NSW DEPARTMENT OF PRIMARY INDUSTRIES

CROP PROTECTION PLANNING – THE FRUIT FLY MENACE

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ABSTRACT

Fruit flies cause significant damage to crops. Controlling fruit flies to produce marketable products causes significant costs to the grower. Time and money spent on combating fruit flies may contribute to poor returns to the grower. Crop protection planning will help minimise fruit fly control costs and market losses by being proactive in fruit fly minimisation and control. This entails a knowledge of crop ripening times, local fruit fly populations and some understanding of fruit fly life and habits. This presentation describes how growers can set up a plan of action to combat fruit flies in a timely and effective way. Some of the questions discussed will be: Where do fruit flies go in the winter? Can fruit flies be controlled in early spring before their population builds up? How can information from fruit fly traps be used? Can field sprays and postharvest treatments be used more effectively?

Introduction

This discussion paper on fruit flies includes some information on fruit flies and poses some questions about crop growing conditions whose answers could be used to develop a Crop Protection Plan to reduce the impact of fruit flies on crops. There is no one way to manage fruit flies. How you do it depends on many factors. Some of these factors are discussed in the following paper and your answers to them might help you to understand how fruit flies become a menace and how you can manage them to your benefit.

1. Australian Fruit Flies

There are about eighty species of fruit fly that are native to Australia that infest mainly native fruit and vegetables but, of these, six are classed by the Horticultural Policy Council as pests of horticultural significance. They are *Bactrocera tryoni* (Queensland fruit fly) *B. neohumeralis* (lesser Queensland fruit fly), *B. cucumis* (Cucumber fly), *B. musae* (banana fly), *B. jarvisi* (Jarvis's fruit fly) and *B. aquilonis* (Northern Territory fruit fly). The Queensland fruit fly is by far the most destructive of these native Australian fruit fly species although another, non-native species, now established in parts of Western Australia and which arrived in Australia in the 1890s – the Mediterranean fruit fly (*Ceratitis capitata*) – is just as damaging and it, too, is a critical quarantine pest.

2. Pest Description

The adult fly is not often seen but if there are some around and you stay still for a while near a fruiting tree you should see them fly in and land on a leaf or fruit.

Generally adult fruit flies range in size from 4mm long and 5mm wide with wings outstretched to 8mm by 16mm although some species are bigger. These bigger species are either not present in Australia or are not pest species. The average size of pest species of fruit fly in New South Wales is about 7mm by 14mm (wing tip to wing tip).

The adult Queensland fruit fly is reddish brown to dark brown and more wasp-shaped than shaped like a house fly having a narrow waste between the thorax and the abdomen. The thorax is decorated with two shoulder patches, two long stripes and various patches on each side. Patches and stripes can range from bright yellow, through cream to, less commonly, white.

In the orchard the adults fly away from their overnight resting place when it is warm, and/or sunny enough to find water and food. Females start to look for a suitable fruit to lay her eggs into and males start to look for a suitable place from which to "call" or attract potential female mates to. During the middle of the day, depending on temperature and relative humidity, both males and females rest under large broad leaves. Later in the day the females travel to the males and mating may occur in the late afternoon, just before dark.

Males attract females by positioning themselves in a suitable tree. Such trees may have fruit on them or may be just large and dark, and therefore, cool, humid and safe. Often several males will pick the same tree and join in together to attract females. They do this by emitting a sex pheromone that they release from their bodies and beat with their wings to disperse it on the breeze. The sound of their wings is called "stridulation" and females will use the stridulation to home in on the males after initially detecting the scent of the sex pheromone. Once the female enters the site of the group of males – called the "lek" - the males then proceed to perform courtship dances. Quite often the male is on the topside of a well lit leaf and the female under it. She can "see" the shadow of the male's movements through the leaf. She then chooses her mate based on the courtship dance.

Adult Queensland fruit flies need water which they obtain from dew, nectar and rain; sugar from nectar and other plant exudates and protein from yeasts and fungi which grow on plant surfaces, bird droppings, etc. Female flies need protein to help their eggs to mature. Male flies need protein to become sexually mature.

3. Evidence of Pest Damage

3.1 Larvae (maggots)

You may not know that fruit flies are in the area until you see larvae in fruit. Larvae grow from about 1.2mm long and 0.3mm wide up to around 8mm to 10mm long and 2mm wide. Usually they range from almost colourless when small to a creamy-white when they are large. Sometimes they have a little extra colour in a stripe down the body which is colour picked up from the fruit and swallowed into its gut.

The larva is long and tubular with a blunt (anal) end and a sharp (mouthpart) end. In mature larvae a pair of dark brown to black toothed mouthparts can be seen.

When the largest larvae are mature enough to form a pupa or "cocoon" they develop a "jumping" or "hopping" habit which can easily be seen. The larva use their mouthparts to gab their backside and curl up into a circle. They build up pressure in their internal organs and then suddenly let go. If their backside is against something solid they can hop about 10 to 15cm high and long. These hops are random so hopping is a good way of avoiding predators.

Larvae, when they are old enough, pupate. Pupae, or "cocoons", are white, through to cream, to honey brown to dark brown. They measure from 2.5mm by 1mm to about 4mm by 2.5mm. They generally pupate in the soil or ground litter under fruit trees or vegetable crops. Sometimes pupae can be found in mummified peaches, apples and citrus either still in the tree or on the ground. Also they can hop out of fruit in your fruit bowl and pupate in the bowl or under the cupboard.

Larvae can make a complete mess of the inside of the fruit. They do this not only by eating it out but by using a relationship they have with certain bacteria. These bacteria are injected into the fruit with the eggs when the female fruit fly lays its eggs. The bacteria break down some of the proteins in the fruit so that when the fruit fly eggs hatch the young larvae have some readily digestible food in easy reach. The bacterial breakdown can spread throughout the fruit or remain in small sections. The larvae, as they grow, spread more bacteria through the fruit and retain them in their gut through pupation and adult hood ready to inject them again when they lay eggs in the next generation.

3.2 Sting marks, eggs

Sometimes you can see where the fly laid its eggs. Egg-laying often causes "sting marks" on the fruit's skin. When green loquats are stung a pinhead-sized black spot forms on the skin at the sting site within the day. The skin around the sting mark yellows earlier than the rest of the fruit. This is caused when the fly wounds the fruit it makes the fruit emit ethylene to help cure the wound. Ethylene is part of the fruit's ripening mechanism, too, so the area around the wound ripens noticeably quicker than the rest.

When peaches and nectarines are stung noticeable black spots are formed, too. Often these spots become infected with brown rot or some other fungus. The sting marks offer rotting fungi a perfect entrance through the natural antifungal barrier which is the fruit's skin.

If a purple passionfruit is stung when it is still green, but at a mature size, a sting mark will form but in a quite different way to loquats and peaches. The fruit reacts to the sting by forming a corky callus around the wound. This is like a scab formed on animals. The corky callus dries out and fruit fly eggs desiccate and die. It is therefore extremely rare for purple passionfruit to be infested by fruit flies. Avocadoes do this too. A word of warning though – both purple passionfruit and avocadoes tend to drop off prematurely in response to fruit fly stings. Yellow, or banana passionfruit, on the other hand do not form calluses and the fly survives very easily.

Some citrus and other fruit, especially rough skinned ones, do not show a sting mark. The sting hole is there but the fruit does not react in any noticeable way.

If you cut the skin around the sting site to a depth of no more than 4mm you can see fruit fly eggs, or their egg cases, if the eggs have hatched. Eggs are smooth and white to creamy white measuring about 1.2mm by 0.4mm. They are slightly bent like a banana.

3.3 Soft patches in fruit

Even if there is no detectable sting mark the fly can be given away by the flesh of the fruit softening under and around the sting site. Softening is caused by bacterial breakdown, larvae eating the flesh, premature ripening around the sting site or a combination of some or all the above.

3.4 Complaints

You may get complaints from your customers, neighbours or family about maggots in your fruit even though you thought the fruit you gave them was of good quality. This is because larvae can take a while to grow large enough to be noticeable, especially if there are only a few eggs in the fruit at the start. Depending on the temperature around the fruit and what type of fruit the fly is in it can take 6 days to 20 or more days before the larvae are large enough to pupate. Flies tend to grow in cherries and peaches quite quickly unless there are chemical residues slowing them down. Flies are slower to grow in oranges and even slower in Granny Smith apples. So you can see that the fruit may look good for several days after harvest but when purchased and then stored at room temperature maggots will eventually become visible.

3.5 Traps, adult flies

You can get early warning of the presence of fruit flies in your area by using traps. These traps are often baited with some fruit fly attractant to entice then into the trap and some way to stop them from leaving the trap.

Once there is a certain number of flies caught in the trap you can then make the decision to do something about them.

4. The Fruit Fly Life Cycle

4.1 Adults

Usually, males and females mate at about 6 to 10 days after breaking out from their pupae. After mating the female can lay fertile eggs within a day. She can lay, in the case of Queensland fruit fly, more than 2,000 eggs in her lifetime after just one mating. If the female is to survive a cool winter she must resorb her fertilised eggs for energy as she will not move very far in the cold. To lay more eggs, then, she will have to mate again.

The female will mate between one and three times during her lifetime. Males will mate many times.

4.2 Eggs

Depending on the temperature around the fruit eggs will hatch in 24 to 48 hours from egg laying. If the wound around the eggs dries out the eggs may desiccate and not hatch at all. Eggs are laid close to the fruit surface, usually less than 4mm deep because that's about how far the female can extend her ovipositor (the "stinger"). If the fruit's skin is very thick, such as you may get in coastal oranges, and the eggs are laid only in the skin and not in or near the flesh the eggs can desiccate and die. If there are many flies trying to infest just a few fruit one fly will lay her eggs into the hole another fly has made. The first flies eggs may then be pushed deeper into the fruit than 4mm.

Eggs are injected into the fruit accompanied by cultures of several fungi and bacteria that attack fruit tissues and cell walls, digesting them down to simpler, more easily ingested proteins and amino acids. Newly hatched larvae feed on these.

4.3 Larvae

The newly hatched larvae are close to the fruit surface but as they ingest more of your fruit they head down towards the fruit centre. If the fruit is very juicy the larvae may not penetrate very far because they need to have access to air to enable then to breathe. If you open an infested, but very juicy, fruit you can see all the larvae together with their heads buried into the juicy flesh and their tales poking up out of the ooze. Their posterior spiracles, which they use to breathe, are located there.

Fruit fly larvae go through three stages inside the fruit. Depending on temperature and what sort of fruit they are infesting, the first stage larvae, or first instar, lasts about 2 or 3 days. During this time the larvae feed and grow from about 1.2mm to about 2.2mm. When they reach this length they stop feeding and moult. They shed their skin like a snake and a new one hardens. They are now at the second instar larval stage. Second instars grow from 2.3mm to about 4mm over about two days and they tend to be as close to the centre of the fruit as possible. Then they stop feeding again and moult into the third instar. The third instars grow from 4mm to 8mm over another two to three days. The third instars now move to the fruit surface and by the time they reach it it is time to hop out and pupate.

Larvae live inside fruit for 6 to 20 days or more depending on temperature and what sort of fruit they are growing in. Cherries, for instance allow fruit flies to grow quickly but some apple varieties make them grow quite slowly.

4.4 Pupae

Pupae remain in the soil for 8 to 15 days before the adult fly breaks out, again depending on the temperature. Some observers have found pupae remaining viable for a month or two in the ground in winter.

5. Fruit Fly Ecology

Fruit flies have been classified into the insect family, Tephritidae. There are many hundreds of species of fruit fly but only a few dozen that are serious pests of fruit and vegetables. Some species are pests of flowers such as daisies. Most of the fruit-producing regions around the world have either their own native fruit flies or have been invaded by an exotic species.

Tasmania, New Zealand and Japan do not have any pest fruit fly species. Consequently their quarantine laws are very strict.

There is some debate about the origins of Queensland fruit fly. Some people say that came from the coastal border region between New South Wales and Queensland and spread down the coast and up by a combination of its inherent adaptability and the linkage caused by the planting of new host crops all along the coast. It then spread inland by adapting to the changed climates. Others say that Queensland fruit fly has existed in the coastal regions of New South Wales and Queensland all the time and just expanded when new host crops were planted.

5.1 How they move into a new area

One way is by being carried in by unwary produce transporters and the public in infested fruit and vegetables. The New South Wales Government protects the fruit fly free status of the Murrumbidgee Irrigation Area by constructing a system of signs, dump bins, random road blocks and fines on roads leading into the area. It was

suggested that the Asian papaya fruit fly incursion that occurred in and around Cairns, in northern Queensland in 1995 was caused by travellers entering Australia from Asia with infested fruit.

Given favourable weather conditions and irrigation practices flies can move from one region into the next and establish there. If conditions are good in the new region the fruit fly population will increase and then spread to the next region providing there is a link between the regions that is suitable to fly survival and/or movement.

Australian weather patterns are notoriously variable. It is possible for mild winters and wet summers to occur every now and again in areas where, on average winters and cold and wet. These regions, such as the Riverina, in New South Wales, are usually fruit fly free because of the adverse winter climate. However, when there is a change, if there happen to be any flies surviving in small pockets with a favourable micro-climate, such as the compost heap or near a brick wall adjacent to a fireplace, fruit fly populations could expand. We think this happened in and around Leeton, in southern New South Wales from 1999 to 2001. Also, if people mistakenly bring in infested fruit and throw them out into the compost heap during these times then that, too, would add to the possibility of fruit flies establishing themselves.

Irrigation, water courses and rivers can act as conduits for the establishment of new fruit fly populations especially if the water ways are lined with fruit fly host plants. These host plants can be commercial plantations, backyard or hobby farm gardens or feral, self sown hosts such as loquats and peaches.

It is possible that fruit flies can move from one region to the next as a result of winds. It has been shown that the melon fly will move from island to island near Japan and Taiwan on the wind. If enough flies arrive in the same spot within a few weeks then a new population will be able to start.

5.2 Host Status

Not all fruits or even all fruit cultivars are equally attractive to fruit flies. This can be due to some physical barrier such as the thickness of its skin (e.g. pineapple) or some pre-maturity protective chemical in the fruit (e.g. benzyl isothiocyanate in green papaya) or for presently unknown reasons (e.g. limes) or the time of year it ripens (e.g. southern NSW cherries harvested before Christmas generally miss out on fruit fly populations which build up in January in cooler climates) or fruit maturity at harvest (e.g. green but mature bananas). Consideration of planting the right crops in the right area at the right time may reduce fruit fly problems.

6. Effects of Geography and Climate on Fruit Fly Presence

6.1 District

Fruit flies can be a pest all year round if environmental conditions allow. Parts of coastal Queensland can be warm enough for fruit flies to remain sexually active all year. The further inland or the further south you go the fewer generations of flies you get each year. Some fruit fly species are less tolerant of cool conditions and so will not move very far south. For example, the Lesser Queensland Fruit Fly will not venture much further south than Coffs Harbour on the Mid North Coast of NSW. The cucumber fly can not be found further south than Brisbane in Queensland. The limiting factors, here, are temperature and relative humidity. If the temperature

remains above about 20°C all day and most of the night all year then it is possible to have a fruit fly problem all year. Twelve generations of Queensland fruit fly a year are possible in these districts.

Cooler districts on coastal NSW around Sydney may allow only 5 of 6 generations of Queensland fruit fly a year while areas with even cooler winters, such as Young, a cherry production area in southern NSW, allow only 2 or 3 generations a year.

In some districts winters are so cold that all fruit flies are killed by exposure to the cold and the insect dies out. The Murrumbidgee Irrigation Area of NSW and Tasmania are examples of this sort of climate. Flies can build up again in these areas by two ways. Firstly if last winter was relatively mild then adult flies can survive and then re-mate and build up again the following Spring. Alternatively new flies might come into the area in infested produce being brought in. This causes an outbreak of new flies and the start of a new population of fruit flies for that region as the weather warms up.

6.2 Time of year – Winter, Christmas

As mentioned before some districts have pest populations of fruit flies all the year. Other, generally cooler, areas can get away with producing crops in the late Autumn to Spring. In Sydney, after a normally cool Winter, tomatoes can be grown fruit fly free if planted early so that fruit ripens before Christmas. Generally cherries from Young are harvested before Christmas and, most often, do not need to be treated against fruit flies.

6.3 Weather – Rain, Humidity, Temperature

Weather can not be predicted very accurately, especially in coastal Australia. Fruit flies do react to weather, though. Fruit fly problems will be lessened during extended droughts. Flies regain problem status quite rapidly after rain. This implies that flies are not killed during droughts. They are just not laying eggs – they are waiting for more favourable climatic conditions in which their offspring will have a better chance for survival.

7. Setting up a Crop Protection Plan for Fruit Flies

The simplest way to set up a crop protection plan against fruit flies is to follow the one currently used by you, your father and his father before him. Or you can follow what your neighbouring farmers do. Also there are district-specific schedules, such as NSW DPI's "Orchard Plant Protection Guide", which will guide you through the various anti fruit fly activities, chemical pesticide options, quantities and timing of application. But are they enough? Or are they overkill? Can you improve their efficacy by combining them with other technologies? The answer to the last question is probably – "Yes". An understanding of the answers to the following questions will aid in evaluating current and potential crop protection plans for your district:

- *Where do fruit flies go in the winter?*
- *Can fruit flies be controlled in early spring before their population builds up?*
- *How do you control fruit flies as the crop ripens?*
- *What can you do after harvest to minimise fruit fly problems?*

The next section will attempt to answer these questions by combining knowledge of the growing district and an understanding of the fly's habits.

7.1 Where do fruit flies go in the winter?

If flies are to survive the winter they generally over-winter as adult flies. In rare circumstances when the winter is mild and the level of natural predation (such as fowls and other insect-eating birds, predatory insects and parasites) is low some insects may survive as pupae. These circumstances would be unlikely except possibly in a monoculture but chemical applications would kill off over-wintering pupae (and adults). Another possible mechanism for over-wintering of fruit flies is at the larval stage. This can occur on some fruit that persists on the tree over the winter. The main culprits are apples and quinces. Even when old and shrivelled some of these fruit are moist enough to host live fruit fly larvae. There have been no records, however, of fruit flies over-wintering in winter persimmons or pomegranates.

If you have several heavy frosts in a row any over-wintering adult flies, pupae or larvae in the area will die out. But frost is not completely uniform in its severity. It is possible that fruit growing near houses or under trees will be warmer than other more exposed situations and adult flies may survive there. If infested fruit have been disposed of in a compost heap near the end of autumn larvae, pupae and adults may survive in the warmth there. This last scenario is not particularly likely because many predators would be over-wintering or visiting there too.

In areas with mild winters fruit flies will survive the winter months and then be ready to explode in numbers as soon as the weather warms up in late winter and spring. This is a very dangerous situation for subsequent crops. Generally as the nights and mornings cool down as winter approaches flies tend to migrate to warmer positions in the orchard or surrounding urban areas or bush land. At this time of year adults will not travel very far – only a matter of 800m at the most. At the start of cool weather flies will not fly at temperatures less than about 20°C but, being very adaptable, they will acclimatise to cooler temperatures and be able to fly at temperatures as low as about 10°C.

But they will not mate at temperatures below about 20°C. Because flies mate only near sunset and temperatures at that time of day are generally cooler than 20°C in the winter in most areas there will be no mating. If the winter is cool enough the females will resorb any fertilised eggs back into her system in order to survive. When this happens she needs to mate again in the spring. If the winter is mild enough the female will hold onto her fertilised eggs through winter and be able to infest suitable fruits, if available in her vicinity, as soon as the weather is amenable in late winter. If there are ripe fruit available at that time and precautions are not taken then fruit fly populations will expand rapidly.

ACTIONS:

- Check for the presence of apples or quince fruit hanging on into winter and remove trees or strip and destroy fruit.
- If there are house trees or feral trees which are untended and drop fruit late in autumn (e.g. plums, guavas, feijoas) there may be pupae surviving in the soil beneath or there may be adults in surrounding broadleaf evergreens (e.g. citrus). Remove these trees, or pick up, strip and destroy unwanted fruit, run poultry under them or apply pesticide cover sprays (following label directions and cautions).
- Check for untended plants that fruit in early spring, especially loquats and apricots and treat as above.

7.2 Can fruit flies be controlled in early spring before their population builds up?

If you live in a fruit fly prone area then fly numbers might be relatively low in the winter but the remaining population will rapidly increase in the spring if not targeted. In most areas there is a peak in flies trapped in September – early September or possibly late August in Northern NSW and mid to late September in Southern coastal NSW. This population peak varies with climate and also host fruit availability. Early fruiting fruit fly hosts are very important at this time of year to act as a springboard for subsequent populations. Loquats and apricots are favourites.

Over-wintering adult flies will now be craving protein and amino acids which they get from wild bacteria and fungi growing on plant surfaces. This has been in short supply for the fruit flies due to the cool weather and the fact that the flies were not moving around much. Protein is essential to both males and females in order for them to become sexually mature and to mate. In fact protein baits can be more effective than para-pheromone lures (such as Dak Pots®) at this time of year than when the weather warms up and alternative food sources abound. Flies are more interested in food than in sex. Food-based fruit fly traps such as the perforated drink bottle with vegemite and water hung in the tree would be useful in gauging fruit fly build-up.

There has been recent advances in protein baits with the newly-approved organically acceptable Naturalure®. This bait uses a very low concentration per hectare of an insecticide derived from a common fungus to kill fruit flies attracted to a protein solution. There are other baits in common use such as protein mixed with malathion. All can be used at this time of year and during the season to attract and kill fruit flies. Don't forget to follow label directions and cautions.

It would be advantageous to commence the active reduction of male fruit flies early in the season using male annihilation techniques (MATs) and male lure traps. As with the protein traps described above the male lure traps are generally used only to gauge fruit fly population build-up and to give the grower an idea when it is time to start anti fruit fly activities whether they be cover sprays with insecticides or application of protein baits, MATs, etc. Males won't go to these until they have had a feed of protein but they are very attractive to flies – more so than food-based or protein traps. Again take care with these chemicals and ensure all label directions and cautions are followed.

Currently available male lures for traps include Dak Pots®, Wild May® and for MATs there are Amulet C-L® pads and Bugs for Bugs®. MAT blocks / pads are good because you can place out quite a few in the orchard and around its perimeter. They, with protein baits can help intercept flies coming out of surrounding bush and urban areas into your orchard.

Another method to keep fruit flies from crops is by using physical barriers such as exclusion netting or other types of covering. Insect sensitive sections of a crop can be housed under exclusion netting. Individual trees can be covered. Individual fruits or fruit trusses can be covered. They can be expensive and time-consuming to apply. They can increase problems with other insects and microflora. But they can also be very effective in excluding fruit flies. It is up to growers to work out their benefit: cost ratios to evaluate exclusion netting for their situation.

ACTIONS:

- Apply protein baits to crop boundaries, untended fruiting trees, and crop trees early in the season, even before fruits mature to reduce the fruit fly load in and near your orchards. Follow label directions and cautions.
- Commence placement of fruit fly traps and male annihilation blocks around and within orchards. Maintain throughout the year. Follow label directions and cautions.
- Learn the differences between pest and non-pest fruit flies caught in traps.
- Check for untended early fruit crops such as apricots and loquats and treat the trees and fruits with chemicals (following label directions and cautions), grubbing-out or fruit-stripping and destruction.
- Evaluate the benefits or otherwise of exclusion netting / covers.

7.3 How do you control fruit flies as the crop ripens?

This is the time of the cropping season that fruit flies make their presence felt the most. On the other hand steps taken earlier on in the season to reduce fruit fly impact by adhering to a Crop Protection Plan will have an major effect on fruit fly numbers at this time. Without fruit fly control strategies fruit fly numbers will increase rapidly and, when this happens, traps and baits will have little effect except to demonstrate how many flies are out there. Pesticide cover sprays following approved label requirements will probably be necessary at this stage.

Again fruit fly exclusion netting will keep flies out of the crop as long as they have not got in in the first place. Once fruit flies get in under exclusion netting they may be difficult to eradicate.

Note that if the orchard operates under an Interstate Certification Assurance (ICA) system then its requirements must be followed otherwise non-compliance could result in the rejection of your product.

ACTIONS:

- Keep an eye on the numbers of pest fruit flies caught in traps. Identify the pest species and decide on how many pest fruit flies in traps will trigger action.
- Set up a list of anti fruit fly activities based on trapped fly numbers.
- Apply cover sprays following approved label directions, and repeat applications also following approved label directions.
- If there are low numbers of flies in traps and the crop is some way off ripening bait sprays might replace cover sprays and so pull the fruit fly population down prior to harvest.
- If you are registered under an ICA you must adhere to its requirements.

7.4 What can you do after harvest to minimise fruit fly problems?

This, too, is an important time in the life of fruit flies. It is now when the survival of the population is set. The problem will come from adult fruit flies over-wintering in or near the orchard and from adults that emerge from late pupae in the soil beneath the crop. If possible you must not allow fruit flies to survive after harvest. This means ensuring fallen and non-harvested fruit are cleaned up somehow. Raking, collection and deep burial is one way but make sure the buried crop residue is covered by at least a metre of compacted soil. Running poultry, cattle, etc under the crop will remove a large number of flies that are still in the fallen fruit or have pupated in the top centimetre or so of soil. Slashing fallen fruit into mulch and inter-row ploughing will also help.

Flies left in the soil after harvesting deciduous crops could still be a problem later in spring even though trees are now leafless. Because these trees have lost their leaves over-wintering adult flies and adults just newly emerged from over-wintering pupae will leave the orchard and move into the protective canopies of surrounding evergreen plants. In these climates winter bait spraying and MATs around the orchard perimeter would be beneficial.

ACTIONS:

- Harvest or pick up and destroy fallen fruit, or unharvested fruit still hanging.
- Consider perimeter bait spraying and MATs.

8. Conclusions

There are as many variables impacting on the magnitude of fruit fly problems as there are on how to grow a good crop of fruit. Many of the climatic and management factors that affect product volume and product quality also impact on the ability of a fruit fly to be a severe pest or a manageable one.

The main message when developing a Crop Protection Plane against the fruit fly menace is that it is not a problem which occurs only during harvest. A year-round plan of anti fruit fly actions and a knowledge of the pest and the crop will help reduce the impact of fruit flies on your crop during harvest.

9. Suggested Reading Material

- "Area-wide Control of Fruit Flies and Other Insect Pests". Keng-Hong Tan (Ed.). Joint proceedings of the International Conference on Area-wide Control of Insect Pests, May 28 – June 2, 1998 and the Fifth International Symposium on Fruit Flies of Economic Importance, June 1 – 5, 1998. International Atomic Energy Agency, Vienna, 2000.
- "Economic Fruit Flies of the South Pacific Region" RAI Drew, GHS Hooper and MA Bateman (Eds). Queensland Department of Primary Industries, Brisbane, 2nd Edition 1982.
- "The Distribution and Host Plants of Fruit Flies (Diptera: Tephritidae) in Australia". DL Hancock, EL Hamacek, AC Lloyd and MM Elson-Harris (Authors). Queensland Department of Primary Industries, Brisbane, 2000.
- "World Crop Pests – Volumes 3A and 3B Fruit Flies: Their Biology, Natural Enemies and Control" AS Robinson and G Hooper (Eds). Elsevier Science Publishers, Amsterdam, 1989.
- "Impact of fruit flies on Australian horticulture". MA Bateman. Horticultural Policy Council. HPC Industry Report 3. Canberra, 1991.
- "Orchard Plant Protection Guide for Deciduous Fruits in NSW". S Hetherington, J Bright and A Mooney (Authors). NSW Department of Primary Industries, Orange, 15th Edition, 2005.