

# Orchard plant protection guide for deciduous fruits in NSW 2026–27

NSW PRIMARY INDUSTRIES MANAGEMENT GUIDE



Compiling author, Jessica Fearnley-Pattison



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# Orchard plant protection guide for deciduous fruit in NSW 2026–27

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# About this guide

The 2026–27 edition of the *Orchard plant protection guide for deciduous fruit in NSW* is the latest in a series of annual publications that have supported the pest and disease management decisions of generations of NSW temperate fruit producers for over 60 years. The guide is recognised as a respected and valuable reference for temperate fruit industries.

## Feature articles

This year's guide highlights NSW DPIRD's current research, development and activities for the temperate fruit industries in NSW.

Jessica Fearnley-Pattison gives us an update on the Hort-Innovation-funded project 'Communication and extension for the Australian cherry industry' ([page 8](#)), then she teams up with Summer Song to give us an update on the 'Optimising protected cherry production' project (CY24004; [page 9](#)). Jessica and Bruno Holzapfel provide an introduction to a new project, funded by the Australian Government's Future Drought Fund, on adapting temperate horticulture systems to seasonal drought and climate volatility ([page 13](#)).

Led by the team at the Tasmanian Institute of Agriculture, the 'Building sustainable soil' (AP22003) project aims to improve the adoption of profitable and sustainable soil, nutrient and water management practices in apple orchards ([page 15](#)). This is part of the 'Productivity, irrigation, pests and soil' (PIPS) program. Continuing with soil, Jessica gives us a new article on managing nutrition in temperate fruit crops on [page 17](#).

NSW DPIRD has also included some new additions within the guide, including:

- what to do to increase pollination in orchards as the varroa mite has reduced wild populations ([page 26](#))
- comparing historical climate patterns with seasonal conditions in the 25-26 growing season and how this might have influenced crops ([page 29](#))
- identifying and controlling plant viruses in orchards ([page 142](#)).

The authors would like to acknowledge Dr Sally Bound for her contribution to the chemical thinners section on [page 152](#).

## Distribution

This guide aims to provide commercial orchardists with up-to-date technical information on all aspects of crop protection. The guide is available free to commercial fruit growers and is distributed to rural retailers and key industry bodies in pome and stone fruit growing regions. For a full list of these locations, refer to the [NSW DPIRD website](https://www.dpi.nsw.gov.au/agriculture/horticulture/pomes/pests-etc/orchard-plant-protection-guide) (<https://www.dpi.nsw.gov.au/agriculture/horticulture/pomes/pests-etc/orchard-plant-protection-guide>).

Additional copies can be obtained through [NSW DPIRD Tocal bookshop](https://shop.regional.nsw.gov.au/products/orchard-plant-protection-guide?_pos=1&_psq=orcha&_ss=e&_v=1.0) ([https://shop.regional.nsw.gov.au/products/orchard-plant-protection-guide?\\_pos=1&\\_psq=orcha&\\_ss=e&\\_v=1.0](https://shop.regional.nsw.gov.au/products/orchard-plant-protection-guide?_pos=1&_psq=orcha&_ss=e&_v=1.0)).

## Feedback please

NSW DPIRD wants to make sure the information we are providing is what you need to help your business grow. We welcome suggestions, comments and ideas from growers and technical people that might improve the usefulness and relevance of the guide. Please either contact me with your suggestions or scan the QR code to fill out a very short survey.

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# How to use this guide

Finding the information you need is as easy as 1–2–3.

**Step 1:** go to [Table 6](#) or [Table 7](#) and find the pest or disease you are interested in. These are listed alphabetically in the column titled Common name.

**Step 2:** check to see if the pest or disease is considered a major problem in your crop ([Figure 1](#)). If there is a red cross (✗) in the cells intersected by the pest or disease and the crop, then that crop is not likely to be affected. If there is a green tick (✓) in the cells intersected by the pest or disease and the crop, then the crop is likely to be affected and control strategies are recommended.

**Step 3:** scan across the table to find the relevant page number for the pest or disease.

Alternatively, see the contents table on [page 5](#) and search for the pest or disease there. The contents table also includes details of other important plant protection articles covering subjects including crop regulation, postharvest diseases and responsible use of pesticides.

This guide provides orchardists with suggestions for managing the main pests and diseases through responsible pesticide use ([page 166](#)). Pesticide use can be moderated even further with good orchard management and implementing practices such as integrated pest, disease and weed management (IPDWM).

Weather influences the pests and diseases that appear in temperate fruit orchards. By observing the weather, fruit growers can predict the occurrence and severity of some pest and disease outbreaks and only spray when a threat exists. Watching the weather and knowing the pests are essential.

Additional ways to reduce the risks posed by a broad range of pests and diseases include:

- pruning to open tree canopies will allow better spray penetration and help leaves to dry more quickly, reducing the threat of many diseases
- avoiding or carefully managing overhead irrigation to prevent conditions favourable for disease (especially if required for frost protection or heat stress mitigation)
- practising good hygiene, including appropriately disposing of unwanted fruit, to reduce the threats posed by many insect pests and diseases
- timing weed control to reduce the likelihood of pests finding alternative sites to survive over winter
- destroying feral fruit trees and neglected orchards
- encouraging predatory and parasitic insects by not using disruptive chemicals.

The sections on pests (from [page 42](#)) and diseases (from [page 112](#)) provide specific details on weather conducive to pest or disease outbreaks and on non-pesticide management options where applicable. Orchardists should always use a variety of management strategies (cultural, biological and chemical) to produce satisfactory fruit quality.

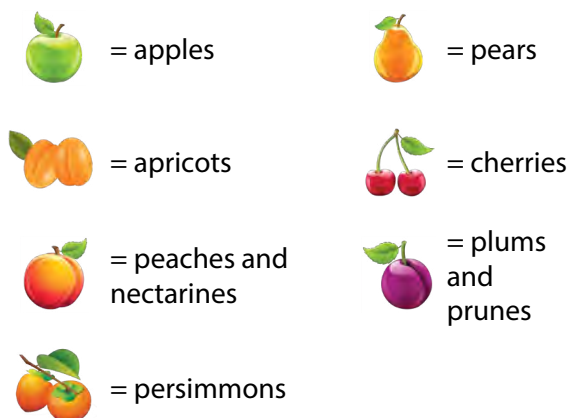


Figure 1. The icons used to identify the crops included in this guide. Source: [Vector Graphics Blog](https://www.tumblr.com/vectorgraphics-blog) (<https://www.tumblr.com/vectorgraphics-blog>); persimmon icon, [PNG images](https://pngimg.com/) (<https://pngimg.com/>).

# Communication and extension for the Australian cherry industry – update

Jessica Fearnley-Pattison, Development Officer – Temperate Fruit, NSW DPIRD

The Hort Innovation-funded project, 'Communication and extension for the Australian cherry industry' (CY22002), led by NSW DPIRD, is in its third year. The project aims to increase communication and extension activities for the Australian cherry industry.

This year the project team has been working on developing case studies to provide industry with up-to-date, relevant information on a variety of topics, including using cover crops, bird deterrents and protective covers in orchards (Figure 2). The case studies can be viewed on the [Cherry Growers Australia website](https://www.cherrygrowers.org.au/case-studies/) (<https://www.cherrygrowers.org.au/case-studies/>) or scan the QR code (Figure 3).



Figure 2. NSW DPIRD have created a bird deterrent case study as part of the CY22002 project. Photo: Lesley Ingram, Bugwood.org.



Figure 3. Scan the QR code to see the case studies on the Cherry Growers Australia website.

The team also held a recent webinar series on the many different research projects currently underway in the Australian cherry industry. If you missed these webinars, you can listen to the recordings on the [Cherry Growers Australia YouTube channel](https://www.youtube.com/@CherryGrowersAustralia) (<https://www.youtube.com/@CherryGrowersAustralia>).

## Acknowledgement

This project is funded by Hort Innovation using the cherry research and development levy, and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.





# Optimising protected cherry production

Jessica Fearnley-Pattison, Development Officer – Temperate Fruit, NSW DPIRD  
Summer Song, Project Officer – Climate Smart Pilots, NSW DPIRD

The 'Optimising protected cherry production' (CY24004) project, led by NSW DPIRD and supported by the Tasmanian Institute of Agriculture, is entering its second year. To help Australian cherry growers make informed decisions about investing in and managing protective cropping systems (PCS), several case studies have been established in key cherry-growing regions (Figure 4). These will be used to investigate how PCS influence temperature, humidity, wind speed and light, as well as fruit quality, while exploring different management practices under covers.



Figure 4. Locations of case studies in Australia.



## Optimising Protected Cherry Production



UNIVERSITY OF TASMANIA  
**TIA**  
Tasmanian Institute of Agriculture  
TIA is a joint venture of the University of Tasmania and the Tasmanian Government



This project has been funded by Hort Innovation using the cherry research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit [horticulture.com.au](http://horticulture.com.au)

## Case study 1: nitrogen use in protected cherry production

Variety: Samba

Location: Orange, NSW

### The challenge

Excessive vegetative growth is common when using covers, as they can reduce light and increase humidity. Consequently, growers have raised concerns that business-as-usual nitrogen (N) application rates might be excessive under covers, as the combination of increased N availability and a growth-promoting environment could lead to overly vigorous trees and negatively affect cherry quality.

To better understand N requirements in covered cherry production, different N application rates are being investigated. This will help determine whether cherry production under covers needs more, less or the same amount of N as those without covers.

### Research question

How do different N rates under rain covers affect soil N, leaf N, new shoot growth (tree vigour) and fruit quality including size, weight, firmness, external colour and Brix?



Figure 5. The nitrogen trial in Orange, NSW.

## Case study 2: irrigation management in protected cherry production

Variety: Santana

Location: Orange, NSW

### The challenge

Protective rain covers can alter traditional irrigation requirements by reducing evapotranspiration and increasing humidity. Anecdotal evidence suggests that irrigation under covers could be reduced by around 30%. Some growers have said it could be reduced by up to 50% without negatively affecting tree performance or cherry quality.

### Research question

Compared to business-as-usual irrigation (100%), how does deficit irrigation (50%) affect crop stress and fruit quality?



Figure 6. The irrigation trial in Orange, NSW.

## Case study 3: microclimate and cherry quality under hail netting

Variety: Santina

Location: Gulgong, NSW

### The challenge

Protective covers, including hail and bird nets, can alter microclimate conditions such as temperature and humidity, thus affecting cherry quality. However, little is known about the effects of hail nets in Australia, particularly in mainland growing regions. Such knowledge will help growers better manage cherry production under nets.

### Research question

How does permanent hail netting affect the microclimate and cherry quality in Australia?



Figure 7. The hail netting trial in Gulgong, NSW.

## Case study 4: microclimate and cherry quality under rain covers

Varieties: Samba, Giant Ruby, Lapins

Location: Shepparton and Alexandra, Vic; Sidmouth, Tas

### The challenge

Protective rain covers can alter orchard microclimate, such as temperature, humidity and wind speed. Such changes in microclimate can then affect cherry quality. However, evidence on how covers influence microclimate and cherry quality in Australia, particularly in mainland growing regions, remains limited.

### Research question

How do protective rain covers affect microclimate and cherry quality in Australia?



Figure 8. The rain cover trials in Victoria.

## Case study 5: gibberellic acid use under rain covers

Variety: Sweet Aryana

Location: Shepparton, Vic

### The challenge

Anecdotal evidence suggests that protective rain covers might increase the risk of soft fruit due to higher temperatures, increased humidity and reduced calcium uptake. Gibberellic acid (GA) can be used to improve fruit firmness and size; however, determining the appropriate application rate under covers can be challenging, as excessive GA use might negatively affect tree performance and cause soft fruit.

### Research question

What are the effects of 3 different GA applications on cherry quality under protective rain covers?

## Case study 6: root pruning of cherry trees under covers

Variety: Late Garnett

Location: Alexandra, Vic

### The challenge

Excessive vegetative growth can occur under protective covers, potentially due to increased humidity, reduced wind stress and moderated temperatures that favour tree growth. While some suggest that root pruning might help control tree vigour and vegetative growth, limited evidence is available to support its effectiveness in protected cherry production.

### Research question

How does root pruning affect crop vigour and fruit quality under rain covers?



Figure 9. The root pruning trial in Victoria.

## Next steps

Data from the 2025–26 season are currently being analysed and further improvement of the trials will be implemented where necessary. During the 2026–27 season, more data will be collected and analysed to strengthen the recommendations for protected cherry production in different regions and systems. Results will focus on understanding how different types of covers influence orchard microclimate and cherry quality, and identifying management strategies to support the production of high-quality cherries. Keep an eye out for upcoming workshops and use the information to inform your investment decisions and management practices for protected cherry production.

# Adapting temperate horticulture systems to seasonal drought and climate volatility

Jessica Fearnley-Pattison, Development Officer – Temperate Fruit  
Bruno Holzapfel, Senior Research Scientist – Perennial Crop Physiology

NSW DPIRD is proud to be a partner in a new project focused on adapting our temperate fruit industries to future drought conditions. To help apple, cherry and wine grape growers strengthen their resilience to drought, the NSW Government and Charles Sturt University are investigating adaptation and management practices with support from the Australian Government's Future Drought Fund.

Starting in 2026, this 5-year project aims to develop and test new agronomic management practices to improve orchard and vineyard drought resilience by:

- Conducting long-term trials in the main apple and cherry growing regions in NSW and Tasmania to capture the seasonal cycle of perennial crops, giving growers detailed insights into how different management approaches perform in different conditions.
- Having additional demonstration sites in the Central West, southern NSW, and Tasmania, to include diverse horticultural production systems in apple, cherry and winegrape.
- Testing a combination of researcher-designed and grower-suggested treatments to evaluate how different practices influence drought tolerance and productivity over time.

For cherries, NSW DPIRD have so far identified areas of production to maximise efficiency and maintain production during dry and hot times (Figure 10). In Gulgong and Young, cherry trials have been designed to focus on water requirements, optimising postharvest management and protecting bud initiation. A key area of interest is understanding the effect of heat and water stress on crop load and how this can be manipulated to maintain fruit size, firmness and quality, year on year.

A smaller project investigating the rooting depth of different cherry rootstocks (dwarfing vs non-dwarfing) and water interactions will also form part of the cherry outputs available to growers. At the end of the project, the team aim to provide recommendations on:

- water requirements
- critical water demand periods to avoid yield and quality penalties
- identifying when irrigation can be safely withheld
- postharvest practices that optimise crop load and bud initiation for subsequent seasons.

Matching irrigation inputs to tree water requirements is important for optimising orchard water balance, maximising water-use efficiency, and improving resilience under drier conditions and drought. This is particularly relevant as temperatures are rising and rainfall is likely to decline in the cooler regions where perennial crops are grown. Often, the inter-row or under-tree areas in these systems are kept bare using herbicides. This exposure can lead to considerable soil water loss. Various amendments can be used to reduce these losses and/or improve soil structure, thereby improving water-holding capacity. The amendments used include compost and mulch, the latter of which can also be produced within the orchard system (e.g. mow-and-throw).



Figure 10. Cherries being grown in hot and dry conditions in the USA.

A replicated trial is being established near Batlow in an apple orchard with the variety 'Bravo' grafted onto M26 rootstock (Figure 11). Baseline data are being collected this winter, specifically on soil structure and carbon content, before applying amendments to the orchard floor under the tree row (approximately 600 mm on either side of the trunk). The amendments will be sourced locally where possible and will be applied to a thickness of 80–100 mm under the tree line, except for the biochar, which will be applied at a rate of 200 m<sup>3</sup>/ha. Orchard productivity and fruit quality will be assessed, as well as soil moisture and temperature, and plant water and nutrient status. Soil moisture instrumentation and a weather station will be installed to ensure accurate data collection.

The outcomes from these trials will occur via a range of extension activities, including field days, workshops, and industry publications. These will inform growers of trial progress, improve knowledge of orchard water use, and help with preparing for the predicted drier conditions.

As part of the project, NSW DPIRD will be partnering with the Tasmanian Institute of Agriculture's (TIA) climate modelling team to model these systems based on climatic, soil and plant physiology data. This will give an in-depth understanding of how these systems might work in changing climatic conditions.

Research findings from the NSW trial sites will give growers access to information through workshops, fact sheets, orchard walks, and a grower management guide/training manual, which will be published at the conclusion of the project.

Strong industry engagement and knowledge sharing will be critical to the project's success. The aim is to ensure research findings translate into tangible benefits for growers so that they can use these in day-to-day orchard and vineyard practices. If any growers are interested in being involved, or would like to know more about the project, please contact:

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Figure 11. The apple orchard trial site in Batlow, NSW.

This project received funding from the Australian Government's Future Drought Fund.



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**Charles Sturt  
University**  
Gulbali Institute  
Agriculture Water Environment



**Department of  
Primary Industries and  
Regional Development**



# PIPS 4 Profit program – Australian apple and pear industry R&D

## Building sustainable soil (AP22003) project update

The 'Productivity, irrigation, pests and soil' (PIPS) program began in 2009 to deliver whole-of-orchard research, development and demonstrations, and continues to inform the Australian apple and pear industry today. The current program, PIPS 4 Profit, aims to answer research needs to deliver productivity, sustainability and economic benefits to Australian businesses. The program comprises 4 research projects until mid-2028, each with a specialised focus in apple and pear production systems. It is funded by Hort Innovation using the apple and pear research and development levy and contributions from the Australian Government.

New South Wales (NSW) apple growing regions host 2 PIPS 4 Profit 'Building sustainable soil' (AP22003) experimental sites, delivered through NSW DPIRD. Now entering its third year, the preliminary findings are included here.

## Building sustainable soil for apples in NSW

Led by the team at the Tasmanian Institute of Agriculture (TIA), the nation-wide PIPS 4 Profit 'Building Sustainable Soil' (AP22003) project aims to improve the adoption of profitable and sustainable soil, nutrient and water management practices in apple orchards. In NSW, the project has 2 research sites, one in Orange (Central West) and one in Picton (Sydney Basin). The aim of the trials is to understand how orchard floor management influences soil carbon sequestration in apple orchards, and soil physical, chemical and biological parameters, tree health, and fruit yield and quality.

## Building sustainable soil

Both trials are randomised block designs with 6 and 3 replicates per treatment in Orange and the Sydney Basin, respectively ([Table 1](#)). Soil physical and biological properties and soil carbon will be assessed annually to determine treatment effects.

Table 1. Orchard floor treatments in the 'Building sustainable soil' (AP22003) trial sites.

| Orange                                                                                                                                                                                                                                        | Sydney Basin                                                                                                                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| <b>Herbicide strip (control):</b> regular applications of herbicide under the tree to maintain a bare, weed-free strip.                                                                                                                       | <b>Herbicide strip (control):</b> regular applications of herbicide under the tree to maintain a bare, weed-free strip.      |
| <b>Organic compost:</b> 10 cm application of organic compost under the tree line.                                                                                                                                                             | <b>Organic compost:</b> 10 cm application of organic compost under the tree line.                                            |
| <b>Shallow-rooted cover crop:</b> a legume/grass cover crop with root systems in the top 30 cm of the soil profile. This treatment is made up of red creeping fescue, kidney weed, red clover and subterranean clover.                        | <b>Shallow-rooted cover crop:</b> a shallow-rooted legume/grass cover crop with a spreading nature planted in the tree line. |
| <b>Deep-rooted cover crop:</b> a legume/grass deep-rooted cover crop planted under the tree to investigate if nutrients are mined deeper in the soil. This treatment is made up of a winter-active lucerne, burr medic and French serradella. | NA                                                                                                                           |
| <b>Grass mulch:</b> symbolic of the 'mow and throw' system in an orchard, grass clippings will be regularly added under the tree line to form a grass mulch.                                                                                  | NA                                                                                                                           |

## Increasing soil organic carbon

Preliminary results from the first 2 years at Orange show all treatments, except the control, have increased soil organic carbon (SOC) levels in the topsoil (0–10 cm; [Table 2](#)). Each treatment is now above 2% SOC, typically the level considered the 'good' benchmark for Australian agricultural soil.

Table 2. Preliminary results for soil organic carbon levels in the top 10 cm of plots.

| Treatment          | Soil organic carbon (%) |                |                |
|--------------------|-------------------------|----------------|----------------|
|                    | Baseline                | 2024–25 Season | 2025–26 Season |
| Herbicide          | 1.75                    | 1.99           | 1.74           |
| Compost            | 1.75                    | 2.01           | 2.38           |
| Shallow cover crop | 1.75                    | 1.04           | 2.31           |
| Deep cover crop    | 1.75                    | 2.21           | 2.04           |
| Mow and throw      | 1.75                    | 1.98           | 2.13           |

At subsoil depth (10–30 cm), SOC is showing a different trend. While all treatments increased in SOC in the first year, the organic compost was the only treatment to show an increase after 2 years (1.44% to 1.56%). The shallow-rooted cover crop and grass mulch (mow and throw) treatments reduced SOC after 2 years compared to the 1.44% baseline (1.36% and 1.23%, respectively). The greatest reduction in SOC was in the herbicide strip (Table 3).

Table 3. Preliminary results for soil organic carbon levels in the 10–30 cm (subsoil) of plots.

| Treatment          | Soil organic carbon (%) |                |                |
|--------------------|-------------------------|----------------|----------------|
|                    | Baseline                | 2024–25 Season | 2025–26 Season |
| Herbicide          | 1.44                    | 1.64           | 1.06           |
| Compost            | 1.44                    | 1.65           | 1.56           |
| Shallow cover crop | 1.44                    | 1.82           | 1.36           |
| Deep cover crop    | 1.44                    | 1.82           | 1.45           |
| Mow and throw      | 1.44                    | 1.62           | 1.23           |

These early findings suggest that organic inputs and ground cover can improve topsoil SOC within 2 years, while changes at depth might take longer. Further data collection and investigation are needed over the next 2 years to determine whether fluxes in SOC over years in the subsoil are typical, and whether the applied treatments increase SOC overall and over a longer period. It will also be interesting to explore whether the treatments continue to have a 'buffering' effect on decreases in SOC compared to the herbicide strip.

As the project continues for the next 2 years, researchers will explore the relationship between changes in soil property measurements and production parameters (yield and quality). Economic analysis will also be undertaken to determine the value proposition of orchard floor management options.

## Want to find out more about the PIPS 4 Profit program?

For more information on the PIPS 4 Profit program, please visit the [industry website](https://apal.org.au/programs/more-industry-programs/pips-4-profit-program/) (https://apal.org.au/programs/more-industry-programs/pips-4-profit-program/).



# Nutrition basics for temperate fruit

Jessica Fearnley-Pattison, Development Officer – Temperate Fruit, NSW DPIRD

Plant nutrition is fundamental to tree growth, fruit development and orchard productivity. Trees require a balanced supply of essential nutrients throughout the growing season. Understanding the role of these nutrients, together with regular soil and plant tissue testing, provides the foundation for effective nutrition management. Healthy soil also supports tree growth and disease resistance. Good soil fertility results from the interaction of the soil's mineral, biological, physical, and chemical properties.

## Soil

### Mineral properties

The mineral component of the soil makes up the largest volume and can be broken into primary and secondary minerals. Primary minerals are derived from the parent material from which the soil was formed. Secondary minerals result from the weathering of primary minerals (Nanzyo and Kanno 2018). Mineral properties influence soil fertility by controlling the availability, retention, and release of essential nutrients, which in turn affect plant growth and soil fertility.

### Biological properties

Biological soil properties include the living and non-living components of the soil. A single handful of soil is home to millions of living organisms, ranging from those that are easily seen, such as earthworms (Figure 12), beetles and ants, down to microscopic fungi and bacteria.

Most biological activity occurs in the top 100 mm of the soil where plant residues are being broken down and made available for plant growth. Biological properties influence soil nutrition through the activity of these microorganisms, plant roots, and soil fauna that decompose organic matter, cycle nutrients, and make essential elements more available for plant uptake.

### Physical properties

The physical properties of a soil refer to its structure and texture. Structure is the arrangement of soil particles into small clumps, called peds or aggregates (Figure 13), which are made from soil particles (sand, silt and clay) that bind together.



Figure 12. A single handful of soil is home to millions of living organisms.



Figure 13. Soil structure is made up of different-sized peds and aggregates.

### Chemical properties

Chemical properties influence soil nutrition by affecting nutrient solubility, pH balance, and cation exchange capacity, which together determine how easily plants can access essential nutrients.

Nutrients are classified as either anions or cations. An anion is a nutrient that has a negative charge in its natural state, whereas a cation is a nutrient that has a positive charge in its natural state. The strength of the charge will depend on the soil's texture. For example, sandy soil that has a coarse texture will have a low negative charge and clay soil that has a fine texture will have a high negative charge.

The ability of a soil to hold onto cations is determined by this charge and is referred to as the cation exchange capacity (CEC). The CEC is a useful indicator of the soil's fertility as it shows the soil's ability to supply plant nutrients (Lines-Kelly 1993). The CEC is also a soil property influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilisers (Hazelton and Murphy 2007).

Soil can be naturally acidic or alkaline and this is known as a soil's pH. Generally, apple and cherry trees prefer slightly acidic to neutral soil, with an optimal pH range for apples between 6.0 and 6.5, and cherries from 6.5 to 7.0. If the pH is out of this range, it can cause nutrients to become unavailable to plants, leading to poor tree and fruit development. It is important to correct the pH before trying to improve nutrient imbalances in the soil.

## The main nutrients for temperate fruit crops

Growers should be aware that this section is intended as a guide to nutrient deficiencies and toxicities. It is not a replacement for soil and leaf sampling, nor a visual assessment of orchards.

Healthy, unstressed trees will usually resist damage from pests and diseases. Therefore, maintaining good plant nutrition is an important component of any crop protection strategy. All plants require an adequate supply of essential macro and micronutrients to reach their potential. Insufficient or unbalanced nutrient supply can impede nutrient uptake, affecting yield, quality and productivity. Plant nutrition is a key factor in temperate fruit tree growth and yield. It is not always easy to know which nutrients the trees might be missing or which fertiliser is best for the crop.

## Monitoring nutrient status through soil and plant tissue testing

Regular monitoring, testing and interpreting soil properties are essential to understanding how different nutrients might behave in an orchard. Soil testing can provide information on soil pH, nutrient availability, salinity, organic matter levels and other factors that can influence tree growth, fruit yield and quality.

By interpreting soil test results correctly, growers can make informed decisions about fertiliser applications, soil amendments and irrigation management, helping to optimise tree health while reducing unnecessary input costs. For established orchards (>5 years old), comprehensive soil testing (Figure 14) is generally recommended every 2 years, with the addition of annual testing where nutrient-related issues or variable soil conditions exist. Soil testing should be complemented by annual leaf analysis, typically collected during the active growing season from fully developed leaves.

Combining soil and plant tissue testing gives a more complete understanding of nutrient availability and uptake before imbalances affect yield or fruit quality.

For more information on [correct soil sampling techniques](https://www.soilscienceaustralia.org.au/resources/smart-soils-for-farming/a-guide-for-fit-for-purpose-soil-sampling/), visit <https://www.soilscienceaustralia.org.au/resources/smart-soils-for-farming/a-guide-for-fit-for-purpose-soil-sampling/>

The main nutrients needed for temperate fruit production can be split into macro and micronutrients, which differ in the amounts the plant needs. Macronutrients such as nitrogen, phosphorus, and potassium are required in large quantities because they are essential for major processes such as growth, energy transfer, and fruit development. Micronutrients, including elements such as zinc, boron, and iron, are only needed in smaller amounts, but they are essential for enzyme function, nutrient transport, and overall plant health.



Figure 14. Regular soil sampling should be undertaken in the orchard to gain an understanding of nutrient requirements.

## Macronutrients needed for temperate fruit production

Macronutrients are fundamental to tree growth, canopy development, root function, flowering, fruit set and quality. Ensuring the right levels of these nutrients are available to the trees is necessary to optimise the yield and quality of fruit.

### Nitrogen

Nitrogen (N) is essential for tree growth, leaf cover, blossom formation, fruit set and fruit size, all of which contribute to crop yield. It is a vital part of protein and chlorophyll development. Protein is important in plant production for metabolism, while chlorophyll is involved in making sugar using carbon dioxide from the atmosphere and sunlight.

N is mobile in plants. Excess N can cause excessive vegetative growth and delay fruit maturity, resulting in poorly coloured fruit with a short storage life as firmness is lost more readily. Fruit firmness is often compromised in excessively vegetative blocks with high N as calcium (a key building block of cell walls), is preferentially directed to shoots rather than the developing fruit. Excessive tree vigour from too much nitrogen can be partially controlled by late summer pruning, which will also help improve fruit colour and limit root growth. Blocks that are deficient in N will have weak or little new growth. Symptoms will first appear on the older leaves as N is transferred to actively growing younger leaves. Young leaves will be small, pale green to yellow (Figure 15) and tend to drop early in autumn. Trees deficient in N can also produce short terminal shoots.



Figure 15. The yellow apple leaf (left) shows signs of nitrogen deficiency compared to a healthy leaf (right).

### Apple

Recommendations for the most appropriate time to apply N in apple orchards are region-specific. An effective N fertilisation program should be based on understanding the root uptake period, the N storage pattern in the trees, the time of the season and the tree physiological stage. About 80% of the annual N use is from tree reserves, while only 20% is from an immediate N application. In N-deficient orchards, N from fertilisers applied during the current season can be absorbed immediately. Young non-bearing trees will benefit more from higher N programs than older bearing trees. The goal with younger trees is to produce wood and vegetative growth, while the goal with bearing trees is strong yields of high-quality fruit.

### Cherry

In cherries, uptake of N from the soil starts about 30 days after full bloom, so the first growth in spring draws upon remobilised N from stored reserves. The production of cherry flowers and the early spring growth of leaves, stems, and new fine roots are fully dependent on the remobilisation of stored N. Cherry trees on dwarfing rootstocks have smaller root systems and trunks for storing N and might require an autumn foliar N spray to improve uptake.

Research from the Tasmanian Institute of Agriculture suggests that when N is applied pre-harvest, most of it goes into fruit, but when it is applied postharvest, most will be stored in the branches. There is a strong recommendation to apply N often, but in small amounts. To find out more about [nitrogen management in cherry orchards](https://www.utas.edu.au/__data/assets/pdf_file/0005/1545314/CRD21004-014-Cherry-Guidelines-MK3.pdf), scan the QR code ([https://www.utas.edu.au/\\_\\_data/assets/pdf\\_file/0005/1545314/CRD21004-014-Cherry-Guidelines-MK3.pdf](https://www.utas.edu.au/__data/assets/pdf_file/0005/1545314/CRD21004-014-Cherry-Guidelines-MK3.pdf)).



## Phosphorus

Phosphorus (P) is one of the main limiting nutrients in Australian soil, but deficiencies are rare in tree fruit production (Long et al. 2020). It is required for cell division, new tissue development, forming and moving carbohydrates, as well as regulating meristematic activity.

Leaves of P-deficient plants will be dull–dark green, possibly with bronze or purple tints. This will usually be seen on the older leaves first because P is mobile in the plant. Phosphorus-deficient trees can have impaired vegetative and floral meristem development, delayed bud burst, poor root development and stunted plant growth.

Phosphorus will rarely move more than 40–50 mm from where it was placed on the soil. As P is required for root development, it is best applied close to the root zone at the start of the main growing season. Phosphorus does not leach readily, so frequent applications should not be necessary.

Phosphorus is most available to plants when the soil pH is between 6 and 7. When soil pH is below 5.5, soluble oxides of iron, aluminium and manganese form, reducing phosphorus availability, while at pH above 7, soluble calcium phosphate is formed. Continually monitoring soil P and pH levels will help ensure the right amount of available P can be applied to the trees.

## Potassium

Potassium (K) is one of the most important nutrients for fruit production and can pose the most problems in stone fruit (Long et al. 2020). It is essential for fruit shape, size, colour and taste. Potassium also regulates the opening and closing of stomata and controls water uptake, therefore improving drought resistance.

During the fruit expansion phase, fruit become a significant sink for K, and as this nutrient is mobile, deficiency symptoms often appear initially in older leaves. The margins of these leaves will turn yellow, then brown, and the leaf edges might become tattered and curl inwards (Figure 16). Yield and quality can be affected by K deficiency long before the symptoms appear in the leaves. As fruit ripens, K will move out of the leaves and into the fruit, so symptoms might be apparent during the later stages of ripening (Long et al. 2020).

Potassium-deficient plants will usually have stunted growth, poor resistance to temperature changes and be more susceptible to pests and diseases.

Appropriate levels of potassium, calcium and magnesium are required as these elements compete with each other at soil exchange sites. The potassium–magnesium ratio in the soil needs to be close to 1:2 (Rainham 2015). As some potassium fertilisers can have a high salt index, they should not be applied directly to the roots.



Figure 16. Potassium deficiency symptoms can include older leaf margins turning yellow, then brown, and the leaf edges might become tattered and curl inwards.

## Calcium

Calcium (Ca) is the building block for plant cell walls and helps to protect against heat stress and diseases. It also plays a major role in regulating enzymes, hormonal processes and the opening of stomata. Calcium is the most important nutrient for postharvest quality as it acts as the ‘glue’ between cell walls. Fruit with low calcium levels does not store well.

As Ca does not move easily throughout the tree, growers will often apply multiple foliar Ca applications. However, care must be taken when applying Ca, as high levels of calcium chloride and calcium citrate have been found to negatively affect fruit size (Long et al. 2020).

## Apple

In apples, calcium deficiency causes a nutritional disorder known as bitter pit. Early symptoms can be difficult to see as the disorder starts internally, but as it progresses, external blemishes develop on the skin. These small bruise-like spots develop and worsen to sunken ‘pits’ about 3–6 mm in

diameter. Spots will usually develop at the calyx end of the fruit; however, highly susceptible varieties can be damaged right up to the shoulder (Figure 17).

Calcium deficiency is usually seen in fruit that receives an irregular water supply, which prevents calcium from being taken up by the tree. Bitter pit is generally worse in seasons when there are fluctuations in rainfall and temperature, combined with a shortage of water to trees at critical times during fruit development. Excessive use of nitrogen, potassium and magnesium fertilisers can also cause or worsen the problem.

### Cherry

Ca deficiency in cherries will show in trees as shortened internodes and reduced growth. On young trees, light brown to yellow marks might appear on leaves. Good levels of Ca can reduce fruit cracking and increase fruit storability (Long et al. 2020).

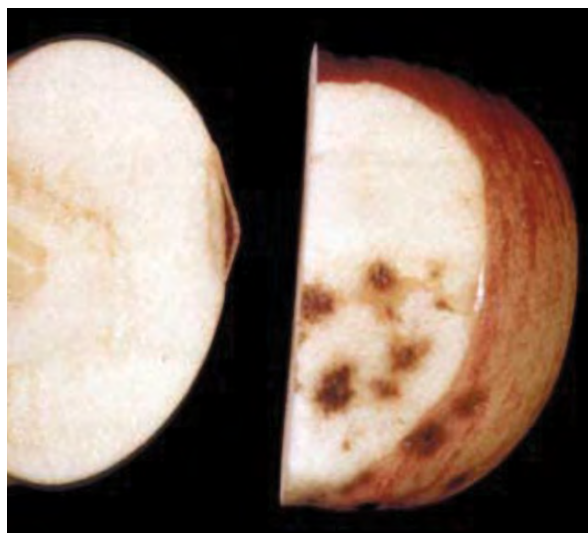


Figure 17. Bitter pit is a calcium disorder in apples.

## Micronutrients required for temperate fruit production

Micronutrients are vital for the biochemical processes that ensure trees are productive, yielding high-quality fruit. Micronutrients support good flowering, fruit set, sugar accumulation, and strong cell structure. Even the smallest deficiencies can lead to poor pollination, reduced yield and smaller fruit.

### Zinc

Zinc (Zn) is a trace element for temperate fruit. It is used to form auxin (Swietlik 2001), a growth hormone produced by shoot tips. Zn has an important role in cell division, leaf and shoot growth and fruit development. Zn deficiency affects tree health and fruit yield. It can affect orchards in all districts with all soil types. Deficiency symptoms will initially appear on the younger leaves and are usually seen in spring. The most characteristic symptom of Zn deficiency is abnormally narrow, short and irregularly shaped leaves with wavy margins. Leaves can sometimes show a mottled pattern (Figure 18), but this should not be confused with other deficiencies or herbicide damage.

Shoot growth will be delayed and leaves at the top of affected shoots will appear tufted or rosetted, with smaller (sometimes chlorotic) leaves below. In affected blocks, leaf growth often looks sparse compared with healthy trees nearby, and it will be easy to see through the canopy to adjacent rows.



Figure 18. In severe cases, zinc deficiency will show up as mottling on the leaves.

### Boron

Boron (B) is required for flowering, fruiting, pollination, fruit quality and cell wall structure. B deficiency causes a variety of fruit and growth abnormalities. The most common sign starts as small, clear, water-soaked areas in the flesh. These turn brown and dry out, forming spongy lesions in the flesh, which develop into dark depressions, leaving a lumpy appearance on the fruit surface; this is known as internal cork.

## Apples

External cork is more likely if deficiency occurs early in the growing season, causing irregular depressions to appear as the fruit matures. Raised brown or reddish spots might occur, which can later crack as the skin dries up and scales off, leaving a rough, corky layer (Figure 19). Dark brown to greenish-black lesions with a green border occur on or just beneath the skin.



Figure 19. External cork in apples.

## Magnesium

Magnesium (Mg) is important for converting sunlight into carbohydrates in plants (Ishfaq et al. 2022). Symptoms usually appear during late summer in the older basal spur leaves, which become yellow and then scorched around the margin and between the main veins; these leaves tend to drop early (Figure 20). Excessive use of potassium fertilisers or over-liming with calcium carbonate can worsen magnesium deficiency. Toxicity appears quickly in trees growing in acidic or waterlogged soil, and interferes with several key physiological processes, including the absorption and uptake of other vital cations, specifically calcium (Ca) and potassium (K).



Figure 20. Magnesium deficiency causes interveinal yellowing in older apple leaves.

## Iron

Iron (Fe) is required in small amounts for the formation of chlorophyll and processes associated with photosynthesis. Deficiency symptoms will show as interveinal chlorosis, especially in high pH or calcareous soil.

## Manganese

Manganese (Mn) is important for photosynthesis, the activation of enzymes in biochemical processes within the tree and nitrogen metabolism. Deficiency symptoms include interveinal chlorosis and reduced vigour in the tree.

## Copper

Copper (Cu) is involved in lignin formation, reproductive growth and disease resistance within the tree. Deficiency of copper can result in weak shoots, dieback and poor fruit development.

## Molybdenum

Molybdenum (Mo) is required in small amounts for nitrogen metabolism within the tree. Deficiency is uncommon but can affect tree growth where the soil pH is very low.

## A summary of the main nutrients for temperate fruit

| Nutrient        | Important for                                                                                                                                                                                                        | Deficiency symptoms                                                                                                                                                                                                                                                                                      | Excess causes                                                                                                                                                                        |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Nitrogen (N)    | <ul style="list-style-type: none"> <li>• Tree growth</li> <li>• Leaf cover</li> <li>• Blossom formation</li> <li>• Fruit set and size</li> </ul>                                                                     | <ul style="list-style-type: none"> <li>• Leaf yellowing</li> <li>• Poor leaf and shoot growth</li> <li>• Smaller fruit</li> <li>• Fruit prone to early maturity</li> </ul>                                                                                                                               | <ul style="list-style-type: none"> <li>• Excessive vegetative growth</li> <li>• Poorly coloured fruit</li> <li>• Poor fruit storability</li> <li>• Loss of fruit firmness</li> </ul> |
| Phosphorus (P)  | <ul style="list-style-type: none"> <li>• Cell division</li> <li>• New tissue development</li> <li>• Forming and moving carbohydrates</li> <li>• Regulating meristematic activity</li> </ul>                          | <ul style="list-style-type: none"> <li>• Dull/dark green leaves</li> <li>• Bronze or purple tinted leaves</li> <li>• Impaired vegetative and floral meristem development</li> <li>• Delayed bud burst</li> <li>• Poor root development</li> <li>• Stunted plant growth</li> </ul>                        | <ul style="list-style-type: none"> <li>• Can hinder micronutrient uptake</li> </ul>                                                                                                  |
| Potassium (K)   | <ul style="list-style-type: none"> <li>• Fruit shape, size, colour and taste</li> <li>• Regulating stomata and water uptake</li> </ul>                                                                               | <ul style="list-style-type: none"> <li>• Margins of older leaves turn yellow, then brown</li> <li>• Leaf edges tattered and curl inwards</li> <li>• Slow and stunted growth</li> <li>• Defoliation</li> <li>• Poor resistance to temperature changes</li> <li>• Susceptible to pests/diseases</li> </ul> | <ul style="list-style-type: none"> <li>• Poor fruit storability</li> </ul>                                                                                                           |
| Calcium (Ca)    | <ul style="list-style-type: none"> <li>• Building cell walls</li> <li>• Protecting against heat stress and diseases</li> <li>• Hormonal processes</li> <li>• Opening of stomata</li> <li>• Fruit firmness</li> </ul> | <ul style="list-style-type: none"> <li>• Stunted roots</li> <li>• Reduced fruit firmness</li> <li>• Causes bitter pit in apples</li> <li>• Short internodes and reduced growth in cherries</li> <li>• Light brown/yellow marks on young cherry trees</li> </ul>                                          | <ul style="list-style-type: none"> <li>• Can increase pH, and as a result, the availability of some nutrients</li> <li>• Reduced fruit size</li> </ul>                               |
| Zinc (Zn)       | <ul style="list-style-type: none"> <li>• Growth hormone (auxin) formation</li> <li>• Cell division, leaf and shoot growth and fruit development</li> <li>• Forming chlorophyll (green leaf pigment)</li> </ul>       | <ul style="list-style-type: none"> <li>• Small, narrow, irregularly shaped leaves with wavy margins</li> <li>• Branch dieback</li> <li>• Reduced yield and small fruit</li> </ul>                                                                                                                        | <ul style="list-style-type: none"> <li>• Very uncommon, but it causes plant tissue damage</li> </ul>                                                                                 |
| Boron (B)       | <ul style="list-style-type: none"> <li>• Developing cell wall structure</li> <li>• Flowering, pollination and fruit set</li> <li>• Pollen tube growth</li> <li>• Reproductive growth in plants</li> </ul>            | <ul style="list-style-type: none"> <li>• Stumpy roots, yellow veins on young leaves</li> <li>• Lopsided, malformed, grey to brown fruit with gum pockets</li> <li>• Heavy fruit shedding</li> <li>• Internal and external cork in apples</li> </ul>                                                      | <ul style="list-style-type: none"> <li>• Early maturation</li> <li>• Lower storage suitability</li> </ul>                                                                            |
| Magnesium (Mg)  | <ul style="list-style-type: none"> <li>• Synthesis and function of chlorophyll and protein</li> <li>• Internal nutrient balance</li> </ul>                                                                           | <ul style="list-style-type: none"> <li>• Yellowing of leaves</li> <li>• Defoliation and shoot dieback</li> <li>• Smaller fruit and lower yield</li> </ul>                                                                                                                                                | <ul style="list-style-type: none"> <li>• Uncommon, but can cause uptake issues of Ca and K</li> </ul>                                                                                |
| Iron (Fe)       | <ul style="list-style-type: none"> <li>• Chlorophyll formation</li> <li>• Photosynthesis</li> </ul>                                                                                                                  | <ul style="list-style-type: none"> <li>• Interveinal chlorosis</li> </ul>                                                                                                                                                                                                                                | <ul style="list-style-type: none"> <li>• Uncommon</li> </ul>                                                                                                                         |
| Manganese (Mn)  | <ul style="list-style-type: none"> <li>• Photosynthesis</li> <li>• Enzyme activation</li> <li>• Nitrogen metabolism</li> </ul>                                                                                       | <ul style="list-style-type: none"> <li>• Interveinal chlorosis</li> <li>• Reduced vigour</li> </ul>                                                                                                                                                                                                      | <ul style="list-style-type: none"> <li>• Premature leaf drop</li> </ul>                                                                                                              |
| Copper (Cu)     | <ul style="list-style-type: none"> <li>• Lignin formation</li> <li>• Reproductive growth</li> <li>• Disease resistance</li> </ul>                                                                                    | <ul style="list-style-type: none"> <li>• Weak shoots</li> <li>• Dieback</li> <li>• Poor fruit development</li> </ul>                                                                                                                                                                                     | <ul style="list-style-type: none"> <li>• Root damage</li> <li>• Leaf necrosis</li> </ul>                                                                                             |
| Molybdenum (Mo) | <ul style="list-style-type: none"> <li>• Nitrogen metabolism</li> </ul>                                                                                                                                              | <ul style="list-style-type: none"> <li>• Reduced vigour</li> </ul>                                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>• Can cause copper deficiency</li> <li>• Marginal leaf scoring</li> </ul>                                                                     |

## Summary

Plant nutrition underpins tree growth, fruit development, yield and quality in temperate fruit orchards. Each nutrient plays a distinct role in supporting tree performance, and deficiencies or imbalances can limit productivity. Regular soil and plant tissue testing provides valuable information on nutrient availability and uptake, allowing growers to make informed decisions about fertiliser programs and orchard management.

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## Farms of the Future

### CASE STUDY

Tom and Georgie Ward

# Grow with Agtech

Using Agtech to monitor what matters, from anywhere.

Tom and Georgie Ward have 6 hectares of vineyard on cool, dry slopes at 900m. Their new Agtech delivers precise, accessible data to help produce premium grapes and wines. Tom identified goals and pain points through a workshop run by the Farms of the Future.

Tom & Georgie invested in Wi-Fi connected soil moisture probes, a weather station and water tank monitors that sync with computer and phone apps.

“Getting that data onto my phone, that’s been the massive improvement. Tech lets me make instant decisions wherever I am.”

Tom Ward | Swinging Bridge Wines



### Benefits

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# Honey bee pollination and varroa mite

Elizabeth Frost, Technical Specialist Honey Bees – Intensive Livestock Industries, NSW DPIRD

Honey bees make a significant contribution to pollination in many temperate fruit production regions. Feral honey bee colonies have historically provided pollination services, but the establishment of varroa mite in NSW has resulted in substantial declines in feral honey bee populations.

Varroa mite (*Varroa destructor*) is a honey bee parasite that completes its entire life cycle inside bee hives and needs to feed on both juvenile and adult honey bees. Honey bees are varroa's only host species, meaning it will not negatively affect Australia's 2,000+ native bee species (Heard et al. 2022). Varroa can hitchhike on adult honey bees and can be easily transported from one bee hive to another, including to feral hives.

NSW had some of the highest densities of feral honey bee colonies in the world until varroa mite became established in the state. With an abundance of nutritious native plant species to provide nectar and pollen throughout the year and a diversity of hollow-forming trees, unmanaged honey bee colonies were found in many areas. This included farmland with nearby suitable habitat. These feral hive populations declined rapidly once varroa mite established (Figure 21). The pollination each feral colony would have undertaken, mostly within a 2 km radius of the hive, also disappeared when the colony died out due to varroa. This means growers will need to plan for and manage their crop pollination, instead of relying on feral bees.



Figure 21. Left, honey bees actively flying from their hive entrance in a sheoak trunk in March 2023 in the NSW Hunter Valley. Right, 6 months later, in October 2023, the same hive is dead from varroa mites. Photos: Rod Bourke, NSW DPIRD.

Once varroa was established in western Sydney, surveys indicated local feral hive numbers had been decimated. Research Apiculturist Michael Duncan has monitored 5 drone congregation areas around Western Sydney University's (WSU) Richmond campus for the past decade. A drone congregation area is where both male drone bees and female queen bees fly to mate when they are sexually mature. Surveys can capture drone bees representing hives from within a 44 km<sup>2</sup> area. The number of bees caught at the Richmond drone congregation areas between 2015 and 2025 has decreased dramatically since varroa established itself in the area (Table 4).

Table 4. Western Sydney University honey bee drone surveys indicate feral hive decline since varroa mite has established.

| Date            | Drone honey bees                                                                             |
|-----------------|----------------------------------------------------------------------------------------------|
| March 2015–2024 | 500+ drones caught at each of the 5 drone congregation areas on average.                     |
| March 2025      | 6 drones caught at 1 drone congregation area. 0 drones caught at 2 drone congregation areas. |

Duncan links the low drone numbers surveyed in 2025 to the decimation of feral hives in the immediate area due to varroa. Once a bee hive has varroa, it can never be completely eliminated from the hive, even with chemical treatment. Instead, beekeepers must monitor their mite thresholds and implement integrated pest management for varroa (Lees et al. 2025).

### Planning for reliable pollination: what can growers do?

While varroa management remains the responsibility of beekeepers, growers can take steps to support reliable pollination in their orchards. This is becoming increasingly important as feral honey bee populations decline and pollination services rely more heavily on managed hives.

For deciduous fruit growers, where crops can be highly dependent on honey bee pollination (Table 5), securing pollination services well ahead of flowering is critical. Winter is usually when growers arrange pollination contracts for the following season, and the availability of strong, well-managed colonies can have a significant influence on fruit set and yield.

Growers should aim to have an attractive orchard for high-calibre beekeepers and their well-managed colonies. Not every orchard is planned with the logistics of hive delivery in mind, which can contribute to poor pollination outcomes and workplace health and safety risks for both the beekeeper and orchard employees.

Table 5. Deciduous tree crops can be up to 100% reliant on honey bee pollination depending on the crop. Source: Gillespie et al. (2024).

| Crop                   | Reliance on honey bee pollination for yield (%) |
|------------------------|-------------------------------------------------|
| Apples                 | 100                                             |
| Apricots               | 70                                              |
| Cherries               | 90                                              |
| Peaches and nectarines | 60                                              |
| Pears                  | 75                                              |
| Persimmons             | 80                                              |
| Plums and prunes       | 70                                              |

Before bee hives are delivered to the orchard, some key points growers and beekeepers should agree on are:

- **Delivery and removal dates** – set by the grower for hive introduction and removal from the crop. Any re-negotiation of these dates, such as for pesticide application, should be done with as much notice as possible.
- **The strength of the hive** – the number of bees within the hive needed to pollinate the crop. This can vary by crop, but as an example, the starting grade for almond pollination is generally an average of 8 frames of bees per hive at 6–7 hives/hectare.
- **Shade** – in spring, shade early in the season will reduce bee pollination activity, which is related to temperature.
- **Slope** – it is preferable to place hives on flatter land for access and to prevent rain from pooling inside hives, which causes hive stress and health issues.
- **Ground cover** – it is preferable to mow the site before hives are delivered as tall plants can inhibit bee access to hives and pollen forager flights out of hives, which are essential for pollination.
- **Sufficient area to unload the hives** – a difficult site to access will be less attractive to beekeepers and adjacent trees could be unintentionally damaged during hive unloading if there is not enough room to work.
- **Water** – bees must have access to sufficient clean water. They will need it in cool months or drought times to soften stored honey, and in warmer months to help them maintain the temperature within the hive.



Figure 22. Beekeepers prefer to contract their hives into accessible, sunny deciduous fruit orchards where pesticide sprays are not applied while bees are on the farm.

Growers who have never contracted a beekeeper formally to pollinate their crop are advised to do so next season. Varroa mite is reducing feral, unmanaged honey bee hives, which previously provided free pollination services (When Bee Foundation 2026). It is high risk to rely on feral hives for pollination in the 2026–2027 season in states where varroa is established. Beekeeping industry associations, which represent commercial beekeepers in NSW, QLD, VIC, WA, SA, and TAS, can point growers toward beekeepers who provide pollination services. Their contact details can be found on the [Australian Honey Bee Industry Council website](http://www.honeybee.org.au/industry-hub/industry-contacts/) ([www.honeybee.org.au/industry-hub/industry-contacts/](http://www.honeybee.org.au/industry-hub/industry-contacts/)).

## More information

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Lees K, Page M, Frost E and Chapman N (2025) *A guide to varroa management*. National Varroa Mite Management Program, <https://static1.squarespace.com/static/66c40de13a8bf712315e2089/t/68e6edbd167ae374a6578155/1759964605569/A+Guide+to+Varroa+Management-ED1V1.pdf>

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When Bee Foundation (2026) *Pollination security status report 2026*. When Bee Foundation, <https://www.whenbeefoundation.org.au/our-work/research-projects/australian-pollination-strategy/pollination-security-status-report/>



# Climate summary 2025–26

Kim Broadfoot and Kel Langfield, Seasonal Conditions Coordinators, NSW DPIRD

Agronomic commentary: Jessica Fearnley-Pattison, Development Officer, NSW DPIRD

The climate analysis has been carried out for the 2025–26 season. The data are derived from ANUClimate 2.0. This dataset is quality-controlled, interpolated daily and monthly climatic elements throughout Australia from 1970 to the current year. It serves as an invaluable resource for understanding long-term climate patterns and their influence on agriculture. The data for NSW can be accessed through the [ANU Climate 2.0 portal](https://geonetwork.nci.org.au/geonetwork/srv/eng/catalog.search#/metadata/f2576_7854_4065_1457) ([https://geonetwork.nci.org.au/geonetwork/srv/eng/catalog.search#/metadata/f2576\\_7854\\_4065\\_1457](https://geonetwork.nci.org.au/geonetwork/srv/eng/catalog.search#/metadata/f2576_7854_4065_1457)).

These datasets provide a useful resource for strategic planning and management by offering insights into current seasonal conditions and the long-term climatic environment for production.

In the NSW temperate growing regions of Batlow, Young, Orange and Bilpin, crop development was delayed, but fruit was generally of good quality, and there was relatively low pest and disease pressure during the 2025–26 season.

The major challenge in all regions was water management, with hot and dry conditions during January (except Bilpin) placing pressure on irrigation supplies and increasing the risk of tree stress heading into next season.

## Batlow region

Minimum temperatures were near or above the long-term average (1981–2010) during the season (Figure 23). Maximum temperatures were below the long-term average during September to December 2025 and above average in 2026, except in April.

Below-average rain fell in all months except for February and March 2026, the latter having very high rainfall totals.

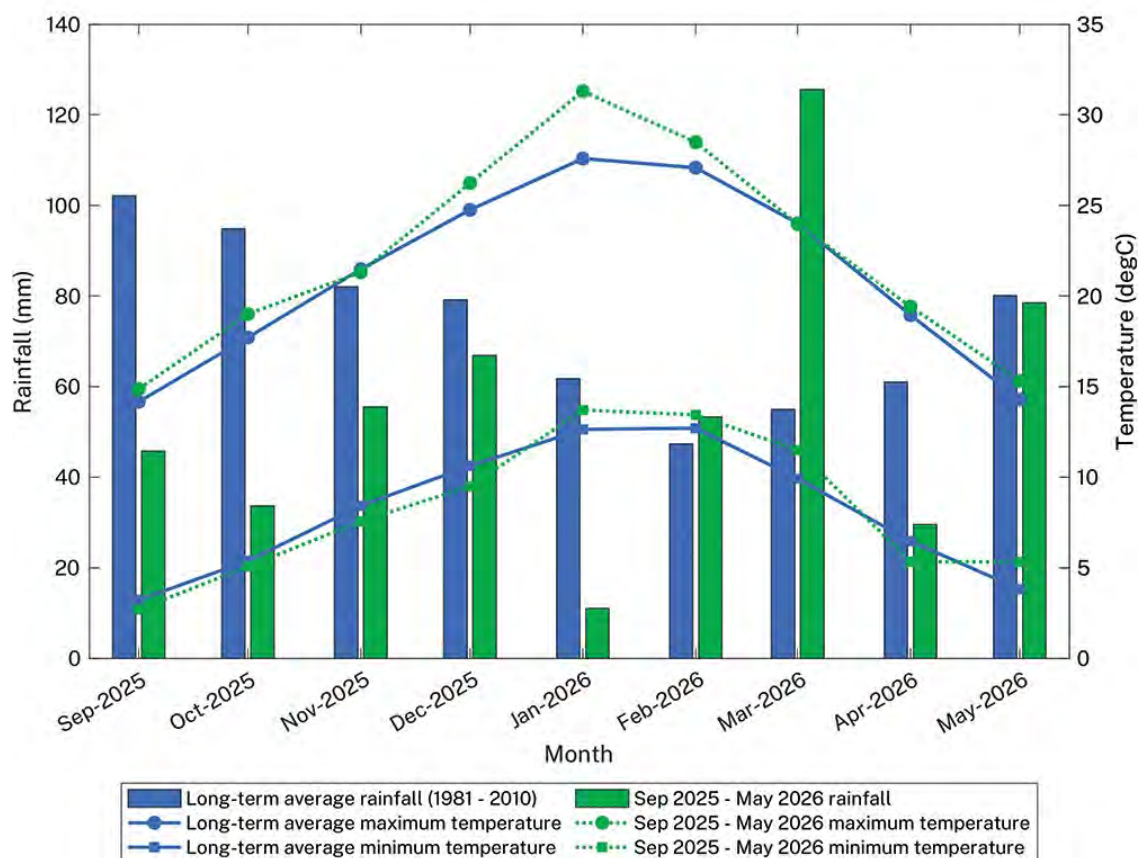


Figure 23. Climograph of the average monthly minimum and maximum temperatures, total monthly rainfall from September 2025 to May 2026, and long-term averages (1981–2010 baseline period) at Batlow. Source: ANUClimate, Australian National University.

Growers in Batlow reported good fruit set following lighter crops in several varieties during the previous season. Fruit development was generally 5–9 days later than usual, but crop potential was improved, particularly for growers targeting farm-gate and pick-your-own markets. Orchard observations indicated good fruit size and quality where crop loads were lighter, while western flower thrips required increased management attention this season.

Batlow apple growers reported a productive season with strong fruit quality, colour development and yields. Harvest conditions were generally favourable, although a hot period during January caused some minor sunburn. Labour shortages remained a major challenge throughout the district, particularly late in harvest as seasonal workers moved to warmer growing regions. Despite these challenges, growers described overall apple quality as better than in recent seasons, with good pack-outs.

## Bilpin region

Minimum temperatures were above the long-term average (1981–2010) in October 2025, and February, March and May 2026 (Figure 24). Maximum temperatures were above the long-term average for the whole season.

Below-average rain fell in all months except for January, February and May 2026.

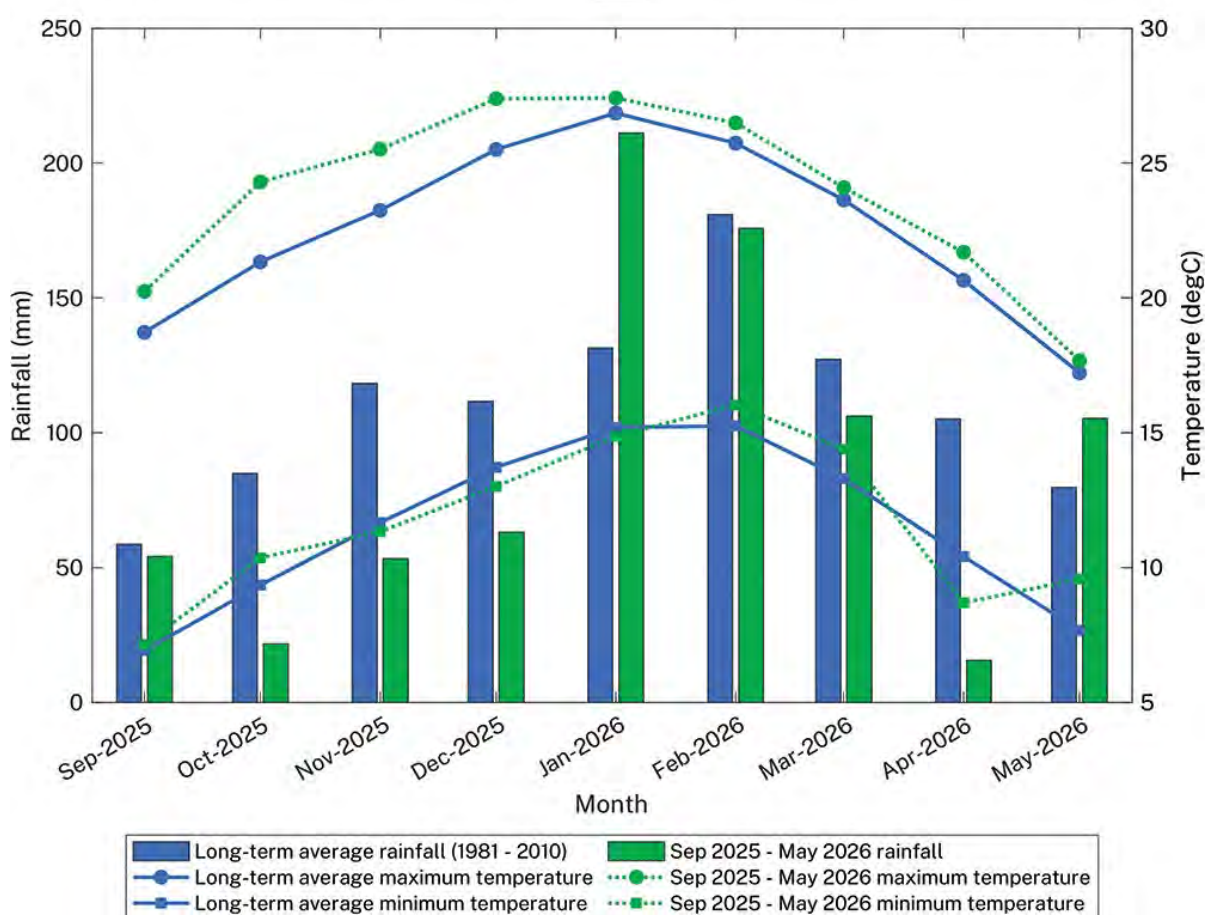


Figure 24. Climograph of the average monthly minimum and maximum temperatures, total monthly rainfall from September 2025 to May 2026, and long-term averages (1981–2010 baseline period) at Bilpin. Source: ANUClimate, Australian National University.

Conditions during spring and early summer were generally favourable for apple production in Bilpin. However, growers reported significantly lower fruit volumes in some orchards during the 2025 season, with concerns raised about the combined effects of weather during flowering, pollination challenges and broader environmental factors affecting fruit set. Despite lower crop loads, fruit quality was generally good, and growers focused on irrigation management during the hot, dry conditions in January. Maintaining adequate soil moisture was essential for fruit size and quality.

## Orange region

Minimum temperatures were near or above the long-term average (1981–2010) for most of the season except for November and December 2025, and April 2026 (Figure 25). Maximum temperatures were above the long-term average for the whole season.

Below-average rain fell in all months except for December 2025, and March and May 2026.

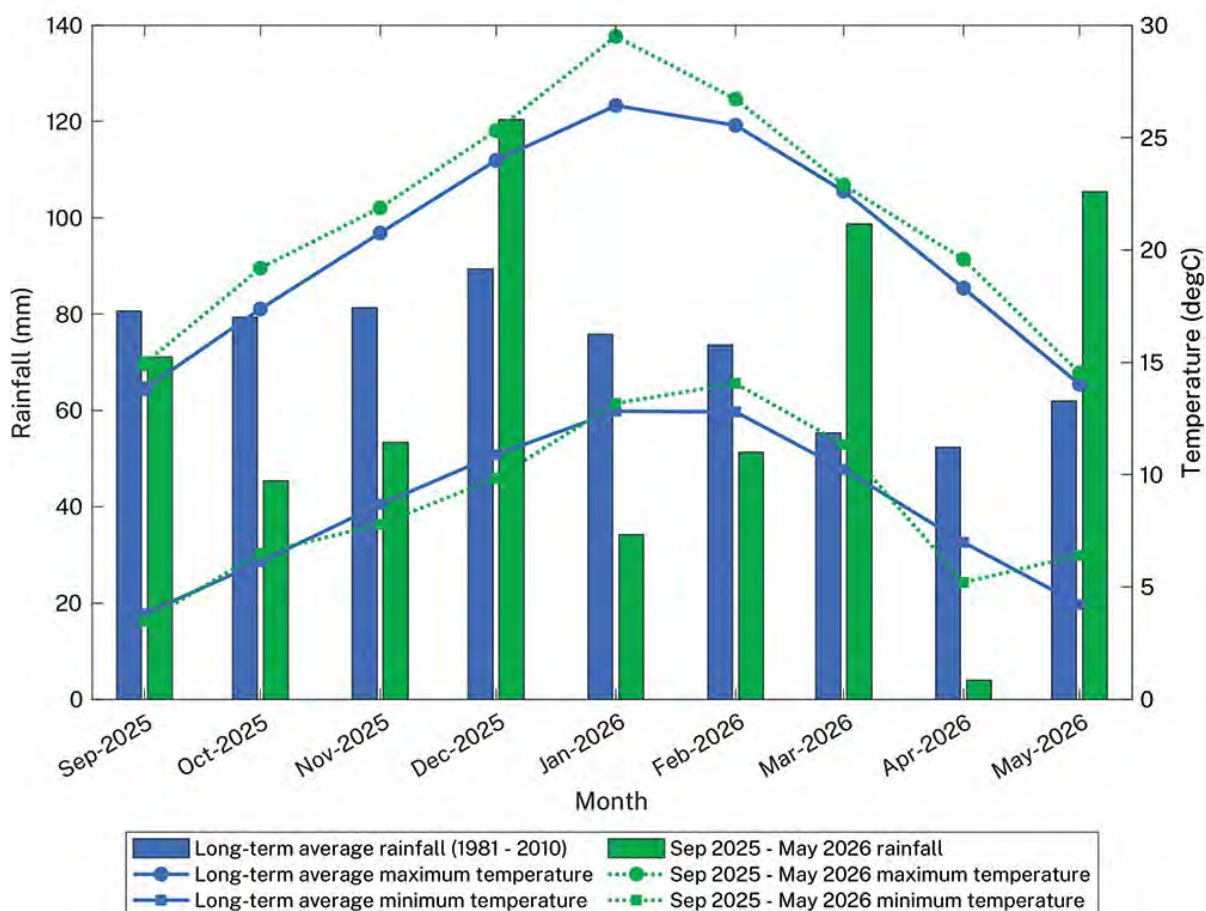


Figure 25. Climograph of the average monthly minimum and maximum temperatures, total monthly rainfall from September 2025 to May 2026, and long-term averages (1981–2010 baseline period) at Orange. Source: ANUClimate, Australian National University.

The season in Orange was later than average, with varieties maturing approximately 5–9 days behind the previous year. Spring rainfall was substantial, improving soil moisture reserves before harvest, although variable temperatures and windy conditions were common.

There were some severe wind and storms in December, which damaged some mid-season cherry blocks and contributed to rain cracking in susceptible varieties. Despite these challenges, rapid drying efforts using helicopters and spray carts enabled many growers to harvest a high-quality crop successfully before Christmas.

Fruit size and quality were generally good, while pest and disease activity remained lower than usual due to the relatively dry growing season. In January, hot and dry conditions increased water stress in orchards, highlighting the importance of maintaining irrigation to sustain tree recovery and bud development for the following season. Apple growers needed to ensure irrigation was applied to the blocks to maintain fruit size. Apples this season went for good prices, which was welcomed after the last few years.

## Young region

Minimum temperatures were near or below the long-term average (1981–2010) during the season, except for January, February, March and May 2026 (Figure 26). Maximum temperatures were near or above the long-term average most of the season.

Below-average rain fell in all months except for February, March and May 2026; the latter 2 had very high rainfall totals.

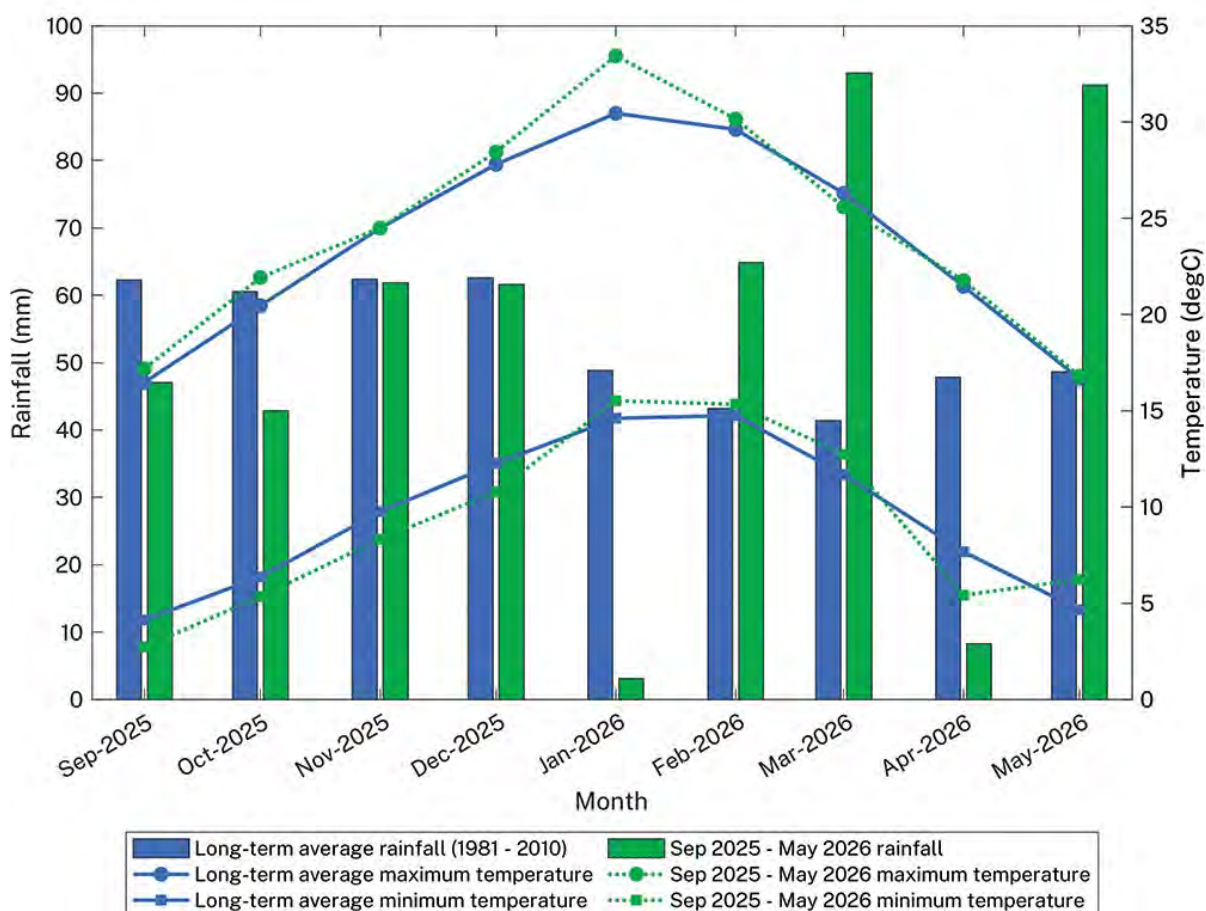


Figure 26. Climograph of the average monthly minimum and maximum temperatures, total monthly rainfall from September 2025 to May 2026, and long-term averages (1981–2010 baseline period) at Young. Source: ANUClimate, Australian National University.

Young had a delayed start to the season, with cherry varieties several days behind normal maturity. Spring conditions were generally mild to warm, with moderate rainfall helping fruit development, although wet weather reduced volumes of some early-season varieties. Harvest activity accelerated in subsequent weeks and overall fruit quality remained high. Rainfall and storms during harvest resulted in some rain cracking in susceptible varieties, but growers generally reported large fruit with excellent eating quality. By January, very hot and dry conditions increased tree stress and reduced water availability, making irrigation management critical to protect current tree health and next season's productivity. Pest and disease pressure remained relatively low and manageable due to the dry season.

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# Apple blossom development stages

Photos by Shane Hetherington, formerly NSW DPIRD.



Figure 27. Dormant.



Figure 28. Green tip.

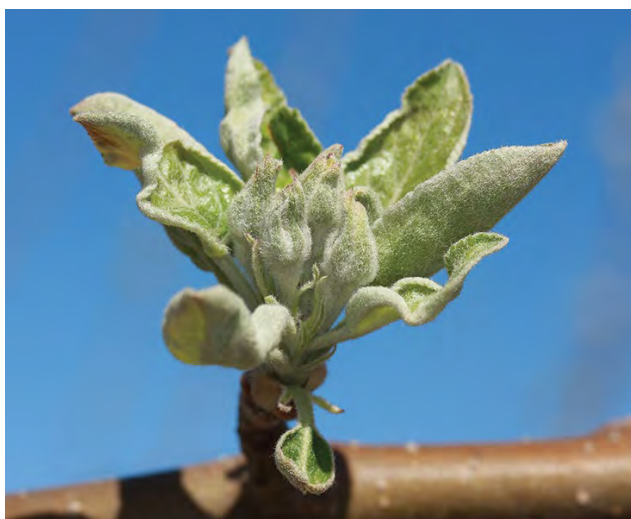


Figure 29. Spur burst.



Figure 30. Pink.



Figure 31. King bloom.



Figure 32. Full bloom.



# Stone fruit blossom development stages

Photos by Shane Hetherington, formerly NSW DPIRD.



Figure 33. Dormant.



Figure 34. Bud swell.



Figure 35. Bud break.



Figure 36. Full bloom.



Figure 37. Petal fall.



Figure 38. Shuck fall.



# Persimmon development stages

Photos from García-Carbonell S, Yagüe B, Bleiholder H, Hack H, Meier U and Agustí M (2002) [Phenological growth stages of the persimmon tree \(\*Diospyros kaki\*\). Annals of Applied Biology, 141: 73–76, <https://onlinelibrary.wiley.com/doi/10.1111/j.1744-7348.2002.tb00197.x>](https://onlinelibrary.wiley.com/doi/10.1111/j.1744-7348.2002.tb00197.x)

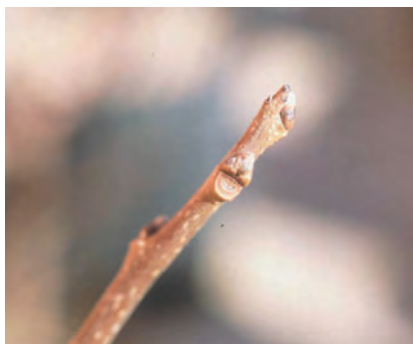


Figure 39. Late dormancy.

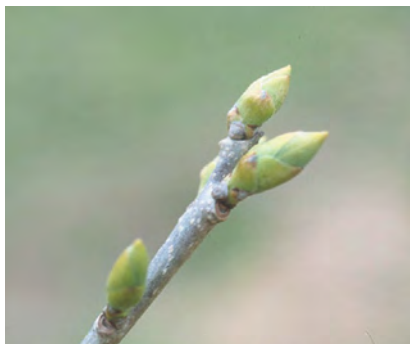


Figure 40. Green leaf tips.



Figure 41. First leaves unfolded.



Figure 42. Flower bud develops on new growth.



Figure 43. Flower sepals begin to separate.



Figure 44. Full flowering (50% open).



Figure 45. Flowers fading.

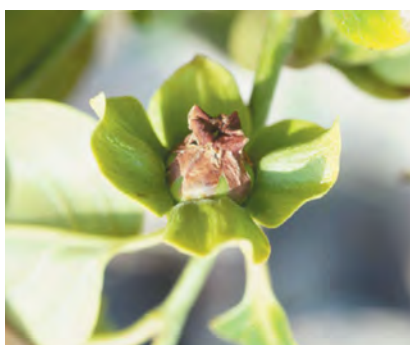


Figure 46. Fruit set, petals browning.

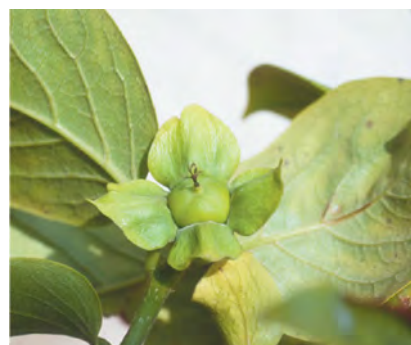


Figure 47. Early fruit development.



Figure 48. Late fruit development.



Figure 49. Start of fruit colouration.



Figure 50. Fruit ripe.



# Orchard pests and diseases

## Pests

Table 6. Key pests affecting pome fruit, stone fruit and persimmons in NSW.

| Common name                             | Scientific name                                        | Which crops are primarily affected?                                               |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     | Where to look |
|-----------------------------------------|--------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------|
|                                         |                                                        | Apples                                                                            | Pears                                                                             | Apricots                                                                          | Cherries                                                                          | Peaches/<br>nectarines                                                              | Plums/<br>prunes                                                                    | Persimmons                                                                          |               |
|                                         |                                                        |  |  |  |  |  |  |  |               |
| Apple dimpling bug                      | <i>Campylomma liebkechti</i>                           | ✓                                                                                 | ✗                                                                                 | ✗                                                                                 | ✗                                                                                 | ✗                                                                                   | ✗                                                                                   | ✗                                                                                   | page 42       |
| Apple leafhopper                        | <i>Edwardsiana froggatti</i>                           | ✓                                                                                 | ✓                                                                                 | ✗                                                                                 | ✗                                                                                 | ✗                                                                                   | ✗                                                                                   | ✗                                                                                   | page 44       |
| Australian plague locust                | <i>Chortoicetes terminifera</i>                        | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✓                                                                                   | page 45       |
| Black peach aphid and green peach aphid | <i>Brachycaudus persicae</i> and <i>Myzus persicae</i> | ✗                                                                                 | ✗                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✗                                                                                   | page 46       |
| Bryobia mite                            | <i>Bryobia rubrioculus</i>                             | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✗                                                                                   | page 48       |
| Budworms ( <i>Heliothis</i> )           | <i>Helicoverpa</i> species                             | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✗                                                                                   | page 50       |
| Carpophilus beetle (dried fruit beetle) | <i>Carpophilus</i> species                             | ✗                                                                                 | ✗                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✗                                                                                   | page 52       |
| Cherry aphid                            | <i>Myzus cerasi</i>                                    | ✗                                                                                 | ✗                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✗                                                                                   | page 54       |
| Clearwing borer                         | <i>Ichneumenoptera chrysophanes</i>                    | ✗                                                                                 | ✗                                                                                 | ✗                                                                                 | ✗                                                                                 | ✗                                                                                   | ✗                                                                                   | ✓                                                                                   | page 56       |
| Codling moth                            | <i>Cydia pomonella</i>                                 | ✓                                                                                 | ✓                                                                                 | ✗                                                                                 | ✗                                                                                 | ✗                                                                                   | ✗                                                                                   | ✗                                                                                   | page 58       |
| European earwig                         | <i>Forficula auricularia</i>                           | ✗                                                                                 | ✗                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✗                                                                                   | page 61       |
| European red mite                       | <i>Panonychus ulmi</i>                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✗                                                                                   | page 63       |
| Fruit tree borer                        | <i>Maroga melanostigma</i>                             | ✗                                                                                 | ✗                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✗                                                                                   | page 66       |
| Harlequin bug                           | <i>Dindymus versicolor</i>                             | ✓                                                                                 | ✗                                                                                 | ✗                                                                                 | ✗                                                                                 | ✗                                                                                   | ✗                                                                                   | ✗                                                                                   | page 67       |
| Light brown apple moth                  | <i>Epiphyas postvittana</i>                            | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✓                                                                                   | page 70       |
| Loopers including green loopers         | Various species                                        | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                 | ✓                                                                                   | ✓                                                                                   | ✓                                                                                   | page 73       |

## Pests continued

Table 6. Key pests affecting pome fruit, stone fruit and persimmons in NSW, page 2 of 2.

| Common name                    | Scientific name                   | Which crops are primarily affected?                                                         |                                                                                            |                                                                                               |                                                                                               |                                                                                                           |                                                                                                     |                                                                                                   | Where to look |
|--------------------------------|-----------------------------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|---------------|
|                                |                                   | Apples<br> | Pears<br> | Apricots<br> | Cherries<br> | Peaches/nectarines<br> | Plums/prunes<br> | Persimmons<br> |               |
| Mealybugs                      | Various species                   | ✓                                                                                           | ✓                                                                                          | ✗                                                                                             | ✗                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✓                                                                                                 | page 74       |
| Oriental fruit moth            | <i>Grapholita molesta</i>         | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 76       |
| Pear and cherry slug           | <i>Caliroa cerasi</i>             | ✗                                                                                           | ✓                                                                                          | ✗                                                                                             | ✓                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✗                                                                                                 | page 79       |
| Pear leaf blister mite         | <i>Eriophyes pyri</i>             | ✗                                                                                           | ✓                                                                                          | ✗                                                                                             | ✗                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✗                                                                                                 | page 80       |
| Queensland fruit fly           | <i>Bactrocera tryoni</i>          | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✓                                                                                                 | page 81       |
| Rutherglen bug                 | <i>Nysius vinitor</i>             | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 89       |
| San José scale                 | <i>Diaspidiotus perniciosus</i>   | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 90       |
| Thrips – plague thrips         | <i>Thrips imaginis</i>            | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 95       |
| Thrips – western flower thrips | <i>Frankliniella occidentalis</i> | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✓                                                                                                 | page 97       |
| Thrips – onion thrips          | <i>Thrips tabaci</i>              | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✓                                                                                                 | page 99       |
| Two-spotted mite               | <i>Tetranychus urticae</i>        | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 100      |
| Weevils                        | Various species                   | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 103      |
| Wingless grasshoppers          | <i>Phaulacridium vittatum</i>     | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 105      |
| Woolly apple aphid             | <i>Eriosoma lanigerum</i>         | ✓                                                                                           | ✓                                                                                          | ✗                                                                                             | ✗                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✗                                                                                                 | page 106      |

## Diseases

Table 7. Key diseases affecting pome fruit, stone fruit and persimmons in NSW.

| Common name                           | Scientific name                                                                | Which crops are primarily affected?                                                         |                                                                                            |                                                                                               |                                                                                               |                                                                                                           |                                                                                                     |                                                                                                   | Where to look |
|---------------------------------------|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|---------------|
|                                       |                                                                                | Apples<br> | Pears<br> | Apricots<br> | Cherries<br> | Peaches/nectarines<br> | Plums/prunes<br> | Persimmons<br> |               |
| Alternaria leaf blotch and fruit spot | <i>Alternaria</i> species                                                      | ✓                                                                                           | ✗                                                                                          | ✗                                                                                             | ✗                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✗                                                                                                 | page 112      |
| Angular leaf spot                     | <i>Cercospora</i> species and <i>Pseudocercospora</i> species                  | ✗                                                                                           | ✗                                                                                          | ✗                                                                                             | ✗                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✓                                                                                                 | page 114      |
| Apple scab and pear scab              | <i>Venturia inaequalis</i> and <i>Venturia pirina</i>                          | ✓                                                                                           | ✓                                                                                          | ✗                                                                                             | ✗                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✗                                                                                                 | page 116      |
| Bacterial canker                      | <i>Pseudomonas syringae</i> pv. <i>syringae</i>                                | ✗                                                                                           | ✗                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 120      |
| Bacterial spot                        | <i>Xanthomonas arboricola</i> pv. <i>pruni</i>                                 | ✗                                                                                           | ✗                                                                                          | ✓                                                                                             | ✗                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 122      |
| Bitter rot                            | <i>Glomerella cingulata</i> (anamorph: <i>Colletotrichum gloeosporioides</i> ) | ✓                                                                                           | ✓                                                                                          | ✗                                                                                             | ✗                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✗                                                                                                 | page 123      |
| Blossom blight and brown rot          | <i>Monilinia</i> species                                                       | ✗                                                                                           | ✗                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 124      |
| Circular leaf spot                    | <i>Mycosphaerella</i> species                                                  | ✗                                                                                           | ✗                                                                                          | ✗                                                                                             | ✗                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✓                                                                                                 | page 127      |
| Crown gall                            | <i>Agrobacterium tumefaciens</i>                                               | ✗                                                                                           | ✗                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 128      |
| Peach leaf curl                       | <i>Taphrina deformans</i>                                                      | ✗                                                                                           | ✗                                                                                          | ✗                                                                                             | ✗                                                                                             | ✓                                                                                                         | ✗                                                                                                   | ✗                                                                                                 | page 129      |
| Phytophthora root and collar rot      | <i>Phytophthora</i> species                                                    | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 131      |
| Powdery mildew                        | <i>Podosphaera leucotricha</i>                                                 | ✓                                                                                           | ✓                                                                                          | ✗                                                                                             | ✗                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✗                                                                                                 | page 133      |
| Rust                                  | <i>Tranzschelia discolor</i>                                                   | ✗                                                                                           | ✗                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 135      |
| Shot hole                             | <i>Stigmina carpophila</i>                                                     | ✗                                                                                           | ✗                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 137      |
| Silver leaf                           | <i>Chondrostereum purpureum</i>                                                | ✓                                                                                           | ✗                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✗                                                                                                 | page 139      |
| Sooty blotch                          | <i>Gloeodes pomigena</i>                                                       | ✓                                                                                           | ✓                                                                                          | ✗                                                                                             | ✗                                                                                             | ✗                                                                                                         | ✗                                                                                                   | ✗                                                                                                 | page 140      |
| Sooty mould                           | Various species                                                                | ✓                                                                                           | ✓                                                                                          | ✓                                                                                             | ✓                                                                                             | ✓                                                                                                         | ✓                                                                                                   | ✓                                                                                                 | page 141      |

Table 8. The peak risk periods for pests in apple orchards.

| Pest                                    | Bud swell/green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy | Page number |
|-----------------------------------------|---------------------|-------|------------|---------|-------------|----------|-------------|
| Apple dimpling bug                      |                     |       |            |         |             |          | page 42     |
| Apple leafhopper                        |                     |       |            |         |             |          | page 44     |
| Australian plague locust                |                     |       |            |         |             |          | page 45     |
| Black peach aphid and green peach aphid |                     |       |            |         |             |          | page 46     |
| Bryobia mite                            |                     |       |            |         |             |          | page 48     |
| Budworms                                |                     |       |            |         |             |          | page 50     |
| Carpophilus beetle                      |                     |       |            |         |             |          | page 52     |
| Cherry aphid                            |                     |       |            |         |             |          | page 54     |
| Codling moth                            |                     |       |            |         |             |          | page 58     |
| European earwig                         |                     |       |            |         |             |          | page 61     |
| European red mite                       |                     |       |            |         |             |          | page 63     |
| Fruit tree borer                        |                     |       |            |         |             |          | page 66     |
| Harlequin bug                           |                     |       |            |         |             |          | page 67     |
| Light brown apple moth                  |                     |       |            |         |             |          | page 70     |
| Loopers                                 |                     |       |            |         |             |          | page 73     |
| Mealybugs                               |                     |       |            |         |             |          | page 74     |
| Oriental fruit moth                     |                     |       |            |         |             |          | page 76     |
| Pear and cherry slug                    |                     |       |            |         |             |          | page 79     |
| Pear leaf blister mite                  |                     |       |            |         |             |          | page 80     |
| Queensland fruit fly                    |                     |       |            |         |             |          | page 81     |
| Rutherglen bug                          |                     |       |            |         |             |          | page 89     |
| San José scale                          |                     |       |            |         |             |          | page 90     |
| Thrips – plague thrips                  |                     |       |            |         |             |          | page 95     |
| Thrips – western flower thrips          |                     |       |            |         |             |          | page 97     |
| Thrips – onion thrips                   |                     |       |            |         |             |          | page 99     |
| Two-spotted mite                        |                     |       |            |         |             |          | page 100    |
| Weevils                                 |                     |       |            |         |             |          | page 103    |
| Wingless grasshoppers                   |                     |       |            |         |             |          | page 105    |
| Woolly apple aphid                      |                     |       |            |         |             |          | page 106    |

Table 9. The peak risk periods for diseases in apple orchards.

| Pest                                  | Bud swell/green tip | Bloom | Mid season        | Harvest             | Postharvest | Dormancy | Page number |
|---------------------------------------|---------------------|-------|-------------------|---------------------|-------------|----------|-------------|
| Alternaria leaf blotch and fruit spot |                     |       |                   |                     |             |          | page 112    |
| Apple scab and pear scab              |                     |       | Primary infection | Secondary infection |             |          | page 116    |
| Bacterial canker                      |                     |       |                   |                     |             |          | page 120    |
| Bacterial spot                        |                     |       |                   |                     |             |          | page 122    |
| Bitter rot                            |                     |       |                   |                     |             |          | page 123    |
| Blossom blight and brown rot          |                     |       |                   | Brown rot           |             |          | page 124    |
| Crown gall                            |                     |       |                   |                     |             |          | page 128    |
| Peach leaf curl                       |                     |       |                   |                     |             |          | page 129    |
| Phytophthora root and collar rot      |                     |       |                   |                     |             |          | page 131    |
| Powdery mildew                        |                     |       |                   |                     |             |          | page 133    |
| Rust                                  |                     |       |                   |                     |             |          | page 135    |
| Shot hole                             |                     |       |                   |                     |             |          | page 137    |
| Silver leaf                           |                     |       |                   |                     |             |          | page 139    |
| Sooty blotch                          |                     |       |                   |                     |             |          | page 140    |
| Sooty mould                           |                     |       |                   |                     |             |          | page 141    |

Table 10. The peak risk periods for pests and diseases in persimmon orchards.

| Pest               | Bud swell/green tip | Shoot extension | Flowering and fruit development | Harvest | Postharvest | Dormancy | Page number |
|--------------------|---------------------|-----------------|---------------------------------|---------|-------------|----------|-------------|
| Clearwing borer    |                     |                 |                                 |         |             |          | page 56     |
| Angular leaf spot  |                     |                 |                                 |         |             |          | page 114    |
| Circular leaf spot |                     |                 |                                 |         |             |          | page 127    |



# Pests

## Apple dimpling bug



*Campylomma liebknehti*

Commonly known as the apple dimpling bug (ADB) on mainland Australia, *Campylomma liebknehti* is primarily a pest of apples. It is a small sap-feeding insect that damages young fruitlets, causing dimples and deformities that can significantly reduce marketable yield.

### Risk period

Table 11. The peak risk period for apple dimpling bug.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

### Pest identification

Adult ADBs are greenish-brown and about 3 mm long. They have spiny legs, shield-shaped wing covers and dark bands at the base of the antennae (Figure 51).

### Damage

Apple dimpling bugs feed by inserting their needle-like sucking mouthpart (proboscis) into the developing ovary of the flower or fruitlet and sucking the sap. The scarring at the feeding site fails to grow as the surrounding flesh expands, resulting in a typical dimple (Figure 52), reducing the fruit's saleability.



Figure 51. Apple dimpling bug adult.



Figure 52. Dimpling on an apple caused by apple dimpling bug feeding during bloom.

### Monitoring

The main risk period for ADB is between early pink and petal fall. The danger is increased if fruit tree flowering coincides with, or immediately follows, the flowering of native trees in the surrounding bush, especially tree lucerne (Figure 53), wattle (Figure 54) and Geraldton wax. Monitoring ADB activity in these species in the lead-up to apple flowering can indicate the likely level of seasonal risk.

Monitor ADB numbers at least twice weekly from late spur burst through to complete petal fall by tapping bud and flower clusters over a 4 L white ice cream container (or equivalent). The bugs are very active so the container needs to be inspected quickly to see the bugs before they escape. For most of the risk period (until 100% petal fall), the potential for significant ADB damage is high, even if bugs are present in only low numbers (i.e. 2 to 5 bugs per 250 flower clusters). Be aware that population numbers can quickly escalate to significant levels with weather changes. Experience has shown that ADB numbers often increase following the arrival of warm, northerly winds.



Figure 53. Tree lucerne is an apple dimpling bug host.

## Management

**Cultural and physical:** maintain vigilance on blocks or rows that neighbour native trees and shrubs. Consider removing nearby host species, particularly lucerne and wattle trees.

Hand-thinning for crop load from late November to early December is a good opportunity to remove any apples with signs of dimpling damage. Some damaged fruit will drop naturally between petal fall and harvest.

**Biological:** there are no known biological control agents for ADB. Interestingly, after complete petal fall, ADB might actually be a beneficial insect in the orchard, feeding on *Helicoverpa* spp. moth eggs and pest mites.

**Chemical:** the chemical options for controlling apple dimpling bug are listed in [Table 12](#).

Table 12. Registered or permitted products for apple dimpling bug in NSW.

| Active constituent (example trade name) | Insecticide group(s) | WHP <sup>1</sup> (days)            | Effect on beneficials | Registered for use in... <sup>2</sup> |
|-----------------------------------------|----------------------|------------------------------------|-----------------------|---------------------------------------|
| Acetamiprid + novaluron (Cormoran®)     | 4A + 15              | 70                                 | Medium                | Apples                                |
| Bifenthrin (Talstar® 80 SC)             | 3A                   | 0                                  | High                  | Apples                                |
| Sulfoxaflor (Transform® Isoclast™)      | 4C                   | 7                                  | Medium                | Pome fruit, stone fruit               |
| Tau-fluvalinate (Mavrik® Aquaflow)      | 3A                   | Not required when used as directed | High                  | Apples                                |
| Thiacloprid (Cobra® 480SC)              | 4A                   | 21                                 | Medium                | Apples                                |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.



Figure 54. Wattle is an apple dimpling bug host.

# Apple leafhopper

*Edwardsiana froggatti*



The apple leafhopper is an occasional pest in commercial apple and pear orchards. Infestation tends to be worse during dry years and in orchards where few insecticides are used, such as in organic systems.

## Risk period

Table 13. The peak risk period for apple leafhopper.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Adult apple leafhoppers are 3–4 mm long and are pale to bright yellow (Figure 55). Nymphs are small, wingless and whitish-green. They are usually found on the underside of older leaves.

## Damage

Apple leafhoppers can cause leaf distortion and mottling (Figure 56). If the infestation is severe, apple leafhoppers can cause premature leaf drop.



Figure 55. Apple leafhopper adult.



Figure 56. Apple leafhopper feeding damage.  
Photo: Whitney Cranshaw, Colorado State University, Bugwood.org.

## Monitoring

Monitor for apple leafhopper if the weather forecast is for a dry season or if the insect was a problem in previous seasons.

## Management

**Cultural and physical:** good orchard weed management will help reduce the potential for apple leafhopper infestations.

**Biological:** the introduced parasitoid, *Anagrus armatus*, has been effective as a biocontrol agent for apple leafhopper in Tasmania. However, its status on mainland Australia is unknown.

**Chemical:** the chemical option for controlling apple leafhopper is listed in Table 14.

Table 14. Registered or permitted product for apple leafhopper in NSW.

| Active constituent<br>(example trade name) | Insecticide group | WHP <sup>1</sup> (days) | Effect on beneficials | Registered for use in... <sup>2</sup> |
|--------------------------------------------|-------------------|-------------------------|-----------------------|---------------------------------------|
| Malathion (Fyfanon® 440 EW)                | 1B                | 3                       | High                  | Apples, pears                         |
| Thiacloprid (Cobra® 480SC)                 | 4A                | 21                      | Medium                | Apples                                |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Australian plague locust



## *Chortoicetes terminifera*

Australian plague locusts usually prefer to feed on grasses and cereal crops such as wheat. However, they will attack a wide range of plants including horticulture crops. When locusts are present in large swarms, all crops are at risk.

## Risk period

Table 15. The peak risk period for the Australian plague locust.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Australian plague locusts can be green or brown (Figure 57), have a dark spot on the end of their wings and a dark 'X' mark on top of their thorax. When numbers are high, Australian plague locusts will form swarms.



Figure 57. Australian plague locust adult.

## Damage

Australian plague locust swarms can severely damage crops; a large swarm can cause up to 100% crop loss. Often the swarm will land overnight, and by morning, the entire crop will be eaten. In orchards, the foliage will receive more damage than the fruit as the locusts will feed on green material first.

## Monitoring

Australian plague locusts usually begin hatching in late August and early September and will be flying by November. Both the hopper stage and the flying adult locusts feed on green plant material. Monitoring paddocks adjacent to orchard areas for hopper emergence and observing trees for infestation and/or damage will give early indications of Australian plague locust activity.

Any locust activity must be reported as soon as possible. A toll-free call to the Australian Plague Locust Commission hotline can be made on 1800 635 962.

## Management

**Cultural and physical:** Australian plague locust eggs can be reduced by cultivating egg beds, but this is generally ineffective in orchards as the locust swarms are transient. Management should focus on regular monitoring and applying sprays when locusts are in a concentrated band.

**Chemical:** the chemical option for controlling the Australian plague locust is listed in Table 16. There are no registered or permitted products to control this pest in persimmons.

Table 16. Registered product for the Australian plague locust in NSW.

| Active constituent<br>(example trade name)     | Insecticide<br>group | WHP <sup>1</sup> (days) | Effect on<br>beneficials | Registered for use in... <sup>2</sup>                    |
|------------------------------------------------|----------------------|-------------------------|--------------------------|----------------------------------------------------------|
| Alpha-cypermethrin (PER10927, expires 30.6.30) | 3A                   | 14                      | High                     | Pome fruit, apricots, nectarines, peaches, plums, prunes |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Black peach aphid and green peach aphid



*Brachycaudus persicae* and *Myzus persicae*

Aphids can be significant pests of stone fruit, attacking leaves and shoots, reducing crop potential and causing fruit quality issues.

## Risk period

Table 17. The peak risk period for black peach aphids and green peach aphids.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Adult black peach aphids (BPA) can be winged or wingless, are shiny, black and about 2 mm long. Nymphs are reddish-brown (Figure 58).

Green peach aphid (GPA) nymphs are pale yellowish-green and have 3 dark lines on the back of the abdomen. Mature aphids are pale green or pinkish and about 2 mm long (Figure 59).

## Damage

GPA is a particular concern because of its role in transmitting plant viruses. Aphid infestation can cause leaf and shoot tip distortion. Aphids feed on the leaves, extracting sap and causing leaves to turn yellow and drop. Honeydew produced by a heavy infestation during the growing season can result in sooty mould developing on the tree and fruit.

## Monitoring

Check leaves and new growth for BPA and GPA infestation weekly from bud swell to ripening. Aphid numbers can increase quickly, making regular inspections important.



Figure 58. Various life stages of the black peach aphid. Source: adapted from Zeck (1965).



Figure 59. Wingless adult female and nymph stage green peach aphids.

## Management

**Cultural and physical:** avoid excessive amounts of nitrogen fertilisers as these promote soft plant tissue growth that is favoured by aphids. Prune out water shoots and control weeds around the orchard as these can act as a reservoir for migrating aphids.

**Biological:** natural biological predators of the aphids include lacewings (Figure 60) and lady beetles. The activity and efficiency of biological control agents will be influenced by the absence of insecticides that are likely to be toxic to them. To maximise the effect of beneficial insects, avoid using broad-spectrum insecticides, particularly in spring and summer. In cool growing regions, GPA can overwinter as eggs around the buds. In the lead-up to bud burst, eggs and newly hatched nymphs are susceptible to oil sprays applied to control San José scale (page 90).

**Chemical:** in Australia, green peach aphid populations have developed high levels of resistance to synthetic pyrethroids and carbamates, and low-level resistance to organophosphates, neonicotinoids, sulfoxaflor, and recently spirotetramat.

CroLife Australia provides an [online insecticide resistance management](https://www.croplife.org.au/resources/programs/resistance-management/insecticide-resistance-management-strategies/) (IRM) plan to help preserve insecticide efficacy. (<https://www.croplife.org.au/resources/programs/resistance-management/insecticide-resistance-management-strategies/>).

The chemical options for controlling BPA and GPA are in Table 18.



Figure 60. Lacewing larvae are important natural predators of aphids.

Table 18. Registered or permitted products for black peach aphids (BPA) and green peach aphids (GPA) in NSW.

| Active constituent (example trade name) | Insecticide group(s) | WHP <sup>1</sup> (days) | Effect on beneficials | Registered for use in... <sup>2</sup> |
|-----------------------------------------|----------------------|-------------------------|-----------------------|---------------------------------------|
| Acetamiprid + novaluron (Cormoran®)     | 4A + 15              | 7                       | Medium                | Stone fruit, BPA and GPA              |
| Clothianidin (Samurai®)                 | 4A                   | 7                       | High                  | Peaches and nectarines, GPA only      |
| Imidacloprid (Confidant 200SC)          | 4A                   | 21                      | Medium                | Stone fruit                           |
| Malathion (Fyfanon® 440 EW)             | 1B                   | 3                       | High                  | Stone fruit, BPA and GPA              |
| Methomyl (Methomyl 225)                 | 1A                   | 1                       | High                  | Stone fruit, GPA only                 |
| Pymetrozine (Chess®)                    | 9B                   | 28                      | Low                   | Stone fruit, BPA and GPA              |
| Spirotetramat (Movento® 240 SC)         | 23                   | 21                      | Medium                | Stone fruit, BPA only                 |
| Sulfoxaflor (Transform® Isoclast™)      | 4C                   | 7                       | Medium                | Stone fruit, BPA and GPA              |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

Note: in addition to the above chemicals, the active constituent thiacloprid (e.g. Cobra® 480SC), although not registered for controlling GPA, the product label does claim that when used as directed for oriental fruit moth control, sprays for GPA will not be required.

# Bryobia mite

## *Bryobia rubrioculus*



Bryobia mites feed on fruit tree leaves by puncturing the leaf tissue with their sucking mouthparts. Bryobia mites have become more prevalent in recent years as integrated pest and disease management programs have moved away from broad-spectrum chemicals. Therefore, growers need to regularly monitor their crops to identify the incidence of these pests early.

## Risk period

Table 19. The peak risk period for bryobia mite.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Adult mites are broad and flat, approximately 0.5 mm long and deep reddish-brown. Their front legs are as long as their body (Figure 61). They are often seen pressed flat against the leaf surface or as masses of red eggs on branches and stems (Figure 62). Without a microscope or a good hand lens, bryobia mite can be confused with European red mite.

## Damage

Bryobia mites damage the leaves by sucking sap, generally feeding on the upper surface. Damage from this feeding will appear as whitish-grey spots, giving the leaf a stippled appearance. Heavily infested leaves will become pale and can prematurely fall, but fruit growth is rarely affected.

There are several ways to quantify the risk posed by mite populations, including counts, presence or absence, percentage of leaves infested and cumulative leaf-infested days (CLIDs). Your local IPM consultant should be able to assist with more advice on applying these methods in your orchard.

## Monitoring

Monitor for bryobia mites fortnightly from late spring to the end of summer. More frequent monitoring might be needed if conditions are hot and dry as this accelerates pest development. Inspecting leaves throughout the orchard using a hand lens can be a good way to detect early mite activity. Collect leaf samples and inspect them using a microscope to determine the number of eggs, active mites, predatory mites and other beneficial insects present. Commercial mite monitoring services exist in some growing regions.



Figure 61. Bryobia mite adult.



Figure 62. Bryobia mite eggs are laid in large groups on branches and stems. Photo: Whitney Cranshaw, Colorado State University, Bugwood.org.

## Management

**Cultural and physical:** a dusty environment will favour pest mite activity. If weather conditions are hot and dry, orchard traffic should be limited and operators should drive slowly to limit the dust on trees. Maintaining green ground cover can reduce dust while also providing an attractive alternative habitat for beneficial predatory insects. Take particular care to control tall or climbing weeds that provide a bridge between other mite hosts and trees.

**Biological:** bryobia mites can be controlled by predatory mites including *Galendromus pyri*. Other naturally occurring biological control agents of pest mites include lacewings and *Stethorus* spp. beetles. Careful selection of IPM-friendly insecticides and fungicides will help to encourage predatory mites and other beneficials. Consult your chemical supplier for the least disruptive options.

**Chemical:** an effective chemical control program (Table 20) for pest mites usually includes a winter (dormant) or early spring (bud swell, green-tip) oil spray to control overwintering eggs, followed by targeted miticide application(s) during the growing season as determined by monitoring.

Table 20. Registered or permitted products for bryobia mite in NSW.

| Active constituent (example trade name)             | Insecticide group(s)             | WHP <sup>1</sup> (days)                 | Effect on beneficials | Registered for use in... <sup>2</sup>                                                            |
|-----------------------------------------------------|----------------------------------|-----------------------------------------|-----------------------|--------------------------------------------------------------------------------------------------|
| Bifenazate (Acramite®)                              | 20D                              | Apples, pears 7                         | Low                   | Apples, pears                                                                                    |
| Clofentezine (Apollo®)                              | 10A                              | 21                                      | Low                   | Pome fruit, stone fruit                                                                          |
| Cyflumetofen (Danisaraba®)                          | 25A                              | 7                                       | Low                   | Pome fruit                                                                                       |
| Etoxazole (Paramite®)                               | 10B                              | 7                                       | High                  | Pome fruit, stone fruit except cherries                                                          |
| Fenbutatin oxide (Talk Miticide)                    | 12B                              | Apples, pears 2; peaches, nectarines 14 | Low                   | Apples, pears, peaches, nectarines                                                               |
| Horticultural mineral oil (various)                 | Paraffinic oil and petroleum oil | 1                                       | Low                   | Pome fruit, stone fruit                                                                          |
| Sulfur as polysulfide sulfur (Grochem Lime Sulphur) | M2                               | Not required when used as directed      | Medium                | Pears, apricots, nectarines, peaches, plums, prunes; stone fruit dormant to bud swell spray only |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Budworms



## *Helicoverpa* species

*Helicoverpa* species (previously known as *Heliothis* and commonly known as budworms) are becoming more common in all Australian growing regions. The cotton bollworm, *Helicoverpa armigera*, and the native budworm, *Helicoverpa punctigera*, are the main insect pests of many agricultural and horticultural crops in Australia. The moth larvae can cause extensive feeding damage and create entry points for secondary pests and diseases.

## Risk period

Table 21. The peak risk period for budworms.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

*Helicoverpa* spp. larvae are cream with dark-brown heads. As they mature, the larvae will become darker and develop stripes running along their bodies (Figure 63). These will then develop into the identifying characteristics between species. Female moths (Figure 64) generally have brown forewings, while males are usually cream.

## Damage

*Helicoverpa* spp. larvae will bore into developing fruitlets (Figure 65), causing them to either fall or become deformed. Fruit damage usually appears as clean, isolated holes in the fruit surface, 5–10 mm deep and around 5 mm wide. These develop a russet lump or depression as the fruit matures. Larvae can also feed on the leaves and buds.

## Monitoring

During spring and early summer, the undersides of damaged leaves should be carefully monitored for young caterpillars. *Helicoverpa* spp. damage can also occur in early autumn and around harvest, making this a good time to monitor trees.

## Management

**Cultural and physical:** *Helicoverpa* spp. will lay eggs on a wide range of plants, including weeds. Managing weeds, particularly during dormancy, can help reduce the resident population.

**Biological:** protecting beneficials by using 'softer', more selective insecticides will help with biological control of *Helicoverpa* spp. Pathogen-based insecticides are commercially available, including *Bacillus thuringiensis* (Bt) and *nucleopolyhedrovirus* (NPV).



Figure 63. *Helicoverpa* spp. caterpillars.



Figure 64. Female *Helicoverpa* spp. adult.



Figure 65. *Helicoverpa* spp. damage to an apple.

**Chemical:** budworms and other early-season caterpillars can damage fruit before spray programs for other key moth pests have started. Early spring monitoring can help to determine if early-season chemical intervention is needed ([Table 22](#)).

Table 22. Registered or permitted products for budworms in NSW.

| Active constituent (example trade name)                           | Insecticide group(s) | WHP <sup>1</sup> (days)                      | Effect on beneficials | Registered for use in... <sup>2</sup>           |
|-------------------------------------------------------------------|----------------------|----------------------------------------------|-----------------------|-------------------------------------------------|
| Abamectin + chlorantraniliprole (Voliam Targo®)                   | 6 + 28               | 7                                            | High                  | Pome fruit                                      |
| <i>Bacillus thuringiensis</i> subsp. <i>Aizawai</i> (Bacchus® WG) | 11C                  | Not required when used as directed           | Low                   | All crops <sup>3</sup>                          |
| <i>Bacillus thuringiensis</i> subsp. <i>Kurstaki</i> (DiPel®)     | 11                   | Not required when used as directed           | Low                   | All crops <sup>3</sup>                          |
| Carbaryl (Bugmaster®)                                             | 1A                   | Pome fruit 77; stone fruit 35                | High                  | Pome fruit, stone fruit; do not use on cherries |
| Chlorantraniliprole (Altacor® X-Force)                            | 28                   | 14                                           | Low                   | Apples, pears                                   |
| Indoxacarb (Avatar® eVo)                                          | 22A                  | Stone fruit (except cherries) 7; cherries 14 | Low                   | Stone fruit                                     |
| Methomyl (Nufarm Methomyl 225)                                    | 1A                   | 1                                            | High                  | Stone fruit                                     |
| Nucleopolyhedrovirus (Vivus® Max)                                 | 31                   | Not required when used as directed           | Low                   | Pome fruit                                      |
| Spinetoram (Delegate®)                                            | 5                    | 7                                            | Medium                | Pome fruit                                      |
| Spinosad (Entrust® Organic)                                       | 5                    | 3                                            | Medium                | Pome fruit                                      |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label. <sup>3</sup> All crops = apples, pears, apricots, cherries, nectarines, peaches, plums and persimmons.

# Carpophilus beetle (dried fruit beetle)



## *Carpophilus* species

Carpophilus beetle is an economically significant pest of stone fruit. It can cause serious damage to fruit on the tree and postharvest, especially when temperatures exceed 20 °C after wet weather and when the fruit is ripening.

## Risk period

Table 23. The peak risk period for carpophilus beetle.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Carpophilus beetles are small (2–3 mm long) and black or brown (Figure 66 and Figure 67). Their wing covers are short and they have clubbed antennae. The larvae are yellowish, about 5 mm long when fully grown, have a brown head and a forked tail.

## Damage

Most commercial damage is done to ripening stone fruit on the tree as beetles burrow into the fruit, particularly near the stem end suture line. In other fruit, such as apples, only fallen fruit is damaged and the pest is not considered economically important. Adults lay eggs in rotting and damaged fruit on the orchard floor. Mature larvae emerge from the fruit and pupate in the ground. Adults overwinter on the tree under bark or in mummified fruit.

The adult can fly several kilometres in search of hosts. Summer rain and rotting fruit are ideal conditions for breeding. Carpophilus beetle adults are a major vector of brown rot (page 124).

## Monitoring

Using pheromone traps early in the season will indicate carpophilus beetle arrival or emergence, helping with early control and management. Weekly fruit inspections leading up to harvest might help identify the start of fruit infestation.

## Management

**Cultural and physical:** the most important management strategy for carpophilus beetle is good orchard hygiene, which is improved by removing and destroying waste fruit from orchards. Controlling Queensland fruit fly will decrease the amount of fallen fruit and reduce the potential for infestation.



Figure 66. Chewing damage on a nectarine and carpophilus beetle (inset image).



Figure 67. Carpophilus beetle. Photo: Pest and Diseases Image Library, Bugwood.org.

Using weekly monitoring and/or mass trapping between stone hardening and harvest, good orchard hygiene and fruit fly control will give the best result. Traps are available from rural retailers.

**Biological:** an attract-and-kill system using synthetic aggregation pheromones plus food-attractant provides effective protection of ripening crops when deployed at least 4 weeks before harvest. Continuing to mass-trap through harvest and for an additional 2 weeks will help reduce the resident pest population. Placing traps (Figure 68) upwind on the outside edges of the orchard will ensure maximum pheromone spread.

**Chemical:** the chemical options for controlling carpophilus beetle are listed in Table 24.



Figure 68. Carpophilus pheromone trap. Photo: Dan Papacek, Bugs for Bugs.

Table 24. Registered or permitted products for carpophilus beetle in NSW.

| Active constituent<br>(example trade name) | Insecticide<br>group(s) | WHP <sup>1</sup> (days) | Effect on<br>beneficials | Registered for use in... <sup>2</sup> |
|--------------------------------------------|-------------------------|-------------------------|--------------------------|---------------------------------------|
| Bifenthrin (Bifenthrin® 250 EC)            | 3A                      | 1                       | High                     | Stone fruit except cherries           |
| Bifenthrin (PER82062, expires 31.10.28)    | 3A                      | 1                       | High                     | Cherries                              |
| Carpophilus Trapping Systems               | Pheromone               | 0                       | Low                      | Pome fruit, stone fruit               |
| Clothianidin (Samurai®)                    | 4A                      | 7                       | High                     | Stone fruit                           |
| Tetraniliprole (Vayego® 200 SC)            | 28                      | 3                       | Low                      | Stone fruit; suppression only         |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

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# Cherry aphid

## *Myzus cerasi*

Cherry aphids can be a major pest in all stone fruit, feeding on leaves and shoots, which can result in reduced and deformed growth.



## Risk period

Table 25. The peak risk period for cherry aphid.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Adult cherry aphids are dark (Figure 69) and approximately 2 mm long. The adult population consists of winged and wingless individuals (Figure 70). The nymphs are dark brown to black. Cherry aphid eggs are shiny, oval and usually found on the underside of leaves.



Figure 69. Cherry aphids. Photo: Whitney Cranshaw, Colorado State University, Bugwood.org.



Figure 70. Various stages of the cherry aphid life cycle. Source: adapted from Zeck (1965).

## Damage

Aphids will often inhabit terminal leaf shoots, particularly young leaves. Infested leaves will curl, providing a protected space for aphids to continue feeding. Honeydew secreted by the aphids can result in sooty mould growth on the fruit, making it unmarketable. If the infestation is severe, leaves might turn brown and drop.

## Monitoring

Examine trees regularly during and shortly after bud break for aphids (Figure 71). Particular attention should be paid to the terminal shoot tips. Continued monitoring each fortnight until harvest is recommended.



Figure 71. Cherry aphids on a bud. Photo: Mariusz Sobieski, Bugwood.org.

## Management

**Cultural and physical:** high levels of nitrogen can promote soft new growth and this is favoured by aphids. Using smaller, more targeted amounts of fertiliser throughout the growing season can help moderate vegetative growth and reduce aphid infestation. Good weed management can reduce potential harbour sites and therefore migrating aphid populations.

**Biological:** good aphid control can be achieved using naturally occurring biological agents. Lacewings are aggressive general predators that will feed on aphids and can provide useful control. Lady beetles can be important aphid predators as both the adults and larvae feed on aphids (Figure 72).

**Chemical:** the chemical options for controlling cherry aphid are listed in Table 26.



Figure 72. Lady beetle adult, eggs and larvae.

Table 26. Registered or permitted products for cherry aphid in NSW.

| Active constituent<br>(example trade name) | Insecticide<br>group(s)             | WHP <sup>1</sup> (days) | Effect on<br>beneficials | Registered for use in... <sup>2</sup> |
|--------------------------------------------|-------------------------------------|-------------------------|--------------------------|---------------------------------------|
| Malathion (Fyfanon® 1000 EC)               | 1B                                  | 3                       | High                     | Stone fruit                           |
| Paraffinic Oil (CropCover®)                | Paraffinic oil and<br>petroleum oil | 0                       | Low                      | Peaches, nectarines                   |
| Pirimicarb (Pirimor®)                      | 1A                                  | 2                       | Medium                   | Stone fruit                           |
| Spirotetramat (Movento® 240 SC)            | 23                                  | 21                      | Medium                   | Stone fruit                           |
| Sulfoxaflor (Transform® Isoclast™)         | 4C                                  | 7                       | Medium                   | Stone fruit                           |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Clearwing borer

## *Ichneumonoptera chrysophanes*



The predominant species of clearwing borer found in NSW and Qld persimmon orchards is *Ichneumonoptera chrysophanes* (formerly *Carmenta chrysophanes*). Early spring is a critical time for monitoring and applying controls, although clearwing borers can be present all season.

### Risk period

Table 27. The peak risk period for clearwing borer in persimmon orchards.

| Bud swell/<br>green tip | Shoot extension | Flowering and fruit<br>development | Harvest | Postharvest | Dormancy |
|-------------------------|-----------------|------------------------------------|---------|-------------|----------|
|                         |                 |                                    |         |             |          |

### Pest identification

The adult borers look similar to wasps, with clear wings and narrow bodies. Males are usually black with bands of yellow hair (Figure 73, left), while the females are black with bands of orange (Figure 73, right). The forewings are usually 7–10 mm long. The larval stage is a borer 10–15 mm long, creamy-white caterpillar with a brown head capsule (Figure 74).

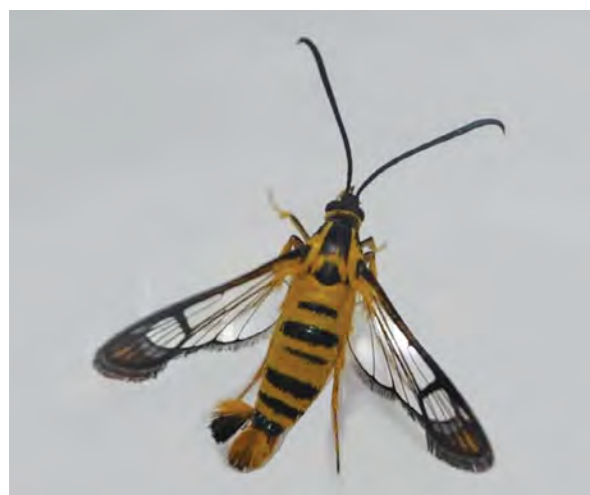


Figure 73. Male (left) and female (right) clearwing borers. Photo: George et al. (2017).

### Damage

The larval stage of the clearwing borer damages persimmon trees by tunnelling under the bark, but unlike other fruit tree borers, they do not bore into the heartwood. Their feeding sites (usually covered in sawdust-like frass) can cause significant damage to the tree's conductive tissues (Figure 75). In severe cases, branches will be girdled, become weakened and break off. Sustained feeding over several borer generations can result in tree death.

### Monitoring

Adult borer populations and flights can be monitored using pheromone traps. Usually, these traps will detect significant activity in early spring, indicating the need for control measures to be implemented early.



Figure 74. Clearwing borer larvae. Photo: George et al. (2017).

Warm coastal districts can have up to 4 peaks of adult borer activity in the growing season. If using pheromone dispensers to control this pest, it is important to note that traps can also be disrupted and borer catch suppressed, making it difficult to interpret the numbers.

### Management

**Cultural and physical:** cultural methods for managing clearwing borer are limited. Some growers have reported success using a high-pressure handheld spray directed at the feeding sites during crop dormancy. This approach is usually employed to reduce overwintering pest numbers and to complement pheromone mating disruption.

**Biological:** Braconid wasps can be an effective biological control, parasitising a high percentage of clearwing borer larvae in south-east Qld. The wasps are active in late spring but might not be present in sufficient numbers to prevent some damage from occurring.

Trials using the parasitic nematode *Steinernema feltiae* sprayed onto persimmon trees in August achieved up to 20–30% clearwing larvae mortality.

**Chemical:** pheromone mating disruption of clearwing borer involves applying dispensers (Figure 76) throughout the orchard just before the first generation emerges. These dispensers flood the orchard with female pheromones, confusing the male borers, preventing mating and subsequent egg-laying. Grower experience suggests that 2 applications per season might be necessary to achieve satisfactory control. Mating disruption for borer pests is usually most effective in large contiguous areas of the orchard, where the edge-to-area ratio of the block is low. For orchards smaller than 3 ha, consider placing pheromone dispensers in the adjacent bush to extend the coverage area.

The pheromone mating disruption product currently permitted for managing clearwing borer in NSW persimmon orchards is listed in Table 28. There are currently no registrations or permits for chemical sprays for this pest in persimmons.

Table 28. Registered or permitted product for managing clearwing borer in persimmons in NSW.

| Active constituent (example trade name)                                       | Insecticide group | WHP <sup>1</sup> (days) | Effect on beneficials | Registered for use in... <sup>2</sup> |
|-------------------------------------------------------------------------------|-------------------|-------------------------|-----------------------|---------------------------------------|
| inSense mating disruption agent ( <a href="#">PER88722</a> , expires 31.5.28) | Pheromone         | 0                       | Nil                   | Persimmons                            |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.



Figure 75. Clearwing borer feeding damage and associated frass covering. Photo: George et al. (2017).



Figure 76. Clearwing borer pheromone mating disruption dispenser.

# Codling moth

## *Cydia pomonella*



Codling moth is one of the most damaging pests of apple and pear in Australia. Other hosts susceptible to codling moth include crab apple, some stone fruit, walnut and quince.

## Risk period

Table 29. The peak risk period for codling moth.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Adult codling moths are approximately 9 mm long with a wingspan of 12–19 mm. Wings are mottled grey, with a brown and gold band at the tip. When the moth is at rest, its wings are held in a tent-like structure over its body ([Figure 77](#)). Larvae are white to light pink with a dark brown head. They appear worm-like and are 15–19 mm long. Larvae are most commonly seen when damaged fruit is cut open for inspection ([Figure 78](#)).



Figure 77. Codling moth larvae (left) and adult (right).



Figure 78. Codling moth larvae inside an apple.

## Damage

A tell-tale sign of codling moth presence is frass (sawdust-like material) at the point where the larvae have entered the fruit ([Figure 79](#)). Young codling moth larvae will initially feed just below the skin of the fruit, creating what looks like a small sting on the surface ([Figure 80](#)). Most of the damage occurs as the moth tunnels into the fruit and feeds on the flesh and seeds. Bacteria often break down the flesh around the tunnels, causing more internal damage, which can lead to premature ripening and fruit drop. Codling moth larvae feed on the internal parts of the fruit and can damage almost an entire crop if not discovered and controlled.



Figure 79. Sawdust-like frass covering the area where codling moth larvae entered an apple.



Figure 80. Codling moth sting marks on the apple surface. Photo: Eugene E Nelson, Bugwood.org.

## Management

**Cultural and physical:** where possible, infested fruit (either on the tree or fallen) should be removed from the orchard and destroyed. It can also be moved to the inter-row and mulched.

Scraping loose bark from trees removes overwintering sites. Take preventative action by burning old tree stacks during re-establishment and before moths emerge in spring. Timber fruit bins can also harbour overwintering codling moth pupae and are a source of infestation and transfer between orchards. Store bins away from orchard blocks if possible.

**Biological:** various biological measures help with managing codling moth and the effectiveness of these depends on the size of the orchard block. For larger blocks or where area-wide management is being practised, mating disruption can be a good alternative to spraying. This technique uses commercial dispensers to emit massive amounts of female moth pheromones into the orchard. This confuses male moths, which are then unable to find female moths to mate with. For smaller blocks (or to supplement mating disruption), other management strategies might be effective. Pheromone traps (Figure 81) and mating disruption dispensers must be deployed before full bloom.

Although natural codling moth predators are not totally effective in controlling populations, they should be encouraged by using softer chemicals where possible.

The parasitic wasp *Mastrus ridens* (Figure 82) was recently released in limited locations in the key apple-growing regions of Australia. The performance of this new biological control agent for codling moth will be assessed over the coming seasons and further releases are planned. *M. ridens* will work best as part of an integrated control program using mating disruption and avoiding broad-spectrum chemicals.



Figure 81. A delta trap with sticky inserts and a pheromone lure to monitor adult codling moth activity.



Figure 82. An adult parasitic wasp (*Mastrus ridens*). Photo: Plant and Food Research, New Zealand.

**Chemical:** codling moth control is achieved by using pheromone mating disruption (PMD) or a chemical spray program. In very high-pressure situations, a combination of PMD and insecticide (Table 30) might be necessary to reduce a large resident population.

Table 30. Registered or permitted products for codling moth in NSW, page 1 of 2.

| Active constituent (example trade name)         | Insecticide group(s) | WHP <sup>1</sup> (days) | Effect on beneficials | Registered for use in... <sup>2</sup> |
|-------------------------------------------------|----------------------|-------------------------|-----------------------|---------------------------------------|
| Abamectin + chlorantraniliprole (Voliam Targo®) | 6 + 28               | 7                       | High                  | Pome fruit                            |
| Acetamiprid + novaluron (Cormoran®)             | 4A + 15              | Apples 70; pears 35     | Medium                | Apples, pears                         |
| Carbaryl (Bugmaster®)                           | 1A                   | 77                      | High                  | Pome fruit                            |
| Chlorantraniliprole (Altacor® Hort)             | 28                   | 14                      | Low                   | Pome fruit                            |
| Clothianidin (Samurai®)                         | 4A                   | 7                       | High                  | Apples, pears                         |

Table 30. Registered or permitted products for codling moth in NSW, page 2 of 2.

| Active constituent<br>(example trade name)   | Insecticide<br>group(s)   | WHP <sup>1</sup> (days)               | Effect on<br>beneficials | Registered for use in... <sup>2</sup> |
|----------------------------------------------|---------------------------|---------------------------------------|--------------------------|---------------------------------------|
| Cyclaniliprole (Teppan®)                     | 28                        | 28                                    | Medium                   | Pome fruit                            |
| Cydia pomonella granulosis virus<br>(CYD-X®) | Biological<br>insecticide | Not required when<br>used as directed | Low                      | Apples, pears                         |
| Fenoxycarb (Insegar®)                        | 7B                        | 14                                    | Low                      | Apples, pears                         |
| Indoxacarb (Avatar® eVo)                     | 22A                       | 14                                    | Low                      | Apples, pears                         |
| Malathion (Fyfanon® 440 EW)                  | 1B                        | 3                                     | High                     | Apples, pears                         |
| Mating disruption agent (Isomate®)           | Pheromone                 | Not required when<br>used as directed | Low                      | Apples, pears                         |
| Methomyl (Methomyl 225)                      | 1A                        | 1                                     | High                     | Apples                                |
| Spinetoram (Delegate®)                       | 5                         | 7                                     | Medium                   | Pome fruit                            |
| Tebufenozide (Ecdypro 700 WP)                | 18                        | 21                                    | Low                      | Apples, pears                         |
| Tetraniliprole (Vayego® 200 SC)              | 28                        | 7                                     | Low                      | Pome fruit                            |
| Thiacloprid (Cobra® 480SC)                   | 4A                        | 21                                    | Medium                   | Pome fruit                            |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# European earwig

## *Forficula auricularia*



European earwig has a very broad host range, feeding on a variety of horticultural and broadacre crops. Earwigs can be particularly damaging in stone fruit crops, including cherries, where they feed on stems and fruit. In apples, earwigs do not generally attack the crop and are considered an important beneficial insect.

## Risk period

Table 31. The peak risk period for European earwigs.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

European earwig adults are dark brown with yellow-brown legs and shoulders. They are 12–24 mm long and have thin, segmented antennae with a pair of pincers at the rear of the body. European earwig males have longer, curved pincers and females have straight pincers (Figure 83).

## Damage

European earwigs will feed on foliage, leaving irregularly shaped holes. In fruit trees, most economic loss occurs from the earwigs feeding on the fruit, causing shallow depressions (Figure 84) that can be the perfect host for brown rot (page 124). In cherries, significant damage can occur when earwigs feed on the stems of developing fruitlets (Figure 85).



Figure 83. Adult European earwigs, male (left) and female (right).



Figure 84. European earwig feeding damage on ripening cherries.



Figure 85. European earwig feeding damage on young cherry stems.

## Monitoring

Monitoring for European earwigs can include physically inspecting the fruit and leaves as well as trapping. When inspecting fruit, look closely among fruit clusters as the adult earwigs will use these areas as shelter, particularly during daylight.

Earwig activity can also be monitored by placing sections of rolled corrugated cardboard in the tree canopy and checking once or twice a week for the pest. Adult earwigs will use the cardboard rolls as shelter, making them easy to find. Monitoring pest activity can help with the timing of spraying and/or baiting programs.

## Management

**Cultural and physical:** practising good farm hygiene will prevent the introduction and spread of European earwig. Generally, European earwigs will seek shelter during the day within the tree canopy and among fruit clusters, so keeping canopies open and thinning fruit to singles (where appropriate) will help reduce the potential for fruit damage. Removing pruned branches from around the base of trees will remove alternative nesting sites. Removing drooping branches that

are touching the ground will prevent earwigs from accessing the trees. Reducing the height of weeds in the inter-row will reduce shelter options for the earwigs.

**Biological:** currently there are no known natural predators of the European earwig. Some birds and lizards will feed on earwigs, but this is unlikely to reduce populations significantly. In apple and pear orchards, European earwig is considered a beneficial insect because it preys on woolly apple aphids.

**Chemical:** the chemical options for controlling European earwig are listed in [Table 32](#).

Table 32. Registered or permitted products for European earwig in NSW.

| Active constituent<br>(example trade name) | Insecticide<br>group(s) | WHP <sup>1</sup> (days)    | Effect on<br>beneficials | Registered for use in... <sup>2</sup> |
|--------------------------------------------|-------------------------|----------------------------|--------------------------|---------------------------------------|
| Carbaryl (Bugmaster®)                      | 1A                      | 35                         | High                     | Stone fruit except cherries           |
| Fipronil (Albatross® 200SC)                | 2B                      | Do not graze treated area  | High                     | Cherries; single ground<br>spray only |
| Indoxacarb (Avatar® eVo)                   | 22A                     | Stone fruit 7; cherries 14 | Low                      | Stone fruit                           |
| Piperonyl butoxide + pyrethrins<br>(Py-Bo) | 3A                      | 1                          | High                     | Fruit crops                           |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# European red mite

## *Panonychus ulmi*



European red mite (ERM) is a serious pest of apple and pear foliage. Severe infestations can result in defoliation, particularly in pears. The pest is also found in stone fruit trees, but this is less common.

## Risk period

Table 33. The peak risk period for European red mite.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Adult ERM females are about 0.4 mm long and rounded. They are dark maroon with prominent white spines on their body ([Figure 86](#)). In contrast, adult males are smaller than females and lighter coloured. They have a less rounded body and a pointed, angular abdomen. ERM eggs are light red, round and have a slight depression on the top. When infestations are heavy, eggs will be found clustered in hundreds around branch angles and buds ([Figure 87](#)).

## Damage

ERM feeding will cause mottling on the upper leaf surface. Heavy infestations result in leaf bronzing and premature leaf fall, leading to reduced photosynthesis. Prolonged feeding can affect fruit size and colour and might affect bud development for the following season.

There are several ways to quantify the risk posed by mite populations including counts, presence or absence, percentage of leaves infested and cumulative leaf-infested days (CLIDs). Your local IPM consultant should be able to assist with more advice on applying these methods in your orchard.

## Monitoring

During the growing season, and particularly as spring and summer temperatures increase, monitor the undersides of leaves for ERM and their eggs. The presence of webbing can also indicate that mite populations are in the canopy, although this is more common with two-spotted mite ([page 100](#)). Scouting the orchard for plant damage, such as bronzed or yellowed leaves, can be a quick way to identify pest mite hotspots.

Monitor for ERM fortnightly using a hand lens or by taking a random sample to the office or laboratory for closer inspection under a light microscope. Commercial mite monitoring services might be available in some districts.



Figure 86. A female European red mite.

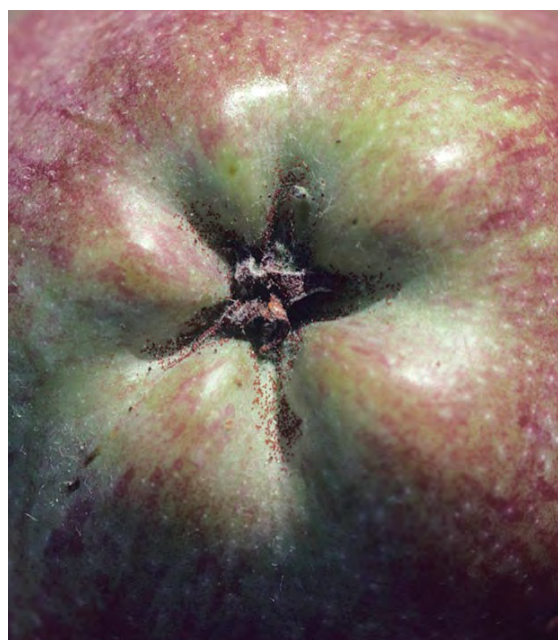


Figure 87. European red mite eggs on an apple.

When monitoring, record both pest and beneficial insect activity found on the leaves. It is a good idea to record both mites and predators as a percentage of leaves infested. This way, from sample to sample, you will know if the infestation is getting worse or if the beneficials, such as predatory mites, are maintaining control. For more information, refer to the article titled ['The importance of protecting beneficial insects' on page 110](#).

Look for ERM eggs among the branches while pruning, especially in winter. This can help identify potential pest pressure and hotspots for the next season.

### Management

**Cultural and physical:** physical management of ERM can include measures to reduce heat and dust in the orchard and ensure adequate soil moisture, thereby minimising any tree stress.

**Biological:** the predatory mite *Galendromus pyri* (formerly *Thyphlodromus pyri*) can be a very effective biological control agent for ERM. *G. pyri* adults are about the same size as adult ERM but have a pear-shaped body. When combined with the effects of other beneficial insects, including lacewings and *Stethorus* beetles, and with a soft (selective) insecticide program, full biological control of ERM is possible.

Predatory mites ([Figure 88](#)) are often found on the underside of leaves close to the mid-vein. Before feeding on pest mites, the adults are an opaque white or cream, similar to their oval-shaped eggs. After feeding, the gut of the predatory mites takes on the colour of their prey and they become more visible.

If predatory mite numbers are low or absent from an orchard, they can be seeded by transferring leaves and shoots from a block known to have a good population.

**Chemical:** European red mite is a high-profile pest, and there are resistant populations to several key insecticidal groups. CropLife Australia maintains an insecticide resistance management (IRM) plan for European red mite, two-spotted mite and green peach aphid, [available online](#). IRM is essential to maintain the efficacy of valuable insecticides. Preventing resistance from occurring is easier than trying to regain susceptibility.

Early-season sprays should use chemistry with a low effect on beneficial insects to conserve predatory mite populations. In contrast, broad-spectrum insecticides or those with a high impact on beneficial insect populations have the potential to flare up mite populations.

Regular monitoring for both predatory insects and pest mite populations to inform spray decisions is critical. Wherever possible, make no more than one application from each registered miticide group per season. Effective mite control spray programs usually incorporate a single horticultural mineral oil during winter or just before bud burst. Consider also chemical rotation and insecticide mode of action to control other pests of pome fruit, such as codling moth, light brown apple moth and woolly aphid. These sprays can promote chemical resistance in mite pests.

The chemical options for controlling European red mite are listed in [Table 34](#).



Figure 88. Adult predatory mites on an apple leaf.

Table 34. Registered or permitted products for European red mite in NSW.

| Active constituent (example trade name)         | Insecticide group(s) | WHP <sup>1</sup> (days) | Effect on beneficials | Registered for use in... <sup>2</sup> |
|-------------------------------------------------|----------------------|-------------------------|-----------------------|---------------------------------------|
| Abamectin (Vertimec®)                           | 6                    | 14                      | High                  | Apples, pears                         |
| Abamectin + chlorantraniliprole (Voliam Targo®) | 6 + 28               | 7                       | High                  | Pome fruit                            |

Table 34. Registered or permitted products for European red mite in NSW, page 2 of 2.

| Active constituent<br>(example trade name) | Insecticide<br>group(s)             | WHP <sup>1</sup> (days)                                    | Effect on<br>beneficials | Registered for use in... <sup>2</sup>                     |
|--------------------------------------------|-------------------------------------|------------------------------------------------------------|--------------------------|-----------------------------------------------------------|
| Bifenazate (Acramite®)                     | 20D                                 | Apricots, nectarines,<br>peaches, plums 3;<br>pome fruit 7 | Low                      | Apples, pears, apricots,<br>nectarines, peaches,<br>plums |
| Cyflumetofen (Danisaraba®)                 | 25A                                 | 7                                                          | Low                      | Pome fruit                                                |
| Etoxazole (Paramite®)                      | 10B                                 | 7                                                          | High                     | Pome fruit, stone fruit<br>except cherries                |
| Fenbutatin oxide (Talk Miticide)           | 12B                                 | Apples, pears 2;<br>peaches, nectarines 14                 | Low                      | Apples, pears, peaches,<br>nectarines                     |
| Hexythiazox (Calibre®)                     | 10A                                 | 3                                                          | Low                      | Apples, pears, stone fruit                                |
| Horticultural mineral oil (various)        | Paraffinic oil and<br>petroleum oil | 1                                                          | Low                      | Pome fruit, stone fruit                                   |
| Malathion (Fyfanon® 440 EW)                | 1B                                  | 3                                                          | High                     | Stone fruit                                               |
| Milbemectin (Milbeknock®)                  | 6                                   | 14                                                         | High                     | Pome fruit                                                |
| Propargite (Omite®)                        | 12C                                 | 7                                                          | Medium                   | Apples, stone fruit                                       |
| Tebufenpyrad (Pyranica®)                   | 21A                                 | 14                                                         | Medium                   | Apples, pears, peaches                                    |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.



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# Fruit tree borer



## *Maroga melanostigma*

The fruit tree borer is the larval stage of *Maroga melanostigma*. This Australian native moth can affect a wide range of tree species, however, stone fruit (*Prunus* spp.) are more susceptible.

## Risk period

Table 35. The peak risk period for fruit tree borer.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Usually the first sign of fruit tree borers will be webbed sawdust material on scaffold branches or on the trunk where major branches intersect. Adult moths are cream-white with a black and orange abdomen, about 20 to 25 mm long, with a wingspan of about 40 mm. The forewings each have one small black dot on their surface. The larvae are cream with a dark head (Figure 89).

## Damage

Fruit tree borers damage stone fruit trees when the larvae (caterpillars) chew the bark and tunnel into the stem or trunk. This damage often results in a complete ring-barking of the branch or trunk. When severe, it can lead to tree decline and eventual death. In young trees, the damage can cause the loss of a leader branch, affecting tree training and shape.

## Monitoring

Inspect structural limbs and tree trunks for tell-tale sawdust patches (Figure 90).

## Management

**Cultural and physical:** physical management is labour-intensive as it involves scraping away the sawdust and destroying the larvae found under the bark or in its tunnel. A fine wire can be used to penetrate the feeding tunnel and kill the larvae.

**Biological:** *Trichogramma* species wasps will parasitise fruit tree borer eggs, but it is unknown if this will provide commercial-level control.

**Chemical:** for effective larvae control, use the registered chemical carbaryl (Table 36), expose and saturate feeding sites with the spray, ensuring that some insecticide penetrates the borer tunnels.



Figure 89. Fruit tree borer larva.



Figure 90. Sawdust patch on a borer-infested tree.

Table 36. Registered or permitted product for fruit tree borer in NSW.

| Active constituent<br>(example trade name) | Insecticide<br>group | WHP <sup>1</sup> (days) | Effect on<br>beneficials | Registered for use in... <sup>2</sup> |
|--------------------------------------------|----------------------|-------------------------|--------------------------|---------------------------------------|
| Carbaryl (Bugmaster®)                      | 1A                   | 35                      | High                     | Stone fruit except cherries           |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Harlequin bug

## *Dindymus versicolor*



The harlequin bug, *Dindymus versicolor*, is a native Australian plant bug. It was documented as a pest of pome and stone fruit in the 1950s. However, between then and the 1990s, the use of synthetic insecticides might have suppressed harlequin bug numbers to the point where it was no longer considered a significant pest. Since the mid-1990s, orchardists have reported increasing harlequin bug activity. This is likely due to changes in crop protection chemistry and pest management strategies.

## Risk period

Table 37. The peak risk period for the harlequin bug.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

The adult harlequin bug is about 12 mm long and is very conspicuous ([Figure 91](#)). The head, inner margins and tips of the forewings are black; the thorax and base of the forewings are reddish-orange. The underside of the body is tinged with yellow or green and has some red and black markings.

The harlequin bug develops through 5 immature stages (instars) and is often found swarming in large numbers on native tree trunks, trellises, hail netting posts and in sheds. Mating adults can be seen moving in pairs, joined at the abdomen and facing in opposite directions.

## Damage

The harlequin bug is a sap-sucker that uses a proboscis (needle-like mouthpart) to pierce the skin of the host plant tissue. On fruit, this feeding results in slight depressions on the skin of the apple and is associated with the browning of the underlying flesh ([Figure 92](#)). The damage could be easily confused with that of boron deficiency (cork disorder).

## Monitoring

Common orchard weeds such as *Malva* spp. (marshmallow), *Rumex* spp. (dock) and *Polygonum aviculare* (wire weed) are known hosts and should be the focus of monitoring and weed control programs. Inspect weeds, timber stacks, trellises, netting structures and nearby native bush for harlequin bug colonies ([Figure 93](#)).



Figure 91. Adult harlequin bug.



Figure 92. Mid-season harlequin bug feeding damage to Cripps Pink apples.



Figure 93. Harlequin bug juveniles are often found swarming on tree trunks and timber posts in or near the orchard.

## Management

**Cultural and physical:** the severity of damage in some orchards seems to be associated with the bugs having easy access to the trees via weed growth within the tree row and/or canopy, low-growing branches, nearby trellis posts or wires and irrigation tubes.

Due to the harlequin bug's association with certain weed species, controlling weeds in the orchard will help reduce the likelihood and intensity of infestations. Particular attention should be given to removing and controlling common orchard weeds in the *Malva* (marshmallow; [Figure 94](#)), *Rumex* (dock; [Figure 95](#)) and *Polygonum* (wireweed; [Figure 96](#)) genera.

Removing sheltering sites such as timber stacks and other rubbish from within the orchard should also help reduce bug numbers.

**Biological:** there are no known biological control agents for the harlequin bug.

**Chemical:** as there are no chemicals registered for controlling harlequin bug in orchards in Australia, managing this pest is dependent on using cultural practices.



Figure 94. Marshmallow (*Malva parviflora*).



Figure 95. Dock (*Rumex crispus*).



Figure 96. Wireweed (*Polygonum erectum*).

# Early research exploring behavioural cues for harlequin bug management

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Harlequin bugs (*Dindymus versicolor*, [Figure 97](#)) are emerging as an increasing concern for several horticultural crops during the warmer months. These sap-sucking insects can feed on developing fruit and vegetables, leading to surface damage, deformation, and in some cases, fruit drop, reducing marketability and causing economic loss. In recent seasons, reports have increased in apple orchards, with grape growers also beginning to see the bugs.

To help develop longer-term, sustainable management options, the NSW DPIRD entomology team at Yanco is working with researchers at Macquarie University to understand how these insects communicate and interact using chemical signals.

The project team is investigating chemicals produced by harlequin bugs and their potential role in behaviour and communication. Laboratory-based analyses are being used to identify insect-emitted volatile compounds and determine whether there are any consistent chemical signatures ([Figure 98](#)). This work will help assess whether behaviour-based monitoring and management approaches, such as attractant-driven trapping systems, might be possible.

While still at an early stage, this research is an important step towards developing targeted, non-chemical management strategies for this emerging pest.

We will continue to update the industry as the work progresses and welcome observations from growers about harlequin bug activity in apples, grapes and other horticultural crops. Such information will help guide future research priorities and improve our understanding of this pest's distribution and its effect.



Figure 97. *Dindymus versicolor* culture at NSW DPIRD Yanco Agricultural Institute.



Figure 98. Volatile collection in process from *Dindymus versicolor* adults.

# Light brown apple moth



## *Epiphyas postvittana*

The light brown apple moth (LBAM) is a native Australian leaf roller with a wide host range including fruit crops, broadleaf pastures and weed species. It can cause significant damage to temperate fruit crops, particularly in cool-climate growing regions.

## Risk period

Table 38. The peak risk period for light brown apple moth.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Adult moths are pale brown (Figure 99) and about 10 mm long. Caterpillars start yellow and become green with a brown head. Pupae are 10–12 mm long and turn from green to brown. Egg masses can be green to yellow–brown. LBAM do not survive well at high temperatures and are more likely to be in cooler areas with mild summers. Feeding and pupating sites in fruit are usually accompanied by webbing.

## Damage

Larvae (or caterpillars) feed on fruit (Figure 100) or under leaves webbed to the fruit. This damage results in fruit being downgraded during sorting and packing.



Figure 99. Light brown apple moth adult.



Figure 100. Light brown apple moth caterpillar with typical surface feeding damage on apple. Photo: Department of Primary Industries and Water, Tasmania, Bugwood.org.

## Monitoring

Monitor for LBAM using pheromone traps (Figure 101), starting before flowering. Use trap catches to determine a biofix date (first sustained flight; refer to 'Calculating degree days for temperate fruit moth pests' on page 108).

Start fruit inspections in mid to late spring, especially among fruit clusters and under leaves as LBAM usually feeds in sheltered sites. To identify the timing of LBAM egg lay, inspect foliage, bearing in mind that egg masses can be hard to spot.

## Management

**Cultural and physical:** reduce broadleaf weeds such as capeweed (*Arctotheca calendula*) and dock (*Rumex* spp.) as LBAM can overwinter in these. Thinning fruit to singles where practical (while maintaining an appropriate crop load) will reduce the number of suitable feeding sites for LBAM.

**Biological:** *Trichogramma carverae* is a commercially available parasitic wasp for LBAM control. Other biological controls include other parasitic wasps, lacewings, spiders and predatory shield bugs.

*Bacillus thuringiensis* (Bt) is a naturally occurring bacterium that is toxic to LBAM larvae when consumed, making it an effective biological control method.

Pheromone ties (Figure 102) placed in the orchard at a rate of 500–600/ha can be an effective non-chemical management tool. They flood the orchard with pheromones to confuse the male moths, disrupting mating and subsequent egg laying.

**Chemical:** the chemical options for controlling light brown apple moth are listed in Table 39.



Figure 101. Monitor pheromone traps weekly from early bud burst. Photo: Evergreen Growers Supply.



Figure 102. Pheromone mating disruption is a non-chemical management option. Photo: Peaceful Valley Farm Supply.

Table 39. Registered or permitted products for light brown apple moth in NSW.

| Active constituent (example trade name)                         | Insecticide group(s) | WHP <sup>1</sup> (days)                | Effect on beneficials | Registered for use in... <sup>2</sup>                     |
|-----------------------------------------------------------------|----------------------|----------------------------------------|-----------------------|-----------------------------------------------------------|
| Abamectin + chlorantraniliprole (Voliam Targo®)                 | 6 + 28               | 7                                      | High                  | Pome fruit; do not apply more than 1 spray per season     |
| Acetamiprid + novaluron (Cormoran®)                             | 4A + 15              | Apples 70; pears 35; stone fruit 7     | Medium                | Apples, pears, stone fruit; do not apply during flowering |
| Acetamiprid + pyriproxyfen (Trivor®, PER89943, expires 30.9.27) | 4A + 7C              | 28                                     | Unknown               | Persimmons                                                |
| <i>Bacillus thuringiensis</i> (various)                         | 11 and 11C           | 0                                      | Low                   | All crops <sup>3</sup>                                    |
| Carbaryl (Bugmaster®)                                           | 1A                   | Pome fruit 77; stone fruit 35          | High                  | Pome fruit, stone fruit; do not use on cherries           |
| Chlorantraniliprole (Altacor® Hort)                             | 28                   | 14                                     | Low                   | Pome fruit, stone fruit                                   |
| Fenoxycarb (Insegar®)                                           | 7B                   | 14                                     | Low                   | Apples, pears                                             |
| Indoxacarb (Avatar® eVo)                                        | 22A                  | Pome fruit, cherries 14; stone fruit 7 | Low                   | Pome fruit, stone fruit                                   |
| Mating disruption agent (various)                               | Pheromone            | Not required when used as directed     | Low                   | Apples                                                    |
| Methomyl (Methomyl 22S)                                         | 1A                   | 1                                      | High                  | Apples                                                    |
| Methoxyfenozide (Prodigy®)                                      | 18                   | 14                                     | Low                   | Pome fruit                                                |
| Methoxyfenozide (Venturi® Max)                                  | 18                   | 7                                      | Low                   | Persimmons                                                |

Table 39. Registered or permitted products for light brown apple moth in NSW, page 2 of 2.

| Active constituent<br>(example trade name) | Insecticide<br>group(s) | WHP <sup>1</sup> (days)                                     | Effect on<br>beneficials | Registered for use in... <sup>2</sup>                                                                      |
|--------------------------------------------|-------------------------|-------------------------------------------------------------|--------------------------|------------------------------------------------------------------------------------------------------------|
| Spinetoram (Delegate®)                     | 5                       | Pome fruit 7; stone fruit 3                                 | Medium                   | Apples, pears, apricots, cherries, nectarines, peaches, plums. Target mature eggs and newly hatched larvae |
| Spinosad (Entrust® Organic)                | 5                       | Apples, pears and stone fruit (except peaches) 3; peaches 7 | Low                      | Pome fruit, stone fruit                                                                                    |
| Tebufenozide (Ecdypro 700 WP)              | 18                      | 21                                                          | Low                      | Apples, pears                                                                                              |
| Tetraniliprole (Vayego® 200 SC)            | 28                      | 7                                                           | Low                      | Pome fruit                                                                                                 |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label. <sup>3</sup> All crops = apples, pears, apricots, cherries, nectarines, peaches, plums and persimmons.

# Loopers



## Various species

Several different looper species can damage apples and pears, including apple looper (*Phrissogonus laticostata*); pome loopers (*Chloroclystis testulata* and *C. approximata*) and green looper (*Chrysodeixis eriosoma*). Loopers are present in all growing regions in NSW.

## Risk period

Table 40. The peak risk period for loopers.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Looper larvae are greyish-white, green or pale brown and can be mottled or striped. Some loopers will have green larvae with faint white lines running along their body (Figure 103). Most looper larvae will grow to about 40 mm long and move with the characteristic looping of the body.



Figure 103. A green looper caterpillar.

## Damage

Loopers feed on the fruit surface, causing superficial damage that usually develops into a russet scab or lump, which is similar to, but smaller than, the damage caused by budworms (*Helicoverpa* spp., page 50).

## Monitoring

Adult looper moths begin to emerge from late September to October. Monitoring should occur then, paying particular attention to the foliage and young fruitlets. Feeding will usually occur early morning and late afternoon. This time is ideal for monitoring loopers.

## Management

**Cultural and physical:** controlling broadleaf weeds in the orchard might help reduce the potential for looper infestation.

**Biological:** *Bacillus thuringiensis* (Bt) is a bacterium that controls the caterpillar stage of loopers.

**Chemical:** the chemical options for controlling loopers are listed in Table 41.

Table 41. Registered or permitted products for loopers in NSW.

| Active constituent (example trade name)                           | Insecticide group(s) | WHP <sup>1</sup> (days)                                     | Effect on beneficials | Registered for use in... <sup>2</sup> |
|-------------------------------------------------------------------|----------------------|-------------------------------------------------------------|-----------------------|---------------------------------------|
| <i>Bacillus thuringiensis</i> subsp. <i>Aizawai</i> (Bacchus® WG) | 11C                  | Not required when used as directed                          | Low                   | All crops <sup>3</sup>                |
| <i>Bacillus thuringiensis</i> subsp. <i>Kurstaki</i> (DiPel®)     | 11                   | Not required when used as directed                          | Low                   | All crops <sup>3</sup>                |
| Methoxyfenozide (Prodigy®)                                        | 18                   | 14                                                          | Low                   | Pome fruit                            |
| Spinetoram (Delegate®)                                            | 5                    | 7                                                           | Medium                | Pome fruit                            |
| Spinetoram (Success® Neo)                                         | 5                    | 7                                                           | Medium                | Persimmons                            |
| Spinosad (Entrust® Organic)                                       | 5                    | Pome fruit 3; persimmon, not required when used as directed | Medium                | Pome fruit, persimmons                |
| Tebufenozide (Ecdypro 700 WP)                                     | 18                   | 21                                                          | Low                   | Apples and pears                      |
| Trichlorfon (PER14743, expires 28.2.30)                           | 1B                   | 7                                                           | High                  | Persimmons                            |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label. <sup>3</sup> All crops = apples, pears, apricots, cherries, nectarines, peaches, plums and persimmons.

# Mealybugs



## Various species

Mealybugs are sap-sucking insects that feed on a wide range of tree crops. They can shelter in the calyx of pome fruit and persimmons.

## Risk period

Table 42. The peak risk period for mealybugs.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Female adult mealybugs are about 3 mm long, oval and usually covered in a white waxy coating (Figure 104). Males are usually small, aphid-like, winged insects. When squashed, mealybugs secrete a pale yellow liquid. Nymphs hatch from eggs within the female and are born live. They are small and orange–brown. Long-tailed mealybugs can be distinguished by their long tail filaments that can be as long as, or longer than, their body (Figure 105).



Figure 104. Adult female and juvenile mealybugs. Photo: Peggy Greb, USDA Agricultural Research Service, Bugwood.org.



Figure 105. Adult long-tailed mealybug. Photo: David Cappaert, Bugwood.org.

## Damage

Mealybugs cause damage by inserting their mouthparts directly into the plants. Infested plant material might be spotted, curled or wilted. Mealybugs also secrete a honeydew sap that encourages sooty mould growth, downgrading fruit quality. In severe infestations, tree health can be greatly reduced. Mealybugs can act as virus vectors and should be removed.

## Monitoring

Monitor at least fortnightly during the growing season. Look in the calyx of the developing fruit weekly during harvest and record any mealybug presence. During dormancy, check under bark or other sheltered places for overwintering larvae or adults.

While monitoring for mealybugs, look for ant activity to determine if additional management measures are required. If ants are present, try to identify the location of their nests. Physically destroying ant nests in the orchard will reduce the number of ants that are protecting and spreading the mealybugs, rendering them more vulnerable to predation by beneficial insects. For more information on the role of ants in orchards and their association with temperate fruit pests.

## Management

**Cultural and physical:** good orchard hygiene is critical for mealybug control. Infested material should be removed from the orchard and destroyed; do not use it as mulch. Mealybug infestations are worse on dusty trees, so avoid vehicle movement near trees on the windward side of infested blocks, and where possible, wet tracks down regularly.

**Biological:** a range of biological controls is available for mealybugs including various lady beetles, lacewings (Figure 106 and Figure 107) and specific parasitic wasps (Figure 108). Wasps can be extremely effective as they are highly mobile and efficient at seeking out their prey.

**Chemical:** the chemical options for controlling mealybugs are listed in Table 43.



Figure 106. Brown lacewing.



Figure 107. Green lacewing.



Figure 108. Parasitic wasp.

Table 43. Registered or permitted products for mealybugs in NSW.

| Active constituent<br>(example trade name)                                          | Insecticide<br>group(s) | WHP <sup>1</sup> (days)               | Effect on<br>beneficials | Registered for use in... <sup>2</sup>                       |
|-------------------------------------------------------------------------------------|-------------------------|---------------------------------------|--------------------------|-------------------------------------------------------------|
| Acetamiprid + novaluron (Cormoran®)                                                 | 4A + 15                 | Apples 70; pears 35                   | Medium                   | Apples, pears                                               |
| Acetamiprid + pyriproxyfen<br>(Trivor®, <a href="#">PER89943</a> , expires 30.9.27) | 4A + 7C                 | 28                                    | Unknown                  | Persimmons                                                  |
| Buprofezin (Strident®)                                                              | 16                      | Pears 56;<br>persimmons 28            | High                     | Pears (long-tailed<br>mealybug only),<br>persimmon          |
| Clothianidin (Samurai®)                                                             | 4A                      | 7                                     | High                     | Apples, pears                                               |
| Clothianidin (Samurai®, <a href="#">PER14779</a> ,<br>expires 30.9.27)              | 4A                      | Not required when<br>used as directed | High                     | Persimmons                                                  |
| Flonicamid (Mainman®)                                                               | 29                      | 21                                    | Low                      | Apples (tuber mealybug),<br>pears (long-tailed<br>mealybug) |
| Flonicamid (Mainman®, <a href="#">PER89215</a> ,<br>expires 31.5.28)                | 29                      | 21                                    | Low                      | Persimmons                                                  |
| Orange oil (PREV-AM®)                                                               | NA                      | Not required when<br>used as directed | Unknown                  | Apples                                                      |
| Potassium salts of fatty acids<br>(Hitman®)                                         | Bio-pesticide           | Not required when<br>used as directed | Unknown                  | Fruit trees                                                 |
| Prothiofos (Tokuthion®)                                                             | 1B                      | 56                                    | Medium                   | Pears                                                       |
| Spirotetramat (Movento® 240 SC)                                                     | 23                      | 21                                    | Medium                   | Pome fruit, stone fruit                                     |
| Sulfoxaflor (Transform® Isoclast™)                                                  | 4C                      | 7                                     | Medium                   | Pome fruit                                                  |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Oriental fruit moth

## *Grapholita molesta*

The Oriental fruit moth (OFM) is one of the most economically damaging pests of stone fruit and pome fruit orchards, particularly peaches, nectarines, apricots, and apples.



## Risk period

Table 44. The peak risk period for oriental fruit moth.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Oriental fruit moths are small, grey-brown and approximately 5–7 mm long (Figure 109). Although rarely seen in the orchard during the day, they might be seen near tree tops in the late afternoon when temperatures are above 18 °C. OFM eggs are cream, small, round and approximately 0.7 mm in diameter. Larvae are creamy white and overwinter as pupae under bark or in tree wounds, particularly around the lower tree trunk.



Figure 109. Adult oriental fruit moth. Photo: Eric LaGasa, Washington State Department of Agriculture, Bugwood.org.

## Damage

Warm, moist conditions favourable for tree growth and brown rot also favour the OFM. Hot, dry, windy conditions can reduce heavy infestations in spring. Cold winters with multiple frosts can reduce the carry-over population.

During spring, the newly hatched larvae will burrow into the young shoot tips to feed for up to 4 weeks. This causes the young shoots to wilt and collapse (Figure 110). The second generation can attack shoots and green or ripening fruit. Peaches and nectarines can be damaged early in the season by larvae after they leave the shoots. Fruit damage is first noticeable as a gummy exudate that might include some sawdust-like frass (Figure 111).

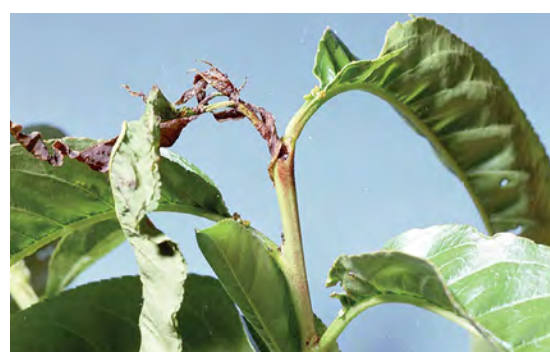


Figure 110. Wilted stone fruit shoot caused by burrowing oriental fruit moth larvae. Photo: Clemson University, USDA Cooperative Extension Slide Series, Bugwood.org.

## Monitoring

Pheromone traps can indicate when moths are active and provide an estimation of population levels, but are not an effective monitoring tool where mating disruption is used, as the pheromone cloud will interfere with the traps. In sprayed orchards, pheromone traps deployed early in the season (around bloom) will help determine a biofix date as the basis for calculating degree days and predicting first-generation egg hatch. For more information, refer to '[Calculating degree days for temperate fruit moth pests](#)' on page 108.

Regularly inspecting shoots and fruit will help identify early stages of OFM infestations. Look for dying shoot tips and/or gummy exudate on fruit.



Figure 111. Oriental fruit moth larvae damage on young peach showing typical gummosis and frass. Photo: Jonas Janner Hamann, Universidade Federal de Santa Maria (UFSM), Bugwood.org.



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## Management

OFM is particularly difficult to manage because it produces multiple overlapping generations per year, with population pressure building rapidly under warm conditions. A series of management techniques must be implemented to prevent damage in the orchard.

**Cultural and physical:** good orchard management will help with OFM control. Smooth-barked, calm, unstressed, well-managed trees will generally only support lower populations of OFM, so reduce tree vigour where practical. Disinfect wooden storage bins before moths emerge in spring. Destroy large prunings and remove all fruit remaining after harvest from the tree. Any trees that have been bulldozed should be destroyed by chipping or burning so they are not a source of infestation in the following season.

**Biological:** mating disruption might replace the need for pesticide application for OFM and works best for orchards:

- that are isolated from other pome fruit or stone fruit orchards
- that are part of an area-wide management scheme
- where migration and internal sources of OFM can be controlled
- where OFM numbers are low but cause sufficient damage to warrant investment in mating disruption.

The native parasitic wasp *Glabridorsum stokesii* is a natural OFM predator. Avoiding insecticides should help encourage beneficial insects. Introducing the commercially available parasitic wasp *Trichogramma carverae* is another biological control option (Figure 112).



Figure 112. *Trichogramma* spp. wasps can parasitise oriental fruit moth eggs.

**Chemical:** the chemical options for controlling oriental fruit moth are listed in Table 45.

Table 45. Registered or permitted products for oriental fruit moth in NSW.

| Active constituent (example trade name)         | Insecticide group(s)   | WHP <sup>1</sup> (days)                                  | Effect on beneficials | Registered for use in... <sup>2</sup>                                |
|-------------------------------------------------|------------------------|----------------------------------------------------------|-----------------------|----------------------------------------------------------------------|
| Abamectin + chlorantraniliprole (Voliam Targo®) | 6 + 28                 | 7                                                        | High                  | Pome fruit                                                           |
| Acetamiprid + novaluron (Cormoran®)             | 4A + 15                | 7                                                        | Medium                | Stone fruit                                                          |
| Carbaryl (Bugmaster®)                           | 1A                     | 35                                                       | High                  | Apricots, nectarines, peaches, plums, prunes; do not use on cherries |
| Chlorantraniliprole (Altacor® Hort)             | 28                     | 14                                                       | Low                   | Pome fruit, stone fruit                                              |
| Clothianidin (Samurai®)                         | 4A                     | 7                                                        | High                  | Nectarines, peaches                                                  |
| Cydia pomonella granulosis virus (Grandex®)     | Biological insecticide | 0                                                        | Low                   | All crops <sup>3</sup>                                               |
| Indoxacarb (Avatar® eVo)                        | 22A                    | 7                                                        | Low                   | Apricots, nectarines, peaches, plums                                 |
| Malathion (Fyfanon® 1000 EC)                    | 1B                     | 3                                                        | High                  | Stone fruit                                                          |
| OFM mating disruptant                           | Pheromone              | Not required when used as directed                       | Low                   | Various (check labels)                                               |
| Spinetoram (Delegate®)                          | 5                      | Pome fruit 7; stone fruit 3                              | Medium                | Pome fruit, stone fruit                                              |
| Spinosad (Entrust® Organic)                     | 5                      | Stone fruit 3; peaches 7                                 | Low                   | Stone fruit                                                          |
| Tetraniliprole (Vayego® 200 SC)                 | 28                     | 3                                                        | Low                   | Stone fruit                                                          |
| Thiacloprid (Cobra® 480SC)                      | 4A                     | Stone fruit except peaches 14; pome fruit and peaches 21 | Medium                | Pome fruit, stone fruit                                              |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label. <sup>3</sup> All crops = apples, pears, apricots, cherries, nectarines, peaches, plums and persimmons.

# Pear and cherry slug

## *Caliroa cerasi*



The pear and cherry slug is the larval stage of the sawfly *Caliroa cerasi*. As its name suggests, it is a pest of pear and cherry trees.

## Risk period

Table 46. The peak risk period for pear and cherry slug.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Pear and cherry slugs are easily identified in the field as dark-brown to black slugs or leech-like larvae (Figure 113), approximately 5–10 mm long.

## Damage

The larvae damage pear and cherry trees by feeding on the upper surfaces of leaves, giving them a skeletonised appearance. Severe infestations will deplete the trees' photosynthetic capacity, affecting shoot and fruit growth.

Pear and cherry slug infestations are common throughout the growing season but can also accelerate after harvest (particularly in cherry orchards) when the tree canopy can turn brown prematurely.



Figure 113. Pear and cherry slug on a leaf, showing typical feeding damage.

## Monitoring

Look for pear and cherry slug activity while working in the orchard throughout the season. Early detection can help prevent serious leaf damage.

## Management

**Cultural and physical:** cultural controls for this pest in the commercial-scale orchard are limited, particularly if slugs are present throughout the orchard. However, if found on only a small number of trees and in low numbers, slugs can be physically removed or washed off with a jet of water.

**Biological:** pear and cherry slugs are often controlled by naturally occurring predators. Encouraging biological control agents such as hoverflies and lacewings in the orchard will help control.

**Chemical:** the chemical options for controlling pear and cherry slug are listed in Table 47.

Table 47. Registered or permitted products for pear and cherry slug in NSW.

| Active constituent<br>(example trade name)                                      | Insecticide<br>group | WHP <sup>1</sup> (days)              | Effect on<br>beneficials | Registered for use in... <sup>2</sup>                           |
|---------------------------------------------------------------------------------|----------------------|--------------------------------------|--------------------------|-----------------------------------------------------------------|
| Carbaryl (Bugmaster®)                                                           | 1A                   | Pome fruit 77; stone fruit 35        | High                     | Pome fruit, stone fruit except cherries; do not use on cherries |
| Indoxacarb (Avatar® eVo)                                                        | 22A                  | Stone fruit 7; cherries 14           | Low                      | Apricots, cherries, nectarines, peaches, plums                  |
| Piperonyl butoxide + chilli + garlic extract + pyrethrins (Richgro Beat-A-Bug®) | 3A                   | 1                                    | Low                      | Fruit trees                                                     |
| Spinetoram (Delegate®)                                                          | 5                    | Pome fruit 7; stone fruit 3          | Medium                   | Pome fruit, stone fruit including cherries                      |
| Spinosad (Entrust® Organic)                                                     | 5                    | Pome fruit, stone fruit 3; peaches 7 | Low                      | Pome fruit, stone fruit                                         |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Pear leaf blister mite

## *Eriophyes pyri*

The pear leaf blister mite is a problem mostly in pears but can occasionally affect apples.



## Risk period

Table 48. The peak risk period for pear leaf blister mite.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Pear leaf blister mites are significantly smaller than most other pest mite species and are difficult to see in the field using a standard hand lens. Pear leaf blister mites can be identified by their white or pinkish appearance. Their abdomen is ringed and elongated and they have 2 pairs of legs next to their head.

## Damage

Pear leaf blister mite damage can occur on leaves, fruit and stems. It is most noticeable on the leaves and appears as small, green pimples on the underside, which then develop into blisters. These blisters take on a reddish appearance (Figure 114), eventually becoming brown, dead spots (Figure 115). Infested fruit will have depressed, russeted spots.

## Monitoring

Monitoring for pear leaf blister mites fortnightly is recommended, although in hot and dry conditions, more frequent monitoring might be required.

## Management

**Cultural and physical:** when trees are dusty, mite infestations can worsen. If weather conditions are hot and dry, orchard traffic should be limited and operators should drive slowly to limit dust on trees. Maintaining a green ground cover can reduce dust while also providing an attractive alternative habitat for mites.

**Biological:** predatory mites could be useful for controlling pear leaf blister mites.

**Chemical:** decisions to spray (Table 49) for pear leaf blister mite should be based on the results of regular mite monitoring.

Table 49. Registered or permitted products for pear leaf blister mite in NSW.

| Active constituent<br>(example trade name)             | Insecticide group(s)                | WHP <sup>1</sup> (days)               | Effect on<br>beneficials | Registered for use in... <sup>2</sup> |
|--------------------------------------------------------|-------------------------------------|---------------------------------------|--------------------------|---------------------------------------|
| Carbaryl (Bugmaster®)                                  | 1A                                  | 77                                    | High                     | Pome fruit                            |
| Horticultural mineral oil<br>(various)                 | Paraffinic oil and<br>petroleum oil | 1                                     | Low                      | Pears                                 |
| Sulfur as polysulfide sulfur<br>(Grochem Lime Sulphur) | M2                                  | Not required when<br>used as directed | Medium                   | Pome fruit                            |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.



Figure 114. Pear leaf blister mite on a pear tree. Photo: L Giunchedi, Università di Bologna, Bugwood.org.



Figure 115. Pear leaf blister mite on leaves. Photo: Adobe Stock.

# Queensland fruit fly



## *Bactrocera tryoni*

Queensland fruit fly (QFF) is a significant pest of temperate fruit crops in northern and eastern Australia, including coastal and warm inland districts. It is an important quarantine pest of concern to most importing countries and often requires end-point treatment control to trade.

## Risk period

Table 50. The peak risk period for Queensland fruit fly.

| Bud swell/<br>green tip | Blossom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|---------|------------|---------|-------------|----------|
|                         |         |            |         |             |          |

## Pest identification

Adult QFF are about 6–8 mm long and reddish-brown with yellow markings (Figure 116). Queensland fruit flies are most active in warm, humid conditions and after rain. Adult flies might be seen walking on the undersides of leaves or on maturing fruit but will take flight if disturbed.

## Damage

Queensland fruit flies damage the fruit by inserting their ovipositor and laying their eggs into the skin of the developing fruit (most commonly as the fruit approaches maturity). This is referred to as stinging the fruit and results in a mark on the skin about the size of a match head. In severe infestations, there can be multiple sting marks on each fruit (Figure 117).

When the eggs hatch, the developing larvae burrow into the fruit, causing the flesh to decay (Figure 118). In many instances, the affected fruit can look intact from the outside.



Figure 116. Dorsal view of an adult Queensland fruit fly.



Figure 117. Multiple Queensland fruit fly stings on an apple.



Figure 118. Queensland fruit fly larvae (maggots) and feeding damage in an apple.

## Monitoring

Monitor QFF activity in and around the orchard using a combination of adult fly trapping and visual fruit inspections. Trapping serves as a warning system to indicate when flies are active in the orchard and when to start control treatments. Several types of traps are available including the Lynfield trap (Figure 119), Bugs for Bugs, Bio-Trap, Eco-Lure, Probodelt Cone and McPhail traps.

Lures are available to attract male or female flies depending on the attractant used. There are also registered and permitted options for making your own chemical lures (Table 52). Consult your trap supplier for further advice.



Figure 119. A Lynfield trap.

## Management

**Cultural and physical:** Queensland fruit fly pupate in the soil under infested trees, making orchard hygiene an important part of managing QFF. Removing and destroying fallen and/or infested fruit from the orchard will help break the cycle and limit the available host material. Fruit fly barrier netting can be used to exclude flies from the crop, but this is not a practical option in commercial-scale orchards.

Mass trapping and male annihilation technique (MAT) cups (Figure 120) are also available as non-spray tools to manage adult QFF numbers.

**Biological:** Queensland fruit fly has several natural predators including the parasitoid *Diachasmimorpha tryoni*.

Sterile insect technique (SIT) involves mass rearing and sterilising fruit flies that are then released as part of an area-wide management program. Commercial-scale SIT is currently being developed.

Grazing chickens or ducks in the orchard can help reduce pest pressure, but this might only be practical on a small scale.

**Chemical:** an effective integrated chemical management program for QFF will include trap monitoring, protein bait sprays, male annihilation, orchard hygiene and cover spraying as required (Table 51 and Table 52).



Figure 120. Male annihilation technique (MAT) cups include a lure and pesticide wick and can be placed inside a trap for monitoring or deployed separately in larger numbers to attract and kill. Photo: Bugs For Bugs (<https://bugsforbugs.com.au/product/mat-cup/>).

Table 51. Registered or permitted **sprays** for Queensland fruit fly in NSW.

| Active constituent (example trade name)                         | Insecticide group(s) | WHP <sup>1</sup> (days)     | Effect on beneficials | Registered for use in... <sup>2</sup>                          |
|-----------------------------------------------------------------|----------------------|-----------------------------|-----------------------|----------------------------------------------------------------|
| Acetamiprid + novaluron (Cormoran®)                             | 4A + 15              | 7                           | Medium                | Stone fruit; suppression only                                  |
| Acetamiprid + pyriproxyfen (Trivor®, PER89943, expires 30.9.27) | 4A + 7C              | 28                          | Unknown               | Persimmons; suppression only                                   |
| Alpha-cypermethrin (PER91059, expires 30.6.27)                  | 3A                   | 7                           | High                  | Stone fruit except cherries                                    |
| Alpha-cypermethrin (PER96678, expires 30.9.30)                  | 3A                   | 14                          | High                  | Persimmons                                                     |
| Clothianidin (Samurai®)                                         | 4A                   | 7                           | High                  | Pome fruit, stone fruit, persimmons                            |
| Etofenprox (Trebon®)                                            | 3A                   | 3                           | High                  | Stone fruit except cherries                                    |
| Malathion (Fyfanon® 440 EW)                                     | 1B                   | 3                           | High                  | Apples, pears, stone fruit, persimmons                         |
| Pyrethrins (Pyganic®)                                           | 3A                   | Stone fruit 0; cherries 1   | High                  | Stone fruit including cherries; preharvest clean-up spray only |
| Spinetoram (PER12590, expires 31.5.29)                          | 5                    | Pome fruit 7; stone fruit 3 | Medium                | Pome fruit, stone fruit; suppression only                      |
| Trichlorfon (Dipterex®)                                         | 1B                   | 2                           | High                  | Pome fruit, stone fruit                                        |
| Trichlorfon (PER12450, expires 31.8.30)                         | 1B                   | 2                           | High                  | Persimmons                                                     |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

Table 52. Registered or permitted **baits and lures** for Queensland fruit fly in NSW.

| Active constituent<br>(example trade name)                                   | Insecticide<br>group(s) | WHP <sup>1</sup> (days)               | Effect on<br>beneficials                   | Registered for use in... <sup>2</sup>          |
|------------------------------------------------------------------------------|-------------------------|---------------------------------------|--------------------------------------------|------------------------------------------------|
| Dichlorvos (Biotrap DDVP Cubes)                                              | 1B                      | Not required when<br>used as directed | Low                                        | For use in traps with a<br>suitable attractant |
| Fipronil + 4-(p-acetoxypheyl)-<br>2-butanone (AgriPest DACLURE®<br>Cue-Lure) | 2B                      | Not required when<br>used as directed | Low when used<br>as bait                   | Male attract and kill                          |
| Hydroxyphenylbutanone acetate<br>(Fly Bye®)                                  | Lure                    | Not required when<br>used as directed | Low                                        | Male lure only for traps                       |
| Malathion (Fyfanon® 440 EW)                                                  | 1B                      | Not required when<br>used as directed | Low when used<br>with bait for<br>trapping | Poison for fruit fly trap<br>trapping          |
| Malathion + 4-(p-acetoxypheyl)-2-<br>butanone (Eco-Lure®)                    | 1B                      | Not required when<br>used as directed | Low when used<br>as bait                   | Male attract and kill                          |
| Spinosad (Naturalure®)                                                       | 5                       | Not required when<br>used as directed | Low                                        | Fruit crops; attract and<br>kill bait          |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

## Useful resources for managing Queensland fruit fly

Managing Queensland fruit fly in NSW temperate fruit orchards is critical due to the rising populations over recent seasons. This, coupled with an expected earlier population increase in the growing regions, highlights the need for proactive and integrated management strategies, including monitoring, baiting, exclusion techniques, and community-wide collaboration.

As a widespread and priority pest, the [Area-wide management website](https://area-wide-management.com.au/) (https://area-wide-management.com.au/) for QFF is available free for growers (Figure 121).

Area-wide management (AWM) is a proven, effective management approach for mobile pests around the world. AWM is used in a well-defined area or region, including all pest habitats within that area, to reduce the total pest population. This reduces the likelihood of the pest moving into farms and orchards from habitats such as gardens and/or native hosts. AWM provides opportunities to incorporate sterile insect techniques.

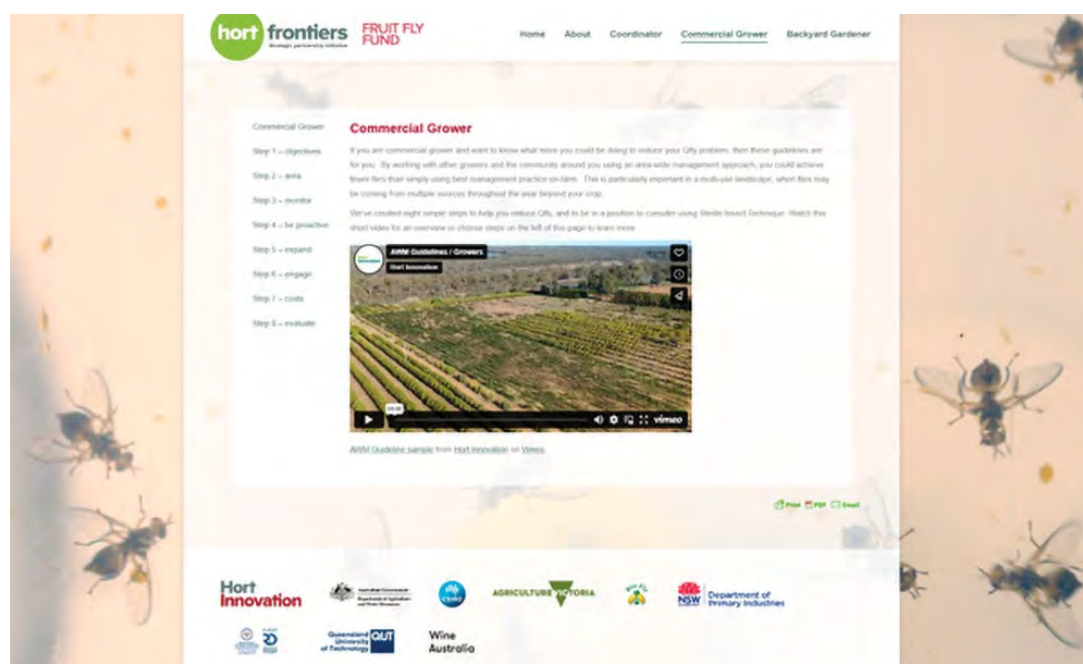


Figure 121. A screenshot of the area-wide management website.

## Cherry-picked podcast: climate change and the Queensland fruit fly

In this episode of the cherry-picked podcast (Figure 122), NSW DPIRD discuss the climate vulnerability assessment (CVA) results for the Queensland fruit fly. Climate change is projected to affect its distribution, life cycle, and timing in NSW. The episode (Figure 123) highlights key findings from the CVA modelling, including seasonal shifts in climate suitability, potential expansion of fruit fly populations, and what this means for growers, exporters, and biosecurity planning.



Figure 122. The cherry-picked podcast logo.



Figure 123. Scan the QR code to listen to the podcast.

### Other useful links for QFF resources

Ekman J (2019) [Implementing brown sugar flotation for ensuring freedom from fruit fly](https://www.vegkit.com.au/globalassets/laserfiche/assets/project-reports/cy16011/cy16011---final-report-complete.pdf). Final report to Hort Innovation, <https://www.vegkit.com.au/globalassets/laserfiche/assets/project-reports/cy16011/cy16011---final-report-complete.pdf>

NSW DPIRD (2010) [Queensland fruit fly: an increasing biosecurity risk under a changing climate](https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/1499814/Climate-Vulnerability-Assessment-Factsheet-Queensland-fruit-fly.pdf), [https://www.dpi.nsw.gov.au/\\_\\_data/assets/pdf\\_file/0009/1499814/Climate-Vulnerability-Assessment-Factsheet-Queensland-fruit-fly.pdf](https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/1499814/Climate-Vulnerability-Assessment-Factsheet-Queensland-fruit-fly.pdf)

NSW DPIRD (2023) [Queensland fruit fly](https://www.dpi.nsw.gov.au/dpi/climate/climate-vulnerability-assessment/commodity-pages/queensland-fruit-fly), <https://www.dpi.nsw.gov.au/dpi/climate/climate-vulnerability-assessment/commodity-pages/queensland-fruit-fly>

NSW DPIRD (2025) [Climate vulnerability assessment Queensland fruit fly results report](https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/1602549/Climate-Vulnerability-Assessment-Queensland-Fruit-Fly-Results-Report.pdf), [https://www.dpi.nsw.gov.au/\\_\\_data/assets/pdf\\_file/0009/1602549/Climate-Vulnerability-Assessment-Queensland-Fruit-Fly-Results-Report.pdf](https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/1602549/Climate-Vulnerability-Assessment-Queensland-Fruit-Fly-Results-Report.pdf)

# Your Fruit Fly Toolkit



BUGS  
FOR  
BUGS

Fruit fly is a difficult but manageable pest.  
There is no silver bullet.  
You need to use a systems approach to get the best results.

## What are the essentials of a systems approach?

1. **Protein baits** - Attract and kill female flies
2. **Male annihilation technique (MAT)** - Attract and kill male flies
3. **Monitoring** - Inspect crops regularly and use male traps
4. **Sanitation** - Remove residual fruit after harvest and destroy neglected fruit trees

When combined and maintained rigorously, these strategies can provide excellent control. In certain high-risk crops, additional tools such as female traps, may also be of value and insecticide cover sprays are sometimes necessary. Currently registered insecticides are very toxic to beneficial insects and are not compatible with integrated pest management. Cover sprays should only be used as a last resort.

We encourage all fruit growers to think of fruit fly as a seasonal pest that needs to be managed all year round - even when susceptible fruit are not necessarily present.

Bugs for Bugs has been helping growers manage fruit fly for more than 40 years. We supply a comprehensive range of fruit fly management products including protein baits, MAT cups and traps.

This fruit fly toolkit provides a practical guide to using our fruit fly management products. For more information about [fruit fly management](#), visit our website.



# Fruit Fly Lure

## protein bait



Fruit Fly Lure is an Australian-made, easy-to-mix, autolysed protein. It is highly attractive to Queensland fruit fly and other fruit fly species. When mixed with a toxicant, it can be used to attract and kill adult fruit flies.

### How does it work?

- The protein plus toxicant attracts and kills adult flies
- Female fruit flies must feed on protein before they can sting fruit

### How to mix our protein bait

- Mix Fruit Fly Lure with water at 2 L per 100 L of water
- Add the toxicant at the label rate

### How to apply

- Apply fresh on the day of mixing
- Use 15 L of mixture per ha
- Apply as a spot or band to the host plants or a suitable substrate
- Note: this is not a cover spray

### When to apply

- Start early (before fruit becomes susceptible) and continue for at least 3 weeks after harvest
- Apply every 5-7 days (more often if you see any signs of damage or increased fruit fly activity)
- Re-apply after rain

### Tips for best results

- Start early (at least 2 weeks before fruit becomes susceptible)
- Apply regularly and do not miss a treatment
- Increase frequency during high-risk periods
- Apply mixture to foliage or trunk of host plant (not on ground or grass)
- On some varieties, protein might cause fruit burn (test before use and minimise fruit contact)
- Treating larger areas, including non-fruiting blocks and surrounds, will improve results
- For improved longevity and rainfastness, use with our Fruit Fly Lure Thickener



# MAT cups for male annihilation



MAT cups are designed to reduce the male fruit fly population. They are a powerful management tool, however they should only be used in addition to (not instead of) protein baiting.

## We offer two styles of MAT cup

- An impregnated cotton wick in a plastic housing
- A cardboard cup with an impregnated corrugated cardboard inner
- Both MAT cup styles are designed to protect the ingredients from rain and UV degradation. We have developed the cardboard version as a biodegradable option.

## How does it work?

- MAT is a targeted attract and kill strategy for male Queensland fruit flies
- MAT cups contain a powerful male sex attractant (cue lure) and a toxicant
- Male Queensland fruit flies are attracted to the cups and die as a result of ingesting the toxicant
- MAT cups are most effective when used over large areas or entire cropping regions to achieve area wide management
- MAT cups can significantly reduce the local fruit fly population when used over successive seasons

## How many do I need?

- Apply 10-20 MAT cups per hectare, depending on crop sensitivity and local fruit fly pressure
- Apply new cups three times per year (in Spring, Summer and Autumn)
- Leave each MAT cup in the field for a full 12 months (biodegradable cups can be left in the field indefinitely)

## How does MAT affect male fruit fly monitoring?

MAT cups compete with male fruit fly traps. It is important to take this into account when using male trap counts to assess fruit fly activity.



# Fruit Fly Trap Pro for monitoring



Monitoring fruit fly populations helps us understand fruit fly activity in an area, and we can use this information to fine tune control programs. The Fruit Fly Trap Pro specifically attracts male Queensland fruit flies.

## We offer two colour variations

- Clear base with yellow lid
- Yellow base with clear lid

## How does it work?

- The trap contains a cotton wick impregnated with a powerful male sex attractant (cue lure) and an insecticide
- Male Queensland fruit flies are attracted from distances of up to 400 meters and collect in the trap where they can be counted

## How many traps do I need?

1 trap per 5-10 ha (minimum 3 traps per farm)

## How to assemble the Fruit Fly Trap Pro

- Wear gloves (to avoid contact with the pheromone wick)
- Push the hook through the lid into the pheromone wick holder
- Insert 4 plastic entry ports into the side of the trap (align tab at top of hole)

## How to deploy the Fruit Fly Trap Pro

- Place traps in areas where fruit fly is likely to be active (e.g. along borders and rivers/waterways)
- Hang at head height in the host tree/crop shaded from direct sunlight
- Empty traps and record fly catches at least weekly
- Replace the pheromone wick every three months
- Replacement Q Fly Wicks are available from Bugs for Bugs

## How to interpret your trap counts

Male traps are a useful tool for monitoring population trends but trap counts must be interpreted carefully. It is important to note that:

- These traps only catch male fruit flies
- Trap counts are not a good indication of potential for fruit fly damage in the crop (your monitoring program should include regular crop inspections, looking for adult flies and evidence of stinging)
- Fruit fly traps do not control fruit fly



Contact us for more information about fruit fly management

Phone: 07 4646 2628 E-mail: [info@bugsforbugs.com.au](mailto:info@bugsforbugs.com.au) Website: [www.bugsforbugs.com.au](http://www.bugsforbugs.com.au)

# Rutherglen bug



## *Nysius vinitor*

Rutherglen bug is a native insect that affects many temperate crops, and in some seasons, is a particular problem in stone fruit. In years of heavy infestation, it can also affect pome fruit.

## Risk period

Table 53. The peak risk period for Rutherglen bug.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Adult Rutherglen bugs are grey-brown with clear wings. They are 4 mm long with a narrow body and prominent eyes (Figure 124). They are highly mobile and often swarm over the fruit and shoot surfaces in the hundreds (Figure 125).

## Damage

Rutherglen bugs damage the fruit by sucking sap. Damage in peaches can be identified by thin strings of clear gum hanging down from green fruit. In other temperate fruit, the damage will appear as multiple small feeding marks on the skin. Rutherglen bug can also feed on young foliage, causing leaves and fruit to shrivel.

## Monitoring

Monitor for Rutherglen bug during spring and summer. If canola or sorghum in surrounding areas is infested, increase monitoring.

## Management

**Cultural and physical:** Rutherglen bugs will use nearby weeds as stepping stones into the orchard trees. Manage weeds in and around the orchard to reduce potential hosts (refer to 'Managing weeds' on page 156).

**Biological:** birds and spiders might provide some predation of Rutherglen bug, but this will not control large populations.

**Chemical:** the chemical options for controlling Rutherglen bug are listed in Table 54.

Table 54. Registered or permitted products for Rutherglen bug in NSW.

| Active constituent<br>(example trade name) | Insecticide<br>group(s) | WHP <sup>1</sup> (days)                                    | Effect on<br>beneficials | Registered for use in... <sup>2</sup>                |
|--------------------------------------------|-------------------------|------------------------------------------------------------|--------------------------|------------------------------------------------------|
| Malathion (Fyfanon® ULV)                   | 1B                      | 3                                                          | High                     | Stone fruit                                          |
| Pyrethrins (Pyganic®)                      | 3A                      | Cherries 1; apricots, nectarines, peaches, plums, prunes 0 | High                     | Apricots, nectarines, peaches, plums, prunes (fresh) |
| Trichlorfon (Dipterex®)                    | 1B                      | 2                                                          | High                     | Pome fruit, stone fruit                              |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.



Figure 124. Rutherglen bug adult.



Figure 125. Rutherglen bug swarm on an apple.

# San José scale

## *Diaspidiotus perniciosus*



San José scale (SJS) is an extremely important pest of pome and stone fruit. It is a sucking insect that injects a toxin into the plant as it feeds, causing localised discolouration, resulting in fruit being downgraded during processing and packing.

## Risk period

Table 55. When to monitor and manage for San José scale.

| Bud swell/<br>green tip | Blossom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|---------|------------|---------|-------------|----------|
|                         |         |            |         |             |          |

## Pest identification

San José scale adult females are yellow with rounded dark grey scales (Figure 126). They are wingless and legless, about 2.5 mm in diameter. Males have a dark band across their back, long antennae, legs and wings. Crawlers are approximately 0.25 mm long and bright yellow.

## Damage

San José scale sucks the sap and juice out of the tree and fruit while also injecting a toxin. This causes loss of tree vigour, stunted growth and limb death. On fruit, SJS feeding will cause slight depressions with a red–purple halo (Figure 127). If populations are low, the damage will be concentrated on the bottom of the fruit.



Figure 126. San José scale adult. Photo: United States National Collection of Scale Insects Photographs, USDA Agricultural Research Service, Bugwood.org.

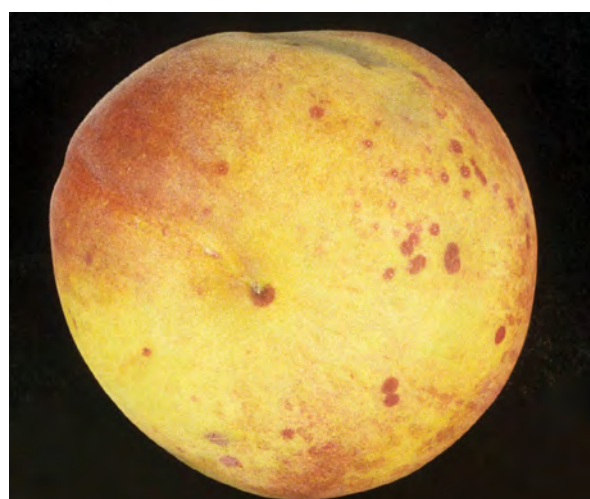


Figure 127. San José scale on a peach.

## Monitoring

During the growing season, monitor fruit for signs of the red–purple halos caused by the feeding scale insect. Be sure to look closely around the calyx end of the fruit.

Crawlers can be monitored 4–6 weeks after bloom using double-sided tape with a thin layer of petroleum jelly around infested tree limbs. Monitoring during winter should focus on identifying scale colonies on the branches.

## Management

San José scale overwinters primarily as immature nymphs, tucked beneath a dark, waxy protective covering on twigs and branches. In spring, the winged males emerge and mate with the wingless females. Approximately 1 month after the first male flight, the first crawlers can be seen. Understanding this life cycle helps target control and management. Treatments applied during dormancy are the most effective.

**Cultural and physical:** the most effective cultural control is to prune out infested branches. This will reduce scale insect numbers and open up the tree canopy, improving spray penetration and coverage. Control ant populations as they spread the scale insect crawlers and protect them from natural predators.

Healthy trees supplied with appropriate nutrition and irrigation will be more likely to resist SJS infestation. Good weed management will help ensure minimal competition for resources.

**Biological:** several natural predators can be used to control SJS. The most common predatory insects and naturally occurring parasitoid wasps include *Cryptolaemus* (*Cryptolaemus montrouzieri*), green lacewings (*Mallada signata*) and Chilocorus beetles (*Chilocorus circumdatus*). Several fungi and bacteria are available that can infect and kill scale insects, however, these are less likely to reduce populations unless they become abundant. It should be noted that almost all pesticides for SJS control will harm beneficial insect populations.

**Chemical:** the chemical options for controlling SJS are listed in [Table 56](#). Note that SJS can also be referred to as *Quadraspidiotus perniciosus* on some labels.

Table 56. Registered or permitted products for San José scale in NSW.

| Active constituent (example trade name)             | Insecticide group(s)             | WHP <sup>1</sup> (days)            | Effect on beneficials | Registered for use in... <sup>2</sup>                                                            |
|-----------------------------------------------------|----------------------------------|------------------------------------|-----------------------|--------------------------------------------------------------------------------------------------|
| Acetamiprid + novaluron (Cormoran®)                 | 4A + 15                          | Apples 70; pears 35; stone fruit 7 | Medium                | Apples, pears, stone fruit                                                                       |
| Fenoxycarb (Insegar®)                               | 7B                               | 14                                 | Low                   | Apples, pears                                                                                    |
| Horticultural mineral oil (various)                 | Paraffinic oil and petroleum oil | 1                                  | Low                   | Pome fruit, stone fruit                                                                          |
| Spirotetramat (Movento® 240 SC)                     | 23                               | 21                                 | Medium                | Pome fruit, stone fruit                                                                          |
| Sulfoxaflor (Transform® Isoclast™)                  | 4C                               | 7                                  | Medium                | Pome fruit                                                                                       |
| Sulfur as polysulfide sulfur (Grochem Lime Sulphur) | M2                               | Not required when used as directed | Medium                | Pears, apricots, nectarines, peaches, plums, prunes; stone fruit dormant to bud swell spray only |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Temperate fruit thrips

Thrips are among the most economically important insect pests affecting Australian temperate fruit production. The main thrips species for pome and stone fruit include:

1. **Plague thrips** (*Thrips imaginis*)
2. **Western flower thrips** (WFT, *Frankliniella occidentalis*)
3. **Onion thrips** (*Thrips tabaci*) is often a secondary pest in temperate fruit orchards.

Thrips damage fruit directly by feeding on them and indirectly by injuring flowers, causing fruit russetting, scarring, bronzing and, in some crops, transmitting plant viruses. Western flower thrips are particularly problematic due to their broad host range and persistence within orchards.

## Thrips life cycle

Most thrips species have a life cycle (Figure 128) involving the following stages:

1. Egg: inserted into the flower, leaf or fruit tissue.
2. Larva (1st instar): active feeding stage.
3. Larva (2nd instar): active feeding stage.
4. Prepupa: non-feeding stage.
5. Pupa: non-feeding stage.
6. Adult: winged, mobile reproductive stage.

The rate of thrips development is strongly influenced by temperature. Under warm spring and summer conditions, a generation can be completed in approximately 2–3 weeks, allowing multiple generations annually. Pupation generally occurs in soil, leaf litter, bark crevices or protected plant areas.

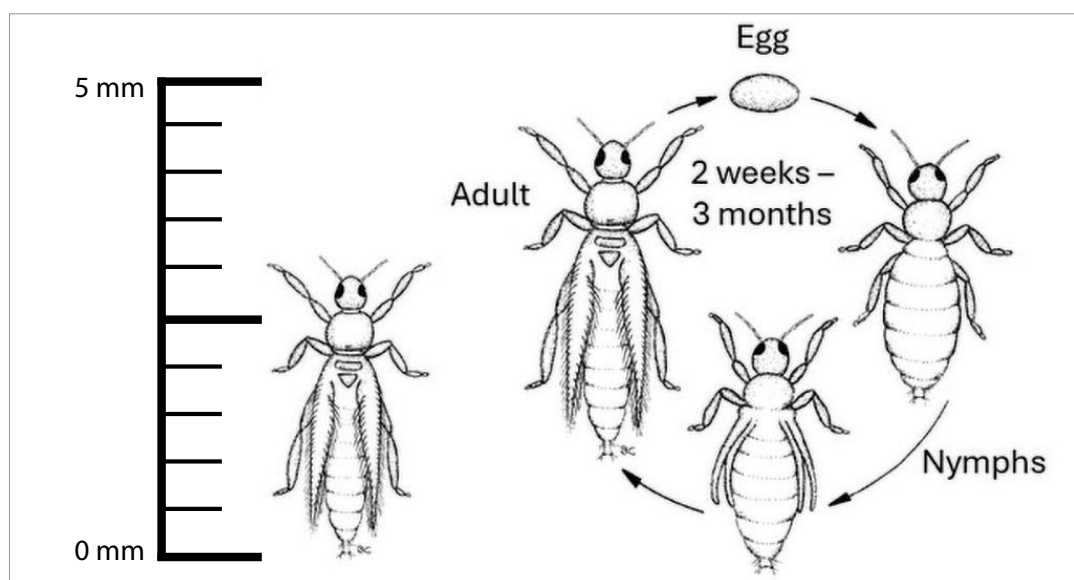


Figure 128. Thrips life cycle. Source: Adapted from Goodwin (2002, p 25).

## Identification

As different types of thrips can be found in the orchard, correctly identifying which one is causing damage is important for treatment. Below are the main differences between the 3 major thrips types in temperate fruit orchards.

**Western flower thrips** (Figure 129) are the largest of the 3 species. The female is between 1.4 and 1.8 mm long while the male is about 0.9 to 1.1 mm long. Females have banded antennae, hairs on the front margin of the prothorax, a black tip on their abdomen and darker spots on the top side of their abdominal segments.



Figure 129. Western flower thrips female top side (left), female underside (middle) and male (right). Source: Steiner et al. (n.d.).

**Plague thrips** (Figure 130) are a smaller species; the female is between 1.1 and 1.3 mm and the male between 0.8 and 1.0 mm long. The last 2 segments of the female abdomen are darker, antennal segments are mostly dusky, and there are no strong hairs on the front margin of the prothorax.



Figure 130. Plague thrips female top side (left), female underside (middle) and male (right). Source: Steiner et al. (n.d.).

**Onion thrips** (Figure 131) are the smallest species and there are no males. The female is between 1.0 and 1.2 mm long. They have more uniform colouring of the abdominal segments and no strong hairs on the front margin of the prothorax.



Figure 131. Onion thrips female top side (left) and female underside (right). Source: Steiner et al. (n.d.).

## Monitoring

The best time to start monitoring for all thrips species is during flowering. The following gives a rough estimate of where to look for thrips during certain time periods.

### Early season

Adult thrips are mostly found in flowers. Females lay eggs in sepals and other flower parts as early as bud swell. These hatch into larvae by late bloom. Few thrips are found on leaves. Plague thrips are usually the most common species during flowering. WFT are more likely to be found during summer on ripening fruit, but even low spring populations in flowers can cause economic losses, especially in nectarines. Plague thrips can migrate from some distance away, but WFT usually overwinters nearby on broad-leaved weeds or garden plants.

### Late season

Thrips feed in protected places on fruit, often under leaves or between fruits. Weeds, particularly clover, can harbour a large breeding population.

Growers can use several techniques to monitor for incursions in the orchard including:

**Ice cream container flower sampling:** using an ice-cream container, bang a cluster of flowers over the container and count the adults and larvae in the sample. Thresholds of approximately 6–8 thrips per flower usually show it is time for management interventions.

**Sticky traps** (Figure 132) should be deployed before flowering and continue until harvest.



Figure 132. Yellow sticky trap in an apple orchard. Photo: Howard F Schwartz, Colorado State University, Bugwood.org.

Selecting samples from fruit throughout the block and checking the calyx, stem cavity, fruit clusters and developing fruitlets.

## References

Goodwin S (2002) *Pests, diseases, disorders and beneficials in greenhouse vegetables: field identification guide*. NSW Agriculture.

Steiner M, Hardy S and Thwaite G (n.d.) *Which thrips is that? A guide to the key species damaging stone and pome fruit in NSW*. NSW Department of Primary Industries.

The following fact sheets give more detailed information about each of the major thrips pests in temperate fruit orchards.

# Thrips – plague thrips



## *Thrips imaginis*

Plague thrips are native insects that are primarily a concern when present in large numbers from pink bud to early fruit set. They can damage both pome and stone fruit.

## Risk period

Table 57. The peak risk period for plague thrips.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Adult plague thrips are visible to the naked eye and can be seen during flowering, crawling on petals and around the reproductive parts of the flowers (Figure 133). They are usually brown, narrow-bodied and about 1.0–1.3 mm long.

## Damage

Plague thrips can damage temperate fruit crops in 2 main ways. Firstly, when they are present in very large numbers, their feeding on flowers results in damage to the stamens and stigmas, thereby affecting pollination and fruit set. Secondly, feeding on the developing fruitlet surface causes a russet to develop that becomes unsightly as the fruit grows, making it unmarketable (Figure 134).

## Monitoring

Monitor for plague thrips using yellow sticky traps (Figure 135) placed throughout the orchard from bud burst to shuck fall. The traps can indicate thrips activity levels and can also be used to obtain a formal identification of the pest species.



Figure 133. Plague thrips adult on a flower stamen.

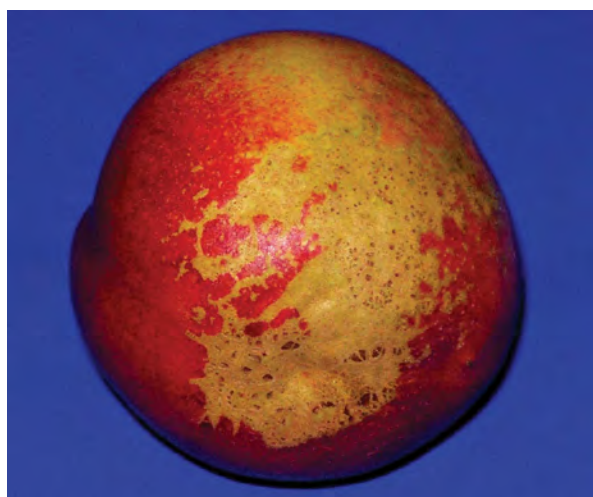


Figure 134. Fruit russet caused by early thrips feeding on the fruitlet.

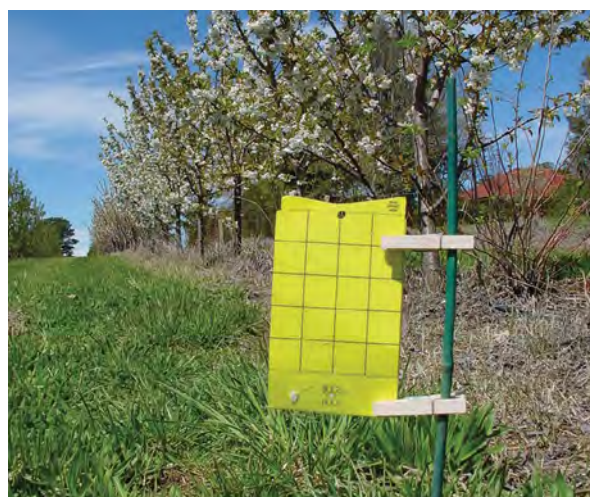


Figure 135. Sticky traps are a useful monitoring tool.

Monitor plague thrips activity by tapping flower clusters over a white ice cream container (or similar). Inspecting individual flowers can also help determine a measurable population size (i.e. thrips/flower) and damage, which will appear as brown spots on the stamens and stigmas. Plague thrips are known to migrate in large numbers on the wind and can invade an orchard very quickly. Regular monitoring will help to identify any sudden increases in thrips numbers.

## Management

**Cultural and physical:** avoid mowing orchard inter-rows and adjacent pastures at or just before bloom as this might move thrips into the crop.

**Biological:** there are several natural plague thrips predators including predatory mites, bugs, lacewings, predatory thrips, lady beetles and parasitic wasps. However, these are unlikely to provide complete control of plague thrips, particularly during periods of rapid pest influx.

**Chemical:** an effective control program for plague thrips will be based on strategic spraying (Table 58) that is informed by monitoring and observation. When spraying at or around bloom, be particularly aware of any label warnings and recommendations for protecting bees and other off-target species.

Table 58. Registered or permitted products for plague thrips in NSW.

| Active constituent (example trade name)                           | Insecticide group(s) | WHP <sup>1</sup> (days)            | Effect on beneficials | Registered for use in... <sup>2</sup>        |
|-------------------------------------------------------------------|----------------------|------------------------------------|-----------------------|----------------------------------------------|
| Acetamiprid + novaluron (Cormoran®)                               | 4A + 15              | 70                                 | Medium                | Apples                                       |
| Bifenthrin (Talstar® 80 SC)                                       | 3A                   | 0                                  | High                  | Apples                                       |
| Flonicamid (Mainman®, <a href="#">PER89215</a> , expires 31.5.28) | 29                   | 21                                 | Low                   | Persimmons; suppression only                 |
| Malathion (Fyfanon® 440 EW)                                       | 1B                   | 3                                  | High                  | Apples, pears                                |
| Methomyl (Methomyl 225)                                           | 1A                   | 1                                  | High                  | Stone fruit                                  |
| Methomyl ( <a href="#">PER14548</a> , expires 31.5.28)            | 1A                   | Not required when used as directed | High                  | Persimmons                                   |
| Potassium salts of fatty acids (Hitman®)                          | Bio-pesticide        | Not required when used as directed | Unknown               | Fruit trees                                  |
| Piperonyl butoxide + pyrethrins (Py-Bo)                           | 3A                   | 1                                  | High                  | All crops <sup>3</sup>                       |
| Tau-fluvalinate (Mavrik® Aquaflo)                                 | 3A                   | Not required when used as directed | High                  | Apples, cherries, nectarines, peaches, plums |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label. <sup>3</sup> All crops = apples, pears, apricots, cherries, nectarines, peaches, plums and persimmons.

# Thrips – western flower thrips

## *Frankliniella occidentalis*

Western flower thrips (WFT) are a pest of all the main temperate tree fruit crops. They are known to be particularly damaging to nectarines.



## Risk period

Table 59. The peak risk period for western flower thrips.

| Bud swell/<br>green tip | Blossom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|---------|------------|---------|-------------|----------|
|                         |         |            |         |             |          |

## Pest identification

Adult western flower thrips (WFT) are pale brown to yellow, with narrow bodies (Figure 136) and are about 1–2 mm long. Western flower thrips are hard to identify in the field and inspection under a light microscope will usually be required to differentiate them from other pest species such as plague thrips and onion thrips.

## Damage

WFT damages the skin of certain temperate fruit, including apples and nectarines, by feeding on the fruit surface. As the damaged skin cells grow, the injury develops into a russet (Figure 137), or in apples, the fruit develops an unusual pansy flower-shaped spot (Figure 138).



Figure 136. Western flower thrips adult.



Figure 137. Western flower thrips feeding damage on a nectarine.



Figure 138. Pansy spot caused by western flower thrips.

## Monitoring

Monitor for thrips species using yellow sticky traps (Figure 139) hung throughout the orchard from bud burst to harvest. The traps will indicate thrips activity and can also be sent to a laboratory to obtain a formal identification of the pest species.

## Management

**Cultural and physical:** controlling established WFT populations will require timely pesticide application. However, several management practices will reduce pest numbers and minimise damage. As broad-leaved weeds (particularly clover) are an alternative host for WFT, keep ground cover mown short throughout the year to prevent flowering, but do not mow when fruit trees are in blossom. Choose pesticides that are less harmful to beneficial insects to encourage their presence and survival. Where practical, thin fruit to singles or aim to keep clusters open, as this will make the environment around the fruit less attractive to thrips.

**Biological:** there are several natural predators of thrips including predatory mites, bugs, lacewings, predatory thrips, lady beetles and parasitic wasps. However, these are unlikely to provide complete control of WFT.

**Chemical:** registered or permitted chemical options for controlling WFT (Table 60) are limited and differ from those used to manage plague thrips (page 95), therefore, correctly identifying the pest thrips species is vital.



Figure 139. Use sticky traps to monitor for various thrips species.

Table 60. Registered or permitted products for western flower thrips in NSW.

| Active constituent (example trade name)          | Insecticide group(s) | WHP <sup>1</sup> (days)                                           | Effect on beneficials | Registered for use in... <sup>2</sup>                         |
|--------------------------------------------------|----------------------|-------------------------------------------------------------------|-----------------------|---------------------------------------------------------------|
| Flonicamid (Mainman®, PER89215, expires 31.5.28) | 29                   | 21                                                                | Low                   | Persimmons; suppression only                                  |
| Orange oil (PREV-AM®)                            | NA                   | Not required when used as directed                                | Unknown               | Apples; suppression only                                      |
| Spinetoram (Delegate®)                           | 5                    | Pome fruit 7; stone fruit 3                                       | Medium                | Apples, pears, apricots, cherries, nectarines, peaches, plums |
| Spinosad (Entrust® Organic)                      | 5                    | Apples, pears, apricots, cherries, nectarines, plums 3; peaches 7 | Low                   | Apples, pears, apricots, cherries, nectarines, peaches, plums |
| Spirotetramat (PER84804, expires 31.12.28)       | 23                   | 21                                                                | Medium                | Stone fruit                                                   |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Thrips – onion thrips



## *Thrips tabaci*

Although considered a secondary pest in temperate fruit orchards, onion thrips are regularly detected and can damage flowers and fruit.

## Risk period

Table 61. The peak risk period for onion thrips.

| Bud swell/<br>green tip | Blossom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|---------|------------|---------|-------------|----------|
|                         |         |            |         |             |          |

## Pest identification

Adult onion thrips are pale yellow to light brown and generally 1.0–1.2 mm long (Figure 140). In Australia there are only all-female populations. Pale eyes distinguish them from plague thrips and WFT. Onion thrips develop rapidly in temperatures between 16 and 28 °C, and multiple generations can occur during the growing season.

## Damage

Both adult and nymph onion thrips can cause damage when feeding by piercing and rasping the leaf surface. The feeding areas later appear as silvery patches on the leaves. When feeding areas are large, the plant's ability to photosynthesise and maintain water balance is greatly reduced, resulting in yield loss or reduced fruit size. Apart from direct damage, onion thrips are a vector of various viruses that can be transmitted by their feeding habits.

## Monitoring

Monitor for onion thrips using yellow sticky traps placed throughout the orchard from bud burst to shuck fall. The traps can show thrips activity levels and can also be used to obtain a formal identification of the type of thrips present in the orchard.

## Management

**Cultural and physical:** avoid mowing orchard inter-rows and adjacent pastures at or just before bloom as this might move thrips into the crop.

**Biological:** there are several natural predators of plague thrips including predatory mites, bugs, lacewings, predatory thrips, lady beetles and parasitic wasps. However, these are unlikely to provide complete control of onion thrips, particularly during periods of rapid pest influx.

**Chemical:** an effective control program for onion will be based on strategic spraying that is informed by monitoring and observation. When spraying at or around bloom, be particularly aware of any label warnings and recommendations for protecting pollinators. It should be noted that, like WFT, onion thrips can develop significant insecticide resistance.



Figure 140. Adult onion thrips. Photo: Alton N Sparks Jr, University of Georgia, Bugwood.org.

Table 62. Registered or permitted products for onion thrips in NSW.

| Active constituent<br>(example trade name) | Insecticide group(s) | WHP <sup>1</sup> (days)            | Effect on beneficials | Registered for use in... <sup>2</sup> |
|--------------------------------------------|----------------------|------------------------------------|-----------------------|---------------------------------------|
| Methomyl (Methomyl 225)                    | 1A                   | Not required when used as directed | High                  | Stone fruit                           |
| Orange oil (PREV-AM®)                      | NA                   | Not required when used as directed | Unknown               | Apples; suppression only              |
| Potassium salts of fatty acids (Hitman®)   | Bio-pesticide        | Not required when used as directed | Unknown               | Fruit trees                           |
| Piperonyl butoxide + pyrethrins (Py-Bo)    | 3A                   | 1                                  | High                  | All crops <sup>3</sup>                |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label. <sup>3</sup> All crops = apples, pears, apricots, cherries, nectarines, peaches, plums and persimmons.

# Two-spotted mite

## *Tetranychus urticae*



Two-spotted mite (TSM) is the most common pest mite species affecting all temperate fruit. It is more likely to become a problem in warm to hot, dry summers and when sprays for other pests and diseases disrupt predatory insects.

## Risk period

Table 63. The peak risk period for two-spotted mite.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Pest identification

Adult female TSM are approximately 0.6 mm long and, while they can be seen with the naked eye, are best viewed with a 10× hand lens or light microscope. They are opaque, cream, and have 2 distinctive dark patches (spots) on either side of the upper and forward part of the body (Figure 141). Adult males are smaller and less distinctive than females. Eggs are also opaque, cream and very small, about 0.1 mm (Figure 142). TSM activity is often associated with webbing over the affected foliage.



Figure 141. Two-spotted mite adults.



Figure 142. Juvenile two-spotted mites with eggs on an apple leaf.

## Damage

TSM damages crops by feeding mostly on the underside of leaves, causing cells to turn yellow–white and lose their photosynthetic capacity. Heavy feeding causes severe speckling of the foliage, giving the trees a bronzed look. Leaf bronzing can significantly affect normal tree function and can lead to premature leaf drop, negatively affecting fruit development and colouring in red fruit varieties. With TSM, this feeding damage is usually first noticed in the inner and lower third of the tree canopy.

## Monitoring

During the growing season, and particularly as spring and summer temperatures increase, monitor the undersides of leaves for TSM and their eggs. Webbing can indicate that mite populations are in the canopy. TSM should not be confused with other orchard pest mites, such as European red mite (page 63) or bryobia mite (page 48). Scouting for plant damage, such as bronzed or yellowed leaves, can be a quick way to identify pest mite hotspots. There are several ways to quantify the risk from mite populations, including mite counts, presence or absence, percentage of leaves infested and cumulative leaf-infested days (CLIDs). Your local IPM consultant should be able to help with applying these methods.

## Management

**Cultural and physical:** similar to most mite pests, TSM seems to prefer dusty conditions and often thrives in orchard trees adjacent to unsealed roads. Any method that reduces dust arising from such sources will help decrease TSM activity. Maintaining good soil moisture and minimising tree stress, particularly through the hottest part of the season, will help trees resist damage and recover from mite attack.

**Biological:** the predatory mites *Galendromus occidentalis* (formerly *Typhlodromus occidentalis*), *Phytoseiulus persimilis* (Figure 143) and *Neoseiulus californicus* can be effective biological control agents for TSM if seasonal conditions and crop protection chemical selection are favourable. *G. occidentalis* is established in the key apple-growing regions and can be effectively seeded into blocks via leaves and cuttings. *P. persimilis* is reared commercially for purchase and release.

There are many other naturally occurring predators of TSM including lacewings and *Stethorus* beetles, which will help control TSM populations, provided they are not killed by sprays used for other orchard pests.

**Chemical:** two-spotted mite is a high-profile pest, and there are resistant populations to several key insecticidal groups. CropLife Australia maintains an [insecticide resistance management](https://www.croplife.org.au/resources/programs/resistance-management/insecticide-resistance-management-strategies/) (IRM, <https://www.croplife.org.au/resources/programs/resistance-management/insecticide-resistance-management-strategies/>) plan for European red mite, two-spotted mite and green peach aphid, available online. IRM is essential to maintain the efficacy of valuable insecticides. Preventing resistance from occurring is easier than trying to regain susceptibility.

Early season sprays should use chemistry with a low effect on beneficial insects to conserve predatory mite populations. In contrast, broad-spectrum insecticides or those with a high impact on beneficial insect populations have the potential to flare up mite populations.

Regular monitoring for both predatory insects and pest mite populations to inform spray decisions is critical. Wherever possible, make no more than one application from each registered miticide group per season. Effective mite control spray programs usually incorporate a single horticultural mineral oil during winter or just before bud burst. Consider also chemical rotation and insecticide mode of action to control other pests of pome fruit, such as codling moth, light brown apple moth and woolly aphid. These sprays can promote chemical resistance in mite pests. The chemical options for controlling TSM are listed in Table 64.



Figure 143. The predatory mite, *Phytoseiulus persimilis*, attacking two-spotted mites.

Table 64. Registered or permitted products for two-spotted mite in NSW, page 1 of 2.

| Active constituent (example trade name)         | Insecticide group(s) | WHP <sup>1</sup> (days)                              | Effect on beneficials | Registered for use in... <sup>2</sup>               |
|-------------------------------------------------|----------------------|------------------------------------------------------|-----------------------|-----------------------------------------------------|
| Abamectin (Vertimec®)                           | 6                    | 14                                                   | High                  | Apples, pears                                       |
| Abamectin + chlorantraniliprole (Voliam Targo®) | 6 + 28               | 7                                                    | High                  | Pome fruit                                          |
| Acequinocyl (Kanemite®)                         | 20B                  | 14                                                   | Low                   | Pome fruit, stone fruit including cherries          |
| Bifenazate (Acramite®)                          | 20D                  | Apricots, nectarines, peaches, plums 3; pome fruit 7 | Low                   | Apples, pears, apricots, nectarines, peaches, plums |
| Clofentezine (Apollo®)                          | 10A                  | 21                                                   | Low                   | Pome fruit, stone fruit                             |
| Cyflumetofen (Danisaraba®)                      | 25A                  | 7                                                    | Low                   | Pome fruit                                          |

Table 64. Registered or permitted products for two-spotted mite in NSW, page 2 of 2.

| Active constituent<br>(example trade name)  | Insecticide<br>group(s)                | WHP <sup>1</sup> (days)                    | Effect on<br>beneficials | Registered for use in... <sup>2</sup>      |
|---------------------------------------------|----------------------------------------|--------------------------------------------|--------------------------|--------------------------------------------|
| Etoxazole (Paramite®)                       | 10B                                    | 7                                          | High                     | Pome fruit, stone fruit<br>except cherries |
| Fenbutatin oxide (Talk Miticide)            | 12B                                    | Apples, pears 2;<br>peaches, nectarines 14 | Low                      | Apples, pears, peaches,<br>nectarines      |
| Hexythiazox (Calibre®)                      | 10A                                    | 3                                          | Low                      | Apples, pears, stone fruit                 |
| Horticultural mineral oil<br>(various)      | Paraffinic<br>oil and<br>petroleum oil | 1                                          | Low                      | Pome fruit, stone fruit                    |
| Milbemectin (Milbeknock®)                   | 6                                      | 14                                         | High                     | Pome fruit, stone fruit                    |
| Orange oil (PREV-AM®)                       | NA                                     | Not required when<br>used as directed      | Unknown                  | Apples                                     |
| Potassium salts of fatty acids<br>(Hitman®) | Bio-pesticide                          | Not required when<br>used as directed      | Unknown                  | Fruit trees                                |
| Propargite (Omite®)                         | 12C                                    | 7                                          | Medium                   | Apples, stone fruit                        |
| Spiromesifen (Interrupt®)                   | 23                                     | 14                                         | High                     | Pome fruit, stone fruit                    |
| Tebufenpyrad (Pyranica®)                    | 21A                                    | 14                                         | Medium                   | Apples, pears, peaches                     |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Weevils



## Various species

Many weevil species can affect pome and stone fruit but they are relatively uncommon in conventionally sprayed orchards in NSW. Weevils can be a significant problem in organic orchards and some weevil species are high-priority pests in export markets.

## Risk period

Table 65. The peak risk period for weevils.

| Bud swell/<br>green tip | Blossom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|---------|------------|---------|-------------|----------|
|                         |         |            |         |             |          |

The most potentially damaging weevils are:

- Apple weevil (*Otiorynchus cribricollis*)
- Eucalyptus weevil (*Goniapterus scutellatus*; [Figure 144](#))
- Fuller's rose weevil (*Asynonychus cervinus*; [Figure 145](#))
- Fruit tree root weevil (*Leptopius robustus*; [Figure 146](#))
- Garden weevil (*Phlyctinus callosus*; [Figure 147](#))

## Pest identification

Weevils are small beetles that have snouts, a set of antennae, a rounded thorax, 6 legs and are usually coloured dark brown to red-brown. Different weevil species can be distinguished by the markings on their back.



Figure 144. Eucalyptus weevil. Photo: William M. Ciesla, Forest Health Management International, Bugwood.org.



Figure 145. Fuller's rose weevil.



Figure 146. Fruit tree root weevil. Photo: Pest and Diseases Image Library, Bugwood.org.



Figure 147. Garden weevil. Photo: Pest and Diseases Image Library, Bugwood.org.

## Damage

Weevils damage the fruit, leaves and roots of fruit trees (Figure 148). Feeding on fruit causes scarring, making it unsuitable for the fresh market. Weevils feeding on leaves deposit excreta around the stem end of the fruit, which results in downgrading. Some weevils cause partial or complete ringbarking on the fruit stalks, resulting in reduced fruit size or abortion. The Eucalyptus weevil is a quarantine pest that can contaminate export consignments.

## Monitoring

Monitor for weevils from late October to late December, depending on the species. Weevil infestations tend to be localised to one area of the orchard and infestation is likely to recur in these areas. Trunk banding with a sticky coating, such as polybutenes and wax, or using a fibrous material can be a useful way to monitor for weevil activity.

## Management

**Cultural and physical:** good orchard hygiene will prevent weevil populations from establishing. Carefully inspect any equipment, including ladders and bins being moved from one area of the orchard to another, and always work on clean blocks before moving to infested blocks. Weeds and rubbish on the orchard floor can act as hosts for weevils to lay eggs and provide an alternative feeding site. Maintaining a clean weed strip and having a mown inter-row (Figure 149) will reduce the number of weevils in the orchard.



Figure 148. Fuller's rose weevil damage to apple leaves.



Figure 149. A mown inter-row will reduce the number of weevils in the orchard.

**Biological:** weevils can be eaten by small birds and preyed upon by parasitic wasps. Avoid using harmful pesticides to increase the population of parasitic wasps, which will help control the number of weevils in the orchard.

**Chemical:** the chemical options for controlling weevils are listed in Table 66.

Table 66. Registered or permitted products for weevils in NSW.

| Active constituent (example trade name)      | Insecticide group(s) | WHP <sup>1</sup> (days)                | Effect on beneficials | Registered for use in... <sup>2</sup>                                                |
|----------------------------------------------|----------------------|----------------------------------------|-----------------------|--------------------------------------------------------------------------------------|
| Alpha-cypermethrin (Imtrade Dictate Duo 100) | 3A                   | 14                                     | High                  | Pome fruit. NSW, Vic, SA and WA only.                                                |
| Indoxacarb (Avatar® eVo)                     | 22A                  | Pome fruit, cherries 14; stone fruit 7 | Low                   | Pome fruit and stone fruit for apple weevil, Fuller's rose weevil and garden weevil. |
| Tetraniliprole (Vayego® 200 SC)              | 28                   | Pome fruit 7; stone fruit 3            | Low                   | Pome fruit, stone fruit                                                              |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Wingless grasshoppers

## *Phaulacridium vittatum*



Wingless grasshoppers are native to Australia and can be a problem in most temperate fruit crops in all growing regions.

## Risk period

Table 67. The peak risk period for wingless grasshoppers.

| Bud swell/<br>green tip | Blossom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|---------|------------|---------|-------------|----------|
|                         |         |            |         |             |          |

## Pest identification

Wingless grasshoppers develop through a series of growth stages. Newly emerged wingless grasshoppers are dark grey and less than 2 mm long. Adults grow to about 10–20 mm long and have white stripes along both sides of the upper body (Figure 150). Most grasshoppers have short, non-functional wings, but a small proportion of the population is capable of flight and, therefore, wider dispersal. Unlike Australian plague locusts (page 45), wingless grasshopper populations are usually localised and do not form large migratory swarms.



Figure 150. Adult wingless grasshopper. Photo: Harvey Perkins, Canberra Nature Map.

## Damage

Wingless grasshoppers feed on leaves and young shoots and can cause substantial defoliation.

## Monitoring

Monitor for grasshoppers from September to November when the newly hatched grasshoppers are emerging. Look for hopper activity and signs of foliage and shoot feeding.

## Management

**Cultural and physical:** weeds in the orchard should be removed as these can provide shelter for emerging and developing grasshopper nymphs.

**Biological:** wingless grasshoppers are prey for several predators. Parasites, including nematodes and *Scelio* spp., can have a substantial effect on egg survival. Poultry, such as chickens, can also be an effective option for control.

**Chemical:** the chemical options for controlling wingless grasshoppers are listed in Table 68.

Table 68. Registered or permitted products for wingless grasshoppers in NSW.

| Active constituent<br>(example trade name) | Insecticide<br>group(s) | WHP <sup>1</sup> (days)                                                  | Effect on<br>beneficials | Registered for use in... <sup>2</sup>                     |
|--------------------------------------------|-------------------------|--------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------|
| Carbaryl (Bugmaster®)                      | 1A                      | Pome fruit 77; stone fruit 35                                            | High                     | Pome fruit, stone fruit;<br>do not use on cherries        |
| Fenitrothion (Sumithion® ULV)              | 1B                      | 14                                                                       | High                     | Apples, cherries                                          |
| Indoxacarb (Avatar® eVo)                   | 22A                     | Apricots, nectarines,<br>peaches, plums 7; apples,<br>pears, cherries 14 | Low                      | Apples, pears, apricots,<br>nectarines, peaches,<br>plums |
| Malathion (Fyfanon® ULV)                   | 1B                      | 3                                                                        | High                     | Pome fruit, stone fruit                                   |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Woolly apple aphid



*Eriosoma lanigerum*

Woolly apple aphids (WAA) are a serious pest of apple and pear trees.

## Risk period

Table 69. The peak risk period for woolly apple aphid.

| Bud swell/<br>green tip | Blossom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|---------|------------|---------|-------------|----------|
|                         |         |            |         |             |          |

## Pest identification

Woolly apple aphids are most noticeable during the growing season when they cluster in white woolly colonies on young green shoots (Figure 151) and around pruning cuts.

Woolly apple aphids survive through winter as an early-stage nymph called a crawler, which is oblong, flattened and grey to brown. Crawlers find sheltered positions in cracks and crevices in the bark, although most disperse to the base of the tree and infest the roots. Adults are purple and about 1–2 mm long (Figure 152).

## Damage

Galls (lumps) occur on shoots and roots when aphid feeding induces swelling of the surrounding plant tissue. Galls in leaf axils can interfere with fruit and vegetative bud development, reducing normal tree growth and potential yield. Damage to root systems (particularly on young trees) can be extensive and result in reduced tree growth and root death.

Heavy infestations will produce sticky honeydew that can land on fruit and lead to unsightly sooty mould developing.

## Monitoring

The results of regular pest monitoring should guide woolly apple aphid management. This can be carried out in conjunction with other routine activities in the orchard.

Woolly apple aphids can enter the orchard on young nursery stock; always check nursery trees at delivery and before planting for infestations, particularly on the young root systems.

In mature and developing orchards, check the tree canopy for aerial colonies from late spring through to postharvest. This can be a random visual inspection of trees throughout a block but make sure to check different varieties within a block as rootstocks and varieties can differ in their susceptibility and likelihood of infestation. During inspections, look for signs of parasitism.



Figure 151. Woolly apple aphid colonies on an apple tree.



Figure 152. Woolly apple aphid adult. Photo: Jeffrey W Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org.

## Management

**Cultural and physical:** woolly apple aphids prefer to colonise sheltered sites within the tree, so pruning to maintain an open canopy will help make the tree less attractive to them. Paint large pruning cuts to deter WAA.

Rootstocks vary in susceptibility to colonisation by WAA. Some of the main dwarfing rootstocks currently used in Australia are susceptible to WAA, including M26 (moderately susceptible) and M9 (very susceptible). The semi-dwarfing rootstock MM106 is considered resistant but is less suited to modern high-density production systems in most regions.

**Biological:** lady beetles (Figure 153) and lacewing larvae (refer to 'The importance of protecting beneficial insects' on page 110) are useful natural WAA predators and should be encouraged in the orchard by maintaining a diverse plant species mix in the tree inter-row and by avoiding disruptive insecticides. *Aphelinus mali* is an effective parasitic wasp of WAA. It lays eggs in the live aphids, causing them to stop producing wool and turn black. Check for *A. mali* parasitism when monitoring. When mature, the wasp inside the aphid's body will emerge by chewing a circular hole in the aphid's abdomen.

European earwigs (*Forficula auricularia*) can be an important predator of WAA. Studies in apple orchards showed that when present in high numbers early in the growing season, European earwigs (particularly in combination with the parasitic wasp *A. mali*) can control WAA.

**Chemical:** a chemical control strategy will focus firstly on controlling the root colonies (using a soil or collar drench) in early spring before they become a major problem in the tree canopy. Controlling aerial colonies during late spring to summer should seek to maximise the effects of *A. mali* and other beneficial insects. Avoid chemicals likely to harm any beneficial insects or use with caution and only when necessary (Table 70).



Figure 153. Lady beetles feeding on woolly apple aphid and galls caused by the aphids.

Table 70. Registered or permitted products for woolly apple aphid in NSW.

| Active constituent (example trade name) | Insecticide group(s) | WHP <sup>1</sup> (days)            | Effect on beneficials | Registered for use in... <sup>2</sup> |
|-----------------------------------------|----------------------|------------------------------------|-----------------------|---------------------------------------|
| Acetamiprid + novaluron (Cormoran®)     | 4A + 15              | Apples 70; pears 35                | Medium                | Apples, pears; suppression only       |
| Clothianidin (Samurai®)                 | 4A                   | 7                                  | High                  | Apples; foliar spray or soil drench   |
| Flonicamid (Mainman®)                   | 29                   | 21                                 | Low                   | Apples                                |
| Imidacloprid (Confidant 200SC)          | 4A                   | Not required when used as directed | Medium                | Apples                                |
| Malathion (Fyfanon® 440 EW)             | 1B                   | 3                                  | High                  | Apples, pears                         |
| Orange oil (PREV-AM®)                   | NA                   | Not required when used as directed | Unknown               | Apples; suppression only              |
| Pirimicarb (Pirimor®)                   | 1A                   | 2                                  | Medium                | Apples                                |
| Spirotetramat (Movento® 240 SC)         | 23                   | 21                                 | Medium                | Pome fruit; suppression only          |
| Sulfoxaflor (Transform® Isoclast™)      | 4C                   | 7                                  | Medium                | Pome fruit                            |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

Note: thiacloprid (e.g. Cobra® 480SC) is not registered for WAA, but if used to control codling moth as indicated, early-season sprays for WAA might not be required.



# Calculating degree days for temperate fruit moth pests

## What are degree days?

Degree days (DD) are a measure of temperature over time and are used to predict the timing of life stages of certain insect pests. A degree-day model counts the total time the temperature is above the minimum required for the pest to develop (lower developmental threshold).

There are established DD models for codling moth (CM), light brown apple moth (LBAM) and oriental fruit moth (OFM). These are best at predicting the first generation of activity and usually become less reliable with subsequent generations as the season progresses. For this reason, some insecticide labels for these key pests include DD recommendations for the timing of the first sprays. Knowing how to calculate DD will help growers time their first sprays effectively.

## What do you need?

To use DD for your first spray timing, you will need:

- pheromone traps to determine biofix
- thermometer (max–min or weather station)
- calculator or spreadsheet

## What is biofix?

Biofix is the date of the first sustained flight of adult moths recorded in pheromone traps. It is used as a starting point for the accumulation of degree days and to guide the timing of the first spray.

## How to determine biofix

Deploy traps at a density of about one per hectare, ensuring coverage of the warmest part of the orchard and any known hotspots where damage occurred in the previous season(s). Establish traps at least 1 week before bloom for CM and OFM, and at bud break for LBAM. The aim is to record at least 2 weeks with no moths in the traps before the first flights begin. This will increase confidence in determining the biofix when moths emerge from their overwintering pupation sites and fly into the canopy.

Checking traps daily until the first sustained moth flight is recorded will increase the accuracy of the biofix date that you set.

## Calculating and accumulating degree days from biofix

A simple formula for calculating DD using daily maximum and minimum temperatures and the lower developmental threshold for the pest is:

$$\text{Degree days} = \frac{(\text{max temp } ^\circ\text{C} + \text{min temp } ^\circ\text{C})}{2} - \text{lower developmental threshold } ^\circ\text{C}$$

### Example calculation

For codling moth (with a lower developmental threshold of 10 °C; [Table 71](#)) on a day where the daily maximum temperature was 18 °C and the minimum was 7 °C, the DD for that day would be 2.5, calculated as follows:

$$\text{Degree days} = \frac{(18\text{ }^\circ\text{C} + 7\text{ }^\circ\text{C})}{2} - 10$$

$$\text{DD} = 25 \div 2 - 10$$

$$\text{DD} = 12.5 - 10$$

$$\text{DD} = 2.5$$

The lower developmental thresholds for CM, LBAM and OFM are listed in [Table 71](#).

DDs are calculated daily from biofix and added together to give cumulative degree days (CDD).

If using a max-min thermometer, this is best housed in a Stevenson screen to ensure accurate measurement of ambient temperature, which can be recorded in a spreadsheet or on paper. Some weather stations (Figure 154) with built-in models will track DD accumulation and predict first spray timing. Table 72 provides an example of how to accumulate degree days in a spreadsheet format.

Label recommendations for spray timing

Most insecticides for CM, OFM and LBAM target the start of egg hatch (i.e. larval stages). The active ingredient, fenoxycarb (e.g. Insegar®), is a notable exception that only controls newly laid eggs. Codling moth and OFM egg hatch occur on average at approximately 110 CDD from biofix, while LBAM egg hatch occurs around 140 CDD. Refer to product labels for recommendations on timing applications based on cumulative degree days.

Table 71. Lower developmental thresholds for 3 key moth pests.

| Moth pest              | Lower developmental threshold (°C) |
|------------------------|------------------------------------|
| Codling moth           | 10.0                               |
| Light brown apple moth | 7.0                                |
| Oriental fruit moth    | 7.5                                |

Table 72. An example of a codling moth DD record sheet showing degree days (DD) and cumulative degree days (CDD).

| Date of temperature recording | Maximum temperature (°C) | Minimum temperature (°C) | Degree days | Cumulative degree days |
|-------------------------------|--------------------------|--------------------------|-------------|------------------------|
| 3.10.19 Biofix                | 12                       | 5                        | 0.0         | 0.0                    |
| 4.10.19                       | 22                       | 6                        | 4.0         | 4.0                    |
| 5.10.19                       | 25                       | 10                       | 7.5         | 11.5                   |
| 6.10.19                       | 19                       | 8                        | 3.5         | 15.0                   |
| 7.10.19                       | 27                       | 12                       | 9.5         | 24.5                   |
| 8.10.19                       | 24                       | 10                       | 7.0         | 31.5                   |



Figure 154. A weather monitoring station in an apple orchard.



# The importance of protecting beneficial insects

Modern orchard crop protection programs employ an integrated pest and disease management (IPDM) approach. This includes using a combination of tools, such as biological control agents and beneficial insects as well as synthetic chemicals, to manage the target pest or disease. Concerns about the environment and occupational health and safety mean that biological controls and beneficial insects are becoming increasingly important.

The absence of beneficial insects in the orchard can cause pest outbreaks, reduce pollination, increase crop damage, reduce tree health and lower fruit quality and yields. Without beneficial insects, growers can become reliant on chemical interventions, leading to pesticide resistance.

Orchard IPDM programs should minimise synthetic chemical use by identifying the target pest and using the least disruptive chemical ('softest') for control and only using synthetic chemicals when necessary. This also requires growers to use monitoring regimes that rely on pest thresholds (or achieving a certain number of pests in the orchard) before spraying. Choosing IPDM-friendly chemistry will help ensure beneficial insect populations have a chance to increase in the orchard, allowing nature to make a useful contribution to controlling the target pest or disease.

Some examples of beneficial insects that are found in temperate fruit orchards are listed in [Table 73](#).

Table 73. Beneficial insects found in temperate fruit orchards.

| Beneficial group                                                      | Target pests                                                           |
|-----------------------------------------------------------------------|------------------------------------------------------------------------|
| Earwigs                                                               | Woolly apple aphid, codling moth eggs and larvae, pear and apple pests |
| Hoverflies (Syrphidae)                                                | Aphids                                                                 |
| Lacewings                                                             | Aphids, mealybugs, small caterpillars, scale crawlers                  |
| Ladybird beetles (Coccinellidae, <a href="#">Figure 155</a> )         | Aphids, scale insects, mites                                           |
| Native bees and other pollinators                                     | Pollination services                                                   |
| Parasitic wasps (e.g. <i>Trichogramma</i> spp., <i>Aphidius</i> spp.) | Codling moth eggs, aphids and other pest insects                       |
| Predatory mites ( <a href="#">Figure 156</a> )                        | European red mite, two-spotted mite and other pest mites               |
| Spiders                                                               | Broad range of insect pests                                            |



Figure 155. Lady beetle. Photo: David Cappaert, Michigan State University, [www.msu.edu](http://www.msu.edu).



Figure 156. Predatory mite.

Knowing the current status of any pest or beneficial population can greatly improve the effectiveness of an IPDM strategy in the orchard. When a pest problem arises that requires a chemical input, always consider all the control options available and choose the one that will have the least effect on biological control agents living in the orchard.

## Protecting biological control agents

1. Be able to recognise orchard pests, beneficial insects and mites. Reference material is available on the [Bugs For Bugs](#) and the [Good Bug](#) websites.
2. Monitor orchard pests, beneficial insects and predatory mites to effectively time sprays. Growers can use the risk period tables on [page 40](#) and [page 41](#) to create a monitoring plan.
3. Use chemicals with the least toxicity to beneficials ([Table 74](#)). Consult the chemical label or the [Good Bug website](#) ([www.goodbugs.org.au/](http://www.goodbugs.org.au/)) for chemical toxicity.
4. Modify the orchard environment to encourage beneficials. Many predatory species rely on pollen from grasses, native flowers and herbs while waiting for prey.

Table 74. Pesticides toxic to predatory mites, lady beetles and lacewings.

|                     | <i>Phytoseiulus persimilis</i> | <i>Galendromus occidentalis</i> | <i>Galendromus pyri</i> | Lady beetles | Lacewings |
|---------------------|--------------------------------|---------------------------------|-------------------------|--------------|-----------|
| <b>Insecticides</b> |                                |                                 |                         |              |           |
| Bifenthrin          | XX                             | XX                              | XX                      | ?            | ?         |
| Carbaryl            | 0                              | X                               | 0                       | XX           | XX        |
| Malathion           | X                              | X                               | X                       | XX           | XX        |
| Methomyl            | XX                             | X                               | XX                      | X            | X         |
| Tau-fluvalinate     | XX                             | XX                              | XX                      | ?            | ?         |
| Trichlorfon         | XX                             | 0                               | ?                       | ?            | ?         |
| <b>Miticides</b>    |                                |                                 |                         |              |           |
| Abamectin           | X                              | X                               | X                       | X            | XX        |
| Tebufenpyrad        | XX                             | 0                               | 0                       | ?            | ?         |
| <b>Fungicides</b>   |                                |                                 |                         |              |           |
| Mancozeb            | X                              | 0                               | XX                      | X            | X         |
| Metiram             | X                              | 0                               | X                       | ?            | ?         |
| Ziram               | 0                              | 0                               | X                       | ?            | ?         |

Toxicity rating: XX = very harmful; X = harmful; 0 = nil or minor effect; ? = unknown.

This list is not exhaustive; other chemistries might be available.

For more information on chemicals, refer to the [Good Bug website](#) ([www.goodbugs.org.au/chemicals.html](http://www.goodbugs.org.au/chemicals.html)).

### Protect your beneficials by:

- Monitor for pests and beneficials regularly.
- Use economic thresholds before spraying.
- Choose selective pesticides whenever possible.
- Avoid unnecessary broad-spectrum insecticide use.
- Provide flowering plants, cover crops and habitat diversity.
- Protect pollinators during flowering.
- Encourage natural enemies as part of an IPDM strategy.

## More resources

[Australian apple and pear IPDM program](https://extensionaus.com.au/ozapplepearipdm/) (<https://extensionaus.com.au/ozapplepearipdm/>)

[Australasian biological control](http://www.goodbugs.org.au) (<http://www.goodbugs.org.au>)

[Beneficial insects for agriculture](https://www.nsw.gov.au/regional-and-primary-industries/natural-resource-management/biodiversity-on-farms/beneficial-insects) (<https://www.nsw.gov.au/regional-and-primary-industries/natural-resource-management/biodiversity-on-farms/beneficial-insects>)

[Good Bug website](http://www.goodbugs.org.au/) ([www.goodbugs.org.au/](http://www.goodbugs.org.au/) and [www.goodbugs.org.au/suppliers.html](http://www.goodbugs.org.au/suppliers.html))

[Integrated pest, disease and weed management manual for Australian apples and pears](https://www.horticulture.com.au/Information-Hub/Our-Projects/Historical-Reports/AP07009) (<https://www.horticulture.com.au/Information-Hub/Our-Projects/Historical-Reports/AP07009>)

[Strengthening cultural and biological management of pests and diseases in apple and pear orchards](https://www.horticulture.com.au/Information-Hub/Our-Projects/Project-Reports/AP19002) (<https://www.horticulture.com.au/Information-Hub/Our-Projects/Project-Reports/AP19002>)



# Diseases

## Alternaria leaf blotch and fruit spot

### Alternaria species

Alternaria leaf blotch and fruit spot is a fungal disease that causes dark, irregular lesions on apple leaves and fruit, reducing both tree health and crop quality. It can be particularly damaging in warm growing regions with high summer rainfall.



### Risk period

Table 75. The peak risk period for alternaria leaf blotch and fruit spot.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

### Disease identification

Alternaria **leaf blotch** is characterised by irregular red–brown lesions on the leaves that often exhibit blackish-purple borders (Figure 157). Typically, leaf blotch first appears from late spring to early summer and can increase in severity through to harvest.

Alternaria **fruit spot** is characterised by small, slightly sunken, light to medium brown spots appearing on the lenticels of the fruit (Figure 158), often surrounded by a black border. Fruit spotting is commonly observed in late summer through to harvest.



Figure 157. Alternaria leaf blotch on apple leaves.



Figure 158. Alternaria fruit spot on an apple.

### Damage

In favourable weather conditions, the alternaria leaf blotches will continue to grow. When the leaf is half covered by lesions, it will turn yellow (Figure 159) and drop prematurely from the tree. Fruit spotting symptoms appear after warm weather and usually no earlier than 42 days before harvest.

### Monitoring

Due to the similarity of alternaria leaf blotch and fruit spot symptoms to those caused by other problems (e.g. fungal diseases and physical damage). If you are thinking of applying



Figure 159. Leaf yellowing from alternaria leaf blotch.

fungicides (or other treatments) to combat this disease, make sure the diagnosis is correct and consider having the symptoms assessed.

The presence of leaf blotch in mid-summer can be an early warning for the likely appearance of fruit spotting later in the season and the need for preventative sprays. Scout the orchard from late spring to look for symptoms of leaf blotch and again for fruit spot in late summer.

Be particularly vigilant with susceptible apple varieties including Fuji, Gala, Cripps Pink and Red Delicious.

## Management

**Cultural and physical:** managing alternaria leaf blotch and fruit spot includes removing or breaking down all leaf and pruning residue during winter (after leaf fall), especially if there was leaf disease last season. In very small orchards, this is done manually by raking and removing leaf litter. In larger orchards, mechanised sweeping (Figure 160) and mulching are more cost-effective at hastening the breakdown of last season's leaf matter.

**Biological:** there are no known biological controls for alternaria leaf blotch and fruit spot in apples.

**Chemical:** the chemical options for controlling alternaria leaf blotch and fruit spot are listed in Table 76.



Figure 160. The Sadie sweeper moves leaf and pruning residue to the centre of the row for mulching. Photo: Crendon Machinery.

Table 76. Registered or permitted products for alternaria leaf blotch and fruit spot in NSW.

| Active constituent (example trade name)       | Fungicide group(s) | WHP <sup>1</sup> (days)            | Effect on beneficials | Registered for use in... <sup>2</sup> |
|-----------------------------------------------|--------------------|------------------------------------|-----------------------|---------------------------------------|
| Boscalid + pyraclostrobin (Pristine®)         | 7 + 11             | 14                                 | Low                   | Apples                                |
| Cyprodinil + fludioxonil (Switch®)            | 9 + 12             | 14                                 | Low                   | Apples; suppression only              |
| Dithianon (Dinon 700 WG)                      | M9                 | 21                                 | Low                   | Apples                                |
| Fluopyram + trifloxystrobin (Luna® Sensation) | 7 + 11             | 14                                 | Low                   | Apples; suppression only              |
| Fluxapyroxad (Sercadis®)                      | 7                  | 0                                  | Low                   | Apples                                |
| Mefentrifluconazole (Belanty®)                | 3                  | 7                                  | Low                   | Apples; suppression only              |
| Metiram (Fruitcote)                           | M3                 | 14                                 | Medium                | Apples                                |
| Penthiopyrad (Fontelis®)                      | 7                  | 28                                 | Low                   | Apples; suppression only              |
| Polyoxin D zinc salt (Intervene® WG)          | 19                 | Not required when used as directed | Low                   | Apples                                |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Angular leaf spot



## *Cercospora* species and *Pseudocercospora* species

Angular leaf spot is a bacterial disease in persimmons that produces sharply defined, angular lesions on leaves, often leading to premature defoliation and reduced fruit quality.

### Risk period

Table 77. The peak risk period for angular leaf spot in persimmons.

| Bud swell/<br>green tip | Shoot<br>extension | Flowering and fruit<br>development | Harvest | Postharvest | Dormancy |
|-------------------------|--------------------|------------------------------------|---------|-------------|----------|
|                         |                    |                                    |         |             |          |

### Disease identification

Angular leaf spot will show as straight-edged leaf spots that are found on infected persimmon foliage ([Figure 161](#)). Spots range in size up to 7 mm, with dead tissue in the centre and a green halo. The spots sometimes merge as the disease progresses, forming large necrotic areas. The shape of the leaf spots can be used to differentiate angular leaf spot infections from another important pathogen in persimmons, *Mycosphaerella* spp. ([page 127](#)), which results in similar leaf spots but with round margins.



Figure 161. Angular leaf spot on persimmon leaves, showing characteristic angular lesions. Photo: George et al. (2017).

### Damage

The disease is favoured by wet growing seasons, especially in Qld and NSW. Differences in varietal susceptibility have been reported, with the Izu cultivar being particularly vulnerable. Severe leaf infections can lead to yellowing, premature leaf fall and lost photosynthetic capacity, affecting fruit growth and carbohydrate reserves for the following season.

### Monitoring

Start random leaf inspections in early spring and continue weekly throughout the season. Inspect all varieties to ensure any varietal differences are seen. Identifying the infection early will help target treatments before it becomes too severe.

### Management

**Cultural and physical:** *Cercospora* spores survive over winter on infected leaves and leaf stalks for 5–6 months and are a source of inoculum for infections in the following season. Therefore, good orchard hygiene to remove or destroy fallen leaves by thoroughly mulching will help reduce the disease potential. The fungus is spread by rainfall and is thought to be favoured by dense canopies and high humidity.

Pruning trees to encourage an open canopy will speed up drying, reduce humidity and allow for good spray penetration and coverage.

**Chemical:** the chemicals currently registered or permitted for managing angular leaf spot in NSW persimmon orchards are listed in [Table 78](#).

Table 78. Registered or permitted products for angular leaf spot in NSW.

| Active constituent (example trade name)                      | Fungicide group(s) | WHP <sup>1</sup> (days) | Effect on beneficials | Registered for use in... <sup>2</sup> |
|--------------------------------------------------------------|--------------------|-------------------------|-----------------------|---------------------------------------|
| Chlorothalonil ( <a href="#">PER13445</a> , expires 30.4.30) | M5                 | 7                       | Low                   | Persimmons                            |
| Difenoconazole ( <a href="#">PER87599</a> , expires 31.3.29) | 3                  | 28                      | Low                   | Persimmons                            |
| Mancozeb ( <a href="#">PER12488</a> , expires 30.11.29)      | M3                 | 14                      | Medium                | Persimmons                            |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Apple scab and pear scab



## *Venturia inaequalis* and *Venturia pirina*

Apple scab (or black spot) is one of the most serious diseases in apples and pears and is found in all NSW growing regions. The fungus that infects apples (*V. inaequalis*) cannot infect pears, nor can the pear fungus (*V. pirina*) infect apples.

## Risk period

Table 79. The peak risk period for apple scab and pear scab.

| Bud swell/<br>green tip | Bloom | Mid season          | Harvest | Postharvest | Dormancy |
|-------------------------|-------|---------------------|---------|-------------|----------|
| Primary infection       |       | Secondary infection |         |             |          |

## Disease identification

Scab infection results in small, olive green–brown, irregularly shaped lesions on the leaves (Figure 162) that become larger as they mature. Symptoms on the fruit are similar to those on the leaves but tend to have well-defined margins. As fruit lesions mature, they become brown to black and appear dry (Figure 163 and Figure 164).



Figure 162. Primary scab infection on an apple leaf. Photo: RW Samson, Purdue University, Bugwood.org.

## Damage

Primary infections occur on leaves and fruit when overwintering spores (mostly from last season's leaf litter) land on wet foliage and germinate. Once mature, primary infections can lead to secondary infections when spores are splashed through the canopy by rain.

Growth around the lesions becomes distorted as the fruit expands, giving it an uneven shape. Fruit lesions are superficial and the fungus does not extend into the flesh, but scabbed fruit is considered unsuitable for wholesale and retail fresh markets.



Figure 163. Scab lesions on an apple. Photo: Andrew Taylor, WA DPIRD.

## Monitoring

For apple or pear scab to occur, the host plant must remain wet long enough for the fungal spores that cause the disease to germinate. Warm (17–20 °C), wet conditions are ideal for infection. Disease models using rainfall, temperature and period of wetness to predict the likelihood of infection are available. Infection warning services operate in some regions. Alternatively, growers can establish weather station(s) and monitor infection risk in their orchards.

Inspect foliage and fruit closely when the primary infection period is over (around the end of November to the start of December).

## Management

**Cultural and physical:** good orchard hygiene, especially during autumn and winter, helps to reduce scab carry-over and disease pressure in spring. A postharvest foliar nitrogen spray (usually Lo-biuret urea at 500 g/100 L of spray) at early leaf fall will encourage microbial action to break down fallen leaves. Any action that removes or helps break down fallen leaves will be beneficial. This includes raking, removing or sweeping and slashing to chop leaves into small pieces.



Figure 164. Scab lesions on a pear. Photo: Bruce Watt, University of Maine, Bugwood.org.

**Biological:** there are currently no biological control agents available for apple and pear scab. Growing scab-resistant varieties can reduce or negate the need for intensive fungicide spray programs. Consult your fruit nursery supplier for information on resistant varieties.

**Chemical:** spray programs (Table 80) for scab should focus on achieving thorough control during the spring primary infection period (from green tip to the end of spring). If controlled well during the primary infection period, the potential for secondary infections through the rest of the season is dramatically reduced.

Table 80. Registered or permitted products for apple scab and pear scab in NSW.

| Active constituent (example trade name)                    | Fungicide group(s) | WHP <sup>1</sup> (days)            | Effect on beneficials | Registered for use in... <sup>2</sup>                           |
|------------------------------------------------------------|--------------------|------------------------------------|-----------------------|-----------------------------------------------------------------|
| Boscalid + pyraclostrobin (Pristine®)                      | 7 + 11             | 14                                 | Low                   | Apples, pears                                                   |
| Captan (Captan®)                                           | M4                 | 7                                  | Low                   | Apples, pears                                                   |
| Copper-based fungicides (various)                          | M1                 | 1                                  | Low                   | Apples, pears                                                   |
| Cyprodinil (Chorus®)                                       | 9                  | Not required when used as directed | Low                   | Apples, pears                                                   |
| Difenoconazole (Bogard®)                                   | 3                  | 28                                 | Low                   | Apples, pears                                                   |
| Dithianon (Dinon 700 WG)                                   | M9                 | 21                                 | Low                   | Apples, pears                                                   |
| Dodine (Syllit®)                                           | U12                | 5                                  | Low                   | Apples, pears                                                   |
| Fluopyram + trifloxystrobin (Luna® Sensation)              | 7 + 11             | 14                                 | Low                   | Apples, pears                                                   |
| Fluxapyroxad (Sercadis®)                                   | 7                  | 0                                  | Low                   | Apples                                                          |
| Hexaconazole (Hexaconazole 50 SC)                          | 3                  | Apples 7; pears 14                 | Low                   | Apples, pears                                                   |
| Ipflufenquin (Migiwa® Kinoprol®)                           | 52                 | 42                                 | Low                   | Apples                                                          |
| Isopyrazam (Seguris Flexi®)                                | 7                  | 21                                 | Low                   | Apples, pears                                                   |
| Kresoxim-methyl (Stroby®)                                  | 11                 | 42                                 | Low                   | Apples, pears                                                   |
| Mancozeb (Dithane® Rainshield® NeoTec®)                    | M3                 | 14                                 | Medium                | Pome fruit                                                      |
| Mefentrifluconazole (Belanty®)                             | 3                  | 7                                  | Low                   | Apples                                                          |
| Metiram (Polyram®)                                         | M3                 | 14                                 | Medium                | Pome fruit                                                      |
| Myclobutanil (Myclonil® WG)                                | 3                  | 21                                 | Low                   | Apples, pears                                                   |
| Penconazole (Topas®)                                       | 3                  | 14                                 | Low                   | Apples, pears                                                   |
| Penthiopyrad (Fontelis®)                                   | 7                  | 28                                 | Low                   | Pome fruit                                                      |
| Potassium bicarbonate + potassium silicate (Ecocarb® Plus) | M2                 | Not required when used as directed | Low                   | Apples                                                          |
| Sulfur as polysulfide sulfur (Grochem Lime Sulphur)        | M2                 | Not required when used as directed | Medium                | Apples, pears; do not apply to Delicious or Cox's Orange Pippin |
| Thiram (Thiram WG)                                         | M3                 | 7                                  | Low                   | Apples, pears                                                   |
| Trifloxystrobin (Flint® 500 WG)                            | 11                 | 35                                 | Low                   | Apples, pears                                                   |
| Triforine (Saprol®)                                        | 3                  | 1                                  | Low                   | Apples; do not apply to Golden Delicious or Cox's Orange Pippin |
| Zineb (Barmac Zineb)                                       | M3                 | 14                                 | Low                   | Pome fruit                                                      |
| Ziram (Ziram WG)                                           | M3                 | 7                                  | Medium                | Apples, pears                                                   |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# PIPS 4 Profit investigates biological control options for apple and pear

Tonya Wiechel and Greg Lefoe, Senior Research Scientists, Agriculture Victoria Research

The PIPS 4 Profit Program's 'Pest and disease management project' (AP22001) team is working to identify and evaluate biological control agents for managing key plant diseases affecting fruit quality and yield. These include apple scab (caused by the fungus *Venturia inaequalis*), pear scab (caused by the fungus *Venturia pirina*) and Phytophthora root rot (*Phytophthora* sp.).

Sustainably managing plant diseases is essential for the health of apple and pear crops, and the marketability of a quality fruit product. Biological control offers an environmentally friendly alternative to chemical pesticides, using natural organisms to suppress plant pathogens. Current research, led by plant pathologist Tonya Wiechel from Agriculture Victoria, is being conducted to see how biological control agents researched in vitro worldwide perform against isolates collected from Australian apple and pear orchards.



## Identifying potential biological control agents

The first step involves identifying potential biological control agents. Agriculture Victoria researchers are assessing prior global research on potential biological agents with a focus on in vitro studies that have shown promising results in suppressing plant pathogens. These insights can streamline the biological selection process and focus on the most viable candidates.

## In vitro bioassays: laying the foundation

Initial laboratory experiments will be undertaken to test the efficacy of selected biological agents. These in vitro bioassays will be conducted using amended agar methodologies, allowing Agriculture Victoria researchers to see the interaction between the biological agents and pathogen isolates collected during field surveys. These isolates (Figure 165), representing apple scab from throughout Australia including Victoria, NSW, Tasmania, South Australia and Western Australia, will serve as the foundation for testing the inhibitory properties of the biological agents.

Additionally, green fruit bioassays will be used to provide a more realistic assessment of the biological agents' potential. This approach will help determine their ability to protect plant tissues in conditions that mimic real-world scenarios. By the end of this phase, Agriculture Victoria researchers will have a clearer understanding of which biological agents show the most promise in controlling these pathogens.

## Advancing to tree assays

Biological agents showing efficacy in in vitro tests will progress to more complex evaluations in potted tree assays to assess the agents' effectiveness in a controlled environment that closely replicates field conditions. This phase will provide critical data on the biological agents' ability to protect plants over time, their interactions with the host plants, and any potential side effects. These insights are vital for deciding whether the biological agents are suitable for practical application.

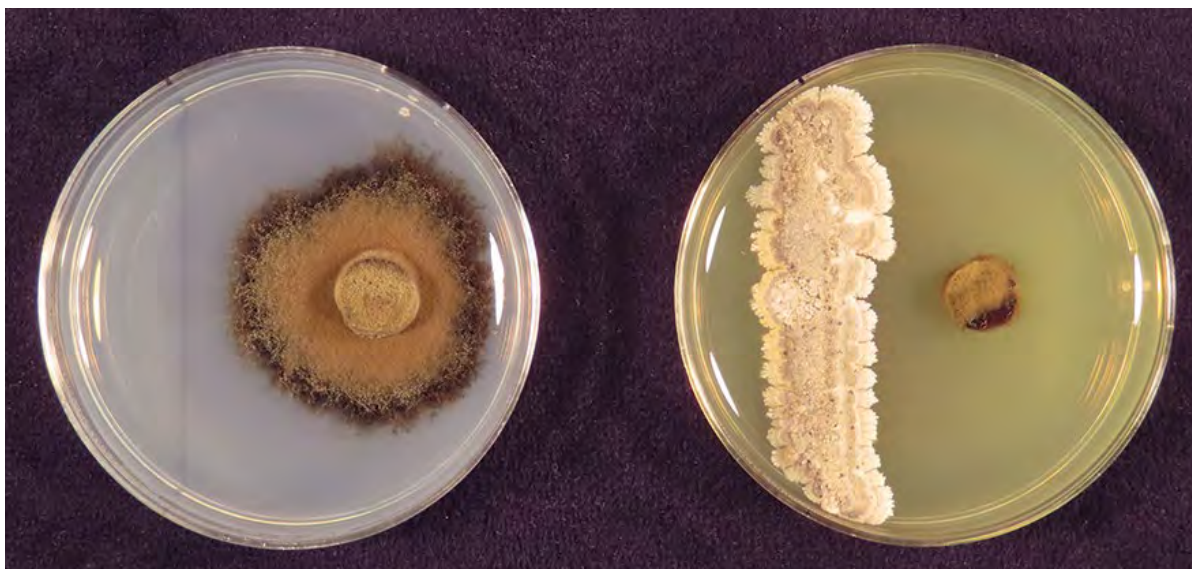


Figure 165. A laboratory bioassay testing whether beneficial *Streptomyces* can slow the growth of *Venturia inaequalis*, the fungus that causes apple scab. Reduced fungal growth indicates potential for biological control.

### Towards sustainable plant disease management

This work is a significant step in the quest for increased sustainable plant disease management options for the Australian apple and pear industry. By focusing on biological control, it aligns with horticulture's efforts in Australia to reduce chemical inputs and promote integrated management solutions. The collaboration between Agriculture Victoria and regional partners such as Pomewest, NSW DPIRD, Fruit Growers Victoria, and the Tasmanian Institute of Agriculture researchers underscores the importance of industry partnerships for encouraging innovation and delivering practical solutions to growers through PIPS 4 Profit.

As the project progresses, the potential to revolutionise the management of apple and pear scab and *Phytophthora* grows closer to reality. With continued research and support, biological control agents could soon become indispensable tools in the fight against plant diseases, more sustainably.

### Acknowledgement

This part of the PIPS 4 Profit program's 'Integrated pest and disease management' project (AP22001) has been funded by Hort Innovation, using the apple and pear research and development levy, contributions from the Australian Government, and co-investment from Agriculture Victoria.

**Hort  
Innovation** **APPLE AND  
PEAR FUND**

# Bacterial canker



## *Pseudomonas syringae* pv. *syringae*

Bacterial canker is one of the most damaging diseases affecting stone fruit orchards. It can significantly reduce the health, yield, and longevity of the trees. Once bacterial canker becomes established, it is very difficult to control. Young or stressed trees are most vulnerable.

## Risk period

Table 81. The peak risk period for bacterial canker.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Disease identification

Trees infected with bacterial canker will have dead bark, and when this is removed, the underlying tissue will be orange–brown (Figure 166). Large amounts of gum can exude from the trunk and bark cankers. The infection first appears on the leaves as water-soaked spots, which can turn brown and fall out as the leaves age (Figure 167). Leaves can also have a yellowing, rolled appearance. Bacterial canker can be identified on the fruit by sunken spots with dark centres and occasionally with underlying gum pockets. Growers should be careful when pruning and performing other management activities not to damage the bark of trees during winter, as this can encourage bacterial canker infection.



Figure 166. Bacterial canker on a cherry tree.



Figure 167. Bacterial canker on cherry leaves.

## Damage

Bacterial canker is favoured by wet, windy conditions in autumn and early winter before and during leaf fall. Damage to trees and limbs from pruning and hail or wind during early dormancy increases disease risk. Rain during the growing season will encourage the disease to spread throughout the orchard. Bacterial canker will cause economic loss through a reduced fruit yield and branches or whole trees dying.

## Monitoring

Inspect orchard trees regularly throughout the growing season for signs of dieback and/or gum-producing cankers. Severely infected trees should be promptly removed.

## Management

**Cultural and physical:** it is good practice to avoid pruning stone fruit trees in winter. Prune soon after harvest or as close to bud burst as possible. Prune areas of the orchard with canker problems last and paint large pruning wounds with white acrylic paint or a proprietary tree wound dressing. As canker can be particularly severe in young plantings, it is important to maintain a complete disease control schedule.

Control wildlife such as rabbits, hares and macropods that will chew young green bark, creating disease entry sites.

Cherries and apricots are more susceptible than nectarines, peaches and plums. Therefore, in orchards prone to bacterial canker infection, avoid planting cherries and apricots.

**Biological:** there are currently no biological controls available for controlling bacterial canker in stone fruit.

**Chemical:** the chemical options for controlling bacterial canker are listed in [Table 82](#).

Table 82. Registered or permitted products for bacterial canker in NSW.

| Active constituent<br>(example trade name)                                                                  | Fungicide<br>group(s) | WHP <sup>1</sup> (days)            | Effect on<br>beneficials | Registered for use<br>in... <sup>2</sup> |
|-------------------------------------------------------------------------------------------------------------|-----------------------|------------------------------------|--------------------------|------------------------------------------|
| <i>Bacillus amyloliquefaciens</i> (Serenade® Opti Biofungicide, <a href="#">PER88559</a> , expires 30.6.29) | 44                    | Not required when used as directed | Low                      | Cherries; suppression only               |
| Copper-based fungicides (various)                                                                           | M1                    | 1                                  | Low                      | Apricots, cherries, stone fruit          |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Bacterial spot

*Xanthomonas arboricola* pv. *pruni*

Bacterial spot is a disease that causes spotting on plum, apricot and peach leaves and fruit.



## Risk period

Table 83. The peak risk period for bacterial spot.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Disease identification

Fruit infected with bacterial spot will have small, circular, greasy spots that will sink and darken as the fruit enlarges (Figure 168). These spots often crack, providing entry points for secondary diseases. Similar greasy or water-soaked spots can be seen on the leaves of infected trees (Figure 169).

## Damage

Up to half the fruit can become unsaleable due to cosmetic damage. Extensive leaf spotting results in ripping and tattering of foliage, reducing photosynthetic capacity.

## Monitoring

Monitor leaves and fruit throughout the season to ensure early detection as the infection is difficult to control once established. Wet conditions between blossom and petal fall favour infection on peach and nectarine leaves and fruit. Windy, wet conditions and heavy dew during the growing season will also favour secondary infections. Extra caution is recommended during these conditions.

## Management

**Cultural and physical:** trees suffering from other pest and disease are more susceptible to bacterial spot. Maintain soil fertility and good pest management. Destroy any nearby neglected trees as they can act as a source of inoculum for the disease. Do not prune during wet weather.

**Biological:** there are currently no known biological control agents for bacterial spot.

**Chemical:** control options for bacterial spot in NSW are limited (Table 84). However, applying a full control schedule for leaf curl, shot hole and rust, which includes an early-season copper application, should help control bacterial spot.

Table 84. Registered or permitted products for bacterial spot in NSW.

| Active constituent (example trade name)                                                    | Fungicide group | WHP <sup>1</sup> (days)            | Effect on beneficials | Registered for use in... <sup>2</sup> |
|--------------------------------------------------------------------------------------------|-----------------|------------------------------------|-----------------------|---------------------------------------|
| <i>Bacillus amyloliquefaciens</i> (Serenade® Opti Biofungicide, PER88559, expires 30.6.29) | 44              | Not required when used as directed | Low                   | Cherries                              |
| Copper oxychloride (Coppox® WG)                                                            | M1              | 1                                  | Low                   | Stone fruit                           |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.



Figure 168. Bacterial spot on plums.



Figure 169. Bacterial spot on leaves. Photo: University of Georgia Plant Pathology, Bugwood.org.

# Bitter rot

*Glomerella cingulata* (anamorph: *Colletotrichum gloeosporioides*)



Bitter rot is a fruit-rotting disease of apples and pears that is more common in orchards with minimal fungicide spray programs.

## Risk period

Table 85. The peak risk period for bitter rot.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Disease identification

Bitter rot symptoms will usually appear as small, light brown circular spots when the fruit is almost full size (Figure 170). These spots can enlarge rapidly and become sunken. If left untreated, the rot can penetrate deep into the flesh. Occasionally, if disease pressure is high, leaves of infected trees might show small, red flecks on the surface.



Figure 170. Bitter rot in an apple. Photo: University of Georgia Plant Pathology, Bugwood.org.

## Damage

Infection on fruit makes it unsaleable and prone to decay. Fruit infection is less common in orchards that receive a full protective spray program for apple or pear scab.

## Monitoring

Bitter rot is usually seen in warmer coastal districts after November, particularly in the Sydney basin. It is favoured by warm, humid and wet conditions during the growing season. Careful monitoring of susceptible areas is recommended from 3 weeks after petal fall until harvest.

## Management

**Cultural and physical:** good orchard hygiene is critical for bitter rot control. The disease can survive over winter on mummified fruit and dead wood; this must be removed and destroyed. All prunings should be removed from the orchard floor or mulched.

**Biological:** there are currently no biological controls available for controlling bitter rot in pome fruit.

**Chemical:** the chemical options for controlling bitter rot are listed in Table 86.

Table 86. Registered or permitted products for bitter rot in NSW.

| Active constituent (example trade name) | Fungicide group | WHP <sup>1</sup> (days) | Effect on beneficials | Registered for use in... <sup>2</sup> |
|-----------------------------------------|-----------------|-------------------------|-----------------------|---------------------------------------|
| Copper oxychloride (Coppox® WG)         | M1              | 1                       | Low                   | Pome fruit                            |
| Dithianon (Dinon 700 WG)                | M9              | 21                      | Low                   | Apples                                |
| Mancozeb (Dithane® Rainshield® NeoTec®) | M3              | 14                      | Medium                | Pome fruit                            |
| Metiram (Polyram®)                      | M3              | 14                      | Medium                | Pome fruit                            |
| Zineb (Barmac Zineb)                    | M3              | 14                      | Low                   | Pome fruit                            |
| Ziram (Ziram WG)                        | M3              | 7                       | Medium                | Apples                                |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Blossom blight and brown rot



## *Monilinia* species

Blossom blight and brown rot are the most important diseases of stone fruit. The causal fungi are the 2 related pathogens, *Monilinia fructicola* and *Monilinia laxa*.

## Risk period

Table 87. The peak risk period for blossom blight and brown rot.

| Bud swell/<br>green tip | Bloom          | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|----------------|------------|---------|-------------|----------|
|                         | Blossom blight | Brown rot  |         |             |          |

## Disease identification

Blossom blight results in brown, shrivelled, dead flowers (Figure 171) and some dieback of the associated shoot growth. Brown rot infection appears as a soft brown decay of the developing fruit, which exhibits profuse brown–grey spores over the surface of the infection as it matures (Figure 172 and Figure 173). Infected fruit will sometimes shrivel and hang on the tree. These mummified (or mummy) fruit (Figure 174) and infected shoots are a major source of spores for the next season and should be removed from the orchard.

The first blossoms on cherry trees are the first susceptible tissue for infection at the start of the growing season (Figure 175). Conidia (spores produced asexually by various fungi), inoculum from mummified fruit, infected peduncles (the stalk bearing a flower or fruit) and cankers can be dispersed by splashing or wind-blown rain early in the season (Dowling et al. 2019).

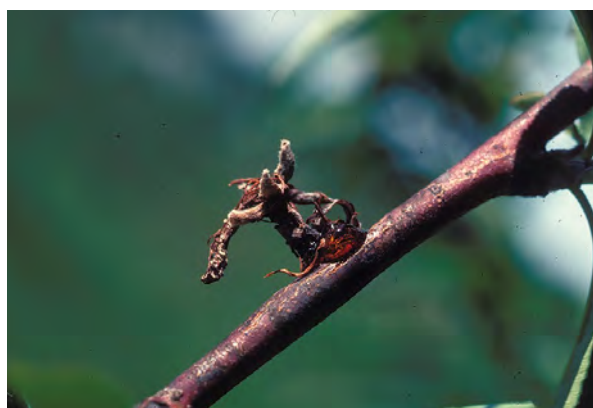


Figure 171. A peach flower infected by blossom blight. Photo: University of Georgia Plant Pathology, University of Georgia, Bugwood.org.



Figure 172. Peach fruit showing typical brown rot infection. Photo: Rebecca A Melanson, Mississippi State University Extension, Bugwood.org.



Figure 173. Brown rot on cherries.



Figure 174. Mummified fruit. Photo: Clemson University, USDA Cooperative Extension Slide Series, Bugwood.org.

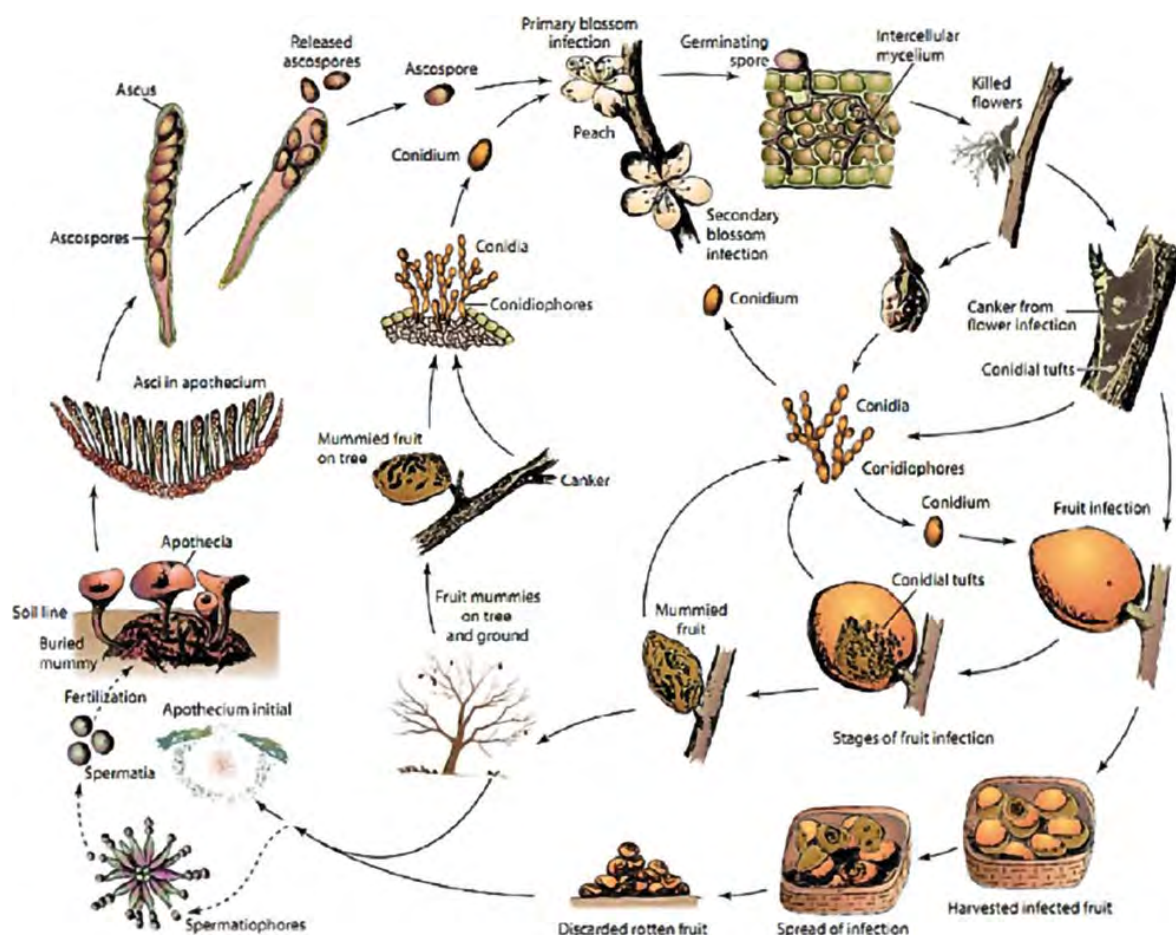


Figure 175. *Monilinia* species life cycle. Reprinted with permission from Plant Pathology, Elsevier Limited.

## Damage

Blossom blight and brown rot can cause significant flower, shoot and crop loss if not carefully managed. Blossom blight reduces the number of viable flowers and damages fruiting shoots, which can result in poor pollination and fruit set. Brown rot makes fruit unsaleable and late-season infections can lead to fruit breakdown during postharvest storage, handling and marketing.

## Monitoring

Blossom and/or fruit infection is likely if the disease was present in the previous season, and with warm conditions (around 20 °C or greater) combined with moisture from heavy dew or rainfall. Due to the high potential for losses, particularly in warm, wet seasons, it is worth monitoring for these diseases regularly. Check flowers, shoots and developing fruit for signs of rot at least weekly, and particularly following favourable weather conditions.

## Management

**Cultural and physical:** remove and destroy infected shoots and mummified fruit as soon as they are noticed. Doing this early in the season will reduce the potential for the infection to spread to healthy fruit later in the season. Winter pruning is a good time for a final check to ensure all mummified fruit and infected shoots are removed before the start of the new season.

**Biological:** research into potential biocontrol agents for *Monilinia* species in stone fruit is ongoing. The plant protein-based biological fungicide, Problad® Verde, has label registration for suppression of brown rot and blossom blight in stone fruit (Table 88).

**Chemical:** an effective spray program for blossom blight and brown rot will include a combined approach of protective cover sprays and curative fungicides as needed from bud burst through flowering and to harvest, depending on weather conditions and disease pressure. Postharvest chemical options are also included in Table 88. For more information on managing storage rots, including brown rot, refer to [Managing postharvest diseases and disorders on page 147](#).

Table 88. Registered or permitted products for blossom blight and brown rot in NSW.

| Active constituent<br>(example trade name)                                                                        | Fungicide<br>group(s) | WHP <sup>1</sup> (days)                                  | Effect on<br>beneficials | Registered for use in <sup>2</sup> ...                                                |
|-------------------------------------------------------------------------------------------------------------------|-----------------------|----------------------------------------------------------|--------------------------|---------------------------------------------------------------------------------------|
| <i>Bacillus amyloliquefaciens</i><br>(Serenade® Opti Biofungicide,<br><a href="#">PER88559</a> , expires 30.6.29) | 44                    | Not required when<br>used as directed                    | Low                      | Cherries; suppression only                                                            |
| BLAD (ProBlad® Verde)                                                                                             | BM01                  | Not required when<br>used as directed                    | Low                      | Stone fruit; suppression only                                                         |
| Captan (Captan®)                                                                                                  | M4                    | 7                                                        | Low                      | Stone fruit except apricots                                                           |
| Chlorothalonil (Bravo Weather<br>Stik®)                                                                           | M5                    | Apricots, cherries,<br>nectarines, peaches 7;<br>plums 1 | Low                      | Apricots, cherries, nectarines,<br>peaches, plums                                     |
| Copper oxychloride (Coppox® WG)                                                                                   | M1                    | 1                                                        | Low                      | Stone fruit                                                                           |
| Cyprodinil (Chorus®)                                                                                              | 9                     | Not required when<br>used as directed                    | Low                      | Apricots, nectarines, peaches,<br>plums                                               |
| Dithianon (Dinon 700 WG)                                                                                          | M9                    | 21; canning peaches 1                                    | Low                      | Apricots, cherries, nectarines,<br>peaches, plums, prunes                             |
| Dodine (Syllit®)                                                                                                  | U12                   | Not required when<br>used as directed                    | Low                      | Nectarines, peaches; do not<br>apply after petal fall                                 |
| Fludioxonil (Starling)                                                                                            | 12                    | Not required when<br>used as directed                    | Low                      | Stone fruit                                                                           |
| Fluopyram + trifloxystrobin<br>(Luna® Sensation)                                                                  | 7 + 11                | 1                                                        | Low                      | Stone fruit                                                                           |
| Iprodione 250 g/L (Rovral Liquid®)                                                                                | 2                     | 0                                                        | Low                      | Stone fruit; orchard spray only                                                       |
| Iprodione 500 g/L<br>(Rovral Aquaflo®)                                                                            | 2                     | 0                                                        | Low                      | Stone fruit; orchard spray and<br>postharvest dip                                     |
| Mancozeb (Dithane® Rainshield®<br>NeoTec®)                                                                        | M3                    | 14                                                       | Medium                   | Stone fruit                                                                           |
| Mandestrobin (Intuity™)                                                                                           | 11                    | 7                                                        | Low                      | Stone fruit                                                                           |
| Penthiopyrad (Fontelis®)                                                                                          | 7                     | Not required when<br>used as directed                    | Low                      | Stone fruit                                                                           |
| Potassium bicarbonate +<br>potassium silicate (Ecocarb® Plus)                                                     | M2                    | Not required when<br>used as directed                    | Low                      | Nectarines                                                                            |
| Procymidone (Sumislex® 500)                                                                                       | 2                     | 9                                                        | Low                      | Stone fruit                                                                           |
| Propiconazole (Tilt® 500 EC)                                                                                      | 3                     | 1                                                        | Low                      | Stone fruit; blossom and fruit<br>phases only                                         |
| Pyraclostrobin + fluxapyroxad<br>(Merivon®)                                                                       | 11 + 7                | 2                                                        | Low                      | Cherries                                                                              |
| Sulfur as polysulfide sulfur<br>(Grochem Lime Sulphur)                                                            | M2                    | Not required when<br>used as directed                    | Medium                   | Stone fruit (dormant to bud<br>swell spray only)                                      |
| Sulfur (Thiovit Jet®)                                                                                             | M2                    | Not required when<br>used as directed                    | Medium                   | Nectarines, peaches, plums                                                            |
| Thiram (Thiram WG)                                                                                                | M3                    | 7                                                        | Low                      | Stone fruit                                                                           |
| Triforine (Saprol®)                                                                                               | 3                     | 0                                                        | Low                      | Apricots, nectarines, peaches,<br>plums, prunes; orchard spray<br>and postharvest dip |
| Ziram (Ziram WG)                                                                                                  | M3                    | 7                                                        | Low                      | Cherries, nectarines, peaches                                                         |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

\*Note: some of the chemicals listed have label claims for both blossom blight and brown rot, while others are only registered for one of these diseases. Always check the product label to ensure the correct product choice.

# Circular leaf spot



## *Mycosphaerella* species

Circular leaf spot was first identified in persimmons by NSW DPIRD in 2003. As the symptoms are similar, this leaf disease is often confused with angular leaf spot, which is also found in persimmons ([page 114](#)).

## Risk period

Table 89. The peak risk period for circular leaf spot in persimmons.

| Bud swell/<br>green tip | Shoot extension | Flowering and fruit<br>development | Harvest | Postharvest | Dormancy |
|-------------------------|-----------------|------------------------------------|---------|-------------|----------|
|                         |                 |                                    |         |             |          |

## Disease identification

Infected persimmon foliage will have large circular spots with green halos ([Figure 176](#)). However, the lesions are generally larger and more rounded (i.e. not constrained by the leaf cell or vein structures) than with angular leaf spot.

## Damage

Circular leaf spot is a major problem, especially in wet seasons, and particularly in northern NSW and the Sydney basin growing regions. It can lead to reduced photosynthetic capacity and premature leaf drop, which can affect fruit size in the current season and carbohydrate accumulation for the following season.

## Monitoring

Start random leaf inspections in early spring and continue checking weekly throughout the season. Make sure all varieties are included to ensure any varietal differences are captured. Identifying the infection early will help to target treatments before it becomes too severe.

## Management

**Cultural and physical:** circular leaf spot spores survive over winter on infected leaves and leaf stalks for 5–6 months and are a source of inoculum for infections in the following season. Therefore, good orchard hygiene to remove and destroy fallen leaves will help reduce the disease potential. The fungus is spread by rainfall and is thought to be favoured by dense canopies and high humidity. Pruning trees to encourage an open canopy will speed up drying, reduce humidity and allow for good spray penetration and coverage.

**Biological:** there are currently no biological control treatments available for circular leaf spot.

**Chemical:** there are currently no chemicals registered or permitted to control circular leaf spot in persimmons. However, spray programs targeting angular leaf spot ([page 114](#)) might reduce the incidence of this disease.



Figure 176. Circular leaf spot (*Mycosphaerella* spp.) symptoms on a persimmon leaf. Photo: George et al. (2017).

# Crown gall

## *Agrobacterium tumefaciens*

The bacterium *Agrobacterium tumefaciens* causes crown gall. It occurs mostly on stone fruit and some ornamentals, for example roses, but less commonly on pome fruit, grapes and olives.



## Risk period

Table 90. The peak risk period for crown gall.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Disease identification

Crown gall can be identified by galls on the crown of the plant (the point at the soil line where the main roots join the stem) and on the roots. They can also form on the main stem above the soil level or on branches. An example of a severe gall infection at the upper crown area on the roots of a peach seedling is shown in [Figure 177](#). There might not be any visible effect on the plant other than the galls. If infection is severe and many galls are present, plants, particularly young ones, can be stunted and unthrifty and can die if they are stressed by dry conditions. However, these symptoms are not diagnostic for crown gall; the presence of galls identifies the disease.



Figure 177. Crown gall on a peach seedling. Illustration: Margaret Senior.

## Damage

Galls first appear as small, pale, roughened lumps of tissue. They enlarge, darken and become convoluted. The galls can be 25–50 mm in diameter on nursery plants and up to 300 mm on trees in the field.

Crown gall causes the greatest financial loss in the nursery; up to 80% of plants can be lost, with the symptoms only being noticed when the plants are dug up for sale. Suppliers are legally required to reject all infected plants before sale.

## Monitoring

Check nursery stock and new trees for galls on receipt and before planting; notify the nursery supplier if crown gall is suspected. Young trees that look weak or stunted can be dug up and the crown area can be inspected for galls.

## Management

**Cultural and physical:** the disease can be transferred between trees on pruning and grafting equipment; frequently disinfecting tools will help prevent this. Avoid unnecessary damage to the root system. The bacterium is thought to spread in water, so selecting a well-drained orchard site for establishment might help minimise the risk. Resistant rootstocks might also have a role in preventing crown gall in some tree crops. Speak with the nursery supplier to enquire about rootstock choices for your crop.

**Biological:** the only effective biological treatment for crown gall is listed in [Table 91](#).

Table 91. Registered treatment for crown gall in NSW.

| Active constituent (example trade name)     | Treatment type | WHP <sup>1</sup> (days) | Effect on beneficials | Registered for use in... <sup>2</sup> |
|---------------------------------------------|----------------|-------------------------|-----------------------|---------------------------------------|
| Rhizobium rhizogenes strain K1026 (Nogall®) | Biological     | 0                       | Low                   | Stone fruit                           |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Peach leaf curl



## *Taphrina deformans*

Peach leaf curl is a fungal disease that affects peaches and nectarines. If untreated, it is one of the most serious and common diseases of these crops.

### Risk period

Table 92. The peak risk period for peach leaf curl.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

### Disease identification

Leaf curl is often seen at the top of the canopy, where spray coverage might not have reached. Infection will appear on younger leaves first; they will be pink-red with the characteristic curling leaf (Figure 178).

### Damage

Peach leaf curl is favoured by a cool, wet spring during bud swell, followed by warm, humid conditions, which bring about rapid growth. The optimum temperature range for fungal growth is between 20 °C and 26 °C.

After the initial infection, leaves will curl and become severely distorted. Leaves then tend to turn yellow and fall, causing new tissue to replace fallen leaves. The energy required for this new growth reduces fruit set and weakens trees. Leaf curl can also affect young shoots, which become stunted and distorted, often resulting in shoot death. Infected fruit will have raised, irregularly shaped and rough areas on the skin surface (Figure 179).



Figure 178. Peach leaf curl. Photo: Whitney Cranshaw, Colorado State University.



Figure 179. Peach leaf curl symptoms on a peach. Photo: Gerald Holmes, Strawberry Centre, Cal Poly San Luis Obispo.

## Monitoring

Correct timing of protectant sprays in early spring (particularly copper-based fungicides) is vital for controlling the disease. Monitor bud development in late winter to early spring to ensure correct spray timing according to label instructions.

Monitor and record the incidence of leaf infection in the current season to inform management decisions for the next season.

## Management

**Cultural and physical:** where leaf curl has been a serious problem, it is important to put more effort into maintaining tree vigour. Thin more fruit than usual, ensure adequate irrigation and apply extra nitrogen fertiliser.

**Biological:** there are no known biological control agents for peach leaf curl. However, copper sprays provide effective control and some copper-based fungicides have been approved for use in organic production systems.

**Chemical:** the chemical options for controlling peach leaf curl are listed in [Table 93](#).

Table 93. Registered or permitted products for peach leaf curl in NSW.

| Active constituent<br>(example trade name)             | Fungicide<br>group(s) | WHP <sup>1</sup> (days)               | Effect on<br>beneficials | Registered for use in... <sup>2</sup>                               |
|--------------------------------------------------------|-----------------------|---------------------------------------|--------------------------|---------------------------------------------------------------------|
| Chlorothalonil (Bravo Weather Stik®)                   | M5                    | 7                                     | Low                      | Peaches                                                             |
| Copper-based fungicides (various)                      | M1                    | 1                                     | Low                      | Nectarines, peaches                                                 |
| Dithianon (Dinon 700 WG)                               | M9                    | 21                                    | Low                      | Nectarines, peaches                                                 |
| Dodine (Syllit®)                                       | U12                   | Do not apply after<br>petal fall      | Low                      | Nectarines, peaches                                                 |
| Sulfur as polysulfide sulfur (Grochem<br>Lime Sulphur) | M2                    | Not required when<br>used as directed | Medium                   | Stone fruit except cherries<br>(dormant to bud swell spray<br>only) |
| Ziram (Ziram WG)                                       | M3                    | 7                                     | Low                      | Cherries, nectarines, peaches                                       |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Phytophthora root and collar rot



## *Phytophthora* species

*Phytophthora* species soil pathogens cause root and collar rots in pome and stone fruit trees, causing significant tree decline and losses. Periods of high rainfall and wet soil create the highest risk for phytophthora root and collar rots.

## Risk period

Table 94. The peak risk period for phytophthora root and collar rots.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Disease identification

Although several species of *Phytophthora* can cause root and collar rot in temperate fruit orchards, the symptoms are generally the same in all temperate fruit trees. The first obvious sign of an infection is likely to be leaf yellowing, followed by premature leaf drop and a gradual decline in tree health, leading to tree death (Figure 180). This can occur in individual trees or groups, usually along a tree row. Closer inspection around the base of sick trees should reveal the tell-tale wood rot (collar rot) where the tree trunk meets the soil (Figure 181).



Figure 180. *Phytophthora* collar rot on an apple tree, showing various stages of decline from a light yellowing to premature leaf drop.



Figure 181. Apple tree on M26 rootstock with typical collar rot symptoms.

## Damage

*Phytophthora* spp. are water-borne soil pathogens that infect tree roots and crowns, causing a loss of root mass, trunk collar rot and significant tree decline. They are usually associated with poorly drained and waterlogged soil. Spores move through the soil in water, so disease spread might be increased with excessive irrigation.

## Monitoring

Treatment options are limited, so strategies for prevention and early detection are essential. Monitor orchards regularly for the early signs of leaf yellowing and tree decline.

## Management

**Cultural and physical:** cultural control of phytophthora root and collar rot focuses on preventative measures including:

- selecting well-drained sites for establishing new orchards
- using resistant rootstocks (options exist for apple and cherry)
- maintaining and improving soil structure
- managing irrigation water to avoid periods of soil saturation
- good orchard biosecurity practices, such as washing boots in footbaths before entering orchards, can prevent the disease from spreading.

**Biological:** beneficial soil bacteria and antagonistic fungi can help reduce the risk of soil-borne diseases. Building healthy soil by adding organic matter will help encourage beneficial soil organisms.

**Chemical:** the chemical options for controlling phytophthora are listed in [Table 95](#).

Table 95. Registered or permitted products for phytophthora root and collar rot in NSW.

| Active constituent (example trade name)                         | Fungicide group(s) | WHP <sup>1</sup> (days)                               | Effect on beneficials | Registered for use in... <sup>2</sup>       |
|-----------------------------------------------------------------|--------------------|-------------------------------------------------------|-----------------------|---------------------------------------------|
| Copper-based fungicides (various)                               | M1                 | 1                                                     | Low                   | Nectarines, peaches, plums; trunk treatment |
| Fosetyl-aluminium (Aliette®)                                    | 33                 | Apples 14; peaches not required when used as directed | Low                   | Apples, peaches                             |
| Fosetyl-aluminium ( <a href="#">PER85273</a> , expires 31.1.28) | 33                 | Not required when used as directed                    | Low                   | Apricots, nectarines, peaches, plums        |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Powdery mildew

## *Podosphaera leucotricha*



Powdery mildew is one of the most common diseases in apples. It can severely affect tree growth, particularly in young trees.

### Risk period

Table 96. The peak risk period for powdery mildew.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

### Disease identification

Leaves and shoots are most susceptible to powdery mildew in the first few days after opening. The first indication of powdery mildew is pale patches on the upper leaf surface (Figure 182). As the disease advances, the patches become powdery white and will cover both sides of the leaf. Leaves infected with mildew will have crinkled and cupped edges (Figure 183), giving them a narrow appearance.

### Damage

Infected leaves can often fall during summer, reducing the photosynthetic rate. Powdery mildew can severely affect tree growth, particularly on young trees. Infected floral buds might abort or produce small, stunted fruit, resulting in reduced yield and pack-out. Infections during flowering and early fruit development can damage the skin of apples, resulting in a russet that makes the fruit unmarketable.

### Monitoring

Powdery mildew outbreaks are most likely in spring and early summer, and with new growth in autumn. Relatively humid, mild conditions (10–25 °C) without rain favour this disease, although it can withstand hot, dry conditions and produce spores. These spores are then spread by wind but are killed in high temperatures. Monitor powdery mildew during winter and throughout the growing season. Growers can choose designated monitoring trees and assess 10 extension shoots on these trees. Inspect the top 5 unfolded leaves per shoot for the signs of powdery mildew, recording any incidences. Frequent monitoring of these shoots will increase the opportunity to intervene at the correct time, as powdery mildew can develop rapidly.



Figure 182. Early signs of powdery mildew infection on an apple leaf.



Figure 183. Powdery mildew on a new season apple shoot.

## Management

**Cultural and physical:** powdery mildew can be controlled by removing infected buds as this reduces the source of spores for infecting new leaves and buds. Winter pruning is a good time to remove infected shoot tips. Look for the white stems of infected one-year-old shoots and cut them back to uninfected wood. Removing infected prunings from the orchard will help reduce the potential for the disease to spread.

Pruning to open the canopy can also help reduce infection, as it encourages airflow through the canopy. Modifying the environment around the trees can also reduce the incidence of powdery mildew. Windbreaks, netting and tree planting should be managed to optimise airflow, particularly in regions where powdery mildew is problematic.

**Biological:** there are no known biological control agents available for powdery mildew in apples.

**Chemical:** the chemical options for controlling powdery mildew are listed in [Table 97](#).

Table 97. Registered or permitted products for powdery mildew in NSW.

| Active constituent (example trade name)                    | Fungicide group(s) | WHP <sup>1</sup> (days)            | Effect on beneficials | Registered for use in... <sup>2</sup>                           |
|------------------------------------------------------------|--------------------|------------------------------------|-----------------------|-----------------------------------------------------------------|
| Boscalid + pyraclostrobin (Pristine®)                      | 7 + 11             | 14                                 | Low                   | Apples                                                          |
| Bupirimate (Nimrod®)                                       | 8                  | 7                                  | Low                   | Apples                                                          |
| Difenoconazole (Bogard®)                                   | 3                  | 28                                 | Low                   | Apples, pears; suppression only                                 |
| Fluopyram + trifloxystrobin (Luna® Sensation)              | 7 + 11             | 14                                 | Low                   | Apples                                                          |
| Fluxapyroxad (Sercadis®)                                   | 7                  | 0                                  | Low                   | Apples                                                          |
| Hexaconazole (Synan)                                       | 3                  | 7                                  | Low                   | Apples                                                          |
| Ipflufenquin (Migiwa® Kinoprol®)                           | 52                 | 42                                 | Low                   | Apples                                                          |
| Isopyrazam (Seguris Flexi®)                                | 7                  | 21                                 | Low                   | Apples                                                          |
| Kresoxim-methyl (Stroby®)                                  | 11                 | 42                                 | Low                   | Apples                                                          |
| Mefentrifluconazole (Belanty®)                             | 3                  | 7                                  | Low                   | Apples                                                          |
| Myclobutanil (Systhane® 400 WP)                            | 3                  | 21                                 | Low                   | Apples                                                          |
| Orange oil (PREV-AM®)                                      | NA                 | Not required when used as directed | Unknown               | Apples                                                          |
| Penconazole (Topas®)                                       | 3                  | 14                                 | Low                   | Apples                                                          |
| Penthiopyrad (Fontelis®)                                   | 7                  | 28                                 | Low                   | Pome fruit                                                      |
| Polyoxin D zinc salt (Intervene® WG)                       | 19                 | Not required when used as directed | Low                   | Apples                                                          |
| Potassium bicarbonate + potassium silicate (Ecocarb® Plus) | M2                 | Not required when used as directed | Low                   | Apples                                                          |
| Proquinazid (Talendo®)                                     | 13                 | 28                                 | Low                   | Apples, pears                                                   |
| Sulfur as polysulfide sulfur (Grochem Lime Sulphur)        | M2                 | Not required when used as directed | Medium                | Apples                                                          |
| Sulfur (Thiovit Jet®)                                      | M2                 | Not required when used as directed | High                  | Pome fruit                                                      |
| Trifloxystrobin (Flint®)                                   | 11                 | 35                                 | Low                   | Apples, pears                                                   |
| Triforine (Saprol®)                                        | 3                  | 1                                  | Low                   | Apples; do not apply to Golden Delicious or Cox's Orange Pippin |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Rust



## *Tranzschelia discolor*

Rust is caused by a fungus (*Tranzschelia discolor*) and is identified by brown rust spores on the undersides of leaves. It can be a serious disease in stone fruit. Note, another genus of rust-causing fungi is *Uromyces* spp., and some chemical product labels list this on the label.

## Risk period

Table 98. The peak risk period for rust.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Disease identification

Rust symptoms can appear on the leaves, shoots and fruit. The upper surface of the leaf will become speckled with small yellow patches, while the underside develops rusty brown spots (Figure 184). Infected shoots will have small dead patches where the bark splits. Rust infection on the fruit can be identified by small, depressed spots with a dark reddish centre, often with a pale green border.

## Damage

Severe rust infection can cause premature leaf fall. Trees with rust will have considerably reduced yield, with fruit on defoliated trees having reduced sugar levels. Infected fruit is unsaleable as the infection can penetrate several millimetres into the flesh.

## Monitoring

Rust is favoured by warm weather with rain or heavy dew. Wet periods of 4 hours or more with an optimum temperature range of 13–26 °C are adequate for spore germination and subsequent leaf infection. Dry, windy conditions help to spread the rust spores, while rain can splash them onto young leaves. Carefully monitoring weather conditions (Figure 185) and treating orchards in periods that favour disease development is crucial for reducing rust in trees.



Figure 184. Rust on a plum leaf.



Figure 185. Monitoring the weather in an apple orchard.

## Management

**Cultural and physical:** good orchard hygiene will moderate the severity of rust infections. Where possible, remove all diseased wood and leaves during pruning and remove all fallen leaves from branches and crotches. Trees can carry small numbers of green leaves throughout winter. These should be removed and destroyed.

**Biological:** biological control agents are not currently available for the rust pathogen.

**Chemical:** the chemical options for controlling rust are listed in [Table 99](#).

Table 99. Registered or permitted products for rust in NSW.

| Active constituent (example trade name)             | Fungicide group(s) | WHP <sup>1</sup> (days)                | Effect on beneficials | Registered for use in... <sup>2</sup>                    |
|-----------------------------------------------------|--------------------|----------------------------------------|-----------------------|----------------------------------------------------------|
| Chlorothalonil (Bravo Weather Stik®)                | M5                 | Apricots, cherries, peaches 7; plums 1 | Low                   | Apricots, cherries, peaches, plums                       |
| Copper oxychloride (Coppox® WG)                     | M1                 | 1                                      | Low                   | Stone fruit                                              |
| Dithianon (Dinon 700 WG)                            | M9                 | 21                                     | Low                   | Nectarines, peaches, plums, prunes                       |
| Mancozeb (Dithane® Rainshield® NeoTec®)             | M3                 | 14                                     | Medium                | Stone fruit                                              |
| Metiram (Polyram®)                                  | M3                 | 14                                     | Medium                | Stone fruit                                              |
| Propiconazole (Tilt® 500 EC)                        | 3                  | 1                                      | Low                   | Plums for prune production                               |
| Sulfur as polysulfide sulfur (Grochem Lime Sulphur) | M2                 | Not required when used as directed     | Medium                | Apricots, peaches, plums, prunes, nectarines             |
| Sulfur (Thiovit Jet®)                               | M2                 | Not required when used as directed     | Medium                | Nectarines, peaches, plums                               |
| Zineb (Barmac Zineb)                                | M3                 | 14                                     | Low                   | Nectarines, peaches, plums (not early varieties), prunes |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Shot hole

## *Stigmina carpophila*

Shot hole is caused by a fungus (*Stigmina carpophila*) and affects the leaves, fruit and buds. It is very common in cherry orchards in NSW.



## Risk period

Table 100. The peak risk period for shot hole.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Disease identification

Shot hole is initially identified by small brown spots with reddish rims on the leaves (Figure 186). These spots grow and the centre falls out, leaving a round shot hole in the leaf. On the fruit, the spots (Figure 187) can develop into deep indentations.



Figure 186. Shot hole infection in cherry leaves.



Figure 187. Shot hole infection on a peach. Photo: William Brown Jr, Bugwood.org.

## Damage

Shot hole reduces the tree's photosynthetic capacity, which can affect fruit yield and quality. If the infection is severe, the tree might suffer from premature leaf fall. Fruit can also be marked and disfigured, making it unmarketable.

## Monitoring

Wet conditions in late winter to early spring can activate shot hole spores that have remained dormant in bud scales and twig lesions during the previous season. Infection requires at least 24 hours of continuous wetness and spores can germinate in temperatures as low as 1 °C. Rain during bud swell helps to spread the disease.

## Management

**Cultural and physical:** where practical, prune out infected wood and burn the prunings. Hastening leaf fall will reduce the amount of inoculum that builds up during autumn.

**Biological:** there are no known biological control agents for shot hole.

**Chemical:** the chemical options for controlling shot hole are listed in Table 101.

Table 101. Registered or permitted products for shot hole in NSW.

| Active constituent (example trade name)             | Fungicide group(s) | WHP <sup>1</sup> (days)                            | Effect on beneficials | Registered for use in... <sup>2</sup>          |
|-----------------------------------------------------|--------------------|----------------------------------------------------|-----------------------|------------------------------------------------|
| Chlorothalonil (Bravo Weather Stik®)                | M5                 | Apricots, cherries, nectarines, peaches 7; plums 1 | Low                   | Apricots, cherries, nectarines, peaches, plums |
| Copper-based fungicides (various)                   | M1                 | 1                                                  | Low                   | Stone fruit                                    |
| Dithianon (Dinon 700 WG)                            | M9                 | Stone fruit 21                                     | Low                   | Stone fruit                                    |
| Fluopyram + trifloxystrobin (Luna® Sensation)       | 7 + 11             | 1                                                  | Low                   | Stone fruit                                    |
| Mancozeb (Dithane® Rainshield® NeoTec®)             | M3                 | 14                                                 | Medium                | Stone fruit                                    |
| Metiram (Polyram®)                                  | M3                 | 14                                                 | Medium                | Stone fruit                                    |
| Sulfur as polysulfide sulfur (Grochem Lime Sulphur) | M2                 | Not required when used as directed                 | Medium                | Stone fruit (dormant to bud swell spray only)  |
| Thiram (Thiram WG)                                  | M3                 | 7                                                  | Low                   | Stone fruit                                    |
| Ziram (Ziram WG)                                    | M3                 | 7                                                  | Low                   | Cherries, nectarines, peaches                  |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Silver leaf

## *Chondrostereum purpureum*

Silver leaf occurs mainly in apples and stone fruit in all growing regions but is particularly common in areas with high humidity during the growing season.



## Risk period

Table 102. The peak risk period for silver leaf.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Disease identification

The foliage of infected trees will develop a silvery sheen (Figure 188) that is caused by light shining through leaf cells that are damaged by toxins produced by the fungus.

## Damage

Overall tree health declines, with reduced leaf area, poor root growth and low yields of poor-quality fruit that does not store well. In storage, infected fruit is susceptible to decay caused by other secondary infections.

Apple trees tolerate the disease better than stone fruit trees, which often die. The disease can lead to an increased incidence of water core in apples.



Figure 188. The silver sheen on an apple leaf affected by silver leaf.

## Monitoring

Damp, overcast conditions can increase the incidence of silver leaf in orchards. Particular attention to pruning wounds when these conditions are present is recommended. Other forms of wound sites, such as from hail, could create infection sites for silver leaf and should be monitored regularly.

## Management

**Cultural and physical:** silver leaf can be controlled by careful pruning and using wound dressings. Winter pruning should be avoided, particularly on damp, overcast days. Apply wound dressings as soon as possible after pruning and grafting to avoid infection.

**Biological:** there are currently no biological control options for this disease.

**Chemical:** the chemical options for controlling silver leaf are listed in Table 103.

Table 103. Registered or permitted products for silver leaf in NSW.

| Active constituent<br>(example trade name)   | Fungicide group(s) | WHP <sup>1</sup> (days)                          | Effect on<br>beneficials | Registered for use in... <sup>2</sup> |
|----------------------------------------------|--------------------|--------------------------------------------------|--------------------------|---------------------------------------|
| Cyproconazole + iodocarb<br>(Garrison Rapid) | 3 + 28             | Do not use on trees during<br>the growing season | Low                      | Apples, apricots,<br>peaches, plums   |
| Tebuconazole (Green Seal®)                   | 3                  | Not required when used as<br>directed            | Low                      | Apples, cherries                      |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Sooty blotch

## *Gloeodes pomigena*

Sooty blotch is a fungal disease that causes surface blemishes on apples and pears, usually late in summer.



## Risk period

Table 104. The peak risk period for sooty blotch.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Disease identification

Sooty blotch is identified by patches of interconnecting irregular-shaped brown–black spots on the fruit surface (Figure 189).

## Damage

The disease results in unappealing markings on the fruit skin, making it unmarketable. In unsprayed orchards, infection levels can be very high. It is rarely seen where conventional fungicide spray programs for other diseases are used.

## Monitoring

Cool, wet conditions and dense, slow-drying canopies favour sooty blotch. Monitor by inspecting fruit for blotches through mid to late summer.



Figure 189. Sooty blotch on unsprayed Cripps Pink apples.

## Management

**Cultural and physical:** pruning to encourage airflow and light penetration through the canopy is recommended.

**Biological:** there are currently no biological control measures for sooty blotch.

**Chemical:** the chemical options for controlling sooty blotch are listed in Table 105.

Table 105. Registered or permitted products for sooty blotch in NSW.

| Active constituent (example trade name) | Fungicide group(s) | WHP <sup>1</sup> (days) | Effect on beneficials | Registered for use in... <sup>2</sup> |
|-----------------------------------------|--------------------|-------------------------|-----------------------|---------------------------------------|
| Mancozeb (Dithane® Rainshield® NeoTec®) | M3                 | 14                      | Medium                | Apples, pears                         |
| Mancozeb + zinc EDTA (Manic® WG)        | M3                 | 14                      | Medium                | Apples, pears                         |
| Metiram (Polyram®)                      | M3                 | 14                      | Medium                | Apples, pears                         |
| Zineb (Barmac Zineb)                    | M3                 | 14                      | Low                   | Pome fruit                            |

<sup>1</sup> WHP = withholding period. <sup>2</sup> Always refer to the label.

# Sooty mould



## Various species

Sooty mould is a dark, powdery fungus that coats leaves, stems and fruit. Sooty mould is not a single disease, but a collective term that is used for several fungi that grow on honeydew produced by sap-sucking insects such as aphids and scale. The most commonly associated genera are *Alternaria* spp., *Capnodium* spp., and *Cladosporium* spp.

## Risk period

Table 106. The peak risk period for sooty mould.

| Bud swell/<br>green tip | Bloom | Mid season | Harvest | Postharvest | Dormancy |
|-------------------------|-------|------------|---------|-------------|----------|
|                         |       |            |         |             |          |

## Disease identification

Sooty mould is a black, superficial fungal growth on leaves (Figure 190), twigs and fruit (Figure 191). It grows on the sugary, sticky honeydew secreted by sap-sucking insects. Ants are also attracted to the honeydew.

## Damage

Sooty mould causes a thick black coating on the surface of the fruit and can reduce marketability if left unclean. It can reduce tree and fruit growth as it blocks out sunlight, reducing photosynthesis.

## Monitoring

Sooty mould can grow all year but is more likely from spring to summer when scale insects are most active. Inspect the underside of leaves, stems and new growth.

## Management

**Cultural and physical:** trim heavily affected, dense branches to improve airflow and discourage mould growth. Control populations of honeydew-producing insects (for example, aphids, soft scales and mealybugs) to reduce sooty mould.

**Biological:** there are currently no biological controls registered for sooty mould.

**Chemical:** there are currently no chemical controls registered specifically for sooty mould, but there are for *Alternaria* spp. (page 112). Growers can use horticultural oils to help control sooty mould.



Figure 190. Sooty mould on leaves. Photo: Florida Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Bugwood.org.



Figure 191. Sooty mould on pears. Photo: Ministry of Agriculture, Food and Rural Affairs, Government of Ontario.

# Protecting your orchard from viruses

Jessica Fearnley-Pattison, Development Officer – Temperate Fruit, NSW DPIRD

## Introduction

Plant viruses can cause serious loss of yield and production in a variety of crops. In temperate fruit, more than 26 viruses that could significantly affect production have been identified worldwide (Manzoor et al. 2025). There are always novel viruses or variants caused by genetic evolution, changes in agricultural practices, and climate change. This means the industry should implement good monitoring and testing protocols for viruses (Tatineni and Hein 2023).

Managing plant viruses is not easy because chemical control is usually unavailable. Diagnosing the virus early is important to minimise the spread throughout the orchard and growing regions. Preventing plant viruses from getting into the orchard must start in the nursery, with testing and identification being critical before trees are planted.

## Identifying viruses in temperate fruit

In orchards, virus symptoms can be variable and slow to show, sometimes only expressing in blocks years after planting. Viruses are usually spread by propagating infected stock. Regularly monitoring blocks for viruses will ensure infected trees are found early and before they can spread the virus. For temperate fruit, growers should watch for:

- Mosaic patterns and yellow mottling such as from apple mosaic virus (Figure 192).
- Chlorotic rings, spots, or vein yellowing.
- Leaf deformation and reduced vigour.
- Reduced fruit size and yield such as from prune dwarf virus (Figure 193).
- Delayed growth and sparse canopies.
- Graft union abnormalities and decline.

If a plant virus is suspected, a tissue sample should be taken from the infected tree and sent to a diagnostic laboratory for analysis. NSW growers can use the Plant Health Diagnostic Services at the Elizabeth Macarthur Agricultural Institute (EMAI) and Orange Agricultural Institute.



Figure 192. Mottled leaves are a sign of apple mosaic virus. Photo: Lesley Ingram, Bugwood.org.

## Ways to protect your orchard

As there are few to no control measures for plant viruses, preventing them from entering the orchard is vital. The most important step to ensuring your orchard remains virus-free is using certified virus-tested planting material sourced from reputable nurseries, as many fruit tree viruses can be introduced through infected propagation material. Regularly monitoring trees for symptoms is essential for early detection. Growers should promptly remove and destroy infected trees to minimise sources of infection.

Controlling well-known virus vectors such as aphids, mealybugs, mites and leafhoppers will prevent viruses from being transmitted throughout the orchard. Ensuring good orchard hygiene practices, including disinfecting pruning and grafting tools between trees and blocks, controlling weeds, and not moving contaminated plant material throughout the orchard will all help reduce the occurrence and transmission of viruses.

Ensuring that all orchard staff know the signs and symptoms of viruses in trees will ensure they are picked up in blocks quickly, reducing the spread within the orchard.



Figure 193. Small or deformed fruit can be a sign of a prune dwarf virus in the orchard. Photo: HJ Larsen, Bugwood.org.

## References

- Manzoor S, Nabi SU, Ayaz A, Rasool B, Sharma SK, Chesti MH, Parveen S, Verma MK, Diab MA and Rabbee MF (2025) Unveiling viral threats to temperate pome fruit: characterisation, transmission, and sustainable management strategies. *Frontiers in Microbiology*, 16: 1560720, <https://doi.org/10.3389/fmicb.2025.1560720>
- Tatineni S and Hein GL (2023) Plant viruses of agricultural importance: current and future perspectives of virus disease management strategies. *Phytopathology*®, 113(2): 117–141.

# Non-bearing trees

Young trees ([Figure 194](#)) that are not bearing fruit do not need the same intensive spray schedule as bearing trees. However, all non-bearing fruit trees require careful management to establish strong structural growth and long-term productivity before they enter commercial production. During the tree's early years, the priority should be to grow a healthy canopy and root system through balanced nutrition, consistent soil moisture, and protection from pests and diseases that can stunt development. Young trees are particularly sensitive to water stress, weed competition, and nutrient deficiencies, all of which can delay canopy formation and reduce future yield potential.

Training and pruning are also essential for young trees to develop a strong framework for supporting future fruit loads. Growers need to determine the type of training system and structure they plan to use to manage their trees before planting them. As non-bearing trees do not yet divert energy into fruit production, this early period is a critical window for shaping tree architecture and maximising vigour.

Problems most likely to be encountered with young temperate fruit trees are listed in [Table 107](#) to [Table 109](#). However, preparation and prevention provide the best route to healthy trees. Always source new trees from reputable nurseries and choose varieties with known pest and disease resistance. Taking special care of young trees by increasing inputs such as compost, a good fertiliser regime and regular crop monitoring will ensure they reach their maximum potential.

Table 107. Problems most likely to be encountered with young apple and pear trees.

| Pest or disease                 | Damage                                                                                                                                                                             | Control                                                                                                                                                                                                         |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Apple scab                      | Can severely impede young tree development. Scab infections on leaves will result in reduced growth and premature leaf drop.                                                       | A protective schedule is required to minimise leaf infections. Removing and mulching infected leaves in winter will promote breakdown and prevent the infection from overwintering in the orchard.              |
| Pear and cherry slug            | Slug attack can cause leaf damage, leading to premature defoliation.                                                                                                               | Young trees should be inspected periodically and action taken if required.                                                                                                                                      |
| Powdery mildew                  | Can be very damaging to young trees and result in problems with growth and canopy establishment. Particular care needs to be taken with susceptible varieties such as Cripps Pink. | A protective schedule is required but can be minimal if frequent observations are made and infected shoots are pruned out as soon as they are seen.<br>Note: some fungicides will control both scab and mildew. |
| Rabbits and hares               | Tree growth is reduced and the tree can die from ring-barking of the trunk.                                                                                                        | Protecting trees with trunk guards and/or wire netting fencing is the most reliable means of preventing an attack.                                                                                              |
| Wingless grasshoppers           | Tree growth is reduced and tree training problems might occur because of reduced leaf area.                                                                                        | A protective treatment might be necessary when grasshoppers are numerous.                                                                                                                                       |
| Woolly aphid and San José scale | Tree growth can be reduced, and in some cases, lead to tree death.                                                                                                                 | Make sure trees are free from infestation before delivery from the nursery. A pre-planting treatment is advised if these insects are noticed on nursery stock.                                                  |



Figure 194. Young, non-bearing orchards require monitoring for pests and diseases affecting tree health.



Table 108. Problems most likely to be encountered with young stone fruit trees.

| Pest or disease                    | Damage                                                                                                                                                                                                                     | Control                                                                                                                                                                                                                                 |
|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bacterial canker                   | Can cause severe gumming of limbs and trunks, leading to reduced tree growth and sometimes death if severely cankered.                                                                                                     | A protective spray schedule based on copper fungicides is advised between leaf fall and early bud swell. Prevent infection by establishing good orchard hygiene with practices such as cleaning pruning equipment between each tree.    |
| Cherry aphid and black peach aphid | Aphids can infest the lateral growth of stone fruit in autumn and become a problem in spring.                                                                                                                              | Closely observe trees for the insects and take action if warranted.                                                                                                                                                                     |
| Crown gall                         | This bacterial disease can cause significant losses in stone fruit trees by infecting the crown root.                                                                                                                      | Treating seeds, rootstock seedlings and bare-rooted trees before planting with a biocontrol agent is advised. Refer to <a href="#">'The importance of protecting beneficial insects' on page 110</a> .                                  |
| Leaf curl                          | This disease causes distorted foliage, premature leaf fall and marked or misshapen fruit. Heavy leaf fall can lead to fruit drop and small fruit. It affects mainly nectarines, peaches and, to a lesser extent, apricots. | A protective spray schedule based on copper fungicides is advised between leaf fall and early bud swell. In coastal districts, regularly monitor young trees in late winter and early spring (August–September) and spray if necessary. |
| Plague thrips                      | Thrips laying eggs causes leaf damage to the expanding foliage.                                                                                                                                                            | Closely observe trees for thrips and take action if warranted.                                                                                                                                                                          |
| Rabbits and hares                  | Tree growth is reduced and the tree can die from ring-barking of the trunk.                                                                                                                                                | Protecting trees with trunk guards and/or wire netting fencing is the most reliable means of preventing an attack.                                                                                                                      |
| Rust                               | Severe infection causes premature leaf fall, exposing limbs to sun scald and wood-rotting fungi.                                                                                                                           | Apply a protective fungicide program during the growing season.                                                                                                                                                                         |
| Scale insects                      | San José scale and white peach scale infestations can lead to unthrifty trees and tree death.                                                                                                                              | Make sure that trees are free from infestation before delivery from the nursery. A pre-planting treatment is advised if these insects are noticed on nursery stock.                                                                     |
| Shot hole                          | The disease causes leaf shot hole, leaf yellowing, premature leaf fall, twig death and even branch gumming.                                                                                                                | A protective spray schedule based on copper fungicides is advised between leaf fall and early bud swell.                                                                                                                                |
| Summer trunk canker                | This is a potentially serious disease affecting stone fruit on peach rootstock in wet soil. Severely infected trees might die.                                                                                             | Staking the trees to prevent movement during rain and windy weather will reduce disease incidence. Orchard mounding and using fungicide treatments can help.                                                                            |

Table 109. Problems most likely to be encountered with young persimmon trees.

| Pest or disease                | Damage                                                                                                                                                                                        | Control                                                                                                                                   |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Ants, mealybugs, scale insects | Before they become productive, young trees can be infested by scale insects and/or mealybugs. Ants can protect and encourage these pests, leading to problems when trees start bearing fruit. | Monitor young trees closely for ants, mealybugs and scale insects and treat with insecticide or oil as required to keep pest levels down. |
| Leaf-spotting diseases         | If left unprotected, young trees can suffer significant leaf infection, resulting in premature leaf drop or defoliation.                                                                      | Consider maintaining some fungicide inputs to protect young trees from infection.                                                         |

Are you thinking about planting new trees in the next few years, and want to intensify the planting through new training systems? Make sure you have a look at the outputs from the '[Narrow orchard systems for future climates project](https://www.hin.com.au/current-initiatives/narrow-orchard-systems-for-future-climates)' (AS22002, <https://www.hin.com.au/current-initiatives/narrow-orchard-systems-for-future-climates>) or scan the QR code (Figure 195).

In this project, various narrow orchard systems (NOS) are being investigated in Australia for apple, pear, cherry, nectarine, apricot and plum production systems. The aim is to determine whether transitioning to narrower orchard systems can improve productivity, fruit quality, climate resilience and labour efficiency in Australian orchards.

The five-year project, which runs until spring 2028, forms part of the Hort Innovation-funded AS22002 initiative and includes research and demonstration sites in Victoria, New South Wales, South Australia and Western Australia. Commercial demonstration orchards are also operating in Batlow (NSW) and the Adelaide Hills (SA).

NOS feature narrow two-dimensional (2D) canopies with closely spaced upright leaders and reduced row spacing (Figure 196). The systems are designed to optimise light interception and penetration throughout the canopy while improving labour efficiency and orchard uniformity.



Figure 195. The QR code for information from the 'Narrow orchard systems for future climates' project.



Figure 196. A narrow two-dimensional (2D) orchard with closely spaced upright leaders and reduced row spacing.

NSW DPIRD is a proud subcontractor of the narrow orchard systems project, and Kevin Dodds is currently working on an apple demonstration site in Batlow. The apple demonstration orchard is evaluating the performance of WA 38 (Cosmic Crisp®) on Nic®29 rootstock under a twin cordon narrow orchard system. Kev has developed a series of videos on the progress of the trial with the host grower, Jeremy Smart. These videos can be accessed [online](https://www.hin.com.au/current-initiatives/narrow-orchard-systems-for-future-climates/narrow-orchard-systems-apples#video1) (<https://www.hin.com.au/current-initiatives/narrow-orchard-systems-for-future-climates/narrow-orchard-systems-apples#video1>) or by scanning the QR code (Figure 197).



Figure 197. The QR code for videos about the narrow orchard systems project.

For more information about the project, contact:

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# Managing postharvest diseases and disorders

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Crop protection does not end at picking. The fruit continues to be at risk of infection and breakdown throughout harvest, storage, packing and during marketing (i.e. the postharvest supply chain). Many postharvest rots start during flowering and fruit growth in the orchard, but the decay is only seen after harvest. Therefore, maintaining good crop protection measures in the orchard is critical. Fungal infections are the main pathological diseases in temperate fruit and these can cause large postharvest losses during storage.

Numerous pre- and postharvest factors interact to influence the incidence of postharvest decay, including the fungal spore load in the orchard or packing shed, fruit nutritional status, maturity and type of calyx of the apple. For example, apple varieties with open calyxes (i.e. open between the external calyx and the core) are more prone to rots such as mouldy core or core rot, which can enter via the calyx during postharvest handling.

Common postharvest fungal diseases and their pathogens of temperate fruit in NSW include brown rot (*Monilinia fructicola* and *M. laxa*), alternaria rot (*Alternaria alternata*), blue mould (*Penicillium* spp.), grey mould (*Botrytis cinerea*), anthracnose, target rot/spot (*Phlyctaema vagabunda* and others), mucor rot (*Mucor piriformis*), ripe fruit spot (*Gloeosporium* spp.) and transit rot (*Rhizopus* spp.).

Blue mould is the most common and important postharvest disease. It is caused by the fungus *Penicillium expansum* (Figure 198) and, less often, other *Penicillium* species.

Grey mould, caused by *Botrytis cinerea*, is the most common disease in untreated fruit stored in bins. As *B. cinerea* frequently spreads from fruit to fruit, losses from an initial infection can be significant.

Anthracnose rots have been called ripe fruit rot, lenticel rot, target rot or spot, and bitter rot and are primarily caused by the related fungi *Phlyctaema vagabunda*, *Cryptosporiopsis malicorticis* and *Colletotrichum gloeosporioides*. Infection starts during fruit growth and remains dormant but can develop when the fruit becomes less resistant to disease during ripening.



Figure 198. Blue mould (*Penicillium expansum*) is the most common and important postharvest disease of apples.

## Preharvest disease management

Controlling postharvest diseases begins with good crop protection and orchard hygiene throughout the growing season. This ensures the fruit is as clean as possible when harvested, thus minimising postharvest decay during storage. Information on controlling diseases associated with postharvest decay in the field is provided in the diseases section of this guide (page 112), with specific information given for bitter rot (page 123), brown rot (page 124) and *Alternaria* species (page 112).

Some fungicide-based orchard sprays include label recommendations for application leading up to and just before harvest for certain diseases. Additionally, late-season sprays can help to ensure fruit enters the storage and processing chain with reduced spore loads and lower potential for infection and breakdown. Check individual product labels for registered crops, diseases and harvest withholding periods.

Resistance can be common due to the overuse of postharvest fungicides in the packhouse. To prevent fungicide resistance in postharvest systems, rotate fungicides with different modes of action, adhere strictly to label rates and timing, and integrate non-chemical practices such as sanitation and temperature control.

The susceptibility of the fruit tissue to fungal attack is influenced by fruit maturity, nutritional status and the spore load in the packing shed. Therefore, fruit should be harvested at optimum maturity

and always handled carefully to prevent creating injury points for infection, such as puncture marks or bruising. Fruit injury sites are ideal entry points for fungal spores such as *Penicillium* and *Mucor* species.

### Postharvest dipping and drenching

Other postharvest diseases that are primarily a problem during storage include blue mould, grey mould, ripe fruit spot and transit rot.

Dipping or drenching the fruit as it comes into the storage and packing facility (Figure 199) is essential for minimising potential fruit losses.

Table 110 lists chemicals with registration for use as postharvest dips or drenches in NSW for pome and stone fruit and the target diseases for these crops.



Figure 199. Dipping or drenching fruit in a fungicide solution as it comes into the packing shed.

### Equipment and water transport systems

Many postharvest temperate fruit handling and grading systems (such as in apples and cherries) use water flumes to transport fruit from harvest bins to sorting, washing lines and packing lines (Figure 200).

The water used must be properly treated to prevent bacterial and fungal pathogens from spreading, potentially causing fruit infections and food safety issues for human health. Good packing shed hygiene and sanitation (including dump tanks and flotation conveyors) are crucial for reducing the build-up of fungal spore populations and should be a part of good postharvest and food safety practices.

Some of the key chemical products available for sanitising packing shed fruit dipping water transport systems and/or fruit washing systems are listed in Table 111. Always consult your chemical supplier and the product label for details of registered or approved uses and applications in fruit processing.



Figure 200. Sanitising water transport systems is essential to prevent the build-up and spread of fungal and bacterial infections.

Table 110. Chemicals registered for use in NSW for protecting postharvest fruit from fungal diseases.

| Active constituent (example trade name) | Fungicide group | For managing or controlling...                                                                                                                                           |
|-----------------------------------------|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fludioxonil (Starling)                  | 12              | Pome fruit: blue mould, grey mould<br>Stone fruit: brown rot, grey mould, rhizopus rot                                                                                   |
| Imazalil (Imazacure 500 EC)             | 3               | Apples and pears: blue mould                                                                                                                                             |
| Iprodione (Rovral Aquaflor®)            | 2               | Apples and pears: storage rots caused by <i>Botrytis</i> spp., <i>Gloeosporium</i> spp. and <i>Penicillium</i> spp.<br>Stone fruit: brown rot, transit rot (suppression) |
| Pyrimethanil (EcoFOG-160 PYR)           | 9               | Apples and pears moulds caused by <i>Penicillium</i> spp., <i>Botrytis</i> spp. and <i>Neofabraea</i> spp.                                                               |
| Thiabendazole (Storite®)                | 1               | Apples and pears: blue mould, grey mould, fruit rot ( <i>Gloeosporium album</i> )                                                                                        |
| Triforine (Saprol®)                     | 3               | Apricots, nectarines, peaches, plums, prunes: brown rot                                                                                                                  |

Table 111. Common chemicals used for sanitising harvested fruit, equipment and processing water in fruit processing facilities. Note, these are approved for use in postharvest fruit.

| Active constituent (example trade name)          | For managing or controlling...                                                     |
|--------------------------------------------------|------------------------------------------------------------------------------------|
| Bromo-chloro-dimethyl-hydantoin (Nylate®)        | External rot-causing organisms (surface sterilisation in postharvest wash systems) |
| Chlorine as calcium hypochlorite (Activ8®)       | Bacterial and fungal control                                                       |
| Iodine (AIS®)                                    | Bacterial and fungal control                                                       |
| Peroxyacetic acid + hydrogen peroxide (Absolve®) | Bacterial growth in process water                                                  |
| Sodium chlorite (Zydex®)                         | Bacterial growth in flumes, lines and rinses                                       |

## Superficial scald

Superficial scald (scald) is a long-term storage disorder of apples (particularly Red Delicious and Granny Smith) and pears. Scald is a physiological disorder, which means it occurs randomly during storage and is not caused by a disease.

Scald is characterised by brown, irregular patches on the skin (Figure 201) during long-term cold storage. These areas become sunken and turn darker brown as the disorder develops. Although the damage is only superficial (Figure 202), it is sufficient to greatly downgrade fruit quality and grower returns.

Scald symptoms develop slowly in cold storage, usually within 3 months of harvest, and increase with time in storage. They will rapidly increase in severity within a few days at ambient air temperatures.



Figure 201. Superficial scald symptoms on a Granny Smith apple.



Figure 202. The peel removed from a scalded and non-scalded region of a Granny Smith.

## Scald incidence

Several inter-related variety, orchard and management factors influence the incidence of scald, including tree vigour and nutrition, preharvest temperatures, sunlight, rainfall, fruit size and mineral content. However, the main factors influencing scald susceptibility are:

- **fruit maturity:** immature fruit are more susceptible than mature fruit
- **seasonal conditions:** fruit grown in warm, dry areas is more susceptible to scald than fruit grown in cool, moist climates
- **variety:** fruit variety (Table 112) is probably the overriding factor in scald development.

Table 112. Scald susceptibility of apple and pear varieties.

| Highly susceptible                                 | Moderately susceptible                    | Least susceptible                           |
|----------------------------------------------------|-------------------------------------------|---------------------------------------------|
| Apples: Granny Smith, Lady Williams, Red Delicious | Apples: Bonza, Cripps Red, Firmgold, Fuji | Apples: Cripps Pink, Gala, Golden Delicious |
| Pears: Packham's Triumph, Anjou                    | Pears: Beurre Bosc, Josephine             | –                                           |

## Scald severity

Scald severity depends on storage temperature and duration, room ventilation, and atmospheric composition.

## Scald control

Scald can be controlled by postharvest chemical treatments such as:

1. diphenylamine (DPA)
2. 1-methylcyclopropene (1-MCP)

In addition, scald can be managed with non-chemical treatments such as:

1. ventilation
2. dynamically controlled atmospheres (DCA)
3. ultra-low oxygen controlled atmosphere (ULO-CA).

## Diphenylamine treatment

Scald can be controlled with diphenylamine (DPA) as a postharvest dip, drench or by fogging. However, DPA should not be used on export fruit unless permitted by the importing country.

DPA application rates depend on variety, district and the composition of the storage atmosphere. Therefore, application rates need to be adjusted according to the variety being treated, not only to control scald but to avoid damage to the skin.

DPA must be used according to label instructions; residue issues have occurred from not following label rates, inadequate mixing of the dip tanks and incorrect top-up procedures. The postharvest dipping manual [Guidelines for postharvest drenching of apples and pears](https://apal.org.au/wp-content/uploads/2019/09/dpa-use-guidelines-revised-0407.pdf) (https://apal.org.au/wp-content/uploads/2019/09/dpa-use-guidelines-revised-0407.pdf) provides further information.

## DPA application

DPA can be applied via dip/drench or fogging. As a dip/drench, DPA should be applied as soon as possible after harvest; delaying treatment by 2 weeks or more greatly reduces its effectiveness.

Using a fogging system to apply DPA is a relatively new and efficient method. It involves using a special liquid form of DPA that is suitable for use with a thermal electro-fogger to form a fine fog, which is used on dry fruit. Similar to the dip application of DPA, this treatment should be applied as soon as possible after harvest and within 15 days of harvest and storage.

Electro-foggers should only be used by qualified, certified operators due to the high level of safety requirements (such as a full-face respirator with an organic vapour filter) for this application method.

All product labels and safety precautions must be followed.

### **Potential issues with DPA treatment**

DPA has been used for the last 60 years to successfully manage scald, but some markets, particularly the EU, have no tolerance for DPA residues in fruit. A major problem with the long and continued use of DPA in packing sheds is that chemical residues can sometimes impregnate fruit bins, packing lines and storage cool rooms over time. These DPA residues can then potentially re-contaminate non-DPA-treated fruit, causing potential market access issues. Therefore, alternative scald control measures should be considered.

### **1-methylcyclopropene treatment**

1-methylcyclopropene (1-MCP) inhibits scald while maintaining apple quality during storage. It is registered in apples to:

- reduce the incidence of superficial scald, peel greasiness and mealiness
- maintain firmness and titratable acidity.

1-MCP works with the natural ripening process to temporarily stop the fruit from producing the naturally occurring ripening hormone ethylene, and from responding to outside sources of ethylene, such as other apples. 1-MCP works in a non-toxic way and has no detectable residues.

For effective scald control, 1-MCP must be applied at the appropriate harvest maturity and as soon as possible after harvest (generally within 5 days), and before storage and packing. 1-MCP is applied as a gas so using an airtight room is essential.

When applied correctly, the benefits of 1-MCP treatment continue to work after removal from cold storage. Once treated fruit are removed from storage, ripening continues at a much slower rate. It is this delay in ripening that reduces softening and inhibits superficial scald.

**Note:** 1-MCP is not a substitute for correct postharvest handling, storage and transport practices. Correct temperature management is still paramount for maintaining quality fruit.

In addition to chemical treatments (such as DPA and 1-MCP), non-chemical treatments can be used to minimise and manage scald in storage.

### **Ventilation**

Ventilation is a common practice used to reduce superficial scald in apples. Maintaining adequate ventilation in apple storage facilities helps regulate temperature and humidity levels, thereby reducing the risk of superficial scald. This is achieved by maintaining air circulation in the storage area, which dissipates accumulated heat and moisture. In addition, proper ventilation prevents the accumulation of carbon dioxide and ethylene gases, which are also known to contribute to the development of superficial scald.

### **Dynamically controlled atmospheres**

Dynamically controlled atmospheres (DCA) are a non-chemical method for managing scald and maintaining the postharvest quality of apples in long-term cold storage. This system has been researched for many years and is used commercially in many apple storage rooms around the world, including Australia. DCA maintains very low oxygen in the controlled atmosphere (CA) for long-term storage. The dynamic maintenance of low oxygen in the storage atmosphere is done using methods such as chlorophyll fluorescence or ethanol levels.

DCA can be an effective tool to manage scald during storage, but it is not practical in all long-term storage situations as it relies on good, airtight CA storage rooms. Many commercial CA rooms in Australia are older and not sufficiently airtight to maintain the very low oxygen levels required for DCA to be effective.

### **Ultra-low oxygen controlled atmosphere**

Ultra-low oxygen controlled atmosphere (ULO-CA) storage is another method used to reduce the risk of superficial scald. This technology involves reducing oxygen levels to 0.5% or less, while maintaining elevated carbon dioxide levels, which slows ethylene production, inhibits the production of fruit volatiles that cause superficial scald and prevents microbial growth.

# Chemical thinners

## Chemical thinning

Responses from chemical thinning can be unpredictable, making optimal crop load management a difficult task. There are many interacting factors influencing the thinning response of chemical thinning agents, including cultivar, climate, pollination and tree history. A structured program combining both blossom and post-bloom chemical thinners will give the most reliable results. To be effective, chemical thinning programs need to start early in the flowering period.

## Blossom thinners

**Ammonium thiosulfate (ATS)** works by desiccating or burning the style and stigma of the flower, preventing pollination and fertilisation. While leaf damage can happen with desiccants, the degree of damage that occurs when using the recommended rates does not affect fruit development, size or quality. Higher temperatures can also cause greater desiccation. Light rain can also re-activate the chemical, causing further desiccation and potential leaf damage. Application timing is critical to achieving satisfactory thinning. The chemical must be applied when sufficient flowers have already been fertilised for a good crop load: in apples this can be as early as 20% bloom. Multiple applications are recommended, as the aim is to remove the later-opening flowers. In cultivars with extended flowering, such as Gala, 3 applications might be necessary.

**Ethephon** can be a vigorous thinner, completely removing weak spurs or depleting fruit positioned low on the tree. Ethephon can also be used for complete fruit removal when used at 40–50 days after full bloom (dAFB) to remove damaged crops, e.g. by hail. This not only saves the time and effort of removing the crop by hand but also has a positive effect on the return bloom.

**Naphthalene acetic acid (NAA)**: while NAA can thin most cultivars between full bloom (FB) and 21 dAFB, the earlier it is applied, the better the response in fruit size. NAA promotes vegetative growth, which is advantageous in green apples such as Golden Delicious or Granny Smith, but a disadvantage in red apples where extra vegetative growth shades fruit, inhibiting red colour production. NAA interacts with plant bioregulators containing the gibberellins GA 4 + 7. Hence, it is not compatible with formulations such as Cytolin® (6-benzyladenine; gibberellin A4 and gibberellin A7) when applied at the normal recommended rate. However, if the rate of NAA is reduced to 3–4 ppm, then a Cytolin®/NAA program works well.

**Lime sulfur (LS)** is a crop protectant often used in organic orchards that has a desiccating effect when applied during flowering. LS is not registered for thinning either pome or stone fruit.

## Post-bloom thinners

**6-benzyladenine (BA)** works most effectively following treatment at flowering with one of the blossom thinners, e.g. ATS, ethephon or NAA. It is temperature-dependent, being more effective in warmer temperatures. BA is suitable for IPM programs as it is not persistent or toxic. It can also increase fruit size independently of the thinning effect and can increase fruit firmness.

**Carbaryl** is regarded as a mild thinner and usually only removes the slower-growing fruit within bunches. Carbaryl is temperature-dependent, requiring warm, dry conditions for effective thinning. The warmer the temperature, the greater the thinning effect. It can also be used on trees where using a primary thinner is not warranted, either because the trees are young or because of sparse blossom buds.

**Metamitron** acts by temporarily inhibiting photosynthesis for 7–10 days after application, targeting the weakest fruit within a cluster. It is rainfast within 2 hours, non-persistent and does not affect beneficials. The thinning effect is dependent on radiation, or rather, a lack of it; thinning will be stronger in reduced light such as cloudy conditions or under netting.

**Thiram** is a protectant fungicide that has a slight thinning effect when applied after petal fall, but its effect is mild and can be unreliable. Thiram improves the efficacy of carbaryl when tank-mixed.

All chemical thinners have some disadvantages ([Table 113](#)). Despite these limitations, a chemical thinning program produces markedly superior results to hand-thinning, both economically and for tree physiology.



The most effective chemical thinning programs combine blossom and post-bloom thinners. A sequential spray program allows lower chemical quantities to be used each time, thus reducing the risk of over-thinning. If chemical thinners have been effective, then all that should be required is a subsequent light hand-thin to remove damaged fruit or break up any remaining bunches.

## Benefits of chemical thinning

To achieve suitable thinning and fruit quality, all chemical thinners need to be applied at the appropriate physiological stage and under the climatic conditions best suited to each chemical. Choice of thinning agent is important, as some cultivars do not respond well to some chemicals.

Table 113. Chemicals available for thinning in Australia.

| Generic name (example trade name)       | Type of thinner                | Crop                                                                | Application timing                                                                                                       | Disadvantages                                                                                                                                                                                                                                        |
|-----------------------------------------|--------------------------------|---------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ammonium thiosulfate (ATS; Culminate®)  | Blossom                        | Apples, plums, some peaches                                         | Apple 20% and 80% bloom.<br>Peach and plum 80–100% bloom.                                                                | <ul style="list-style-type: none"> <li>• Can cause russet.</li> <li>• Timing is critical.</li> </ul>                                                                                                                                                 |
| Benzyladenine (BA; Maxcel™)             | Post-bloom                     | Fuji, Gala, Golden Delicious, Cripps Pink, Red Delicious, Sundowner | Fuji and Gala 15–22 dAFB*.<br>Red Delicious 10–20 dAFB.<br>Golden Delicious 10–20 dAFB.                                  | Is temperature-dependent: needs >15 °C and rising temperature for 2–3 days after application.                                                                                                                                                        |
| Carbaryl (Bugmaster®)                   | Post-bloom                     | Pome fruit                                                          | 14–60 dAFB, repeat at 7–10 day intervals as required.                                                                    | <ul style="list-style-type: none"> <li>• Requires warm, dry conditions.</li> <li>• Toxic to bees, beneficial invertebrates and mammals.</li> <li>• Can cause russet and reduce seed number.</li> <li>• Banned from some export markets.</li> </ul>   |
| Ethephon** (Gro-Phon 720)               | Blossom                        | Apples                                                              | Balloon blossom to 7 dAFB.                                                                                               | <ul style="list-style-type: none"> <li>• Tendency to flatten fruit.</li> <li>• Higher rates can depress fruit size.</li> <li>• Not effective at cooler temperatures.</li> </ul>                                                                      |
| Gibberellic acid (GA; ProGibb® LV PLUS) | Inhibits next season's blossom | Apricots, nectarines, peaches                                       | Flower bud initiation stage.                                                                                             | <ul style="list-style-type: none"> <li>• Needs to be applied in the previous season.</li> <li>• Might delay harvest.</li> </ul>                                                                                                                      |
| Metamitron (Brevis®)                    | Post-bloom                     | Apples, pears                                                       | 8–16 mm fruitlet diameter.                                                                                               | <ul style="list-style-type: none"> <li>• Can cause minor leaf phytotoxicity.</li> <li>• Thinning effect depends on radiation.</li> </ul>                                                                                                             |
| Naphthalene acetic acid (NAA; NAA20)    | Blossom                        | Apples, pears                                                       | Full bloom to 5 dAFB.<br>2 sequential sprays might be required, the first applied at full bloom and the second 3–5 dAFB. | <ul style="list-style-type: none"> <li>• Can depress fruit size, cause russet and reduce seed number.</li> <li>• Pygmy fruit if applied later than 10 dAFB.</li> <li>• Interacts with cytolin.</li> <li>• Rewetting causes over-thinning.</li> </ul> |

\*dAFB = days after full bloom. \*\*Ethephon is not registered in NSW for fruit thinning but can be used for complete fruit removal.

The PIPS 4 Profit project 'Optimising apple production systems' (AP22002) aims to improve the profitability of apple production by investigating crop load management strategies and technologies suited to the Australian environment. Through this project new and efficient ways of using chemical, pruning and mechanical thinning strategies are being investigated for their effect on return bloom, fruit set, yield, quality and economic benefit. You can find out more by visiting the [PIPS 4 Profit website](https://apal.org.au/programs/more-industry-programs/pips-4-profit-program/) (https://apal.org.au/programs/more-industry-programs/pips-4-profit-program/).



# Chemical tools for managing bud dormancy, flowering, vegetative growth, harvest and storage quality

Plant growth regulation (PGR) products are important tools in modern temperate fruit production systems. PGRs provide cost-effective management solutions for some of the tree and crop management issues faced by producers. In this section, we have grouped some of the most important PGRs for pome and stone fruit production according to their uses in:

- managing vegetative growth
- managing harvest and fruit quality
- bud dormancy and manipulation of flowering.

Vegetative growth management products ([Table 114](#)) can be used in conjunction with other management tools such as pruning, root pruning, thinning and fertiliser and water management to encourage the desired shoot growth within the tree canopies.

Harvest and fruit quality management products ([Table 115](#)) can be used to delay or advance maturity and improve postharvest fruit quality attributes such as colour, firmness and storage potential.

Marginal or insufficient winter chilling can result in a delayed, protracted and uneven bloom. Bud dormancy products ([Table 116](#)) can help break dormancy and/or compress flowering to encourage more even bloom, pollination and fruit set.

Table 114. Vegetative growth management products registered for use in NSW.

| Active constituent (example trade name)                      | Purpose                                                                  | Registered for use in...                                                             |
|--------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Ethephon (Promote®)                                          | Retard vegetative growth and stimulate flowering in the following season | Apples                                                                               |
| Gibberellins A4 and A7 + 6-benzyladenine (7 Worlds Ag BaGA®) | Stimulate lateral growth                                                 | Apples, cherries                                                                     |
| Paclobutrazol (Payback®)                                     | Reduce vegetative growth                                                 | Apples (Red Delicious, Granny Smith), apricots, cherries, nectarines, peaches, plums |
| Prohexadione-calcium (Regalis-Plus®)                         | Reduce shoot growth                                                      | Apples, cherries                                                                     |

Table 115. Harvest management and fruit quality products registered in NSW, page 1 of 2.

| Active constituent (example trade name)                     | Purpose                                                                   | Registered for use in...                               |
|-------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------|
| 1-methylcyclopropene (1-MCP)                                | (Harvista®) Decrease fruit maturation rate                                | Apples preharvest                                      |
|                                                             | (SmartFresh™) Improve postharvest quality                                 | Apples, apricots, nectarines, pears, plums, persimmons |
| 6-benzyladenine + gibberellins A4 and A7 (7 Worlds Ag BaGA) | Improve fruit typiness (elongation)                                       | Apples (Braeburn, Gala, Cripps Pink and Red Delicious) |
| Aminoethoxyvinylglycine (AVG; Retain®)                      | Delay fruit maturity, increase fruit firmness, size and storage potential | Apples, stone fruit except cherries                    |



Table 115. Harvest management and fruit quality products registered in NSW, page 2 of 2

| Active constituent (example trade name)           | Purpose                                                                                  | Registered for use in...                  |
|---------------------------------------------------|------------------------------------------------------------------------------------------|-------------------------------------------|
| Ethephon (Promote®)                               | Apples (certain varieties): advances maturity, enhances fruit colour                     | Apples (varieties, refer to label)        |
|                                                   | Cherries (certain varieties): promotes evenness of maturity and early colour development | Cherries (varieties, refer to label)      |
| Gibberellic acid (GA; ProGibb®)                   | Delays harvest maturity                                                                  | Cherries, prunes                          |
| Forchlorfenuron (Ambitious 10SL)                  | Increases fruit size in apples and cherries                                              | Apples (Royal Gala and Fuji) and cherries |
| Naphthalene acetic acid (NAA) (7 Worlds Ag NAA20) | Helps prevent preharvest fruit drop                                                      | Apples, pears                             |

Table 116. Bud dormancy and flowering manipulation products registered in NSW.

| Active constituent (example trade name) | Purpose                       | Registered for use in...                                               |
|-----------------------------------------|-------------------------------|------------------------------------------------------------------------|
| Aminoethoxyvinylglycine (AVG; Retain®)  | Extend flower life            | Cherries                                                               |
| Cyanamide (Dormex®)                     | Regulate dormancy             | Apples, cherries, plums, prunes                                        |
| Cyanamide (Duomax)                      | Regulate bud dormancy         | Apples                                                                 |
| Decanol alkoxylate (Erger®)             | Break dormancy                | Fertiliser adjuvant with label recommendations for apples and cherries |
| Fatty acid esters-canola (Waiken®)      | Advance or set back bud break | Apples, cherries                                                       |

# Managing weeds

## Why manage weeds?

A weed is simply a plant growing where it is not wanted. Usually, the significance of a weed species is determined by its effect on agricultural production, the environment, aesthetics, or the risk it poses to human health.

An effective weed control strategy is vital when establishing an orchard to enable rapid canopy establishment and early cropping. Both are essential for profitability in any orchard block, particularly modern, capital-intensive systems. Controlling or removing pest habitat can reduce pest and disease pressure in a system and, therefore, the associated inputs required to manage them. Lastly, it is good agricultural practice and stewardship to prevent the spread of agricultural weeds to neighbours and the environment.

One of the high-priority weed species often found in temperate horticulture orchards is marshmallow weed, which is also known as small-flowered mallow, cheeseweed, and mallow.

## Marshmallow weed

Marshmallow (*Malva parviflora*) is a high-priority weed in cherry and pome fruit orchards and a significant concern in persimmon orchards. Its dense growth (Figure 203, left) competes for moisture and nutrients, interferes with irrigation infrastructure, and can disrupt harvest operations. In grain and vegetable cropping industries, marshmallow is an aggressive competitor for light, nutrients, and water, often reducing crop yields.

Marshmallow plants can be up to 1.5 metres tall and spread several metres wide. Depending on environmental conditions, it can behave as an annual, biennial, or short-lived perennial. Its deep, woody taproot (Figure 203, middle) makes it resilient to mechanical control. In ideal conditions, it can reproduce within 2 months of germination, producing thousands of seeds per plant (Figure 203, right). Seeds rapidly become hard-seeded, meaning there is only a narrow opportunity to prevent them from entering the soil seed bank.



Figure 203. Marshmallow (*Malva parviflora*) has dense growth, a woody taproot and can reproduce quickly.

*Malva parviflora* also acts as a reservoir for insect pests such as harlequin bugs and aphids and provides a green bridge for plant viruses and fungi. This makes established marshmallow populations a potential source of reinfestation and spread within and between growing seasons. Seeds are dispersed by water, soil, and ingestion by birds or mammals, contributing to the plant's persistence. Marshmallow is highly adaptable, capable of thriving in a wide range of soil types, including saline and compacted soil. Its seeds are long-lived, with the potential to remain viable in the soil for decades, making early and sustained control efforts essential.

An integrated weed management (IWM) approach is critical when dealing with *Malva parviflora* infestations. Single-method strategies, such as herbicide-only programs, are often insufficient due to the species' natural tolerance to glyphosate and its seed longevity. Effective management should combine cultural, mechanical, and chemical control methods, with a strong emphasis on preventing seed set and maintaining strict farm hygiene to limit the spread. Early intervention is vital.



## Management strategies and control options

The most appropriate weed management strategy will vary from site to site and will depend on orchard size, tree age, weed spectrum and density, soil type, available moisture and choice of under-tree management (i.e. bare earth, mulched or sod culture). No single approach will suit all situations and strategies will need to change with different growing conditions. Weed management methods can be grouped as either physical or chemical, and the best programs combine elements of both.

### Hygiene comes first

Good orchard hygiene is the first step in any weed management strategy. It will help prevent any new weed species from establishing or moving between blocks. Be aware of new weeds appearing, have them identified, and act quickly to eradicate them before they spread. Moving machinery from non-crop areas to the orchard and between blocks is a common method for spreading new weeds. Reduce the spread of new weeds by regularly cleaning orchard equipment.

Table 117. Strategies to manage weeds, and particularly marshmallow (*Malva parviflora*), page 1 of 2.

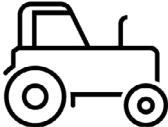
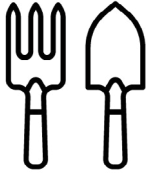
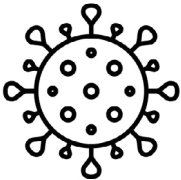
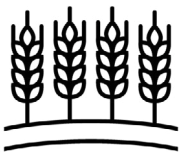
| Strategy                                                                                                  | Summary                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br>Tillage              | <p>Tillage or cultivation is an effective control strategy where feasible, particularly between rows and on headlands. It is most successful when repeated and timed early in the weed's life cycle to prevent seed set and maturation. However, tillage in areas with a history of marshmallow infestation can stimulate germination by scarifying dormant seeds. Notably, marshmallow tends to establish more successfully in zero-till systems than in minimal tillage systems.</p> <p>Take care that cultivation does not cause root damage to trees, particularly in blocks on dwarf rootstocks, where root architecture is usually shallower and less extensive.</p>                                                                                                                                                                                                                                                                                                                                                                    |
| <br>Herbicides         | <p>Marshmallow exhibits a natural tolerance to glyphosate. However, its tolerance can be significantly reduced by tank-mixing glyphosate with certain herbicides, including Group 14 herbicides, such as carfentrazone (e.g. Hammer®) or oxyfluorfen (e.g. Goal®). Note also that control with knockdown herbicides can be unreliable. Always follow label directions when using herbicides.</p> <p>For best results, apply herbicides when plants are small, young, and actively growing (early post-emergence). Avoid spraying when plants are stressed due to drought, physical damage or frost.</p> <p>To date, herbicide resistance has not been reported in Australian populations of marshmallow. Rotating between the several herbicide modes of action available to growers remains best practice.</p> <p>Refer to '<a href="#">Weed control using chemical control methods</a>' on page 158 for best practice guidance on herbicide selection, application and resistance management when relying on chemical control of weeds.</p> |
| <br>Slashing or mowing | <p>Slashing or mowing is a valuable strategy to reduce seed set. Aim for early autumn and spring. In spring, removing flowering weeds from the inter-row can promote pollinator activity in the canopy.</p> <p>Note that slashing or mowing is not effective on mature plants unless they are cut below the crown, as marshmallow readily regrows and re-establishes from above-ground cuts.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <br>Grazing            | <p>Marshmallow has low palatability to livestock. Sheep are known to tolerate marshmallow, but consuming large quantities might cause 'staggers', a condition involving tremors and falling. Note also that sheep can cause damage to trees if other feed is scarce.</p> <p>Research has shown that marshmallow seeds can survive mastication and rumen digestion by sheep, indicating that grazing might contribute to the plant's spread.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <br>Mulching           | <p>Marshmallow seeds do not require sunlight to germinate. However, if applied in a thick layer, mulching the under-tree row with large quantities of organic materials such as straw, old hay or bark chips can suppress weed growth and provide other benefits to tree and soil health.</p> <p>Growers should be aware of the possibility of nitrogen tie-up effects when using some raw, non-composted mulches.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

Table 117. Strategies to manage weeds, and particularly marshmallow (*Malva parviflora*), page 2 of 2.

| Strategy                                                                                                    | Summary                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Hand weeding</p>        | <p>Hand weeding is made difficult by marshmallow's long taproot, but it can be effective for light infestations of young plants or for isolated larger plants. It is also a useful follow-up method after herbicide or tillage treatments.</p>                                                                                                                                                                                                                                                                                             |
| <p>Thermal weeding</p>     | <p>No reports were available on the viability of thermal weeding using propane burners, hot air or hot water on marshmallow weed.</p> <p>As a general rule, do not use thermal weeding near trees younger than 3 years old, as crops can be severely damaged.</p>                                                                                                                                                                                                                                                                          |
| <p>Biological control</p>  | <p>In South Australia, viticulturists have reported that the rust fungus <i>Puccinia malvacearum</i> can reduce the vigour and abundance of marshmallow in vineyard settings. However, this is not yet a widely adopted or formally evaluated control method. Conversely, marshmallow plants can be frequently seen covered in rust pustules, and despite this, they readily reproduce.</p>                                                                                                                                                |
| <p>Cover crops</p>        | <p>As a minimum, mulch and inter-row grass cover should be used to reduce reliance on herbicide control for weeds.</p> <p>Research in the vegetable production industry has shown that cover crops can suppress marshmallow re-establishment through competition, particularly when the cover crop produces a large biomass. However, in dry seasons, maintaining this biomass might come at the expense of nutrient and water availability, increasing stress, particularly for young trees, potentially affecting crop productivity.</p> |

## References and further reading

Coleman M, Kristiansen P, Sindel B and Fyfe C (2019) *Marshmallow (Malva parviflora): weed management guide for Australian vegetable production*. School of Environmental and Rural Science, University of New England, Armidale.

Grains Research and Development Corporation (2019) [Integrated weed management manual: section 2 – herbicide resistance](https://grdc.com.au/resources-and-publications/all-publications/publications/2019/iwmm), <https://grdc.com.au/resources-and-publications/all-publications/publications/2019/iwmm>

Kelly J (2021) [Marshmallow intoxication \(Malva parviflora\) in sheep following drought-breaking rain in the Coonamble district](http://www.flockandherd.net.au/sheep/ireader/marshmallow-intoxication.html). *Flock and Herd*, <http://www.flockandherd.net.au/sheep/ireader/marshmallow-intoxication.html>

## Weed control using chemical control methods

Chemical herbicides have been the mainstay of weed management in orchards since the mid-1940s. Using herbicides remains the most cost-effective and reliable approach to managing weeds in commercial orchards.

### Types of herbicide and when to spray

The best time to spray for weeds is either just before (pre-emergent) or just after (post-emergent) germination. Most weeds germinate in either spring or autumn, and small weeds are easier to control than older, more mature weeds. Orchard herbicides can be grouped into 3 broad categories:

1. **Pre-emergent residual herbicides** (Table 118) perform best if applied to bare soil that is totally free of weeds, mulch and debris. Any material that prevents the herbicide from contacting and penetrating the soil surface will reduce its effectiveness on germinating weeds. Most pre-emergent herbicides will provide effective control for a wide range of annual broadleaf weeds and grasses. Established perennials, such as paspalum, will not be controlled using a pre-emergent herbicide.

2. **Post-emergent selective grass herbicides** (Table 119) are useful where the predominant weed species are grasses. The 3 active ingredients with registrations for use in NSW as selective grass herbicides are all members of the Group 1 herbicide mode of action (MoA). This group is considered highly prone to developing resistance and should be used in accordance with resistance management principles.
3. **Post-emergent non-selective knockdown herbicides** (Table 120) perform best when applied to young, actively growing weeds. As these herbicides are non-selective, some can be harmful to fruit trees. Young trees are particularly prone to injury if not protected from knockdown herbicides. Consult product labels for specific recommendations.

A summary of the range of active ingredients available for use in deciduous fruit orchards is in 'Herbicides and their uses' on page 161.

Please read the product labels thoroughly before applying any herbicide in your orchard. Failure to do so could result in poor product performance or damage to trees.

## Herbicide resistance

Herbicides function by disrupting specific biological processes in plants, a concept known as their mode of action (MoA). To help growers manage herbicide use effectively, herbicides are classified into MoA groups, which identify how each product works. Some MoA groups are more prone to resistance development and are considered high risk, with groups 1 and 2 being particularly notable. Resistance occurs when a herbicide that once controlled a weed population at the label rate no longer works, often defined by a survival rate of 20% or more in testing. This resistance is exacerbated when the same MoA group is used repeatedly, creating selection pressure that favours the survival and reproduction of resistant individuals. Viable seeds in the soil can sustain weed populations and perpetuate resistance for many years. It is important to consider that while herbicide use reduces overall weed density, it does alter the ratio of resistant to susceptible individuals in the population.

To minimise the risk of resistance, it is essential to rotate herbicides rather than relying on the same group for every spray. Choosing lower-risk herbicides when possible, monitoring for surviving weeds after application, and preventing them from setting seed are all vital steps.

Effective resistance management also depends on the quality of spray application. It starts with 3 core principles:

1. always read and follow product labels carefully
2. apply the full recommended rate of registered pesticides
3. ensure the application method achieves thorough coverage of the target area to maximise herbicide contact. Poor application practices can lead to sublethal dosing and uneven coverage, both of which contribute to the development of resistance.

Some MoA groups are more likely to develop resistance and are considered high risk. Refer to product labels or Table 118 to Table 120 to determine the MoA group.

## Herbicide sprayer setup

A properly configured and well-calibrated sprayer is essential to ensure herbicides are applied in accordance with label recommendations and to achieve the intended weed control. Some important points to consider are:

- Always ensure effective agitation, especially when using dry flowable (DF), suspension concentrate (SC), water dispersible granule (WG) and wettable powder (WP) formulations.
- Ensure pressure gauges are working accurately.
- Use the correct (specified) pressure range for the nozzles.
- If a nozzle's output (litres per minute) varies by more than 5% from the manufacturer's specifications, replace that nozzle.
- Always use a low-drift type nozzle wherever possible, such as an air induction (AI) nozzle. Flat fan nozzles were the popular choice for herbicide spraying, but these are no longer appropriate when it comes to reducing spray drift. For more information, refer to 'Simple and easy calibration' on page 160.

- Select the correct nozzle size from the manufacturer's chart once you have decided on a safe ground speed and the recommended application volume for the herbicide being used.
- Ensure a 'double overlap' of the spray fans at the top of the target, not at ground level. Too low will result in uneven application of herbicide, while too high will increase the risk of off-target damage.
- Ensure all equipment is properly calibrated before use.
- Herbicide labels can include mandatory advice on droplet spectrum, e.g. medium coarse; always choose the right nozzle and operating pressure.

## Managing herbicide spray drift

Selecting nozzles to apply herbicides should primarily focus on reducing the risk of spray drift without compromising efficacy. Drift (or loss) is a significant issue facing the industry and those applying herbicides have a moral and legal obligation to adopt current best practices.

Although there remains confusion among some growers about nozzle selection, the industry in general, backed largely by several years of trials on application rates, nozzle designs and travel speeds, generally agrees (and recommends) that growers can apply most herbicides with coarser spray quality without any detrimental effect on efficacy. How coarse still depends on the herbicide, the target and the conditions at the time of spraying, and growers need to be prepared to adjust either the application rate or nozzle design appropriately. For example, if using very coarse droplets, higher water volumes might be required to maintain high levels of efficacy, particularly when targeting fine-leaf grasses with selective (Group 1) products.

Consult your spray equipment supplier for appropriate nozzle types and configurations.

More information on managing spray drift can be found on the [APVMA website](https://apvma.gov.au/node/10796) (<https://apvma.gov.au/node/10796>).

## Simple and easy calibration

The most common procedure for calibrating herbicide spray equipment is:

1. Select the tractor engine revolutions per minute (rpm) and gear to give a satisfactory ground speed in the orchard and the correct pump pressure.
2. Fill the spray tank with water and note the exact level reached.
3. Measure a 100 m strip and spray it with water.
4. Measure the width of the sprayed strip.
5. Return the rig to the exact position where it was filled the first time and measure how much water it takes to refill the tank to the same level as in step 2.

The area covered by a full tank can then be calculated using the following:

### Assume

Length of sprayed area [L] = 100 m

Width of sprayed area [W] = 1.5 m

Tank capacity [T] = 500 L

Volume of water used in test spray [V] = 10 L

Application rate of product [R] = 3.75 kg/ha

### Then

Area covered by the full tank is  $(L \times W \times T) \div V$

In the example, the area covered is

$(100 \text{ m} \times 1.5 \text{ m} \times 500 \text{ L}) \div 10 \text{ L} = 7,500 \text{ m}^2$  or 0.75 ha (there are 10,000 m<sup>2</sup> per hectare)

### Herbicide required in a full tank

= application rate [R]  $\times$  area covered by a full tank

In our example the amount of herbicide required =  $3.75 \text{ kg/ha} \times 0.75 \text{ ha} = 2.8 \text{ kg}$

## Herbicides and their uses

Table 118. Pre-emergent residual herbicides.

| Active ingredient<br>(example trade name) | Herbicide group | Crop                                       | Weeds controlled                                    | Remarks                                                                                                                                                                                                                                                                                     |
|-------------------------------------------|-----------------|--------------------------------------------|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Flumioxazin (Chateau®)                    | 14              | Pome and stone fruit                       | A wide range of grass and broadleaf weeds.          | Requires at least 15 mm of rain or irrigation to activate. Applied postharvest to bud break, add a knockdown for weeds taller than 100 mm.                                                                                                                                                  |
| Isoxaben (Gallery® 750)                   | 29              | Orchards                                   | Certain broadleaf weeds.                            | Requires incorporation by at least 12.5 mm of rainfall or irrigation within 21 days of application.                                                                                                                                                                                         |
| Napropamide (Devrinol-C 500 WG)           | 0               | Stone fruit                                | Annual grasses and some broadleaf weeds.            | Incorporate to a depth of 20–50 mm.                                                                                                                                                                                                                                                         |
| Norflurazon (Zoliar® 800 DF)              | 12              | Apples, pears, stone fruit                 | A wide range of annual broadleaf weeds and grasses. | Do not use more than 4.2 kg of product/ha in one season. Do not apply to trees younger than 18 months.                                                                                                                                                                                      |
| Oryzalin (Cameo™ 500)                     | 3               | Apples, pears and stone fruit              | A wide range of annual broadleaf weeds and grasses. | Use a lower rate for short-term (up to 4 months) and a higher rate for longer-term (6–8 months) control. Activated by moisture.                                                                                                                                                             |
| Oxyfluorfen (Goal®)                       | 14              | Apples, pears, apricots, plums and peaches | A wide range of annual broadleaf weeds and grasses. | For pre-emergent or early-stage seedling control, apply 3–4 L/ha. Do not apply after bud swell.<br>For a post-emergent spike, use at 75 mL/ha with a glyphosate product or 250 mL/ha with a paraquat or diquat/paraquat product.<br>Do not use on apples or pears younger than 3 years old. |
| Pendimethalin (Stomp 440®)                | 3               | Deciduous fruit                            | A wide range of annual broadleaf weeds and grasses. | Requires moisture for incorporation.                                                                                                                                                                                                                                                        |
| Simazine (various)                        | 5               | Apples, pears                              | A range of broadleaf weeds.                         | Do not use on trees younger than 2 years old. Use a higher rate for medium to heavy textured soil types.                                                                                                                                                                                    |
| Terbacil (Sinbar®)                        | 5               | Apples, peaches                            | Annual weeds and perennial grasses.                 | Do not apply to trees younger than 3 years old. Do not apply to sandy or gravelly soil types. Sorrel can become predominant after repeated applications of terbacil.                                                                                                                        |

Table 119. Post-emergent selective grass herbicides.

| Active ingredient<br>(example trade name) | Herbicide group | Crop                                   | Weeds controlled             | Remarks                                                                    |
|-------------------------------------------|-----------------|----------------------------------------|------------------------------|----------------------------------------------------------------------------|
| Clethodim (Status®)                       | 1               | Non-bearing fruit trees                | Annual grasses               | Apply to 2-leaf to fully tillered grasses.                                 |
| Fluazifop-p-butyl (Fusilade® Forte)       | 1               | Apples, pears, stone fruit             | Annual and perennial grasses | A withholding period is not required on these crops when used as directed. |
| Haloxifop (Verdict®)                      | 1               | Apples, pears, stone fruit, persimmons | Annual and perennial grasses | Apply to small, actively growing grasses.                                  |

Table 120. Post-emergent non-selective knockdown herbicides.

| Active ingredient (example trade name)                | Herbicide group | Crop                          | Weeds controlled                                                                 | Remarks                                                                                                                                                                                                                                    |
|-------------------------------------------------------|-----------------|-------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Amitrole + ammonium thiocyanate (Amitrole T)          | 34              | Orchards                      | Broad-spectrum: broadleaf weeds (including marshmallow) and sedges.              | Trees should be at least 3 years old. Do not apply within 56 days of harvest. Wet weeds thoroughly. Use a higher rate for marshmallow.                                                                                                     |
| Amitrole + paraquat <sup>1</sup> (Guerrilla®)         | 22 + 34         | Orchards                      | Various.                                                                         | Spray young weeds in late winter for spring–summer. Use a higher rate in spring.                                                                                                                                                           |
| Asulam (Rattler® 400)                                 | 18              | Apples                        | Dock.                                                                            | Apply to actively growing dock in spring when leaves are fully expanded but before flower shoots emerge.                                                                                                                                   |
| Carfentrazone-ethyl (Spotlight Plus®)                 | 14              | Young or established orchards | Small-flowered mallow and certain other annual broadleaf weeds.                  | Tank mix with a knockdown herbicide to assist with weed control. Registered for sucker control in pome and stone fruit including prunes (plums).                                                                                           |
| Diquat <sup>1</sup> (Reglone®)                        | 22              | Orchards                      | Capeweed.                                                                        | Avoid spray drift onto green plant parts. Spray only actively growing weeds (50–100 mm high). Wet thoroughly (add wetter).                                                                                                                 |
| Glufosinate ammonium (Basta®)                         | 10              | Pome and stone fruit orchards | Broad-spectrum: a wide range of grass and broadleaf weeds including willow herb. | Do not use around trees younger than 2 years old, unless they are effectively shielded from spray and spray drift. Ensure thorough spray coverage. Works best in warm, humid conditions. Do not harvest for 21 days following application. |
| Glufosinate-ammonium + carfentrazone-ethyl (Hellcat®) | 10 + 14         | Pome and stone fruit          | Perennial and annual weeds.                                                      | Do not allow spray or spray drift to contact desirable foliage or green (uncalloused) bark.                                                                                                                                                |
| Glyphosate (Roundup®)                                 | 9               | Apples, pears and stone fruit | A wide range of annual and perennial weeds.                                      | Do not allow spray or spray drift to contact green bark, suckers, fresh wounds, foliage or fruit. Do not use near trees younger than 3 years old unless they are properly protected from spray and drift.                                  |
| Glyphosate + carfentrazone-ethyl (Broadway®)          | 9 + 14          | Pome and stone fruit orchards | Broadleaf weeds including marshmallow.                                           | Do not allow spray or drift to contact green bark, stems, foliage or fruit.                                                                                                                                                                |
| Nonanoic acid (Slayer® Organic Herbicide)             | Unknown         | Orchards                      | Seedling and young annual and perennial weeds.                                   | Use on fallow soil. Spray to completely cover the weed surface. Reapplication at around 7 days might be necessary if regrowth occurs.                                                                                                      |
| Paraquat (Gramoxone®)                                 | 22              | Orchards                      | Most annual grasses and some broadleaf weeds. Add diquat to control capeweed.    | Avoid spray drift onto green plant parts. Spray only actively growing weeds (50–100 mm high). Wet thoroughly.                                                                                                                              |
| Paraquat + diquat (Spray.Seed®)                       | 22              | Orchards                      | Broad-spectrum.                                                                  | Avoid spray drift onto plant parts with green pigment. Spray only actively growing weeds (50–100 mm high). Wet thoroughly.                                                                                                                 |
| Saflufenacil (Sharpen®)                               | 14              | Pome fruit orchards           | A range of broadleaf weeds and grasses.                                          | Do not apply as a spray near trees younger than 3 years old unless they are effectively shielded from spray and spray drift.                                                                                                               |



# Avoiding pesticide resistance

Farm Chemicals Unit, Agriculture and Biosecurity, NSW DPIRD

A pest or disease is resistant to a specific chemical when that chemical no longer provides the control it did previously. Genetically, all populations contain some individuals with resistance to a pesticide. While repeatedly spraying pests and diseases with a particular chemical will continue to kill susceptible individuals, it will also increase the number of resistant individuals. This is referred to as resistance pressure. Once the resistant population reaches a critical proportion, the chemical will no longer be effective. Managing resistance to all pesticides is essential when choosing a control strategy.

## Managing resistance

Resistance management starts with the 3 principles of best practice spray application:

1. Product labels are carefully read and followed.
2. Full recommended rates of registered pesticides are used.
3. The application method achieves thorough coverage of the target area to maximise contact.

Product labels incorporate a resistance warning. Many include crop-specific instructions relating to the number of applications permitted for that crop. Agricultural chemical users must always read the label and any permit before using the product and strictly follow the conditions as directed. Following all label and permit instructions is vital to managing resistance.

In addition to good spray application, chemical groups used should be rotated to prevent the target from being repeatedly treated with the same active ingredient. All registered pesticides have a symbol on the label that identifies the action group to which they belong. This helps growers choose a product from a different chemical action group to rotate the active ingredients used in a program. There are identification schemes for herbicides ([Table 118](#) to [Table 120](#)), fungicides ([Table 121](#)), and insecticides and miticides ([Table 122](#)).

CropLife Australia manages the insecticide resistance management review group (IRMRG). There are specific chemical rotation plans for high-profile horticulture pests such as two-spotted mite, European mite, and green peach aphid on the [CropLife Australia website](#). CropLife Australia also facilitates the [fungicide resistance action committee](#) (FRAC) activities, including annually reviewing and updating fungicide resistance management recommendations for modes of action and specific crops.

Table 121. Fungicide groups<sup>1,2</sup>, page 1 of 2.

| Group | Chemical class | Common name         | Example trade name*             |
|-------|----------------|---------------------|---------------------------------|
| 1     | Benzimidazole  | Thiabendazole       | Tecto Flowable®                 |
| 2     | Dicarboximide  | Iprodione           | Rovral®                         |
|       |                | Procymidone         | Sumisclex® 500                  |
|       | Imidazole      | Imazalil            | Fungaflor®                      |
|       | Piperazine     | Triforine           | Saprol®                         |
| 3     | Triazole       | Cyproconazole       | Garrison Rapid (a component of) |
|       |                | Difenoconazole      | Bogard®                         |
|       |                | Hexaconazole        | Synan                           |
|       |                | Mefentrifluconazole | Belanty®                        |
|       |                | Myclobutanil        | Systhane®                       |
|       |                | Penconazole         | Topas®                          |
|       |                | Propiconazole       | Tilt® 500 EC                    |
|       |                | Tebuconazole        | Greenseal®                      |

Table 121. Fungicide groups<sup>1,2</sup>, page 2 of 2.

| Group | Chemical class             | Common name                                | Example trade name*                  |
|-------|----------------------------|--------------------------------------------|--------------------------------------|
| 7     | Pyrazole carboxamide       | Fluxapyroxad                               | Merivon® (a component of), Sercadis® |
|       |                            | Penthiopyrad                               | Fontelis®                            |
|       |                            | Isopyrazam                                 | Seguris® Flexi                       |
| 7     | Pyridine carboxamides      | Boscalid                                   | Pristine®                            |
|       | Pyridinyl-ethyl-benzamides | Fluopyram                                  | Luna® Sensation                      |
| 8     | Hydroxypyrimidine          | Bupirimate                                 | Nimrod®                              |
| 9     | Anilinopyrimidine          | Cyprodinil                                 | Chorus®                              |
| 11    | Strobilurin                | Kresoxim-methyl                            | Stroby®                              |
|       |                            | Trifloxystrobin                            | Flint®                               |
|       |                            | Mandestrobin                               | Intuity™                             |
|       |                            | Pyraclostrobin                             | Merivon® (a component of)            |
| 12    | Phenylpyrrole              | Fludioxonil                                | Scholar®                             |
| 13    | Quinazolinone              | Proquinazid                                | Talendo®                             |
| 19    | Polyoxins                  | Polyoxin-D zinc salt                       | Intervene®                           |
| 28    | Carbamates                 | Iodocarb                                   | Garrison Rapid (a component of)      |
| 33    | Ethyl phosphonate          | Fosetyl                                    | Aliette®                             |
| 52    | Phenyl-propanol            | Ipflufenquin                               | Migiwa® Kinoprol®                    |
| M1    | Inorganic                  | Copper fungicides                          | Coppox® WG                           |
| M2    | Inorganic                  | Potassium bicarbonate + potassium silicate | Ecocarb® Plus                        |
|       |                            | Sulfur as polysulfide sulfur               | Grochem Lime Sulphur                 |
|       |                            | Sulfur (elemental)                         | Thiovit Jet®                         |
| M3    | Dithiocarbonate            | Mancozeb                                   | Dithane® Rainshield® NeoTec®         |
|       |                            | Metiram                                    | Polyram®                             |
|       |                            | Thiram                                     | Thiram WG                            |
|       |                            | Zineb                                      | Barmac Zineb                         |
|       |                            | Ziram                                      | Ziram WG                             |
| M4    | Phthalimide                | Captan                                     | Orthocide®                           |
| M5    | Chloronitrile              | Chlorothalonil                             | Bravo®                               |
| M9    | Quinone                    | Dithianon                                  | Dinon 700 WG                         |
| U12   | Guanidine                  | Dodine                                     | Syllit®                              |

Table 122. Insecticide and miticide groups<sup>1,2</sup>, page 1 of 2.

| Group | Chemical class             | Common name | Example trade name* |
|-------|----------------------------|-------------|---------------------|
| 1A    | Carbamate                  | Carbaryl    | Bugmaster®          |
|       |                            | Methomyl    | Nufarm Methomyl     |
|       |                            | Pirimicarb  | Aphidex®            |
| 1B    | Organophosphate            | Malathion   | Fyfanon®            |
|       |                            | Prothiofos  | Tokuthion®          |
|       |                            | Trichlorfon | Lepidex®            |
| 2B    | Phenylpyrazoles (fiproles) | Fipronil    | Amulet Cue-Lure®    |

Table 122. Insecticide and miticide groups<sup>1,2</sup>, page 2 of 2.

| Group | Chemical class               | Common name                                          | Example trade name*        |
|-------|------------------------------|------------------------------------------------------|----------------------------|
| 3A    | Pyrethroid                   | Alpha-cypermethrin                                   | Alpha-Scud®                |
|       |                              | Bifenthrin                                           | Talstar®                   |
|       |                              | Piperonyl butoxide + pyrethrins                      | Py-Bo                      |
|       |                              | Pyrethrins                                           | Pyganic®                   |
|       |                              | Tau-fluvalinate                                      | Mavrik® Aquaflow           |
|       | Pyrethroid-ester             | Etofenprox                                           | Trebon®                    |
| 4A    | Neonicotinoid                | Acetamiprid                                          | Cormoran® (a component of) |
|       |                              | Clothianidin                                         | Samurai®                   |
|       |                              | Imidacloprid                                         | Confidant 200SC            |
|       |                              | Thiacloprid                                          | Cobra® 480SC               |
| 4C    | Sulfoximine                  | Sulfoxaflor                                          | Transform®                 |
| 5     | Spinosyn                     | Spinetoram                                           | Delegate®                  |
|       |                              | Spinosad                                             | Entrust® Organic           |
| 6     | Avermectin                   | Abamectin                                            | Vertimec®                  |
|       | Milbemycin                   | Milbemectin                                          | Milbeknock®                |
| 7B    | Juvenile hormone mimic       | Fenoxycarb                                           | Insegar®                   |
| 9B    | Feeding blocker              | Pymetrozine                                          | Chess®                     |
| 10A   | Tetrazine                    | Clofentezine                                         | Apollo®                    |
|       | Thiazolodine                 | Hexythiazox                                          | Calibre®                   |
| 10B   | Diphenyloxazoline            | Etoxazole                                            | Paramite®                  |
| 11    | Microbial                    | <i>Bacillus thuringiensis</i> subsp. <i>Kurstaki</i> | DiPel®                     |
| 12B   | Organotin                    | Fenbutatin oxide                                     | Talk Miticide              |
| 12C   | Organosulfur miticide        | Propargite                                           | Betamite®                  |
| 15    | Benzoylureas                 | Novaluron                                            | Cormoran® (a component of) |
| 16    | Thiadiazine                  | Buprofezin                                           | Applaud®                   |
| 18    | Diacylhydrazine              | Methoxyfenozide                                      | Prodigy®                   |
|       |                              | Tebufenozide                                         | Ecdypro 700 WP             |
| 20B   | Quinoline                    | Acequinocyl                                          | Kanemite®                  |
| 20D   | Carbazate                    | Bifenazate                                           | Acramite®                  |
| 21A   | Mite growth inhibitor        | Tebufenpyrad                                         | Pyranica®                  |
| 22A   | Oxadiazine                   | Indoxacarb                                           | Avatar® eVo                |
| 23    | Tetramic acid derivative     | Spirotetramat                                        | Movento®                   |
|       |                              | Spiromesifen                                         | Interrupt®                 |
| 25    | Beta-ketonitrile derivatives | Cyflumetofen                                         | Danisaraba®                |
| 28    | Diamide                      | Chlorantraniliprole                                  | Altacor® Hort              |
|       |                              | Cyclaniliprole                                       | Teppan® 50 SL              |
|       |                              | Tetraniliprole                                       | Vayego® 200 SC             |
| 29    | Pyridincarboxamide           | Flonicamid                                           | Mainman®                   |

<sup>1</sup> Trade names that include the common chemical name are not listed. <sup>2</sup> The table shows fungicide groups based on mode of action only. For a chemical's compatibility with integrated pest management (IPM), please refer to the individual crop tables and the label. \*Example only.

Source: [CropLife Australia](https://www.croplife.org.au/) (<https://www.croplife.org.au/>).

## Resources

[Fungicide Resistance Action Committee \(FRAC\)](https://www.frac.info/) <https://www.frac.info/>

[Insecticide Resistance Management Review Group \(IRMRG\)](https://www.croplife.org.au/resources/programs/resistance-management/insecticide-resistance-management-strategies/) <https://www.croplife.org.au/resources/programs/resistance-management/insecticide-resistance-management-strategies/>



# Your responsibilities when applying pesticides

## Farm Chemicals Unit, Plant Biosecurity and Product Integrity, NSW DPIRD

The Australian Pesticides and Veterinary Medicines Authority (APVMA), NSW Environment Protection Authority (EPA), SafeWork Australia and SafeWork NSW are the government agencies that regulate pesticides in NSW.

### *Agricultural and Veterinary Chemicals Code Act 1994 (Commonwealth)*

The APVMA administers the *Agricultural and Veterinary Chemicals Code Act 1994*. Under the Act, the APVMA is responsible for the import, registration and labelling of pesticides. States and territories regulate the use of pesticides.

#### Permits for off-label use

Where there is a need to use pesticides outside the registered use pattern, the APVMA can approve off-label use by issuing a **minor use, emergency or research permit**. In NSW, the *Pesticides Act 1999* does not allow off-label use unless a permit is approved by the APVMA. A list of current permits and registered products is available on the [APVMA website](https://portal.apvma.gov.au/pubcris) (<https://portal.apvma.gov.au/pubcris>).

Any individual or organisation can apply for a permit. The APVMA can be contacted on 02 6770 2300 or by [email](mailto:enquiries@apvma.gov.au) ([enquiries@apvma.gov.au](mailto:enquiries@apvma.gov.au)).

#### The label

Chemical labels are legal documents. The *NSW Pesticides Act 1999* requires all chemical users to read and comply with label instructions.

#### Signal heading

Pesticides fall into 3 of the 10 schedules in the Poisons Standard. All pesticides carry a signal heading. Signal headings for pesticides include:

- Caution (Schedule 5)
- Poison (Schedule 6)
- Dangerous Poison (Schedule 7).

#### Re-entry intervals

The re-entry interval is the time that must elapse between applying a pesticide and entering the sprayed crop, unless the person is wearing full personal protective equipment (PPE).

#### Pesticides and the environment

Many pesticides are toxic to aquatic organisms, bees and birds. Following label instructions will minimise the risk to off-target organisms.

Many labels carry the warning: '**Dangerous to bees. Do not spray any plants in flower while bees are foraging**'. It is often safe to spray early in the morning or late in the afternoon but only when bees are not foraging.

Organophosphate and carbamate insecticides are toxic to some birds, especially in granular formulations. Refer to the label for details on how to minimise the danger to birds.

#### Withholding periods

The withholding period (WHP) is the minimum time that must elapse between the last application of a pesticide and harvest, grazing or cutting the crop or pasture for fodder. The purpose of the WHP is to minimise the risk of residues in agricultural commodities and foods for human and animal consumption.

Some export markets have a lower residue tolerance than the Australian maximum residue limits (MRL). Contact your processor or packing shed to determine their market requirements.

## Managing spray drift

Spray drift is the physical movement of chemical droplets onto non-target areas where humans, sensitive plants, animals, and the environment might be unduly exposed. Drift can be onto adjacent areas or travel long distances.

Buffer zones reduce the risk of drift onto non-target areas. Applicators must adhere to buffer zones and other drift reduction instructions on labels and avoid application during temperature inversion conditions.

## Safety instructions

Safety instructions on labels provide information about personal protective equipment and other safety precautions that are essential when using the product.

**Note:** before opening and using any farm chemical, consult the label and the Safety Data Sheet (SDS) for safety directions.

## Applying pesticides by aircraft

Product labels indicate which products are suitable for application by aircraft. They also provide a recommendation for the minimum water volume for aerial application. Drones are also aircraft.

More information on the legal requirements for aerial application is available on the [EPA website](https://www.epa.nsw.gov.au/Your-environment/Pesticides/Licences-and-advice-for-occupational-pesticide-users/aerially-applying-pesticides) (<https://www.epa.nsw.gov.au/Your-environment/Pesticides/Licences-and-advice-for-occupational-pesticide-users/aerially-applying-pesticides>).

## Pesticides Act 1999 (NSW)

The Environment Protection Authority administers the *Pesticides Act 1999* and Pesticides Regulation 2017, which control pesticide use in NSW. The aim is to minimise risks to human health, the environment, property, industry and trade.

The primary principle of the *Pesticides Act 1999* is that pesticides must only be used for the purpose described on the product label and label instructions must be followed.

The Act and Regulation require pesticide users to:

- Only use pesticides registered or permitted by the APVMA.
- Obtain an APVMA permit if they wish to use a pesticide contrary to label instructions.
- Read the approved label and/or APVMA permit for the pesticide product (or have the label/permit read to them) and strictly follow the directions on the label.
- Keep all registered pesticides in containers bearing an approved label.
- Prevent damage to people, property, non-target plants and animals, the environment and trade when applying pesticides.

## Training

The minimum prescribed training qualification is the AQF2 competency unit, 'Apply chemicals under supervision'. However, chemical users are encouraged to also complete the AQF3 competency units: 'Prepare and apply chemicals' and 'Transport, handle and store chemicals'.

## Record keeping

All people who use pesticides for commercial or occupational purposes must make a record of their pesticide use. Records must be made within 24 hours of applying a pesticide and include:

- date, start and finish time
- operator details – name, address and contact information
- crop treated, e.g. apples
- property address and a clear delineation of the area where the pesticide was applied
- type of equipment used to apply the pesticide, e.g. knapsack, air-blast sprayer, boom spray
- full name of the product or products (e.g. Bayfidan 250 EC Fungicide® – not just 'Bayfidan')
- total amount of concentrate product used
- total amount of water, oil or other products mixed in the tank with the concentrate
- size of the block sprayed and the order of blocks treated
- an estimate of the wind speed and direction at the start of spraying

- weather conditions at the time of spraying and weather conditions specified on the label
- changes to wind and weather conditions during the application
- records must be made in English and kept for 3 years.

## Globally Harmonised System of classifying and labelling chemicals

The Globally Harmonised System (GHS) is an international system for classifying hazards and communicating about dangerous goods and hazardous substances. The GHS replaces the old hazardous substances and dangerous goods classification.

The [SafeWork Australia website](https://www.safework.nsw.gov.au/resource-library/list-of-all-codes-of-practice) (<https://www.safework.nsw.gov.au/resource-library/list-of-all-codes-of-practice>) lists all the codes of practice you will need, including 'Labelling of workplace hazardous chemicals' and another for 'Preparation of safety data sheets for hazardous chemicals' to provide industry with guidance on how to comply with the GHS.

## Work Health and Safety Act 2011 (Commonwealth)

SafeWork Australia administers the *Commonwealth Work Health and Safety Act 2011* and the Work Health and Safety Regulation 2011.

The Act defines the responsibilities of employers or the person conducting a business or undertaking (PCBU) and the responsibilities of workers.

The Regulation covers hazardous substances and dangerous goods, including applying the GHS in Australia.

SafeWork Australia has published several [Codes of Practice](https://www.safeworkaustralia.gov.au/search?search=codes+of+practice) for different industries and situations (<https://www.safeworkaustralia.gov.au/search?search=codes+of+practice>).

## Work Health and Safety Act 2011 (NSW)

SafeWork NSW administers the [Work Health and Safety Act 2011](https://www.legislation.nsw.gov.au/#/view/act/2011/10) (WHS Act; <https://www.legislation.nsw.gov.au/#/view/act/2011/10>) and the [Work Health and Safety Regulation 2017](https://www.legislation.nsw.gov.au/#/view/regulation/2017/404) (<https://www.legislation.nsw.gov.au/#/view/regulation/2017/404>).

The Act implements the Commonwealth WHS Act in NSW. It outlines the primary responsibility of the employer or the PCBU to maintain a safe workplace. There is an emphasis on consultation with workers, risk assessment and management, and attention to worker training and supervision.

The WHS Regulation 2017 includes managing hazardous substances (i.e. most pesticides). It covers identifying hazardous substances in the workplace, and assessing and managing risks associated with their use.

The WHS Regulation 2017 includes responsibilities for managing risks to health and safety at a workplace including:

- correctly labelling containers
- maintaining a register of hazardous chemicals
- identifying risk and ensuring the stability of hazardous chemicals
- ensuring that exposure standards are not exceeded
- information, training and supervision for workers
- spill containment kits to be kept on-site
- SDS for chemicals kept on-site
- controlling ignition sources and the accumulation of flammable and combustible materials
- providing fire protection, fire-fighting equipment, emergency and safety equipment
- developing and displaying an emergency plan for the workplace
- stability, support and appropriate plumbing for bulk containers.

## Dangerous Goods (Road and Rail Transport) Act 2008

The Environment Protection Authority (EPA) and SafeWork NSW administer the *Dangerous Goods (Road and Rail Transport) Act 2008* and Regulation. The EPA deals with transport while SafeWork NSW is responsible for classification, packaging and labelling. This act regulates the transport of all dangerous goods except explosives and radioactive substances.

## Acknowledgements

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Natalie O'Leary, Profarm Trainer.

## Analytical laboratories

Below is a list of commercial laboratories that undertake analysis of food commodities and other materials for chemical residues:

### **Eurofins Agrosience Testing**

Phone 02 9900 8442

Website <https://www.eurofins.com.au/locations/eurofins-agrosience-testing-lane-cove/>

### **National Measurement Institute**

Phone 1800 020 076

Email [info@measurement.gov.au](mailto:info@measurement.gov.au)

### **National Association of Testing Authorities**

Phone 02 9736 8222

Website <https://www.nata.com.au>

## Information sources

[APVMA](http://www.apvma.gov.au) ([www.apvma.gov.au](http://www.apvma.gov.au))

[Australian Code for the Transport of Dangerous Goods by Road and Rail](http://www.ntc.gov.au/heavy-vehicles/safety/australian-dangerous-goods-code/) ([www.ntc.gov.au/heavy-vehicles/safety/australian-dangerous-goods-code/](http://www.ntc.gov.au/heavy-vehicles/safety/australian-dangerous-goods-code/))

[Bureau of Meteorology](http://www.bom.gov.au) ([www.bom.gov.au](http://www.bom.gov.au))

[Environment Protection Authority](http://www.epa.nsw.gov.au/) ([www.epa.nsw.gov.au/](http://www.epa.nsw.gov.au/))

[Hazardous Substances Information System](http://hcis.safeworkaustralia.gov.au/) (<http://hcis.safeworkaustralia.gov.au/>)

[Managing risks of hazardous chemicals in the workplace](https://www.safeworkaustralia.gov.au/doc/model-code-practice-managing-risks-hazardous-chemicals-workplace) (<https://www.safeworkaustralia.gov.au/doc/model-code-practice-managing-risks-hazardous-chemicals-workplace>)

[National Association of Testing Authorities](http://www.nata.com.au/) ([www.nata.com.au/](http://www.nata.com.au/))

[Safe use and storage of chemicals in agriculture](https://www.safework.nsw.gov.au/advice-and-resources) (<https://www.safework.nsw.gov.au/advice-and-resources>)

[Work Health and Safety Act 2011](http://www.legislation.gov.au/Details/C2017C00305) ([www.legislation.gov.au/Details/C2017C00305](http://www.legislation.gov.au/Details/C2017C00305))

[Work Health and Safety Regulation 2017](https://legislation.nsw.gov.au/view/html/inforce/current/sl-2017-0404) (<https://legislation.nsw.gov.au/view/html/inforce/current/sl-2017-0404>)



# Useful conversions

Most pesticide labels quote use rates in mL or g of product per 100 L of water. Exceptions do occur, such as the rates of chemical thinners and diphenylamine (DPA), which are commonly expressed in parts per million (ppm). If the dosage required is incorrectly calculated, costly mistakes can be made in the orchard or packing shed. Dipping rates for postharvest treatment for Queensland fruit fly (QFF) are quoted as milligrams per litre (mg/L), the equivalent of ppm.

## Standard formula – amount per 100 L

To calculate the amount of product (in litres or kilograms) per 100 L of spray or dip, given the rate or concentration in ppm or mg/L, use the following formula:

### Required amount of product for 100 L

$$= \frac{\text{dip strength (ppm or mg/L)}}{\text{product strength (g/L or g/kg)} \times 10}$$

### For a tankful

Multiply the figure obtained from the standard formula (above) by the tank size and  $\div 100$ .

## Examples

### Spraying thinners

How much carbaryl (product strength 500 g/L) is required per 100 L of water if the concentration rate for Granny Smith apples is 1,000 ppm (or mg/L)?

#### Required amount of product (in L)

$$= \frac{1,000 \text{ ppm or mg/L}}{500 \text{ g/L} \times 10}$$

$$= 0.2 \text{ L/100 L}$$

To convert L to mL, multiply by 1,000. In this case the amount of product is 200 mL/100 L.

### Fruit dipping – DPA (diphenylamine)

A grower needs to dip Red Delicious apples at 2,000 ppm (2 g/L) using a 310 g/L DPA product in a 1,100 L dipping tank. The quantity (in litres) of DPA needed to give the required dip concentration is:

#### Required amount of product (in L)

$$= \frac{2,000 \text{ ppm or mg/L} \times 1,100 \text{ L}}{310 \text{ g/L} \times 10}$$

$$= 7 \text{ L of DPA product per tankful.}$$

### Field spraying for QFF

#### Dilute

An orchardist needs to spray orchard trees for QFF using product A. The label rate is 75 mL of product A per 100 L. The spray is to be made up in a 1,500 L vat.

#### Required amount of product A (in L)

$$= \frac{75 \text{ mL} \times 1,500 \text{ L}}{100 \text{ L}}$$

$$= 1,125 \text{ mL (1.125 L) product in the vat.}$$

This is the dilute spray mix.

### Concentrate

If the same grower, using the same equipment but correctly set up for concentrate spraying, wanted to control QFF, then the calculation is:

#### *Required amount of product A (in L)*

$$= \frac{75 \text{ mL} \times 1,500 \text{ L} \times 4}{100 \text{ L}}$$

= 4,500 mL (4.5 L) product in the vat.

For this example, the sprayer puts out 2,000 L/ha dilute spray to wet the trees 'to the point of run-off'. Re-nozzled and adjusted for concentrate spraying, the 1,500 L sprayer vat now applies 500 L/ha. The concentration factor in this example is therefore  $2,000 \div 500$  or 4x.

When configured for concentrate spraying, the spray unit now covers 4 times the area compared to its previous dilute setup. Always consult the product label for specific instructions on concentrate application. Be sure to follow all safety directions and precautions to manage exposure appropriately.



Figure 204. Hand spraying at Schramm Orchard.



# Useful resources

## Publications

Several publications are mentioned in this guide. Many are available from NSW DPIRD through the Tocal Agricultural College bookshop. Contact details are:

Phone: 1800 025 520

Email [tocal.college@dpiird.nsw.gov.au](mailto:tocal.college@dpiird.nsw.gov.au)

Web [www.tocal.nsw.edu.au/publications](http://www.tocal.nsw.edu.au/publications)

The [NSW DPIRD horticulture website](http://www.dpiird.nsw.gov.au/agriculture/horticulture) ([www.dpiird.nsw.gov.au/agriculture/horticulture](http://www.dpiird.nsw.gov.au/agriculture/horticulture)) contains many publications that are available for downloading.

***Integrated pest and disease management for Australian summer fruit*** is a practical guide for summer fruit orchardists wanting to implement IPDM. This is available free from the [NSW DPIRD website](http://www.dpiird.nsw.gov.au/agriculture/horticulture/stone-fruit/pests,-diseases-and-disorders/summerfruit-ipdm) ([www.dpiird.nsw.gov.au/agriculture/horticulture/stone-fruit/pests,-diseases-and-disorders/summerfruit-ipdm](http://www.dpiird.nsw.gov.au/agriculture/horticulture/stone-fruit/pests,-diseases-and-disorders/summerfruit-ipdm)).

George A, Nissen B, Bignell G, Hutton D, Broadley R and Dunn D (2017) ***Integrated pest and disease management manual for persimmon***, second edition. Department of Agriculture and Fisheries, Queensland, <https://www.horticulture.com.au/Information-Hub/Our-Projects/Project-Reports/PR13007>

## Internet sites

### Pesticides – use and disposal

[Australian Pesticides and Veterinary Medicines Authority](http://www.apvma.gov.au) ([www.apvma.gov.au](http://www.apvma.gov.au))

[bagMUSTER](https://www.bagmuster.org.au/) (<https://www.bagmuster.org.au/>)

[ChemClear](http://www.chemclear.com.au) ([www.chemclear.com.au](http://www.chemclear.com.au))

[drumMuster](http://www.drummuster.org.au) ([www.drummuster.org.au](http://www.drummuster.org.au))

### Agricultural industry organisations

[Apple and Pear Australia Ltd](http://www.apal.org.au) ([www.apal.org.au](http://www.apal.org.au))

[Cherry Growers Australia](http://www.cherrygrowers.org.au) ([www.cherrygrowers.org.au](http://www.cherrygrowers.org.au))

[Hort Innovation](http://www.horticulture.com.au) ([www.horticulture.com.au](http://www.horticulture.com.au))

[National Farmers' Federation](http://www.nff.org.au) ([www.nff.org.au](http://www.nff.org.au))

[NSW Farmers' Association](http://www.nswfarmers.org.au) ([www.nswfarmers.org.au](http://www.nswfarmers.org.au))

[Persimmons Australia](http://www.persimmonsaustralia.com.au) ([www.persimmonsaustralia.com.au](http://www.persimmonsaustralia.com.au))

[Summerfruit Australia Ltd](http://www.summerfruit.com.au) ([www.summerfruit.com.au](http://www.summerfruit.com.au))

### State government

[Department of Jobs, Skills, Industry and Regions](https://djsir.vic.gov.au/) (<https://djsir.vic.gov.au/>)

[Department of Natural Resources and Environment, Tasmania](http://www.dpipwe.tas.gov.au) ([www.dpipwe.tas.gov.au](http://www.dpipwe.tas.gov.au))

[Department of Primary Industries and Regional Development, WA](https://www.dpiird.wa.gov.au/) (<https://www.dpiird.wa.gov.au/>)

[Department of Primary Industries and Regions, SA](https://www.pir.sa.gov.au/) (<https://www.pir.sa.gov.au/>)

[Department of Primary Industries, Queensland](https://www.dpi.qld.gov.au/) (<https://www.dpi.qld.gov.au/>)

[Local Land Services](http://www.lis.nsw.gov.au) ([www.lis.nsw.gov.au](http://www.lis.nsw.gov.au))

[NSW Department of Primary Industries and Regional Development](http://www.dpiird.nsw.gov.au) ([www.dpiird.nsw.gov.au](http://www.dpiird.nsw.gov.au))

[NSW Environment and Heritage](http://www.environment.nsw.gov.au) ([www.environment.nsw.gov.au](http://www.environment.nsw.gov.au))

[NSW Rural Assistance Authority](http://www.raa.nsw.gov.au) ([www.raa.nsw.gov.au](http://www.raa.nsw.gov.au))

[SafeWork NSW](http://www.safework.nsw.gov.au) ([www.safework.nsw.gov.au](http://www.safework.nsw.gov.au))

### Rural assistance

[Health NSW](http://www.health.nsw.gov.au) ([www.health.nsw.gov.au](http://www.health.nsw.gov.au))

[NSW Rural Assistance Authority](http://www.raa.nsw.gov.au) ([www.raa.nsw.gov.au](http://www.raa.nsw.gov.au))

[Services Australia](https://www.servicesaustralia.gov.au/) (<https://www.servicesaustralia.gov.au/>)

**Federal government**

[ABC Rural Department](http://www.abc.net.au/rural) ([www.abc.net.au/rural](http://www.abc.net.au/rural))

[Australian Trade and Investment Commission](http://www.austrade.gov.au) ([www.austrade.gov.au](http://www.austrade.gov.au))

[Department of Agriculture, Fisheries and Forestry](http://www.agriculture.gov.au) ([www.agriculture.gov.au](http://www.agriculture.gov.au))

[Plant Health Australia](http://www.planthealthaustralia.com.au) ([www.planthealthaustralia.com.au](http://www.planthealthaustralia.com.au))

**Climate**

[Bureau of Meteorology](http://www.bom.gov.au) ([www.bom.gov.au](http://www.bom.gov.au))

**Environment**

[Department of Climate Change, Energy, the Environment and Water](http://www.environment.gov.au) ([www.environment.gov.au](http://www.environment.gov.au))

[NSW Environment and Heritage](http://www.environment.nsw.gov.au) ([www.environment.nsw.gov.au](http://www.environment.nsw.gov.au))

[NSW Environment Protection Authority](http://www.epa.nsw.gov.au) ([www.epa.nsw.gov.au](http://www.epa.nsw.gov.au))

**Alternative systems (organics)**

[Australian Organic](http://www.austorganic.com) ([www.austorganic.com](http://www.austorganic.com))

[National Association for Sustainable Agriculture Australia](https://nasaaorganic.org.au/) (<https://nasaaorganic.org.au/>)

[Organic Operators Australia](https://organicoperators.au/) (<https://organicoperators.au/>)

**Economic information**

[Australian Bureau of Agricultural and Resource Economics and Sciences](http://www.agriculture.gov.au/abares) ([www.agriculture.gov.au/abares](http://www.agriculture.gov.au/abares))

[Department of Agriculture, Fisheries and Forestry](https://www.agriculture.gov.au/) (<https://www.agriculture.gov.au/>)

**Export and import support**

[Biosecurity Import Conditions Database](http://www.agriculture.gov.au/import/online-services/bicon) (BICON; [www.agriculture.gov.au/import/online-services/bicon](http://www.agriculture.gov.au/import/online-services/bicon))

[Codex – International Food Standards](http://www.agriculture.gov.au/ag-farm-food/food/codex) ([www.agriculture.gov.au/ag-farm-food/food/codex](http://www.agriculture.gov.au/ag-farm-food/food/codex))

[Manual of Importing Country Requirements](http://www.agriculture.gov.au/export/micor) (Micor; [www.agriculture.gov.au/export/micor](http://www.agriculture.gov.au/export/micor))

**Technical production information****Agencies and universities**

[Commonwealth Scientific and Industrial Research Organisation](http://www.csiro.au) (CSIRO; [www.csiro.au](http://www.csiro.au))

[Fruit and Nut Research and Information Centre, University of California](http://fruitandnuts.ucdavis.edu) (<http://fruitandnuts.ucdavis.edu>)

[New Zealand Ministry for Primary Industries](http://www.mpi.govt.nz) ([www.mpi.govt.nz](http://www.mpi.govt.nz))

[South Australia Research and Development Institute](http://www.pir.sa.gov.au/research) ([www.pir.sa.gov.au/research](http://www.pir.sa.gov.au/research))

[Tasmanian Institute of Agriculture](http://www.utas.edu.au/tia) ([www.utas.edu.au/tia](http://www.utas.edu.au/tia))

[United Kingdom Department for Environment, Food and Rural Affairs](http://www.gov.uk/defra) ([www.gov.uk/defra](http://www.gov.uk/defra))

[United States Department of Agriculture](http://www.usda.gov) (USDA; [www.usda.gov](http://www.usda.gov))

**Integrated pest management**

[Australasian Biological Control Association Inc](http://www.goodbugs.org.au) ([www.goodbugs.org.au](http://www.goodbugs.org.au))

[Australian apple and pear IPDM](https://extensionaus.com.au/ozapplepearipdm/home) (<https://extensionaus.com.au/ozapplepearipdm/home>)

[Australian apple and pear IPDM Facebook page](https://www.facebook.com/groups/579194849206452/) (<https://www.facebook.com/groups/579194849206452/>)

[Integrated pest disease and weed management manual for Australian apples and pears](https://extensionaus.com.au/ozapplepearipdm/ipdm-manual-for-apples-and-pears/) (<https://extensionaus.com.au/ozapplepearipdm/ipdm-manual-for-apples-and-pears/>)

[The AgVic Pocket Guide](https://extensionaus.com.au/ozapplepearipdm/draft_useful-tool-pests-pocket-guide/) ([https://extensionaus.com.au/ozapplepearipdm/draft\\_useful-tool-pests-pocket-guide/](https://extensionaus.com.au/ozapplepearipdm/draft_useful-tool-pests-pocket-guide/))

**Quality assurance**

[Freshcare Australia](http://www.freshcare.com.au) ([www.freshcare.com.au](http://www.freshcare.com.au))

**Nurseries**

[Australian Nurserymen's Fruit Improvement Company](http://www.anfic.com.au) (ANFIC; [www.anfic.com.au](http://www.anfic.com.au))

[Fleming's Nurseries](https://www.flemings.com.au/nurseries/) (<https://www.flemings.com.au/nurseries/>)

# Need more help or information?

Talk with our Temperate Fruit Development Team



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## Feedback please

The authors want to make sure the information we are providing is what you need to help your business grow. We welcome suggestions, comments and ideas from growers and technical people alike that might improve the usefulness and relevance of the guide. Please contact us with your suggestions or scan the QR code to fill out a very short survey.



## Other sources of information

### NSW Local Land Services (Horticulture)

Local Land Services (LLS), launched in January 2014, delivers quality, customer-focused services to farmers, landholders and the community throughout rural and regional NSW. LLS bring together agricultural production advice, biosecurity, natural resource management and emergency management into a single organisation. LLS horticulture officers help producers with the challenges they might face today, take advantage of opportunities, and achieve improvements in crop yields, orchard management and market access.

Producers can contact their nearest [LLS office](https://www.lls.nsw.gov.au/) (<https://www.lls.nsw.gov.au/>) by phoning 1300 795 299.

### NSW DPIRD Biosecurity and Food Safety

Biosecurity NSW is the contact point in this state for anyone who requires advice on moving fruit or plants and other issues of a biosecurity nature in Australia. All enquiries should be directed to [Plant Health Australia](https://www.planthealthaustralia.com.au/) (<https://www.planthealthaustralia.com.au/>) on **1800 084 881**. This phone number will connect you with an automated system to allow you to choose the state or territory that your report or enquiry relates to.



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