ME are registered for control of the pest in South Africa. The application rates and methods of MAT products registered for control of Oriental fruit fly are provided below:

Product	Dose/ha	Application method
Invader-b-Lok	10-12 stations	Hang within tree canopy about 1.5 m above ground and evenly dispersed throughout treated area. Replace every 6 weeks.
Chempac ME lure **plus** malathion impregnated into fibre board blocks	4-9 blocks. Blocks impregnated with 3:1, Chempac ME liquid: Mercaptothion 500 EC	Place lure blocks at 2 m above ground. Replace blocks every 4 weeks.
STATIC Spinosad ME	248-500 ml	Apply as targeted spot applications to non-crop surfaces using a spatula or applicator. The distance between application spots varies from 4.6-18.3 m. Re-apply at 2-6 week intervals.

2.2.2.3.3. Pre-harvest intervals for fruit fly control products

Some fruit fly control spray products may not be applicable throughout the season. The pre-harvest intervals of the toxicants used in bait sprays are provided in the table below. Trichlorfon residues on fruit may not be tolerated

by some international retailers. Malathion residues might also be problematic for some EU retailers. As such, the specific requirements of the retailers would have to be checked before incorporating this product in the fruit fly programme.

Spray product	Pre-harvest interval/days (Applicable to specific export markets)
Mercaptothion/Malathion/ in fruit fly bait sprays	7 (EU*), 14 (Canada), 7 (CODEX A**, CODEX B***, USA, Japan). S. Korea & Switzerland : 28 d
Trichlorfon/Dipterex	28 (EU*, CODEX A**, Canada, USA & Japan), 10 (CODEX B***, USA). S. Korea : 10 d for soft citrus and 28 d for other citrus
Cyantraniliprole/Exirel (Ground-based application)	1 (EU*, CODEX B***, Canada, USA & Japan), Not later than 90% petal fall (CODEX A** & Taiwan).
GF-120 (Spinosad)	1 (all markets)

* European Union
** CODEX A applies to specific countries within Africa and Asia (such as People's Republic of China, Hong Kong)
*** CODEX B applies to specific countries within Africa, Asia, Middle East and other regions (such as Russian Federation and Georgia)