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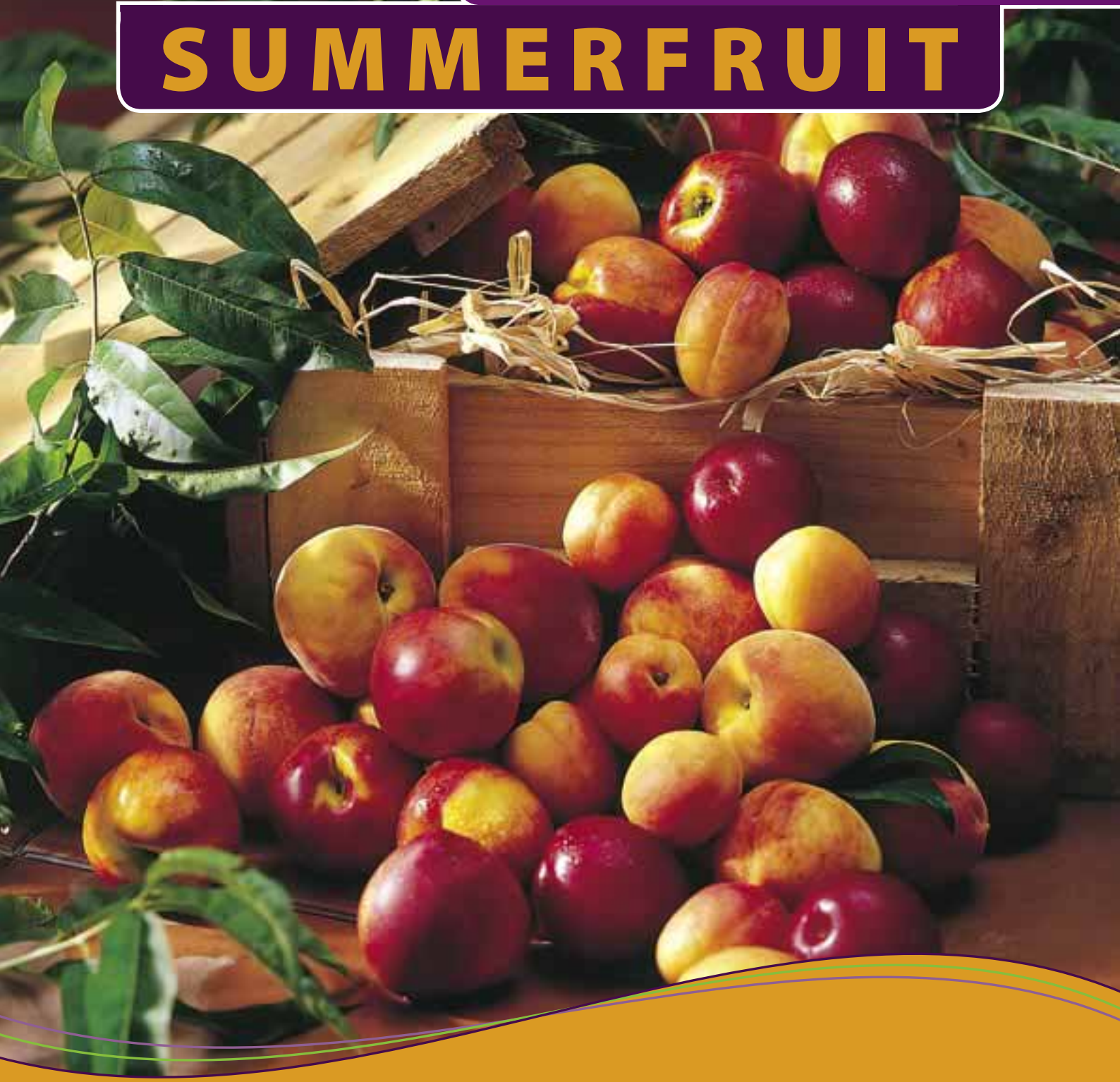
Summerfruit AUSTRALIA

INTEGRATED PEST AND DISEASE MANAGEMENT FOR

AUSTRALIAN SUMMERFRUIT



State Government Victoria Department of Primary Industries

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Tasmania DEPARTMENT of PRIMARY INDUSTRIES, WATER and ENVIRONMENT

HAL Know-how for Horticulture™

NSW DEPARTMENT OF PRIMARY INDUSTRIES

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About this manual

Introduction

This manual outlines the Australian summerfruit IPDM strategy.

From its initiation, this strategy has involved collaboration between Australian summerfruit orchardists, researchers and extension specialists. The objective was to create a strategy that gave practical pest and disease management options instead of 'warm fuzzy' philosophy.

The information-gathering phase of the strategy involved 66 peach orchardists, 65 nectarine orchardists, 50 plum orchardists and 31 apricot orchardists in 13 Australian Summerfruit regions in six Australian states. The objective was to identify the problems that were most important to industry. Orchardists were asked what their major pest and disease problems were. This series of interviews took place before and after the 2003–04 fruit season. Many of Australia's orchard regions were in the grip of a long-running drought. The interviewees were asked to compensate for the possible reduction in pest and disease problems due to the drought by recalling their problems from up to 10 years ago.

Australian summerfruit is grown in a range of climatic zones from the sub-tropical low-chill enterprises of the northern states to the cold temperate zones of Tasmania. Naturally, the pest and disease problems experienced by orchardists in our regions are diverse. The creation of a national strategy was therefore challenging. This manual deals with this diversity by providing information on which regions have had problems with specific pests and diseases over the past 10 years. Where the information provided is region-specific, this is highlighted in the manual.

This manual provides a framework for setting up IPDM in your orchard. Many orchardists will want to be personally responsible for monitoring and decision-making. Others may not have the confidence or time to do this. Consultants are available for this work in most regions. In any case, a successful IPDM program will save money and improve your orchard and personal health.

As we moved about the country asking questions, we realised that some of the issues being raised weren't quite what we expected. Bird damage was an issue that came up at almost all of the meetings. Initially we wanted to limit the manual to insect pests and diseases, but birds were such an issue that we invited a guest author to write a section on bird control. John Tracey works for the NSW Department of Primary Industries and is a respected authority on control of pest birds in horticulture. His article can be found on page 122.

Many orchardists were interested in the life cycles of their pests and diseases and wanted this included in the manual. This was difficult, because life cycles vary from region to region, usually in line with temperatures. The manual therefore presents a representative life cycle for each pest and disease. In most cases (except where noted) this life cycle is typical for the Goulburn Valley or the NSW Central West. Orchardists should make their own modifications to this to suit their region.

What is IPDM?

IPDM is 'Intelligent Pesticide Decision Making'. Alternatively (and more conventionally) IPDM is integrated pest and disease management. More simply, IPDM involves evaluating your pest and disease problems and then applying the most appropriate solution. The complication is that, when choosing this option, you must consider its impact on the entire block. For example, applying bifenthrin for a small *Carpophilus* beetle infestation may kill the natural enemies of mites. This, in turn, may create larger problems (and lose you more money) by creating a two-spotted mite problem.

Fewer pesticides are used in well-run IPDM programs. Although this isn't the overall objective of IPDM, it is a natural consequence of considering the entire range of control options available. When an orchardist using IPDM chooses a management option, it is because it is the most effective at controlling the pest or disease, without any bias toward or against chemical pesticides or other management options.

Prevention of pests and diseases is also an important component of IPDM. Many problems can be avoided by making your orchard an inhospitable place for pests and diseases. Some general strategies for doing this are outlined in this manual (page 1), and specific prevention strategies for each pest and disease are given throughout.

The key to IPDM success is to keep good records. Records should be used to think about what you're currently doing and honestly evaluate whether you're choosing the best options. This allows you to constantly refine your management strategy and cope with new threats.

Making the decision to use IPDM: personal choices

Australian summer fruit orchardists are understandably conservative. Bad and damaged fruit costs money. Our survey of Australian orchardists showed that an average pack-out of 96.2% of picked fruit is acceptable. To move toward IPDM, orchardists are willing to accept a slight reduction in pack-out, to 95%. Of course, these figures are averages and vary widely among individual orchardists, regions, types of pest and disease damage and crops. Some orchardists are willing to accept up to a 10% reduction in pack-out.

IPDM involves making personal choices about what you think is acceptable and what level of risk you're willing to accept. There are no firm rules and regulations.

A well run IPDM program involves no reduction in pack out. However, during the first few seasons inexperience means that mistakes will happen. The strategy in this manual provides a way of minimising that risk:

- Start small: Orchardists with limited experience in IPDM should never convert an entire enterprise or a large, high-value block during the first seasons of transition. Start with a small, low-value block until you build up confidence.
- Take it step by step: Change one aspect of your pest management and evaluate the impact of the change over several seasons. At the end of each season modify the strategy until you're happy with the result. Gradually introduce changes to other management practices.

Some IPDM terms defined

IPDM comes with its own jargon. The terminology is quite simple and will help you to understand this manual. It's important that you understand the following four terms and the relationship between them.

1. Monitoring

Monitoring is a structured system for quantifying the likelihood of pests and disease becoming a problem in the orchard. It involves either:

- carefully monitoring certain trees in the orchard, paying particular attention to trees prone to problems (i.e. hot spots), or
- carefully monitoring the weather for conditions likely to favour pests or diseases.

2. Sample unit

This is the precise item that is monitored. For example:

- if two-spotted mite is being monitored, the sample unit is a leaf
- if bacterial canker is being monitored, the sample unit is a limb
- if rust is being monitored, the sample units are the temperature and rainfall.

3. Action threshold

This is the point in time when monitoring indicates that damage to the crop will be unacceptable unless the pest or disease is managed. The action threshold can be the time at which:

- a certain number of pests is seen while monitoring
- a certain amount of damage is seen while monitoring
- the weather is so favourable to a pest or disease that it is almost certain that damage will follow.

4. Appropriate action

When the action threshold has been reached appropriate action must be taken. Appropriate action must:

- be effective over a relatively long period
- not cause secondary problems.

Six steps to controlling summerfruit pests and diseases

Six steps to controlling summerfruit pests and diseases

These steps are outlined in Table 1 and in the text that follows.

Table 1. The six steps to successful control of summerfruit pests and diseases

Step 1	**Set up and maintain your orchard to minimise pests and diseases (page 3).**
Step 2	**Start the season with a plan (page 4).** Getting started: • Which blocks am I going to manage using IPDM? • How much time will I need to devote to monitoring? • How do I set up my orchard for monitoring? • What equipment do I need? • Which pests and diseases are likely to cause problems? • How much damage am I willing to accept before I control my pests and diseases?
Step 3	**Monitor (page 7).** • Know the life cycles of your pests and diseases and their predators. • For each pest and disease use the most effective monitoring technique. • Keep good records.
Step 4	**Take action only if you need to (page 8).** • If damage has reached an unacceptable level, control the pest or disease responsible with the most appropriate management action.
Step 5	**Evaluate your season (page 9).** • Immediately after the season use your records to make a list of which pests and diseases were troublesome. • Record which management actions were most effective.
Step 6	**Plan for next season (page 10).** • Prepare to be more vigilant in monitoring the pests and diseases that caused problems. • Take ineffective management options out of your schedule. • Decide whether more blocks can be managed using IPDM.

Step 1: Set up and maintain your orchard to minimise pests and diseases

Source your planting material from a reputable nursery

Choose planting material from nurseries that supply virus-tested budwood and rootstock seed. Nurseries that supply bud-wood grafted from commercial orchards should be avoided, as they can give no guarantee as to the disease status of their trees.

Choose your site carefully

Healthy trees have fewer pest and disease problems. Maintaining tree health is easier if the best soils, aspect and topography for tree growth are part of the orchard plan.

Topography can have an effect on the prevalence of pests and diseases in the orchard. Valleys and south-facing slopes are prone to frost, and this can damage tree bark, providing an entry point for diseases such as bacterial canker. In summer, valleys tend to trap humidity and trees can become prone to diseases such as rust. Valleys also tend to have poor drainage and are more prone to soil-borne diseases such as *Phytophthora*. Plum rootstocks are less prone to disease problems associated with poor drainage and should be considered as an option.

Where native vegetation is cleared to establish a new orchard, clear as many roots as possible before planting. Native vegetation harbours the disease *Armillaria* root rot.

Rest replant sites for up to 4 years to avoid replant disease. A good option during this rest period is to plant a 'hot' *Brassica* crop. Replant disease is generally a syndrome caused by a number of organisms and is therefore difficult to control. Planting between the old rows, rather than on top of them, has been shown to be effective in some cases. A rootstock different to the one previously used in that block should be planted.

Choose varieties that are more resistant to the pests and diseases in your region

The predominant reason for favouring a particular variety will be its market acceptability. Other issues are secondary but will contribute to the profit from that planting. The susceptibility of that variety to pests and diseases is an important secondary issue.

Typically varietal information supplied by nurseries to industry contains very little information on disease susceptibility. However, if you ask the nursery operator they will often know the disease susceptibility of the varieties they are supplying.

Where it is practical, orchardists should consider using varieties that mature at different times to those in neighbouring blocks. Many pests and diseases attack during specific growth phases (e.g. green peach aphid, blossom blight). Spread of the pest or disease throughout the entire orchard is impeded if certain blocks are resistant because of their stage of maturity.

The use of nematode-resistant rootstocks is also recommended where nematodes are known to be a problem.

Manage the orchard floor to minimise pests and diseases

Managing ground cover is an important component of the control of some pests and diseases in summer fruit orchards.

Pests such as western flower thrips can be managed through careful ground cover management (page 65).

Remove alternative hosts

Certain pests and diseases have broad host ranges and can therefore move to an alternative host when the summer fruit host is unavailable. Pests and diseases can also use alternative hosts as 'stepping stones' to spread within the orchard.

Of particular concern are viruses, which can originate from common orchard weeds and affect the productive performance of trees without causing obvious symptoms.

Very little Australian research has been conducted in this area, but it is almost certain that weeds act as reservoirs for pathogenic viruses. Prunus necrotic ring spot virus causes symptoms ranging from asymptomatic yield reduction to tree death. It has been implicated in peach rosette and decline virus disease in Victoria. This virus is transmitted by pollen from host to host. Its host range includes rose, raspberry and blackberry and is expanding and may include other weed hosts.

Rutherglen bug (*Nysius vinitor*) commonly moves from docks to summer fruit orchards as its weed host dries out.

Training, pruning, thinning and fertilisers

Training systems that provide open canopies result in greater air flow and shorter drying times. Consequently, disease incidence tends to be lower.

Training systems that minimise pruning and, subsequently, pruning cuts (disease entry points) result in fewer problems from bacterial and fungal cankers.

Although benefits can be gained through opening up the canopy through pruning and training, orchardists need to be aware of the problems that may arise from sunburn in warmer areas. Sunburn can result in bark cracking and splitting and predispose the tree to fungal infections.

Pruning should:

- remove water shoots
- remove diseased tissue
- open the canopy to allow air movement and better spray penetration.

Selective pruning to remove diseased tissue during the production season has been shown to reduce the incidence of disease in the following season (e.g. silver leaf; page 80). Pruning to open the canopy allows more rapid drying, greater airflow and more effective pesticide coverage.

Water shoots should be regularly removed, as their soft vegetative growth provides a haven for sap-feeding pests such as black peach aphid.

Fruit thinning results in larger fruit. A secondary consequence of thinning is the removal of a sheltered habitat that provides a haven for insect pests and diseases. In crowded canopies, tight fruit clusters do not allow adequate spray penetration. Because some early season damage does not become apparent immediately, it may be possible to delay thinning until insect pest and disease damage is visible.

Flush-feeding pests, such as aphids, are attracted to new growth. Reducing nitrogenous fertiliser application early in the season reduces new growth and aphid infestation.

Step 2: Start the season with a plan

Which blocks am I willing to use IPDM on?

Start small! No one likes to take risks. IPDM usually involves a reduction in the number of pesticide sprays applied. A well-run IPDM system will not result in more pests or diseases, but until you have gained some experience there is a risk. By reducing the number of pesticide sprays you run the risk of more pests and diseases and greater financial loss. Therefore, it is a good idea to introduce IPDM gradually.

In the first season, use IPDM on a low-value block. It would be best if this block is relatively large, but if a large block isn't available a small block will do.

Most IPDM management strategies work best on larger blocks or even across whole orchards and even regions. Using a small block to start means that you don't get the full benefit from IPDM. As you gain confidence and IPDM spreads across the whole orchard, pest and disease control will become easier.

How much time should I spend monitoring?

Do I have time to monitor my orchard thoroughly? Should I hire a consultant or scout? Make an honest decision. To be successful, IPDM will take up a significant amount of time.

IPDM will not be successful unless the person doing the job is willing to devote a reasonable amount of time to monitoring. Monitoring should never be deferred because of other commitments: IPDM nearly always fails because monitoring loses priority at peak times. Be realistic—if you don't have enough time to do the job properly, hire a consultant.

For a beginner, as a rough guide, the time needed will be:

- 15 to 20 minutes per hectare every 7 to 14 days at peak times.
- It will take several months for an inexperienced person to monitor confidently and accurately.

For an experienced person the time needed will be:

- 10 to 15 minutes per hectare every 7 to 14 days at peak times.

It is useful to have someone you can share problems and experiences with (a mentor). This should be someone who you can e-mail

photographs to quickly or take samples to on the same or the next day. A reliable diagnostic service is essential. Incorrect identification can be costly in many ways.

If you are using a consultant to monitor your orchard and you don't think IPDM is working, make sure that they are spending at least this recommended length of time in your orchard.

What pests and diseases are likely to cause problems this season?

The most effective way to control pests and diseases is to anticipate which ones are likely to cause a problem and be ready to control them. Make a list of the pest and diseases that have been in your orchard over the last four seasons. As a general rule **if a pest or disease hasn't been seen for four seasons it shouldn't be necessary to monitor for it**. Pests and diseases that have caused financial losses should be given priority. If pests and diseases have been present but haven't caused losses, then include them on the list, but it may not be necessary to do anything about them in the coming season.

Pest and disease lists will vary from orchard to orchard and probably from block to block and in some cases are linked to climatic conditions.

The chapters in this manual that outline strategies for individual pests give an indication of where these pests have become a problem in Australian summerfruit production regions. It's important to also be aware that pests and diseases react to the weather.

Become familiar with the life cycles of your pests, diseases and beneficial organisms.

Find out all you can about the pests and diseases that attack your orchard.

- When can you expect them to occur?
- What do they look like (particularly early, before they've had a chance to do serious damage)?
- When is the most effective time to control them?

The pest and disease fact sheets in the following chapters provide this information for the most common pests and diseases of the Australian summerfruit industry.

You should also become familiar with the beneficial organisms that are likely to become more common in your orchard as you convert more and more blocks to IPDM.

What are my action thresholds for each pest and disease?

An action threshold is the point in time at which monitoring indicates that the financial loss caused by a pest or disease is unacceptable. At this point something must be done to control the pest or disease. If a pest or disease isn't costing you money or causing other problems, why waste time, money and effort controlling it?

In this manual there are three types of action thresholds

1 The pest or disease is present on a certain percentage of leaves, fruit, bark (the sample unit; page 12).

2 The pest or disease has caused damage on a certain percentage of sample units.

3 The weather is conducive to the development of the disease or large populations of the pest.

But how do orchardists know when pest or disease damage has reached this point?

- Very little research has been done on the relationship of damage to economic loss.
- The level of acceptable damage will vary from orchardist to orchardist.
- The level of acceptable damage will vary from year to year, depending on the market.
- For some pests or diseases it's too late by the time you see damage.

The key to deciding on a reasonable action threshold is to keep good records.

- What pests or diseases have been problems in the block over the last 2 to 5 years?
- How much damage have they done?
- What control measures were used and how much did they cost?
- Did the control measures work?

A lot of this information will be recorded in your spray diary. You can keep the few extra details required for IPDM in a hard-bound diary in your office.

This manual provides approximate action thresholds for the most serious pests and diseases of the Australian summerfruit industry. These are suggested starting points and may not suit you. Modify them to suit your enterprise, review whether they worked after two or three seasons, and then revise them up or down.

Preparing the orchard for monitoring

In IPDM a 'block' is a group of trees that are fairly uniform in terms of physical characteristics, variety and tree age. It is an area that is managed

as a unit. This includes pest and disease management (eg. spraying).

Most orchardists don't have time to monitor the entire orchard. In these cases, indicator blocks can be used. Choose indicator blocks with care. The blocks chosen for monitoring should be those with a history of infestation or infection.

Monitor the same trees during the entire season. Mark these trees with flagging tape or by painting their butts. Number the trees so that you know where in the orchard problems are occurring. Numbering tree rows is time consuming to start with, but it's helpful over a number of years in terms of time saved in big blocks looking for particular trees (especially in trellised orchards).

Table 1 gives an indication of the number of trees to monitor in orchards of various sizes. The 'time taken' column in the table is for an experienced operator; allow more time when you first start.

Choose trees:

- that have been pest or disease 'hot-spots' in past seasons.
- in a pattern that makes you visit all parts of the orchard during monitoring. Even though the trees between the monitored trees aren't formally part of the IPDM system, watch out for unusual pest or disease activity as you walk through each time. If it helps, use an aerial photo or hand-drawn plan to mark orchard regions to be targeted.

Equipment

Surprisingly little equipment is needed to run an IPDM strategy. Close examination of pests and the symptoms of diseases can generally be done with a hand lens.

Temperatures can be monitored using a simple thermometer, but more information can be gained by using a maximum–minimum thermometer (these are available at most rural suppliers). It is important that thermometers be mounted in the orchard but not in direct sunlight.

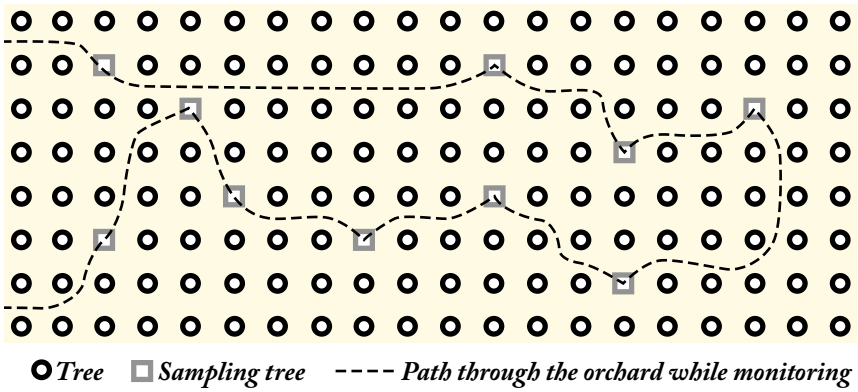
Using a data logger will give you better weather information. Small, relatively inexpensive units are available from a number of Australian suppliers. It is useful to buy loggers that measure temperature, humidity, rainfall and leaf wetness.

Professional consultants will need more equipment, including a binocular microscope for counting and identification of mites and thrips.

Table 1. The number of trees that should be monitored in an IPDM system depends on the size of the block.

Number of trees in block	Area (ha)	Number of trees sampled	Time taken (minutes) to check block
< 500	< 1	10	20–30
500–1499	1–3	15	30–45
1500–1999	3–4	20	40–60
2000–3000	4–6	25	50–75
> 3000	>6	30	60–90

A 10× hand lens



Above: Certain trees should be examined whenever monitoring is carried out, and these trees should be marked with flagging tape or paint. Choose these trees in such a way that a rambling walk between them takes you through the majority of the orchard.

A max–min thermometer

Step 3: Monitor

Monitoring pests and diseases: two types of monitoring

Most IPDM systems monitor only the presence of pests and beneficials and the damage they cause. In many cases, by the time pests or damage are seen financial losses have already occurred. By monitoring the weather that is conducive to the development of pest infestations or diseases, action can be taken earlier.

Monitoring for weather that is favourable for pests or diseases

Some pests or disease quickly become damaging after weather that favours their development. Most diseases of summerfruit become obvious only after they develop in conditions that suit them. In general, by the time these organisms can be seen, serious damage has been done to the crop. Fortunately these organisms tend to respond to weather in a predictable way.

By carefully monitoring the weather, it is possible to apply management before these organisms become a problem. The pest and disease fact sheets in this manual give the weather that favours the development of such organisms and indicate when to apply management.

Monitoring for the presence of pests and diseases

Populations of some pests and diseases can be seen before they can grow to cause serious damage. For these organisms, regular monitoring is a useful way of deciding when to apply a management strategy. The pest and disease fact sheets in this manual tell you what to look for when you monitor, and they give an approximate action threshold.

Sample units

A sample unit is the item on which you are most likely to detect low populations of pests or diseases. A sample unit can be:

- a whole trees
- a portion of the tree (e.g. the sample unit for two-spotted mite is leaves, and for blossom blight, blossoms)
- a trap (e.g. for western flower thrips and fruit fly)
- the weather (e.g. it is possible to anticipate diseases before they are visible).

In this manual, the most appropriate sampling unit for each pest and disease is listed in the 'IPDM quick facts' section at the beginning of each pest and disease fact sheet.

When to monitor

In general, blocks should be monitored every 7 to 14 days throughout the season from budswell to after the harvest–peak season. In some cases it will be necessary to monitor for specific problems more frequently. Where an orchard has susceptible varieties, a history of infestation/infection, and weather favourable for the problem to develop, monitoring should be done at least weekly. These danger periods are dealt with in the sections about specific pests and diseases.

Some pests and diseases can also be detected during the dormant period (e.g. brown rot, San José scale). Therefore, a less regular monitoring schedule at that time of the year is also advisable. In most cases monthly monitoring during dormancy is sufficient.

Action thresholds

An action threshold is the point at which monitoring indicates that an orchardist must take action to avoid economic damage. This manual suggests action thresholds for each of the major pests and diseases of the Australian summerfruit industry. Some orchardists are willing to accept more damage than others; therefore, action thresholds will vary from orchardist to orchardist. We suggest that the action thresholds in this manual should be regarded as a starting point and reviewed at the end of each season.

What to look for?

The pest and disease fact sheets provided in this manual give descriptions of the most serious pests and diseases of the Australian Summerfruit industry. Consult these when monitoring your orchard. They provide details of:

- sample units
- when to monitor
- danger periods
- action thresholds
- what to look for
- prevention and management of the pest or disease.

If you are unsure about which pest or disease you're dealing with, all State Government primary industry departments provide diagnostic services (Fees may apply; contact the service for details before submitting samples—see page 133).

Keep good records

Good management of pests and diseases saves money. The only way to evaluate your pest and disease management is to keep good records. A review of pest and disease management should be done at the end of each season. By looking at your monitoring records (pages 130-132), your spray/management records and your pest management costs, you will be able to see what your best IPDM options are.

Step 4: Take action only if you need to

When pests or diseases reach the action threshold, control them

How will I control pests that have reached the action threshold? What is the appropriate action?

A pest or disease that reaches the action threshold must be controlled. There is usually a range of management options for controlling pests and diseases. IPDM asks you to consider which is the most appropriate in the context of the whole orchard over a period of seasons. This is 'appropriate action'.

In many cases, appropriate action will involve the application of a chemical pesticide. Pesticides can harm the natural enemies of orchard pests and pathogens and cause secondary problems (see the chapter on biological control; page 101).

Management options other than pesticides should always be considered. If a pesticide is the only option likely to be effective, always consider the pesticide's effect on beneficial organisms such as predatory mites. Cheaper chemicals may **not** be the most economical option if they kill beneficial organisms and extra money needs to be spent in controlling pests. This manual contains a spray schedule for Australian Summerfruit (page 137). This schedule is a guide to the most effective options suitable for IPDM.

This manual also outlines other management options for the most serious pests and diseases of the Australian summerfruit industry.

Step 5: When the last of the fruit is sold, evaluate your season

How much damage was done by each specific pest or disease?

Keep accurate records of pest and disease incidence in your orchard during the season. Monitoring forms for diseases (page 131) and insect pests (page 132) are included in this manual. These forms can be modified to suit your orchard by including only the pests and diseases that are likely to cause you a problem. Keep your records for 10 years. The more historical information on your orchard that you have, the better the decisions you're likely to make.

Losses caused by pests and diseases that generally affect leaves or branches (e.g. silver leaf or two spotted mite) are more difficult to assess then those affecting fruit. Keeping accurate records of the percentage of trees affected and comparing these to previous seasons' is the only way that management action can be evaluated.

Examine rejected fruit regularly in the orchard after picking and in the shed. Determine the major reason why the fruit wasn't packed. Some pests and diseases can be very obvious in the orchard but really don't cause major problems. More effort than is needed is sometimes put into controlling these problems than other, less obvious—and perhaps more damaging—pests and diseases.

What was done to control each pest and disease and was it effective?

After reviewing losses due to specific pests and diseases, think about how you tried to control that problem during the season. For example, for pesticides, estimate the total volume of pesticide applied for each pest or disease (spray records will provide this information); the price of the pesticide; and the total cost of control, including application time (labour) and running and maintenance of equipment.

More accurate records allow for better decision-making, and the overall objective of IPDM is to find the best management options.

Step 6: Plan for next season

For all of the blocks you have in your IPDM program it is important to do a pest and disease management review at the end of each season.

The best way to improve your pest and disease management is to look at what you've done and put more emphasis on the things that worked and find alternatives for those that didn't.

A plan for next season should include each insect pest and disease you think you may have to control. Answer some questions:

Do I need to do anything?

Has the pest or disease caused a problem in my orchard during the previous four seasons?

1 Yes. Formal monitoring will be needed. Control may be needed, depending on the results of monitoring.

2 No. Only casual monitoring will be needed. Specific control measures will probably not be needed next season.

Do I have all of my preventive management strategies in place?

If the pest or disease was a problem last season, start by carrying out some preventive management. Often prevention reduces the number and severity of problems encountered during the season. This manual contains suggested preventive management strategies for the most serious pests and diseases of the Australian summerfruit industry.

What is my plan for each pest and disease that has been a problem recently?

Planning on the run usually doesn't work; plan well in advance.

Have you been happy with the management options you've used for each pest and disease in the past? Look at your records and consider:

- Did it work?
- Was it cost effective?
- Did it cause secondary problems, such as mite outbreaks?
- Did it cause any other problems? Health, disposal problems?
- Residues?

Consider alternatives

Even if something is working well, there may be an even better alternative. If for any reason you're not happy with some aspect of pest and disease management, change it. Be conservative to reduce risk: trial major changes to your pest and disease management on small, low value blocks before using them more generally.

This manual provides a number of pest and disease management options for the major insect pests and diseases of Australian Summerfruit.

Can more blocks be put under IPDM?

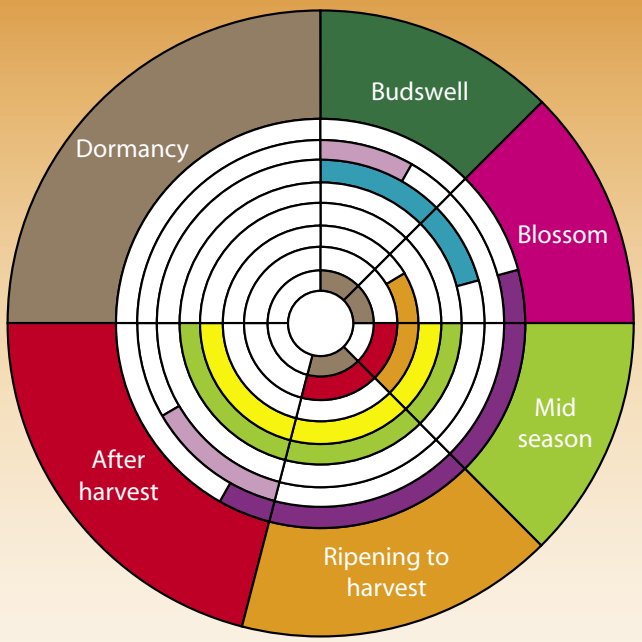
Consider switching more blocks to IPDM if:

- pest and disease losses in IPDM blocks are no higher than those in other blocks, and/or
- pest and disease losses in IPDM blocks are no higher than they were before conversion to IPDM.

Pest and disease fact sheets

Summary of pest and disease monitoring times

Summerfruit disease monitoring times

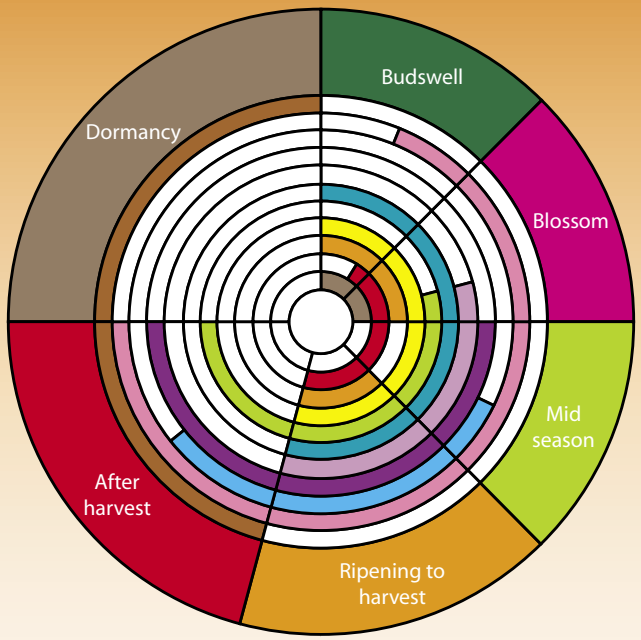


What to monitor

- Fruit
- Flowers
- Leaves
- Twigs and branches
- Whole tree

	Brown Rot and Blossom Blight	Page 27
	Freckle	Page 40
	Leaf Curl	Page 50
	Silver Leaf	Page 80
	Rust	Page 70
	Bacterial Spot	Page 18
	Bacterial Canker	Page 14
	Shot Hole	Page 77

Summerfruit insect pest monitoring times



What to monitor

- Fruit
- Flowers
- Leaves
- Twigs and branches
- Whole tree
- Trap

	Plague Thrips	Page 65
	Western Flower Thrips	Page 65
	Lightbrown Apple Moth	Page 53
	Peach Aphids	Page 23
	San José Scale	Page 74
	European Earwigs	Page 37
	Fruit Flies	Page 43
	Two-Spotted Mite	Page 84
	Carpophilus Beetle	Page 32
	Oriental Fruit Moth	Page 57
	Peach White Scale	Page 63

Bacterial canker

Pseudomonas syringae* pv. *syringae
Pseudomonas syringae* pv. *morsprunorum

IPDM quick facts

Sample unit: *Whole tree*

When to monitor: *Early to mid-budswell*

How often: *Check fortnightly*

When to monitor: *After harvest but before leaf fall*

Action level: *If present*

Weather should also be considered when determining action levels.

Take action if the block has been infected during the last two seasons and:

- ***it has been wet and windy in autumn and early winter (before and during leaf fall)***
- ***limbs have been damaged by pruning, hail or wind during early dormancy***
- ***there has been rain during the growing season (this spreads the disease)***
- ***wind-driven rain and hail rip leaves off and damage bark when cankers are active.***

Causes and consequences

Bacterial canker is caused by the bacterial pathogen *Pseudomonas syringae* pv. *syringae*. *Pseudomonas syringae* pv. *morsprunorum* also causes the disease and is present in Australia. This disease can affect all tree parts. It is a major problem in all summerfruits.

Economic losses result from a reduction in fruit yield, and from branches or whole trees dying.

Symptoms

Trunks and branches

The bark is killed, and when the sunken surface bark is removed the underlying bark tissue is orange to brown, often with a strong, sour smell. Copious amounts of gum may exude from the trunk and bark cankers. Dead areas of tissue become sunken as surrounding areas of healthy

tissue continue to grow, resulting in the typical canker. These symptoms are similar to those caused by other summerfruit diseases. The differences between these diseases is outlined in Table 6; page 93. Peach trees can carry cankers that are not visible externally but weaken the tree throughout its life.

There is often extensive suckering following infection.

Shoots

Soft new shoots wilt and die back from the tips and turn brown. Cankers can form on shoots as a result of infection through the leaf scar (where leaf was attached).

Buds

Dormant buds become brown and fail to break. Behind the bud, an area of dead tissue develops on the shoot. This area may be sunken and appear brown and damp underneath.

Flowers

Infection in spring causes flowers to turn brown and die. This symptom is easily confused with blossom blight caused by the fungal pathogens *Monilinia fructicola* and *Monilinia laxa* (page 27). If fungicide applications for blossom blight are not effective it is possible that the disease is actually bacterial canker (also known as bacterial blast).

Leaves

On younger leaves infection appears as water soaked spots. As leaves age, the spots turn brown and drop out, giving a 'shot-hole' effect. Other symptoms can occur, such as thin, narrow, often rolled yellow leaves, particularly on peach and plum trees.

Fruit

Infection causes sunken spots with dark centres and sometimes underlying gum pockets.

A serious regional issue during the last 10 years in:

- Adelaide Hills
- Riverlands
- Manjimup/Donnybrook
- Swan Hill
- Perth Hills
- Sydney basin

Dead limbs can be seen on trees infected with bacterial canker

Prevention

Choosing species and varieties

All species of summerfruit are susceptible to bacterial canker. Apricots are more susceptible than peaches, nectarines and plums. Therefore, in orchards prone to bacterial canker infection, avoid planting apricots.

Orchard management

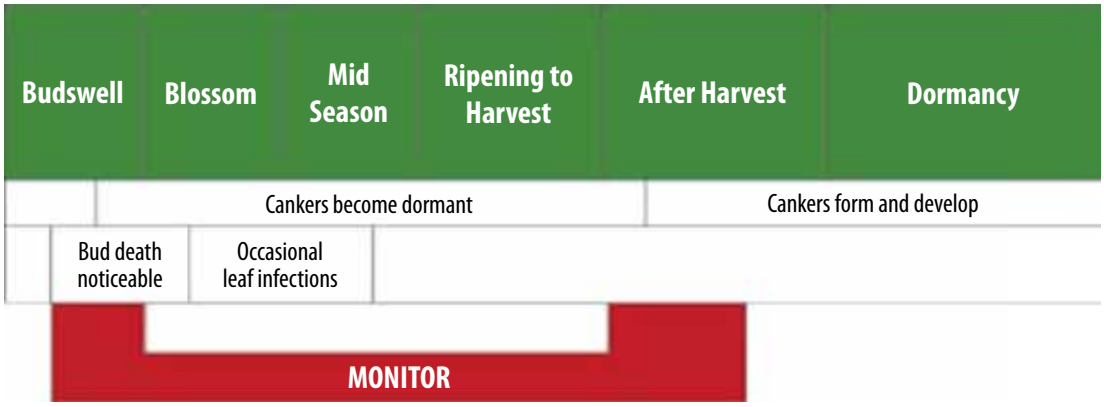
Avoid any damage to trees during the highly susceptible autumn period. Protect trees from wind-driven rain. Avoid overhead irrigation. Avoid using high nitrogen fertiliser rates in mid- to late summer, as this will encourage late season growth, and the soft tissue will become infected as the cankers become active. Do not damage trees when moving equipment around the orchard, particularly around headlands. Paint tree butts with white acrylic paint to prevent wounds caused by sunscald. Avoid planting in shallow, coarse and/or acidic soils, as these soils favour disease development.

Monitoring

When to look

There are two critical times for monitoring for bacterial canker (see chart overleaf).

Look carefully at marked monitoring trees soon after leaf fall. Observation at this time is useful, as it is easier to observe limb lesions. Observe marked monitoring trees carefully at weekly intervals for approximately 3 weeks after leaf fall. This will help to plan for next season. Examine your other trees during your walk between the marked trees. Pruning can also be done at this time. Pruning out cankers is effective only when there are relatively few of them.



Carefully monitor marked trees weekly from early to mid-budswell for bud death. Also consider the amount of rain that has fallen during the growing season, as rain spreads the disease through the orchard.

What to look for

When monitoring the orchard, look for rough cankers with amber-coloured gum. Sometimes gum is not produced, but when the bark is peeled back the flesh of the tree is fermented, brown and sour smelling. Look particularly hard around crotches.

Bacterial bud dieback (bacterial blast) looks similar to blossom blight caused by the fungus *Monilinia* (page 27).

A monitoring form for this disease is included on page 131.

Appropriate action

Action threshold

If canker is seen (see chart at top of following page).

Active bacterial canker on a peach tree

Pruning

In badly affected orchards avoid pruning in winter when cankers are active. Winter pruning will spread the disease. It is recommended that:

- pruning should be delayed, possibly until as late as bud burst. This is particularly the case for young non-bearing trees and apricots, which are highly susceptible, or
- pruning should be done after harvest, well before leaf fall.

Bacterial canker can also be spread by pruning implements. Prune areas in the orchard with bad canker problems last, and be sure to disinfect pruning implements frequently in an effective disinfectant (such as a 1 in 10 solution of household bleach). If you are pruning out discrete cankers on limbs, ensure the cut is at least 15 cm below the visible lesion.

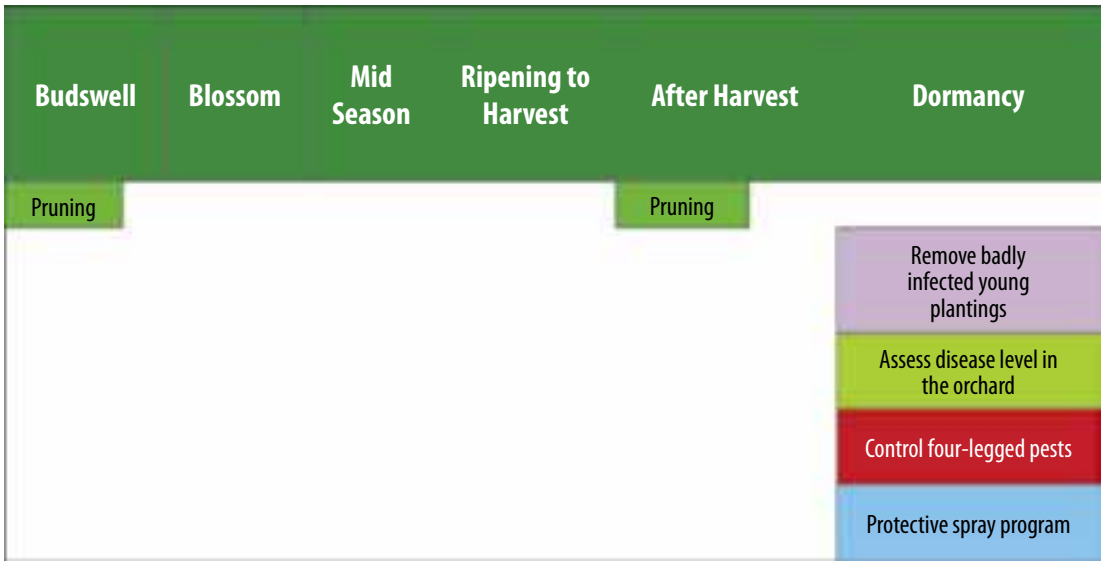
Prune so that the weight of a heavy crop isn't likely to split the tree at the crotch. Splits create sites for canker infections.

Paint large pruning wounds with white acrylic paint, particularly where canker has been a problem.

In all but the mildest of infestations, pruning should be considered supplementary to a thorough spray schedule.

Remove badly infected young plantings

Don't neglect young trees (less than 4 years old). Winter is a good time to assess whether recent plantings have bad bacterial canker infections. Pay particular attention if there has been hail. Treatment depends on the severity of the problem. If the problem is small to moderate, treat young trees as you would mature trees. If the problem is serious, consider pulling out the affected trees and planting healthy ones. Seriously infected young trees are unlikely ever to do well and will be a source of infection for the rest of the orchard.



Assess disease level in the orchard

Quantify the number of trees with the disease in your orchard every winter. Examine 20 trees in each hectare and record the number with bacterial canker. This allows you to determine whether your control strategy is working and plan for next season.

Control four-legged pests

Wounds are prime sites for bacterial infection as well as for a number of other diseases. Try to minimise rabbit, hare and wallaby damage. Young trees can be severely damaged from early May through to late August. Place apple or plum prunings around headlands—these are very attractive to pests and help to divert them from trees. Scatter a fresh lot of prunings every 2 or 3 weeks. Another option is to cover the trunks with aluminium-coated paper. Staple the paper around the tree, foil side out. Plastic guards are also available commercially. Sound netting fencing may keep pest animals out.

Protective spray program

Where conditions favour the disease, or disease levels during the last dormancy indicate heavy disease pressure, a full schedule of protective copper bactericide applications is recommended. This disease has the potential to seriously reduce yield, and under conditions conducive to this bacterium a conservative approach is warranted.

Thorough spraying is essential. Aim to get the best possible coverage of the limbs.

A spray schedule for this disease can be found on page 137.

Spot spray copper oxychloride if

- the tree splits at the crotch
- trees are damaged by animals (e.g. hares, wallabies) when cankers are active.

Fungicides applied for fungal blossom blight will not control bacterial bud dieback. If fungicides have been applied without effect, there is a possibility that the problem is bacterial—pay close attention to early copper applications next season.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Dick J, Wood P (1998) *Bacterial Diseases of Stone Fruit.* Farmnote 98/91. Agriculture Western Australia. Available through the DAWA website, www.agric.wa.gov.au

Bacterial spot

Xanthomonas arboricola* pv. *pruni

IPDM quick facts

Sample unit: *Inspect whole trees*

When to monitor: *Early budswell to mid-blossom*

How often: *Weekly*

Action level: *If present.*

Weather should also be used to determine action levels

Take action if the block has been infected during the last four seasons and:

- ***it has been wet between blossom and petal fall***
- ***if early season infections have occurred and conditions have been windy and wet during the growing season (secondary infections).***

Causes and consequences

Bacterial spot is caused by the bacterial pathogen *Xanthomonas arboricola* pv. *pruni*. Losses can occur directly from infection of fruit. Up to 50% of the fruit on susceptible varieties may be unsaleable. Extensive defoliation and twig dieback result in stunting and gradual loss of leaders from season to season.

Symptoms

Buds

Expanded buds become blighted and may fail to unfurl.

Leaves

Leaf spots appear in spring as greasy or water-soaked angular areas (partly confined by leaf veins). Spots dry to a light tan, then darken with age, becoming dark brown to black. As the leaves expand, diseased tissue separates from surrounding healthy tissue and may drop out to give a shot-hole symptom. This is easily confused with fungal shot-hole caused by the pathogen *Wilsonomyces carpophilus*, but the bacterial spot disease can usually be recognised by the oily sheen and sharp angles of the young lesions.

The spots often join, and where infection is heavy, affected areas become pale yellow-green or reddish. Extensive spotting results in ripping and tattering of the leaves. Premature defoliation may occur.

Stems

Small greasy lesions appear on the rapidly growing young branches in early spring. They become elongated, depressed and tan. Cracks may form in the lesions and develop into open cankers from which gum exudes. Cankers may also develop during summer after leaf symptoms are well developed.

Bacterial spot on young plum fruit

Bacterial spot leaf lesions on plum (A) and peach (B)

Plum fruit infected by bacterial spot. Note the water-soaked appearance of lesions.

Stem cankers are rarely larger than 1 or 2 cm but, if numerous, they may cause shoot distortion or dieback.

Fruit

Lesions appear in late spring as circular greasy spots that become sunken and darken as the fruit enlarges. The centre of each spot frequently cracks and may ooze gum. Roughened cork tissue develops on the edges of lesions as the fruit continues to expand.

Plums develop fewer, larger lesions, whereas peaches and nectarines develop numerous small spots, sometimes with deep cracking and pitting.

Peach fruit infected by bacterial spot

A serious regional issue during the last 10 years in:

- Adelaide Hills
- Goulburn Valley
- NSW southwest slopes
- Perth Hills
- Alstonville
- Riverlands
- Granite Belt
- Swan Hill
- Tasmania
- Sydney Basin

Prevention

All bacterial diseases are difficult to control once established, and it is therefore important that

you are vigilant in preventing the disease from entering your orchard.

Choosing species and varieties

Bacterial spot affects all summerfruit. The most serious symptoms occur on plums. Although no varieties of plum are resistant, some are more susceptible than others (Table 2). Buy and plant only vigorous, disease-free trees from a reputable nursery.

Table 2. Susceptibility of plum varieties to bacterial spot

Name	Susceptibility†
Autumn Giant	1
Blackamber	1
Durado	1
Friar	1
Roysum	1
Stirling	1
Tegan Blue	1
Queen Rosa	2
Queensland Red Ace	2
Red Beaut	2
Casselman	3
Ruby Blood	3
Santa Rosa	3
Satsuma	3
Bellerosa	4
Black Santa Rosa	4
Kelsey	4
Simka	4
Donsworth	5
Earlisweet	5
Mariposa	5
Narrabeen	5
Radiance	5
Wilson	5

† Rated from 1 (very susceptible) to 5 (less susceptible) Information courtesy of the Queensland Department of Primary Industries and Fisheries

Orchard design

Orchards in exposed locations are more vulnerable to attack by the disease than those in sheltered situations. Avoid low-lying sites with poor air and soil drainage.

Overhead irrigation is a serious obstacle to disease control. Avoid irrigation systems that wet the leaves. Plant windbreaks because they reduce the chance of spread by windblown rain. However, dense windbreaks can block the spring and summer breezes that dry trees. Therefore, make sure that the undergrowth at the base of the windbreak allows some gentle air movement.

Dieback due to bacterial spot stem lesions

Pruning and shaping trees

Pruning to allow thorough spray penetration and more rapid drying of the canopy helps to reduce the severity of the disease and increases tree vigour. Do not prune or tree train during wet weather. Pruning of visible disease cankers is of little value in controlling the disease.

Maintaining soil fertility

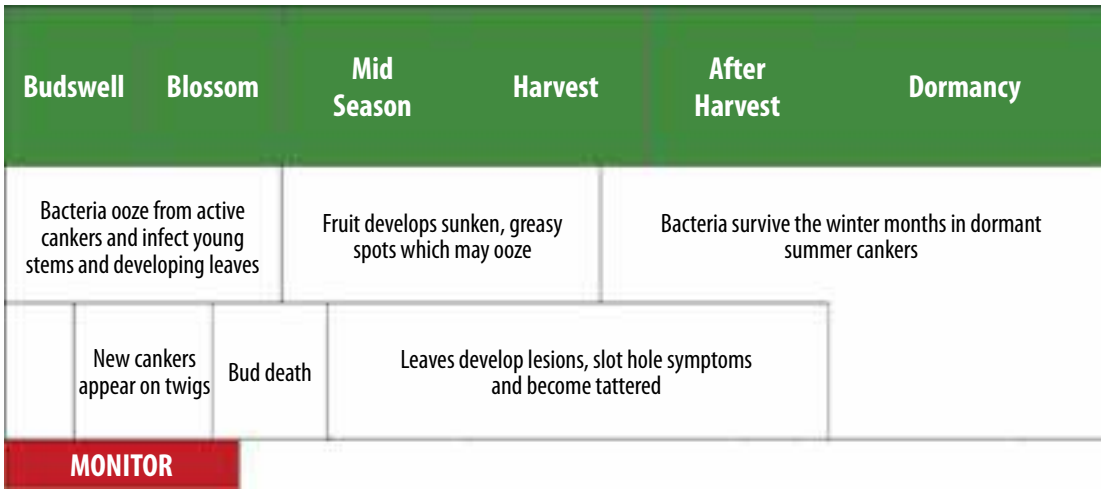
Trees under nutrient stress or stress caused by the presence of other diseases or insect pests are more susceptible to bacterial spot infection. Therefore it is advisable to maintain high levels of soil fertility and use a good pest management program.

Prevent the introduction of new disease.

Destroy nearby feral or neglected *Prunus* trees, as they can act as reservoirs for the disease. Avoid planting new blocks near blocks that have the disease.

Monitoring

Bacterial spot spreads quickly through an orchard and can cause serious losses. Symptoms occurring early in the season are often difficult to detect. Monitoring is therefore difficult and in some cases ineffective. The presence of the disease indicates that early disease control is necessary next season.



When to look

Monitor weekly from early budswell to mid-blossom. Bacterial spot is favoured by periods of rain, heavy dews, hail, warm temperatures and high winds during the growing season. Be particularly careful with your control measures during these times, (see chart at top of page).

What to look for

Examine the twigs and young growth on your marked monitoring trees very carefully. Look for lesions. You will find them only by thorough examination.

Control must be applied early in the season. Therefore, monitoring must target the small cankers that become active on twigs. These are difficult to see, but by the time fruit infection is obvious control measures are futile.

Cankered twigs

Appropriate action

Action threshold

If bacterial spot is seen. Once bacterial spot is detectable it is difficult to control. Orchardists should

- use strategies to reduce its rate of spread (see 'Prevention')
- take precautions early next season.

In reality, by the time symptoms are seen it is probably too late for complete control. Expect some losses. In this case the action threshold is an indicator that appropriate action will be required very early next season.

Protective spray program

No effective protectant bactericides have Australia-wide registration for application after shuckfall. Copper oxychloride is registered in **Queensland only** for this use. In cases where bacterial spot has been a serious problem in previous years it is best to be cautious and apply a protectant copper fungicide schedule for other diseases. For example, protectant copper applications are frequently made during dormancy to control bacterial canker (page 137). These may have an effect on bacterial spot. A Summerfruit Australia Limited project is currently developing control strategies for this disease.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it

has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Dick J, Wood P (1991) *Bacterial Diseases of Stone Fruit.* Farmnote 98/91. Agriculture Western Australia. Available through the DAWA website, www.agric.wa.gov.au

Horlock C (2003) *Bacterial Spot of Stonefruit. Identification Chart for Fruit, Leaves and Stems*. Queensland Department of Primary Industries and Fisheries. Available at the QDPIF website, www.dpi.qld.gov.au/

Russell D, Topp B, Banks A (2004) *Japanese Plum Cultivars for the Granite Belt.* Queensland Department of Primary Industries and Fisheries. Available at the QDPIF website, www.dpi.qld.gov.au/

Stephens P (2001) *Clay may get the Better of Stonefruit Disease.* Queensland Department of Primary Industries and Fisheries. Available at the QDPIF website, www.dpi.qld.gov.au/

Black and green peach aphids

Brachycaudus persicae* and *Myzus persicae

IPDM quick facts

Sample unit: *Trees*

When to monitor: *Budswell to mid-summer*

How often: *Fortnightly*

Action level:

- *young trees (< 3 years old): one colony per tree*
- *older trees: > 2 colonies per tree*

Take extra care when monitoring during spring, when growing conditions are good. Populations decline during hot, dry winds and conditions that harden tree growth.

The pests and their damage

Winged and wingless adults of black peach aphid are shiny black and about 2 mm long. Nymphs are reddish-brown.

Green peach aphid nymphs are pale yellowish-green and have three dark lines on the back of the abdomen. Wingless females and winged individuals are pale green or pinkish and around 2 mm long. This is the most important aphid in virus transmission; this aphid can transmit over 100 plant viruses.

Aphid infestation can cause leaf distortion.

Aphids feed on the leaves, extracting sap and causing leaves to yellow and drop. Honey dew produced by a heavy infestation during the growing season may result in the development of sooty mould on the tree and fruit.

Black peach aphid

Winged green peach aphid

Green peach aphid

Leaf distortion caused by black peach aphid

Sooty mould at the stem ends of nectarines that have been heavily infested by black peach aphid. Note that many of the remaining aphid bodies have been parasitised by natural predators.

A serious regional issue during the last 10 years in:

- Adelaide Hills
- Goulburn Valley
- Sydney Basin
- Tasmania

Prevention

Encourage biological control agents

The activity and efficiency of biological control agents will depend partly on the absence of insecticides likely to be toxic to them. Therefore, to maximise natural control within the IPDM program, avoid using these insecticides in spring (for more information see page 112).

Appropriate use of fertilisers

Avoid excessive amounts of nitrogen fertilisers, which promote soft plant tissue. New soft plant tissue promotes higher aphid populations.

Reduce weeds

Control weeds around orchards. Weed host plants are often reservoirs for migrating aphids. Prune out water shoots.

Monitoring

When to look

Look at leaves on four lateral branches of each of the marked monitoring trees from budswell to ripening at weekly intervals. Aphid numbers can build up very quickly, so it is advisable to monitor relatively frequently (see chart on next page).

Biological control agents can be effective controls of peach aphids

Budswell	Blossom	Mid Season	Ripening to Harvest	After harvest	Dormancy
Wingless adult aphids emerge on leaves			Winged adults form	Aphids return to orchard. Eggs laid on bark	Eggs overwinter on bark or around the buds
MONITOR					

What to look for

Inspect the underside of leaves for colonies as growth begins, and continue until midsummer.

Appropriate action

Action threshold

Young trees (< 3 years old): one colony per tree

Older trees: > 3 colonies per tree

(See chart overleaf).

There are now several very effective insecticides for control, but growers practising IPDM can limit or even avoid the need for these.

Oil sprays

In cooler inland districts, green peach aphid overwinters as eggs around the buds. As spring approaches, the eggs hatch and the aphid life cycle begins. At about this time the eggs and the young aphid nymphs are vulnerable to suffocation by oil sprays.

Oil at budswell will provide reasonable control of aphids. Those that do survive will become prey for predators and parasites that will arrive later in spring.

Examine the undersides of leaves for peach aphid infestations

The oil spray can be combined with copper sprays for leaf curl and shot-hole. A decision on the use of oil at budswell needs to be made in conjunction with the use of oil for San José scale control (page 76). It is important that two applications of dormant oil are not made in the one winter.

If you decide to try to control two pests with the one oil spray, then use only one application of horticultural mineral oil (HMO) at budswell. Use a maximum concentration of 2 L per 100 L, applied thoroughly. A product such as D-C-Tron Plus is registered for use at budswell for scale. Its use then will also help control green peach aphid. Other HMOs that can be used and are registered for both pests are Biopest® and Sunspray® Ultra-Fine™. If used at budswell on summer fruit, limit the concentration to 2 L per 100 L.

Selective aphicides and spot spraying

Where monitoring indicates that the action level has been exceeded, selective aphicides should be applied. Younger trees are more susceptible to aphid damage, and the action level for younger trees is lower. Appropriate action should be taken in blocks of trees younger than 3 years when monitoring indicates that the trees most severely infested have one colony. For older trees, take appropriate action when the most severely infested trees have three or more colonies.

A list of recommended aphicides for each type of summerfruit can be found in the spray schedules at the end of this manual (page 137)

Aphid infestations tend to be patchy, particularly if seen early as a result of monitoring. Consider spot-spraying individually infested trees or groups of trees, rather than spraying the entire block. Considerably less chemical can be used in this way, and money saved.

More information

Some of the information provided in these references comes from other countries (marked †).

Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Strand LL (1999) Aphids. In *Integrated Pest Management for Stone Fruits* †. Statewide Integrated Pest Management Project. University of California Division of Agriculture and Natural Resources, Oakland, California pp. 93–95 †

Blossom blight and brown rot

Monilinia fructicola* and *Monilinia laxa

IPDM quick facts

Blossom blight

Sample unit: *Blossom*

When to monitor: *Budswell to full blossom*

How often: *Weekly*

Action threshold: *If present. Weather should also be used to determine action levels.*

Take action if the orchard has previously been infected and:

- *bud/blossom is wet from rain or dew for 3 to 5 hours when the temperature is more than 20°C, or*
- *there has been hail, or*
- *the temperature has been 20 to 25 °C with showery conditions and cool nights.*

Brown rot

Sample unit: *Fruit*

When to monitor: *Midseason – after harvest*

How often: *Weekly*

Action threshold: *If present.*

Weather should also be used to determine action levels.

Take action if:

- *the orchard has previously been infected, and*
- *there have been frequent rain periods and warm conditions near or at harvest.*

Causes and consequences

Two closely related fungi – *Monilinia fructicola* and *Monilinia laxa* – cause blossom blight and brown rot in Australia.

Blossom blight reduces fruit set by infecting and killing blossom. Brown rot attacks fruit either on the tree or after harvest.

Blossom infection can also lead to dieback of new shoots. It also attacks green fruit, leaves and shoots. Some brown rot infection can be expected in humid areas every year, especially for fruit under netting.

Symptoms

Brown rot causes symptoms on the leaves, shoots, blossom and fruit. Fruit can also be infected close to harvest and remain symptomless but then rot in storage.

Blossoms become infected from spores that have survived through winter on mummified fruit and infected twigs. Infected blossoms turn brown and die and the shoots bearing them are often cankered or blighted. Spores produced on these infected flowers and shoots then spread the disease throughout the orchard.

Blossom blight

Brown rot

Where shoots are infected there is an area of dead or dying bark, which is usually sunken. These cankers often ooze honey-coloured gum.

Fruit is usually infected as it begins to soften and mature. Green fruit can be infected when injured. Monitoring after hail or insect damage is also important.

The first symptoms of brown rot on maturing fruit are small brown spots that rapidly develop into characteristic brown rot. Small grey to buff-coloured tufts of powdery fungus spores form on the discoloured areas about 36 hours after infection. Within 5 days the fruit can be completely rotted and covered with spores.

Infected fruit either fall or remain attached to, or lodge in the tree, where they become dried out and shrivelled or 'mummified'. These 'mummies' can produce spores over a long period of time and are a major source of infection. Brown rot is spread by wind, rain splash and some insects, especially dried fruit beetles (*Carpophilus* spp.).

Although both species of the fungus cause similar symptoms, it is necessary to start treatment for blossom blight caused by *M. laxa* 2 weeks earlier than for brown rot. Symptoms of blossom blight tend to appear earlier when caused by *M. laxa* – as opposed to *M. fructicola*. In trying to control the disease it is therefore important to know which pathogens are present in you orchard. Send disease samples to a diagnostic laboratory and they will be able to tell you which pathogen is dominant in your orchard. If the dominant species is *M. laxa*, you should begin treatment approximately 2 weeks earlier than if it is *M. fructicola*.

Symptoms similar to those of blossom blight and twig canker can also be caused by *Pseudomonas syringae* pv. *syringae* (the bacterium that causes bacterial canker; page 14). Treatment for blossom blight will not affect the symptoms caused by this bacterium.

If you are unsure about the pathogen causing the symptoms, submit a sample for diagnosis.

A serious regional issue during the last 10 years in:

- Adelaide Hills
- Manjimup/Donybrook
- Riverlands
- Sydney Basin
- NSW southwest slopes
- NSW central west
- Granite Belt
- Tasmania
- Alstonville
- Goulburn Valley
- Swan Hill

Prevention

Choosing species and varieties

If you know that your area has a problem with brown rot, select varieties or species with higher resistance to the disease. For example, apricots are generally more susceptible to blossom blight than are peaches, nectarines and plums. Small flowered peach varieties are less susceptible to blossom blight than are large flowered varieties. Thick-skinned fruit, such as the sugar plum, are often less prone to fruit rot than thin-skinned varieties. However, no summer fruit species or variety is immune to infection.

Orchard design

When designing a new orchard or planting, align the rows to allow good spring and summer breezes through the whole planting (north–south rows). Thin out the surrounding bush and the undergrowth in dense windbreaks. Anything that will increase the rate of drying after rain or dew will help to reduce brown rot. Brown rot tends to be more severe under bird, flying fox or hail netting.

Blossom blight on apricots. Note the gumming at the bases of the flowers.

Early symptoms of brown rot on peach

Early symptoms of brown rot on plum

Pruning and shaping trees

Prune and shape trees to allow good spray penetration. It is hard to get adequate spray coverage on trees that are very dense or tall. Fruit in dense trees dries more slowly than fruit in open trees. Dew can provide enough moisture to allow infection of ripe fruit, and because fruit remains wet longer in dense trees, the risk of infection is increased.

When pruning and thinning, try to prevent fruit from touching. This will make it easier to achieve proper spray coverage before harvest and will prevent the spread of brown rot by fruit-to-fruit contact.

Monitoring

Because blossom blight and brown rot are widespread and have the potential to seriously reduce crop production, it is recommended that a combination of monitoring for the disease and weather be used to determine whether appropriate action should be undertaken. If **any** action threshold is reached, take appropriate action.

When to look

Weekly monitoring is recommended during the critical times for infection. Monitor more frequently if possible (see chart below).

Examine all developing flowers on four lateral branches of all marked monitoring trees for symptoms during the period from budswell to late blossom.

Examine all fruit on four lateral branches of the marked monitoring trees from mid-season to harvest.

What to look for

Blossom blight. Look for dead twigs and blossom. Examine them closely and look for clear to honey-coloured gum.

Brown rot. Look for soft brown areas on the surface of the fruit, usually accompanied by fluffy white-grey fungal material.

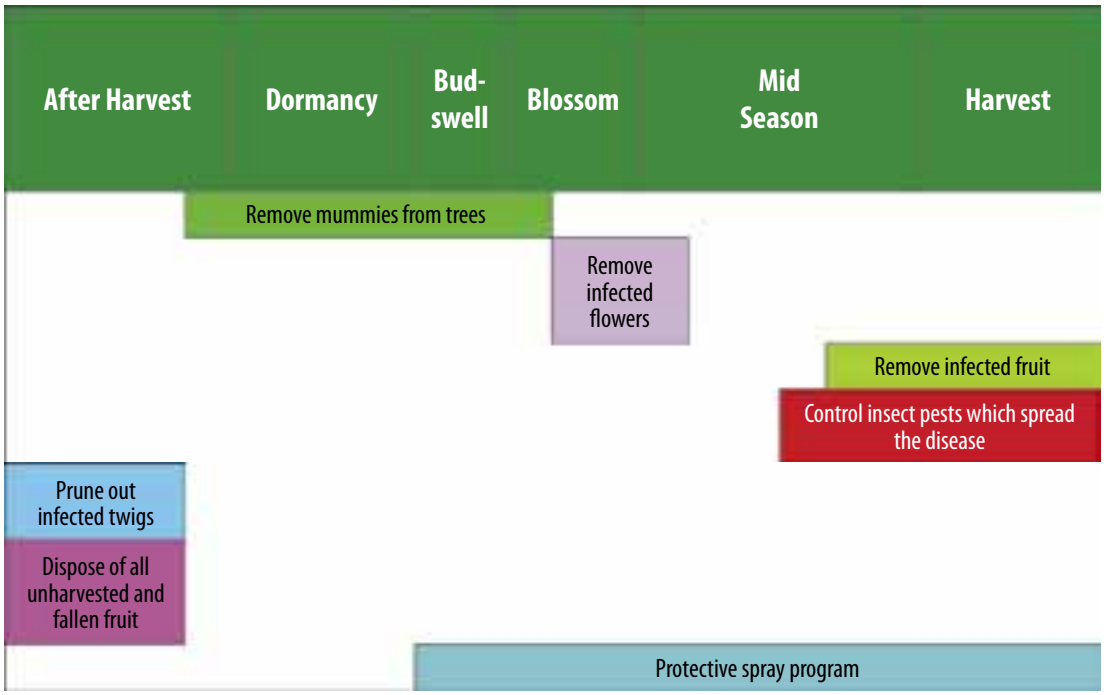
Appropriate action

Action threshold

If either blossom blight or brown rot is observed (see chart overleaf).

Good orchard sanitation is critical. Unless sanitation measures are thoroughly carried out, spraying with fungicides will be of limited use.

After Harvest	Dormancy	Budswell	Blossom	Mid Season	Harvest
Rotten fruit provides an infection source for next season	Mummified fruit and infected twigs provide overwintering sites		Spores infect blossoms	Spores dormant in developing fruit	Maturing fruit triggers fungal development. Infection spreads on wet fruit surfaces
			MONITOR		



Remove mummies from trees

During the growing season, remove any mummies or shrivelled or dead fruit that have been overlooked earlier. Also remove any fruit that has been damaged by hail or insects.

Remove any remaining mummies during winter pruning, as they are easier to see at this stage. Take care to examine the crotch of each tree for lodged mummies (particularly in larger trees). Bury or burn all of this diseased material with the prunings.

Remove infected flowers

Towards the end of blossoming, remove and burn any diseased shoots. Check again for diseased shoots when thinning.

Remove infected fruit

One month before harvest, start inspecting each variety every few days. Remove from the orchard any fruit infected with brown rot. Continue removing infected fruit until harvesting is complete. Removing infected fruit restricts the build-up of spores and slows the spread of the disease. It also restricts the opportunity for the fungus to grow from fruit into the peduncles and reduces the number of sites that can produce spores the following season. Remove rotted fruit during periods of high humidity and low wind velocity (usually early in the morning), as spores are not well dispersed in these conditions.

Control insect pests that spread the disease

Brown rot spores need a wet surface to germinate and infect tissue, and injury can provide a surface wet with sap or fruit juice. Control insect pests that cause fruit injury, such as the oriental fruit moth (*Grapholita molesta*), the lightbrown apple moth (*Epiphyas postvittana*) and dried fruit beetles (*Carpophilus* spp.). Good insect pest control is essential for successful brown rot control.

Brown rot mummies

Remove rotting fruit from the orchard floor

Prune out infected twigs

If bad weather makes it impossible to maintain a sanitation program and a serious outbreak of brown rot occurs, prune out blighted and badly cankered shoots immediately after harvest. Remove any remaining mummified fruit by pruning out the shoots to which they are attached.

Cut out all remaining cankered or dead shoots during winter pruning. They are easier to see at this stage.

Dispose of fruit left after harvest

After each variety is harvested, check the trees again and remove remaining fruit, whether rotten or sound. If possible, collect any fruit remaining on the ground and bury it. In districts where Queensland fruit fly occurs, it is not satisfactory to bury rotten fruit—it must be burned.

Protective spray program

If conditions favour the disease, or monitoring indicates heavy disease pressure, or an orchard has a history of brown rot, then a full schedule of protective fungicide applications is recommended. This disease has the potential to seriously reduce yield, and under these conditions a conservative approach is warranted.

Thorough spraying is essential. Aim to get the best possible coverage of fruit and flowers. Calibrate your orchard sprayers regularly to maximise efficiency. Because of variation in maturity times, varieties may need to be sprayed separately. Spray application at budswell and blossom is particularly important.

After considering the level of infection during previous seasons and the results of monitoring, you may find it possible to reduce fungicide applications. Begin a program of spray reduction by applying sprays at a frequency that you are confident will control brown rot. Monitor the level of disease season-by-season. If infection levels are consistently low to moderate, reduce the number of sprays applied to a small number of trees or rows and monitor the disease. If the disease level is low in the test trees or rows, and **dependent on weather**, reduce fungicide applications to a larger area next season. Infection is unlikely during fine and dry weather, particularly between shuckfall and fruit softening; take this opportunity to reduce fungicide applications.

A spray schedule for this disease can be found on page 137.

Postharvest

Avoid picking when fruit is wet.

Several fungicides are registered for postharvest dipping of summer fruit. Where control of brown rot prior to harvest has been good, it is often unnecessary to use a postharvest fungicide dip. Consider your target market and the possible length of storage.

Brown rot resistance to fungicides

In some areas the fungus *M. fructicola* is resistant to some fungicides. For example, in many summer fruit orchards in NSW it is resistant to the benzimidazole (Group A) fungicides. Check with your local district horticulturist if you suspect control failure due to fungicide resistance.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Strand LL (1999) Brown rot. In *Integrated Pest Management for Stone Fruits. Statewide Integrated Pest management Project.* University of California Division of Agriculture and Natural Resources, Oakland California pp. 115–120 †

Washington WS (1999) *Brown Rot of Stone Fruits*. State of Victoria, Department of Primary Industries. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Pocock D (2004) *Brown Rot*. Technical Bulletin, Australian Fresh Stone Fruit Growers Association. Department of Agriculture, Western Australia. Available through DAWA website, www.agric.wa.gov.au

Carpophilus beetle

***Carpophilus* spp.**

IPDM quick facts

Sample unit: *Trap*

When to monitor: *Mid-season to harvest*

How often: *Weekly*

Action level: ***Depends on varietal susceptibility, stage of crop development, climate and block history.***

Pay particular attention to monitoring:

- ***following summer rainfall***
- ***if your orchard or neighbours' orchards have large amounts of fallen fruit***
- ***if the block is near early-maturing varieties of summerfruit or other fruit that hosts* Carpophilus *beetles.***

The pest and its damage

Carpophilus beetles are small (2 to 3 mm long) and brown or black. A distinguishing feature is that their wing covers (elytra) are short and do not cover the last two or three segments of the abdomen. In most other beetles the elytra extend over the whole abdomen.

At least 12 species of *Carpophilus* beetles occur in Australia, although only three (*Carpophilus davidsoni, Carpophilus mutilatus* and *Carpophilus hemipterus*) appear to be economically important.

Carpophilus beetles are serious pests of ripening summer fruit (mainly peaches, nectarines and apricots) in Australia. They are attracted to and penetrate ripening fruit, causing rapid breakdown, which can result in substantial fruit losses. The beetles also serve as mechanical carriers of brown rot (*Monilinia* spp.; page 27), which frequently develops at the sites of beetle entry.

Beetles enter the fruit by chewing through the skin. This entry is usually around the stem end or in sutures. They can also enter through sites of mechanical damage.

In recent years, growers have indicated that losses caused by *Carpophilus* beetles have been as high as 30% of their crops. Many Australian orchardists believe that *Carpophilus* beetle problems have increased over the last 10 years owing to a decline in the use of organophosphates and other insecticides to control other pest species. Damage by *Carpophilus* beetle is most severe as the fruit ripens. *Carpophilus* beetles are highly active pests and can quickly move between blocks and from fruit to fruit within a crop.

A serious regional issue during the last 10 years in:

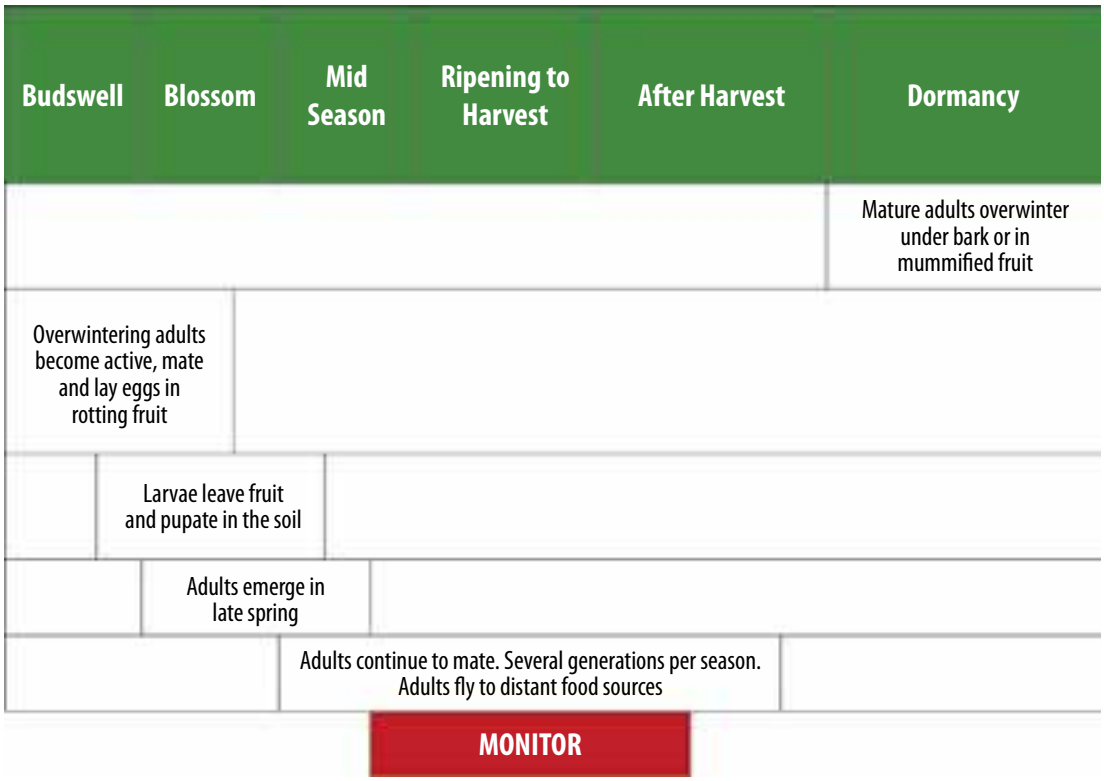
- Sydney Basin
- Southeast Queensland
- Riverlands
- NSW southwest slopes
- NSW central west
- Granite Belt
- Alstonville
- Goulburn Valley
- Swan Hill

Prevention

Orchard hygiene

Many fruit growers dispose of their rejected or waste fruit on their own properties. Fruit packers

Fruit damage caused by Carpophilus beetle



and processors dispose of waste fruit in sites that are often located near orchards. These fruit dumps may act as important sources of *Carpophilus* beetles if they provide good protection and breeding sites during winter and early spring. *Carpophilus* beetle populations that develop in the fruit dumps may invade summer fruit orchards as fruit ripens. If the fruit stays on the ground after harvesting, problems may also occur. The fermentation odours associated with rotting fruit can be detected by the beetles up to 0.5 km from their source and will attract them. The beetles will breed in rejected fruit, increase their numbers and then infest the later-maturing blocks. *Carpophilus* beetles have also been found in mummified fruit during winter and in rotting fruit residues from other crops such as citrus, apples and pears. The removal and destruction of waste fruit from commercial orchards have provided some success in reducing *Carpophilus* beetle numbers.

Fruitfly control

Good fruitfly control (page 46) will mean that less fallen fruit is available for use by *Carpophilus* beetles as breeding sites.

Monitoring

When to look (See chart above)

Carpophilus beetles are good fliers, and adults can travel quite large distances (several kilometres) to find a food source. Populations can build up very rapidly. It is therefore important to monitor the crop frequently so that appropriate action can be taken before severe damage is done.

Early-season crops are more consistently attacked, because populations are at their peak during late spring to mid-summer. This threat is reduced if there have been dry conditions during the previous autumn and/or unfavourable winter conditions.

Weekly monitoring is recommended in the period between stone hardening and harvest. Casual monitoring should also be done after harvest, as this will give an indication of the likelihood of problems next season.

What to look for

Growers can use knowledge of their own orchards to work out which blocks they consider at highest risk of *Carpophilus* beetle damage and monitor with a few traps scattered in these crops weekly until harvest. Just before harvest they should check for *Carpophilus* beetle damage to fruit on trees and on the ground.

Monitoring should only take a few minutes for each trap. We can't give you an example of the beetle numbers that will cause damage to your summer fruit crops, as damage will depend on a range of factors such as the varietal susceptibility, stage of crop development, climate and block history. If you monitor 2 years in a row you will be able to see trends in the number of beetles trapped and compare those trends with your

Carpophilus beetles and the weather

When monitoring, orchardists should also consider the weather, which has an effect on beetle development and life cycles.

- The development duration from egg to adult is 47 to 65 days at 20 °C and 14 to 18 days at 32 to 35 °C.
- More beetles survive at 25 to 30 °C.
- Beetles start to develop only at 14.6 to 15.4 °C.
- Flight does not occur at temperatures below 18 °C.

Southern regions

- The number of beetles peaks in November–December in southern NSW. If there is adequate moisture in December–January, another population peak will occur in February–March.
- If there is average or below-average rainfall in December–January, there will be a lower beetle population in January to March. Beetle problems tend to occur only when the rainfall in December–January is at least double the long-term average.

Inland regions

- Summer populations are usually low, especially when there has been below-average rain.
- Summer rainfall in inland regions is often related to localised thunderstorms, so beetle populations can vary across a region.

Northern coastal regions

- Populations remain at moderate levels around Nambour during summer; this is perhaps associated with high summer rainfall.

levels of fruit damage. This will allow you to determine the risk of *Carpophilus* beetle damage to your blocks.

Funnel traps can be used to monitor *Carpophilus* beetle. Hang the traps approximately 1.5 m high on a branch of peach tree.

To monitor beetles we use an attractant. To make enough attractant for two monitoring traps you need:

1 g bakers' yeast (dry)

200 mL apple juice (100% pure juice)

10 g water storage crystals (Waterwise, Arthur Yates Co., available from hardware stores)

Dissolve the yeast in apple juice uniformly before adding the crystals. Wait approximately 1 hour for the water crystals to absorb the apple juice. Once the crystals have absorbed the juice, store them at 5 °C if you are not going to use them the same day.

Half fill a plastic container with the bait (approx. 250 mL) and secure a piece of fine mesh mosquito net over the top with a rubber band (to prevent the beetles getting into the crystal). Put the plastic container inside the trap and close the trap properly.

Check traps every week and place trapped beetles into a plastic container. Label the container with the date of collection and the trap number. Count the trapped beetles and record the number and location in a field notebook. If the beetle number is high, count a subsample and calculate the approximate number. To do this, use a clear plastic tube such as a blood sample tube (ask your doctor or local hospital for a clean, empty tube). Count 200 beetles and put them in the tube.

Funnel trap for monitoring Carpophilus beetle

Mark the side of the tube to indicate the level of the beetles. Add another 200 beetles and mark the tube. Keep doing this until you have reached 600 beetles. You can now use this calibrated tube to calculate the number of beetles in your traps.

Appropriate action

Action threshold

Because varieties vary in their susceptibility to *Carpophilus* beetles, we suggest that orchardists develop their own thresholds for this pest by considering:

- the number of beetles observed in previous seasons and the subsequent damage
- the loss caused by this level of damage
- the cost of control
- the possible impact on predators and the likely impact that this will have on other pests and diseases.

(See chart at top of page).

Spray insecticides

At present, growers facing infestations beyond their action thresholds have only one control option: spraying insecticides. A spray schedule for this purpose can be found on page 137. Bifenthrin is registered for the control of *Carpophilus* beetles, but remember that this insecticide will also kill non-target, beneficial insects (see page 112). Spray only when it is necessary. The use of bifenthrin can often lead to high populations of two-spotted mite later in the season.

Aggregation pheromone and its use for future management

Male *Carpophilus* beetles produce a special type of secretion called 'aggregation pheromone' when they locate a suitable food source. This attracts other *Carpophilus* beetles to the vicinity. Our team has developed a control strategy based on the use of synthetic aggregation pheromone and a synthetic version of the smell of ripening fruit to attract *Carpophilus* beetles outside the orchards and kill them. The synthetic food attractant was 12 times more effective than fermented apple juice (FAJ). FAJ was used in the comparison because it had been thoroughly evaluated in previous field experiments. The number of *Carpophilus* beetles captured in funnel traps baited with synthetic pheromone and synthetic food attractant was highest compared with the numbers in other traps tested by DPIV scientists. Funnel traps will be used for limited commercial testing of the attract-and-kill system in the 2004–05 season in Goulburn Valley summer fruit orchards.

This system relies on the attract-and-kill system to drastically reduce *Carpophilus* beetle populations in the orchard before the crop ripens and becomes ready to serve as a host to *Carpophilus* beetles. Furthermore, it could be used to reduce the impact of any migrating *Carpophilus* beetles.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Department of Agriculture Western Australia. AGIRD Pest web. Dried fruit beetle. Available through the DAWA website, www.agric.wa.gov.au

Horticulture Australia Limited projects: Summaries are available on the web at www.horticulture.com.au/[.] Final reports may be ordered from Horticulture Australia Limited.

- SF99023—*Chemical Control of Carpophilus Beetle by Bifenthrin & Fipronil*
- SF97003—*Integrated Management of Carpophilus Beetles in Stone Fruit Orchards*
- FR99031—*Developing an Integrated Pest Management Strategy using Pheromones for Controlling Oriental Fruit Moth and Carpophilus Beetles in Orchards*

Il'ichev A (2004). *Integrated Pest Management*

Strategy Using Pheromones for Control of Oriental Fruit Moth and Carpophilus Beetles in Orchards. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

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Primary Industries and Resources South Australia (2001) *Carpophilus Beetle.* Available through PIRSA website, www.dpi.vic.gov.au/dpi/index.htm

Steiner E, Learmonth S, Woods W (1999) *Carpophilus (Dried Fruit Beetles): a Pest of Stonefruit.* Farmnote 56/99. Available through the DAWA website, www.agric.wa.gov.au

European earwig

Forficula auricularia

IPDM quick facts

Sample unit: *Trap*

When to monitor: *Budswell to harvest*

How often: *Fortnightly*

Action level: *When any trap contains five or more earwigs*

European earwigs and their damage on peach

Male (upper) and female (lower) European earwigs

The pest and its damage

Earwigs are brown, elongated insects with distinctive pincers at the ends of their abdomens. Males have broadly bowed pincers; those of females are slender and relatively straight. Adult earwigs are approximately 12 to 13 mm long. They are usually reddish brown. Young earwigs look similar to adults but are olive green.

Earwigs are nocturnal and nest during the day in cool shady places (e.g. beneath stones or debris)

Earwigs have chewing mouthparts and bite holes in young and ripening fruit and eat the flowers. All summerfruit can be attacked by earwigs, but these pests are particularly troublesome on white-fleshed nectarine varieties.

Earwigs cause shallow, irregular depressions in fruit where feeding has occurred. These wounds can be become infected by brown rot.

A serious regional issue during the last 10 years in:

- Adelaide Hills
- Swan Hill
- NSW central west
- Tasmania
- Riverlands

Prevention

Remove alternative shelter

Remove prunings and other debris from around the bases of trees that could provide alternative nesting sites for earwigs. Remove any drooping branches that come in contact with the ground, providing access to earwigs.

As male earwigs emerge (around the middle of budswell), remove mulch from under trees, as this provides shelter and encourages large numbers to build up. Tall weeds that provide shelter for earwigs and keep the orchard floor shaded and moist should be controlled throughout the season, particularly from bud-burst to the end of harvest.

Tree guards can also become nesting sites for earwigs (and snails); if they are not necessary, remove them.

Thinning

Thinning of fruit reduces the shelter available to earwigs and lowers the numbers in the canopy.

Avoid planting near sultana grapes

Earwigs can be a problem in summer fruit orchards that are grown close to vineyards, particularly those producing sultana grapes.

Monitoring

During the day earwigs seek out cool moist refuges (see chart overleaf).

Fruit damaged by European earwigs

Earwig traps made of rolled cardboard are used for monitoring.

You can monitor using corrugated cardboard 'earwig houses'. Secure them in the forks of trees, and monitor fortnightly.

There are several important points to remember when monitoring for earwigs in this way:

- Earwigs move into trees in two distinct waves.
- The first wave is made up of males. These males move into trees after being ejected from the brood chamber by the females, as they pose a threat to the developing young earwigs on the orchard floor.
- The second wave has more females and young earwigs.
- You need to consider these waves when monitoring. Management action after the first wave will not control later earwigs. Maintain monitoring from budswell to ripening, and take appropriate action whenever numbers reach the action threshold of five earwigs per trap.
- Cardboard traps may need to be changed periodically, particularly after rain, but change them as little as possible. When they have found a suitable shelter, earwigs secrete an aggregation pheromone to attract others. For this reason, older traps are more likely to attract earwigs and be more effective in monitoring.
- A more durable (though probably less effective) alternative to rolled corrugated cardboard is an upturned piece of treated pine-grooved decking wood.
- Don't secure cardboard traps in trees with drawing pins or any other fasteners containing copper, as this will kill the tree.

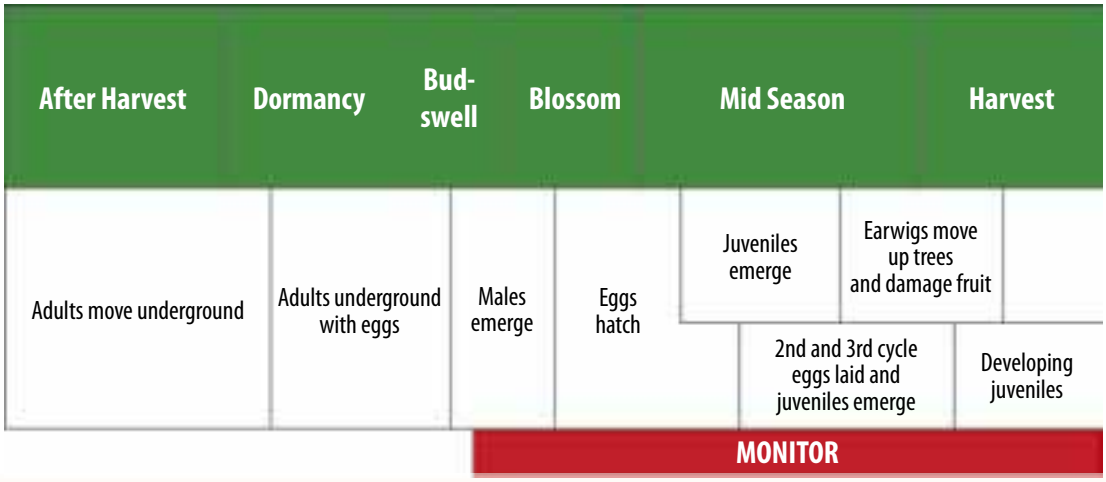
Appropriate action

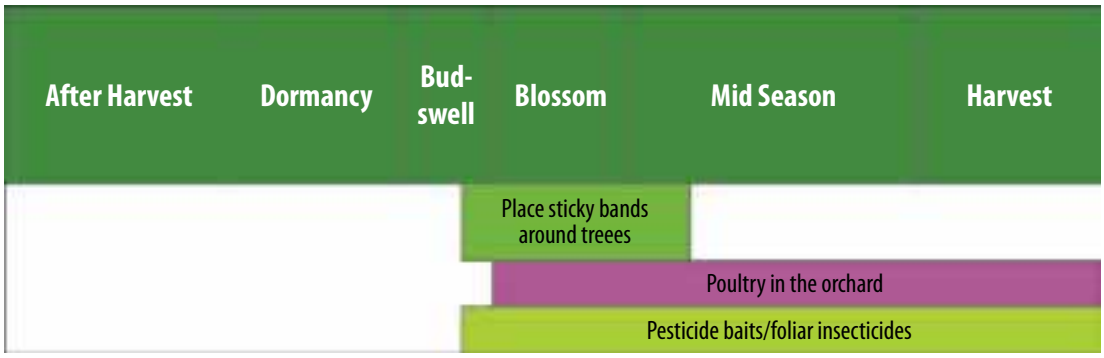
Action threshold

When any trap in the orchard contains five or more earwigs (see chart at top of next page).

Place sticky bands around trees

Sticky bands can be placed around the butts of trees. This must be done early (budburst). If this is left until later in the season there is a risk that earwigs that have moved into the canopy of the tree will be trapped there and cause severe damage.





Poultry in the orchard

Keeping poultry in the orchard from the end of bud-burst through until the end of harvest can help with earwig problems and may also be useful where European snails are a problem. However, be aware that this is not an option if chemical baits are used.

Pesticide baits / foliar insecticides

If earwigs have been a persistent problem in previous seasons, consider supplementing other control measures with insecticides. **Be aware that registration of the insecticides used against earwigs varies between States. Orchardists may use only products that are registered for use within their own States. Always check the product label.**

Chemical baits can be applied where monitoring indicates that earwigs are present in large numbers in the orchard.

Chlorpyrifos product labels include instructions for mixing baits to control earwigs. Spread them at dusk: apply around the tree butts in every second row.

Where baits have failed in previous seasons, foliar or butt applications of insecticides can be used as a last option. Chlorpyrifos is preferred to carbaryl, as carbaryl is likely to disrupt the activity of natural predators of pest mites. Some orchardists consider this option ineffective, as earwigs tend to move into shelters and these applications may not make contact with them.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Domeney P (2002) *Helpful Insect or Harmful Pest—The Earwig*. Available at the Tasmanian Department of Primary Industries Water and Environment website, www.dpiwe.tas.gov.au

Elliot J (2002) *European Earwig* (*Forficula auricularia*). Available through the Department of Agricultue Western Australia website, www.agric.wa.gov.au

Freckle

Cladosporium carpophilum

IPDM quick facts

Sample unit: *Fruit*

When to monitor: *Mid season to after harvest*

How often: *Fortnightly*

Action threshold: *If the block has been infected during the last 4 years and it has been raining and temperatures during the 4 week period following shuckfall have been between 18 and 24 °C.*

Take care when monitoring and managing young orchards.

Causes and consequences

Freckle or scab is caused by the fungal pathogen *Cladosporium carpophilum*. The main symptoms of the disease occur on the fruit, but lesions also occur on leaves, twigs and young branches. The fungus survives through winter on these twig lesions. In spring, spores are produced and splashed onto developing fruitlets and young twigs by wind-blown rain.

Symptoms

Fruit

Symptoms first appear on fruit when they are half formed, approximately 6 or 7 weeks after petal fall. The first symptoms are greenish brown to black spots that appear primarily around the stem end of the fruit.

When the infection is severe these lesions can coalesce to form a greenish, velvety, blotched area.

Although the lesions are superficial and do not extend into the flesh of the fruit, they affect normal growth and the fruit becomes misshapen and cracks.

Twigs

Raised lesions occur on the current year's growth. They are initially light brown but become darker later in the season. Although they are superficial and do little harm to trees, they play a crucial role in the disease cycle by providing a site for spore survival through winter.

Leaves

Leaf lesions first appear late in summer as pale green areas. These develop into dark brown,

Freckle on nectarines

Freckle symptoms around the stem end of the fruit

narrow lesions. In extreme cases these lesions can cause premature defoliation.

A serious regional issue during the last 10 years in:

- NSW southwest slopes
- Swan Hill
- NSW central west
- Sydney Basin
- Riverlands

Prevention

Orchard design

When planting a new block, align the rows to allow good spring and summer breezes through the whole planting. Thin out surrounding bush and the undergrowth in dense windbreaks. Anything that will increase the rate of drying after rain or dew will help to reduce the incidence of freckle.

Avoid planting in low-lying areas.

Pruning

Prune trees to allow good air circulation; this promotes rapid drying of fruits, twigs and leaves.

Monitoring

To prevent the occurrence of the disease in the current season it is far more effective to monitor the weather than the disease, particularly where blocks have a history of freckle infection. Twig lesions are difficult to see, and because the disease becomes visible on fruit only 40 to 70 days after infection a substantial disease outbreak can occur before monitoring detects the problem. (See chart on next page).

Freckle on fruit is usually most severe in the first year that trees bear. Be extra vigilant in monitoring young blocks. When monitoring fruit, pay particular attention to the stem end, as this is where lesions first appear.

When to look

Monitor the weather from late blossom to after harvest.

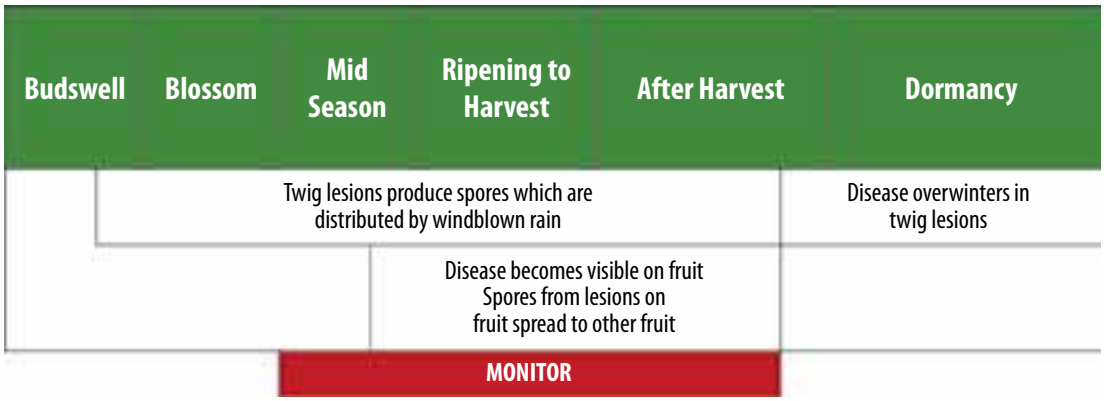
Monitor all fruit on four lateral branches of marked monitoring trees during this time. If disease is observed it is likely that substantial damage will have occurred, but immediate appropriate action will limit this. Twig and fruit infection indicates that appropriate action should be taken early next season.

What to look for

Weather favouring infection is the most reliable early indicator of this disease.

Twig infection is difficult to see and is unlikely to be observed. Fruit infection indicates that appropriate action should be applied early next season.

Freckle lesions on twigs



Appropriate action

Action threshold

Take appropriate action (see chart at bottom of page) if the block:

- has been previously infected, and
- it has been raining and temperatures during the 4-week period following shuckfall have been between 18 and 24 °C.

Monitoring allows early detection of freckle in the block. You should then take appropriate action to minimise spread. Take action **before** symptoms appear the following season.

Prune out twig lesions

Twig lesions are responsible for the first infections of the season. Although they are difficult to see, prune them out where possible and destroy the prunings.

Destroy infected fruit

Infected fruit perpetuate the disease in your orchard by providing infections to nearby healthy fruit. Remove and destroy infected fruit (particularly young fruit).

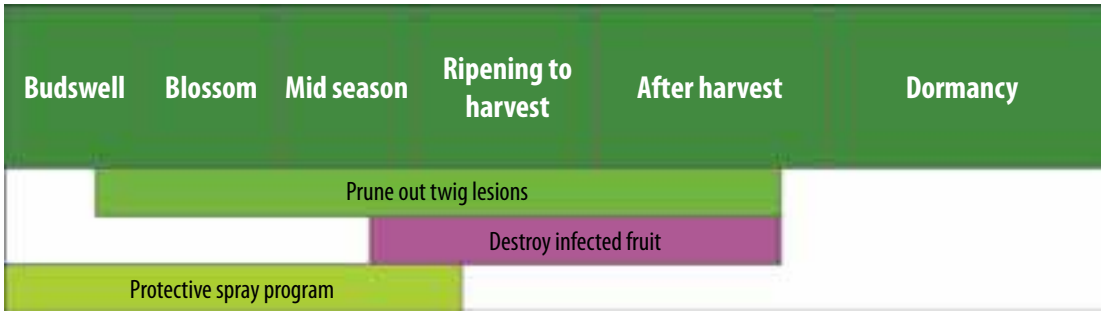
Protective spray program

In most cases sprays applied for other diseases such as rust and shot-hole will control freckle and no specific sprays need be applied. A spray schedule for these diseases is included in this manual (page 137).

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Washington WS (1999) *Scab or Freckle of Stone Fruit.* State of Victoria, Department of Primary Industries. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm



Fruit fly (Queensland and Mediterranean)

Bactrocera tryoni **(Queensland fruit fly)**
Ceratitis capitata **(Mediterranean fruit fly)**

IPDM quick facts

Sample unit: *Trap*

When to monitor: *Late blossom to harvest*

How often: *Every 3 or 4 days*

Action level: *20 flies per trap*

Sample unit: *Fruit*

When to monitor: *Mid-season to harvest*

How often: *Every 3 or 4 days*

Action level: *Stung fruit*

Take extra care when monitoring:

- ***Rainfall and a drop in temperature lead to an increase in fruit fly activity.***
- ***Hot and dry weather keeps the numbers of flies low.***

The pests and their damage

There are two species of economically important fruit flies in Australia. Queensland fruit fly (*Bactrocera tryoni*) is native to Australia and can be found in parts of the Northern Territory, Queensland, New South Wales and the eastern corner of Victoria. Mediterranean fruit fly (*Ceratitis capitata*) is one of the world's most destructive agricultural pests and was introduced to Australia and first recorded in 1895. Although it is currently restricted to South West Western Australia, it poses a serious incursion threat to other States, particularly South Australia.

Adult Mediterranean fruit flies are 3 to 5 mm long. The thorax (back) is mottled, with shiny, dull black and yellowish-white areas. The abdomen is yellowish to brown with two pale cross bands. The wings are patterned, with yellow, brown and black spots and bands.

Adult Queensland fruit flies are about 7 mm long, and reddish brown with yellow markings.

Fruit flies lay their eggs in maturing and ripe fruit. Larvae (maggots) hatch from these eggs, and the fruit is usually destroyed within days by their feeding and the associated rotting.

A serious regional issue during the last 10 years in:

- Alstonville
- Manjimup/Donnybrook
- South Queensland
- Granite Belt
- Perth Hills

Queensland fruit fly

Mediterranean fruit fly

Fruit fly larvae

Rotting fruit following fruit fly infestation

Prevention

Exclusion zones, quarantine and restrictions on movement

The Fruit Fly Exclusion Zone (FFEZ).
The Commonwealth Government and the governments of South Australia, Victoria and New South Wales have collaborated to form the FFEZ. The FFEZ covers key production areas, including the Riverlands, Sunraysia, Mid Murray, Goulburn Valley and Murrumbidgee Irrigation Area.

Queensland fruit fly is excluded from this area, so that fruit fly sensitive markets within Australia and export markets can remain open. Import of fresh fruit to this area is not allowed. Roadside signs and road blocks have been set up to enforce this ban.

Regular monitoring is carried out within the FFEZ to ensure that outbreaks are controlled quickly.

Interstate restrictions on movement.
Movement of fruit and other hosts of fruit fly is restricted in all summerfruit-growing States. Details for each State are provided by State government departments of agriculture at their websites (page 133). A quick reference to restrictions on fruit movement can be obtained by looking at the 'Travellers' Guide to Interstate Quarantine' at

http://www.affa.gov.au/corporate_docs/publications/pdf/quarantine/pr/reader.pdf

Remove alternative breeding and feeding sites

Remove unwanted fruit trees from around sheds and houses and along boundary fences and irrigation channels. Practise good packing shed hygiene, with thorough inspection to remove any infested fruit. Properly dispose of reject fruit by burning, boiling, or soaking in water with a surface layer of kerosene for 3 days. Do not bury fruit, as fruit flies have a soil-inhabiting phase in

Fines are imposed for illegal transport of fruit.

Remove fallen fruit from the orchard, as it provides an alternative breeding site for fruit flies.

their life cycle and burial will help them survive. Remove all late-hanging and fallen fruit missed during harvest.

Pruning

Keep the orchard canopy open for better spray penetration.

Monitoring

Government monitoring of exclusion zones

State government departments of primary industries or agriculture carry out regular, rigorous monitoring to ensure that incursions of exotic fruit flies are detected quickly. Examples of these programs can be found on the websites of all State government departments of primary industries.

Monitoring by orchardists

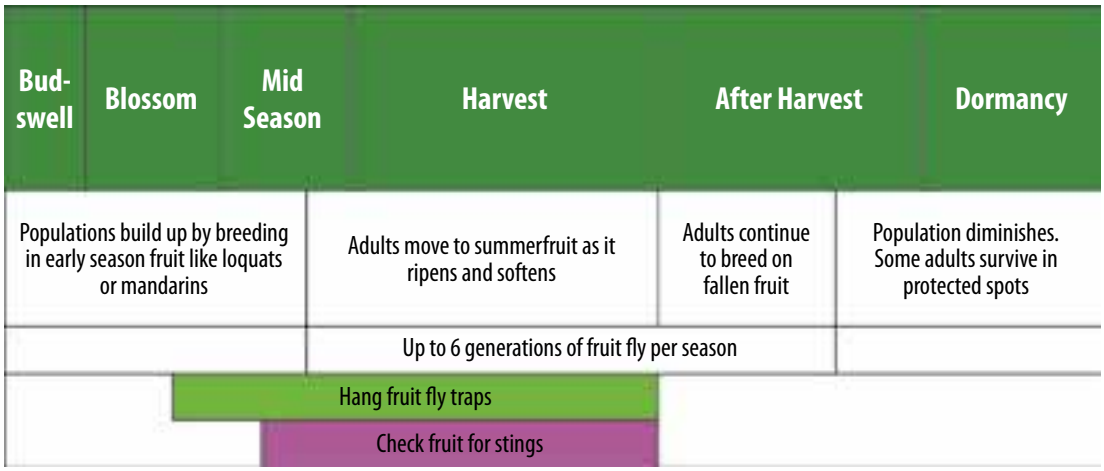
Monitoring in your orchard will allow you to detect fruit flies early and take appropriate action before too much damage is done. It also increases the number of control options available to you (see charts at top of page overleaf).

Hang fruit fly traps

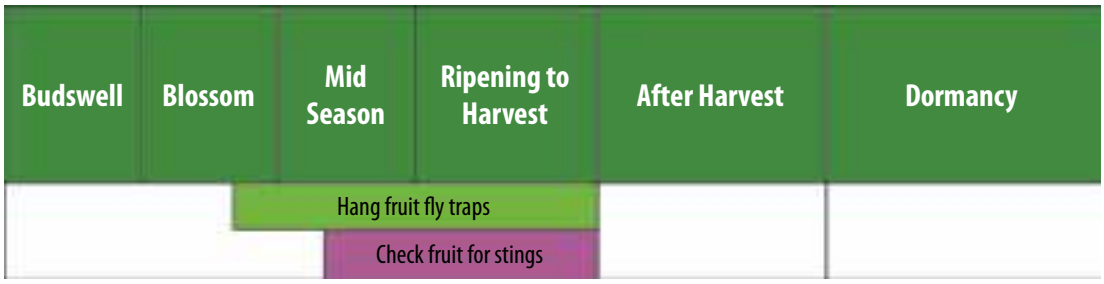
Trapping in the orchard allows orchardists to monitor fruit fly numbers and control them early. The most common type of trap used in Australian orchards is the Lynfield lure trap. Traps are commercially available from rural suppliers in fruit fly-prone areas. Traps attract only the male fly and therefore do not give an accurate indication of female fly activity. This is a

A Lynfield fruit fly trap

Coastal and low-chill fruit monitoring



Monitoring in other regions



major limitation of this monitoring technique, as females are responsible for fruit damage through egg laying and subsequent maggot infestation.

There are two types of synthetic lures commonly used:

- **Capilure:** a pink, aromatic liquid used for Mediterranean fruit fly
- **Cuelure:** a lemon-coloured liquid used for Queensland fruit fly.

These lures must not be mixed or allowed to contact your hands or the trap body, otherwise their attraction to different fly species is affected. This could lead to non-target fruit flies being caught and make identification difficult.

Traps should be hung in the tree canopy at about head height and two-thirds of the way out from the trunk. The trap should be in semi-shade and well clear of foliage. This allows easy access for the flies through the entry hole of the trap.

Hang fruit fly traps at around late blossom. Hang one trap in the centre of each large block. In regions with high fruit fly pressure (South East Queensland, Northern New South Wales, South East Western Australia) check traps every 3 or 4 days as the fruit softens, and count the male fruit flies. Empty the traps after counting.

It is also a good idea to check fruit and leaves visually for fruit fly at this stage.

Check fruit for stings

Around the middle of the season fruit should be monitored for stings. Eggs are often laid up to 8 weeks before the fruit is mature. The sting sites on fruit may show as discoloured (sometimes prematurely coloured), often blackish spots that may exude filaments or blobs of clear gum. If you're unsure, cut through the tentative sting with a very sharp knife or razor blade and inspect it with a hand lens. You should be able to see fly eggs.

Appropriate action

Following detection in orchards outside exclusion zones (see chart on page 48).

Bait sprays

Bait spraying is a good alternative to orchard cover sprays in areas where fruit fly pressure is low. Once monitoring indicates that fruit fly is present in the orchard, start the baiting program and continue this every 7 to 10 days until the harvest is completed.

In endemic areas, at least eight bait applications are recommended for all fruit trees 3 years and older:

- spring (September to October): four or more bait sprays at 7-day intervals

- autumn (March to April): four to eight baits at 7-day intervals.

Baits are prepared using a protein source and an insecticide (chlorpyrifos, maldison or trichlorfon). Both males and females are attracted to the protein. As they feed they are killed by the insecticide.

Observe the mixing and safety directions on pesticide labels. To make 100 L of bait spray based on maldison, take:

- 435 mL maldison (1150 g ai/ L), plus
- 2 L yeast autolysate 50% or Natflav 500.

Add the protein lure (yeast autolysate or Natflav 500) to 75 L of water. Mix thoroughly, add the maldison and top up to 100 L with water. The bait mix can also be prepared using maldison (500 g ai/ L), as follows:

- 2.5 L maldison (500 g ai/L), plus
- 2 L yeast autolysate 50% or Natflav 500
- 100 L of water.

An alternative bait for summerfruit can be made using chlorpyrifos wettable granules or wettable powder (Lorsban™ 750WG or Pyrinex 500 WP). A trichlorfon-based bait can be made from Dipterex® 500 SL. Directions for bait preparation are given on product labels.

In low-density plantings, about 100 mL of the prepared bait should be applied to the foliage of every second tree in every second row. For higher-density plantings, apply bait to every fourth tree in every second row. Use 30 L of the mixture per hectare of orchard.

Baiting is more effective when carried out in the morning, when fruit flies are most active. It is important to avoid direct contact between the bait and the fruit, as the protein may induce phytotoxic damage to some fruit.

Killer pads or male annihilation blocks

In towns it is possible to use an 'attract-and-kill' technique for male fruit flies. Killer pads have Cuelure (for Queensland fruit fly) as the male fly attractant and maldison as the killing agent, impregnated in a block about 5 cm × 5 cm made from low-density particle board (Caneite®) or material such as felt or cardboard. The pads are nailed to trees in the orchard at a density of between 10 and 30 per ha, depending on the fly pressure. For trade reasons this technique is prohibited inside the FFEZ. Further details are available from your State government department of primary industries.

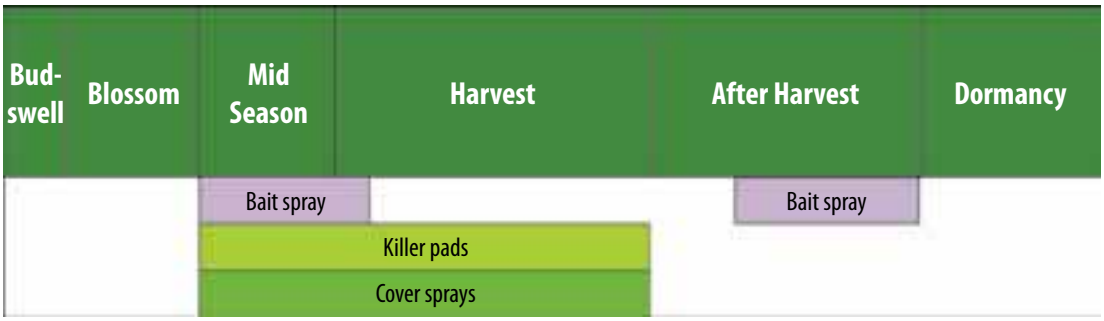
Cover sprays

Where possible, avoid using cover sprays. Spraying with the broad-spectrum insecticides registered for fruit fly control often leads to destruction of the populations of predatory insects that naturally control other pests such as two-spotted mite.

However, bait spraying alone will not be enough to control high populations of fruit fly. Where Interstate Certification Assurance is required (see below) cover sprays are be the only alternative for control. Pre-harvest cover sprays of the trees

Correct hanging position for a fruit fly trap

Cross-section of a fruit fly sting site. Note the fruit fly eggs.



and fruit with insecticide kill the fruit flies that seek shelter in the tree canopy and kill any larvae in the fruit. Trees and foliage should be sprayed to leaf saturation (i.e. when spray droplets just begin to drip from the foliage). Do not pick fruit until the withholding period for the insecticide has expired. For best results make sure you achieve satisfactory spray coverage of the fruit. It's therefore essential that you use correctly calibrated spray equipment.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

HAL projects: Summaries available on the web at www.horticulture.com.au/[.] Final reports can be ordered from Horticulture Australia Limited:

- AH01013: *Use of microsatellite tracking to determine the source of Qfly outbreaks in the Fruit Fly Exclusion Zone*
- AH01025: *Developing the sterile insect technique for eradication of incursions of Mediterranean fruit fly in Australia*
- AH00012: *Improved protein bait formulations for fruit fly control—revised year 3 proposal*

Interstate Certification Assurance: ICA-21 and ICA-23.

Summerfruit destined for interstate markets and originating from Queensland must undergo a prescriptive spray regime, regardless of monitoring. This summerfruit must have a program of cover-sprays consisting of a mixture of 75 mL of a concentrate containing 550 g/L fenthion per 100 L of spray mix. These sprays must be:

- applied to all summerfruit in all blocks in which summerfruit is grown for certification
- applied thoroughly to the fruit
- applied at intervals of
  —6, 4, 3, 2 and 1 weeks before harvest (low-chill summerfruit grown in coastal areas)
  —4, 3 and 2 weeks before harvest (other summerfruit varieties).

Post-harvest inspection. Fruit must be inspected after harvest and found to be free from broken skins and live fruit fly.

Full details of ICA-21 and certification requirements are available at:

www.dpi.qld.gov.au/extra/ica/procedures/ica/ica-21/ICA-21.pdf[.]

Fruit originating in Western Australia and destined for interstate markets is subject to ICA-23. Full details of ICA-23 and certification requirements are available at:

http://www.agric.wa.gov.au/pls/portal30/docs/FOLDER/IKMP/PW/Q/ICA23.pdf

Queensland

ICA-21: *Pre-harvest Treatment and Inspection of Stonefruit.* Full text version available at www.dpi.qld.gov.au/extra/ica/procedures/ica/ica-21/ICA-21.pdf

Queensland Department of Primary Industries and Fisheries (2001) *Exotic Plant Pests: Mediterranean Fruit Fly.* Available at the QDPIF website, www.dpi.qld.gov.au/

Queensland Department of Primary Industries and Fisheries (2001) *Exotic Plant Pests: Exotic Fruit Fly Surveillance.* Available at the QDPIF website, www.dpi.qld.gov.au/

New South Wales

The New South Wales Department of Primary Industries has a large file of information on control, quarantine and identification of fruit flies. It is available at www.agric.nsw.gov.au/reader/pe-qff

Victoria

The following information is available from the Department of Agriculture Victoria at the DPIV website, www.dpi.vic.gov.au

- Queensland fruit fly: *About Queensland Fruit Fly*.
- Mediterranean fruit fly: *About Mediterranean Fruit Fly.*
- *Travelling within Victoria: Fruit Fly.*

South Australia

The following information is available from the Department of Primary Industries and Resources, South Australia, at the PIRSA website, www.pir.sa.gov.au/index.shtml

- *The Sterile Fruit Fly Release Program*
- *The Fruit Fly Exclusion Zone*
- *Identification of Fruit Fly*
- *Travel into South Australia: Quarantine Requirements*

A fruit fly fact sheet (FS 21/77/02) is available at www.pir.sa.gov.au/pages/agriculture/horticulture/fruitfly/fs2177_web.pdf

Leaf curl

Taphrina deformans

IPDM quick facts

Sample unit: *Leaves*

When to monitor: *Early leaf onwards*

How often: *Fortnightly*

Action level: *If the block has previously been infected, and*

- *the temperature around budswell is 20 to 26 °C*
- *it is warm and humid around the time of budswell. If the disease is present you must take appropriate action early next season.*

Causes and consequences

Leaf curl is caused by the fungal pathogen *Taphrina deformans*. If untreated, it is one of the most serious and common disease of peaches and nectarines.

Distortion and loss of foliage result in reduced fruit production. The disease can also disfigure fruit and reduce pack-out.

Symptoms

Symptoms of leaf curl appear early in the season, approximately 1 month after flowering starts. The disease causes symptoms on the leaves, shoots, blossom and fruit. Leaf curl is commonly seen in the tops of trees where spray coverage (with protectant fungicides) has not reached.

Leaf curl on nectarine

Leaves

On young leaves, infected portions may be pink to red.

These areas become thickened and do not expand at the same rate as healthy leaf tissue. This leads to the characteristic curled appearance of leaves in this disease.

The leaves tend to turn yellow and fall and are replaced by new growth. The energy required to develop this new growth reduces fruit set and size and weakens trees.

Shoots

Whole shoots can be infected, becoming swollen and stunted and pale green to yellow. They may exude gum. When this damage affects leaders, lateral branching may occur, leading to 'witches broom'. Young trees are particularly susceptible to shoot infection.

Fruit

Infected fruit has raised, irregularly shaped and roughened areas that may redden long before healthy fruits show any colour change. In peaches, infected fruits lack the normal amount of fuzz. Infected fruit is likely to drop before maturity.

A serious regional issue during the last 10 years in:

- Manjimup/Donnybrook
- Swan Hill
- NSW central west
- Tasmania
- Goulburn Valley

Pink–red infected leaves

Distorted, curled leaves

Prevention

Orchard management

Non-chemical methods are often ineffective in preventing leaf curl. Pruning out infected leaves, fruits and twigs does little to prevent the disease.

If leaf curl has been severe it is important to put extra effort into maintaining tree vigour. Thin more fruit than usual, ensure adequate irrigation and apply extra nitrogen fertiliser. This will ensure that the disease doesn't drastically shorten the life of trees.

Monitoring

In the case of leaf curl, monitoring in the current season determines the level of control necessary in the following season. If leaf curl is observed it will be too late to control the disease in the current season.

When to monitor

Monitor the weather from early budswell to mid-season. Because the leaf curl pathogen tends to infect during cool wet weather, the period of primary infection can be longer if these conditions occur beyond budswell (see chart below).

Primary infections are precisely timed to coincide with budswell, and it is important to monitor all varieties. Appropriate action (see below) also needs to be timed to coincide with budswell on earlier- and later-maturing varieties. Poorly timed monitoring and appropriate action will not be effective.

Carefully observe four lateral branches on the marked monitoring trees for leaf curl at fortnightly intervals from early leaf onwards. Because the symptoms are so obvious, you should observe the other trees in the orchard as you walk between the monitoring trees.

What to look for

Where leaf curl has occurred at any time during the last four seasons, weather favouring disease development should trigger appropriate action.

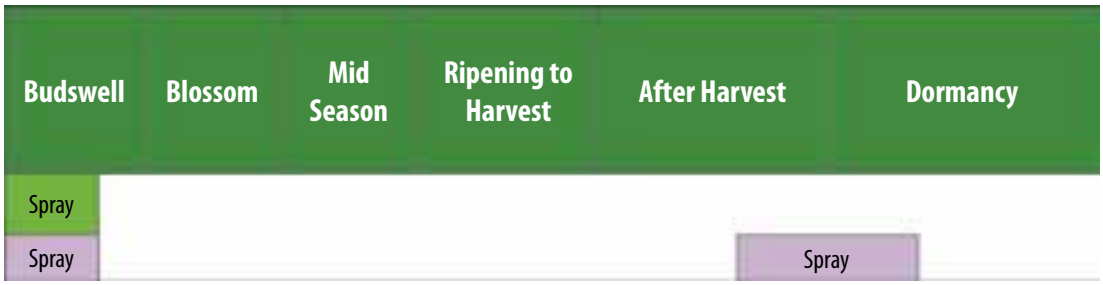
Also look for leaf curl symptoms, which indicate that early treatment next season is necessary.

Appropriate action

Action threshold

Take action if the block has been infected at any time during the last four seasons and

Budswell	Blossom	Mid Season	Ripening to Harvest	After Harvest	Dormancy
Primary infection	Development of leaf curl ceases when young tissue is not developing and the weather is dry and warm (27-30˚C)			Spores overwinter in cracks and crevices on the tree and in the bud-scales	
MONITOR					



- the temperature around budswell is 20 to 26 °C
- it's warm and humid around the time of budswell.

Symptoms of leaf curl indicate that appropriate action is required early next season (see chart above).

Treatments for leaf curl are not effective after infection has occurred or symptoms are seen. Monitoring should be aimed at determining the effectiveness of treatments and planning for the next season.

The appropriate action for this disease depends on the severity of the disease during the previous season.

Spray schedule 1: Infection light to moderate during previous season

Correct timing of this spray application is critical. The fungicides that are effective against this disease are listed in the spray schedules in this manual (page 137). Apply when the buds are swelling but before and within 1 week of bud opening. Because of the precision needed it is important to monitor bud development carefully. Do not rely on flowering times from previous years: flowering varies from year to year because of differences in the weather. Separate applications will need to be made for varieties that mature at different times. Blocks containing more than one variety may need to be treated more than once. Note also that the fungicides registered for use against this disease in peaches are different from those for use in nectarines.

Spray schedule 2: Infection moderate to heavy during previous season

Extra sprays need to be put on trees where leaf curl infection has been moderate to heavy.

Do not use this schedule on a regular basis. After you use this schedule, monitor to check its effectiveness and revert to schedule 1 if the disease level has dropped. Use this schedule for no more than two consecutive seasons. If problems persist, consult you adviser or district horticulturist.

- Apply a registered fungicide in autumn when 90% of leaves have fallen.
- Apply a registered fungicide at first sign of budswell and again 1 week later.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Hetherington S (2004) *Leaf curl of peach and nectarine.* New South Wales Department of Primary Industries Agfact H5.AB.12. Available through the NSW DPI website, www.agric.nsw.gov.au

Washington WS (1999) *Peach Leaf Curl.* AG0160. State of Victoria, Department of Primary Industries. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Sivyer M, Wood P (1999) *Peach Leaf Curl.* Farmnote 24/96. Agriculture Western Australia. Available through the DAWA website, www.agric.wa.gov.au

Lightbrown apple moth

Epiphyas postvittana

IPDM quick facts

Sample unit: *Broad-leaved weeds*

When to monitor: *Budswell to shuckfall*

How often: *Fortnightly*

Action level: *10%*

Sample unit: *Fruit and leaves*

When to monitor: *Fruit ripening to harvest*

How often: *Fortnightly*

Action level: *3% to 5% of leaves infested; fruit infestation*

Take extra care when monitoring:

- *when cool conditions in spring extend into the summer*
- *during autumn when spraying for other pests has ended.*

The pest and its damage

Lightbrown apple moth (LBAM) is native to South Eastern Australia, including Tasmania, and has also been introduced to Western Australia, the British Isles, New Zealand, Hawaii and New Caledonia. It attacks nearly all types of fruit crops and many vegetables and ornamentals. LBAM is adapted to cooler conditions, causing major problems in the cooler regions of New South Wales, Victoria, South Australia and Tasmania.

Adults are about 10 mm long and variable in colour. They are usually yellowish brown, with darker brown markings on their wings.

Eggs are laid on the surface of almost any smooth-leaved plant, and tiny larvae emerge. These larvae undergo several growth stages as

Lightbrown apple moth

Lightbrown apple moths are variable in colour but are usually yellow-brown with darker brown markings

they become bigger, but their appearance remains essentially unchanged.

Larger larvae construct a feeding shelter by curling leaves with silken webbing and pupate to become adult moths.

Leaves

Young larvae construct a silken web on the undersides of leaves and feed on tissue beneath the upper surface. As the larvae grow, they migrate from these protective shelters and construct larger silken shelters between leaves, between leaves and fruit, or on single leaves. These later-stage larvae feed on all leaf tissue except the main veins. Feeding on leaves is not usually economically damaging, but the sticky webbing is uncomfortable for pickers.

Fruit

Feeding damage to fruit takes place beneath the protective canopy of webbed leaves. Feeding sites are shallow but can be extensive. This is particularly the case where larvae have found shelter in the middle of a fruit cluster. The larvae will cause damage to all fruit within the cluster.

A serious regional issue during the last 10 years in:

- Alstonville
- Granite Belt
- Goulburn Valley
- Sydney Basin
- Riverlands
- Tasmania

Prevention

Thinning

Larvae find enclosed, sheltered spots to spin their webs and feed. Thorough thinning reduces these sites and also allows for good spray penetration. Thin to singles if this is an option.

Weed control

Removal of broad-leaved weeds such as capeweed, mallow and dock from the orchard and surrounding areas reduces the number of overwintering sites for LBAM. Selective herbicides, mowing or grazing can be used to reduce these weeds. This job must be done before budswell. After budswell, larvae are large enough to crawl up and into the canopy of the trees.

Lightbrown apple moths pupate in webbing on leaves

Lightbrown apple moth larvae

Fruit damage

If LBAM has been a persistent and serious problem, consider planting an inter-row that does not support populations of larvae. Good options are oats or other grasses.

Clean up unpicked fruit

Clean up all of the fruit that is left hanging on trees in the orchard. Waste fruit must also be removed from any apple orchards nearby.

Monitoring

When to look

(See chart below)

1 Note that the LBAM life cycle is slightly delayed with respect to tree growth stages in Tasmania. Monitoring times should be adjusted.

Monitor broad-leaved weeds between budswell and early blossom.

Look at fruit and leaves on four lateral branches of each of the marked monitoring trees from mid-season to harvest, at fortnightly intervals.

What to look for

Monitor broad-leaved weeds for moth larvae. This can give some indication of how severe the LBAM problem may become in the orchard. Keep in mind, though, that the pest's development is closely linked to the weather. If the weather isn't suitable for development after blossoming, the problem may not be as serious as numbers on weeds may indicate. Nevertheless, high larval counts during this early-season monitoring should motivate you to be very thorough when you begin to monitor your trees as the fruit ripens.

Examine the fruit carefully. Only thorough examination will reveal the pest. Examine the stem end of the fruit in the centres of the trees. Pay particular attention to fruit clusters.

Examine the fruit in your other trees during your walk between the marked trees.

Appropriate action

Action threshold

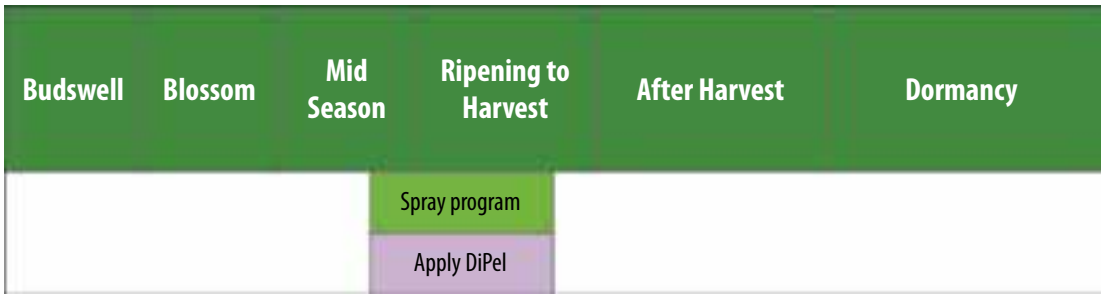
(See chart overleaf)

- 10% of broad-leaved weeds infested
- 3% to 5% of leaves infested
- fruit infestation

Protective spray program

Azinphos-methyl may be used for emergency control, but observe the 14-day withholding period. It will also control oriental fruit moth and help with *Carpophilus* beetle control.

Budswell	Blossom	Mid Season	Ripening to Harvest	After Harvest	Dormancy
Larvae pupate	Adults emerge	Eggs, larvae and pupae on ground cover plants	Larvae in summer fruit foliage. Larval damage to ripening fruit	Larvae in ground cover	
	MONITOR				



Thorough spray coverage is required. Up to three consecutive applications of indoxacarb will give the best results.

Apply DiPel®

DiPel® will not give adequate control in an emergency, but if LBAM is a regular problem, consider a program of DiPel®, especially if you are using oriental fruit moth mating disruption.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Mo J (2004). *Light Brown Apple Moth Development Calculator.* New South Wales Department of Primary Industries. Available through the NSW DPI website, www.agric.nsw.gov.au

Williams D (2000). *Lightbrown Apple Moth in Orchards*. Available through DPIV website, ww.dpi.vic.gov.u/dpi/idexh

Oriental fruit moth

Grapholita molesta

IPDM quick facts

Sample unit:	Pheromone trap	Food lure trap	Shoot tips	Fruit
When to monitor:	August–April	August–April	September–May	November–April
How often:	At least weekly	At least weekly, twice weekly August– October	At the end of each generation	
Action level:	Depends on variety, time of year and whether you are using mating disruption.		Depends on variety, time of year and choice of chemical.	
Helpful hints:	Traps need regular maintenance. Pheromone traps should not be used in blocks treated with mating disruption. Food lure traps catch both sexes. It is useful to count the sexes separately.		Damage is usually obvious, and this leads to biased sampling. It is important to take random samples of shoots and fruit. Also, select the trees at random.	

The pest and its damage

The oriental fruit moth (OFM) has been a serious pest in canning peach orchards of the Goulburn and Murray valleys around Cobram and Shepparton since the 1930s. It now infests cherries, fresh market peaches and nectarines, pears, apples, nashi, some apricots and plums, and quince. OFM is also considered a minor pest in parts of NSW (NSW southwest slopes, Alstonville, Sydney Basin) and South Australia (Renmark). In Alstonville its importance relates more to custard apples than to summer fruit.

Damage is caused by the larvae, which feed on shoots and fruit. Larvae bore into the tips of shoots, causing them to distort and dieback. These infestations are most apparent on the young, green actively growing shoots. During summer, OFM bore into fruit. Mature, softening fruit is most susceptible, but when the numbers of larvae are high immature fruit can also be attacked. The subsequent tunnels in the fruit make it unmarketable and are often an entry point for decay organisms such as bacteria and brown rot (page 27). When boring into both fruit and shoots, larvae excrete frass. This

Oriental fruit moth

Oriental fruit moth

Shoot tip damage caused by oriental fruit moth

Oriental fruit moth larvae in damaged fruit

excretion distinguishes wounds caused by OFM from those caused by mechanical damage such as hail.

A serious regional issue during the last 10 years in:

- Riverlands
- SE Queensland
- NSW southwest slopes
- NSW central west
- Alstonville
- Goulburn Valley

Prevention

Orchard management

OFM overwinters as hibernating larvae under bark and in cracks, wounds, and debris in the crotch of the tree. Smooth-barked, calm, well managed trees will generally support lower populations of OFM than will older, rougher, damaged, or highly vigorous trees.

Manage your trees to reduce vigour and limb breakage. OFM loves succulent shoots, and overwinters in wounds caused by broken limbs, or in cracks in wooden trellis posts.

Manage your trees for optimum spray penetration and regularly calibrate your spray machinery to ensure coverage of shoot tips and fruit. Regularly calibrate spray machinery so that it delivers the right amount of pesticide to the right part of the tree. Good coverage of growing tips is essential for OFM control.

Fruit bins

Never store other people's fruit bins on your property without thoroughly disinfecting them. OFM can hibernate in cracks in the bins and then infest your orchard. Bins that may be sources of OFM must be removed or disinfected before the first moth emergence in spring.

Left-over fruit and prunings

Before the start of moth emergence in August, destroy any large prunings or trees you have removed. Pay attention to fruit left on harvested trees. Leaving as little as three fruit per tree at 275 trees/ha can easily generate 500 moths/ha.

Fruit left on the tree after harvest (especially pome fruit) can become infested and cause a build-up of OFM without you being aware of it. Pome fruit blocks adjacent to summer fruit need particular attention after harvest.

It is important that you burn trees that have been bulldozed in previous seasons. Piles of old trees concentrate the moths, ensuring mating, and then the mated females will disperse into nearby trees. Eliminate this source of infestation.

The neighbours

OFM can fly relatively large distances (2 to 3 km) and can move from infested neighbouring orchards. Know your district and where likely sources of infestation are. Encourage neighbours to clean up neglected orchards on their boundaries and ask them to tighten up their OFM control. Although OFM is principally a

pest of peaches and nectarines, it can also infect other types of summerfruit, apples, pears and quinces. Neighbouring blocks of pome fruit can also be sources of infestation. As a result, control along your boundaries neighbouring these orchards may need to be strengthened (see 'Appropriate action' below).

Monitoring

Before monitoring, decide whether you believe you can use mating disruption to control OFM. The choice of whether or not to use mating disruption will determine the type of monitoring you use (see chart below).

Mating disruption

Mating disruption is suitable for orchards:

- that are isolated from other summerfruit or pome fruit orchards that may act as reservoirs of OFM
- that are part of an area-wide management scheme (e.g. Cobram)
- where both external (moth migration) and internal sources (e.g. infested bins) of OFM can be successfully managed
- where OFM numbers are low but cause sufficient damage to warrant investment in mating disruption.

When to look

Moth flights start in August and can be detected using pheromone traps or lure pots. Traps should be inspected twice a week early in the season and when each generation of moths is expected to start flying. Infestation by larvae can occur at any time from late September and continue throughout the season.

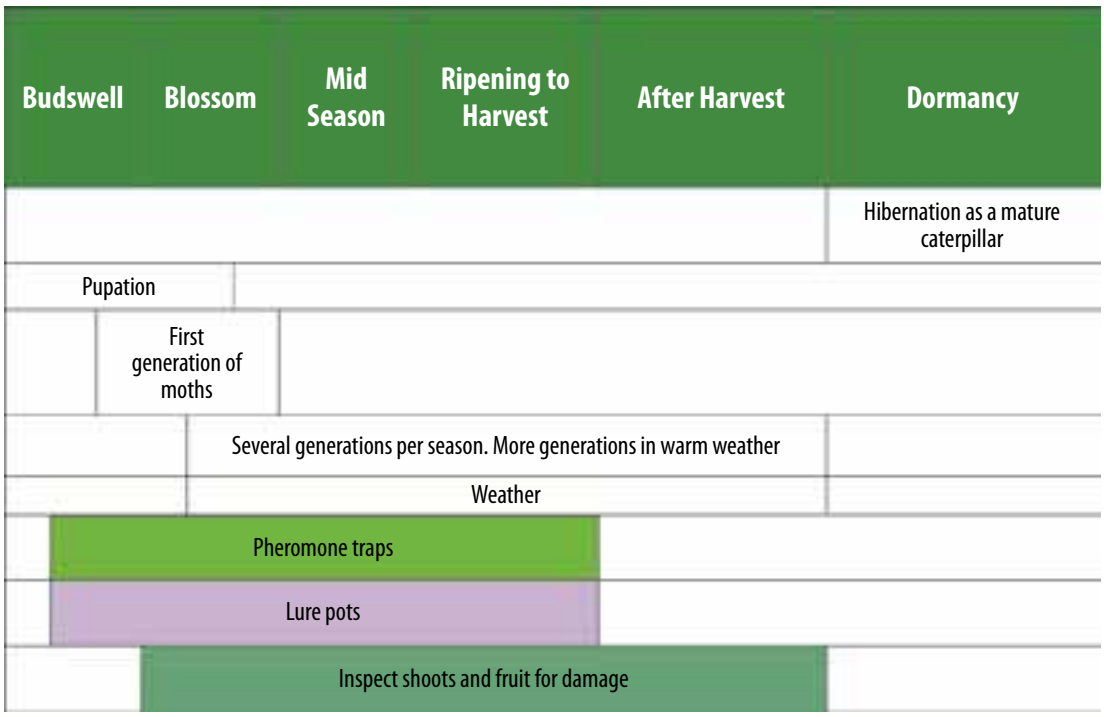
Shoots should be inspected from early spring. Fruit is more susceptible to infestation approaching harvest but should be inspected earlier, as immature fruit can be infested when numbers of larvae are high. Later-maturing varieties are generally most seriously affected by fruit infestation.

Pheromone traps

Pheromone traps **cannot** be used in orchards that use mating disruption. Pheromone traps rely on scents (pheromones) to attract male moths to a point source where they're trapped on a sticky surface. Pheromone traps are not very useful in blocks being treated with mating disruption because the mating disruption pheromone makes it difficult for the moths to find the traps.

Set traps at head height towards the outside of the tree canopy and at a density of 1 trap/1–3 ha. It is preferable to have a minimum of two traps in any block, and the traps should be at least 50 to 60 m apart. Monitor traps twice a week during the early part of the season.

Being able to detect OFM in the orchard very early in spring gives us some useful information. The rate at which the OFM life cycle, and consequently orchard infestation, occurs depends on the weather—primarily the temperature. Traps are placed in the orchard at early budswell,



aiming to trap the first flight of OFMs for the season. The date on which moths are first caught is called the biofix.

Because the growth rate of an insect increases as temperature increases until the optimum temperature for that insect is exceeded, insect growth is measured in physiological time units (degree-days) instead of chronological time units (hours, days). There are a number of ways to calculate degree-days, and computer models that do this are used by consultants to forecast various stages of insect development.

Maximum and minimum daily temperatures should be read every day after biofix using a max-min thermometer. For OFM, a rough approximation of degree-days for each day can be obtained from the formula:

$$\text{Degree-days} = \frac{(\text{Max} + \text{Min})}{2} - 7.5$$

where Max and Min are the daily maximum and minimum temperatures in degrees Celsius. OFM hibernates over winter as a mature caterpillar and transforms into a moth in late winter or early spring. The moths have to mate and lay eggs, and the eggs need to hatch before an infestation starts. It takes about 110 degree-days from moth catch to egg hatch. This could take a few weeks in cool spring weather.

The time between each generation is about 555 degree-days. In warm weather, degree-days are accumulated more rapidly than in cool weather.

Using this information allows orchardists to time appropriate action and minimise unnecessary control.

Lure pots

Lure pots **can** be used in orchards that use mating disruption. Because they rely on the scent of food, they trap both male and female moths. The information from lure pots can be used to determine the biofix and calculate the physiological state of OFM in the same way as the information from pheromone traps (see section above).

Additionally they can be used throughout the season in mating disruption orchards to monitor the numbers of moths and the performance of mating disruption.

An effective food lure can be made by dissolving 100 g of brown sugar in a litre of warm water. Add 12 drops of terpinyl acetate solution, made from mixing 48.5 mL of terpinyl acetate with 1.5 mL of non-ionic wetting agent and 50 mL of warm water. Then pour the solution into the lure pot. Lure pots can be constructed from commercially available fly traps. Change the sugar and terpinyl acetate solutions each week during the monitoring periods. Lure pots are messy to use, and the liquid often removes scales from the moths' wings, making them difficult to identify. Lure pots also require frequent maintenance to function properly. Pest management consultants and scouts are available to monitor OFM lure pots, and the relatively low cost of such a service is well worth it.

Lure pots have relatively low drawing power, so you need more lure pots than you would pheromone traps. Costs can be reduced by concentrating on known OFM hotspots within the orchard.

Inspect shoots and fruit for damage

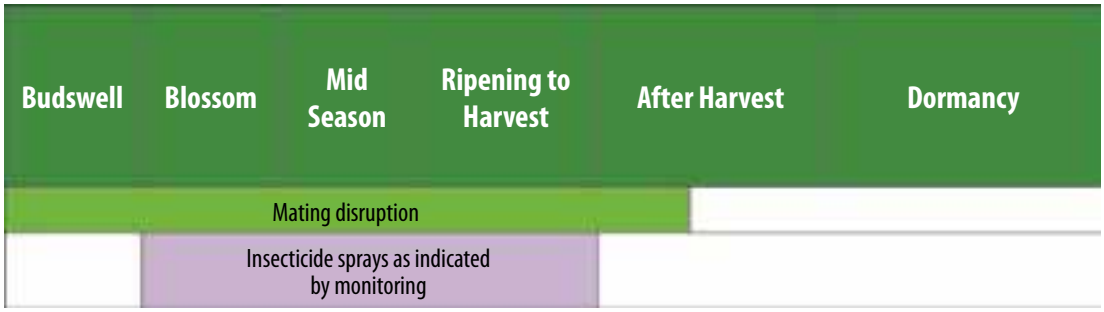
Wilting lateral tips are the first symptoms of infestation on summer fruit.

When such tips are split longitudinally, a tunnel following the centre of the lateral can be seen. Sometimes a cream to pale pink caterpillar up to 12 mm long will be found at the end of the tunnel. The caterpillar will often leave the tunnel and bore into another shoot tip, or tunnel into a fruit. Infested tips die.

Damage usually appears in the leaf axils, starting as sawdust and progressing as a downward tunnel.

Fruit damage occurs when the caterpillars enter the fruit and burrow towards the centre, filling

Young tree with an oriental fruit moth infestation



the tunnel with brown particles of excrement and often causing summer fruit to exude gum.

Shoot tip damage Assessment of shoot tip damage can indicate potential problems in the next generation. A single OFM larva can infest up to seven shoot tips. Shoot tip assessments can be done by randomly selecting 10 trees in a block. Inspect 100 shoots at random from each tree. Damage is obvious, and the assessment does not take very long. Time your inspections to coincide with the end of each OFM generation so that you can make decisions about how to manage the coming generation.

Fruit damage. An inspection process similar to that used for shoot damage assessment is used. Use 10 trees × 100 fruit. Fruit does not need to be picked from the tree. OFM generally does not infect fruit until the third generation, so there is no value in checking fruit until the end of November, unless your orchard has a history of damage to early varieties.

Appropriate action

(See chart above).

Mating disruption

Mating disruption is based on a massive release of the chemical dodecanyl acetate. This chemical is usually released by the female moths to act as an attractant to male moths. Commercial dispensers of this chemical release so much of the chemical that male moths become disorientated and can't find a female and mate; subsequently, no fertile eggs are laid. OFM larvae are therefore not available to infest shoots and fruit. Mating disruption is the preferred method of OFM control in IPDM orchards. It provides the following advantages:

- no effect on non-target organisms means that beneficials are unharmed and secondary problems (e.g. mite outbreaks) don't occur
- no residue concerns
- reduced use of sprays mean fewer resistance concerns
- no mammalian toxicity means greater safety than with pesticide alternatives such as azinphos-methyl.

Twist each mating disruption dispenser one and a half times around a branch that is within 1 m from the top of the tree. You can avoid girdling the branches by placing the dispensers on branches that will be pruned off within 2 years. Apply dispensers at a rate of 500/ha to give an even distribution through the orchard. Apply them at very early budswell.

In many cases mating disruption will provide sufficient protection to keep your crop OFM-free for the entire season. OFM dispensers will last more than 180 days in the orchard under warm growing conditions. However, there are a number of reasons why OFM populations may increase to a point where mating disruption needs to be supplemented by insecticidal sprays:

- The male OFM doesn't rely only on scent to find a female mate. In some cases, particularly where large numbers of moths are present in the orchard, males and females come close enough by chance to see each other and mate.
- If neighbouring orchards aren't protected against OFM, mated females may migrate into orchards protected by mating disruption and lay eggs.

It's therefore important to maintain monitoring throughout the season with lure pots, even when you believe that your orchard is protected. Be especially vigilant when predictive models (see 'Pheromone traps' above) indicate periods of peak egg-laying. The third and fourth generations are often when populations and damage increase rapidly. We don't know why, but you need to be prepared.

Insecticidal sprays, as indicated by monitoring

In an orchard **not** using mating disruption, insecticidal sprays will need to be used. By monitoring with pheromone traps and using predictive models, you can apply sprays when they have the most effect against OFM. The

pesticides that can be used for this purpose are listed in the spray schedules included in this manual (page 137).

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Botha J, Hardie D, Poole M, Reeves A (2004) *Oriental fruit moth (Grapholita molesta). Exotic Threat to Western Australia*. Department of Agriculture Western Australia. Factsheet No. 4/2004. Available through DAWA website, www.agric.wa.gov.au

Il'Ichev A (2004) *Area-wide Mating Disruption for Oriental Fruit Moth and Codling Moth Control in Fruit.* Department of Primary Industries Victoria. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Il'Ichev A (2004). *Integrated Pest Management Strategy Using Pheromones for Control of Oriental Fruit Moth and Carpophilus Beetles in Orchards.* Department of Primary Industries Victoria. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Mansfield C, Il'Ichev A (2000) *Oriental Fruit Moth Control Method*. IHD Media Release, 27 November. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Ridland P(1997) *Dispersal of Oriental Fruit Moth.* Department of Primary Industries Victoria. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Williams D (2000) *Oriental Fruit Moth.* AG0156. Department of Primary Industries Victoria. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Peach white scale

Pseudaulacaspis pentagona

IPDM quick facts

Sample unit: *Trunks and branches*

When to monitor: *Harvest to dormancy*

How often: *Weekly*

Action level: *If present*

Take extra care when monitoring:

- ***under nets***
- ***during hot, humid weather.***

The pest and its damage

As with other scale insects, white peach scale (WPS) exists in several forms depending on the sex and age. The most commonly seen scales are immature males that form encrustations on the trunk and scaffold branches. Females disperse throughout the tree and are less conspicuous. The female is a creamy white to orange sac-like insect that is protected under a circular, convex, white, waxy scale 1 to 2.25 mm in diameter. The scale on immature males is more elongated. Adult males emerge as winged insects from under these scales after approximately five moults and live for only around 24 hours, during which time they must find a female and mate. Females lay eggs from which six-legged nymphs, called crawlers, emerge. The speed with which the insect completes its life cycle is related to temperature. In warmer regions in the USA (Florida) WPS can complete 3 or 4 generations during the peach-cropping season. The number of generations under Australian conditions is unknown.

Peach white scale can infest bark fruit and leaves. As with other scales it feeds by sucking the juice from plant organs. Severe infestations can cause stunting, premature leaf drop and death of entire branches. If the infestation is left untreated for 2 or 3 years entire trees can be killed.

Peach white scale

A serious regional issue during the last 10 years in:

- SE Queensland
- Alstonville

White peach scale is most common on peaches and nectarines under netting and is a particular problem in warmer coastal regions. Although in many respects it is similar to San José Scale (page 74) it is a more serious pest in some regions.

Prevention

Pruning

Prune out infested branches and burn. This will also improve spray penetration.

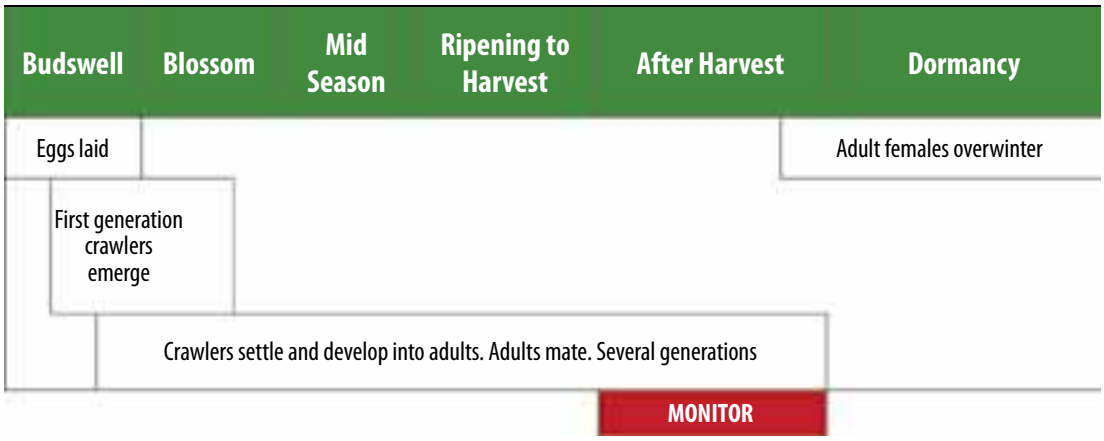
Orchard management

WPS is most common in warmer coastal regions under netting. This would suggest that WPS is more severe given high humidity. Anything that you can do in your orchard to reduce humidity is likely to reduce the impact of WPS.

- Don't over-water, particularly where you are using water-retaining mulches.
- When designing new blocks, orientate them so that the rows are parallel with the prevailing breezes.
- Remove unnecessary windbreaks and prune the undergrowth in windbreaks when necessary.

Neglected trees and other hosts

WPS can build up heavily on neglected fruit trees (particularly seedlings) around orchard areas. It can also infect a wide range of other trees. In the USA it infects several hundred species. Although it is unclear how many plant



species can be infested in Australia there are likely to be large numbers. Therefore, unnecessary vegetation that may serve as an alternative food source for WPS and a reservoir for infestation of orchards should be removed. Be particularly careful with privet, mulberries and persimmons.

Monitoring

When to look

This life cycle information is approximate and is based on information from southern USA. Very little WPS research has been conducted in Australia. As with San José scale, monitoring should aim to determine the severity of the infestation late in the season, after harvest. Infestations will be easier to see at this stage and the infestation severity will give a more accurate indication of the number of scales that will be carried over into next season (see chart at top of page).

What to look for

The most obvious symptoms of WPS infestation are encrustations of male scale. These encrustations give trees a fluffy to whitewashed appearance

Over the years, placing black electricians' tape with the sticky side out around the trunk of trees has been recommended. This is not practical under Australian conditions, as the tape rapidly collects so much dust that is no longer sticky.

Appropriate action

Action threshold

If scale is present (see chart below).

There are no insecticides registered for white peach scale. However, maintenance of a rigorous preventive spray schedule for San José scale will help to control white peach scale. In particular, thorough application of dormant oils for San José scale may preclude the need for any further control of white peach scale. A full control schedule for San José scale and details on application are provided on pages 76 and 137.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Robinson JV (1998) *Scale Insects on Peaches and Plums.* Texas Agricultural Extension Service, www.tamu.edu/extension/publications/sippaplum.html †

Plague thrips and western flower thrips

Thrips imaginis* and *Frankliniella occidentalis

IPDM quick facts

Plague thrips

Sample unit: *Buds and flowers*

When to monitor: *Budswell to shuckfall*

How often: *Fortnightly*

Action level: *If present*

Western flower thrips

Sample unit: *Sticky traps*

When to monitor: *Budburst to harvest*

How often: *Fortnightly*

Action level: *If present*

The pests and their damage

Plague thrips (*Thrips imaginis*) is an Australian native species that feeds on a wide variety of plant hosts. Female plague thrips are 1.1 to 1.3 mm long, whereas males are smaller (0.8 to 1.0 mm). Western flower thrips (WFT) are larger than plague thrips. Female WFT are 1.4 to 1.8 mm long and males 0.9 to 1.1 mm. Plague thrips are almost always female, particularly early in the season. WFT at low population densities are predominantly male, but the sex ratio switches as populations become larger.

Adult thrips have two pairs of fringed wings. Larvae are white or yellow, wingless, with few distinguishing characteristics.

Damage at flowering to fruit set

Damage at this time is largely a result of larvae feeding on the developing fruit surface, causing tissue scarring and russetting, which expands and turns brown as the fruit grows. WFT rarely causes this type of damage in Australia. For example, there have been no confirmed reports of WFT causing damage of this type in NSW. Damage at this time is likely to be caused by plague thrips.

Early season feeding by adult and larval thrips can also result in bronzing of petals and sepals and occasionally fruitlet abortion if stamens and styles are severely damaged.

Damage close to harvest

WFT is more likely to be found during summer on ripening fruit. This damage is caused by adult and larval thrips feeding on the mature fruit surface. Damage can occur on the earliest maturing varieties through to those that are harvested last. This damage appears as either or both of:

- patches of silvering on the fruit surface, especially where it has been protected by leaves or where fruits touch
- white patches around the stem end of the fruit where it is protected by the tree branch.

Damage is more likely to be located on the protected parts of the fruit surface. This silvering damage is done in the final fruit-swell stage up to 21 days before harvest and occurs very quickly. Overseas, increased silvering damage has been associated with drought conditions, when alternative WFT habitats such as ground covers, weeds and native bush have browned off or died.

Plague thrips: a serious regional issue during the last ten years in:

- Goulburn Valley
- Riverlands
- Alstonville
- Swan Hill
- SE Queensland
- Granite Belt
- Perth Hills

Plague thrips

Western flower thrips

Western flower thrips: a serious regional issue during the last five years in:

- Manjimup/Donnybrook
- Perth Hills
- NSW Central West
- Granite Belt
- Goulburn Valley
- Sydney Basin

Orchardists from all Australian summerfruit regions are concerned about the threat posed by WFT, even where its presence has not been confirmed. In many cases symptoms that may have been caused by WFT have been seen but WFT has not been confirmed as the cause of the problem. It is difficult to identify the particular species of thrips responsible for the damage. Orchardists who suspect that they may have WFT are encouraged to monitor (see below) and seek professional identification of their thrips by their State Government department of primary industries or agriculture.

Orchardists in the Forbes (NSW Central West) region observed WFT-like damage during the 2003–04 season. WFT has recently been confirmed as the cause of this damage.

Prevention

Strategies for preventing WFT and plague thrips infestations are similar.

Orchard management

Both thrips species are found on a wide range of broad-leaf weeds and flowering plants. Flowering plants are particularly attractive to WFT, with clover (especially white clover) and lucerne having the highest thrips densities. WFT feeds on the pollen of these plants; therefore, preventing flowering can be an effective strategy. Total removal of clovers and other broad-leaved weeds is one option, but if this is not possible then keep them mown short throughout the year to prevent flowering.

Managing your ground cover and weeds is critical to reducing thrips populations and preventing population carryover. As WFT does not feed on grasses, replace broad-leaved ground cover with grasses.

If ground covers/weeds have been left unmown, it is important **not** to mow them just before or during flowering of summerfruit, as this will send the thrips (if present) up into the flowers on the trees. Wait until shuckfall is complete and then mow. Keep ground covers/weeds mown throughout the fruit development stages and especially close to harvest.

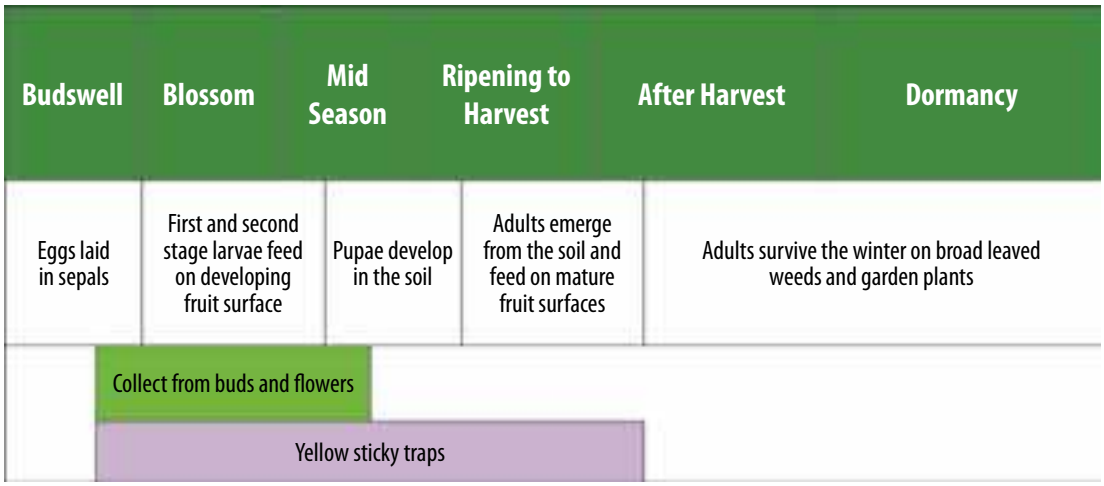
If thrips have been a problem in previous seasons and a decision is made to control weeds using a herbicide, it is advisable to treat for thrips at the same time. If thrips are not treated they will move to trees as the weeds die.

Choosing species and varieties

All species of summerfruit are susceptible to WFT damage. Highly coloured nectarines are favoured by WFT. If damage has occurred during previous seasons, avoid planting these varieties.

Movement

Plague thrips can be carried into the orchard from considerable distances on the wind. There are very few practical measures that can be taken to restrict this movement. However, WFT spend winters on broadleaved weeds or garden plants. Therefore, avoid moving from blocks that have been infested with WFT in previous seasons into 'clean' blocks. Plan your movements around the orchard so that blocks previously infested with WFT are the last to be visited.



Sticky trap in a tree

Sticky trap above the ground cover

WFT can be moved around the orchard on tools and clothes. Avoid wearing yellow, white or blue clothing, as these are attractive to WFT.

Be careful when purchasing new trees from a nursery in an area that has recorded WFT infestations. Check with the supplier to ensure that they monitor for WFT and that the plants are free of the pest.

Monitoring

When to look

(See chart on previous page).

Aim to monitor throughout the season (from bud burst to harvest). The developmental stages of thrips are closely tied to the weather, and particularly temperature. The timings may have to be modified to suit your orchard.

What to look for

There are two methods of monitoring thrips.

Collect from buds or flowers

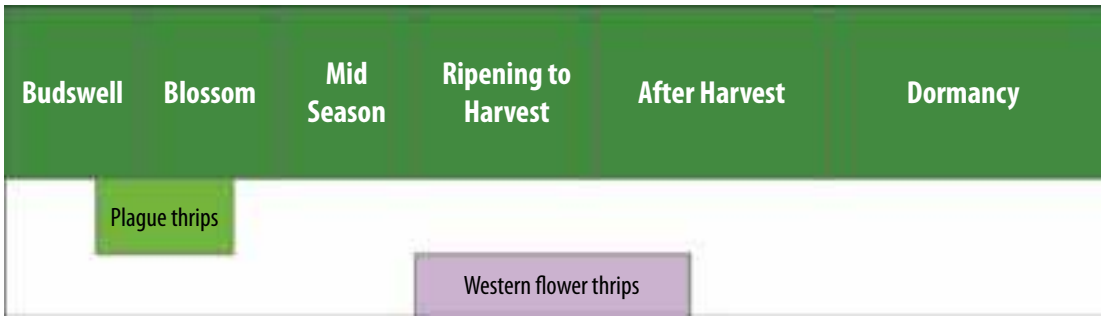
Thrips can be collected from buds or flowers. Collect 20 or 30 from each area and place them in labelled zip-lock bags. Transfer thrips to 70% alcohol to preserve for identification.

For WFT, pay particular attention at full pink and bloom stages. Larval development appears to be well synchronised with bud development.

Yellow sticky traps

Monitoring with yellow sticky traps is useful for determining the presence or absence of WFT within an orchard.

- Varieties in which WFT is detected can be sprayed, minimising damage.
- Varieties that mature subsequently can be monitored more carefully following detection on early varieties.
- The number of beneficial organisms can be assessed.
- The information will help in management decisions the following season.



Locate the traps as follows:

- **Hang some in the trees for the entire season.** As a rough guide, use two traps in a block or 5 traps/hectare. Hang them in the lower third of the tree.
- **Place extra traps in the ground cover from bud burst to fruit set.** Place the traps on a stake at a height of 0.25 to 0.5 m in the inter-row sod.

Replace the traps at intervals of 1 or 2 weeks, especially at peak times of likely activity. The yellow sticky traps in the trees are important in the pre-harvest period. Monitor very carefully in the period 1 month before harvest.

Watch for symptoms of fruit damage in the critical 21 days before expected harvest. If observed, treat the affected variety and prepare to also treat those that ripen subsequently.

Identification can be done by your State Government agricultural authority. Most agencies now charge fees for this service. Check with your local authority to determine what charges apply. By the time thrips are detected through monitoring it is often too late to eliminate their damage. Immediate appropriate action can reduce the severity of the damage and gives an early indication that action will need to be taken late in the season and early next season.

Appropriate action

Action level for plague thrips

If present.

Action level for WFT

If present (see chart above).

Very few thrips are required to cause economically significant damage.

Plague thrips

Apply tau-fluvalinate to nectarines once only between mid-pink and petal fall if monitoring indicates that plague thrips have exceeded the action level. Tau-fluvalinate will affect predatory mites if present, and this could result in a two-spotted mite problem.

Western flower thrips

Chemical control is difficult for WFT early in the season, because the shuck protects the larvae.

If you suspect or confirm the presence of WFT, start chemical control. WFT has developed resistance to chemicals used to control other thrips, including tau-fluvalinate. If you have used tau-fluvalinate to control plague thrips and still have a thrips problem, suspect WFT. Use monitoring and professional identification to confirm these suspicions (note earlier comments on fees for this service). Good control of WFT has been achieved with one application of spinosad Success™ Naturalyte® if it is applied at the right time (2 or 3 weeks before harvest) and the correct rate (80 mL/100 L).

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Herron G (2005) *Western Flower Thrips (WFT) Insecticide Management Plan—Stone Fruit.* Available through the NSW DPI website, www.agric.nsw.gov.au

Herron G, Steiner M, Gollnow B, Goodwin S (2005) *Western Flower Thrips (WFT) Insecticide Resistance Management Plan*. Available through the NSW DPI website, www.agric.nsw.gov.au

Moran J, Miller J (1997) *Western Flower Thrips—Information for Industry.* State of Victoria, Department of Primary Industries. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

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Steiner M, Hardy S, Thwaite G (2004). *Which Thrips is That? A Guide to the Key Species Damaging Stone and Pome Fruit in NSW.* Available through the NSW DPI website, www.agric.nsw.gov.au

Swanson B (1997) *Western Flower Thrips in Victoria.* State of Victoria, Department of Primary Industries. Available through DPIV website, www.dpi.vic.gov.au/dpi/index.htm

Thwaite G, Hardy S, Steiner M (2005) Western flower thrips in stone fruit. In: *Orchard Plant Protection Guide for Deciduous Fruits in NSW 2005/06.* 15th edition. Available through the NSW DPI website, www.agric.nsw.gov.au

Rust

Tranzschelia discolor

IPDM quick facts

Sample unit: *Leaves—temperature and leaf wetness*

When to monitor: *Mid-season to after harvest*

How often: *Weekly*

Action level: *If all three of the following occur simultaneously:*

- *rust present in recent seasons*
- *leaves wet for more than 4 hours*
- *temperature between 13 and 25 °C*

and/or

- *you observe rust symptoms.*

Causes and consequences

Rust is caused by the pathogenic fungus *Tranzschelia discolor*. If it is not controlled, a severe infection can cause premature leaf-fall. Yield from trees infected with rust is considerably reduced. The fruit on trees defoliated before harvest does not mature satisfactorily, with sugar levels remaining low.

The effects of premature loss of leaf may be greater than the loss of the immediate crop. The leafless trees must live on stored food reserves for the rest of the season, depleting food reserves for winter requirements and next season's bud development. This can cause weak bud development and below-normal crop yield in the following season.

Defoliated trees often shoot and flower in autumn, reducing the size of the crop the following season because many flower buds are wasted by premature blossoming. In mid- to late summer, defoliated limbs are exposed to direct radiation from the sun for long periods and are in danger of being sun-scalded and then invaded by wood-rotting fungi. Limbs affected in this way are weakened, less productive, and prone to breaking under the weight of a crop. When rust infection has occurred in several seasons, tree life may be shortened.

Rust lesions on prune

Fruit infected with rust is unsaleable. The infections penetrate several millimetres into the flesh.

Symptoms

Leaves

The upper surface of an infected leaf becomes speckled with small yellow patches that often run together. The underside develops corresponding rusty brown spots. These are powdery masses of fungal spores that are sometimes so numerous that the undersurface of the leaf seems coated by brown dust. As autumn approaches, the spots on the undersides of the leaf often turn black.

Shoots

Shoots may also be attacked, resulting in small dead patches where the bark splits on 1- and 2-year-old shoots.

Fruit

Rust infection occurs on peaches, nectarines and apricots. Symptoms are small, depressed spots with dark, reddish centres and often with pale green borders.

A serious regional issue during the last 10 years in:

- NSW southwest slopes
- Goulburn Valley
- SE Queensland

Prevention

Choosing species and varieties

All species and varieties of summer fruit can be infected by rust, but some are more susceptible than others. In coastal districts, severe rust infection often develops on early-maturing dessert peach varieties. In inland districts, rust is more likely to develop on some canning varieties and sugar plums (French prunes). In cooler regions, mid- to late season peaches usually show severe infection only in autumn. Rust is not usually seen on apricots until autumn.

Orchard design

This disease is very responsive to weather. Setting up and managing an orchard to minimise weather favouring disease development is a very effective management strategy.

Where possible, avoid planting in valleys. Humid air favours the disease and tends to pool in these areas. Rain and heavy dews during warm weather also favour disease development, and orchards should be set up so as to allow rapid drying of the leaves. Younger trees are more resistant to the disease. If rust is a serious problem in older orchards, replace the trees.

Pruning and shaping trees

Large bushy trees tend to trap air within their canopies and create a humid microclimate. Thorough pruning allows better airflow through the trees and ensures more thorough penetration of sprays if the disease is severe enough to warrant them.

Infections often occur in mid- to late summer but can occur at any time during the growing season. Therefore, careful monitoring throughout the season is advised.

Monitoring

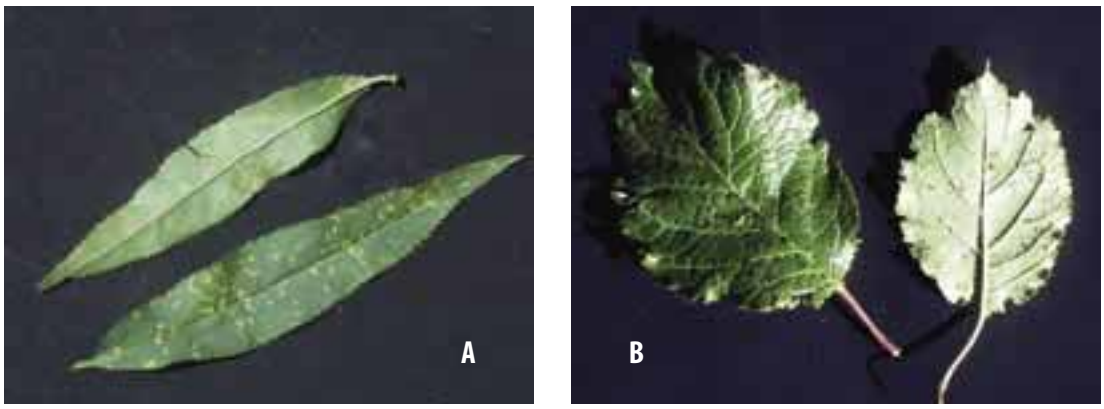
When to look

This disease is spread readily by the wind and can be splashed about by rain. For these reasons, it can appear suddenly in orchards with no previous history of rust infection. Monitoring of the weather from mid-season to leaf fall is recommended in regions prone to rust infection. Infections occur in a predictable way in response to the weather. Because of the potential for rapid spread it is far more effective to monitor for favourable weather rather than symptoms. If the disease has been a problem in previous seasons, it is likely to recur and a protective spray schedule should be used.

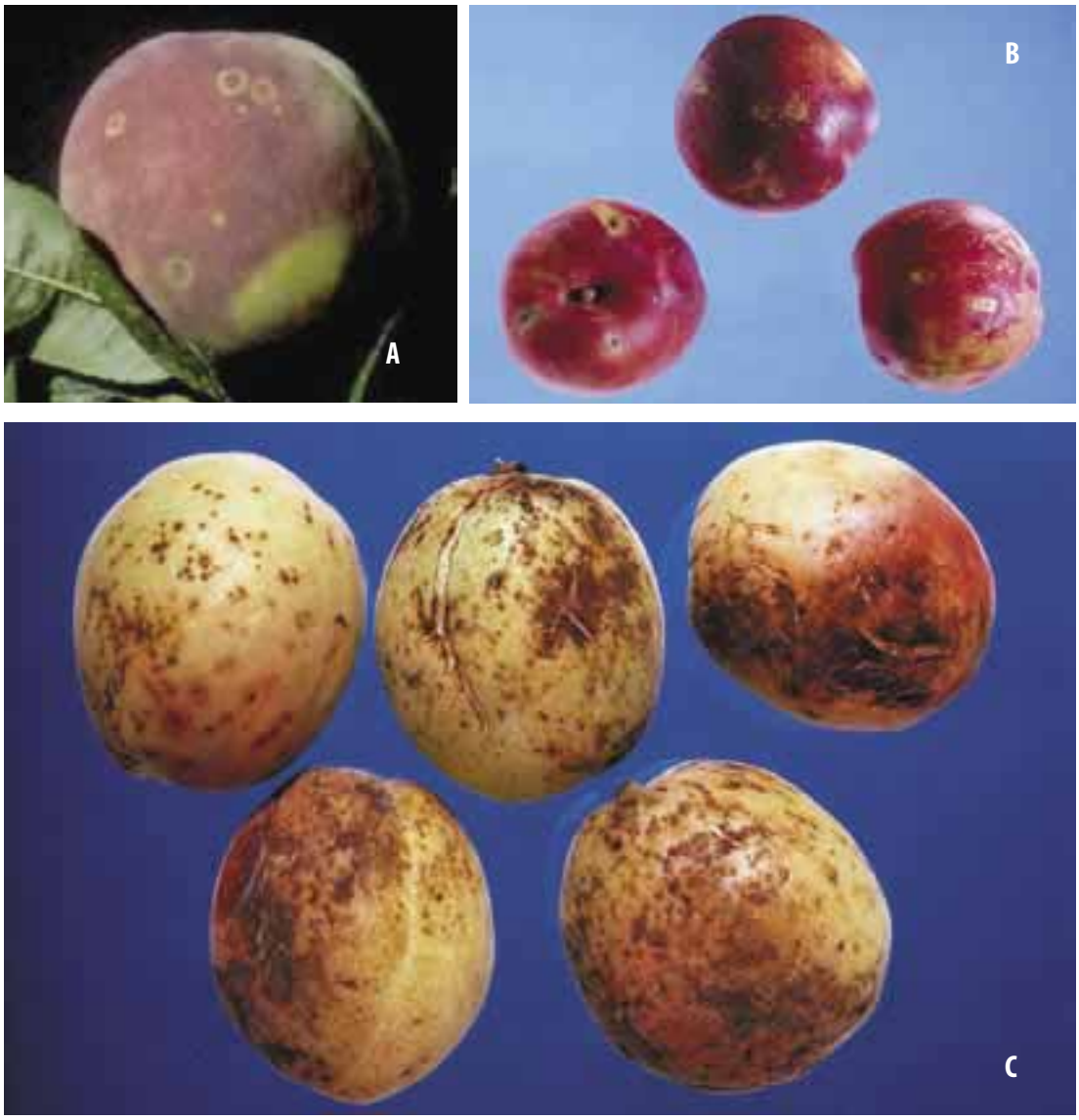
What to look for

Carefully monitor the weather and treat your orchard in response to the periods that favour disease development in your region. In plums, for infection to occur, leaves must remain continually wet for at least 4 hours at temperatures between 13 and 25 °C. If leaves are continuously wet for longer, infection becomes more severe. At temperatures below 13 °C and above 25 °C, infection takes longer to occur. No infection occurs at or above 30 °C.

Monitoring for symptoms is also recommended. Examine the leaves on four lateral branches of each of your monitoring trees at weekly intervals from mid-season to after harvest.



Rust infections on the upper and lower surfaces of (A) peach and (B) plum



Peach (A), nectarine (B) and apricot (C) fruit with rust infections

Appropriate action

Action threshold

(See chart on next page)

If all of the following occur simultaneously:

- rust has been a problem in recent seasons
- leaves have been wet for more than 4 hours
- temperatures are between 13 and 25 °C and/or
- rust is seen on the leaves.

Sanitation measures are designed to break the disease cycle in single orchards. They can also reduce the severity of rust by delaying epidemics. If an orchard is free of the disease at the beginning of a new season, it will take rust much longer to invade from distant orchards or other sources.

Remove all diseased wood and leaves during pruning

When pruning peach trees, remove all diseased wood and where possible burn the prunings and any diseased leaves.

Remove all fallen leaves from branches, crotches etc.

During winter, remove and destroy all dead leaves from within the framework of orchard trees. Leaves commonly lodge in the tree crotch where the main branches divide from the trunk, so look for leaves in these areas while pruning. Removing and destroying dead, infected leaves is preferable to dropping them on the orchard floor: rust spores can survive just as well on dead, infected leaves on the ground as they can within the tree framework.

Remove any green leaves retained by the tree

Some summerfruit species and some varieties within species tend to retain some living leaves through the winter. Remove these leaves if possible, as they may be a source of rust infection in the new season.

Protective spray program

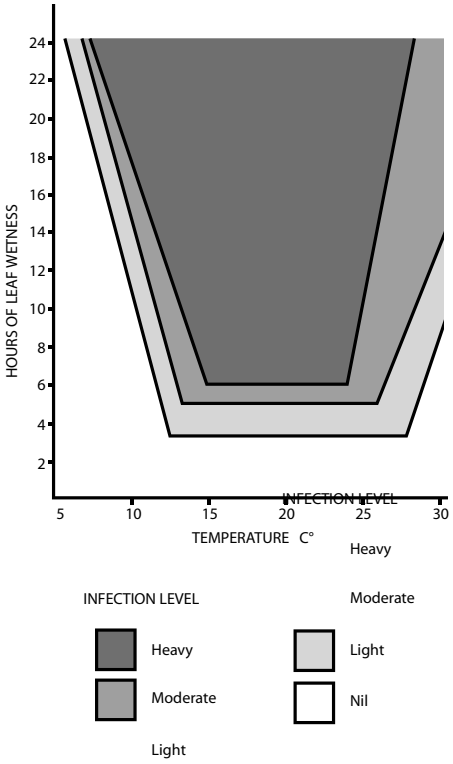
Where rust has been a problem in previous seasons and the crop is being grown in conditions conducive to disease infection, you should undertake a full fungicide spray program to control this disease. A complete program for the control of rust is provided in this manual (page 137).

More information

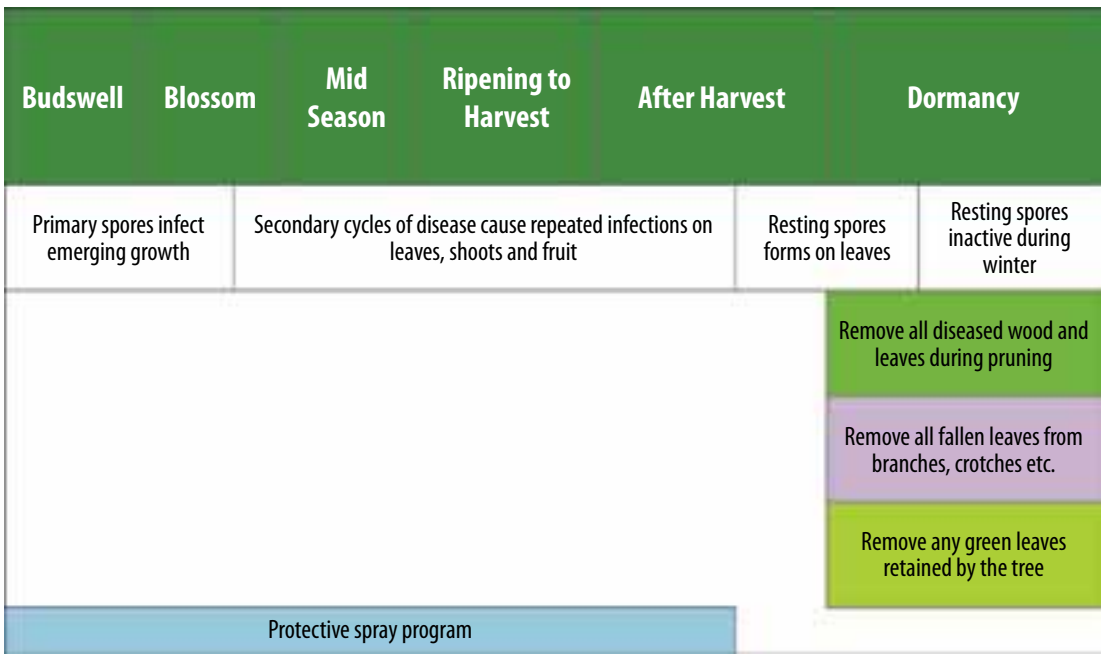
Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Slack JM (1988) *Prune Rust: a Practical Guide to its Control.* Agdex 216/633. NSW Agriculture and Fisheries, Orange

Strand LL (1999). Rust. In: *Integrated Pest Management for Stone Fruits*. Statewide Integrated Pest Management Project. University of California Division of Agriculture and Natural Resources, Oakland California, pp 130-32 †



Relationship between temperature and leaf wetness period and the severity of rust infection in sugar plum (reproduced from Prune Rust Infection Prediction Service: Operator's Manual, Biological and Chemical Research Institute, NSW Agriculture and Fisheries)



San José scale

Diaspidiotus (Quadraspidiotus) perniciosus

IPDM quick facts

Sample unit: *Tree butt and branches*

When to monitor: *Late blossom to dormancy*

How often: *Fortnightly*

Action level:

- *if scale damage has been seen in the previous season*
- *if scale infestation is heavy during the current season*

Take extra care when monitoring:

- *during warm dry weather*
- *when there is dust on trees.*

The pest and its damage

San José scale is a major pest of fruit trees but can be quite inconspicuous until numbers build up. In winter immature nymphs survive on limbs and trunks. In spring these nymphs develop into winged male and stationary female insects. Adult female San José scale insects have a grey circular covering. If the covering is removed, the yellowish scale body can be seen underneath.

They lay eggs that immediately hatch and emerge from under the scale as crawlers. There can be up to four generations of crawlers per season.

San José scale infestation

San José scale damages the tree by feeding on twigs, branches and fruit. A heavy infestation will be obvious on the trunk and branches as a grey, scurfy layer.

When rubbed with the hand, dead scale covers will flake off. If the scale is alive, rubbing will leave the hand with a yellow to reddish deposit. Often the tree will react by producing gum at the site of a San José scale infestation.

In extreme cases entire trees can be killed.

During the growing season, scale crawlers (see description of the pest's life cycle in 'Monitoring') will move to the new lateral growth and onto the fruit. Once the pest has settled and the mouth parts have been inserted into the fruit, individual scales will often be highlighted by a red ring.

A serious regional issue during the last 10 years in:

- Alstonville
- Perth Hills
- NSW central west
- Swan Hill
- Southeast Queensland

Prevention

Pruning

Prune out infested branches and burn. This will also improve spray penetration.

Neglected trees and other hosts

Scale can build up heavily on neglected fruit tree seedlings around orchard areas, on many ornamental trees and shrubs related to summerfruit, and on several unrelated hosts, for

Yellowish body of an adult female San José scale

A heavy infestation of San José scale

example, tree lucerne, osage orange and willow. It can be spread from these to summerfruit by wind or birds. Don't overlook such sources of infestation in areas where scale is a problem. Spray infested deciduous ornamentals with oil. Neglected pome fruit trees, summerfruit trees and other hosts should be cut down and burned.

Monitoring

When to look

Look at the butt and branches of the marked monitoring trees from late blossom to dormancy at fortnightly intervals. San José scale numbers can build up very quickly, so monitor thoroughly (see chart below).

San José scale has quite a complex life cycle that is tied closely to temperature.

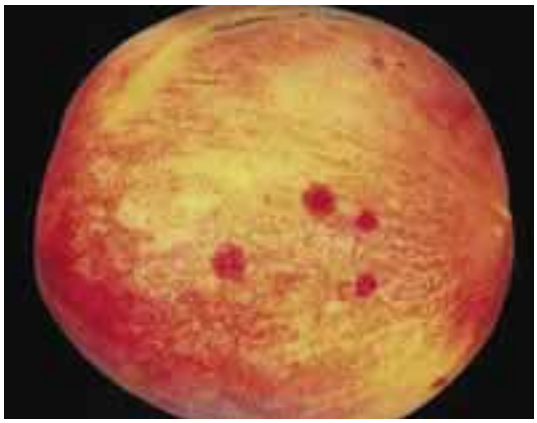
In cooler regions San José scale survives the winter under a black waxy cap. This is the 'black cap stage'. In spring the female lays eggs under the scale; these immediately hatch as 'crawlers'. Crawlers are tiny yellow insects that move about until they find a suitable feeding site. They then settle down and secrete a white waxy covering. After a period of time, the scales turn dark grey. Male scales are more elongated than those of females.

In warmer regions it is possible that all stages of the San José scale life cycle are present throughout the year. The life cycle will vary considerably from region to region, largely corresponding to variations in temperatures.

Because the development of scale is closely associated with temperature, management models have been developed. These allow orchardists to monitor temperature and apply management at a time when scale is most likely to be controlled. These models are currently available only to overseas orchardists but are now being developed for Australia.

At present, in Australia the most effective controls are applied during the dormant period. They are applied in response to damage observed during the previous season(s). Therefore, the most appropriate period for monitoring is during the production season. Be especially vigilant in years of crop failure, when sprays are likely to be reduced. These are the years in which populations will increase to levels that are difficult to control.

Budswell	Blossom	Mid Season	Ripening to Harvest	After Harvest	Dormancy
First-generation crawlers infest trees		Four or five overlapping generations of scale during a growing season			Scale overwinters as black cap stage
		MONITOR			



Fruit damage caused by San José scale

What to look for

Look for any sign of damage due to San José scale or the scale themselves. It is important to look very thoroughly, as numbers can build up quickly.

Appropriate action

(See chart below).

Action threshold

- if scale or scale damage has been seen during the previous season
- if scale infestation is heavy during the current season

Apply dormant oil

This pest is best controlled in winter. Treat summerfruit trees with dormant oil in winter. Thorough application (drenching) is important to achieve good control. Most dormant oil formulations are registered for use at 3 L per 100 L (3%) for the winter application. If cost is an issue, it is acceptable to use 2 L per 100 L (2%) at the dilute spraying volume as specified on the label. Drive slowly to achieve a drenching cover and obtain good control. If this treatment is applied properly, chances are you will not need any other control for San José scale during the season.

Insecticide application

If dormant oil has not provided sufficient control or infestations are very heavy, consider applying an insecticide. A recommended schedule is provided on page 137. Note the warning provided about fruit marking.

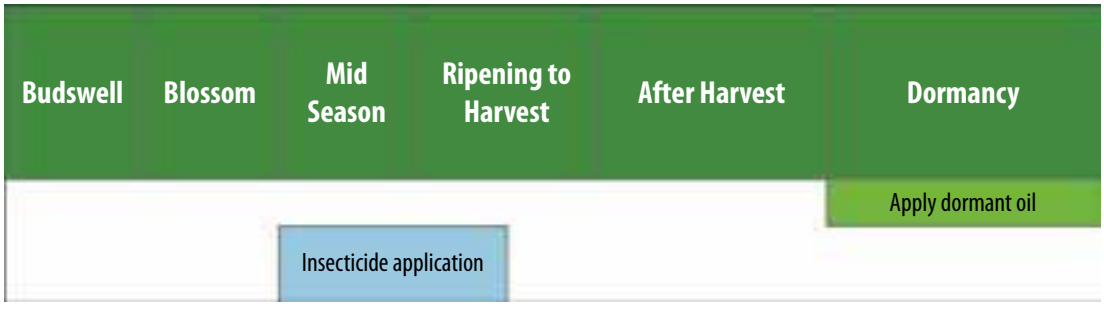
More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Hetherington S, Thwaite G (2004) *IPDM in stone fruit: what to do in winter*. NSW Department of Primary Industries Fruitwise no. 54. pp 6–9

Wearing CH (1998) HortFACT, *San Jose Scale Life Cycle*. The Horticulture and Food Research Institute of New Zealand Limited. www.hortnet.co.nz/publications/hortfacts/hf401021.htm †

Robinson JV (1998) *Scale Insects on Peaches and Plums*. Texas Agricultural Extension Service. entowww.tamu.edu/extension/publications/siopaplum.html †



Shot-hole

Wilsonomyces carpophilus

IPDM quick facts

Sample unit: *Leaves*

When to monitor: *Shuckfall to harvest*

How often: *Fortnightly*

Action threshold: *When 5% of leaves have spore-forming lesions and rain is expected within a week.*

Take extra care when monitoring:

- *when it has been wet in late winter and early spring*
- *leaves have been wet for at least 24 hours*
- *fruit infection is favoured by wet spring weather.*

Causes and consequences

Shot-hole occurs on all types of summerfruit but is less severe on plum. It is caused by the fungus *Wilsonomyces carpophilus* and affects leaves, fruit and buds. The disease decreases the efficiency of the tree by decreasing its photosynthetic capacity. If leaf infection is severe, premature leaf fall can occur. Fruit infections are superficial but disfigure the fruit, making it unmarketable.

Symptoms

Leaves

Leaf lesions start as reddish specks that enlarge and develop tan centres with purplish margins. Often leaf lesions will be surrounded by a light green or yellow halo.

The brown tissue in the centre of leaf lesions usually falls out, leaving a typical 'shot-hole' appearance. Many other diseases can cause similar symptoms. A diagnostic feature of this disease is the presence of tiny, black, spore-forming structures in the centre of the tan lesions. These can be seen with a hand lens.

Twigs and buds

Lesions on twigs look similar to those on leaves. They are initially red and then turn tan with a purplish margin as they enlarge. Again, black spore-forming structures can be seen in the centres of these lesions.

Infected buds turn black, and often—but not always—gum is exuded. When the bark is cut away from beneath the diseased bud, brown water-conducting tissue can be seen.

Fruit

Fruit lesions are similar in appearance to those on leaves and twigs. Older lesions have a brownish-purple border and a tan centre. Unlike leaf and twig infections, no spore-forming bodies form on fruit lesions.

Shot-hole on apricots

Early symptoms of shot hole on apricot leaves

Bud killed by shot hole. Note the darkening of internal tissue under the bud.

Fruit infected by the shot-hole pathogen

A serious regional issue during the last 10 years in:

- NSW southwest slopes
- Tasmania
- Manjimup/Donnybrook
- NSW central west

Prevention

Pruning out infected wood

Prune out as much infected wood as possible during dormancy and burn prunings. A protective spray schedule will still be required in affected orchards, but pruning will improve the efficacy of sprays.

Irrigation

Be careful that irrigation does not wet the leaves. Shot-hole, and many other diseases, will become established only after the leaves, fruit or twigs are wet for prolonged periods.

Hasten leaf fall

Orchardists who hasten leaf fall as part of their management strategy will find that this will also have benefits for shot-hole. It prevents levels of inoculum from building up in late autumn.

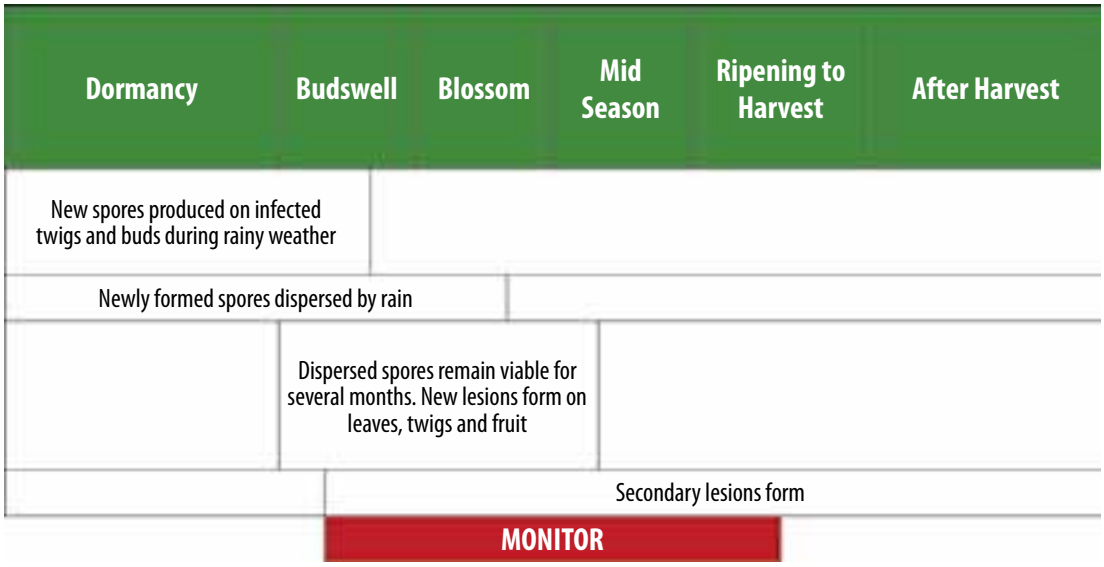
Monitoring

When to look

(See chart below).

Carefully examine leaves on four limbs of each marked monitoring tree at fortnightly intervals until mid-harvest.

Keep accurate records of shot-hole severity in your orchard. Where shot-hole has been present in the orchard in previous seasons it is advisable to use a protective spray schedule before symptoms appear and apply fungicides at regular intervals until shuckfall (see page 137).



Monitoring can reduce the number of sprays required for shot-hole after shuckfall. With a hand lens, carefully inspect lesions that form on leaves in spring.

What to look for

If black spore-forming bodies are present and rain is likely within the next week, apply a fungicide. If either of these conditions is not met it is not necessary to apply a protective fungicide.

Appropriate action

Action threshold

- 5% of lesions seen in spring have spore-forming bodies
- rain is expected within a week.

Protective spray program

In most cases early season application of protective fungicides for diseases such as brown rot and leaf curl will be sufficient to control shot-hole (see chart above). In these cases no specific additional fungicide applications are required.

If shot-hole was present in the orchard in the previous season, and particularly if spore-forming bodies were seen on leaves in autumn, the young buds must be protected up until shuckfall. Do not wait to see symptoms at this stage of the year.

It may be possible to reduce the number of fungicide applications necessary after shuckfall by carefully monitoring the young leaves at this point.

Lime sulfur

Where shot-hole has been a serious problem, an application of lime sulfur during dormancy will reduce the number of spores carried over from the previous crop. In most cases this application should not be necessary.

More information

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Strand LL (1999) Shot-hole. In: *Integrated Pest Management for Stone Fruits. Statewide Integrated Pest Management Project*. University of California Division of Agriculture andNatural Resources, Oakland California pp. 125-127 †

Silver leaf

Chondrostereum purpureum

IPDM quick facts

Sample unit: *Leaves*
When to monitor: *Mid-season to leaf fall*
How often: *Fortnightly*
Action threshold: *If silver leaf is seen*

Silver leaf on peach

Causes and consequences

Silver leaf is caused by the fungal pathogen *Chondrostereum purpureum.* This fungus attacks a wide range of temperate trees and shrubs, including all types of summerfruit, pome fruit, willows, eucalypts and roses. Although the fungus causes symptoms on leaves, it primarily causes an aggressive wood-rotting disease. At worst it can cause tree death, but less severe consequences of the disease include a reduction in fruit size and number, poor colour and reduced storage life.

Symptoms

Leaves

The disease is called silver leaf because of the silvery sheen it causes on the foliage. This sheen is caused by a toxin that is produced by the fungus and is carried through the water-conducting tissue. The toxin causes the leaves to turn silver-grey. They may also curl and turn brown at the edges.

Leaves may turn silver on single branches or the whole tree. The extent of silvering is generally related to the size of the wound that the pathogen has colonised on the limbs or trunk.

These symptoms are easily confused with the damage caused by peach silver mite (page 95). In the case of silver leaf, symptoms on leaves are always associated with nearby limb and trunk infections. Look for these to differentiate between peach silver mite and silver leaf.

Trunks and limbs

The fungus enters the tree through wounds. Unprotected pruning wounds are a prime site of entry. Upon entry it begins to produce toxins, which kill the trunk or branches. The toxin also spreads to the leaves, causing the characteristic silver foliage associated with this disease (see above for more details). Infection can be detected by a dark brown discolouration of the heartwood on dying limbs. The fungus remains confined to the tree's water-conducting vessels until the limb or trunk is dead. When the limb is dead the fungus moves out of the water-conducting tissue and produces its characteristic fruiting body. These are small leathery structures with a greyish white upper surface and purplish lower surface.

A serious regional issue during the last 10 years in:

- Adelaide Hills
- Goulburn Valley

Prevention

If silver leaf has been a problem in the orchard during the last 4 years, you will need to take rigorous preventive action.

Varieties

No varieties are immune to silver leaf, but some are less susceptible. If silver leaf has been a problem in your orchard, ask your supplier about the susceptibility of trees for new plantings.

Pruning

The most common point at which the pathogen enters trees is through pruning wounds. Correct pruning is therefore critical in preventing and controlling silver leaf in disease-prone orchards.

Avoid winter pruning, particularly on calm, damp, overcast days, as these are the days when most fungal spores will be present in the orchard. Aim to produce a pruning wound that will heal quickly to produce a doughnut-shaped callus. Good technique and tools are important. Use good quality sharp pruning tools. Ragged wounds help the pathogen to colonise.

The disease is not easily transmitted on pruning tools, and you don't need to sterilise your tools between cuts.

All prunings must be buried or burnt.

Also note that other forms of wounding may create infection sites for this disease; see information on controlling 'four-legged pests' (page 17).

Wound dressings

Apply wound dressings as soon as possible after pruning; certainly on the same day. The fungus produces more spores in the dark, and leaving wounds unprotected overnight is a recipe for disaster. If for some reason wound dressings aren't applied quickly, it is often best to leave wounds unprotected. Infection is likely to have already occurred. The pathogen is likely to have penetrated some depth into the tree and a surface dressing merely traps the fungus in the tree. Applying a late wound dressing is also likely to kill beneficial organisms that may otherwise kill the fungus.

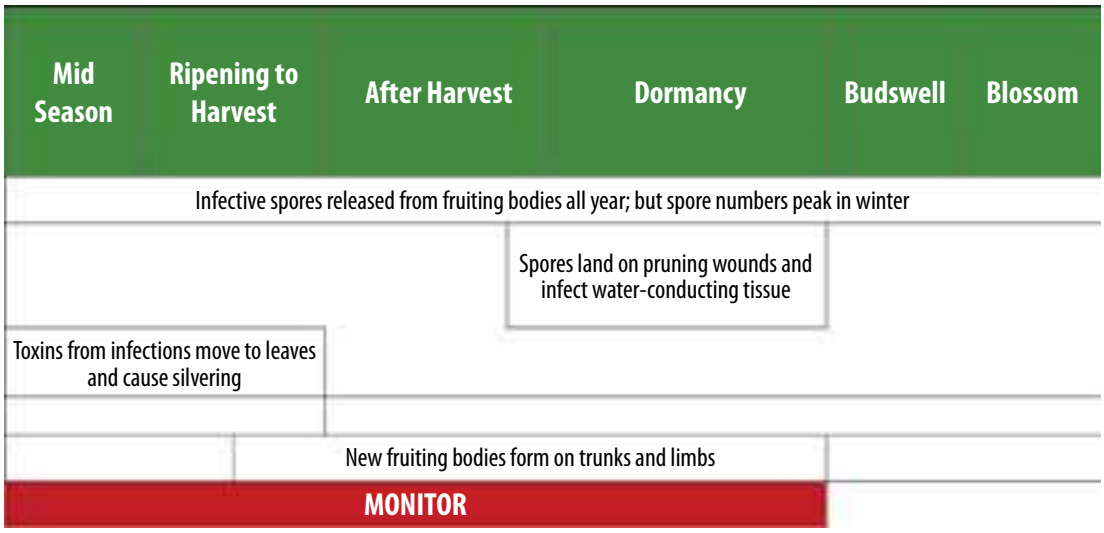
Acrylic paints often form a physical barrier sufficient to stop the pathogen penetrating through wounds. Do not water the paints down; this reduces their effectiveness significantly and is false economy. Where wounds are particularly large, a second coat of paint may be required.

Many fungicides are toxic to trees when applied at the wrong rates and can seriously harm trees. Therefore, avoid home-made mixtures of paint and fungicides. Use of copper-based products is especially dangerous, as they increase the tree's susceptibility to silver leaf. A commercial wound dressing formulation is available that contains the fungicides cyproconazole and iodocarb. Use this formulation if silver leaf has been a serious problem.

Remove alternative hosts

The silver leaf pathogen infects a wide range of trees and shrubs. Some trees should be removed from around orchards, because they pose a particular risk. Willows and poplars are particularly susceptible to the disease, and those close to the orchard should be cut down and burned. Be careful when your orchard is near a watercourse.

Leaves have a silvery grey sheen after infection



Monitoring

When to look

(See chart above).

Silver leaf needs to be included in your monitoring schedule if it has been observed in your orchard at any time during the last 4 years.

Carefully observe four lateral branches on the marked monitoring trees for silvering of the leaves from mid-season to leaf fall. You should also observe the other trees in the orchard as you walk between the trees. Closely investigate any signs of silvering.

Monitoring for new fruiting bodies should concentrate on the period immediately after leaf fall. The fruiting bodies are easier to see at this time.

Spore-producing body of Chondrostereum purpureum, the silver leaf fungus

What to look for

Silvering is the most obvious early indicator of silver leaf infection. Observe monitoring trees for the presence of new fruiting bodies. These may form without any obvious leaf silvering symptoms.

Appropriate action

Action threshold

If silver leaf is seen (see chart on next page).

Prune out infected limbs and burn or bury prunings

Individual fruiting bodies are capable of producing spores for 2 years. Aim to prune out spore forming bodies when you see them, except during cold, wet and still weather. Pruning in early or late winter should help. This pruning should be done in conjunction with careful monitoring. Where leaf silvering and /or fruiting bodies haven't been observed in the orchard for 4 years, a more normal mid-winter pruning schedule can resume.

As spore numbers are highest during cold, wet and still days, new fruiting bodies should be pruned out very early in winter, when these conditions are less frequent.

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 137) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

Strand LL (1999) Silver leaf. In: *Integrated Pest Management for Stone Fruits. Statewide Integrated Pest Management Project.* University of California Division of Agriculture and Natural Resources, Oakland, California pp. 145–146. †

Two-spotted mite

Tetranychus urticae

IPDM quick facts

Sample unit: *Two leaves per sample tree*

When to monitor: *Summer, particularly in hot weather*

How often: *Fortnightly*

Action level: *65% to 80% of leaves infested*

- *Use visual orchard damage assessment when infestations are patchy.*
- *Increase monitoring frequency in hot weather.*

The pest and its damage

Two-spotted mite is a distinctive, common species, easily recognised by the two dark spots on either side of its body. These spots may not always be prominent, and sometimes they almost join into a large dark area at the front of the abdomen. Male two-spotted mites are distinguished from predatory mites by their pointed abdomen, two dark spots and small red 'eye spots' towards the front of the body. The 'eye spots' also occur on female two-spotted mites.

Adult females are about 0.6 mm long, oval and pale green or yellowish green, with a dark green spot on each side of the body. In late autumn in cold climates the females change colour to orange as their development becomes suspended for that season.

Adult males are a little smaller and less abundant than females. They have a triangular, pointed abdomen.

The immature stages resemble the adult females in general appearance, but are smaller and usually pale greenish white. The eggs are minute (0.1 mm diameter), spherical, and clear or pale yellow. They are usually laid on the undersides of leaves, or on fine webbing spun by the females.

Two-spotted mites suck the juice from individual leaf cells, making the leaves turn brown and fall.

Two-spotted mite

In extreme cases almost complete defoliation can occur. If defoliation occurs before harvest, the reduced photosynthesis may reduce the size of the fruit and adversely affect fruit colour. Severe infestations may also reduce fruit bud set and yield for the following year because of a reduction in the amount of reserves going into the tree before dormancy.

Prevention

Reducing dust

Two-spotted mites become more of a problem on trees in dusty blocks. Any measure that will reduce the amount of dust blowing onto trees will minimise mite problems. Wet down dusty tracks, or drive on the leeward side of the orchard during hot dry weather.

Delay spraying

If two-spotted mites have been a problem in the past, it is a good idea to delay spraying other insect pests and diseases for as long as possible. Many insecticides (e.g. bifenthrin) and even fungicides reduce populations of the natural enemies of two-spotted mite (and other mites). These reductions can lead to mite outbreaks.

Irrigation

If the weather is hot and dry there is greater risk of rapid increases in pest mite numbers and greater stress on the trees from mite damage. This stress will be lessened if the block has adequate irrigation.

Biological control

Biological control agents that are effective against two-spotted mite are available from a number of commercial outlets in Australia (page 119). The predatory mites *Phytoseiulus persimilis* and *Typhlodromus occidentalis* will reduce two-spotted mite populations. Predatory mites must

be introduced early, before pest mite numbers build up. The toxicity to predatory mites of the chemicals that have been used or are intended for use in the orchard must be checked (see page 112). Some chemicals have a long-lasting residual effect that will lower the effectiveness of biological control. There is often a need to re-apply biological control agents during the season in response to two-spotted mite build-up. Biological control agents usually need to be re-introduced in subsequent seasons, as they are unlikely to be present in the orchard year after year.

Monitoring

In many cases orchardists employ consultants to monitor their crops for mites. A trained consultant should be able to identify both pest mites and their natural enemies and take account of these in advising action thresholds. Although this is the most accurate method of monitoring, orchardists themselves can also monitor their crops by using visual assessment. Two-spotted mite infestations usually start in the lower part of the tree, in the crotch. This is where the early phase of monitoring should be concentrated. Both monitoring techniques are outlined here (see chart below).

Monitoring by consultants

Professional consultants should use this technique to monitor both mite and predator populations where populations are relatively uniform. In the case of patchy infestations visual assessment (see below) is more effective and should be used by consultants as well.

At fortnightly intervals two leaves are taken from each of the sample trees in the block. Leaves should be dry and mature and come from the lower part of the tree, below head height. One leaf should be taken from the inner part of each tree and one from outer areas. The inner leaf

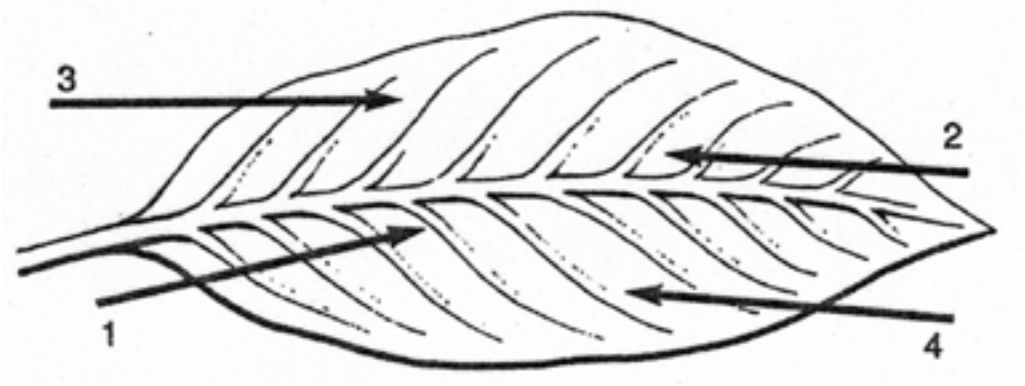
Overwintering female two-spotted mites. Note the orange colour.

will allow detection of the early stages of two-spotted mite infestation. Pick leaves at random; don't deliberately select heavily infested ones or avoid uninfested ones. Put them in a plastic or paper bag and transport them in a cool esky or portable refrigerator. It is essential to keep the sample cool; don't leave it in the sun or in the car. Prolonged exposure to the sun causes the leaves to turn brown and may kill mites, making counting very difficult. Label the sample bag with the orchard name, block number and sample date.

Store leaf samples in a refrigerator or cool room at 4 °C before examination. If the leaf samples are in paper bags, place these in a larger plastic bag before storage to prevent the leaves from drying out. Samples should be assessed within 2 days of collection so that populations don't have time to change before the management strategy is applied.

Only the underside of each leaf is examined, individually, using a binocular microscope at 8 to 10 × magnification.

Budswell	Blossom	Mid Season	Ripening to Harvest	After Harvest	Dormancy
Diapause	Females lay up to 200 eggs each. Many overlapping generations of mites per season				Diapause in cooler regions. Feeding and reproduction continues elsewhere
	MONITOR				



Method of examining leaves for mites. Numbered arrows indicate the timing and direction of observations under the microscope.

Scan each leaf systematically; pay particular attention to the area next to and below the midrib, where predators may be sheltering. Hold the leaf between the thumb and forefinger of each hand and pass it to and fro across the field of view. Adjust the microscope to focus on a plane 1 or 2 cm above the base plate, and keep the field of view in focus by raising or lowering the leaf by hand as you pass it underneath. Examine the leaf in four sweeps.

For speedy assessment place each leaf in one of four piles next to the microscope after examination. The four piles correspond to the four categories of leaves in columns A, B, C and D on the record card shown.

After you have examined all of the leaves, count the number in each category and enter the results on the card. The leaves can then be discarded and the percentages with pest mites or predators calculated.

The data obtained from a 50-leaf sample can be used to decide on the need for spraying. The percentage of leaves occupied by pest mites

Australian Summerfruit IPDM Record Card

ORCHARDIST: John Smith

Sample date	Observer	A Zero mites/predators	B Two-spotted mites only	C Both mites and predators	D Predators only	E Total leaves	Percentage mites	Percentage predators
4-12	IL	32	12	4	2	50	32	12

% mites = ([B + C] × 100)/E
= ([12 + 4] × 100) / 50
= 32% a

% predators = ([D + C] × 100)/E
= ([2 + 4] × 100)/50
= 12%

indicates the likelihood of economic damage occurring. The ratio of pest mites to predators determines the probability of biological control succeeding before economic damage occurs. Knowledge of these relationships allows action thresholds to be set and appropriate spray decisions made.

Monitoring by orchardists: visual damage assessment

Go for a walk through your orchard and identify any hotspots of mite activity. Rate the trees with the worst infestations according to Table 3.

Table 3. Visual damage assessment by consultants: two-spotted mite

Rating code	Description	Visible damage
0	Nil	No damage
1	Trace	Detectable by close inspection
2	Slight	Some bronzing in inner, lower areas of tree
3	Moderate	Obvious bronzing confined to lower quarter of tree
4	Severe	Bronzing extending to halfway along limbs
5	Extreme	More extensive bronzing and defoliation

If there are two or three patches of trees with a rating of three in a block where most trees do not exceed a rating of 1, the block would receive a rating of 3.

Table 4. Actions to be taken depending on pest and predator numbers

Percentage of leaves occupied		
Pest	**Predator**	**Action**
0–49 Very low chance of economic damage		Check again in 2 weeks.
50–64 Low chance of economic damage	0–5	Effective biological control unlikely. Apply a selective miticide at the non-IMC† rate.
	5–20	Biological control may succeed. Check again in 1 week.
	> 40	Effective biological control imminent or is occurring. Check again in 1 week.
65–79 Moderate chance of economic damage. Damage imminent.	0–5	Effective biological control unlikely. Apply a selective miticide at the non-IMC rate, if applicable.
	5–40	Biological control unlikely to succeed before damage occurs. Apply a selective miticide at the IMC rate, if applicable.
	> 40	Effective biological control imminent or is occurring. Check again in 1 week.
80–94 High chance of economic damage.	0–10	Apply a selective miticide at non-IMC rate.
	10–50	Apply a selective miticide at IMC rate, if applicable.
	> 50	Effective biological control imminent or is occurring. Check again in 1 week.
95–100 Very high chance of economic damage.	0–10	Apply a selective miticide at the non-IMC rate.
	> 10	Apply a selective miticide at the IMC rate. Biological control is unlikely to occur quickly enough to prevent excessive damage, which may already be occurring.

†IMC = Integrated mite control. IMC rates are specified on labels.

Appropriate action

For professional consultants counting pest mites and natural enemies

Essentially, unless there is extreme patchiness in the block sampled, the maximum tolerable level of mites is set at 80% of leaves occupied by pest mites. Sprays should be applied **before** the 80% level is reached, not after, to prevent excessive damage to trees. A spray is not usually needed for infestations occupying less than 50% of the leaves, so the decision needs to be made between population levels of 50% to 80% of leaves occupied.

For pest populations in the region of 50% to 65%, there should not be any significant damage occurring and it is advisable to wait a week and sample again, particularly if good numbers of predators are present. Delaying the spraying as long as possible gives predators the maximum opportunity to multiply, and gives the best chance of biological control being maintained after spraying.

For pest populations between 65% and 80% of leaves a spray should be applied, unless biological control is imminent.

Guidelines for the numbers of predators needed to achieve biological control of given pest populations are shown Table 4.

A closer watch is needed on mite populations in hot, dry weather, particularly as they approach critical levels. The decision to spray should allow for the potential for explosive increase in hot weather. A spray schedule for two-spotted mite is included in this manual (page 137).

It is important to remember that quite high numbers of predators are needed to control pest populations near the damage threshold. It is better to err on the side of caution and apply a spray than to wait too long and allow damage to occur.

If early-season monitoring indicates that two-spotted mites occur in some trees but not in

others (the infestation is patchy), then use visual damage assessment of the entire orchard (see below) to help you to decide if you have reached the action level. If the infestation is uniform, continue using the monitoring method above.

For visual damage assessment by orchardists

If the visual damage assessment gives a rating of 3 or more, a spray should be applied, unless it's clear that most of the block is under biological control. In the latter case, it may be worthwhile applying a spot spray in sections where predators are lagging. A spray should also be considered when most trees have been rated at 2, as it will not be long before many will reach a rating of 3, if predators are lagging. A spray schedule for two-spotted mite is included in this manual (page 137).

More information

Some of the information provided in these references comes from other countries (marked †). Always remember that the biology of pests and diseases and the tactics used to control them vary subtly from country to country and will change with time. Be particularly cautious with pesticide recommendations. If a pesticide is not recommended in this manual (page 136) you must check that it has current registration in your State and abide by the conditions of that registration, as specified on the pesticide's label. ALWAYS READ THE LABEL.

The Mite Management Manual is described as a practical guide to integrated mite control. It contains colour photographs of mites and predators and details of how to control orchard mites with predators and miticides. Although this book is primarily intended for use by apple orchardists, many of the principles are useful in summerfruit orchards. It is available through NSW Department of Primary Industries Publications Sales, freecall 1800 028 374.

Barrass I (1995) *Predatory Mites to Control Two-spotted Mite in Orchards*. AGO215. Available through the Department of Agriculture Victoria at the DPIV website, www.dpi.vic.gov.au

Learmonth S (2005) *Using Miticides in Western Australian Deciduous Fruit Tree Crops 2004–05*. Department of Agriculture Western Australia. Available through the DAWA website, www.agric.wa.gov.au

Other pests and diseases of Australian summerfruit

Armillaria

Heavy gumming associated with an Armillaria infection

Armillaria mycelium under the bark of an infected tree

Armillaria fruiting bodies (mushrooms)

Armillaria is a soil-inhabiting fungus that causes root rots. It can be a problem in Stanthorpe, the Perth Hills, the Goulburn Valley and the NSW Central West. There are no registered products for the control of *Armillaria* for Australian summerfruit. The presence of white, fan-shaped mycelia (fungal strands) under the bark distinguishes this disease from that caused by *Phytophthora* (page 98).

Armillaria infects a large number of native and imported tree species, including summerfruit. Many infections arise because blocks are planted on recently cleared land that contained infected native trees, especially wattles. Consider the history of any new block before planting.

No rootstock is resistant to *Armillaria*, although some are more tolerant. Australian growers have noted that summerfruit grown on peach stocks is less likely to become infected. Overseas research has shown that the infection progresses more slowly on slow-growing stocks, and these should be considered in areas prone to infection.

Management recommendations are similar to those for *Phytophthora* (page 98).

Remove infected trees from the orchard and burn them. A thorough and time-consuming clean-up of the tree-removal site must be done to ensure that the disease does not spread to uninfected trees. In addition to the above-ground portion of the tree, all root fragments larger than 2.5 cm must be removed and burnt. Be careful not to drop any infected tree parts as you remove them from the orchard, as this will spread the disease.

Crown gall

Crown gall, caused by the bacterium *Agrobacterium tumefaciens*, is common in Australian orchards (except Western Australia) but is not regarded as a serious problem. It is effectively controlled by a biological control agent. The pathogenic *A. tumefaciens* is believed to be present in most soils and can be spread by water, cultivation, insects and tools used in propagation. Wounds on susceptible trees may be colonised and infected by the pathogen. Once trees are infected nothing can be done to control the disease.

NoGall™ is a product based on a specific strain of another species of bacterium, *Agrobacterium radiobacter*. This organism is not disease causing and was found to be antagonistic to the crown gall-causing bacterium. When *A. radiobacter* gets to a wound first, it inhibits the development of crown gall. Nogall™ is part of an integrated pest and disease management strategy for crown gall. Other components are:

- good site selection to avoid waterlogging
- avoiding unnecessary damage to the roots
- frequently disinfecting pruning and propagating equipment
- avoiding nursery soils known to have pathogenic *Agrobacterium* or nematode infestation
- careful choice of rootstock.

Nogall™ is manufactured and distributed in Australia by:

Becker Underwood Pty Ltd
RMB1084 Pacific Highway
SOMERSBY NSW 2250
Phone: 02 4340 2246, Fax: 02 4340 2243
Toll Free: 1 800 558 399
E-mail: info@beckerunderwood.com.au

Crown gall caused by Agrobacterium tumefaciens

Fruit-sucking insects

A wide range of insects can become minor and occasional pests of Australian summerfruit. These include leaf hoppers (previously known as jassids), mirids (including apple dimpling bug), stink bugs, stainer bugs, chinch bugs (including Rutherglen bugs), squash bugs and rhopalid bugs.

These insects become pests because they suck on developing or mature fruit. Because of the range of insects involved the damage caused also varies, but it tends to involve pitting of the fruit. Sometimes gumming is also associated with the pitting. In peaches, some insect types (e.g. fruit-spotting bugs; *Amblypelta nitida*) cause fruit blemishes with collapsed areas that have gum pockets underneath.

These pest insects tend to become a problem in orchards that have reduced their insecticide applications through IPDM strategies (such as mating disruption) for Oriental fruit moth.

Insecticide options for control of these insects are limited and not recommended. The problem is rarely severe enough to warrant specific control measures.

Apple dimpling bug

More information on fruit sucking insects is available at the NSW Department of Primary Industries website at www.agric.nsw.gov.au

Fruit tree moth borer

Maroga melanostigma

Fruit tree moth borer can be a problem in the NSW Central West, Swan Hill, Riverlands, NSW North Coast, Adelaide Hills and Goulburn Valley. The moth is an Australian native species that attacks many native and ornamental trees, including summerfruit. It is usually regarded as a minor and occasional pest. However, in certain years it can cause severe losses. Although it has been known as a pest of fruit trees in Australia since the 1940s, it only really became noteworthy following the banning of DDT in 1987. Larvae tunnel into main limbs, secondary limbs and the tree trunk. Infestation can lead to ringbarking and the death of limbs.

There is no cost-effective control of this pest, and no insecticide is registered for spraying or injecting trees. Current practice by growers is to either leave the damage untreated or infiltrate the borer workings with a thin wire to pierce the larva. Treatment of large numbers of trees is therefore labour intensive. Severely infested trees approaching the end of their useful lives should be removed and burnt so that they do not serve as sources of infestation to surrounding trees. Use caution when planting orchards near stands of black wattle, as the pest can use other species such as this as alternative hosts. The use of *Trichogramma*, a small parasitoid wasp, as a biological control agent is currently under investigation in Australia.

For more information contact Sue Marte (NSW DPI; e-mail: sue.marte@dpi.nsw.gov.au)

Fruit tree moth borer adult

Fruit tree moth borer larvae

Damage caused by fruit tree moth borer

Fungal gummosis

Fungal gummosis is caused by the pathogen *Botryosphaeria dothidea*. In Australia it can be a serious disease in the Riverlands, Perth Hills, South East Queensland, Northern New South Wales and the Adelaide Hills.

Summer fruit trees produce gum as a result of a number of stresses, including mechanical damage, bacterial canker (page 14), *Phytophthora* (page 98), brown rot (page 27), *Armillaria* (page 90) and physiological stresses. Many orchardists refer to all of these conditions as 'gummosis'. This leads to confusion, as control measures for any one of these problems will not work for the others. In some cases the term 'gummosis' is also used differently in different regions.

The differences between the most frequently confused forms of gummosis are outlined in Table 5.

The pathogen infects through wounds or lenticels low in the tree on scaffold limbs or the trunk. As lesions grow older they exude a gummy resin. Tissue death is usually limited to the area immediately below the infection, and severely infected trees develop very rough-looking bark. If trees are kept healthy and the infection isn't severe they can remain productive, but research in the USA has shown that severely infected, stressed trees can suffer a 40% reduction in fruit production.

There are no pesticides registered for the control of fungal gummosis, but dormant application of copper formulations for bacterial canker may inhibit the disease.

Research in the USA has also shown that varieties show a range of susceptibility to this disease. Few of the American varieties studied are commercially common in Australia, but if fungal gummosis is a concern in your region, before you buy a specific variety you should ask your nursery if they are aware of its disease susceptibility.

Prune out all diseased wood during winter pruning. Remove the prunings from the orchard and burn them. Avoid summer pruning.

Fungal gummosis infection centred on a swollen lenticel

Table 5. Forms of gummosis

Common name of disorder	Caused by	Diagnostic features
Fungal gummosis	*Botryosphaeria dothidea* (fungus)	Young lesions centred on lenticels
Summer canker	*Phytophthora* (fungus; page 98)	Lesions appear in summer. Lesions smell sickly sweet. Infection moves from base of tree upwards
Bacterial canker	*Pseudomonas syringae* (bacteria; page 14)	Lesions appear in winter. Lesions smell sour. Infection often moves from the top of the tree downwards
Sour sap	Physiological condition (no pathogens involved)	Condition occurs when warm spring conditions are followed by a cold snap

Heliothis

Heliothis is an insect pest of a wide range of crops and is also commonly known as looper or budworm.

Although *Heliothis* is usually a minor problem, it can become serious if unmanaged. *Heliothis* is an occasional problem in many areas, including the Sydney Basin, Granite Belt, Goulburn Valley, South East Queensland and Northern New South Wales. Interestingly, growers report that problems emerge at different times of the season in different regions. In the Goulburn Valley *Heliothis* tends to be an early-season pest on developing shoots. In Western Australia problems arise in late spring and continue through to mid-summer. In South East Queensland and Northern New South Wales *Heliothis* problems occur late in the season, during and after harvest. This emergence of *Heliothis* is thought to coincide with reductions in insecticide application for fruit fly approaching harvest.

Heliothis larvae

Adult heliothis (Helicoverpa armigera)

Mealybug

Mealybugs are an occasional and minor problem in some areas. They tend to infect plums and can be a problem under netting, particularly where blocks are being converted from pome fruit.

Mealybugs belong to the same group of insects as scales and cause damage to fruit in two ways. They pierce fruit and feed through straw-like mouthparts known as stylets. They also excrete honeydew as a waste product following feeding, and this is a perfect medium for the growth of sooty mould fungi. Trees infected with mealybug tend to develop a coating of black soot-like fungus on the surfaces of branches, leaves and fruit. This blemish results in a reduction in quality and reduces the light available for photosynthesis.

Ants are also commonly associated with mealybugs, 'farming' them for the sweet honeydew they produce.

Many of the insecticides used against other orchard insect pests are effective and registered against mealybug. It would be rare for a responsibly cared-for orchard to have problems with mealybug. IPDM also helps to control mealy bug, as it is preyed upon by many natural enemies, including the predatory ladybird (*Cryptolaemus montrouzieri*). Predatory insects are available from a number of companies in Australia. See the 'Useful contacts' section in this manual (page 133) or phone the Australasian Biological Control Association on freecall number 1800 000 160.

Mealy bugs

Mites

In addition to two-spotted mite (*Tetranychus urticae*; page 84) Australian Summerfruit orchards are occasionally infested by *Bryobia* mite (*Bryobia rubrioculus*), peach silver mite (*Aculus fockeui)* or European red mite (*Panonychus ulmi*). Identification of the exact species of mite responsible for damage often requires a specialist taxonomist (see 'Useful contacts' page 133).

Bryobia mite

Bryobia mite tends to cause occasional problems on apricots and plums. Heavy infestations cause severe mottling of the foliage, with older leaves being affected more than younger ones. *Bryobia* mite rarely causes leaf browning or premature leaf fall but may reduce photosynthesis and subsequently affect fruit size and colour. *Bryobia* is rarely a problem in orchards, as it is susceptible to many of the modern pesticides used by orchards to control other insect pests.

Peach silver mite (PSM)

PSM Is rarely a problem in Australian summerfruit orchards. During the last 10 years it has reached problem levels only in the Riverlands.

PSM is a very small mite and is difficult to see even with the aid of a 10x hand lens. Therefore, confirmation of infestation may require a sample be submitted to a diagnostic laboratory. Adult PSM are present in infested orchards throughout the year, and populations sometimes reach damaging levels in mid- to late summer, when the leaves take on a silvery appearance.

Control is seldom required, as the mite-eating ladybird *Stethorus* often keeps populations at low levels. In some cases miticides used for other pests should be avoided, as PSM serves as early-season food for predatory mites.

European red mite adult female and eggs

European red mites

Although European red mite can be a problem in apples and pears it is rarely a serious problem in summerfruit. Its presence early in the season can be beneficial, as it acts as a food reserve for predators such as lacewings, allowing their numbers to build up. The increased numbers of predators help to control other pest mites later in the season.

Although this mite can become a pest when it causes pale green or yellowish stippling on leaves, premature leaf fall is rare. Well-managed young orchards are more susceptible, and the use of high rates of nitrogen fertiliser early in the season predisposes orchards to infestation.

Monolepta

Monolepta australis

Monolepta or red-shouldered leaf beetle can be a moderately serious problem in warmer coastal regions such as South East Queensland, Northern New South Wales and the Sydney Basin. The frequency of swarms in these regions varies from 'occasional years' to 2 or 3 infestations per season. The frequency and severity of the problem seems to be associated with the proximity of summerfruit orchards to other subtropical crops such as avocado and lychees. Swarms are also more common in stormy weather.

Damage can occur when fruitlets are very small. Check orchard and windbreak trees after rain for insect activity, and spot treat if beetles are present. Early detection is essential, as beetle numbers can increase quickly. *Monolepta* beetle not only damages green and ripening fruit but can severely damage foliage on young trees. Young leaves are particularly susceptible and infestation will leave only a fine network of leaf veins. Damage is generally more severe on nectarines than peaches.

Some growers feel that good weed management in the orchard and surrounds reduces the number and severity of swarms.

Insecticide registrations for this pest vary from State to State. Check the label of the product to ensure that insecticide application is legal in your State. Because of the swarming nature of this pest, spot sprays are the only efficient way to apply insecticides. It is essential that spot sprays are applied quickly after detection and that windbreak trees are checked in addition to orchard trees.

Adult Monolepta beetle (red-shouldered leaf beetle)

Nematodes

Nematodes can be a relatively severe problem in Swan Hill, the Granite Belt and the Riverlands. Nematodes penetrate roots and cause galling (lumps), resulting in overall lack of vigour, stunting and occasionally tree death. Australian growers also note that the damage caused by nematodes can predispose trees to attack by *Phytophthora* (page 97). Most Australian rootstocks are susceptible to nematodes. Even those bred for nematode resistance are not resistant to all Australian species of nematode. Although Nemaguard rootstocks provide protection against root knot nematode, they are not effective against root lesion nematode. Root lesion nematode is the predominant nematode species in some Australian regions (eg. Stanthorpe). There are no pesticides registered for controlling nematodes in summerfruit, but a number of precautions can be taken. Avoid planting orchards on blocks that were planted to nematode-susceptible crops such as grapes. Fallow sites for a period of time (up to four seasons) before replanting. Grains are not hosts of root lesion nematodes and can be planted on fallow blocks to reduce nematode numbers.

Galling caused by root knot nematode

Painted apple moth

Painted apple moth (*Teia anartoides*) is an Australian native insect that is a minor and occasional pest of Australian summerfruit orchards. It occasionally becomes a more serious problem for pines and acacias. It is found in south Queensland through to Victoria, the south-east of South Australia, and Tasmania. Painted apple moth is not established in Western Australia, where a surveillance program is maintained for this species.

The larva is up to 30 mm long and is covered with brown hairs, with four tufts of hairs on its back. These larvae graze on tender young leaves

Painted apple moth larvae

and are also know to occasionally feed on young green fruit. Painted apple moth infestations often recur at the same locations. This makes monitoring for this pest and subsequent control easier.

There are no insecticides registered for the control of painted apple moth. Control is seldom warranted. Should the larvae become a problem, they are easy to find because they are brightly coloured and the best control is to squash them.

In 1999 painted apple moth was found in Auckland, New Zealand—an incursion thought to have originated from Australia. An eradication and management campaign is ongoing, and further information on this moth can be found on the New Zealand Ministry of Agriculture and forestry website, www.maf.govt.nz[.]

Painted apple moth adult male

Pear and cherry slug

Caliroa cerasi

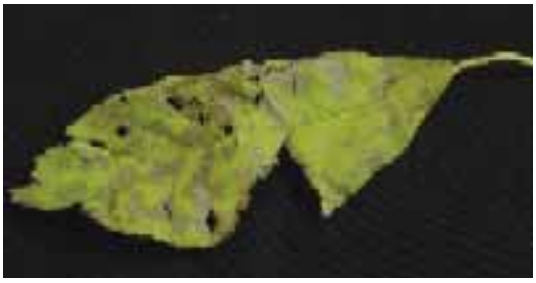
Pear and cherry slug is an occasional and minor pest in all regions, particularly those that are more temperate. Although it will infest all summerfruit commodities, it is most likely to cause problems on plums.

'Pear and cherry slug' is a misnomer. The slug-like pest commonly seen in orchards is the larval stage of a sawfly (a wasp-like insect), which exudes an olive-green coating shortly after hatching. This gives it its slug-like appearance.

Pear and cherry slugs feed on the upper surfaces of the leaves and skeletonise them; leaves appear lacy. They do not directly feed on or affect fruit. However, if an infestation is severe, defoliation (premature leaf loss) can occur and trees are subsequently weakened. In turn, this can reduce fruit size and quality.

Because the damage is relatively obvious, monitoring for this pest is easy and orchardists tend to notice damage before it becomes severe. Similarly, control of the pest is quite easy and a single, well-timed spray application is generally all that is required. Carbaryl and spinosad are registered in all Australian States for this purpose. Infestations can occur late in the season and after harvest because orchardists are reducing their use of insecticidal sprays. In such cases it is important to assess whether an insecticide spray is warranted.

Pear and cherry slug larvae on a peach leaf



Damage caused by pear and cherry slug on a peach leaf

Australian organic orchardists have noted that shield beetles (probably *Oechalia schellembergii*; Schellemberg's soldier bug) prey on pear and cherry slug. Minimising pesticide applications may encourage natural predators.

Phytophthora root and collar rots

Root and collar rots caused by *Phytophthora* can be a problem in all Australian summerfruit growing regions, but particularly in Swan Hill, the Goulburn Valley, Perth Hills, South East Queensland and Northern NSW.

In Australia the disease is caused by three species: *Phytophthora cactorum*, *Phytophthora cinnamomi* and *Phytophthora cambivora*. Regardless of the species causing the disease, the symptoms are identical. They are as follows.

Root rot

A reduction in the number of feeder roots. The roots remaining may be decaying, with brown black lesions. This lack of roots stunts trees and causes leaf yellowing and premature leaf drop and poor quality in fruit.

Collar rots

Infections originating in the roots or through rain splash to the lower part of the tree cause the trunk to develop oozing lesions, which often ring-bark the tree and kill it. When the bark is peeled away at the base of the tree there is a distinct brown margin to the diseased tissue.

Above-ground infection

If heavy rain, sprinklers or flooding move the disease-causing fungal spores into the above-ground parts of the tree, oozing lesions can occur.

Phytophthora can be distinguished from bacterial canker (page 14) by:

- smell: *Phytophthora* cankers smell sickly sweet; bacterial cankers smell sour.
- time of year. *Phytophthora* cankers occur during summer; bacterial cankers occur mainly during winter.
- direction of development. The first aboveground *Phytophthora* lesions occur at the base of the tree and progress upwards. The opposite is true for bacterial cankers.

Once established, *Phytophthora* is difficult to manage. Orchardists should therefore concentrate on preventive management. *Phytophthora* requires wet soil for root infection to occur. Irrigation should be managed so that soils are never waterlogged for prolonged periods.

In areas where *Phytophthora* is suspected, plant on mounds and avoid low spots in the orchard. Shallow planting will also expose less of the roots to suspect soil.

Root rot caused by Phytophthora

Above-ground infection of Phytophthora on apricot

A Phytophthora-infected apricot orchard

No rootstocks are resistant to *Phytophthora*, but susceptibility does vary. Plum rootstocks (e.g. Myrobalan H29C) are more tolerant of the three species of *Phytophthora* infecting Australian summerfruit than are peach or apricot stocks.

Several products are used by the Australian summerfruit industry, but registration varies from State to State. Fosetyl is registered for use on peaches in all Australian States except Queensland. It is recommended for use as a preventive foliar spray or as a curative soil drench for severely diseased trees. Always read the label.

More information

Lim TL (1997) *Phytophthora Root and Trunk Rot of Pome and Stone Fruits*. Agriculture Note AG0191. Department of Primary Industries Victoria.

Postharvest diseases

Postharvest diseases have the potential to cause more serious financial damage than any other pest or disease. If fruit is handled incorrectly, postharvest disease can emerge and spread quickly from fruit to fruit.

In addition to brown rot (page 27), a number of postharvest diseases can be damaging to Australian summerfruit. Orchardists have noted that *Rhizopus* or transit rot and grey mould (caused by *Botrytis*) cause occasional losses.

Fungicide options specifically for the control of these two diseases are limited. Iprodione is registered as a postharvest dip for *Rhizopus* rot but only suppresses the disease at the registered rate. Iprodione dips for the control of brown rot are also likely to reduce grey mould infections. Because of these limitations it is extremely important to carry out a number of good orchard practices that will minimise the impact of these diseases.

- Pick fruit at the correct maturity. Over-ripe fruit is more prone to disease.
- Minimise physical damage to fruit before harvest and during harvest and handling.
- Remove diseased or damaged fruit from the consignment.

Rhizopus or transit rot on nectarines

- Avoid packing wet fruit.
- Cool fruit as quickly as possible after harvest. Keep harvested fruit in the shade and transport it as quickly as possible to the shed. Avoid picking in the middle of the day on hot days.
- Lower the fruit's core temperature to 0 °C as quickly as possible.

More information on the correct handling of summerfruit after harvest can be found at the SARDI COOL Handling website, www.sardi.sa.gov.au/coolchai/[.]

Powdery mildew

Powdery mildew is a rare disease in Australian summerfruit caused by the fungal pathogen *Oidium*. During recent years it has been an occasional and minor problem in the Riverlands and Tasmania. Although all types of summerfruit can be infected, it is most common on apricots. It occurs during hot, humid weather. Some orchardists have observed that infections in summerfruit have occurred near grapes with powdery mildew. Grape powdery mildew is caused by a species of pathogen different from those causing powdery mildew on summerfruit, so this observation is most likely a result of the fact that all powdery mildew species tend to infect under similar weather conditions.

The disease primarily infects leaves, but young fruit (up to stone hardening) can be infected. Infected leaves become covered with a white mealy mass of fungal strands and spores. They are usually stunted and cupped. Older leaves may have only patches of this white material. Fruit becomes deformed, with raised or sunken spots.

There are no pesticides registered for the control of powdery mildew in summerfruit. It is likely that fungicide applications for brown rot will provide sufficient protection, even under conducive conditions. Management options taken to control other diseases are likely to also control powdery mildew. For example, row orientation to maximise breeze and lower humidity reduces all disease problems, as does pruning for an open canopy. Any measures taken to reduce humidity will help.

Powdery mildew on peach

Rutherglen bug

Nysius vinitor

Rutherglen bugs infest summerfruit in the majority of Australian summerfruit regions. They are regarded as minor pests. In some areas infestations occur only every 10 to 20 years.

Adult Rutherglen bugs are 3 to 4 mm long and greyish brown with dark cross marks on either wing. Rutherglen bugs invade orchards in swarms, and because they are sap suckers they cause damage similar to that caused by aphids (page 23). The feeding also spoils the fruits of summerfruit trees, leaving them pitted, with exudates of gum. In extreme cases young trees may be killed.

Rutherglen bugs breed on broad-leaved weeds and in some seasons will reach plague numbers in mid-summer through to harvest. Rutherglen bugs feed on a broad range of crops, such as field crops (including canola and sunflower), vegetables and grape vines, and swarms may migrate from these crops to summerfruit.

Swarms tend to happen during hot dry weather as weeds and pasture begin to hay off. Orchardists should monitor carefully for Rutherglen bug when these conditions occur.

The frequency of swarms can be minimised through broad-leaved weed control in and around the orchard.

In some regions insecticidal sprays won't be required, because the problem is never serious enough. In regions where Rutherglen bug occasionally becomes a significant pest, careful monitoring is required from ripening to harvest.

Adult Rutherglen bug

Where required, spray infestations with fenthion or trichlorfon. Respraying may be necessary within a few days during a plague. Fenthion will also help to control lightbrown apple moth, oriental fruit moth and wingless grasshoppers. Both insecticides will control Queensland fruit fly. Infested weed growth in and adjacent to the orchard should also be sprayed with insecticides.

Viral diseases

The incidence of viruses in the Australian summerfruit industry is probably underrated. Very few regions report significant problems with viral diseases. This is because:

- they can cause reductions in yield and quality without causing overt symptoms
- they can cause symptoms similar to those of other diseases (e.g. *Prunus* necrotic ringspot virus symptoms are similar to those caused by shot-hole) (page 77)
- even when specimens are sent for expert diagnosis, these diseases are often misdiagnosed
- high temperatures and high nutrient levels may mask virus symptoms.

In 1999 an Australian study showed that skin defects caused by viruses reduced the wholesale prices of Flavorcrest peach and Fantasia nectarine by two-thirds, resulting in losses of up to $30,000 a hectare.

Chemical control is totally ineffective against viruses. Therefore, the only options left to orchardists are to:

- avoid planting, propagating or top-working with virus-infected material or any material that has not been virus-tested
- plant healthy trees; infected trees cannot be cured.

More information on viruses is available in the 15th edition of the *Orchard Plant Protection Guide for Deciduous Fruits in NSW 2005/06*, available on the NSW Department of Primary Industries website, www.agric.nsw.gov.au[.]

Prunus necrotic ringspot virus on peach

Plum line pattern virus

Weevils

Weevils are widespread pests of the Australian summerfruit industry. The principal pest species is Fuller's rose weevil (*Asynonychus cervinus*). Apple weevil (*Otiorhynchus cribricollis*) and garden weevil (*Phlyctinus callosus*) are also reported to cause problems in Western Australia. They are considered relatively serious pests in Swan Hill, the Goulburn Valley, Perth Hills and Donnybrook/Manjimup regions. Additionally they are an occasional and minor pest in the Riverlands and Tasmania. Where weevils are a minor problem, control is rarely warranted or used. In some regions weevils are considered to be emerging as pests because of reduced parathion-methyl application as part of strategies for oriental fruit moth mating disruption (page 61).

Weevils can damage trees and fruit in a number of ways:

- **Irrigation blockage.** They lay eggs in irrigation equipment and the developing larvae block sprinkler heads.
- **Fruit damage.** Shallow feeding wounds appear and turn corky with time. These are easily mistaken for feeding wounds caused by European earwig (page 37).
- **Fruit blemish.** Fruit is fouled by weevil excreta, particularly around the stem end.
- **Leaf damage.** This is usually minor and is not considered a problem.

Poultry can be used to reduce weevil numbers (also useful against snails and wingless grasshoppers). Around 50 birds per hectare will appreciably reduce weevil numbers. Some weevils also breed successfully on weeds such as sorrel, capeweed, dandelion and stock, and these weeds should be removed from the orchard where possible. Avoid moving soil, prunings and fruit from infested areas in the orchard to uninfested areas.

Fuller's rose weevil

Pesticide registrations for this pest are limited. Gusathion (for Fuller's rose weevil) and alpha-cypermethrin (for apple and garden weevils) are registered only in Western Australia. Use of these chemicals should be physically targeted to butt sprays and the soil immediately around the trunk. Spraying should be done only when monitoring indicates that it is necessary. Use corrugated cardboard bands to monitor weevil numbers; wrap the bands in a single layer with the corrugations facing in. Although action thresholds have not been developed for summerfruit, the presence of five weevils in one of these cardboard monitoring traps is used in Western Australian vineyards to indicate a need to spray. Remember that these insecticides will harm other organisms and will possibly reduce the number of beneficial organisms in your orchard. They should be used as a last option.

Wingless grasshopper

Phaulacridium vittatum

Wingless grasshoppers tend to be pests in areas such as Swan Hill, the Granite Belt, the Riverlands, Perth Hills, NSW Central West and Donnybrook/Manjimup.

Unlike locusts, grasshoppers don't form large migratory swarms. Therefore, the source of the grasshoppers is likely to be close to the orchard (e.g. an adjacent paddock). This is borne out by Australian orchardists' observations that grasshoppers tend to turn up in the same spot every time there is an infestation. The orchard provides an alternative feeding source for grasshoppers as the grass and other food sources in the paddocks starts to dry of in summer. Grasshoppers move into the orchards from December to February and feed on tender young

shoots and leaves. The problem is worse along boundary rows, where they can completely defoliate trees. Young trees are particularly at risk.

Grasshoppers like bare sandy ground for egg laying. Look for emerging grasshoppers between September and November. If these egg beds can be found they can be cultivated and sown to tall pasture grasses such as rye grass. Grasshoppers do not like these plants. Remove weeds such as capeweed and flatweed, as they provide food for emerging and developing nymphs.

Poultry in the orchard such as guinea fowl and chickens can be an effective option for grasshopper control.

Pesticides should be seen as a last option where monitoring indicates the likelihood of significant damage. Pesticides can be applied to egg-beds, the orchard floor or trees. As pesticides are likely to disrupt IPDM for other pests and diseases it is best to use them in an extremely targeted way by baiting, spot spraying or spraying only boundaries. Because grasshoppers infest only a portion of the orchard it should be possible to leave the majority of the orchard untreated. A commercial bait (David Gray's Cricket and Grasshopper Killer Bait) is registered for this application. Always read the label.

Wingless grasshopper

Biological control

Biological control

Biological control occurs when the numbers of an insect pest or the severity of a disease are reduced because of the actions of a beneficial organism.

Orchardists can manipulate these beneficial organisms to maximise their effectiveness. In some cases biological control organisms are so efficient that they can replace the need to spray.

Biological control should not be used as an emergency cure for a problem. Orchardists should introduce and encourage biological control agents as a preventive strategy.

There are broadly two different types of biological control:

- natural enemies. Organisms that are present in the orchard and reduce pest numbers.
- commercial biological control agents. Organisms that can be purchased and released in orchards. These are often organisms that are already present in orchards but can be purchased and released to supplement natural populations.

Natural enemies

Within any orchard there are populations of beneficial organisms that attack pests. The numbers of these beneficial organisms affect how successful the organisms are at keeping pest species below damaging levels. Summerfruit orchardists should be aware of the presence of these organisms in their crops. If they are present in high numbers early in the season, their activity may mean it is possible to reduce the number of sprays applied. A gradual build-up of these species from season to season is a good indicator of the success of an IPDM program.

Unfortunately, many of the pesticides that are targeted at pests also have an effect on these beneficial organisms. These natural beneficials can be encouraged through minimising spray applications. When a spray application is necessary, use the 'softest' effective option. The relative toxicities of some commonly used pesticides to beneficials are shown in Tables 6, 7 and 8.

A larval lacewing attacking a green peach aphid.

Natural enemies

Ladybird beetles

Target pests: Aphids, mites, moths eggs and small larvae

Both adult and larval ladybird beetles are predators. Younger larval stages tend to pierce their prey and ingest their bodily fluids, whereas older larvae and adults chew and consume their entire prey.

In general, ladybird beetles are easily recognised by their shiny, convex, half-dome shape and short, clubbed antennae. They are often brightly coloured, with contrasting spots. There are many different species of ladybird and many look similar to one another. Differentiation is often a specialist job.

Ladybird larvae are elongated, often colourful, and have long legs and large feeding parts. They are active and voracious predators.

Adult lady beetles preying on black peach aphids

Stethorus beetle

Stethorus

Target pests: Mites and mite eggs

Stethorus is a tiny (2 mm in diameter) jet-black ladybird beetle. The larvae of this ladybird beetle have dull grey hairs, giving them a velvety appearance. *Stethorus* is a voracious feeder on many species of mites and is particularly effective against two-spotted mite (see page 91). It is likely to suppress mite populations if it is present at high enough levels early in the cropping season.

Hover flies

Syrphidae

Target pests: Aphids and mites

Adult hover flies have black and yellow bands around their abdomens and are often seen hovering above flowers early in the season. They feed on pollen and nectar and make no contribution to biological control at this stage of their life cycle. However, their larvae feed on aphids and mites. The presence of large numbers of adult hover flies early in the season is likely to mean fewer aphid and mite problems during the warmer months.

Female hoverflies lay their eggs amongst colonies of aphids and mites. The legless maggots that

Hover fly larva attacking a green peach aphid

Adult hover fly

emerge grope along the plant surfaces, lifting their heads in search of prey. When they find an aphid or mite they seize it, suck it dry and discard the skin. Each fly maggot can consume hundreds of aphids per month.

Parasitoids

Target pests: Aphids

A parasitoid is an organism that lays its eggs in the body of another organism. The developing young of the parasitoid derive their nutrition from their host, eventually killing it and finally emerging from its mummified body.

The most common parasitoids of aphids found in Australian summerfruit orchards belong to the genus *Aphidius*. The adult wasps are small and difficult to detect in orchards. They are sometimes seen flying around colonies of aphids looking for a suitable host. Orchardists wishing to monitor the activity of parasitoids in their orchards should look for the mummified bodies of aphids rather than the parasitoids themselves. Parasitised aphids bloat before they die and are therefore quite easily spotted. When the parasitoid leaves the mummified body of the aphid it cuts a small escape hole.

If 10% of aphids in a colony are mummified and have parasitoid escape holes, it is likely that all of the aphids in the colony have been parasitised and will die. In such cases it is not necessary to spray an insecticide. An insecticide application may damage the parasitoids, limiting their effectiveness.

Aphidius parasitising an aphid

Aphid mummies, showing the wasp escape hole

Predatory mites

Target pests: Pest mites

Predatory mites occur naturally on Australian summerfruit. A recent study identified eight species of phytoseiid mites on sugar plum blocks in Griffith and Young in NSW. The same study also identified populations of predatory stigmaeid mites.

Predatory mites should be encouraged through the use of chemicals that have low toxicity towards them. There is good evidence that even a single spray of a hard, broad-spectrum chemical such as tau-fluvalinate can reduce predatory mite populations to the point where secondary pest species such as two-spotted mite become a problem and require action.

Further information can be obtained from Horticulture Australia Limited Project No. DP99002, *Development of IPDM Strategies for the Prune Industry*. *Final Report*. May 2004, by Graham Thwaite.

A stigmaeid mite

Commercial biological control agents

In some cases, beneficial organisms that could control pest species in orchards are absent or are present only in low numbers. A number of Australian companies grow and supply beneficial organisms that can be used to supplement the natural beneficials in your orchard. The companies listed at the end of this chapter will provide information on the suitability of beneficials for control of your pests and on shipping and application of these beneficials.

Phytoseiulus persimilis

Target pests: Two-spotted mite

This predatory mite is best suited to warm, humid regions such as the Sydney Basin, NSW North Coast or coastal South East Queensland.

This mite is only slightly larger than its two-spotted mite prey but can be distinguished by its orange colouring and long, forward-pointing front legs. When examined using a hand lens or microscope it can be seen moving much more quickly than its prey.

It is an effective predator. A single predatory mite can eat two female two-spotted mites per day or dozens of two-spotted mite eggs.

Its levels should be monitored. This species often needs to be reintroduced, as it is so effective that it consumes all of its available prey.

Phytoseiulus persimilis adult (left); and two-spotted mite (centre); two-spotted mite egg (top right); and Phytoseiulus persimilis egg (lower right)

Typhlodromus adult feeding on two-spotted mite

It is tolerant of some insecticides and fungicides (see Tables 6, 7 and 8). This gives orchardists wishing to undertake IPDM some control options for other pests.

For further details on *Phytoseiulus persimilis* see:

Williams D (2000) *Integrated Control of Two-spotted Mite in Orchards*. Victorian Department of Primary Industries. AG0157. ISSN 1329–8062. Available at the DPIV website www.dpi.vic.gov.au[.]

Typhlodromus occidentalis

Target pests: Two-spotted mite

Typhlodromus occidentalis is a predatory mite that is better suited to drier inland regions than is *Phytoseiulus persimilis* (see above).

It feeds on all stages of two-spotted mite (including eggs) and should be inoculated onto infested trees early in the season, before populations of the pest mite have had a chance to build up.

Typhlodromus is approximately the same size as two-spotted mite but lacks the eyespots of the pest species. It ranges in colour from cream to amber-red, depending on what it has just eaten.

Commercial strains of this beneficial are resistant to organophosphate insecticides.

For further details on *Typhlodromus occidentalis* see:

Williams D (2000) *Integrated Control of Two-spotted Mite in Orchards*. Victorian Department of Primary Industries. AG0157. ISSN 1329–8062. Available at the DPIV website www.dpi.vic.gov.au[.]

Amblyseius victoriensis

Target pests: Various mites

Amblyseius victoriensis is a species of predatory mite. Its use as a biological control agent against mites in summerfruit is currently under development by several Australian companies (Biological Services, Bugs for Bugs; contact details below). It is a naturally occurring species that has been recorded from sub-coastal Queensland to South Australia.

Trichogramma wasps

Target pests: Eggs of lightbrown apple moth and oriental fruit moth

Trichogramma are tiny wasps that seek out the eggs of lightbrown apple moths and oriental fruit

moths. They pierce these eggs and lay their own eggs inside. The wasp larvae develop inside the moth eggs and a fully developed wasp emerges, rather than a caterpillar.

Trichogramma are supplied in the form of parasitised eggs that are released into the orchard. Following release of the eggs orchardists must be careful about pesticide applications, as several products are toxic to *Trichogramma*. The suppliers of these wasps recommend tebufenozide, fenoxycarb, indoxacarb, and spinosad because of their low toxicity towards *Trichogramma*. More details are available from the suppliers listed below.

Hippodamia variegata

Target pests: Aphids

The first discovery of *Hippodamia variegata* in Australia occurred in South East Queensland in November 2000. It is an efficient predator of aphids and has been developed commercially for use against this pest.

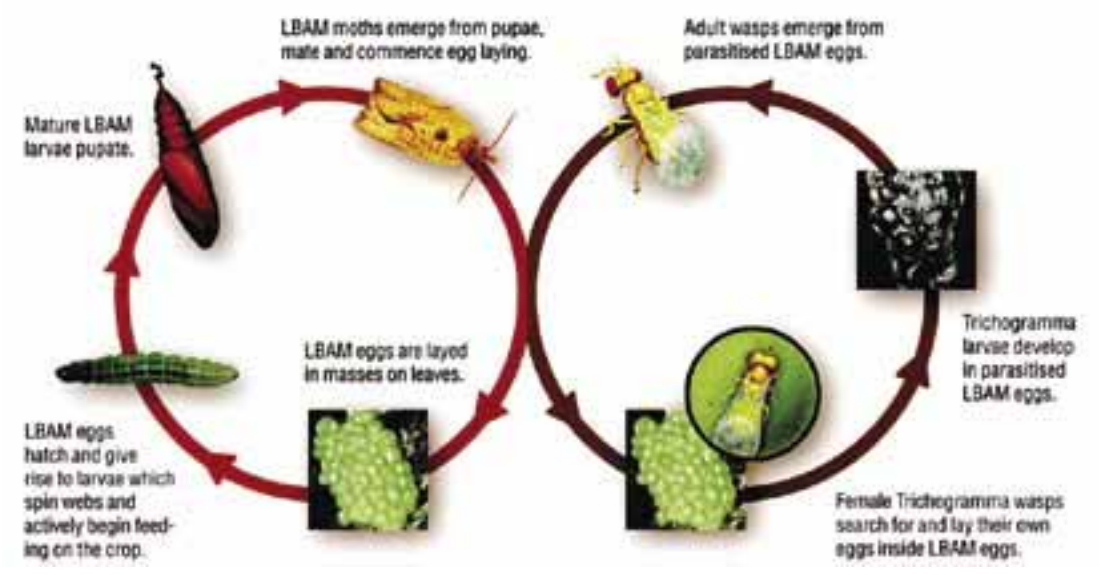
It is the only member of this genus (type) of ladybird beetle in Australia and has several characteristics that suit it to its predatory role in summerfruit. Breeding populations of this beetle can be found during winter and early spring, when other ladybird beetles are inactive. This would allow releases of this beetle to occur earlier in the season. Aphids feeding on green flushes of new growth at this time are more likely to be controlled by *Hippodamia*.

Hippodamia are sold as eggs on tape. This tape is placed near aphid infestations. Emerging *Hippodamia* larvae hunt down and eat the aphids.

Hippodamia eggs

Hippodamia larvae attacking an aphid

Hippodamia adult



Interaction between Trichogramma wasps and lightbrown apple moths

Because of this release strategy it is possible to place the predator very close to aphid outbreaks and it is not necessary to treat entire orchards.

Lace wings

Target pests: Aphids, two-spotted mite, scales (various species), mealybugs, moth eggs and small caterpillars

Both green and brown lacewings are common in Australian summerfruit orchards. Adult lacewings are approximately 15 mm long and feed on nectar and pollen. Monitoring for adults during blossom will give a good indication of the numbers of lacewing larvae present in the orchard later in the season.

Green lacewing egg

Winged adult aphid (left) being attacked by a lacewing larvae (right), which is camouflaged by dead aphids on its back

Adult green lacewing

Female lacewings lay their eggs on long stalks. These stalks reduce ant predation. A single female lacewing can lay up to 600 eggs during her 3 to 4-week adult life. Larvae hatch from the eggs and grow from 1 mm at first emergence up to 8 mm.

Lacewing larvae are generalists and feed on a wide range of orchard pests. Green lacewing larvae impale the remains of their prey and other detritus on short spines on their backs (see picture). This may provide them with a degree of camouflage for hunting.

Lacewing larvae are voracious feeders and can consume up to 60 aphids in an hour.

Adult lacewings tend to fly at night, and the larval stages are often camouflaged and inconspicuous. Therefore, scouting for these insects should rely on the presence of the stalked eggs. The presence of large numbers of stalked eggs early in the season is an indication that insecticide sprays can be reduced.

NoGall™

Agrobacterium radiobacter

The bacterium *Agrobacterium radiobacter* is used as a natural inoculant to prevent the disease crown gall, which is caused by a closely related bacterial species. Details of this product are presented in the section on crown gall (page 91).

DiPel®

Bacillus thuringiensis

Bacillus thuringiensis (Bt) is a bacterium that is the active component of DiPel® and similar products. This bacterium affects only the caterpillar stage of certain insects.

The product is applied in the same way as a conventional spray, preferably in the very early stages of infestation, so that it is on the leaf or fruit and will be eaten by the grazing caterpillar. Enzymes in the caterpillar's gut break down the natural 'capsule' surrounding the bacterium and the toxin is released. The caterpillar stops feeding and soon dies.

Bt is recommended for the control of lightbrown apple moth (LBAM) in summerfruit. It is not suitable as an emergency treatment, and its residual activity is short. However, if it is applied before an infestation becomes established, it will provide LBAM control that is non-disruptive to other beneficials.

Biological control agents and pesticides

Biological control agents vary in their susceptibility to the pesticides used in Australian summerfruit orchards. In general, biological control works best in orchards that have well established IPDM practices such as mating disruption and monitoring. When you are deciding to introduce biological control agents to an orchard it is important to consider the pesticides that have been used and their residual effects, as well as the pesticides that are likely to be used in the future.

Very little is known about the effect of agricultural pesticides on some of the natural beneficial organisms present in orchards. However, more is known about pesticides and commercially available biological control agents.

Notes on Tables 6, 7 and 8

- The following tables contain information on the effects of nearly all of the pesticides registered for use on Australian summerfruit (as at October 2005). The fungicide ziram and a number of copper formulations do not appear in these tables, as no information on their effect on beneficial organisms was available.
- The information is colour coded to reflect the toxicity of the pesticides towards common beneficial organisms in Australian summerfruit orchards:

Low toxicity: nil or low impact on beneficials

Moderately low toxicity: moderate impact on beneficials; but populations recover quickly

Moderately high toxicity: moderate impact on beneficials; populations slow to recover

A high proportion of beneficials killed; populations may not recover

- Numbers within the table indicate the approximate period in weeks for which the effect of the pesticide lasts. For example, '2' means that the harmful effects of this chemical last for 2 weeks. Biological control agents cannot be reintroduced during this period because of these harmful effects.
- The symbol '–' means that the effects of this chemical on the beneficial are unknown.
- The symbol '?' means that the length of time for which the harmful effects of this chemical last is unknown.
- The information for these tables is drawn from:

The Good Bug Book (see page 135 for more details)

Hetherington SD, Bright J, Mooney A (*2005/06, updated annually) The Orchard Plant Protection Guide for Deciduous Fruits in NSW. NSW Department of Primary Industries.*

Koppert Biological Systems, www.koppert.nl/e005.shtml

Biobest Biological Systems, www.biobest.be/

- Occasionally the information from these sources varied. In cases where this occurred, the most harmful rating and longest harmful period found are used in the tables.
- Use these tables as a guide only. In some cases the specific information was unavailable, and that provided is for the interaction between the pesticide and a closely related species. The length of time for which a pesticide remains harmful is also influenced by a range of factors, including climate.
- The lists of pesticides are separated into three tables according to their toxicity to beneficial organisms:

Table 6. IPDM-friendly pesticides. These pesticides are unlikely to harm beneficial organisms in your orchard and should not impede the introduction of commercial biological control agents. When a pest or disease requires a pesticide application and an effective alternative is present on this list, it should be preferred to those appearing in the other tables. On rare occasions these pesticides may harm beneficial organisms, and orchardists should check the table before application.

Table 7. Pesticides to be used with caution in IPDM programs. Because these chemicals are harmful to a number of different types of beneficial organisms, orchardists will need to know which beneficials are present in their orchards. Choose pesticides that are unlikely to cause secondary problems.

Table 8. Pesticides that should be considered only in emergencies when no other effective alternative exists. In some cases harsher chemicals will be required to treat pests (e.g. treatment of fruit fly for interstate export). Where no 'soft' option exists, orchardists should be aware of the possible emergence of secondary pests and plan ahead for their management.

Table 6. IPDM-friendly pesticides

			Predatory mites									Parasitoids				Predator	
			Phytoseiulus persimilis			*Typhlodromus occidentalis*			*Amblyseius* spp.			*Aphidius colemani*		*Trichogramma* wasps		Green lacewings	
	Chemical name	Trade names	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*mummy*	*adult*	*pupa*	*adult*		Comments
Insecticides	pymetrozine	Chess		0									½	-		-	Systemic insecticide. Resistance grouping 9A.
Insecticides	thiacloprid	Calypso	2						-			-	?			-	Systemic insecticide with contact and stomach activity. Resistance grouping 4A.
Miticides	bifenazate	Acramite				-								-		-	Miticide with contact and residual activity against motile stages. Generally ladybird beetle friendly. Resistance grouping 2D.
Miticides	clofentezine	Apollo				-										-	Mite growth inhibitor. Resistance grouping.
Miticides	fenbutatin oxide	Torque														-	Miticide with contact and stomach action, controls motile stages. Resistance grouping 12A.
Fungicides	captan	Captan, Orthocide, Merpan				-			-			-		-		-	Protectant fungicide. Resistance grouping Y
Fungicides	chlorothalonil	Various												-		-	Protectant fungicide. Resistance grouping Y
Fungicides	cyproconazole	Garrison				-			-			-	?	-		-	Application method (wound dressing) minimises exposure to beneficials. Resistance grouping C

Table 6 (continued). IPDM-friendly pesticides

			Predatory mites									Parasitoids				Predator	
			Phytoseiulus persimilis			*Typhlodromus occidentalis*			*Amblyseius* spp.			*Aphidius colemani*		*Trichogramma* wasps		Green lacewings	
	Chemical name	Trade names	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*mummy*	*adult*	*pupa*	*adult*		Comments
Fungicides	cyprodinil	Chorus		?													Protectant fungicide. Resistance grouping I.
	dithianon	Delan, Patrol	-			-			-					-		-	Fungicide with protectant and some curative action. Resistance grouping Y.
	fosetyl	Alliette				-			-			-		-		-	Systemic fungicide with protectant and curative action. Resistance grouping Y.
	propiconazole	Various				-			-						1		Systemic fungicide with protectant and curative action. Resistance grouping C.
	sulfur					1			?				?		2		Resistance grouping Y.
	thiram	Thiragranz	0			-								?			Protectant fungicide. Resistance grouping Y.
	triforine	Saprol		1		1				1				-			Systemic fungicide with protectant action. Resistance grouping C.
	zineb	Zineb	-									-		-			Protectant fungicide. Resistance grouping Y.

Table 7. Pesticides to be used with caution in IPDM programs

	Chemical name	Trade names	Predatory mites: *Phytoseiulus persimilis* egg	*P. persimilis* nymph	*P. persimilis* adult	*Typhlodromus occidentalis* egg	*T. occidentalis* nymph	*T. occidentalis* adult	*Amblyseius* spp. egg	*Amblyseius* spp. nymph	*Amblyseius* spp. adult	Parasitoids: *Aphidius colemani*	*A. colemani* adult	*Trichogramma* wasps pupa	*Trichogramma* wasps adult	Predator: Green lacewings	Comments
Insecticides	imidacloprid	Confidor		0*						2		?			2	4	Systemic contact and stomach insecticide. Resistance grouping 4A.
	indoxacarb	Avatar							-				?			1	Insecticide active by contact and ingestion. Does not harm larval *Stethorus* and *Hippodamia*. Resistance grouping 22A.
	parathion-methyl	Folidol, Penncap		1					-			-			3	3	Insecticide with contact, stomach and some respiratory action. Resistance grouping 1B.
	pirimicarb	Aphidex, Pirimor		½						½					<1		Selective systemic aphicide with contact, respiratory and stomach action. Resistance grouping 1A.
	spinosad	Entrust Naturalyte Success naturalyte	-	1*					-			-		-	2	1	Insecticide active by contact and ingestion. Does not harm larval *Stethorus* and *Hippodamia*. Resistance grouping 5A.
Miticides	propargite	Omite	0	0					-	?							Miticide with contact action against motile stages. Resistance grouping 14A.
	tebufenpyrad	Pyranica			2	2							2	-		-	Miticide with contact action. Resistance grouping 10A.
	benomyl	Benlate, Marvel		4*		2–3				2–3							Systemic fungicide with protectant and curative action. Resistance grouping A.

Table 7 (continued). Pesticides to be used with caution in IPDM programs

			Predatory mites									Parasitoids				Predator	
			Phytoseiulus persimilis			*Typhlodromus occidentalis*			*Amblyseius* spp.			*Aphidius colemani*		*Trichogramma* wasps		Green lacewings	
	Chemical name	Trade names	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*mummy*	*adult*	*pupa*	*adult*		Comments
Fungicides	carbendazim	Various	2	1–2*		1				?					1		Systemic fungicide with protectant and curative action. Resistance grouping A.
	copper oxide	Various	-	?		-			-			-		-		-	Little information is available about the toxicity of copper formulations to beneficial organisms. As they are applied during dormancy, any effects would be on overwintering eggs or adults. Resistance grouping Y.
	copper oxychloride		-			-						-		-		-	
	mancozeb	Various	1*						-	?				-	1		Protectant fungicide. Resistance grouping Y.
	metiram	Polyram	-	?*		-			-						>4	-	Protectant fungicide. Resistance grouping Y.

Table 8. Pesticides that should be considered only in emergencies when no other effective alternative exists

			Predatory mites								Parasitoids				Predator	
			Phytoseiulus persimilis			*Typhlodromus occidentalis*			*Amblyseius* spp.			*Aphidius colemani*		*Trichogramma* wasps		Green lacewings	
	Chemical name	Trade names	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*egg*	*nymph*	*adult*	*mummy*	*adult*	*pupa*	*adult*		Comments
Insecticides	alpha - cypermethrin	Various	8–12			-			8–12			-	4	-		-	Non-systemic insecticide with contact and stomach action. Resistance grouping 3A.
	azinphos-methyl	Gusathion	2						8–12			-	?	>4	>4	2	Insecticide with contact and stomach action. Resistance grouping 1B
	bifenthrin	Various	8–12			?			8–12			8–12		8–12		-	Contact insecticide. Resistance grouping 3A
	carbaryl	Bugmaster	-	2*		1*			-	4–8		-	4	3		2	Contact insecticide with stomach action. Resistance grouping 1A.
	chlorpyrifos	Various		½		0*			6–8			?		>4		2	Contact insecticide with stomach and vapour action. Resistance grouping 1B.
	diazinon	Diazinon	2							3		?		3		1	Non-systemic insecticide and miticide with contact, stomach and respiratory action. Resistance grouping 1B.
	dimethoate	Various	8			1			8–12			?		4–6		3	Broad-spectrum contact and systemic insecticide. Resistance grouping 1B.
	fenthion	Lebaycid	3			2–3*			-			-		4		2	Systemic insecticide with contact, stomach and respiratory action. Resistance grouping 1B.

Table 8 (continued). Pesticides that should be considered only in emergencies when no other effective alternative exists

	Chemical name	Trade names	*Phytoseiulus persimilis* egg	*Phytoseiulus persimilis* nymph	*Phytoseiulus persimilis* adult	*Typhlodromus occidentalis* egg	*Typhlodromus occidentalis* nymph	*Typhlodromus occidentalis* adult	*Amblyseius* spp. egg	*Amblyseius* spp. nymph	*Amblyseius* spp. adult	*Aphidius colemani* mummy	*Aphidius colemani* adult	*Trichogramma* wasps pupa	*Trichogramma* wasps adult	Green lacewings	Comments
Insecticides	maldison	Hy-Mal	1			0			?			4		3		1	Insecticide with contact, stomach and respiratory action. Resistance grouping 1B.
	methamidophos	Monitor, Nitofol	6–8			1			?			>4		4		3	Systemic insecticide and acaricide with contact and stomach action. Resistance grouping 1B.
	methidathion	Supracide, Suprathion	3			1			6–8			?		>4		3	Non-systemic insecticide and miticide with contact and stomach action. Resistance grouping 1B.
	methomyl	Lannate, Marlin, Nudrin	4			1			6–8			8–12		8–12		1	Systemic insecticide and miticide with contact and stomach action. Resistance grouping 1A.
	tau-fluvalinate	Mavrik aquaflow	6			-			4			-		4–6		-	Insecticide and miticide with contact and stomach action. Resistance grouping 3A.
	trichlorfon	Dipterex, Lepidex	2			-			2			-	?		?	-	Insecticide with contact and stomach action. Resistance grouping 1B.
Miticides	chlorfenapyr	Secure	2			2			-				>4	-		-	Miticide with stomach action. Resistance grouping 13A.
	dicofol	Kelthane, Miti-fol	2	2								-	?	3			Non-systemic miticide with contact action. Resistance grouping 2B.

Suppliers of biological control agents and more information

		Supplier								
Beneficial	**Used to control**	**The Beneficial Bug Company (NSW)**	**Bio-Protection (Vic)**	**Bio-Works (NSW)**	**Biological Services (SA)**	**Bugs for Bugs (Qld)**	**BioResources (Qld)**	**Horticultural Crop Monitoring (Qld)**	**IPM Technologies (Vic)**	**Manchil IPM Services (WA)**
Phytoseiulus persimilis	Two-spotted mite	●	●	●				●		●
Typhlodromus occidentalis	Two-spotted mite				●					
Amblyseius victoriensis	Mites				●	●				
Trichogramma wasps	LBAM[1] OFM[2]					●	●			
Lacewings	Aphids, two-spotted mite, scales, mealybugs, moth eggs and small caterpillars					●				
Hippodamia variegata	aphids								●	

● Beneficial available from this supplier
[1] Lightbrown apple moth
[2] Oriental fruit moth

The Beneficial Bug Company
Richmond NSW
E-mail: info@beneficialbugs.com.au
Web: www.beneficialbugs.com.au
Phone: (02) 4570 1331
Fax: (02) 4578 3979

Bio-Protection
PO Box 384
Kilmore VIC 3764
E-mail: rcoy@hyperlink.com.au
Phone: (03) 5781 0033
Fax: (03) 5781 0044

Bio-Works
PO Box 203
Nambucca Heads NSW
E-mail: bioworks@tsn.cc
Phone: (02) 6568 3555

Biological Services
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Phone: (08) 8584 6977
Fax: (08) 8584 5057

Bugs for Bugs
Bowen Street
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IPM Technologies
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Reducing the impacts of birds in horticulture

Reducing the impacts of birds in horticulture

This chapter was written by John Tracey of the Vertebrate Pest Research Unit, Orange Agricultural Institute, NSW Department of Primary Industries.
The article originally appeared in Orchard Plant Protection Guide for Deciduous Fruits in NSW 2004/05 *(Hetherington, Thwaite and Bright eds).*

Many native and introduced birds in Australia can cause significant damage to cultivated fruit, nuts, olives and grapes. The main problem species are common starlings (*Sturnus vulgaris*), silvereyes, psittacines (cockatoos, corellas, galahs), honeyeaters (Meliphagidae), rosellas (*Platycercus elegans*, *Platycercus eximius*) and corvids (crows and ravens).

Introduction

There is a diverse range of management options for pest birds, with variable effectiveness, and no single solution is applicable to all situations. The greatest crop damage is usually caused late in the ripening season, which coincides with the busiest time for growers. As a result, bird management is often not initiated until after considerable damage has

already occurred. Integrated pest management is a concept well understood for insects and disease problems, but birds are usually not managed in the same strategic way.

Rather than focusing on killing as many pests as possible, we now realise that, like most other aspects of agriculture, bird management needs to be carefully planned and coordinated. Bird control is just one aspect of an integrated approach to production management. Many birds are highly mobile and can readily replace those that are killed in control programs. Unless actions are well planned and coordinated they are unlikely to have a lasting effect. When planning bird management, there are some important steps that should be considered.

What is the problem?

In the past the pest was usually seen as the only problem. Hence the solution was to kill as many birds as possible. We now know that the situation is more complex. First, determine what is the problem. It may be reduced crop yields, secondary losses causing downgrading of fruit, complaints from neighbours, or emotional stress from worrying about the next attack. Several factors affect each of these problems, and control of birds is often only part of the solution. The following questions then help define the problem:

- Where is the problem?
- How severe is the problem?
- Will the problem change with time?

Identify the birds involved

Implementing an effective bird control program requires a basic understanding of the ecology and biology of the targeted pest species and, in some cases, those species affected directly (non-targets) or indirectly (prey species) by a control program. It is also essential to understand the impact created by the pest—that is, what is the problem? Control strategies can be targeted for particular birds. For example, some species such as silvereyes and many honeyeaters are highly migratory, moving into orchards only during specific periods. Out-of-season control may hence be inappropriate for these species.

Most birds are beneficial or desirable, and it is important that management does not affect these species. Some birds can be both beneficial and pests. Honeyeaters, for example, can become a more serious problem in orchards during seasons of poor eucalypt flowering, but also consume many damaging insects throughout the year. Other information sheets on pest bird identification,

A starling

biology, movements, habitat, feeding behaviour and the damage they cause are available from your State government department of agriculture or primary industries.

Estimate the damage caused to production

Estimating the damage and calculating the cost will give you a basis for deciding how you can best reduce the damage and how much you can afford to invest in control effort. The percentage of the crop damaged by birds in an orchard block can be estimated by randomly or systematically sampling rows, plants, and individual fruit. Bird damage to individual fruit can be estimated by counting or weighing or by using a visual estimate. Often sampling and calculating damage to the edges of a crop separately will increase the efficiency of your calculations.

Identify any key constraints

Consider legal, social and environmental issues. For example, will scare devices be acceptable to the local community? Are the techniques legally and/or environmentally responsible?

Decide on the most cost-effective time to implement the plan

Even when good information is available it is often not practicable to be immediately responsive to short-term fluctuations in bird numbers or the damage they cause. When damage becomes significant it is usually too late to implement control. For example, effective use of scaring often requires a 'start early' approach to prevent birds establishing a feeding pattern. Likewise, investment in netting can't be simply withdrawn for those seasons in which damage is

below the cost–benefit threshold. Instead, we may need to look at costs and benefits over a longer time frame and make decisions accordingly. Where damage in your area is likely to be high, or you have a history of high damage, you should be more inclined to invest in continuing management action. Measuring damage this year will help you select the optimal management option next year and beyond.

Develop the most appropriate bird management plan

Importantly, the management plan must have details of what will be done, who will do it, when it will be done and how much it will cost. Options can include individual techniques or combinations, and different levels of application. The plan must have long-term, year-to-year strategies to prevent damage, and short-term reactive strategies to cope with sudden increases in damage. For example, in the long term managers may net a small part of their crop every year, and in the short term, when damage is higher, they may also implement a scaring program.

Monitor and evaluate

Has your management been successful? Estimating damage is the most direct way you can measure the effectiveness of your management program. All costs and labour of implementing control should also be considered. For example, nets might have significantly reduced bird damage, but if they were repeatedly removed for maintenance or spraying your crop this, too, comes at a cost. What things worked; what things didn't; what can be improved for next year? Evaluating management will enable improved decision-making for future strategies. It allows you to modify your actions to maximise any economic return.

There is no one simple solution for managing birds effectively, but the following information may help you to decide on the most appropriate action for your situation.

Management options

Scaring

Many visual and sound devices have been used by managers in an attempt to scare birds. Some of these include acetylene and LPG gas guns, electronic devices, radio, flashing or rotating lights, scarecrows, reflective mirrors or tape, helium- or air-filled balloons, and predator models or kites. Habituation is the main drawback of all types of scaring. Birds quickly become accustomed to noise or visual cues. Best results for scaring are achieved when: a combination of techniques is used; scaring starts before the birds establish a feeding pattern; the sound is reinforced by shooting or a threat to shoot; and the timing and placement of devices is changed frequently, but not at regular intervals. The following suggestions may improve or prolong the effectiveness of scaring:

- Loud sounds are more of a deterrent than quiet sounds.
- Sounds with a wide frequency range are more of a deterrent than pure tones.
- Loud sounds produced by simple cheap methods are likely to be just as effective as sounds produced by expensive electronic devices.
- Devices are more effective when used for the shortest time necessary for a response.
- Adult birds are more easily scared than juveniles.
- All species habituate to nearly all sounds tested, so the effect of most sound-generating devices is short term.
- Ultrasonic devices are ineffective, as most birds can't hear ultrasound (≥ 20 kHz).
- Broadcast alarm and distress calls can be effective but are subject to similar habituation to other sounds, are species-specific, and may cause a 'mobbing' rather than an escape response.
- Birds of prey rarely call when hunting, hence pre-recorded raptor calls are likely to represent something novel to birds rather than create an avoidance response from a predator.

Birds of prey

Attracting birds of prey or using falconry is often perceived to be of value in scaring birds or reducing pest numbers. However, although falconry has been used previously in airports to reduce bird strikes, it is impractical in most situations. Falconry is strictly regulated in Australia, requires skilled handlers and considerable training, and is labour intensive.

Encouraging raptors to specific areas is difficult, as different species occupy different niches. For example, sparrowhawks and goshawks prefer hunting amongst trees and tall shrubs to surprise

prey; most falcons prefer open country; and Australian hobbies (*Falco longipennis*) prefer lightly timbered country along watercourses. The most effective predators of adult birds are also unlikely to be attracted by carrion or other food sources. Species that may be attracted (e.g. wedge tailed eagles, little eagles, whistling kites) do not normally hunt birds in flight. Some studies have shown that providing perches increases the numbers of birds of prey. However, this has not yet been demonstrated to reduce the number of pest birds or the damage they cause. More investigation is required.

Lethal control

Many attempts to kill birds, despite alleviating frustration, often do not reduce damage. The techniques used are usually labour intensive and may have legal, welfare and social concerns. Permits from national parks and wildlife agencies are required to kill most native species. Pest birds, particularly introduced species, have high population turnover rates and high rates of natural juvenile mortality. Attempts to reduce populations in the long term need to remove a greater number than are being replaced. Therefore, greater effectiveness may be achieved if the breeding population is targeted.

Traps require considerable labour and are therefore often cost prohibitive. However, trapping may be of benefit in situations where a single resident species is involved and a large proportion of the population can be trapped. A multitude of different trap designs are available, including remotely operated nets, cage and roost traps, funnel entrance traps, modified Australian crow traps, and nest box traps. The success of trapping varies according to the skill of the operator and the time of year. For example, large numbers of starlings can be captured after the breeding season, between late December and March, when many juveniles are congregating. However, this may have little long-term effect on the population size owing to the breeding potential of starlings, which can produce an average of two clutches of four chicks each season. Hence, removing birds during the breeding season (August to November) may result in fewer individuals captured but potentially create a greater reduction in population size for the summer and autumn.

Shooting is most beneficial when employed as a part of a scaring program. If regarded as a training tool rather than a method of population control, it can educate birds to associate noise with a real threat. To reduce habituation, shooting should occur at the same time scaring devices are used. This establishes a connection between the scarer and danger.

Modified Australian crow trap

Although some lethal poisons are registered for use in some States (see www.apvma.gov.au/pubcris/subpage_pubcris.shtml), their use is strictly regulated. For example, many products can be applied only for introduced species, in or around buildings and by licensed pest control operators, and they require site permits from parks and wildlife agencies.

Reducing breeding success by removing eggs or nests or applying oils to eggs has not been adequately investigated. This method may be appropriate for species that reproduce quickly, and has the advantage of reducing the need to kill large numbers of birds. Permits must be obtained for native species. Various fertility control chemicals have been reviewed for birds, but none has been sufficiently field tested, nor is any commercially available.

Orchard management and habitat considerations

A range of landscape and habitat factors influence the number of pest birds and the damage they cause. These factors can be considered when attempting to minimise losses. The varieties grown and timing of maturity can be important. For example, growing varieties that mature simultaneously can help alleviate the damage to individual growers. Depending on the birds involved, sites with adjacent roosting habitat or powerlines can have higher losses. The numbers of pest birds and the levels of damage will vary according to the preferred habitat of different species. For example, common mynas prefer urban environments; cockatoos and starlings are most abundant in cleared agricultural land and areas near cities and towns; and most native species prefer native vegetation. These factors can be considered before planting new crops.

Providing alternative food sources by decoy or sacrificial planting may be effective for some situations. This relies on knowledge of the feeding habits of the main birds involved. A decoy planting ideally will produce food of equivalent or enhanced nutritional requirements and attractiveness for birds; and is available just before, and at the same time as, your crop is susceptible to damage. For honeyeaters and lorikeets, revegetating areas with local native trees and shrubs will increase the availability of their preferred food source. This may offer a long-term solution in reducing damage and has obvious environmental benefits. Birds such as starlings that prefer insects may be attracted to irrigated areas where large numbers of insects are available. However, supplying alternative foods may also attract more pest birds to the area. Hence, for honeyeaters and lorikeets, a more regional approach to revegetation, rather than localised plantings, may be required. A scaring program is likely to be more effective if alternative food sources are available.

Netting

Exclusion netting using throw-over or permanent nets has high up-front costs but may be appropriate where high value crops are grown and levels of damage are high. A variety of netting options are available. Machines can be used to install and remove drape-over nets of varying width (e.g. one, two or four rows). 'Lock-out' netting provides a continuous cover of netting by joining draped nets without the need for poles and cables. Nets can also be used on infrastructure to prevent birds roosting or nesting. If maintained, netting with ultra-violet stabiliser can provide between 5 and 10 years of protection.

Netting overcomes the legal, environmental, social and animal welfare concerns of other techniques. The decision to net is mainly an economic one. Will the increase in returns from excluding birds be beneficial over the life of the netting? As an example, cost–benefit analysis on vineyard netting suggests that drape-over nets are cost effective when damage is consistently greater than 10% and permanent nets are cost effective when damage is over 25%. The value of the crop and the practicalities of netting must be considered.

Roosting deterrents

There are a variety of spikes, coils, and wire products that are available to exclude birds from perching on buildings and infrastructure. Electrified wires, which can be attached to the top of vineyard trellises, are also available. These wires give birds a small electric shock but do not harm them. Monofilament lines have been successful for deterring larger birds from fish farms but ineffective for deterring smaller species from fruit or nut crops.

Chemical deterrents

There are several chemical deterrent products commercially available in Australia. Check with the Agricultural Pesticides and Veterinary Medicines Authority for up-to-date registration information: www.apvma.gov.au/pubcris/subpage_pubcris.shtml and appropriate applications. Some deterrents are based on polybutene, which is a tactile roosting repellent; aluminium ammonium sulfate, which acts on the senses of smell and taste; or methiocarb, which is an insecticide that causes conditioned aversion.

Polybutene is a sticky substance that irritates the bird's feet and can prevent birds from roosting on infrastructure; hence it is applicable for buildings and urban areas. Aluminium ammonium sulfate may be applied to vegetables, nuts, fruit, orchard trees and vines, provided the guidelines on the permit are adhered to (e.g. thorough washing before consumption). Methiocarb is a secondary repellent that causes birds to become ill, creating a learned aversion of the food. This product can be applied to ornamental plants but is not recommended for edible fruit or nuts. Garlic and chilli sprays have been used to deter birds from feeding, but these are unlikely to be effective.

Summary of the main points to consider:

- Identify the bird species
  —Consider behaviour, movements and legalities
- Measure damage
  —How much are birds actually costing you?
- Use integrated control
  —Multiple techniques

For scaring, start early and use persistence, variation and reinforcement.

- Review your bird management strategy
  —Do the benefits outweigh the costs?

Sources and further reading

This information is based on national guidelines for managing pest birds, developed by the Bureau of Rural Sciences, with help from the Natural Heritage Trust and the Australasian Pest Bird Network.

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Forms, schedules and resources

Mite monitoring form for Australian summerfruit

Australian Summerfruit IPDM Record Card
Two-spotted mites and predators

ORCHARDIST:
BLOCK:

Sample date	Observer	A	B	C	D	E		
		Zero mites / predators	Two-spotted mites only	Mites and predators	Predators only	Total leaves	Percentage mites	Percentage predators

Monitoring form for diseases of Australian summerfruit

Orchardist:		Block:		Season:

Sample date	Observer	Brown rot	Blossom blight	Freckle		Leaf curl		Silver leaf	Rust		Bacterial spot	Bacterial canker		Shot-hole	
		Present (✔/✘)	Present (✔/✘)	Temp	Rainfall (✔/✘)	Temp	Humidity	Present (✔/✘)	Leaves wet (hours)	Temp	Present (✔/✘)	Present (✔/✘)		Leaves with lesions (%)	Rainfall expected (•/·)
		Mid-season to after harvest	Budswell to full blossom	4-week period following shuck split		Budswell	Budswell	Mid-season to leaf fall	Mid-season to after harvest		Early budswell to mid-blossom	Early to mid-budswell	After harvest to leaf fall	Shuckfall to harvest	
Action threshold*		✔	✔	18–24 °C	✔	20–26 °C	High	✔	More than 4	13–25 °C	✔	✔	✔	5%	✔

*In all cases the action threshold can be reached only if the disease has been present in the orchard at some time during the last four seasons

Monitoring form for insect pests of Australian Summerfruit

Orchardist					Block				Season				
Sample date	Observer	**Plague thrips**	**Western flower thrips**	**Carpophilus beetles**	**Lightbrown apple moth**		**Black and green peach aphid**		**San José scale**	**European earwig**	**Oriental fruit moth**	**Fruit fly**	
		Present (✔/✘)	Present (✔/✘)		Present on weeds (%)	Leaves or fruit infested (%)	Colonies per tree (trees younger than 3 yrs old)	Colonies per tree (older trees)	Present on trees (✔/✘)	Earwigs / trap		Flies/ Lynfield trap	Fruit: presence of stings (✔/✘)
		Budswell to shuckfall	Budburst to harvest		Budswell to shuckfall	Ripening to harvest	Budswell to mid-summer		Late blossom to dormancy	Budswell to harvest		Late blossom to harvest	Mid-season to harvest
Action threshold		✔	✔		10%	3–5%	1	2	✔	5		20	✔

Useful contacts

New South Wales

Agricultural Scientific Collections Unit (ASCU)

The ASCU holds Australia's most complete collection of insect pests and diseases relevant to the agricultural industry. It offers a fee-for-service, NATA-accredited (ISO/IEC 17025 (1999)) diagnostic service. NSW Department of Primary Industries, Orange Agricultural Institute, Forest Road, Orange NSW 2800. Telephone (02) 6391 3800. Fax (02) 6391 3899.

Deciduous Fruit Pathology Laboratory (DFPL)

The DFPL offers NATA-accredited, fee-for-service diagnostics to the summerfruit industry. Orange Agricultural Institute, Forest Road, Orange NSW 2800. Telephone (02) 6391 3860. Fax (02) 6391 3899

Department of Primary Industries

The New South Wales Department of Primary Industries offers a regional extension and advisory service to the summerfruit industry through its district horticulturists, listed below.

Alstonville

Phillip Wilk
Tropical Fruit Research Station
PO Box 72
Alstonville NSW 2477
Telephone: (02) 6626 2450
Fax (02) 6628 5209
Mobile 0411 139 567

Camden

Lawrence Ullio
Elizabeth Macarthur Agricultural Institute
Menangle Road
Menangle NSW 2520
Telephone (02) 4640 6408
Fax (02) 4640 6300
Mobile 0412 436 871

Gosford

Sandra Hardy
Horticultural Research and Advisory Station
Research Road
Gosford NSW 2250
Telephone (02) 4348 1916
Fax (02) 4348 1910
Mobile 0412 425 730

Orange

Jeremy Bright
Orange Agricultural Institute
Forest Road, Orange NSW 2800
Telephone (02) 6391 3822
Fax (02) 6391 3883
Mobile 0427 213 059

Tumut

Julie Dart
64 Fitzroy Street, Tumut NSW 2720
Telephone (02) 6947 4188
Fax (02) 6947 4149
Mobile 0427 918 315

Richmond

Peter Malcolm
Building M14, Castle Road
University of Western Sydney, Hawkesbury,
Richmond NSW 2753
Telephone (02) 4588 2105
Fax (02) 4588 2159
Mobile 0412 424 628

Young

Sue Marte
Cnr Lynch and Lovell Streets
Young NSW 2594
Telephone (02) 6382 1077
Fax (02) 6382 2228
Mobile 0427 800 379

Victoria

FruitCheque

FruitCheque is a Department of Primary Industries (DPI) extension project working with the fruit, olive and nut growers to achieve best practice in their business. For further information on FruitCheque please contact Cathy Mansfield at DPI Tatura on (03) 5833 5225 or cathy.mansfield@dpi.vic.gov.au

Crop Health Services (CHS)

CHS offers a comprehensive range of diagnostic services on plant diseases and pests and will also provide management recommendations as appropriate. AS/NZS 9001:2000 quality assurance certified. 621 Burwood Highway, Knoxfield. Telephone (03) 9210 9356. Fax (02) 9887 3166.

Queensland

Plant pathology diagnostics

Christine Horlock (Plant Pathologist) and Duncan Cameron (Technical Officer), Applethorpe Research Station, PO Box 501, Stanthorpe QLD 4380. Telephone (07) 4681 6100. Fax (07) 4681 1769.

Insect identification

John Hargreaves and Peter Nimmo. Applethorpe Research Station, PO Box 501, Stanthorpe QLD 4380. Telephone (07) 4681 6100. Fax (07) 4681 1769.

Summerfruit breeding

Bruce Topp, Principal Plant Breeder. Nambour/ Maroochy Research Station. Mayers Road, Nambour QLD 4560. Telephone (07) 5444 9687.

Information and extension

Clinton McGrath, Senior Extension Officer. E-mail Clinton.Mcgrath@dpi.qld.gov.au. Ross Smith, Client Services Officer. E-mail Ross. Smith@dpi.qld.gov.au.

Tasmania

Information and extension

Horticulture Branch, Grove Research Station, 99 Pages Road, Grove TAS 7109. Phone: (03) 6266 4305 Freecall 1300 368 550

Horticulture Branch, Stoney Rise, Rundle Road, Devonport TAS 7310.

Entomology and plant pathology

TASAG ELISA Testing Services

Testing for a wide range of plant viruses, some viroids and selected bacterial pathogens in a wide range of plants and seeds by trained scientists providing authoritative, independent and confidential test results and advice. Our client-base includes private agribusinesses, commercial growers, scientists, quarantine, government research bodies and certification schemes from across the country.

Entomology contacts

Mr Lionel Hill
Rundle Road
DEVONPORT
TAS 7310
Telephone (03) 6421 7636
Facsimile (03) 6424 5142
Mobile 0418 379 726
E-mail Lionel.Hill@dpiwe.tas.gov.au

Dr Catherine Young
13 St Johns Avenue
NEW TOWN
TAS 7008
Telephone (03) 6233 6827
Facsimile (03) 6228 5123
Mobile 0418 571 064
E-mail Cathy.Young@dpiwe.tas.gov.au

Plant pathology contacts

Dr Dean Metcalf
13 St Johns Avenue
NEW TOWN
TAS 7008
Telephone (03) 6233 6864
Facsimile (03) 6278 2716
Mobile 0417 387 370
E-mail Dean.Metcalf@dpiwe.tas.gov.au

Peter Cross
Plant Virologist
13 St Johns Avenue
NEW TOWN TAS 7008
Telephone (03) 6233 6845
Facsimile (03) 6278 2716
E-mail Peter.Cross@dpiwe.tas.gov.au

Western Australia

AGWEST Plant Laboratories

AGWEST Plant Laboratories' horticulture disease diagnostic service is a fee-for-service diagnostics laboratory under Dr Hosseien Golzar offering diagnostic services for the summerfruit industry. Department of Agriculture, AGWEST Plant Laboratories, Baron Hay Court, South Perth WA 6151. Telephone (08) 9368 3721. Fax (08) 9474 2658.

South Australia

Primary Industries and Resources South Australia (PIRSA) provides horticultural advisory services through their Loxton Research Centre, Bookpurnong Road, Loxton (Telephone (08) 8595 9100. Fax (08) 8595 9199) and the PIRSA Lenswood Centre, Swamp Road, Lenswood (Telephone (08) 8389 8800. Fax (08) 8389 8899)

State government departments of primary industries or agriculture websites

Queensland
www.dpi.qld.gov.au

New South Wales
www.dpi.nsw.gov.au

South Australia
www.pir.sa.gov.au

Tasmania
www.dpiwe.tas.gov.au

Victoria
www.dpi.vic.gov.au

Western Australia
www.agric.wa.gov.au

Useful reading

The Good Bug Book (second edition; 2002) is a valuable reference source to the beneficial organisms commercially available for biological control in Australia. It includes illustrations of many of the beneficials, as well as tables of information on their susceptibility to pesticides. It is published by Integrated Pest Management Pty Ltd for the Australasian Biological Control Association Inc. and can be purchased from the Association, PO Box 436, Richmond NSW 2753, phone (02) 4570 1331, at a cost of $35 plus postage.

Spray Sense: safe and effective use of farm chemicals (2004) The Spray Sense series was originally published as 12 individual leaflets between 1995 and 1996. Topics covered include sprayer calibration, testing for residues, storing pesticides, disposal of empty containers, how to read a label, and a number of other topics. The series has recently been updated and expanded and is available from the NSW Department of Primary Industries website www.dpi.nsw.gov.au.

Integrated Pest Management for Stone Fruits (1999) Written in conjunction with the University of California Statewide Integrated Pest Management Project. This book contains a wealth of information on managing orchards to minimise pest and disease problems. Ordering information is available at http://danrcs@ucdavis.edu[.]

Orchard Plant Protection Guide for Deciduous Fruits in NSW (2005/06; Updated annually) An annual publication of the NSW Department of Primary Industries outlining management techniques for pests and diseases in that State. A hard copy of this publication can be ordered online at www.dpi.nsw.gov.au. A pdf of the current edition is also available here.

Low-chill Stonefruit Information Kit (1998) A world-first comprehensive low-chill summerfruit information kit was produced and published by Queensland Department of Primary Industries in collaboration with NSW Agriculture in 1998. The publication, which was produced under the Agrilink information program, provides commercial and potential growers with a complete information package on growing and marketing of low-chill summerfruit. The information kit can be purchased from Queensland Department of Primary Industries and Fisheries publications.

Infopest is the Queensland Department of Primary Industries, pest management information system, aimed at consultants and veterinarians. It is a listing of all agricultural chemicals and their registered uses, supplied as a CD ROM. Contact Infopest, QDPI Animal and Plant Health Service, GPO Box 46, Brisbane Qld, 4001, phone (07) 3239 3967 for more details.

Pests of Pome and Stone Fruit and their Predators and Parasitoids (1996) is a pocket-sized field guide produced by Agriculture Victoria through its Institute for Horticultural Development at Knoxfield. This publication can be ordered from the Institute, Private Bag 15, Scoresby Business Centre, Victoria, 3176 or by phoning (03) 9210 9356.

Integrated Pest and Disease Management Calendar for Tasmanian Stone Fruit. A monitoring and control calendar for pests and diseases of Tasmanian summerfruit. The calendar is available from Anna Steinhauser and Penny Domeney, Fruit Growers Tasmania, 99 Pages Road, Grove, Tasmania, 7109. Phone: (03) 6266 4305 or 1300 368 550.

Pome and Stone Fruit Orchard Spray Guide (2003–04). Bulletin 4596. ISSN 1448–0352. A spray guide recommended specifically for use by the Western Australian deciduous fruits industry. Available at the DAWA website, www.agric.wa.gov.au[.]

Common pests of summerfruit in Western Australia. Bulletin 4585. ISSN 1448–0352. Descriptions of 17 serious insect pests of Western Australia summerfruit. This manual also includes the pests' life histories and suggested control measures.

Plant Quarantine Manual Tasmania (1997) Requirements and procedures for the import of plants, plant products, and other prescribed matter for the purpose of the *Plant Quarantine Act 1997*. Available at the DPIWE website, www.dpiwe.tas.gov.au[.]

Diseases of Fruit Crops (1993) ISSN 0727–6273. Agdex 202/633. A Queensland Department of Primary Industries publication, edited by Denis Persley. Provides good descriptions and illustrations of some of the major diseases of Australian summerfruit.

Postharvest Diseases of Horticultural Products, Vol. 1: Temperate Fruit (1989) This book contains all the information necessary to identify the major postharvest diseases, disorders and injuries of temperate fruit that can be found in the market place. As well, it gives recommendations on the management of the postharvest system, so that managers can adopt better technology and avoid many of the problems that can occur. It is set out in an easy-to-read format with colour illustrations and has concise information on control of the problems. Available from CSIRO publishing at their website, www.publish.csiro.au[.]

Spray schedules

Notes on spray schedules

The following spray schedules do not contain all of the pesticides registered for control of the specified pest or disease. In all cases the 'softest' effective pesticide option is recommended.

Chemical registrations vary from State to State and growers must ensure that their choice of pesticide is registered within their State. The 'Registered' column within the tables specifies the States in which pesticides are registered for the particular use specified, at the time of printing (December 2005). Growers are required to always check the pesticide label before application as registrations change over time. The key for the 'Registered column is:

Q = Queensland
N = New South Wales
V = Victoria
T = Tasmania
S = South Australia
W = Western Australia
Nt = Northern Territory
A = Australian Capital Territory
All States = Application as directed on the label is allowed in all Australian States and Territories

Pests and diseases have developed resistance to some of the chemicals used in the Australian summerfruit industry. Pesticides are classified according to their chemistry and mode of action. Within the following schedules, this classification (in brackets) follows the pesticide name. This allows orchardists to consider to apply pesticides in a way that will minimise the likelihood of resistance developing. In general:

- Consecutive application of pesticides within the same group should be avoided.
- For any given season, the number of pesticides applied within the same group should be minimised.

Plums

Budswell			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
San José scale	Chlorpyrifos (1B) Horticultural mineral oil	QNWA	Apply at budswell. Horticultural mineral oil (2 L per 110 L spray) may be added for control of *Bryobia* mite eggs and frosted scale. Apply at early white stage if oil has not already been applied. Apply if scales are present; otherwise, an oil spray every second year to prevent is advisable.
Shot-hole	Chlorothalonil (Y) or copper oxychloride (Y)	QNVWSNtT QNVWSNtT	Apply at early white to early blossom (1%–10%). If oil spray is to be applied, combine the fungicide with the oil and apply at early white. If no oil spray is required, apply the fungicide at early blossom.
Blossom blight	Chlorothalonil (Y) or copper oxychloride (Y)	QNVWSNtT All States	
Rust	Chlorothalonil (Y) or copper oxychloride (Y) or propiconazole (sugar plums only)	QNVWSNtT All States S	
Shot-hole	Copper hydroxide (Y) or cuprous oxide (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) + copper hydroxide (Y)	All States All States All States All States	Apply as leaf growth commences in blocks of young trees where shot hole is a problem. If unchecked, shot hole may result in leaf loss and restricted growth rate.
Blossoming			
Blossom blight	Carbendazim (A) or iprodione (B) or procymidone (B) or propiconazole (C) or triforine or captan (Y) or chlorothalonil (Y) or dithianon (Y) or mancozeb (Y)	QNVWST QNVWSTA QNVST QNWST QNVWSTA All States All States QNVWST NVWST	Apply at mid to full bloom (50%–100% bloom) and again at petal fall to shuckfall. **Warning:** Resistance of blossom blight to carbendazim is widespread. This fungicide may not control the disease. If resistance is suspected, choose another fungicide. If resistance is not a problem, use carbendazim only once a season. A re-entry period of 9 days applies following application of procymidone.

Plums continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Shot-hole	Chlorothalonil (Y) or dithianon (Y) or mancozeb (Y) or thiram (Y)	All States All States All States All States	If these diseases are troublesome, use one of these fungicides as the petal fall to shuckfall spray. For rust control apply chlorothalonil or mancozeb at 2-weekly intervals; or dithianon or zineb at 4-weekly intervals. Thiram is not registered for rust. A full schedule of protective sprays before shuckfall is essential for rust control. The first sprays for rust should be applied no later than mid-October. **Warning:** Mancozeb may injure Wilson plums.
Rust	Chlorothalonil (Y) or dithianon (Y) or mancozeb (Y)	All States All States All States	
Blossom blight	Chlorothalonil (Y) or dithianon (Y) or mancozeb (Y) or thiram (Y)	All States All States NVWST All States	
Rust	Zineb (Y) plus horticultural mineral oil	All States	'White oil' is recommended on the zineb label. If unavailable use horticultural mineral oil. **Warning:** Zineb may injure Wickson, Wilson and early plums.
Black peach aphid	Imidacloprid (4A) or pymetrozine (9A)	All States All States	Mainly a problem in Japanese plums. Apply as soon as infestations are seen. One application should be sufficient. Do not apply either insecticide in consecutive sprays.
European earwig	Chlorpyrifos (1B)	NWA	
Lightbrown apple moth	*Bacillus thuringiensis* (Bt) (11C)	All States	Apply at first sign of activity. Bt is best used as a program. It is not suitable for emergency treatment.
Midseason — after blossoming to ripening			
Rust, shot hole	Chlorothalonil (Y) or dithianon (Y) or mancozeb (Y)	All States All States All States	Apply 4–5 weeks after blossom. Do not delay if season is wet. Shorten intervals between sprays to 3 weeks if many infections are observed.
Rust	Zineb (Y) plus horticultural mineral oil	All States	'White oil' is recommended on the zineb label. If unavailable use horticultural mineral oil. **Warning:** Zineb may injure Wickson, Wilson and early plums. Mancozeb may injure Wilson plums.
Two-spotted mite	Propargite (14A)	All States	Mites become a problem only if predatory mites are absent. Thorough application is essential.

Plums continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Rust	Zineb (Y) plus horticultural mineral oil	All States	Spray with mancozeb or zineb/oil treatment at intervals until 8 weeks after blossom. Make sure that the interval between sprays is no more than 3 weeks. Monitor your orchard for rust infection periods. The number of infection periods can be reduced by: • pruning to allow air flow • having younger trees • drip irrigation (where irrigation is used) • orchard floor management to reduce humidity. Infection periods are more common: • in hot weather, particularly if humid • where humidity is trapped in valleys. If the season is shaping up as a bad one for rust, the addition of propiconazole to mancozeb may be advisable. Propiconazole is a curative fungicide and should be mixed with a protectant fungicide such as mancozeb or zineb.
	Dithianon (Y) or Mancozeb (Y) or chlorothalonil (Y) or propiconazole (Y) in a tank mix with mancozeb (Y) or zineb (Y) (sugar plums only)	All States All States All States NVS All States	
Two-spotted mite	Propargite (14A)	QNVSWNtTA	Mites are most likely to be troublesome in trees adjacent to blocks of apples and pears that are being sprayed regularly for codling moth control. Monitor trees from 3 weeks after blossom and apply when mites are noticed. One thorough application should be sufficient. Check for predatory mites. In most seasons they will control two-spotted mite without the need to spray, provided disruptive pesticides are avoided.
Lightbrown apple moth (LBAM)	*Bacillus thuringiensis* (Bt) (11C)	All States	Maintain program if LBAM is a problem. Bt is not suitable as an emergency treatment.
	Carbaryl (1A) or indoxacarb (22A)	All States All States	If infestation warrants. Carbaryl will also control pear and cherry slug and European earwig on plums, but will disrupt mite control by predatory mites. Thorough spray coverage is required. Up to three consecutive applications of indoxacarb will give best results.
Rust (Sugar plums only)	Mancozeb or propiconazole (C) in a tank mix with mancozeb (Y) or zineb (Y) (sugar plums only) or zineb (Y) plus horticultural mineral oil 0.5 L in 100 L spray	All States NVS All States All States All States	From 8–10 weeks post-blossom continue rust sprays at intervals recommended by the manufacturer, especially if the season is wet. Propiconazole added to mancozeb will help in a bad rust year.

Plums continued

Ripening to harvest			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Brown rot	Carbendazim (A) or iprodione (B) or propiconazole (C) or triforine (C) or captan (Y) or dithianon (Y) or mancozeb (Y)		Apply 3 weeks and again 1 week before picking is due to begin. Remove and destroy infected fruit. If weather conditions are favourable to brown rot it may be necessary to apply a further spray during the picking period. Observe withholding periods between spraying and picking. **Warning:** Do not use a fungicide for the last field spray from the same group as that to be used as a postharvest dip.
Brown rot	Dithianon (Y) or mancozeb (Y)	All States NVWST	Apply at intervals recommended by the manufacturer if rust or shot-hole is troublesome. In some cases, where the weather is dry and infection periods do not occur, it may not be necessary to spray. Monitor rust infection periods carefully.
Shot-hole	Dithianon (Y) or mancozeb (Y)	All States All States	
Rust	Dithianon (Y) or mancozeb (Y)	All States All States	
Queensland fruit fly	1) Hang male lures in orchard as indicator of fly presence. 2) Apply baits. 3) Spray with dimethoate (1B) or fenthion (1B) or trichlorfon (1B)	 QNVWS QNV (low chill) QNVWNt	Fruit fly may be a problem in more susceptible districts. See fruit fly control on page 46 for bait preparation. Splashing or spraying poison bait on to any suitable foliage around margins of the block may be all that is required to check a potential infestation as indicated by traps. Bait can also be splashed on to the lower portion of trees, but avoid contact with fruit. Repeat at weekly intervals. In susceptible areas and if traps indicate the presence of fruit fly, apply dimethoate 4 weeks, 3 weeks and again 1 week; fenthion 4 weeks, 3 weeks and again 2 weeks before harvest maturity. For trichlorfon, apply 250 mL / 100 L water product rate when stings are first observed, then weekly sprays at 125 mL product rate. Thorough coverage of fruits is essential. **Warning:** Dimethoate may damage early varieties of summerfruit.
Carpophilus beetles	1) Monitoring. 2) Sanitation. 3) Bifenthrin (3A)	All States	Regularly inspect fruit for beetle activity, especially as fruit ripens. Pick up and destroy fallen fruit. This will help to reduce breeding sites and spread of *Carpophilus* beetle, which also spreads brown rot. Spray only when beetles invade. Bifenthrin is toxic to beneficial insects and mites.

Plums continued

After harvest			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Brown rot	Postharvest dip: iprodione (B)	All States	Include a wetting agent in the dip. Immerse fruit for 30–60 seconds (to ensure thorough wetting) as soon as possible after harvest. Iprodione controls brown rot and suppresses *Rhizopus* rot.
Rust	Zineb (Y) plus horticultural mineral oil 0.5 L in 100 L spray	All States	At least one rust spray after harvest is desirable, to keep leaves on the trees until normal leaf-fall time.
	Mancozeb (Y) or propiconazole (C) in a tank mix with mancozeb (Y) or zineb (Y) (sugar plums only)	All States NVS All States	Propiconazole added to mancozeb will help in a bad rust year (Note registration status within your State).
Shot-hole	Copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) and copper hydroxide (Y)	All States All States All States All States All States	Apply when leaves are falling freely.
Bacterial canker Bacterial spot			Copper sprays used for shot-hole will also help in the control of bacterial diseases
Black peach Aphid	Maldison (1B)	NVWSNtT	Mainly a problem in Japanese plums. Lateral growth may become infested in autumn. If this becomes severe it will be necessary to spray, otherwise considerable damage to buds, with premature bud burst, may result.
Dormancy			
Brown rot	Sanitation		Remove all mummies, cankers and dead shoots from trees and destroy by burning.
San José scale	Dormant oil	All States	Watch for infestation while pruning and apply oil if necessary while trees are dormant and up to budswell. Only one full-strength oil spray (3 L/100 L) should be used in any one year. **Warning:** Damage to sugar plums has been observed in some districts following application of oil at this time. If you suspect this to be the case, apply a registered product at a maximum 2 L/100 L, but only if needed. If damage occurs, contact your district horticulturist or adviser.

Peaches and nectarines

Budswell			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Leaf curl	Chlorothalonil (Y) (peaches only) or copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y) or dithianon (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) and copper hydroxide (Y)	All States QNVWSNtA All States All States All States All States All States	Apply at early budswell if leaf curl is the main problem. Delay beyond mid-budswell will result in unsatisfactory leaf curl control. Leaf curl is a common disease and can seriously affect tree development, particularly in the first season of growth. Spraying newly planted trees should not be overlooked. Some formulations of chlorothalonil are also registered for brown rot. Where there is a range of copper oxychloride dosage rates, use the highest recommended amount shown on the registered label.
Shot-hole	Chlorothalonil (Y) or copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y) or dithianon (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) and copper hydroxide (Y)	All States (peaches) NVWSTA (nectarines) All States All States All States All States All States All States	
Brown rot	Copper oxychloride (Y) or dithianon (Y)	All States QNVWST	
Freckle	Copper oxychloride (Y) or dithianon (Y)	All States All States	
Rust	Copper oxychloride (Y) or dithianon (Y)	All States All States	
Bacterial canker Bacterial spot			Copper sprays used to control leaf curl will help to control bacterial diseases.
Leaf curl	Chlorothalonil (Y) (peaches only) or ziram (Y)	All States	Apply 7–10 days after a copper spray at budswell if leaf curl was a problem in the previous season or if weather is cold and wet.

Peaches and nectarines continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Green peach aphid Black peach aphid San José scale	Horticultural mineral oil	All States	Apply thoroughly at early budswell. May be combined, if necessary, with copper oxychloride. This treatment, followed by the activity of aphid predators in spring, is an important component of the resistance management strategy for green peach aphid.
Oriental fruit moth (OFM)	Mating disruption	All States	Attach Disrupt® OFM or Isomate® OFM Rosso dispensers to trees at 500 per ha to give an even distribution through the orchard. See product instructions for more information.
Blossoming			
Plague thrips	Tau-fluvalinate (3A) (nectarines only)	QNVWS	Apply to nectarines once only between mid pink and petal fall, only if thrips are numerous. Tau-fluvalinate will affect predatory mites if present, and this could result in a two-spotted mite problem.
Oriental fruit moth (OFM)	Azinphos-methyl (1B) or	QNVWST	Apply azinphos-methyl at intervals of 3–4 weeks if pest is a problem.
	thiacloprid (4A) or	All States	Apply in a series of 3 sprays of thiacloprid (maximum) at 14-day intervals, commencing at egg hatch of a generational peak, as indicated by monitoring. Apply thoroughly to ensure complete coverage. For the remainder of the season, continue to use other control measures.
	indoxacarb (22A)	All States	Apply up to three applications of indoxacarb at 10-day intervals. Pheromone dispensers are the preferred treatment.
Blossom blight	Carbendazim (A) or iprodione (B) or procymidone (B) or propiconazole (C) or triforine (C) or captan (C) or chlorothalonil (Y) or dithianon (Y)	QNVWST QNVWSTA QNVST QNWST QNVWSTA All States All States (peaches) NWTA (nectarines) QNVWST	Apply at early bloom (1%) and at mid to full bloom. **Warning:** Resistance in brown rot to carbendazim is widespread. This fungicide may not control the disease. If resistance is not a problem, use carbendazim only once a season. See warnings on labels. There are restrictions on the number of sprays per season. A re-entry period of 9 days applies following application of procymidone.

Peaches and nectarines continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Freckle	Dithianon (Y) or mancozeb (Y) (peaches) or thiram (peaches)	All States All States All States	Apply one of these fungicides at petal fall to shuckfall if these diseases are troublesome.
Rust	Dithianon (Y) or mancozeb (Y) (peaches)	All States All States	
Shot hole	Dithianon (Y) or mancozeb (Y) (peaches) or thiram (Y) (peaches)	All States All States All States	
Blossom blight	Chlorothalonil (Y) or dithianon (Y) or thiram (Y)	All States (peaches) NWTA (nectarines) QNVWST All States	Apply at early blossom (10%).
Shot-hole	Chlorothalonil (Y) or dithianon (Y) or thiram (Y)	All States (peaches) NVWSTA (nectarines) All States All States	
Green peach aphid	Pirimicarb (1A) or imidacloprid (4A) or pymetrozine (9A)	All States All States All States	The budswell oil spray and subsequent predator activity should give control, but if this spray was missed or infestation is severe, a spray may be necessary. Delay using insecticide for as long as possible as part of the resistance management strategy. Do not apply consecutive applications of any of these insecticides. Resistance to pirimicarb is already known. All three insecticides will also control black peach aphid.
European earwig	Chlorpyrifos (1B)	NWA	Earwigs can damage fruit in some districts and some seasons. Bait: Prepare according to product label. Apply bait at 5 kg/ha in spring. Spray: Apply in spring. Avoid contact with bees.

Peaches and nectarines continued

Midseason—after blossoming to fruit ripening			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Oriental fruit moth (OFM)	Azinphos-methyl (1A) or thiacloprid (4A) or indoxacarb (22A)	QNVWST All States All States	Apply only if damage to lateral tips is obvious and/or fruit damage was severe last season. Where OFM is a major problem, use of pheromone dispensers for the full season is recommended.
Green peach aphid (GPA)	Pirimicarb (1A) or imidacloprid (4A) or pymetrozine (9A)	All States All States All States	Delay using insecticide for as long as possible as part of the resistance management strategy. Do not apply consecutive applications of any of these insecticides. Resistance to pirimicarb is already known. All three insecticides will also control black peach aphid.
European earwig	Chlorpyrifos (1B)	NWA	Apply if required.
Black peach aphid (BPA)	Pirimicarb (1A) or imidacloprid (4A) or pymetrozine (9A)	All States All States All States	Thorough budswell spraying often gives control for the season. Reinfestation from the roots may occur. When spraying GPA and/or BPA do not use consecutive applications of the same insecticide.
Rust	Chlorothalonil (Y) (peaches only) or dithianon (Y) or mancozeb (Y) (peaches)	All States All States All States	Apply if required. Chlorothalonil or mancozeb should be applied at 2-weekly intervals; dithianon may be applied at 4-weekly intervals.
Freckle	Dithianon (Y) or mancozeb (Y) (peaches) or thiram (Y) (peaches)	All States All States All States	
Shot-hole	Chlorothalonil (Y) or dithianon (Y) or mancozeb (Y) (peaches) or thiram (Y)	All States (peaches) NVWSTA (nectarines) All States All States All States	
Rust	Zineb (Y) plus horticultural mineral oil	All States	'White oil' is recommended on the zineb label. If unavailable, use horticultural mineral oil.

Pest	Pesticide (Pesticide group)	Registered	Comments
Oriental fruit moth (OFM)	Azinphos-methyl (1B) or thiacloprid (4A)	QNVWST All States	Spray again only if renewed activity of larvae is observed.
San José scale	Chlorpyrifos (1B)	QNWA	Apply when crawlers are active. **Warning:** This treatment could cause fruit marking, especially on white-fleshed peaches, when applied under hot, dry conditions.
Two-spotted mite	Bifenazate (2D) or tebufenpyrad (10A) (peaches only) or fenbutatin oxide or chlorfenapyr (13A) (peaches only) or propargite (14A)	All States QNVWST QNVWS All States All States	In most cases mite control is unnecessary because of biological control by predators, particularly the predatory mites *Amblyseius victoriensis, Typhlodromus occidentalis* and *Phytoseiulus persimilis*. In some regions two-spotted mite may become a problem because predators may only become established late. In these cases, use a spray that does not harm the predator. Two-spotted mite will breed during the winter on orchard weeds. This can be a source of infestation. Chlorfenapyr must only be used once on the same block of peaches in a season. It is toxic to *Phytoseiulus persimilis*. Bifenzate and tebufenpyrad are restricted to one application in a season. Avoid consecutive sprays between seasons.
European earwig	Chlorpyrifos (1B) (EC formulation)	NWA	Apply if required.
Lightbrown apple moth (LBAM)	Azinphos-methyl (1B) or indoxacarb (22A)	QNVWST All States	Examine trees thoroughly. Only thorough examination will reveal the pest—examine stem end of fruit in centre of trees. Azinphos-methyl can be used for emergency control, but observe 14-day withholding period. It will also control OFM and will help in *Carpophilus* beetle control. Thorough spray coverage is required. Up to three consecutive applications of indoxacarb will give best results.
	Bacillus thuringiensis (Bt) (11C)	All States	If LBAM is a regular problem, consider a program of Bt, especially if OFM mating disruption is being used.
Two-spotted mite	Bifenazate (2D) or tebufenpyrad (10A) (peaches only) or fenbutatin oxide (12A) or chlorfenapyr (13A) (peaches only) or propargite (14A)	All States QNVWST QNVWS All States All States	Two-spotted mite is likely to be a problem only if azinphos-methyl is applied for LBAM or OFM or if peaches are close to a block of apples or pears being regularly sprayed with the above insecticides. Some aphicides may also cause mite infestation. Monitor trees carefully and spray when mite build-up is noticed. One thorough application should be sufficient, but watch for re-infestation after 4 or 5 weeks. If further treatment is necessary, choose a miticide from another group. Chlorfenapyr must be used only once on the same block of peaches in a season. It is toxic to *Phytoseiulus persimilis*. Use bifenzate and tebufenpyrad only once in a season, and avoid consecutive applications between seasons.

Peaches and nectarines continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Rust	Chlorothalonil (Y) (peaches only) or mancozeb (Y) (peaches only) or zineb (Y) plus horticultural mineral oil	All States All States All States	A spray at fruit ripening is necessary in orchards where rust has been a problem. It may be omitted in clean blocks. Chlorothalonil should not be applied later than 35 days before harvest because of possible phytotoxicity.
Fruit ripening to harvest			
Brown rot	Carbendazim (A) or iprodione (B) or propiconazole (C) or triforine (C) or captan (Y) or dithianon (Y) or mancozeb (Y)	QNVWST QNVWSTA QNVWST QNVWSTA All States All States NVWST (peaches) WST (nectarines)	Apply 3 weeks and again 1 week before picking. If weather conditions are favourable for brown rot it may be necessary to apply a further spray during the picking period. Remove infected fruit and destroy. **Warning:** Observe withholding periods between spraying and picking. Postharvest dipping will not give good results if control of brown rot has been poor in the orchard. An adequate spray program in conjunction with orchard sanitation is therefore important. For the last field spray, do not use a fungicide from the same group as that to be used for postharvest dipping.
Oriental fruit moth (OFM)	Azinphos-methyl (1B) or fenthion (1B) or thiacloprid (4A)	QNVWST NVS All States	If mating disruption is not in use it may be necessary to apply an insecticide. Fenthion will also control Queensland fruit fly, LBAM and wingless grasshopper. Maximum of three sprays for thiacloprid.
Queensland fruit fly	(1) Hang male lures in orchard as indicator of fly presence. (2) Apply baits (3) Spray with dimethoate (1B) or fenthion (1B) or trichlorfon (1B)	 QNVWS (nectarines) QNVW (peaches) QNV (low chill) NVW QNVWNt	Fruit stinging may start in December or early January as fruits approach maturity in districts liable to infestation. Early-maturing varieties usually escape infestation. Baiting may be the only form of control required in less susceptible districts. Repeat at weekly intervals. Apply dimethoate 4 weeks, 3 weeks and again 1 week; fenthion 4 weeks, 3 weeks and again 2 weeks before harvest maturity. A third spray of dimethoate may be required if harvest is delayed. Apply trichlorfon at 250 mL / 100 L product rate at the first sign of stings, then continue weekly at 125 mL product rate. Thorough coverage of fruits is essential. Fenthion should also control OFM, LBAM, Rutherglen bug and wingless grasshopper. Trichlorfon will also control Rutherglen bug. **Warning:** Dimethoate may damage early varieties of summerfruit, especially in coastal areas.

Peaches and nectarines continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Western flower thrips (WFT)	Spinosad (5A)	All States	The danger period for inland districts is 2–3 weeks before harvest. Monitor carefully at this time. If presence of WFT is suspected or confirmed, apply spinosad at the rate for WFT on the label.
Carpophilus beetles	(1) Monitoring		(1) Regularly inspect fruit for beetle activity, especially as fruit ripens.
	(2) Sanitation		(2) Pick up and destroy fallen fruit. This will help to reduce breeding sites and the spread of *Carpophilus* beetle, which also spreads brown rot.
	(3) Bifenthrin (3A)	All States	(3) Spray only when beetles invade. Bifenthrin is toxic to beneficial insects and mites.
Oriental fruit moth (OFM)	Azinphos-methyl (1B) or thiacloprid (4A)	QNVWST All States	Spray again only if renewed activity of larvae is observed.
Lightbrown apple moth (LBAM)	Azinphos-methyl (1B) or indoxacarb (22A)	QNVWST All States	Examine trees thoroughly. Only thorough examination will reveal the pest—examine stem end of fruit in centre of trees. Azinphos-methyl may be used for emergency control, but observe 14-day withholding period. It will also control OFM and will help in *Carpophilus* beetle control. Thorough spray coverage is required. Up to three consecutive applications of indoxacarb will give best results.
	Bacillus thuringiensis (Bt) (11C)	All States	If LBAM is a regular problem, consider a program of Bt, especially if OFM mating disruption is being used.
Two-spotted mite	Bifenazate (2D) or tebufenpyrad (10A) (peaches only) or fenbutatin oxide (12A) or chlorfenapyr (13A) (peaches only) or propargite (14A)	All States QNVWST QNVWS All States All States	Keep trees under observation. Apply miticide if necessary but observe withholding periods.
After harvest			
Brown rot	Postharvest dip: iprodione (B)	QNVWSTA	Include a wetting agent in the dip. Immerse the fruit for 30–60 seconds (to ensure thorough wetting) as soon as possible after harvest. Iprodione controls brown rot and suppresses *Rhizopus* rot. **Warning:** Damage to fruit, especially red-pigmented varieties, can occur when hot or over-mature fruit is dipped.

Peaches and nectarines continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Leaf curl	Copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) + copper hydroxide (Y)	All States All States All States All States All States	Some formulations may be applied when leaves are falling freely. Check label before use.
Shot-hole	Copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) + copper hydroxide (Y)	All States All States All States All States All States	
Bacterial canker Bacterial spot			Copper sprays for leaf-curl or shot-hole will also help in the control of bacterial diseases.
Dormancy			
Black peach aphid	Maldison (1B)	NVWSNtT	Infestation of lateral growth may occur in autumn. If this becomes severe it will be necessary to spray; otherwise, considerable damage to buds (with premature bud burst) may result.
Brown rot	Sanitation		Remove all mummies, cankers and dead shoots from trees and destroy by burning.
San José scale	Dormant oil		In orchards where scale is known to be present, apply oil at 2–3 L/ 100L at any convenient time when trees are dormant. Spraying before pruning is preferable, as scale may survive on prunings on the ground. In districts where this pest is a problem, an annual oil spray may be necessary. Elsewhere, an oil spray every second year is advisable, even if scale is not apparent, because once scale becomes established on trees it is difficult to control. Sprays for San José scale control should be applied dilute and very thoroughly, taking care to get good wetting of trunks, limbs and twigs and penetration of cracks and crevices in the bark. **Warning:** Apply only one full-strength oil spray (3 L/100 L) in any one winter.

Peaches and nectarines continued

Pest	Pesticide (Pesticide group)	Registered	Comments
	Sanitation: Spray with oil as above or cut down and burn		Scale can build up heavily on neglected fruit tree seedlings around orchard areas and on many ornamental trees and shrubs related to summerfruit, pome fruit and other non-related hosts, e.g. tree lucerne, osage orange, willow. It can be spread from these to summerfruit by wind or birds. Such sources of infestation should not be overlooked in areas where scale is a problem. Infested deciduous ornamentals should be sprayed with oil. Neglected fruit trees should be cut down and burnt.

Apricots

Budswell			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Bacterial canker	Copper hydroxide (Y) or cuprous oxide (Y) or tribasic copper sulfate or a proprietary mixture of mancozeb (Y) and copper hydroxide (Y)	All States NVWST All States All States	Apply at first sign of bud movement. Repeat application 7–10 days later. Note label rate.
Freckle	Copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y) or tribasic copper sulfate (Y)	All States All States All States All States	Apply at bud movement.
Shot-hole	Copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) and copper hydroxide	All States All States All States All States All States	
San José scale	Dormant oil		Apply when buds are swollen, but before much pink of petals shows. Very thorough dilute spraying is essential. Scales are not usually troublesome in cooler regions. Spraying with oil every second year may be sufficient to prevent infestation developing in these areas. Do not use more than one full-strength (3 L/100 L) spray in any one year.

Apricots continued

Blossoming			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Bacterial canker	Copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y)	NVWST QNVWSNtT NVWST	Apply one week after petal fall. Repeat application 7–10 days later. This spray controls the high leaf population of the bacteria in mid-late spring.
Blossom blight	Carbendazim (A) or iprodione (B) or propiconazole (C) or triforine (C) or chlorothalonil (Y) or dithianon (Y) or mancozeb (Y)	QNVWST QNVWSTA QNWST QNVWSTA NVWSTA All States NVWST	Apply at mid-full bloom (50%–100%) and petal fall. **Warning:** Resistance in brown rot to carbendazim is widespread. This fungicide may not control the disease. If resistance is suspected, choose another fungicide. If resistance is not a problem, use carbendazim only once a season.
Midseason – shuckfall to ripening			
Brown rot	Chlorothalonil (Y) or dithianon (Y) or mancozeb (Y) or thiram (Y)	NVWSTA QNVWST NVWST All States	Apply chlorothalonil or mancozeb at shuckfall and again 2 weeks later, or dithianon at shuckfall and 4 weeks later.
Shot-hole	Chlorothalonil (Y) or dithianon (Y) or mancozeb (Y) or thiram (Y)	NVWSTA All States All States All States	
Freckle	Chlorothalonil (Y) or dithianon (Y) or mancozeb (Y) or thiram (Y)	NVWSTA All States All States All States	
Rust	Chlorothalonil (Y) or mancozeb (Y)	NVWSTA All States	
Lightbrown apple moth (LBAM)	Chlorpyrifos (1B) (WG formulation)	WT	May appear close to harvest time for early varieties. Watch lower parts of the tree and spray at first sign of infestation. A further application 2 weeks later may be required.
	Bacillus thuringiensis (Bt) (11C)	All States	Spray with Bt when caterpillars are first noticed. Thorough coverage is essential. Repeat at 10–14-day intervals if required. Not suitable as an emergency treatment.

Apricots continued

Ripening to harvest			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Brown rot	Carbendazim (A) or iprodione or propiconazole (C) or triforine (C)	QNVWST QNVWSTA QNVWST QNVWSTA	Apply 3 weeks and again 1 week before picking is due to start. Remove infected fruit and destroy. Observe withholding periods between spraying and picking. If shot-hole or freckle is a major problem, use one of the fungicides listed for those diseases.
Brown rot	Dithianon (Y) or mancozeb (Y) or thiram (Y)	QNVWST NVWST All States	
Rust	Mancozeb (Y)	All States	
Shot-hole	Dithianon (Y) or mancozeb (Y) or thiram (Y)	All States All States All States	
Queensland fruit fly	(1) Hang male lures in orchard as indicator of fly presence. (2) Apply baits (3) Spray with fenthion (1B) or trichlorfon (1B)	 NVW QNVWNt	(1) Fruit fly is unlikely to be a problem on apricots in inland districts, but fruit on coastal highlands may be attacked. (2) Splashing or spraying poisonous bait on to any suitable foliage around margins of block may be all that is required to check a potential infestation indicated by the traps. Bait can also be splashed on to the lower portions of trees, but avoid contact with fruit. Repeat at weekly intervals. (3) In susceptible areas and if traps indicate the presence of fruit fly, apply fenthion 4 weeks, 3 weeks and again 2 weeks before harvest maturity. For trichlorfon, apply 250 mL / 100 L water product rate when stings first observed, then weekly sprays at 125 mL product rate. Thorough coverage of fruits is essential.
Carpophilus beetles	(1) Monitor (2) Sanitation (3) Bifenthrin (3A)	 All States	(1) Regularly monitor fruit for beetle activity, especially as fruit ripens. (2) Pick up fallen fruit, which can attract beetles into the orchard. They spread brown rot. (3) Only when beetles invade. Bifenthrin (3A) is toxic to beneficial insects and mites.

Apricots continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Lightbrown apple moth (LBAM)	Chlorpyrifos (1B) (WG formulation)	WT	May appear close to harvest time for early varieties. Watch lower parts of the tree and spray at first sign of infestation. A further application 2 weeks later may be required.
	Bacillus thuringiensis (Bt) (11C)	All States	Spray with Bt when caterpillars are first noticed. Thorough coverage is essential. Repeat at 10–14-day intervals if required. Not suitable as an emergency treatment.
Brown rot	Postharvest dip: iprodione (B)	QNVWSTA	Include a wetting agent in the dip. Immerse fruit for 30–60 seconds (to ensure thorough wetting) as soon as possible after harvest. Iprodione controls brown rot and suppresses *Rhizopus* rot.
Rust	Chlorothalonil (Y) or mancozeb (Y)	NVWSTA All States	Monitor undersides of young leaves frequently and spray as soon as any rust is observed.
Dormancy			
Shot-hole	Copper hydroxide (Y) or cuprous oxide (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) plus copper hydroxide (Y)	All States All States All States All States	Apply at postharvest.
Bacterial canker	Copper hydroxide (Y) or cuprous oxide (Y) or tribasic copper sulfate (Y)	NVWST NVWST All States	Apply when leaves are falling freely, and again in mid-winter.
Brown rot	Sanitation		Remove all mummies, cankers and dead shoots from trees and destroy by burning.
San José scale	Dormant oil		Watch for infestation and treat with oil if necessary while trees are dormant. **Warning:** Use only one full-strength oil spray (3 L/100 L) in any one winter.

Low- and medium-chill summerfruit (nectarines, peaches, plums)

Early budswell to early pink / early white			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Leaf curl	Chlorothalonil (Y) (peaches) or copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y) or dithianon (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) and copper hydroxide (Y)	All States All States All States All States All States All States All States	Spraying of newly planted trees should not be overlooked. Where there is a range of rates for copper oxychloride, use the highest permitted rate. Chlorothalonil is not registered for leaf curl; copper hydroxide and cuprous oxide are not registered for rust control. Leaf curl is not a problem in plums. The proprietary mixture of mancozeb and copper hydroxide is not registered for rust.
Rust	Chlorothalonil (Y) (peaches and plums) or copper oxychloride (Y) or dithianon (Y)	All States All States All States	
Shot-hole	Chlorothalonil (Y) or copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y) (peaches and plums) or dithianon (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) and copper hydroxide (Y)	All States (peaches and plums) NVWSTA (nectarines) All States All States All States All States All States All States	
Bacterial spot Bacterial canker	Copper oxychloride (Y)	QW	Apply at early bud movement, 7–10 days later, and (on plums only) at blossoming.

Low- and medium-chill summerfruit (nectarines, peaches, plums) continued

Mid pink / mid white to shuckfall			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Blossom blight	Carbendazim (A) or iprodione (B) or procymidone (B) or propiconazole (C) or triforine (C) or captan (Y) or chlorothalonil (Y) or dithianon (Y)	QNVWST QNVWSTA QNVST QNWST QNVWSTA All States All States (peaches and plums) NWTA (nectarines) QNVWST	If rain is forecast and blossom blight infection is likely, apply at early bloom (1%–10%) and at mid- to full bloom. A re-entry period of 9 days applies following application of procymidone.
Plague thrips	Tau-fluvalinate (3A) (nectarines only)	QNVWS	Spray only during flowering and only if thrips are numerous. Tau-fluvalinate is toxic to predatory mites and could result in a two-spotted mite problem later.
Western flower thrips (WFT)	Spinosad (5A)	All States	WFT activity can occur during flowering but is more likely to be a problem closer to harvest. If the pest is detected early (unlikely), then apply spinosad at petal fall. Do not confuse WFT with other thrips that also infest blossoms— the control measures are different. Consult your district horticulturist/adviser if in doubt.
Lightbrown apple moth (LBAM)	*Bacillus thuringiensis* (Bt)	All States	Apply at first sign of activity. Bt is best used as a routine program. It is not suitable for emergency treatment.
Early leafing to fruit ripening			
Rust	Chlorothalonil (Y) (peaches and plums) or dithianon (Y) or mancozeb (Y)	All States All States All States	Rust sprays should start with early leaf development and continue throughout the season. This fungicide program aims to protect the leaf from infection and is the key to rust control. When rust becomes established in an orchard it is difficult to control. Thiram is not registered for rust. Chlorothalonil is not registered for rust on nectarines. **Warning:** Do not apply chlorothalonil later than 35 days before harvest because of possible phytotoxicity.

Low- and medium-chill summerfruit (nectarines, peaches, plums) continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Shot-hole	Chlorothalonil (Y)	All States (peaches and plums) NVWSTA (nectarines)	
	or dithianon (Y)	All States	
	or mancozeb (Y)	All States	
	or thiram (Y)	All States	
Queensland fruit fly	(1) Trapping		(1) Hang male lures in orchard to detect fly presence.
	(2) Baiting		(2) When flies are detected, start a baiting program and repeat weekly.
	(3) Cover sprays		(3) Apply cover sprays at 6, 4, 3, 2 and 1 weeks before harvest. Thorough coverage of fruit is essential.
	Fenthion (1B) or	QNV (low chill) NVW	Cover sprays may also control LBAM, OFM, orange fruit borer and yellow peach moth if used at the highest rate specified on the label.
	Dimethoate (1B) or	QNV (low chill) NVW	Cover sprays may also control LBAM, OFM, orange fruit borer and yellow peach moth if used at the highest rate specified on the label.
	Trichlorfon (1B)	QNVWNt	Trichlorfon may be used during harvest, provided the 2-day withholding period can be observed.
Oriental fruit moth	Azinphos-methyl (1B)	QNVWST (peaches and nectarines)	Apply if damage to young lateral tips of peaches or nectarines is obvious and/or fruit damage was severe last season. These sprays usually result in a two-spotted mite problem, so they should be applied only when absolutely necessary.
	or fenthion (1B) or	NVS	
	thiacloprid (4A) or	All States	Apply thiacloprid in a series of three sprays (maximum) at 14-day intervals, starting at egg hatch of a generational peak, as indicated by monitoring. Apply thoroughly to ensure complete coverage. For the remainder of the season use other control measures.
	Indoxacarb (22A) or	All States	Apply up to three applications of indoxacarb at 10-day intervals. See label for details on timing.
	Mating disruption		The use of OFM mating disruption has not been successful in some northern regions because of attack by orange fruit borer in the absence of insecticides for OFM.

Low- and medium-chill summerfruit (nectarines, peaches, plums) continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Lightbrown apple moth (LBAM)	Azinphos-methyl (1B) or	QNVWST (nectarines and peaches) QW (plums)	Monitor trees regularly. Inspect the stem end of the fruit in the centres of the trees. Azinphos-methyl can be used for emergency control, but observe the 14-day withholding period.
	indoxacarb (22A) or	All States	Thorough application of indoxacarb is essential, using up to three sprays.
	Bacillus thuringiensis (Bt)	All States	Biological control using Bt may not be effective under high pest pressure.
Western flower thrips (WFT)	Spinosad (5A)	All States	Manage ground cover to reduce WFT populations. Monitor for thrips presence. WFT is likely to be a problem in the 2–3 weeks before harvest, especially on nectarines. If the pest is detected then, apply spinosad.
Carpophilus beetles			Beetles can be a serious problem in southern regions growing medium- and low-chill varieties, but are less of a problem in the north. Follow a three-stage management strategy.
	(1) Monitor		(1) Regularly inspect fruit for beetle activity, especially as fruit ripens.
	(2) Sanitation		(2) Pick up and destroy fallen fruit. This will help to reduce breeding sites and the spread of *Carpophilus* beetles, which also spread brown rot.
	(3) Bifenthrin (3A)	All States	(3) Spray only when beetles invade. Bifenthrin is toxic to beneficial insects and mites.

Low- and medium-chill summerfruit (nectarines, peaches, plums) continued

Fruit ripening to harvest			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Queensland fruit fly	(1) Trapping		(1) Hang male lures in orchard to detect fly presence.
	(2) Baiting		(2) When flies are detected, start a baiting program and repeat weekly.
	(3) Cover sprays		(3) Apply cover sprays at 6, 4, 3, 2 and 1 weeks before harvest. Thorough coverage of fruit is essential.
	Fenthion (1B) or	QNV (low chill) NVW	Cover sprays may also control LBAM, OFM, orange fruit borer and yellow peach moth if used at the highest rate specified on the label.
	Dimethoate (1B) or	QNVW (peaches) QNVWS (nectarines and plums)	Dimethoate may damage early varieties of summerfruit.
	Trichlorfon (1B)	QNVWNt	Trichlorfon can be used during harvest, provided the 2-day withholding period can be observed.
Two-spotted mite	Bifenazate (2D) or tebufenpyrad (10A) (peaches only) or fenbutatin oxide (12A) or chlorfenapyr (13A) (peaches only) or propargite (14A) or	All States QNVWST QNVWS All States All States	Two-spotted mite is likely to be a problem if azinphos-methyl, fenthion or carbaryl is used extensively during the season or postharvest after bifenthrin. Monitor the centres of the trees as fruit begins to ripen and spray when a build-up is noticed. One thorough application should be sufficient, but watch for reinfestation after 3 to 5 weeks. Do not rely on one chemical group. Rotate between groups to prevent resistance developing. Use one application only of bifenzate, chlorfenapyr or tebufenpyrad in any one season and avoid consecutive sprays between seasons.
	Predatory mites		An alternative treatment to the use of miticides is the use of predatory mites (*Phytoseiulus persimilis*) to achieve biological control. Some pesticides are toxic to predatory mites and must be avoided for best results. Also refer to advice provided by the mite supplier. Chlorfenapyr is toxic to *P. persimilis*.

Low- and medium-chill summerfruit (nectarines, peaches, plums) continued

Pest	Pesticide (Pesticide group)	Registered	Comments
San José scale	Chlorpyrifos	QNWA	A preharvest treatment will be required only if crawlers are active. Observe withholding periods. This treatment could cause fruit marking, especially on white-fleshed peaches when applied under hot, dry conditions. In subtropical areas this treatment is normally undertaken after harvest is completed.
Brown rot	Carbendazim (A) or iprodione (B) or propiconazole (C) or triforine (C) or captan (Y) or dithianon (Y)	QNVWST QNVWSTA QNVWST QNVWSTA All States QNVWST	Apply 3 weeks and again 1 week before picking. If weather conditions are favourable for brown rot it may be necessary to apply further sprays during the harvest period. Remove infected fruit and destroy. **Warning:** Postharvest dipping will not give good results if control of brown rot has been poor in the orchard. An adequate spray program in conjunction with orchard and packing shed sanitation is very important. This applies especially to late-maturing nectarines. Observe withholding periods between spraying and picking. For the last field spray, do not use fungicide from the same group as that to be used for postharvest dipping.
Harvest and postharvest (fruit)			
Brown rot	Postharvest dip		Include a wetting agent in the dip. Immerse fruit for 30–60 seconds (to ensure thorough wetting) as soon as possible after harvest.
	Iprodione (B)	QNVWSTA	Iprodione controls brown rot and suppresses *Rhizopus* rot.
Rust	Chlorothalonil (Y) (peaches and plums) or dithianon (Y) or mancozeb (Y)	All States All States All States	Continue a rust prevention program after harvest to prevent premature leaf fall leading to early blossoming in autumn. Early leaf fall in mid-summer exposes scaffold limbs to sunscald, killing the bark. Wood-rotting bracket fungi colonise the dead wood. Tree health and longevity of the orchard are reduced. Spray interval is dependent on rainfall. If dry, spray every 21 days; if wet, reduce spray interval to 10 to 14 days. Good spray coverage on the underside of the leaves is essential.
San José scale	Chlorpyrifos (1B)	QNWA	Apply when crawlers are active. In some seasons scale populations can rise dramatically, causing significant limb dieback and tree death. High volume application using hand wands is recommended to ensure good spray coverage.

Low- and medium-chill summerfruit (nectarines, peaches, plums) continued

Pest	Pesticide (Pesticide group)	Registered	Comments
Oriental fruit moth (OFM)	Azinphos-methyl (1B) or fenthion or thiacloprid (4A)	QNVWST (nectarines and peaches) NVS All States	Maintain treatment of peaches and nectarines if damage to lateral tips continues. Maximum of three sprays of thiacloprid.
Two-spotted mite	Bifenazate (2D) or tebufenpyrad (10A) (peaches only) or fenbutatin oxide (12A) or chlorfenapyr (13A) (peaches only) or propargite (14A) or Predatory mites	All States QNVWST QNVWS All States All States	Mites may become a problem after harvest. Two-spotted mite is likely to be a problem if azinphos-methyl, fenthion or carbaryl is used extensively during the season or postharvest after bifenthrin. Monitor the centres of the trees as fruit begins to ripen and spray when a build-up is noticed. One thorough application should be sufficient, but watch for reinfestation after 3 to 5 weeks. Do not rely on one chemical group. Rotate between groups to prevent resistance developing. In any one season, use one application only of bifenzate, chlorfenapyr or tebufenpyrad, and avoid consecutive sprays between seasons. An alternative treatment to the use of miticides is the use of predatory mites (*Phytoseiulus persimilis*) to achieve biological control. Some pesticides are toxic to predatory mites and must be avoided for best results. Also refer to advice provided by the mite supplier. Chlorfenapyr is toxic to *P. persimilis*.
Peach tree fungal gummosis *(Botryosphaeria dothidea)*	No fungicide control program has been established for this disease.		Oozing resin or gum appears on branches or trunks and from swollen lenticels. Multiple infections result in extensive cankers. Bark takes on a black and crusty appearance. Often the branches are girdled, and if complete this leads to limb or tree decline and death. Do not leave prune stubs, as they may be potential entry points for the disease. Remove winter prunings from the orchard to reduce the amount of carryover inoculum. Avoid moisture stress after harvest and maintain tree health with adequate nutrition.

Low- and medium-chill summerfruit (nectarines, peaches, plums) continued

Leaf fall			
Pest	**Pesticide (Pesticide group)**	**Registered**	**Comments**
Leaf curl	Copper hydroxide (Y) or copper oxychloride (Y) or cuprous oxide (Y) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) and copper hydroxide (Y)	All States All States All States QNSWSNtTA All States	Use of copper sprays is often required to hasten leaf fall. Apply four sprays at weekly intervals during the leaf fall period. Delay leaf defoliation if the season is wet, as early flowering may occur if temperatures are mild during late autumn and early winter. Leaf curl is not an issue in plums.
Shot-hole	Copper hydroxide (Y) (peaches and plums) or copper oxychloride (Y) or cuprous oxide (Y) (peaches and plums) or tribasic copper sulfate (Y) or a proprietary mixture of mancozeb (Y) and copper hydroxide (Y)	All States All States All States All States All States	
Bacterial spot Bacterial canker			Copper sprays will also help control bacterial diseases.
Dormancy			
San José scale	Dormant oil		Apply oil no later than early budswell. May be combined if necessary with copper oxychloride for shot-hole and bacterial spot control. Only one full-strength oil spray should be used in any one year.
Green peach aphid	Horticultural mineral oil		
Brown rot Blossom blight	Sanitation		Remove all mummies, cankers and dead shoots from trees and destroy by burning or burying.

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