FRUITION®

FRUIT FLY MANAGEMENT SYSTEM

For the Monitoring & Management of Fruit Flies in Crops

Developed by AgNova Technologies Pty Ltd

Bactrocera dorsalis - Photograph by Scott Bauer, USDA

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FRUITION

SUMMARY

Tephritid fruit flies are major economic pests of crops worldwide and can cause extensive losses in many tropical, subtropical and temperate fruits and vegetables, including apples, citrus, cucurbits, guava, loquats, mangoes, peaches, plums, sapote, starfruit, and tomatoes.

The economic damage caused by pest fruit flies includes the direct losses in yield caused by infestation of marketable produce and costs of control, but also loss of access to lucrative export markets due to quarantine requirements.

The main species causing crop damage through South and South East Asia are *Bactrocera carambolae*, *B. correcta*, *B. cucurbitae*, *B. dorsalis*, *B. latifrons*, *B. tau* and *B. zonata*. Two of the most damaging pest fruit flies throughout South East Asia, South Asia, the Middle East, and North Africa are *B. dorsalis* and *B. zonata*.

Recent discussion in the scientific literature proposes that *B. dorsalis*, *B. invadens*, *B. papayae* and *B. philippinensis* be considered part of the *B. dorsalis* complex.

Adult fruit flies are generally 5-8 mm in length. Female fruit flies lay eggs in maturing fruit and the resulting larvae feed on the ripening fruit causing fruit decay, premature fruit drop in some cases, and damage to the fruit which makes it unmarketable. The majority of pest tephritid fruit flies are multivoltine (produce several generations per year) and polyphagous (feed on a wide range of foods).

The **Fruition® Fruit Fly Management System** consists of **Fruition Nova® Traps** (trap + attractant + fixing apparatus) and **Fruition Natflav® 500** bait (protein autolysate), and was launched commercially in Australia in 2016.

Fruition Nova Traps are a unique new system for monitoring and managing fruit fly populations in an IPM program, and were developed after many years of research at the International Centre for Management of Pest Fruit Flies at Griffith University in Queensland, Australia to specifically attract mature egg-laying female fruit flies through a unique combination of colour, shape and smell.

Fruition Natflav 500 is a premium protein autolysate fruit fly bait for use with suitable insecticides in 'attract and kill' systems.

The **Fruition Nova Trap** developed for use in Australia is a blue colour because Queensland fruit fly (*Bactrocera tryoni*), the major fruit fly pest in Eastern Australia, is preferentially attracted to this colour. Initial trial work in South and South East Asia, and previous work recorded in the scientific literature, indicates that the key pest species in these regions are preferentially attracted to yellow traps. AgNova is conducting trial work in the field to confirm that yellow traps will be preferred for development in South and South East Asia.

In all situations, begin the Fruition Fruit Fly Management System early in the crop, when fruit is hard, green and not yet susceptible to fruit fly attack. Fruition Nova Traps should be deployed early to detect initial fruit fly incursions. When mature egg-laying female fruit flies are detected in traps, additional traps need to be deployed (as per the directions for use table) and a program of protein bait spraying with Fruition Natflav 500 should be implemented, if not already underway. If numbers of mature egg-laying female fruit flies continue to increase following implementation of a program of Fruition Natflav 500 protein bait sprays and Fruition Nova Traps, cover spraying of an approved insecticide may be required.

* Fruition Nova Traps are known as Fruition Traps in Australia

THE MELON FLY* – *BACTROCERA CUCURBITAE*

B. cucurbitae, the melon fly, is considered to be native to India. It is now found in more than 40 countries around the world. The potential risk of its introduction to a new area is facilitated by an increase in international tourism and trade, and is influenced by changes in climate and land use. After introduction, it can easily disperse due to its high reproductive potential, high biotic potential (short life cycle of 3-5 weeks, up to 10 generations of offspring per year), and rapid dispersal ability.

The Asian range of *B. cucurbitae* represents its natural (native) range. In Hawaii it is known to be an introduction, having arrived there late in the 19th century.

Source: https://www.cabi.org/isc/datasheet/17683

In Africa, *B. cucurbitae* is found in several countries in East and West Africa, including Benin, Burkina Faso, Cameroon, Gambia, Guinea, Ivory Coast, Mali, Niger, Nigeria, Senegal and Togo in West Africa, and Kenya, Sudan, Tanzania and Uganda in East Africa.

B. cucurbitae is a very serious pest of cucurbit crops. Over 125 plants, including members of families other than Cucurbitaceae have been recorded as host plants, however, many of the records are based on casual observation of adults resting on plants or caught in traps set in non-host plants. In common with some other species of subgenus *Bactrocera (Zeugodacus)* it can attack flowers as well as fruit, and additionally, will sometimes attack stem and root tissue. In Hawaii, pumpkin and squash fields (varieties of *Cucurbita pepo*) have been known to be heavily attacked before fruit had even set, with eggs being laid into unopened male and female flowers, and larvae even developing successfully in the taproots, stems and leaf stalks

Primary hosts are species of Cucurbitacaeae (*Cucumis melo*: muskmelon, rock melon, honeydew melon; *Cucurbita maxima*: squash; *Cucurbita pepo*: winter squash, pumpkin; and *Trichosanthes cucumerina*: snake gourd). Secondary hosts are species of Cucurbitaceae and, rarely, species of other plant families.

Up to 40 eggs are laid below the skin of the host fruit. Female *B. cucurbitae* can lay more than 1000 eggs. Eggs hatch within 1-2 days and the larvae feed for another 4-17 days (longest in thick-skinned fruits such as pumpkin). Pupation occurs in the soil under the host plant for 7-13 days, but may be delayed for several weeks under cool conditions. Adults occur throughout the year and begin mating (at dusk) after about 10-12 days. Adult flies may live 5-15 months depending on temperature (longer in cool conditions). Adult flight and the transport of infected fruit are the major means of movement and dispersal to previously uninfected areas.

Adult male *B. cucurbitae* are attracted to cue lure.

* Note: Comments above regarding the Oriental Fruit Fly are sourced from http://www.cabi.org/isc/datasheet/17683

THE GUAVA FRUIT FLY* – *BACTROCERA CORRECTA*

B. correcta has been recorded in India from Pusa (Bihar), Coimbatore, Guindy and Tiruchirappalli (Tamil Nadu), Bangalore, Balechonnur, Bijapur, Hagari (Karnataka), South Gujarat, Bilaspur (Madya Pradesh), Haryana, Himachal Pradesh and Punjab. It has also been recorded in Thailand, Pakistan, Nepal and Sri Lanka. In India, *B. correcta* often occurs with serious pest species such as *B. zonata* and *B. dorsalis* and has been recorded as causing 60-80% fruit damage in Tamil Nadu, India.

The pre-oviposition, oviposition and post-oviposition periods of *B. correcta* have been recorded as 14.1, 13.7 and 27.2 days, respectively, at 30±2°C and 70% relative humidity. The incubation, larval and pupal periods have been recorded as 3.1, 19.0 and 7 days, respectively. The adult longevity is around 10 days.

Source: https://www.cabi.org/isc/datasheet/8703

Males are highly attracted to methyl eugenol. Yellow and orange coloured traps have been shown to attract more fruit flies, recording 4.18 and 4.34 numbers/day respectively, compared with green, red, white, violet and blue. Traps placed at heights of between 1.5 and 2.1 m caught the highest numbers of *B. correcta*. Traps placed at the border of orchards intercept invading adults.

* Note: Comments above regarding the Oriental Fruit Fly are sourced from http://www.cabi.org/isc/datasheet/8703

THE ORIENTAL FRUIT FLY* – *BACTROCERA DORSALIS*

One of the main pest fruit fly species across South and South East Asia is *Bactrocera dorsalis*, the Oriental fruit fly, sometimes known as the mango fruit fly. It is a native of Asia and has been recorded in 65 countries, including most Asian countries (Bangladesh, Bhutan, Cambodia, China, Hong Kong, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, Ogasawara Islands, Pakistan, the Philippines, Sri Lanka, Taiwan, Thailand and Vietnam), and sub-Saharan Africa.

Most fruit fly workers now consider that *B. invadens*, *B. papayae* and *B. philippinensis* are part of the *B. dorsalis* complex and can be considered synonymous with *B. dorsalis*. The map below shows the distribution of *B. dorsalis*:

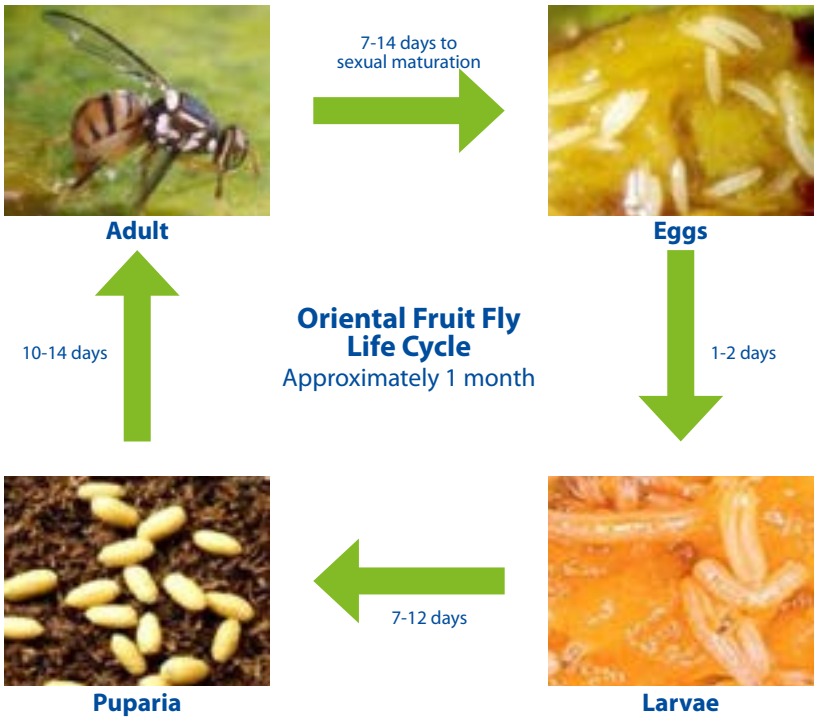
Source: https://www.cabi.org/isc/datasheet/17685

B. dorsalis is a very serious pest of a wide variety of fruits and vegetables throughout its geographic range and damage levels can be up to 100% of unprotected fruit. As a result of its widespread distribution, pest status, invasive ability and potential impact on market access, *B. dorsalis* is considered to be a major threat to many countries, requiring costly quarantine restrictions and eradication measures.

The eggs of *B. dorsalis* are laid below the skin of the host fruit and hatch within a day (this can be delayed up to 20 days in cool conditions) and the larvae feed for another 7-12 days (up to 35 days, depending on the season). Pupation occurs in the soil under the host plant for 10-14 days at 25°C and 80% RH, but may be delayed for up to 90 days under cool conditions. The adults occur throughout the year and begin mating approximately 7-14 days after emergence. Adults may live for approximately one month, depending on temperature (up to 12 months in cool conditions).

* Note: Comments above regarding the Oriental Fruit Fly are sourced from http://www.cabi.org/isc/datasheet/17685

The lifecycle of the Oriental fruit fly is shown below:



Under optimum conditions, female oriental fruit flies can lay more than 3000 eggs in their lifetime (average of 1200-1500) in ripening fruit.

Oriental fruit fly can complete a generation in about 30 days and can go through 10 generations per year. In tropical climates, many overlapping generations per year have been reported. Fruit fly abundance typically coincides with availability of ripening fruit, though they tend to be most common in summer and autumn.

Adult *B.dorsalis* can fly up to 50-100 km and have a broad host range: host plants include 478 types of fruit and vegetable (USDA, 2016), including apricots, avocados, bananas, citrus, coffee, figs, guavas, loquats, mangoes, papayas, passionfruit, peaches, pears, persimmons, pineapples, roseapples, surinam cherry, and tomatoes. Infestation levels of 50-80% have been recorded in untreated fruit crops in Pakistan. Oriental fruit fly is the main pest of mangoes in many countries, including the Philippines.

Because different host plants mature at different times of the year, it is important to be able to relate fruit fly activity with the growth stage of the plant. Generally, fruit is not attacked by fruit flies until it begins to mature. To ensure adequate protection of fruit, it is important to begin fruit fly control measures early, when fruit is at the hard green stage or earlier.

Where several different host crops with different fruiting times are being grown in close proximity to each other, it will be necessary to start trapping and baiting earlier than would otherwise be the case, as maturing fruit from one crop will attract mature egg-laying females into other crops. This is particularly relevant in a home garden situation where several different crops are grown at the same time.

THE PEACH FRUIT FLY* – *BACTROCERA ZONATA*

Native to South and South East Asia, *B. zonata* is now found in more than 20 countries and is widely distributed throughout India and Pakistan, the Middle East, and in North Africa (see map below). It is an important pest of apricots, citrus, eggplant, figs, guava, mango, and peaches, as well as many other fruits and vegetables. In Pakistan, it has been recorded as causing 25-50% crop losses in guava.

Source: https://www.cabi.org/isc/datasheet/17694

Adults of *B. zonata* rest on grasses, bushes and other dense foliage in the vicinity of host crops, and disperse from these refuges in the warmer parts of the day. *B. zonata* overwinters in the pupal stage, with adults emerging as temperatures rise in spring. Females lay 3-9 eggs at any one time into susceptible host fruits. *B. zonata* co-exist with *B. dorsalis* and infest common host plants. Adult peach fruit flies are strong fliers and are highly mobile, with extensive post-teneral dispersal flights, up to 40 km.

Female *B. zonata* produce about 130, and up to 550, eggs which are inserted into the host fruit and hatch within 1–3 days. The larvae feed for 1-2 weeks and drop to the ground, to pupate in the soil. They overwinter in the larval or pupal stages. The lowest temperature at which the fruit flies can complete their lifecycle is around 15°C, and the optimum is 25–30°C. Depending on the climate, peach fruit flies may raise several annual generations. They remain active throughout the year (except in mid-winter), and are strong fliers, a trait which increases dispersal and adds to their pest status.

* Note: Comments above regarding the Peach Fruit Fly are sourced from http://www.cabi.org/isc/datasheet/1794

IDENTIFYING MALE AND FEMALE FRUIT FLIES

It is important to be able to identify the difference between adult male and female fruit flies because they can appear in crops at different times to each other, and require different control strategies.

Both male and female fruit flies tend to be similar in size, around 5-8 mm long and reddish-brown in colour, with distinct yellow markings. The yellow markings are species-specific. The female has a sharp, retractable egg-laying organ (ovipositor) at the base of her abdomen. This is the organ which she uses to penetrate the surface of fruit and through which she lays her eggs into the flesh of the fruit.

Female *Bactrocera tryoni* – note the sharp, needle-like ovipositor at the end of the abdomen, compared to the male below.
(Photo courtesy of Ruben Bensley, International Centre for the Management of Pest Fruit Flies, Griffith University).

Male *Bactrocera tryoni* – the male is very similar in appearance to the female but has a rounded abdomen and no ovipositor.
(Photo courtesy of Ruben Bensley, International Centre for the Management of Pest Fruit Flies, Griffith University).

FRUITION NOVA TRAPS

Fruition Nova Traps are specifically designed to attract and trap mature egg-laying female fruit flies rather than males, which most other traps attract.

The development of the **Fruition Nova Trap** technology, based around attracting mature egg-laying female fruit flies, is a major step forward in fruit fly control. Previous traps have been based on chemicals such as cue-lure and methyl eugenol which act as attractants to male fruit flies but, of course, it is the mature egg-laying females which cause the damage to crops by laying their eggs in the fruit. While the trapping of male fruit flies can give an indication of population dynamics, it is only a proxy for the mature egg-laying female fruit fly population. **Fruition Nova Traps** are the first technology which allows direct measurement of numbers of mature egg-laying female fruit flies in crops.

Fruition Nova Traps can be used to monitor the development of fruit fly populations over time and, when the population reaches the economic threshold for pest control, can be combined with the use of **Fruition Natflav 500** protein bait sprays as the foundation of well-designed IPM programs for management of pest fruit flies.

Fruition Nova Traps consist of several components:

1. Plastic-coated tie for attaching the trap to trees
2. Metal clip to keep the trap shape stable
3. Coloured circular discs coated in glue which attract and trap adult fruit flies
4. Fruition gel lure, specifically formulated to attract sexually mature egg-laying females

HOW FRUITION NOVA TRAPS WORK

Fruition Nova Traps are a novel and effective tool for monitoring populations of mature egg-laying female fruit flies and, in conjunction with **Fruition Natflav 500** protein bait sprays, as a part of an IPM program to control fruit flies, by attracting and killing mature egg-laying female fruit flies.

Fruition Nova Traps specifically target mature egg-laying female fruit flies and are highly effective in attracting this segment of the population through a unique combination of colour, shape and smell. Extensive research has enabled scientists to determine the natural aromas from fruit that are most attractive to the mature egg-laying female fruit flies, as well as the specific colour and shape to which they are attracted. It is a selection of these aromas, in combination with the most attractive colour to fruit flies, which have been developed for use in the **Fruition Nova Trap**.

In Australia, a blue trap is the most attractive colour for Queensland fruit flies (*Bactrocera tryoni*). Preliminary work conducted in South and South East Asia indicates that the best colour for use in the region will be yellow. These findings are supported by the scientific literature.

Mature egg-laying female fruit flies are drawn to the vicinity of the trap using aromas that mimic those of ripe fruit. Once in visual range, the flies are able to detect the colour and shape of the trap structure, to which they are attracted. When the flies contact the discs of the **Fruition Nova Trap**, they are entangled by the glue on the discs so that they can be identified easily.

It is important to note that the **Fruition Nova Trap** is not designed to lure male or immature female fruit flies. However, numbers of these will still be caught on traps as they will be attracted to the colour of the **Fruition Nova Trap**.

As soon as fruit flies are detected on the traps, farmers should implement a full IPM program (see below) as capture of mature egg-laying females on the traps indicates that fruit is susceptible to attack.

WHEN TO USE FRUITION NOVA TRAPS

Fruition Nova Traps can be used for both fruit fly population monitoring and for trapping as part of a fruit fly IPM control program, when susceptible crops are fruiting.

Traps should be inspected regularly, preferably daily, so that trapped flies can be counted, recorded and removed to allow monitoring of population dynamics.

The attractant lure in the plastic sachet is effective for at least 8 weeks. As the gel ages, the colour of the gel will turn from blue to very pale blue-white, but the attractant lure remains active for at least 8 weeks.

The use of **Fruition Nova Traps** alone will not adequately control fruit fly as populations develop through the season, and additional control methods will be required. When fruit fly intensity is expected to be high e.g. the previous year's crop was heavily stung, the orchard is within 5 km of rainforest, is close to residential premises with home garden plants susceptible to fruit fly infestation, or it is a particularly susceptible crop (tomato, stone fruit, mango, vegetables), additional products or control strategies, such as baiting or cover spraying with an insecticide registered for this use, will need to be used in combination with **Fruition Nova Traps**.

WHERE TO PLACE FRUITION NOVA TRAPS

Fruition Nova Traps should be placed evenly around and throughout the site. Traps should be set in host plants in the fruiting zone to attract flies away from fruit and to the trap, usually 1.5 to 2 metres above the ground for tree crops. Ideally traps will be in the tree canopy in a location away from surrounding branches and clearly visible within the orchard. They should be out of direct sunlight but within foliage where they can receive broken sunlight. Intense, direct sunlight will accelerate the breakdown of the chemical attractant and the trap generally.

The photographs above show good trap placement in tree canopies (blue trap) and in vegetable crops (yellow trap).

In vegetable crops, traps should be hung immediately above the crop or adjacent to crop rows suspended from a rigid support such as a steel or wooden stake (see photograph right). Ideally neighbouring crops will also be monitored as these can be a significant source of fruit fly populations.

FEATURES AND BENEFITS OF FRUITION NOVA TRAPS

Fruition Nova Traps:

- Are effective in trapping mature egg-laying female fruit flies;
- Selectively attract mature egg-laying female fruit flies – the segment of the population which is capable of directly causing fruit damage;
- Allow for accurate detection & identification of trapped fruit flies;
- Are safe & easy to transport;
- Are simple to assemble & hang within the crop;
- Leave no pesticide residues;
- Are effective throughout the growing season regardless of climatic conditions;
- Are excellent for inclusion in, and as the basis of, an Integrated Pest Management (IPM) program;
- Are safe to beneficials - trial work carried out to date has shown that beneficial species are not attracted to **Fruition Nova Traps.**

BENEFICIAL SPECIES

Trial work carried out to date has shown that beneficial species are not attracted to **Fruition Nova Traps.** Insects other than fruit flies may be found stuck to **Fruition Nova Traps** – this is because they have contacted the sticky surface of the trap by accident, not because they are attracted to the traps.

CROP SAFETY

Fruition Nova Traps have no associated crop safety issues when used according to the label.

FRUITION NOVA TRAPS AND THE APPLICATION OF PROTEIN BAIT SPRAYS

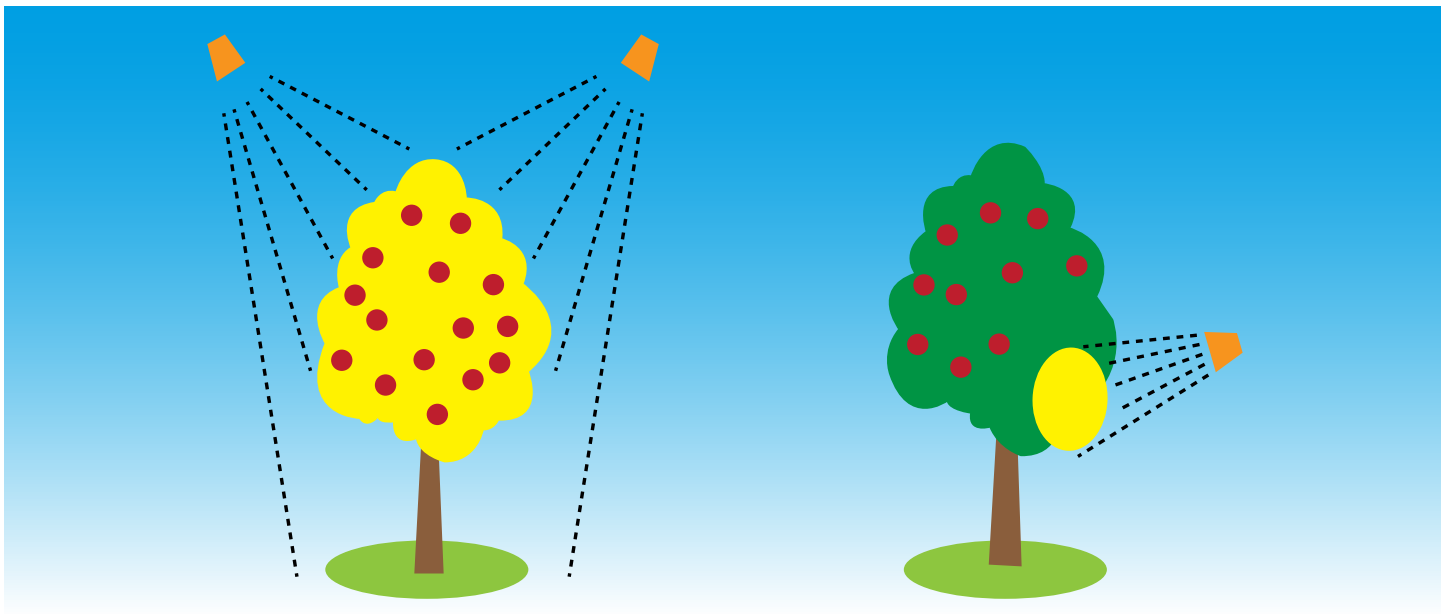
As soon as fruit flies are detected on **Fruition Nova Traps**, or when fruit reaches the hard green stage, commence applications of **Fruition Natflav 500**, a premium quality protein (yeast autolysate) bait, mixed in gelatinised water. Apply in combination with an insecticide registered for this use, if this has not already begun, and reapply at least every 7 days (check the label of the insecticide used and comply with label directions). The addition of a gel thickening agent to the water significantly improves the initial effectiveness of protein bait sprays, as well as enhancing their residual effect.

- In all situations, begin protein bait spraying early, before fruit become susceptible to fruit fly infestation, and complement protein bait spraying with use of **Fruition Nova Traps** to allow monitoring of fruit fly population dynamics. If numbers of mature egg-laying female fruit flies continue to increase following implementation of a program of gelatinised **Fruition Natflav 500** protein bait sprays and **Fruition Nova Traps**, cover spraying of an approved insecticide may be required;
- When applied correctly, gelatinised **Fruition Natflav 500** protein bait sprays will attract and kill immature fruit flies seeking a source of protein to develop their eggs, and also male flies;
- Repeat applications according to the **Fruition Natflav 500** bait label and insecticide label directions. Application frequency may need to be increased in wet weather, and when fruit reaches maturity as it becomes more susceptible to fruit flies prior to harvest;
- The best protein product to use in conjunction with **Fruition Nova Traps** is **Fruition Natflav 500**.

Continue monitoring for the presence of fruit flies until immediately after final harvest.

APPLICATION OF BAIT SPRAYS TO CROPS:

Bait sprays mixed with an insecticide registered for this use are usually spot-sprayed, using a jetstream nozzle, weekly onto the foliage of host trees. Adult flies are attracted to the bait droplets as a food source and are killed by the insecticide.



Difference in spray patterns when applying cover sprays (on the left) vs bait spraying (on the right) where bait sprays are directed to the lower portion of the foliage on trees. (Diagram courtesy of Robyn Barnes)

In vegetable crops, because the mixture of **Fruition Natflav 500** + approved insecticide cannot be easily applied directly to the crop, the spray must be applied to the vegetation at the perimeter of the crop. This is effective as the perimeter vegetation is where fruit flies are most likely to feed, rest and search for mates. Research work has shown that some fruit flies are attracted to plants such as corn which can be planted as trap crops around vegetable plots. These trap crops can then be sprayed with insecticide and/or bait sprays to kill fruit flies which spend time in these crops.

Baits are much more effective when applied to vegetation rather than inert surfaces such as posts or wooden boards. In tree crops, application of bait sprays to tree trunks or vegetation at the base of the tree will not give effective control of fruit flies.

For best results, commence bait spray programs early, before the pest population builds up. Apply weekly or, if rainfall washes the bait off the foliage, reapply immediately and resume the weekly schedule.

FRUITION NATFLAV 500

Fruition Natflav 500 is a premium quality protein autolysate yeast bait specifically designed to attract and, with the addition of an insecticide which is approved for this use, such as maldison, clothianidin or abamectin, kill male and immature female fruit flies. Mortality rates can be increased significantly by mixing a gelatinising agent such as xanthan gum to the **Fruition Natflav 500** + insecticide mixture:

TREATMENT	% MORTALITY		
	2 HRS	3 DAYS	6 DAYS
0.005% INSECTICIDE A + 5% **Fruition Natflav 500**	37	21	18
0.005% INSECTICIDE A + 5% **Fruition Natflav 500** + **0.5% XANTHAN**	**95**	**88**	**92**
0.005% INSECTICIDE B + 5% **Fruition Natflav 500**	39	6	4
0.005% INSECTICIDE B + 5% **Fruition Natflav 500** + **0.5% XANTHAN**	**98**	**94**	**89**

In all situations, begin protein bait spraying early, before fruit becomes susceptible to fruit fly infestation, and complement protein bait spraying with use of **Fruition Nova Traps** to allow monitoring of fruit fly population dynamics. If numbers of mature egg-laying female fruit flies continue to increase following implementation of a program of **Fruition Natflav 500** protein bait sprays and **Fruition Nova Traps**, cover spraying of an approved insecticide may be required.

Xanthan gum is a critical part of the protein bait spray. As can be seen from the table above, the addition of xanthan gum to the spray mix increases significantly the efficacy of the mix against fruit flies. It is believed that the xanthan gum, as a gelatinising agent, increases the weathering ability of the protein bait droplets on the crop foliage, increasing short term and long term mortality.

Fruit fly feeding on protein bait droplet (photo courtesy of: https://www.agric.wa.gov.au/sites/gateway/files/3_FruitFlyFeedingOnProtein120618b.jpg)

USE OF THE FRUITION FRUIT FLY MANAGEMENT SYSTEM IN MANGOES

Mangoes are grown in over 100 countries around the world, with annual global production of around 40 million tonnes. The major producing countries are India, China, Mexico, Thailand, Indonesia, Pakistan, the Philippines, Nigeria, Brazil, Peru, Australia, South Africa, Malaysia and Venezuela. There are many mango varieties grown around the world: India alone has nearly 1,300 varieties (20 grown commercially) and Thailand has about 100 varieties.

In India, the mango harvest season is April to July, with many varieties maturing sequentially over this period. The harvesting season continues for 8-10 months a year in Brazil, Columbia, Kenya and Venezuela and is also long in Burkina Faso, Costa Rica, Indonesia, Jamaica, Mexico, Nicaragua, and Puerto Rico. This pattern of having varieties mature sequentially over a long period of time is ideal for building and maintaining fruit fly populations.

Fruit flies are a major pest of mangoes, restricting local production levels, reducing export opportunities and limiting global trade. In India, it is estimated that fruit flies account for around 27% losses in mangoes, and in Pakistan, estimates are around 12-35% (up to 80% in severe infestations). It is not unusual for importing countries or regions to halt imports of mangoes mid-season from producing countries when shipments are found to contain fruit flies.

Programs for management of fruit flies in mangoes should consist of a number of different strategies combined into an Integrated Pest Management (IPM) program:

1. Use of **Fruition Nova Traps** deployed as fruit is developing to monitor for the presence of fruit flies in the orchard;
2. When fruit flies are caught on **Fruition Nova Traps**, increase the number of traps from 15 per hectare to 30-50 per hectare depending on fruit fly pressure and on the susceptibility of the mango variety to fruit fly attack;
3. Protein bait sprays applied to the foliage of mango trees, initiated as fruit is developing, and applied on a 7-day schedule;
4. Cover sprays using an approved insecticide prior to harvest;
5. Orchard hygiene – removal of fallen fruit on a regular basis. Fallen fruit should be buried in pits at least 60 cm deep to prevent adult flies emerging after pupating in the soil.

LURES FOR MALE FRUIT FLIES*

FRUITION

It has been known for over 100 years that there are a number of chemical lures which selectively attract male fruit flies. Males of many species are attracted to methyl eugenol, some are attracted to cue lure, and some are attracted to different, specific lures. Male lures are used widely to trap male fruit flies for monitoring of populations and, in some case, as a strategy in IPM programs to attract and kill this segment of the population through the use of traps baited with male lures and insecticides.

Flies of the genus *Bactrocera* can be categorised into three groups: cue lure responders (around 200 species), methyl eugenol responders (81 species), and those that do not respond to either cue lure or methyl eugenol (approximately 15 species). There are no species which respond to *both* cue lure and methyl eugenol.

Cue lure is a synthetic chemical first synthesised in 1960 and shown at that time to be a powerful attractant to male fruit flies of some *Bactrocera* species. Cue lure has not been isolated from natural sources but is hydrolysed to raspberry ketone, a naturally occurring product which is also highly attractive to male fruit flies of some *Bactrocera* species. Raspberry ketone occurs widely in nature and is a less powerful attractant than cue lure due to the higher volatility of cue lure.

Methyl eugenol is the most powerful male lure currently used, and occurs naturally in over 450 plant species. It is used in detection, control and eradication programs for fruit flies which are attracted to it.

Two other chemicals, Latilure and zingerone, have been demonstrated to attract male fruit flies of some species of the *Bactrocera* genus:

Latilure (α-ionol) specifically attracts *B. latifrons* (the solanum fruit fly), an economically important pest species which is not attracted to either cue lure or methyl eugenol.

Zingerone, a chemical which occurs naturally in ginger, and in the flowers of some orchids, has been shown to attract males of some cue lure- and methyl eugenol-responsive fruit fly species (such as *B. cucurbitae* and *B. dorsalis*) although the level of attraction is quite weak compared to cue lure and methyl eugenol. However, with *B. jarvisi* the level of attraction of zingerone appears to be very much stronger that for cue lure or methyl eugenol.

SPECIES	COMMON NAME	CUE LURE	METHYL EUGENOL	OTHER LURE
B. carambolae	Carambola fruit fly		+	
B. correcta	Guava fruit fly		+	
B. cucurbitae	Melon fly	+		
B. dorsalis	Oriental fruit fly		+	
B. latifrons	Solanum fruit fly			Latilure
B. tau	Pumpkin fly	+		
B. zonata	Peach fruit fly		+	

(Source: Drew & Romig, 2016)

GLOSSARY

Attract and Kill – baiting techniques which utilise an attractant to lure insects to a bait which contains insecticide, such as **Fruition Natflav 500** + maldison applied to trees to attract and kill immature male and female fruit flies.

Bait – an attractant and food source such as **Fruition Natflav 500** (generally mixed with an insecticide – see 'attract and kill' technique) for treating fruit fly infested areas.

Beneficial organisms – birds, parasites, nematodes or other organisms which aid in controlling pest species.

Cue-lure – a chemical which attracts male fruit flies of some species.

Cover spray – thorough spraying of the entire plant with a registered insecticide for the control of fruit fly.

Development – growth through life stages or life cycle. Fruit flies have 4 growth stages: egg, larva, pupa and adult.

Fruition Natflav 500 – a premium quality protein autolysate yeast bait specifically designed to attract and, when mixed with insecticide, kill fruit flies. It is a key part of the Fruition Fruit Fly Management System.

Generation – the period of time it takes to complete all stages of development, including the pre-oviposition period.

Host plant – a plant which provides food for larval growth.

Hygiene – removal or mulching of fallen fruit and postharvest picking of unharvested fruit to reduce carryover pest populations of fruit flies.

Infestation – presence of fruit fly in a host plant.

Integrated Pest Management – control strategies which integrate cultural, biological and chemical techniques to manage pest populations to levels below economic thresholds.

Larva – maggot; juvenile stage of fruit fly development in infested fruit.

Methyl eugenol – a chemical which attracts male fruit flies of some species.

Multivoltine – having many generations in a year or season.

Ovipositor – egg-laying tube.

Polyphagous – feeding on or utilising many food sources.

Post-teneral – Adult fruit fly stage immediately after emergence from the puparium and after the exoskeleton has hardened.

Pre-oviposition period – time period after adult females emerge from pupation but before they are capable of laying fertilised eggs.

Protein hydrolysate – extracts of yeasts or grains such as **Fruition Natflav 500** which can act as broad-spectrum food attractants for male and female fruit flies.

Protein bait – see Protein hydrolysate.

Pupa – transformation stage of fruit fly development where the insect passes from the larval stage to the adult stage in the soil.

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FRUITION TRAP LABEL - AUSTRALIA

Fruition Nova Traps are a unique new system for monitoring and, in conjunction with other control strategies, managing fruit fly populations, and were developed specifically to target mature egg-laying female Queensland fruit flies.

Fruition Nova Traps are highly effective in attracting mature egg-laying female Queensland fruit fly (*Bactrocera tryoni*) through a unique combination of colour, shape and smell.

Mature egg-laying female Queensland fruit flies are drawn to the vicinity of the trap using aromas that resemble those of ripe fruit, and once in visual range, are able to detect the colour and shape of the trap structure. A sticky surface then traps flies in such a way that they can be easily identified and counted.
As soon as fruit flies are detected, growers should implement a full Integrated Pest Management (IPM) control program if not already commenced.

HOW TO USE FRUITION NOVA TRAPS

Fruition Nova Traps can be used for both population monitoring and, in conjunction with other control strategies, for control of mature egg-laying female Queensland fruit flies as part of an IPM control program, when susceptible crops are fruiting. It is important to deploy Fruition Nova Traps early in the crop for early detection and hence optimal management of fruit fly populations.

In all situations, begin protein bait spraying early, before fruit become susceptible to fruit fly infestation, and complement protein bait spraying with use of Fruition Nova Traps to allow monitoring of fruit fly population dynamics. If numbers of mature egg-laying female fruit flies detected on Fruition Nova Traps continue to increase following implementation of a program of **Fruition Natflav 500** protein bait sprays and Fruition Traps, cover spraying of an approved insecticide may be required.

DIRECTIONS FOR USE:

PEST	SITUATION	TRAPS/HA	CRITICAL COMMENTS
Queensland fruit fly (*Bactrocera tryoni*)	Monitoring fruit fly populations	15 traps/ha	Fruition Nova Traps are suitable for all crops where there is a need to monitor for the presence of mature egg-laying female fruit flies before crop damage occurs. For optimal management of fruit fly populations use of Fruition Nova Traps for monitoring should commence well before the fruit becomes attractive to mature egg-laying female fruit flies i.e. from the early stages of fruit set, when fruit is still hard and green. Ideally neighbouring crops will also be monitored as these can be a source of fruit fly populations. Read section on PLACEMENT OF FRUITION NOVA TRAPS below. Fruition Nova Traps should be monitored daily, with trap catches recorded and records maintained for each monitoring event. **As soon as fruit flies are detected on Fruition Nova Traps a full IPM control program (as below) should be implemented to optimise fruit fly management for the season. This should include protein bait spraying with Fruition Natflav® 500 if this has not already begun.**
	Implementing a full fruit fly IPM program		Efficacy of a fruit fly control program is dependent on a range of factors including pest pressure during the season. For effective management of fruit fly, Fruition Nova Traps should be used as part of a broader strategic control program, involving other approved products and strategies approved for the control of fruit fly. A fundamental part of any IPM program is practicing good crop hygiene, including removal of fallen fruit which may be infested with fruit fly larvae.
		15 – 30 traps/ha	Low susceptibility crops
		30 – 50 traps/ha	Moderate – High susceptibility crops
			Fruition Nova Trap numbers may need to be greater than the minimum stated above based on a range of factors, including numbers of fruit flies trapped during the monitoring phase, crop history and susceptibility, crop canopy, size and density, crop value, surrounding crop type and maturity stage, seasonal conditions, etc. If a protein baiting program has not already started, commence applications of gelatinised **Fruition Natflav 500** according to the label and reapply at least every 7 days. A registered insecticide must be included with **Fruition Natflav 500** according to the insecticide label. Continue to monitor and record trap catches until immediately after final harvest to ensure that the control program is adequate. If trapped fruit fly numbers on Fruition Nova Traps indicate high or erratic pest pressure as fruit develops and becomes more susceptible to fruit fly, additional fruit fly control measures may need to be implemented, such as insecticide cover sprays where product registrations and permits allow. Typically, an effective IPM control program will result in the number of freshly trapped fruit flies declining over time.

PLACEMENT OF FRUITION NOVA TRAPS

Fruition Nova Traps should be placed evenly around and throughout the site.

TREE CROPS: Fruition Nova Traps should be hung in the fruit zone, usually 1.5 to 2 metres above the ground. Ideally traps will be in the tree canopy in a location away from surrounding branches and clearly visible within the orchard.

OTHER CROPS: Fruition Nova Traps should be hung immediately above the crop canopy (around 0.5 metres), suspended from a firmly anchored rigid support such as a 'star picket' driven into the ground, and in adjacent trees or vegetation within 5 metres from the crop where the traps can intercept mature egg-laying female fruit flies flying into the crop to lay eggs.

Ideally neighbouring crops will also be monitored as these can be a source of fruit fly populations.

Fruition Nova TrapS SHOULD BE REPLACED IF:

1. Sticky surfaces are heavily covered by fruit flies or foreign objects;
2. The lure sachet has expired – the Fruition Nova Trap gel lure in the open sachet will continue to be effective for at least 8 weeks, at which time the Fruition Nova Trap and lure should be replaced. The attractant gel will gradually change colour from blue to very pale blue or white.; or
3. The lure sachet or trap is damaged or missing.

FRUITION NATFLAV 500 LABEL - AUSTRALIA

Fruition® Natflav® 500 is a premium quality yeast bait for use as an attractant in a baiting mixture with any insecticide approved for this use. The gelatinised baiting mixture is used in a baiting program for newly emerged and immature fruit flies.
When used in conjunction with Fruition® Traps according to that product label, **Fruition Natflav 500** in a gelatinised baiting mixture can form part of an IPM control program for fruit flies.
Efficacy of a fruit fly control program is dependent on a range of factors including fruit fly numbers, crop history and susceptibility, crop canopy, size and density, crop value, surrounding crop type and maturity stage, seasonal conditions, etc.
For effective management of fruit fly, **Fruition Natflav 500** should be used as part of a broader strategic control program. This should involve other products approved for the control of fruit flies, including Fruition Nova Traps which will attract and trap mature egg-laying female Queensland fruit flies.
In all situations begin protein bait spraying early, before fruit become susceptible to fruit fly infestation, and complement protein bait spraying with use of Fruition Nova Traps to allow monitoring of fruit fly population dynamics. If numbers of mature egg-laying female fruit flies continue to increase following implementation of a program of **Fruition Natflav 500** protein bait sprays and Fruition Nova Traps, cover spraying of an approved insecticide may be required.

DIRECTIONS FOR USE:
USE IN COMBINATION WITH AN INSECTICIDE APPROVED FOR THIS USE AS PART OF AN IPM PROGRAM FOR CONTROL OF FRUIT FLIES.

SITUATION	PEST	RATE	CRITICAL COMMENTS
Crops susceptible to fruit fly attack	For example: Queensland fruit fly (*Bactrocera tryoni*), Lesser Queensland fruit fly (*Bactrocera neohumeralis*), Jarvis' fly (*Bactrocera jarvisi*), Cucumber fly (*Bactrocera cucumis*)	**Fruition Natflav 500**: 2-6 L/100 L gelatinised water, PLUS Recommended rate of approved insecticide	The following recommendations are provided as a general guide. Always adhere to the approved insecticide label for specific directions for use. Yeast autolysate protein products can cause crop phytotoxicity. Always adhere to the approved insecticide label directions to reduce the risk of crop phytotoxicity. Follow the withholding period provided on the label of the insecticide being used. Protein bait sprays attract and kill immature male and female fruit flies both of which require protein to reach sexual maturity. Higher use rates of **Fruition Natflav 500** will increase bait attractiveness. Apply 50-100 mL of gelatinised **Fruition Natflav 500** plus insecticide baiting mixture per tree as a coarse spray. For optimal control of fruit flies, gelatinised **Fruition Natflav 500** plus insecticide bait applications should commence well before the fruit becomes attractive to mature egg-laying female fruit flies i.e., from the early stages of fruit set, when fruit is still hard and green. **Fruition Natflav 500** must ALWAYS be applied using gelatinised water for maximum efficacy and increased bait resistance to weathering. Repeat applications as per the instructions on the label of the insecticide being mixed with **Fruition Natflav 500**, and at least every 7 days. Rainfall will wash the baiting mixture off the crop: it will be necessary to reapply the baiting mixture following rainfall. Avoid application of the baiting mixture to fruit or other edible commodities.
Citrus			Critical comments as above for crops susceptible to fruit fly attack. Apply as above OR at 15-20 L/ha total volume as a 30 cm band at skirt level of trees for area wide control.
Vegetables and berry crops			Critical comments as above for crops susceptible to fruit fly attack. Do not apply directly to crop. Spray perimeter vegetation around the outside of the crop. Where Queensland fruit fly is specifically being targeted apply the spray at a height of 1.5-2 m onto the perimeter vegetation; where cucumber fly is being targeted, apply the spray at a height of 0.5-1 m onto the perimeter vegetation.
Crops susceptible to fruit fly attack	Mediterranean fruit fly (*Ceratitis capitata*)		The following recommendations are provided as a general guide. Always adhere to the approved insecticide label for specific directions for use. Yeast autolysate protein products can cause crop phytotoxicity. Always adhere to the approved insecticide label directions to reduce the risk of crop phytotoxicity. Follow the withholding period provided on the label of the insecticide being used. Protein bait sprays attract and kill immature male and female fruit flies both of which require protein to reach sexual maturity. Commence weekly bait spraying when fruit is half size. Where Mediterranean fruit fly pressure is expected to be high, begin bait spraying at fruit set. SPOT APPLICATION: Apply 50-100 mL of bait mixture in coarse droplets (4-6 mm in size) to foliage. Apply to every tree in a row; alternate the sides treated at each application. BAND SPRAY: Apply as a band spray to each tree in a row or, with a spray rig set up to spray both sides of a row, travel up and down every second row so that trees are not being double sprayed. It is recommended to continue bait spray applications for at least 4 weeks after harvest to ensure that flies emerging from the soil are controlled. Continue treating any citrus trees while fruit remains on other trees as citrus are favoured resting places for Mediterranean fruit fly. Bait spraying in Autumn is recommended as Mediterranean fruit flies present at this time are the source of infestation in the following spring.

PREPARATION
The day prior to spraying the baiting mixture prepare gelatinised water by adding Fruition Xanthan Gum powder to water at a rate of 5 g/L and agitating thoroughly.

On the day of application, mix the gelatinised water thoroughly until a uniform consistency is achieved. Prepare the baiting mixture by adding **Fruition Natflav 500** at a rate of 2 to 6 L/100L of gelatinised water in combination with HY-MAL® INSECTICIDE or an alternative insecticide approved for this use according to the DIRECTIONS FOR USE table on the insecticide label.

Agitation should be maintained throughout the mixing process and until application is completed. Only prepare enough baiting mixture for use on the day of application.

FRUITION NATFLAV 500: WHAT IS AN 'AUTOLYSED YEAST BAIT'?

There are two main types of protein bait sprays used in fruit fly control: acid hydrolysates and yeast autolysates. Acid hydrolysates generally have a high salt content as a result of their production process and have been largely replaced by yeast autolysate-based baits.

Autolysed yeast baits (yeast autolysates) such as **Fruition Natflav 500** are produced by heating then cooling live yeast solutions. This causes the digestion of the proteins in the yeast by enzymes which are also contained in the yeast, giving a product which is lower in salt than acid hydrolysates.

FRUITION FRUIT FLY MANAGEMENT SYSTEM – FREQUENTLY ASKED QUESTIONS

FRUITION NOVA TRAPS

How do Fruition Nova Traps differ from other traps on the market?
Fruition Nova Traps are the only traps on the market which specifically attract and trap mature egg-laying female fruit flies. The other traps on the market use one of the male lures such as cue-lure, methyl eugenol, trimedlure or zingerone to attract mature male fruit flies, or protein baits to attract immature male and immature female fruit flies.

Why do other traps catch more fruit flies than the Fruition Nova Traps?
As discussed in the point above, different traps attract and catch different segments of fruit fly populations.

Traps based on male lures only trap mature male fruit flies of a specific species, but the lures are very powerful and the traps can attract male fruit flies over long distances, sometimes up to 300-400 metres. Traps placed in an orchard can attract male fruit flies from surrounding scrub land or surrounding crops so, even though they trap many male flies, they are not giving a true indication of the fruit fly pressure in the crop.

Protein bait traps attract both immature male and immature female fruit flies, and attract many different species of fruit flies, some of which are not pests of agricultural crops. So, although these traps attract and kill large numbers of immature fruit flies, not all of the flies caught have the potential to damage the crop.

Fruition Nova Traps attract mature egg-laying female fruit flies – the segment of the population with the immediate potential to cause significant crop damage – so while the numbers trapped may be less than numbers caught in other traps, the **Fruition Nova Traps** are selectively trapping the portion of the population which has the capacity to cause economic damage by laying eggs in the crop. This can be explained as follows:

In any given population of fruit flies in a crop, 50% will be males and 50% will be females. Generally, 80% of the females will be immature, and the remaining 20% will be sexually mature and capable of laying eggs. Traps based on male lures will be attractive to 50% of the population, protein bait traps will be attractive to 80% of the population (+ non-pest fruit flies which are in the area), and **Fruition Nova Traps** are attractive to the 20% of the fruit fly population, all of which have the capacity to cause significant crop damage.

When do I start hanging traps in my crop to monitor fruit fly populations?
Fruition Nova Traps should be deployed before the fruit becomes attractive to fruit flies for egg laying. This is early in the fruit development process when fruit is still hard and green, before it starts to ripen.

What trees do I hang the Fruition Nova Traps in?
Fruition Nova Traps should be hung in trees in the orchard, not outside the orchard, so that they are spaced evenly throughout the orchard. The traps should be hung at a height of between 1.5-2.0 metres above the ground, and in fruit-bearing trees.

Do I hang Fruition Nova Traps in the shade or sun?
Fruition Nova Traps should be hung on the outside of the canopy, but so that they are in semi-shade and not totally exposed to the sun.

When is the best time to hang Fruition Nova Traps?
There is no preferred time of day to hang traps.

With regard to stage of crop development, **Fruition Nova Traps** need to be deployed in the crop well before fruit starts to mature, and well before the fruit becomes attractive to mature egg-laying female fruit flies.

Are some crops more susceptible to fruit fly attack than others?
Crops vary widely in their susceptibility to fruit fly attack, and this variability may even exist within the one crop when grown in different regions.
As a general rule, the following applies:
- High susceptibility: stone fruits, feijoa, pome fruits, zucchini;
- Moderate susceptibility: some citrus, strawberries, mango;
- Low susceptibility: some citrus, grapes.

Over what distance will flies be attracted to the Fruition Nova Traps?
Empirical evidence suggests that the lure works to attract mature egg-laying female fruit flies over relatively short distances – the lure will attract flies which are in the orchard. It will not attract flies over long distances or from outside an orchard.

What is the shelf life of lures in traps?
The lure sachets have an indefinite shelf life as long as they are kept in a cool place and they are not exposed to sunlight or UV light.

Is the lure still attractive when it loses colour?
The lure remains attractive for at least 8 weeks regardless of the colour of the gel.

How long does the lure last for?
The lure remains attractive for at least 8 weeks regardless of the colour of the gel.

Where do I find instructions on how to assemble the trap correctly?
The instructions for assembling the **Fruition Nova Trap** is on the label which is in the box containing the traps. There is also a copy of the label and instructions on the AgNova website.

How tightly do I attach the wire tie to the branch of a tree or stake?
The wire tie should be tied tightly around branches of trees and stakes so as to minimise movement and hence reduce stress on the tie itself.

What is a mature egg-laying female fruit fly?
Adult females, after emerging from pupation, feed for up to 2 weeks on protein and sugars before mating and laying eggs. This stage is called a pre-oviposition stage following which the females mate and become mature egg-laying females. They then infest fruit and vegetable commodities by depositing groups of up to 10–12 eggs below the surface of the host fruit via their ovipositor. A single female fruit fly can lay 300–1000 eggs over a six-month period.

FRUITION NATFLAV 500

Are mature egg-laying female fruit flies attracted to protein baits?
Once female fruit flies reach sexual maturity they do not require protein, so they are not strongly attracted to protein baits. The advantage of **Fruition Natflav 500** is that it attracts immature male and immature female fruit flies.

When should I start spraying Fruition Natflav 500?
Spraying of **Fruition Natflav 500** should begin when the fruit is still green and hard, before it starts to ripen, and before fruit fly attack would normally be expected.

Does Fruition Natflav 500 cause phytotoxicity?
Fruition Natflav 500 in mixtures with insecticides approved for use in protein bait sprays can cause phytotoxicity to some crops. **Fruition Natflav 500** should not be applied directly to fruit or vegetables but should be directed to the foliage of target crops.

How do I apply Fruition Natflav 500?
For fruit trees apply 50-100 mL of gelatinised **Fruition Natflav 500** + insecticide mix per tree as a coarse spray. In vegetable crops this mixture should be applied to plants on the perimeter of the target crop.

ALWAYS follow the DIRECTIONS FOR USE stated on the label of the insecticide being used in the bait spray mixture.

For optimal control of fruit flies, gelatinised **Fruition Natflav 500** + insecticide bait applications should commence well before the fruit becomes attractive to mature egg-laying female fruit flies i.e. from the early stages of fruit set, when fruit is still hard and green.

Fruition Natflav 500 must ALWAYS be applied using gelatinised water for maximum efficacy and increased bait resistance to weathering.

What does the name NATFLAV stand for?
Natflav is an abbreviation of 'natural flavours'. The '500' stands for the concentration factor in the product.

XANTHAN GUM

Why do I need to mix this in?

Xanthan gum increases the activity of **Fruition Natflav 500** + insecticide dramatically. Trial work conducted recently in Australia demonstrates the effect of adding xanthan gum to Fruition Natflav + insecticide mixtures and confirms earlier work:

TREATMENT	% MORTALITY		
	2 HRS	3 DAYS	6 DAYS
0.005% INSECTICIDE A + 5% **Fruition Natflav 500**	37	21	18
0.005% INSECTICIDE A + 5% **Fruition Natflav 500** + **0.5% XANTHAN**	**95**	**88**	**92**
0.005% INSECTICIDE B + 5% **Fruition Natflav 500**	39	6	4
0.005% INSECTICIDE B + 5% **Fruition Natflav 500** + **0.5% XANTHAN**	**98**	**94**	**89**

ABOUT AGNOVA

AgNova Technologies Pty Ltd is an Australian company that sources, develops and distributes specialty crop protection and production solutions for agricultural and horticultural producers. AgNova markets a wide range of specialist herbicides, insecticides, fungicides, fertilizers and non-chemical technologies within Australia.

Working closely with agricultural producers and their supporting rural reseller networks, AgNova is well placed to identify market opportunities and develop products to satisfy their requirements.

AgNova Technologies has demonstrated success in developing specialty products in the Australian market. AgNova also has an exciting product portfolio and an even more exciting new product pipeline, therefore is strongly placed to continue to develop value-adding solutions for agricultural and horticultural producers within Australia.

PRODUCT ENQUIRIES

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Always refer to the product label for full directions for use.

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